Competitiveness of the European Cement and Lime Sectors

Final report

December – 2017

EUROPEAN COMMISSION

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Directorate C — Industrial Transformation and Advanced Value Chains
Unit C2 — Resource Efficiency and Raw Materials

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Within the Consortium

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

2018 EN

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Luxembourg: Publications Office of the European Union, 2018

ISBN 978-92-79-64665-2

doi:10.2873/300170

Table of Content

Executive summary

Introduction

The cement and lime industries are mature sectors, which are vital for a range of downstream industries, products and services. Over the last 10 years, both sectors have witnessed major downturns, and future prospects are less than certain. A key issue for both the cement and lime sectors and, in turn, for policy makers, is to better understand how resilient the sectors are when responding to external shocks, notably changes in demand, but also regulatory reforms and new initiatives (at EU, national, regional and local levels). Against this background, the aim of this study is to offer an assessment of the competitiveness of the EU cement and lime sectors.

EU cement industry profile[1]

Production - Cement is obtained by grinding cement clinker and, in some cases, supplementing it with additions. Spain, Italy, Germany, France and Poland are the largest producers of cement clinker in the EU. In 2015, the total quantity of EU cement clinker production was around 105 million tonnes (Eurostat) to 125 million tonnes (CSI). The majority of clinker production (≈85%) is not sold in the market but goes directly into the production of cement. Eurostat production data indicate that EU28 total production of cement products amounted to an estimated 163 million tonnes (of which 136 million tonnes of Portland* cement[2]) in 2016. These amounts compare with a peak production volume of 268 million tonnes in 2007. Looking at Portland* cement alone, the main EU producers are Italy, Germany, Poland, Spain, France and Poland.

Industry characteristics – 2015, the most recent year of available comparative Eurostat data, the cement manufacturing industry in the EU represented an estimated €15.2 billion turnover and €4.8 billion in value added. Germany, France, Italy, Spain, Poland and Belgium together accounted for 71% of EU's turnover, 70% of EU's enterprises and 68% of EU's employment in the cement sector. In 2015, the sector offered employment to 47 thousand persons in the EU, distributed over around 350 enterprises. The industry was seriously affected by the 2008 economic crisis: between 2008 and 2015, turnover declined by 37%, value added by 49%, employment by 25% and the number of enterprises by 20%. After stabilising somewhat between 2013 and 2015, there is evidence of some limited improvement between 2015 and 2016.

Trade perspective - In 2015, the EU28 cement production represented 4% of global production, placing the EU as the third largest producer behind China (51%) and India (6%). Cement clinker tends to be used directly as input for the production of cement on-site and therefore often does not reach the market. Since 2010 the EU enjoys a trade surplus in cement clinker. Key trade indicators (import penetration, export ratio, trade intensity) for cement clinker demonstrate the overall high trade intensity for cement clinker. Extra-EU exports of Portland* cement are around 5% of total production. As there is hardly any import from non-EU countries, the trade balance with the rest of the world has been positive for every year between 2006 and 2015.

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[1] Please note large disparities exist in estimates from Eurostat data and those coming from industry sources (e.g. the Cement Sustainability Initiative, CSI), especially with regard to the total cement clinker production.

[2] Combinantion of Portland cement and Portland cement composites.

EU lime industry profile

Production - Due to its particular chemical characteristics, lime is a fundamental raw material used for a multitude of industrial processes and different economic activities (e.g. iron and steel production, water treatment, etc.). EU28 total production of lime products amounted to an estimated 23.9 million tonnes in 2016, compared to a peak production volume of 34.7 million tonnes in 2007. The largest EU producer is Germany, followed by France, Italy, Poland, Spain and Belgium.

Industry characteristics[3] - In 2015, the most recent year of available comparative Eurostat data, the lime and plaster manufacturing industries in the EU represented an estimated €4.2 billion turnover and €1.4 billion in value added, with approximately 600 enterprises offering employment to almost 15 thousand persons in the EU. Germany, Belgium, Italy, France, Spain and Poland together accounted for 76% of total EU turnover of lime and plaster manufacturing, 64% of employment but only 43% of enterprises. The industry faced a decline in turnover between 2008 and 2009, with a fall of around 14%, followed by a slight rebound in 2010. It has remained relatively stable thereafter at around 90% of its 2008 level.

Trade perspective - China dominates the global lime production, while countries like India, Russia, Malaysia and South Korea show high growth rates over recent years. International trade in lime products is limited as the wide geographical availability of raw materials (i.e. limestone) and the low value to weight ratio means that lime is typically produced close to markets and is not transported over long distances. International trade in lime is also limited relative to EU production. This applies to both trade within the EU (intra-EU trade) as well as the exports out of the EU (extra-EU exports).

Regulatory and other framework conditions

The cement and lime industries operate within a broad set of regulatory and framework conditions, that influence its past, current and future performance. Climate and ETS, (access to) natural resources, energy legislation and industrial emissions are seen as the most important legislative areas by both firms and industry associations interviewed. Climate and ETS are seen by companies as the most relevant regulatory issue. Industries perceive potential policy changes in the ETS segment (including those post 2030) as a risk for business operations and thus call for long-term policy stability. Key elements from the regulatory framework have been taken as inputs for the development of scenarios.

Conclusions and recommendations

EU cement industry

Cement so far remains (despite existing and expected potential further tradability) within the EU context above all a local product which is usually sold in relatively close geographical proximity to the production site. Being part of the civil engineering and construction value chain, the EU cement sector is highly cyclical and external shocks on demand can have substantial consequences for the sector. This is shown by the turnover decline by 38% between 2008 and 2015, value added by 47%, employment by 27% and the number of enterprises by 2013. Only recently, signs of recovery from the crisis have occurred. Access to international markets can serve as an important possibility to cushion the fluctuations on domestic markets, but also contains a risk as facilitated trade goes both ways.

[3] Eurostat's Structural Business Statistics (SBS) database does not allow for a separation between lime and plaster manufacturing.

EU competitiveness vs. Non-EU in cement – China is producing more than 50% of the world's cement, while countries neighbouring the EU competitors may face lower costs. Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario points toward a level playing field between the EU industry versus non-EU players. Another aspect influencing EU competitiveness is long-term stability and predictability of policy frameworks. Particularly concerning ETS policies, companies call for further long-term stability (post 2030). In response to this situation, policy makers are required to actively monitor neighbouring countries and transport costs, launch initiatives to retain a level playing field between EU and non-EU producers and consider actions to address the problem of carbon leakage for all industries.

Competitiveness between EU Member States – Cement remains largely a local market, not being affected by national borders, but proximity to clients. Due to the crisis in the Spanish construction market, local producers cut costs and shifted towards exports. This situation requires from policy makers to remain attentive to regional impacts of EU policy changes.

Competitiveness of cement versus other products – Main potential substitutes of cement are wood and steel. Both products are however not only substitutes, but also complementary products. Existing LCAs suggest different priorities of construction materials, depending on the scope and methodology of the LCA. Policy makers should therefore support the development of a comprehensive life cycle costing approach at the level of construction works and adhere to material neutrality. In light of the ambitions as formulated in the Paris Agreement, more will need to be done to reduce the CO2 emissions of the sector. Thereto, 'out of the box' but cost-effective solutions to address CO2 emissions will need to be developed in the years to come. These need to be enabled and facilitated through dialogue and cooperation between industry and government.

EU lime industry

Lime so far remains (despite existing and expected potential further tradability) within the EU context above all a local product which is usually sold in relatively close geographical proximity to the production site. The structural decline in the EU industrial basis (particularly steel industry) has already had a profound impact on the EU lime sector. Lime prices vary fairly strongly within the EU, underlining the broad product differentiation, the wide divergence in terms of productivity, as well as limited trade intensity due to the rather low value/weight ratio. Nevertheless, an upward trend can be identified in both export and import intensity of lime.

EU competitiveness vs. Non-EU in Lime – The current development is driven by sluggish domestic demand in the EU. Low transport costs (particularly sea transport) support the EU manufacturers' activities to export surplus production based on high value speciality products. The foreign trade balance is fragile and remains vulnerable to changes in price differentials, induced by changes in input costs, taxes or duties. Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario points toward a level playing field between the EU industry versus non-EU players. Another aspect influencing EU competitiveness is long-term stability and predictability of policy frameworks. Particularly concerning ETS policies, companies call for further long-term stability (post 2030). In response to this situation, policy makers are required to actively monitor neighbouring countries and transport costs, launch initiatives to retain a level playing field between EU and non-EU producers and consider actions to address the problem of carbon leakage and promote investments in innovation based on long-term policy stability.

Competitiveness between EU Member States – Lime remains largely a local market, not being affected by national borders, but proximity to clients. In 2015, France, Germany and Belgium accounted for more than 69% of EU trade (exports), revealing a higher concentration than for production. The most cost-competitive Member States are however, Hungary, Romania and Slovakia, all being in border regions of the EU facing strong price competition from outside the EU. Competitiveness between EU Member States is hence affected by impacts of regional policy measures, but also proximity to outside EU competition. The model exercises point to more pronounced impacts of policy measures to Southern and Eastern European regions. Consequently, policy makers should remain very attentive to regional impacts of EU policy changes.

Competitiveness of Lime versus other products – Currently, fear for substitution of lime products appears to be not founded, despite partial substitution through e.g. chemicals. However, this may change in the future. More important for lime is its interdependent relationship with downstream production processes. Its main client, the steel industry is facing serious and structural problems in recent years and shows concentration effects. This causes challenges for the lime industry as it might lose major clients or end up in situations where the client dictates the price. Policy makers should thus consider the impact on up- and downstream industries in policy making and monitor the development of downstream industries.

1 Introduction

1.1 Objectives and methodology of the study

1.1.1 Objectives

The purpose of the study is to provide an assessment of the competitiveness of the EU cement and lime sectors. More specifically, this study comprises:

a) An assessment of the current competitive situation of the industries including the identification of sector-specific features, the assessment of the competitive position of the sector in relation to main competitors at a global scale, description of the value chain and an analysis of policies;
b) An analysis of potential threats and opportunities related to trade and technological innovation as well as an assessment of the future competitive position of the sectors.

1.1.2 Methodology

The general methodology applied in this study consists of the collection and combination of primary and secondary sources. More details are provided in Annex B.

Starting point of the work was the review of academic and business literature describing and analysing the development of the cement and lime industries and to combine it with scoping interviews with sector associations and plant visits. In addition, various publically available data sources (particularly Eurostat SBS and Eurostat Prodcom) and the Amadeus company database were used to further develop industry profiles. To set the basis for assessing the regulatory conditions, a set of legislative acts were reviewed.

The analysis was then deepened through the implementation of a national association and a company survey (capturing 26 companies with about 30% of employment and turnover in both sectors), covering a representative number of Member States and companies in both sectors. In parallel, interviews with downstream industry associations were held. Moreover, interviews with representative from relevant DGs of the European Commission were conducted to better understand the regulatory base.

The data was then analysed using quantitative and qualitative analysis tools. In parallel, an analysis of the total factor productivity (using Amadeus data) was conducted and 5 different scenarios for the sectors modelled using the ADAGIO input-output model.

The process of validating and analysing data and assumptions for modelling was guided by a Mirror Group meeting on a regular basis after each milestone deliverable consisting of representatives from both sectors.

1.2 Definition of competitiveness

Competitiveness is, according to the World Economic Forum, the "*set of institutions, policies and factors that determine the level of productivity of a country*".[4] There are four aspects of "competitiveness" that could be used in a competitiveness assessment:

1) **EU competitiveness vs. non-EU**: defining the ability of EU industries to compete with companies outside the EU on the global market;
2) **Competitiveness between EU Member States**: defining the competitive position of industries of specific Member States with other Member States;
3) **Competitiveness of cement and lime products vs other products**: defining the ability of cement and lime to compete with substitutional goods towards downstream clients;
4) **Competitiveness of individual companies vs. others**: defining the ability of individual companies to compete with other companies within their market[5].

The focus of this study is on the first three aspects, with special attention to the first aspect. The fourth aspect is often confused with 'competition' and falls outside of the scope of this study.

1.3 Definition of the sectors

In accordance with the European classification of economic activities, NACE (Revision 2)[6], cement and lime are included in Division 23 - Manufacture of other non-metallic mineral products, within the Group 23.5 - Manufacture of cement, lime and plaster. At a four-digit level, the sectors under assessment can be further grouped as follows:

1. Manufacture of cement (NACE 23.51), which covers the manufacture of clinkers and hydraulic cements, including Portland, aluminous cement, slag cement and superphosphate cements. Using common classifications, the covered product categories are presented in the next table.

Table 1: Overview product categories – manufacture of cement

PRCCode[a]	Description	HS/CNCode[b]	Description
23511100	Cement clinker	25231000	Cement clinkers
23511210	Portland cement	25232100	White Portland cement, whether or not artificially coloured
		25232900	Portland cement (excl. white, whether or not artificially coloured)
23511290	Other hydraulic cements	25233000	Aluminous cement
		25239000	Cement, whether or not coloured (excl. Portland cement and aluminous cement)

[a] Product code under the European statistical classification of manufactured products (Prodcom)
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade

[4] World Economic Forum, see: https://www.weforum.org/agenda/2017/09/what-is-economic-competitiveness
[5] Ketels, Christian (2016): Review of Competitiveness Frameworks, see: http://www.hbs.edu/faculty/Publication%20Files/Review%20of%20Competitiveness%20Frameworks%20_3905ca5f-c5e6-419b-8915-5770a2494381.pdf , as well as Ecorys competitiveness studies for the European Commission, see: http://www.sectorcompetitiveness.com/
[6] The term NACE is derived from the French Nomenclature statistique des activités économiques dans la Communauté européenne

2. Manufacture of lime (part of NACE 23.52), which covers the manufacture of quicklime, slaked lime and hydraulic lime. Using common classifications, the following product categories are covered:

Table 2: Overview product categories – manufacture of lime

PRCCode[a]	Description	HS/CNCode[b]	Description
23521033	Quicklime	25221000	Quicklime
23521035	Slaked lime	25222000	Slaked lime
23521050	Hydraulic lime	25223000	Hydraulic lime (excl. pure calcium oxide and calcium hydroxide)

[a] Product code under the European statistical classification of manufactured products (Prodcom)
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade

3. Manufacture of articles of cement and other cement based products (e.g. concrete)[7] which covers manufacture of concrete products for construction purposes, manufacture of ready-mixed concrete, manufacture of mortars, manufacture of fibre cement, and manufacture of other articles of concrete, plaster and cement. Using common classifications, the following product categories are covered:

Table 3: Overview product categories – manufacture of articles of cement and other cement based products

PRCCode[a]	Description	HS/CNCode[b]	Description
23611130	Building blocks and bricks of cement, concrete or artificial stone	68101110	Building blocks and bricks, of light concrete with a basis of crushed pumice, granulated slag, etc.
		68101190	Building blocks and bricks of cement, concrete or artificial stone, whether or not reinforced (excl. of light concrete with a basis of crushed pumice, granulated slag, etc.)
23611150	Tiles, flagstones and similar articles of cement, concrete or artificial stone (excluding building blocks and bricks)	68101900	Tiles, flagstones, bricks and similar articles, of cement, concrete or artificial stone (excl. building blocks and bricks)
23611200	Prefabricated structural components for building or civil engineering, of cement, concrete or artificial stone	68109100	Prefabricated structural components for building or civil engineering of cement, concrete or artificial stone, whether or not reinforced
		68 10 99 00	Articles of cement, concrete or artificial stone, whether or not reinforced (excl. prefabricated structural components for building or civil engineering, tiles, paving, bricks and the like)
23631000	Ready-mixed concrete	38245010	Concrete ready to pour
23641000	Factory made mortars	38245090	Non-refractory mortars and concretes (excl. concrete ready to pour)
23651100	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips, particles, sawdust or other waste of wood, agglomerated with cement, plaster or other mineral binders	68080000	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips, particles, sawdust or other waste of wood, agglomerated with cement, plaster or other mineral binders (excl. articles of asbestos-cement, cellulose fibre-cement or the like)

[a] Product code under the European statistical classification of manufactured products (Prodcom)

[7] Corresponds to parts of NACE 23.6 (Manufacture of articles of concrete, cement and plaster), specifically NACE 23.61 Manufacture of concrete products for construction purposes, 23.63 Manufacture of ready-mixed concrete, 23.65 Manufacture of fibre cement, 23.69 Manufacture of other articles of concrete, plaster and cement),

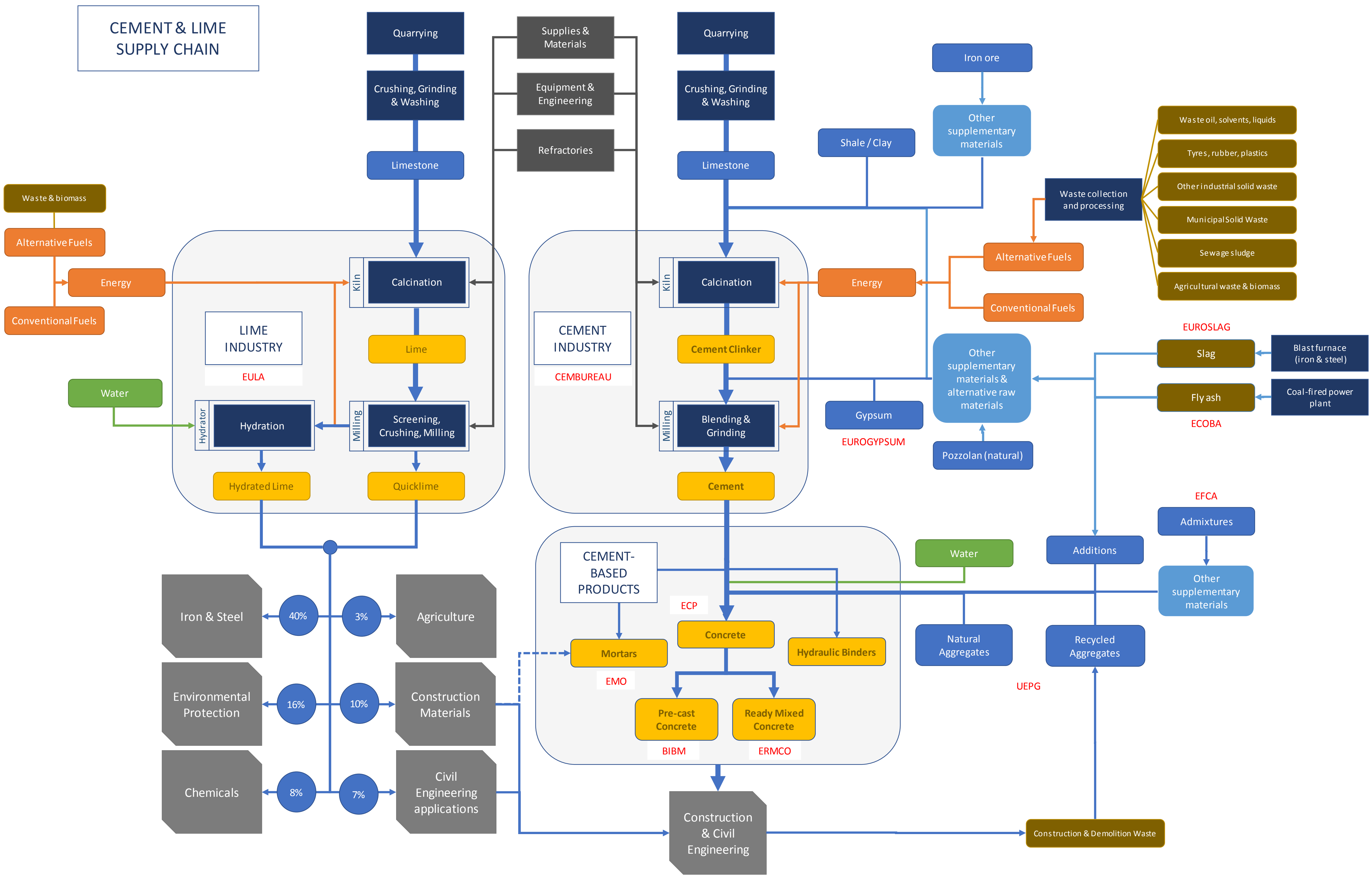
PRCCode[a]	Description	HS/CNCode[b]	Description
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade			

1.4 The cement and lime supply chain linkages

The industries of manufacturing lime, cement and cement-based products analysed in this study are closely related and share in limestone the same source as well as in the construction sector a major common end-client. While this causes similarities in terms of regulatory conditions and pressures, there are also differences due to specificities of the consistency and use of products as well as the competitive environment.

Figure 1 presents the combined supply chain, which depicts the relations between and within the cement and lime industries.

Figure 1 Cement & Lime supply chain



Source: Ecorys

1.5 Reading guide to this report

This report is structured as follows:

- **Chapter 2 – EU cement industry profile:** provides and overview of the competitiveness of the cement industry;
- **Chapter 3 – EU lime industry profile:** provides an overview of the competitiveness profile of the lime industry;
- **Chapter 4 - Regulatory and other framework conditions:** provides an overview of the regulatory and other framework conditions affecting the industries;
- **Chapter 5 – Assessment of industry competitiveness and scenarios for the future:** provides an assessment of industry competitiveness and market conditions and describes the scenarios, both in terms of assumptions and results. Specific attention is paid to the impact of cost changes.
- **Chapter 6 – Conclusions and recommendations.**

Several annexes have been included, covering:

- **Annex A** lists the sector classifications;
- **Annex B** describes the overall methodology of the study;
- **Annex C** shows the (company) questionnaire used for information collection;
- **Annex D** focuses on the analysis of the performance of the industries carried out by using the Amadeus database;
- **Annex E** presents the econometric analysis that was conducted to estimate the 'technological frontier';
- **Annex F** provides more detail on the customisation of the used ADAGIO model;
- **Annex G** presents the bibliography.

2 EU cement industry profile

2.1 Introduction

This chapter gives an overview and assessment of information, based primarily on publicly available statistical data, describing the structure, performance and development of the EU cement industry. The chapter is focussed on the 'upstream' manufacture of the main cement product categories, namely cement clinker, Portland cement, and other hydraulic cement. Demand for cement is almost exclusively dependent on activity in the construction sector, either directly through the supply of 'downstream' cement products such as concrete (ready-mixed and pre-cast), mortars and other hydraulic binders.

Strategies of the large players present in Europe (LafargeHolcim, the HeidelbergCement Group, CEMEX, Buzzi Unicem) include cost leadership (systematic and rigorous management of costs, sharing and implementing best practices and a continuous improvement of operational performance), commercial transformation (anticipating the needs of customers, early involvement in projects etc.) and the standardisation of processes (business processes, technology, and organisational structure across all countries). Mergers and acquisitions between the largest companies (e.g. merger of Lafarge and Holcim, HeidelbergCement's acquisition of Italcementi) form part of a continuous trend, and lead to an increasingly consolidated industry at the European level. Companies develop diversified geographic portfolios as a way of limiting risks and increasing their potential for growth.

2.2 Product overview

2.2.1 Product categories

Cement is obtained by grinding cement clinker and, in some cases, supplementing it with additions. Clinker is produced through the firing/sintering (in a cement kiln) of a mixture of limestone (or other minerals containing high levels of calcium) and other materials (e.g. clay, shale, sand, iron ore, bauxite, fly ash and slag) to provide the necessary final chemical composition; a typically (Portland) cement clinker mix would contain approximately 80% limestone and 20% clay. Clinker is a nodular material before it is ground up; nodules can be anything from 1mm to 25mm or more in diameter.

Portland cement, which is the most common type of cement, is a calcium silicate hydraulic cement produced from grinding (Portland) cement clinker to a fine powder with a small addition of gypsum (normally 3 to 5%). Portland cement is normally grey in colour but may also be white. The European cement standard EN 197-1 provides a classification of common cements based on Portland cement clinker[8] with one or more other main constituents. The standard defines 27 distinct common cement products and their constituents grouped into five main categories[9]. These categories reflect the relative proportions of cement clinker and other main constituents, as follows:

- CEM I **Portland cement** (>95% clinker);

[8] As defined under the standard.
[9] In addition, EN 197-1 sets out performance requirements for strength and volume stability.

- CEM II **Portland-composite cement** (65-94% clinker, and 6-35% other constituents[10]);
- CEM III **Blast-furnace cement** (5-64% clinker, and 36-95% blast-furnace slag);
- CEM IV **Pozzolanic cement** (45-89% clinker, and 11-55% of silica fume or, pozzolana or fly ash or a combination thereof);
- CEM V **Composite cement** (20-64% clinker, and 18-50% blast-furnace slag, and 18-50% pozzolana or siliceous fly ash or a combination thereof).

The EN 197-1 standard for common cements further specifies 7 sulfate resisting common cements, 3 distinct low early-strength blast furnace cements and 2 sulfate resisting low early strength blast furnace cements. There are also a number of special cements that are covered by specific standards, such as super sulfate-cement (EN 15743), very low-heat cement (EN 14216) and calcium aluminate cement (EN 1464). There is also a procedure established by CEN/TC 51 in a technical report outlining how to proceed to standardize new cements. The European Technical Assessment (ETA) route is another way to proceed for innovative products, some of which are of particular interest because of their low-carbon characteristics.[11]

The statistical analysis – based on Eurostat Prodcom data and trade statistics – presented in this chapter identifies three main categories of cement products:
- **Cement clinker**[12] covering all types of cement clinker;
- **Portland* cement**[13] covering both white and grey Portland cement (CEM I) and, in so far as can be ascertained, Portland-composite cement (CEM II), as defined under EN 197-1. (see explanatory note below);
- **Other hydraulic cement**[14] covering aluminous cement (calcium aluminate cements) and other hydraulic cements, except Portland (see explanatory note below).

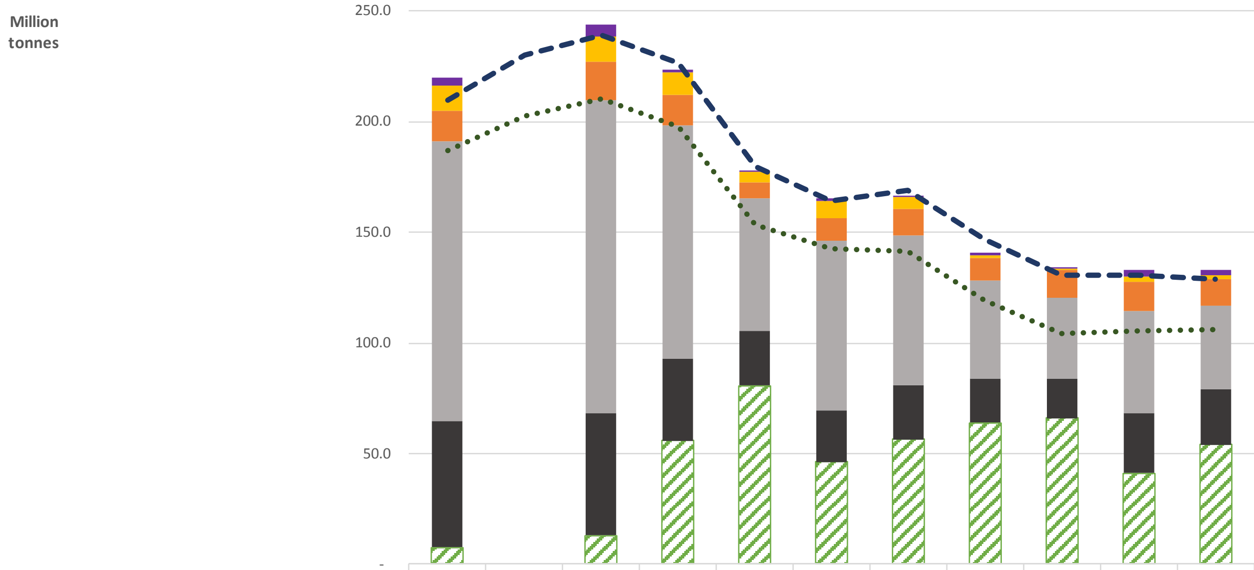
Note on the classification of cement in statistical data

It is difficult to ascertain the correspondence between the classification of cement products used by Eurostat (and other national and international data sources) and the definitions given in the European Standards, primarily the EN 197-1 standard for common cements. The figure below shows a comparison of the breakdown of EU28 domestic deliveries[15] by product type obtained from CEMBUREAU data, and Eurostat data for 'Portland Cement' (PRCCode 23511210) and 'Total cement' (sum of PRCCode 23511210 and PRCCode 23511290 'Other hydraulic cements'). The presence of a significant proportion of 'Unspecified' cement means that an exact comparison between the breakdown for the two data sources is difficult. However, the general pattern revealed by these data suggest that:
- Eurostat code 23511210, hereafter referred to as '**Portland* cement**', covers Portland cement (CEM I) and Portland composite cements (CEM II). However, the precise allocation of products covered under the category Portland-composite cement (CEM II), between the statistical categories of 'Portland cement' and 'Other hydraulic cements' is unclear[16].
- Eurostat code 23511290, '**Other hydraulic cements**', covers all other cement categories; i.e. 'Blast-furnace cement' (CEM III), 'Pozzolanic cement' (CEM IV) and 'Composite cement' (CEM V) and other special cements not defined under EN 197-1. Although, as above, the

[10] Other constituents: one or more of: blast-furnace slag, silica fume, pozzolana, fly ash, burnt shale, or limestone.
[11] See: http://www.brmca.org.uk/documents/European_Standardisation_of_new_and_innovative-cements_Concrete_March_2016.pdf
[12] PRCCode: 23511100 - Cement clinker.
[13] PRCCode: 23511210 - Portland cement.
[14] PRCCode: 23511290 - Other hydraulic cements.
[15] Domestic deliveries are defined as (domestic) EU28 production less exports (intra and extra-EU).
[16] The official 'Explanatory notes to the Combined Nomenclature', (Official Journal, 2015/C 076/01) only offers information on the inclusion under the CN-heading 'Other hydraulic cements' (2523 90 00) of the products 'blast furnace cement' and 'pozzolanic cement'. For the latter, however, the compositional definition provided in the explanatory notes is not coherent with a product category specification(s) as defined under the European Standard EN 197-1.

precise allocation of products covered under the category Portland-composite cement (CEM II) is uncertain.

Figure 2: EU28 cement – breakdown of domestic deliveries by product type 2005-2016



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Composite Cement & Others (CEM V)	3.4		5.0	1.2	0.6	1.0	0.6	1.6	0.2	2.7	2.5
Pozzolanic Cements (CEM IV)	11.3		11.4	10.0	4.7	7.7	5.9	0.9	0.7	2.5	1.5
Blast Furnace & Slag Cements (CEM III)	13.9		17.7	13.7	7.3	10.5	11.5	10.4	12.4	13.3	12.1
Portland Composite Cement (CEM II)	126.4		141.1	105.7	60.0	76.4	67.7	44.3	36.4	45.7	37.8
Portland Cement (CEM I)	56.9		55.5	36.9	24.7	23.2	24.6	19.8	17.8	27.4	24.9
Other (unspecified)	7.7		12.9	56.0	80.7	46.3	56.5	63.9	66.2	41.2	54.1
Eurostat Portland* Cement	186.7	202.7	210.0	197.9	153.6	142.3	141.6	119.4	104.2	105.5	105.9
Eurostat Total (Portland* + Other Hydraulic Cement)	209.9	229.9	239.2	226.3	179.6	163.8	168.8	146.6	130.6	130.8	128.8

Source: Ecorys based on Eurostat Prodcom and CEMBUREAU

2.2.2 Product applications and markets

Cement is a basic ingredient of concrete, mortar, stucco, and non-speciality grout. The overwhelming applications of cement are linked to construction and civil engineering sector; as a key component of concrete, mortars (with sand and water only), for plasters, screeds, papercrete (a construction material made from a combination of water, paper or cardboard pulp, and clay or other soil) and in grouts (cement/water mixes squeezed into gaps to consolidate foundations, road-beds, etc.)[17].

Box 1: Product specialisation

According to interview results, there seems to be a change in business models, as production is shifting towards specialised and customised products, with a high value added. These can also be exported. Despite the general decline in demand and production, there is still a wide range of product types. Ensuring good quality (in terms of energy or environmental performance, as well as strength and durability) is also crucial to maintain relations with clients.

[17] Source: https://en.wikipedia.org/wiki/Portland_cement.

2.2.3 Production Process

Cement production involves multiple stages and actors from the quarry to the final product. The production process can be grouped into four basic steps:

- **Extraction:** The first step is to extract blocks of raw material (limestone, chalk or marl) from quarries. These mostly consist of limestone (approx. 90%), but sand, clay, bauxite and iron ore may be added to reach the desired chemical composition. Because of the high transportation costs, cement plants are typically located close to the quarries;
- **Processing:** Primary raw material (limestone) in boulder form is transported to primary and secondary crushers and are broken into smaller pebble-sized chunks. These are then homogenised and pulverised into a thin powder call "raw meal"[18];
- **Clinker production:** This step covers the calcination of limestone ($CaCO3$) to lime (calcium oxide: CaO), releasing carbon dioxide, and subsequent reaction with the other constituents from the raw material to form cement clinker. There are both 'wet' and 'dry' production technologies for cement clinker, plus intermediate semi-dry/semi-wet. However, in Europe almost all production is based on 'dry' technologies, which are less energy intensive, with wet kilns being phased out. The 'dry' production process encompasses the following sub-steps of production:
  - ***Preheating:*** where hot exhaust gases coming from the kiln preheat the powdered raw meal before it enters the kiln, this improves the efficiency of the process and reduces fuel needs;
  - ***Pre-calcination:*** this takes place in a combustion chamber ('pre-calciner') that links between the preheater and the kiln and where the calcination of limestone takes place;
  - ***Clinker production (rotary kiln)***[19]**:** pre-calcined meal is fed into the kiln and fuels - coal, petroleum coke, gas, oil and alternative fuels – are fired directly into the kiln to heat the raw meal to temperatures of up to 1450°C, thus allowing its sintering into clinker;
  - ***Cooling:*** the clinker is rapidly cooled down to 100-200°C;
- **Grinding & Blending:** clinker is mixed with gypsum (around 4-5%) to control the setting time of cement. This mixture is then ground to form Ordinary Portland Cement (OPC), or can be mixed with other cementitious minerals to produce other types of cement (e.g. composite or blended cements).

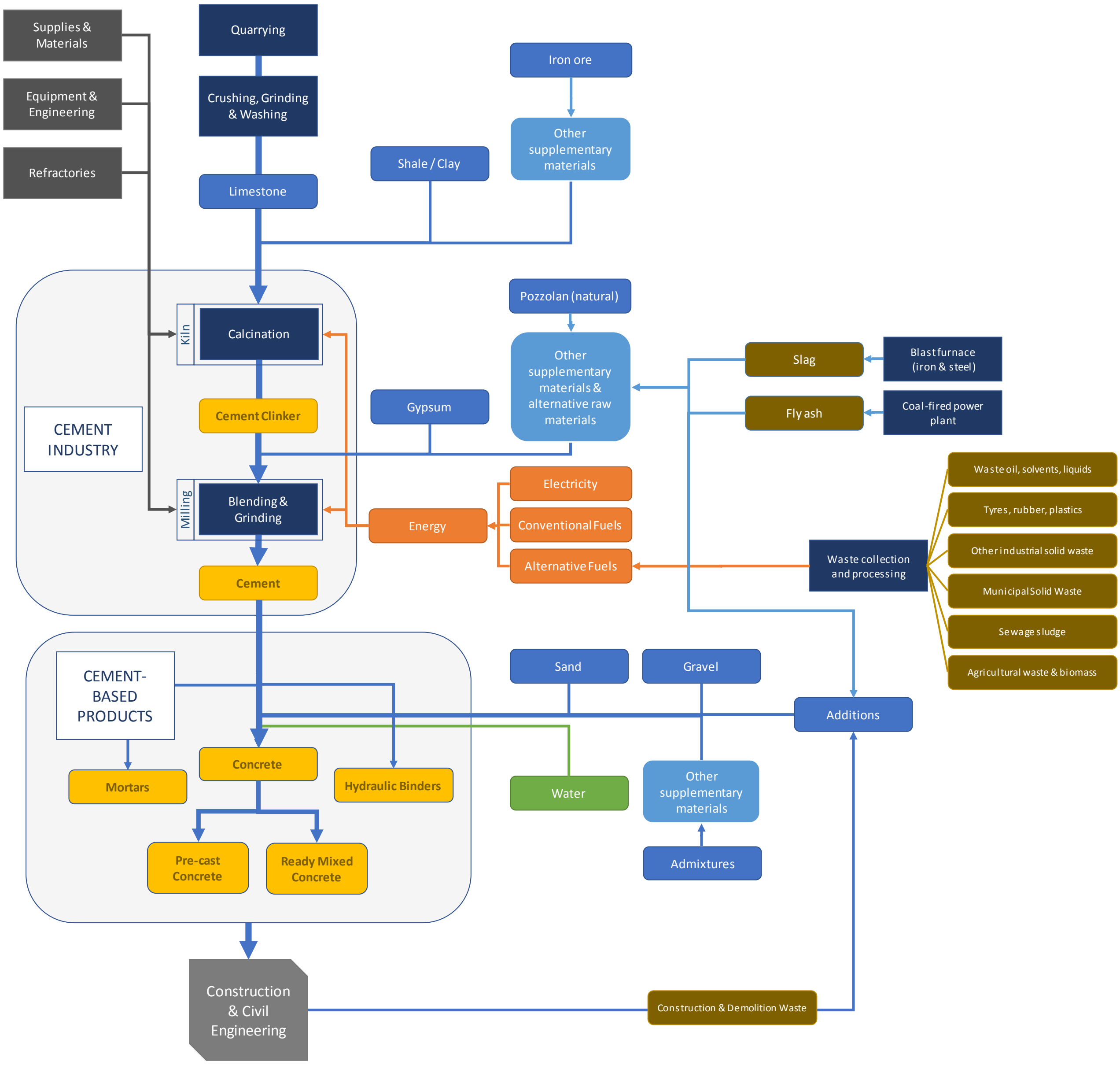
2.2.4 Supply chain

The figure below provides a simplified supply chain for cement, from upstream quarrying activities, through cement production, the production of various cement-based downstream production activities and their eventual use, mainly in the construction sector. Often companies integrate the process from quarrying to the different types of cement and cement products and then supply directly the end-user construction sector.

[18] David Merlin Jones (2010) 'Rock Solid?'An investigation into the British cement industry, p. 3; CEMBUREAU website, The manufacturing process, https://cembureau.eu/cement-101/the-manufacturing-process/

[19] Alternatively, raw meal can be fed as a wet slurry (rather than a powder) into wet kilns; this technology is, however, much less energy-efficient and the dry process has become dominant throughout Europe, with about 90% of the clinker production occurring in dry kilns. Source: CEMBUREAU website: 'The manufacturing process'

Figure 3: Illustrative supply chain of the cement industry



Source: Ecorys

Box 2: Vertical integration of European cement manufacturing enterprises

Many, if not most, cement companies show a high degree of vertical integration and are consequently involved throughout the supply chain.[20] The majority of cement companies own the quarries. Some producers also integrate downstream industries (i.e. concrete and aggregates). The extent of this downstream integration varies by country.

Vertical integration can be a decisive factor, especially in mature markets. This allows companies to optimise their production process and to ensure high and consistent quality of their products. For producers of white cement, a secure the supply of high quality limestone is important. Also, the high level of capital expenditure required for production means that it is important to ensure that plants have the sufficient supply of raw materials to remain operational for many years.

[20] Rootzen and Johnsson (2016) Managing the costs of CO2 abatement in the cement sector, p.5.

2.3 Production profile of cement clinker

2.3.1 Time profile of EU cement clinker[21] production

Eurostat data indicate that total quantity of EU cement clinker production was 111 million tonnes in 2016; see the figure below. However, **there are large disparities between Eurostat production estimates and those coming from industry sources**; for example, data from the Cement Sustainability Initiative (CSI)[22] show total EU28 cement clinker production of 125 million tonnes in 2015 compared to a Eurostat estimate of only 105 million tonnes.

Eurostat PRODCOM (NACE Rev. 2) data on total cement clinker production are only available since 2009 and so do not measure the impact of the economic crisis on total production. Data from CSI indicate a sharp fall from 191 million tonnes in 2007 to 144 million tonnes in 2009, followed by a continuing decline to only 122 million tonnes in 2013, after which there has been a slight increase to 125 million tonnes.[23]

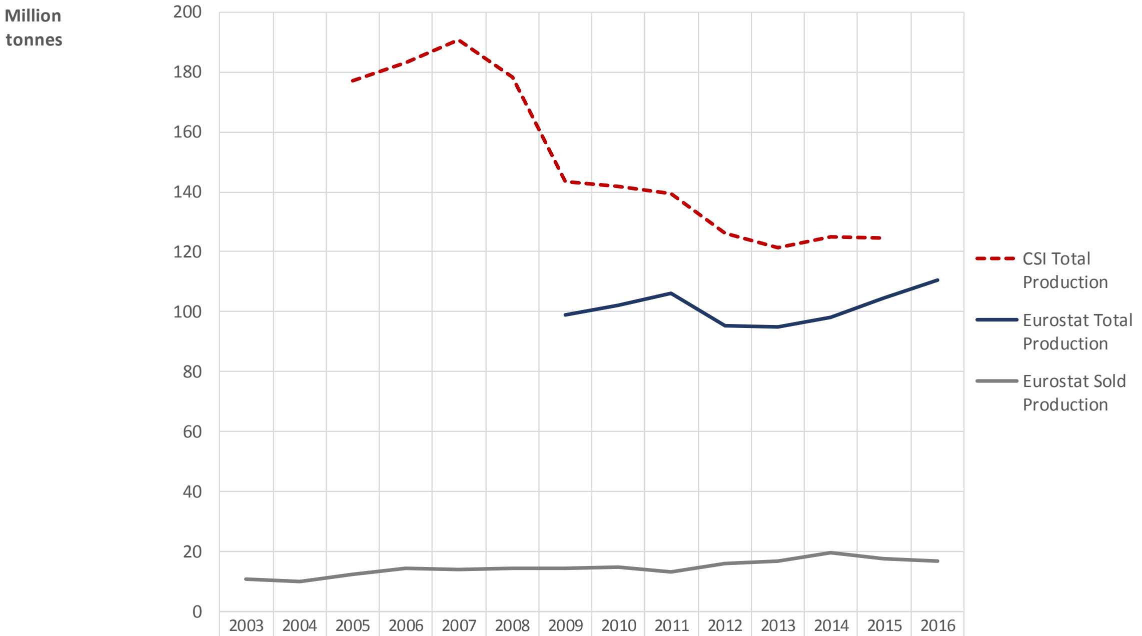
The majority of clinker production is not sold in the market but goes directly into the production of cement. For the EU as a whole, Eurostat data indicate sold production of cement clinker was around 16.6 million tonnes or 15% of the Eurostat estimated total production in 2016; see the figure below. Volumes of sold clinker have generally increased over time, from 11 million tonnes in 2003 to 20 million tonnes in 2014, but show some decline for the last two years for which data are available.

[21] PRCCode: 23511100 - Cement clinker.

[22] The Cement Sustainability Initiative (CSI), is an industry-led grouping – under the umbrella of the World Business Council for Sustainable Development (http://www.wbcsd.org/) – comprising 23 major cement producers commanding around 30% of global production (www.wbcsdcement.org). Part of this initiative is the CSI Global Cement Database "Getting the Numbers Right" (GNR), which includes industry data on cement production, and CO_2 and energy performance information. Data are supplied by CSI members and are subject to partial independent verification.

[23] As clinker production and cement production are closely linked, and given that (extra-EU) trade is limited, it can be assumed that the overall time profile of cement clinker production closely follows that for cement production. The profile of cement production is described in Section 2.4.

Figure 4: EU28 Cement clinker – quantity of production 2003-2016



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CSI Total Production			177.3	183.3	190.8	178.3	143.5	141.8	139.6	126.3	121.5	125.1	124.8	
Eurostat Total Production							99.0	102.2	106.1	95.3	94.8	98.3	104.5	110.8
Eurostat Sold Production	10.8	10.1	12.4	14.2	14.0	14.5	14.5	14.9	13.0	15.9	16.7	19.6	17.5	16.6

Source: Ecorys based on Eurostat Prodcom and CSI[24]

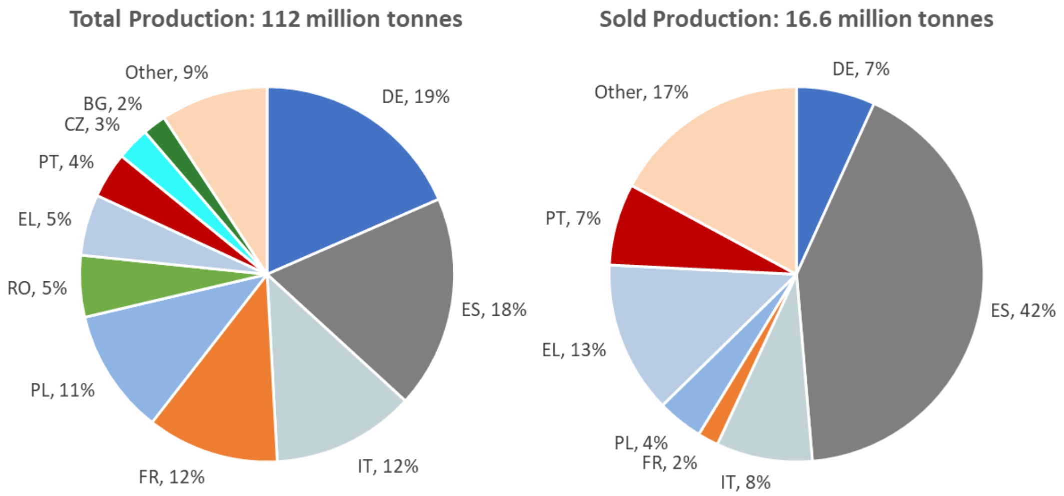
2.3.2 Geographical profile of EU cement clinker production

The figures below show the breakdown of total and sold cement clinker production by country. Both Eurostat data and data from industry sources (CSI) indicate that Germany, Spain, Italy, France and Poland are the largest producers of cement clinker in the EU. Eurostat data indicate that, collectively, these countries account for 70% of EU production in 2016, while data from industry sources gives a joint share of 60% of EU production in 2015. Eurostat does not provide data for the UK, but national industry data suggests that the UK accounts for 5% to 8% of EU production.[25] However, as noted in the previous subsection, there are important discrepancies between Eurostat clinker production data and those available from industry sources. This has an important impact not only on the overall level of production but also on the shares of individual countries. For example, Eurostat data indicate that Spain accounts for 18% of EU clinker production, whereas the corresponding share based on industry data is 10%.

[24] CSI Global Cement Database on CO_2 and Energy Information "Getting the Numbers Right" (GNR) available at: http://www.wbcsdcement.org/index.php/key-issues/climate-protection/gnr-database.

[25] Although Eurostat data indicate zero production for the UK, data from the UK Mineral Products Association (see: http://cement.mineralproducts.org/documents/Annual_Cementitious_01_15.pdf) and from the CSI GNR database indicate that the UK produced 7.8 million tonnes of cement clinker in 2015.

Figure 5: EU28 Cement clinker production - breakdown by country in 2016



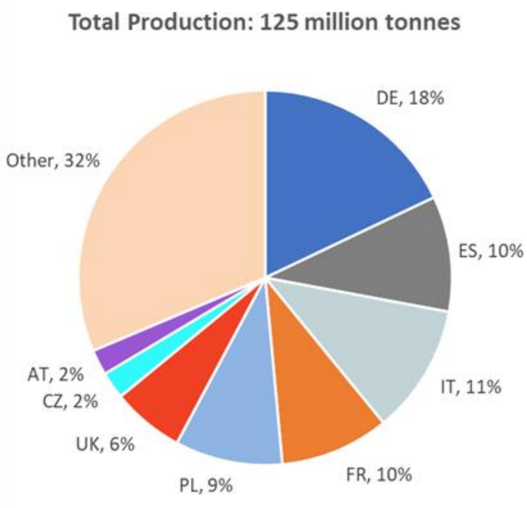
Notes:

a. Zero production indicated for CY, DK, FI, LT, LU, MT, NL, and UK;

b. Data unavailable for AT, BE, EL, IE, LV, SE, SI, SK.

Source: Ecorys based on Eurostat Prodcom

Figure 6: EU28 Cement clinker production - breakdown by country in 2015



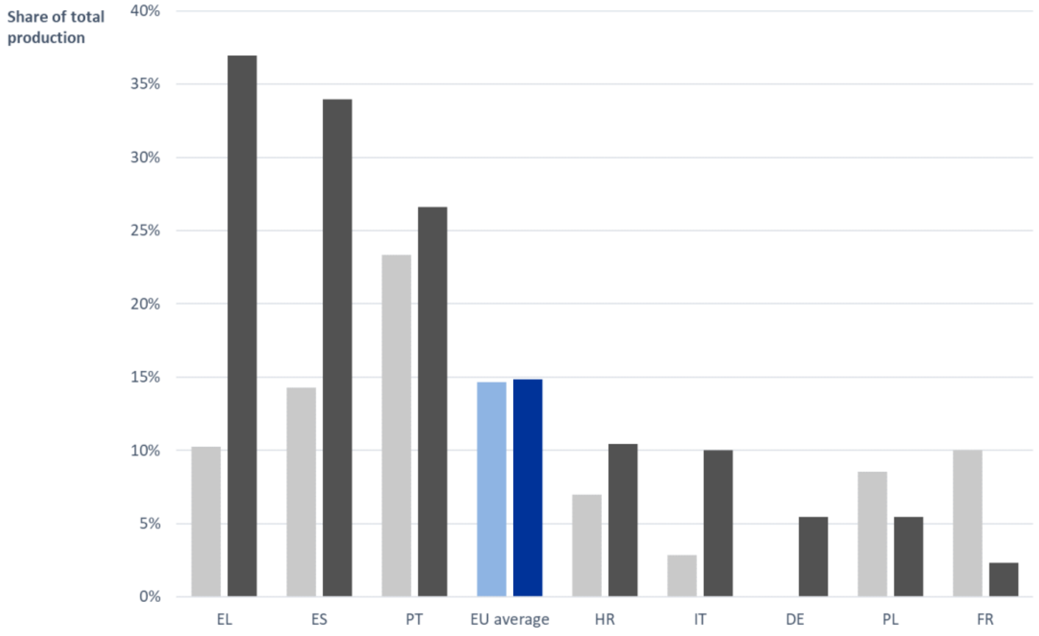
Source: Ecorys based on CSI

In terms of sold production, which may cover production sold domestically or for export, Eurostat data indicate that Spain is the most important EU supplier of (sold) cement clinker, followed by Greece, Italy and Portugal. As shown in the figure below, Greece, Spain and Portugal have the highest share of sold cement clinker from total production, 37%, 34% and 27% respectively in 2016. These countries, together with Italy and Croatia, reveal a marked increase in the share of sold production between 2009 and 2015. This increase is understood to reflect the response of cement manufacturers to the contraction of domestic demand, which has resulted in a shift from production of cement for the domestic market to the production of cement clinker for export.

Box 3: Impact of the crisis on the export orientation of production

Industry sources indicate that when levels of (domestic) demand are low, companies may seek to offset, at least partially, the decline in domestic demand by shifting production for domestic supply (cement) to export (clinker). Provided that domestic demand remains sufficient for production plants to remain operational – essentially sufficient to allow fixed production costs to be covered from the supply of cement to the domestic market – then it is relatively easy to adapt (additional) production towards export (of clinker), which can be supplied at a price that reflects variable costs of production only. Such behaviour has been observed since the onset of the economic crisis in Spain, Italy, Greece, Ireland, Portugal, etc. Conversely, production may be switched back to production for local markets in periods of stronger domestic demand. As clinker exports are recorded as part of 'sold production', such behaviour is reflected in the increase in the share of sold production in total production observed in Spain, Portugal and Italy and, also, their leading positions in total EU sold production of clinker. Although the shift from domestic supply to export appears important for some countries, its overall impact for the EU as a whole may be relatively limited given that (extra-EU) exports of cement clinker represent less than 10 percent of total EU clinker production.[26]

Figure 7: Cement clinker - sold production as share of total production by country (2009, 2016)



Notes:
a. Zero production indicated for CY, DK, FI, LT, LU, MT, NL, and UK;
b. Data unavailable for AT, BE, EL, IE, LV, SE, SI, SK.

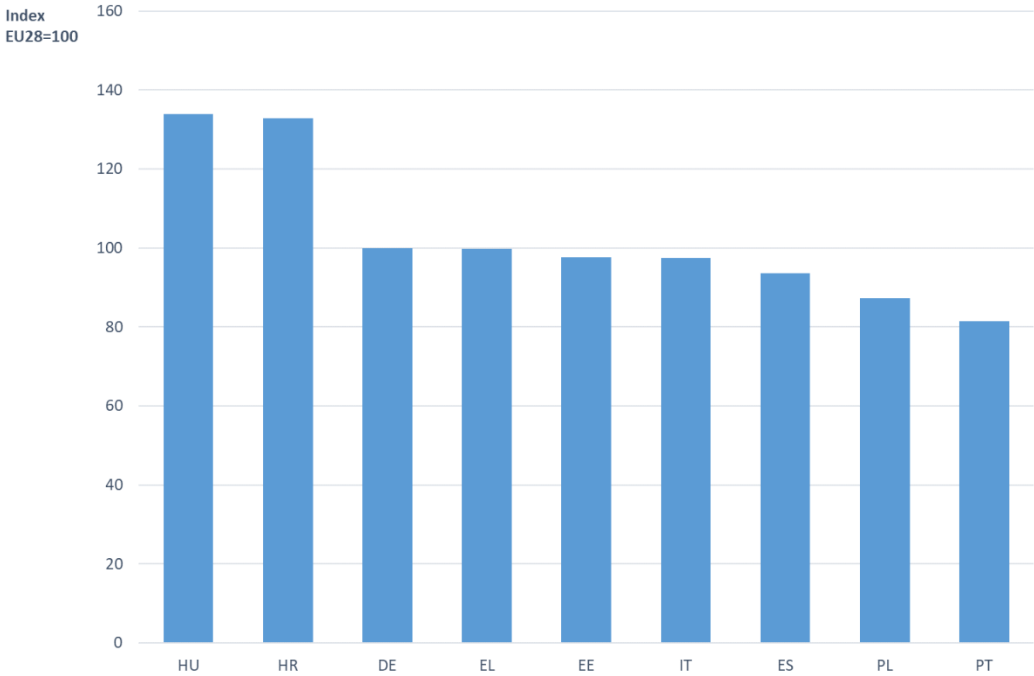
Source: Ecorys based on Eurostat Prodcom

2.3.3 Price (unit value) profile of EU cement clinker production

Based on Eurostat data, estimates of unit values for (sold) cement clinker– which can be interpreted as an indicator of average factory gate prices – are shown in the figures below, for those countries for which data are available. Although unit values are higher in Croatia and Hungary, countries with relatively small players in the production and sale of cement clinker, there appears to be little variation in average cement clinker prices (unit values) for those countries for which data are available.

[26] See Section 2.8.2 for information on the trade performance of cement clinker.

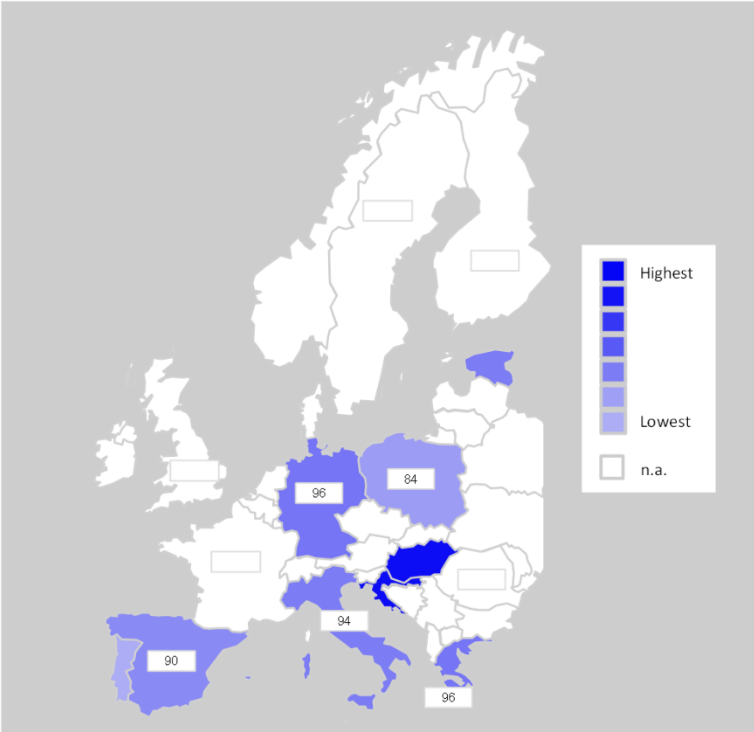
Figure 8: Cement clinker - average unit value per tonne of sold production by country in 2016 (index, EU28=100)



Notes:
a. Zero sold production indicated for CY, DK, FI, LT, LU, MT, NL, RO and UK;
b. Data unavailable for AT, BE, BG, CZ, EL, IE, LV, SE, SI, SK;
c. Data for FR not included.

Source: Ecorys based on Eurostat Prodcom

Figure 9: Cement clinker - mapping of average unit values in 2016 (index, EU28=100)



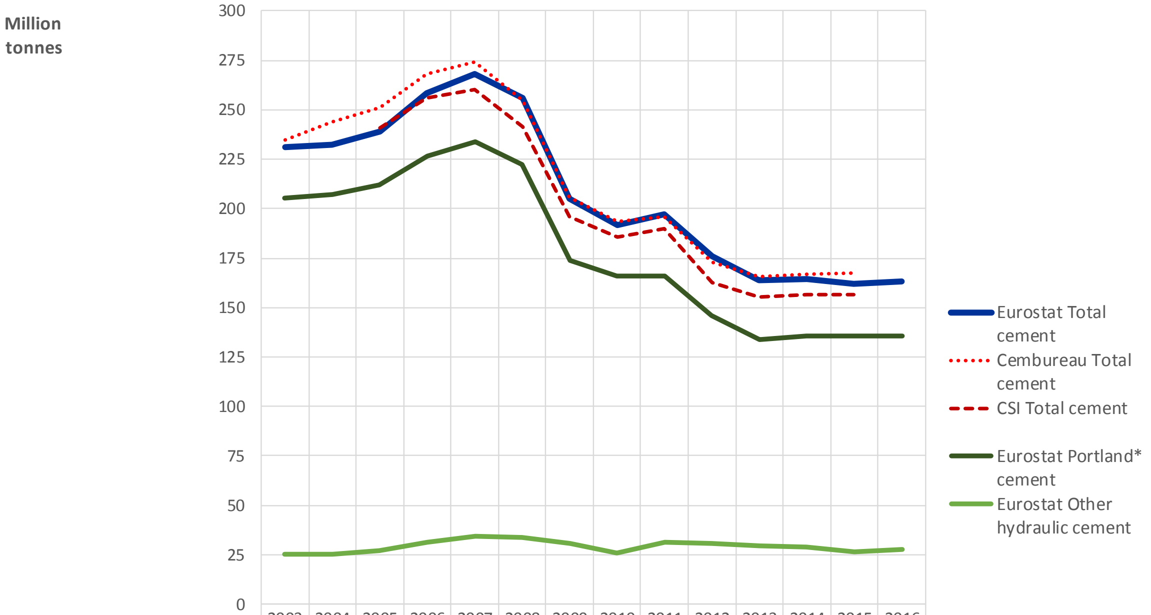
Source: Ecorys based on Eurostat Prodcom

2.4 Production profile of cement

2.4.1 Time profile of EU cement production

Eurostat production data indicate that EU28 total production of cement products amounted to an estimated 163 million tonnes (of which 136 million tonnes of Portland* cement)[27] in 2016, with a value of €11.9 billion[28]. These amounts compare with a peak production volume of 268 million tonnes and a sales value of €20.2 billion in 2007; see the figures below. The Eurostat production estimates are broadly comparable with data from CEMBUREAU, the European cement association, which estimates EU28 cement production at 167 million tonnes in 2015[29], and data from the Cement Sustainability Initiative (CSI)[30].

Figure 10: EU28 cement – quantity of sold production 2003-2016

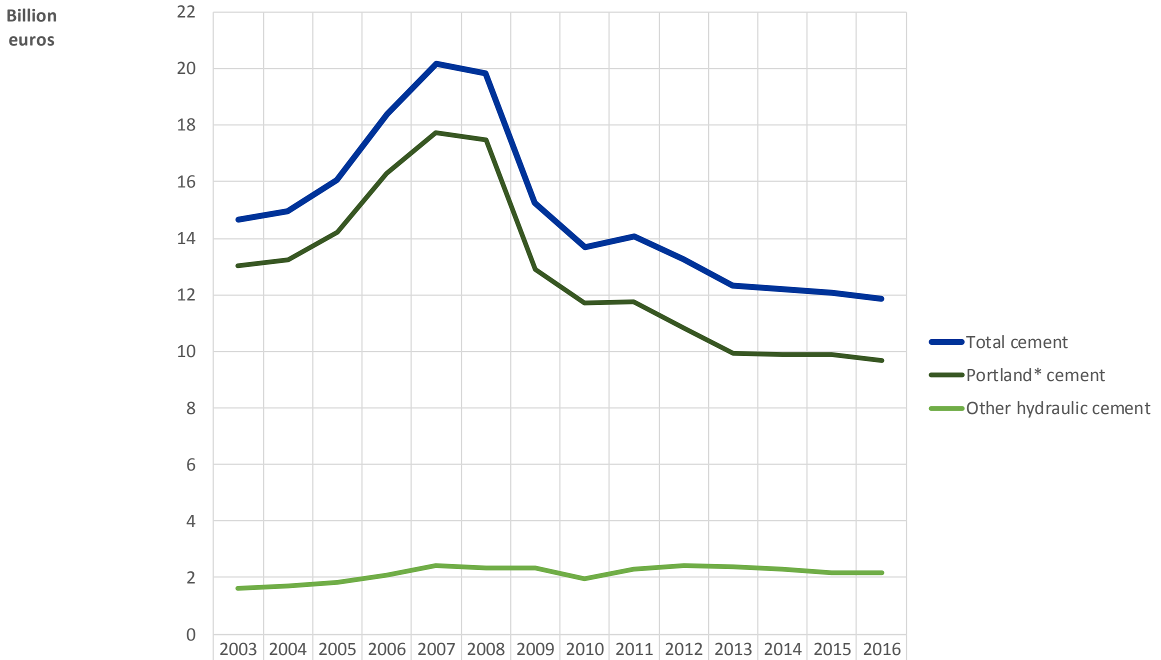


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Eurostat Total cement	231.0	232.5	239.0	258.3	268.1	256.0	204.9	191.7	197.1	176.1	163.6	164.4	162.3	163.2
Cembureau Total cement	234.5	243.7	251.1	268.3	274.4	254.9	205.7	193.5	195.7	172.6	165.5	166.8	167.2	
CSI Total cement			240.7	255.8	260.3	241.4	196.0	185.6	190.0	162.6	155.4	156.7	156.7	
Eurostat Portland* cement	205.6	207.1	212.2	226.8	234.1	222.4	174.1	165.9	166.0	145.7	134.0	135.7	135.7	135.7
Eurostat Other hydraulic cement	25.4	25.4	26.8	31.5	34.0	33.6	30.8	25.8	31.1	30.4	29.6	28.7	26.5	27.5

Source: Ecorys based on Eurostat Prodcom, CEMBUREAU and CSI

[27] See Section 2.2.1 for information on the coverage of the 'Portland* cement' and 'Other hydraulic cement' product categories.
[28] Prodcom values are based on the ex-work selling price. The ex-works price should include charges only up to the seller's factory or premises. All further charges, such as delivery, distribution, and commissions, should not be reflected in the ex-works price.
[29] Cembureau (2017), 'Activity Report 2016'.
[30] CSI Global Cement Database on CO_2 and Energy Information "Getting the Numbers Right" (GNR) available at: http://www.wbcsdcement.org/index.php/key-issues/climate-protection/gnr-database

Figure 11: EU28 cement – value of sold production 2003-2016



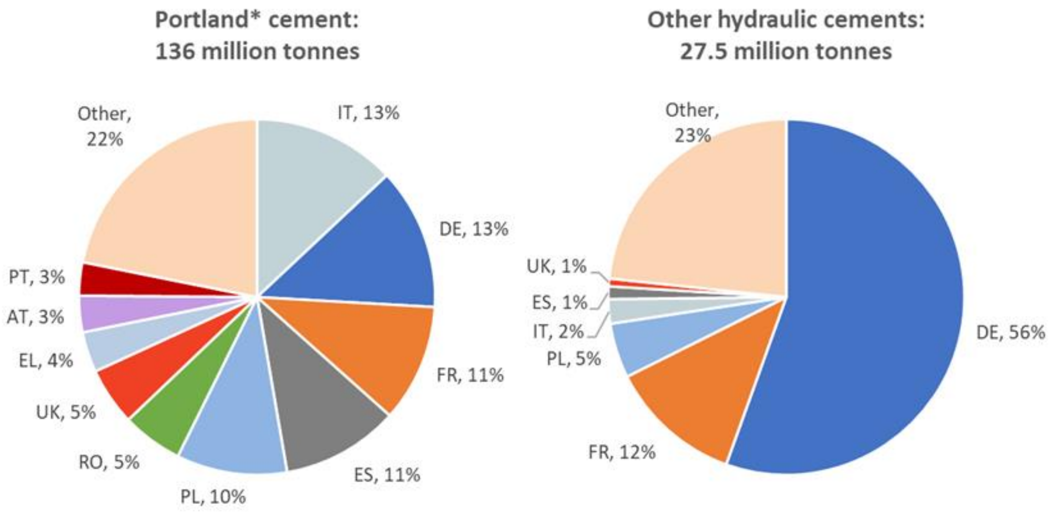
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total cement	14.7	14.9	16.0	18.4	20.2	19.8	15.3	13.7	14.0	13.3	12.3	12.2	12.1	11.9
Portland* cement	13.0	13.3	14.2	16.3	17.7	17.5	12.9	11.7	11.8	10.8	9.9	9.9	9.9	9.7
Other hydraulic cement	1.6	1.7	1.8	2.1	2.4	2.4	2.3	2.0	2.3	2.4	2.4	2.3	2.2	2.2

Source: Ecorys based on Eurostat Prodcom

2.4.2 Geographical profile of EU cement production

In terms of the geographical distribution of cement production, as shown in the figure below, the largest EU producer is Germany (13% of Portland* cement production and 56% of other hydraulic cement by weight). Looking at Portland* cement alone, the main EU producers are Italy, Germany, France, Spain, and Poland, which collectively account for 57% of total EU production.

Figure 12: EU28 Cement sold production quantity - breakdown by type and country in 2016



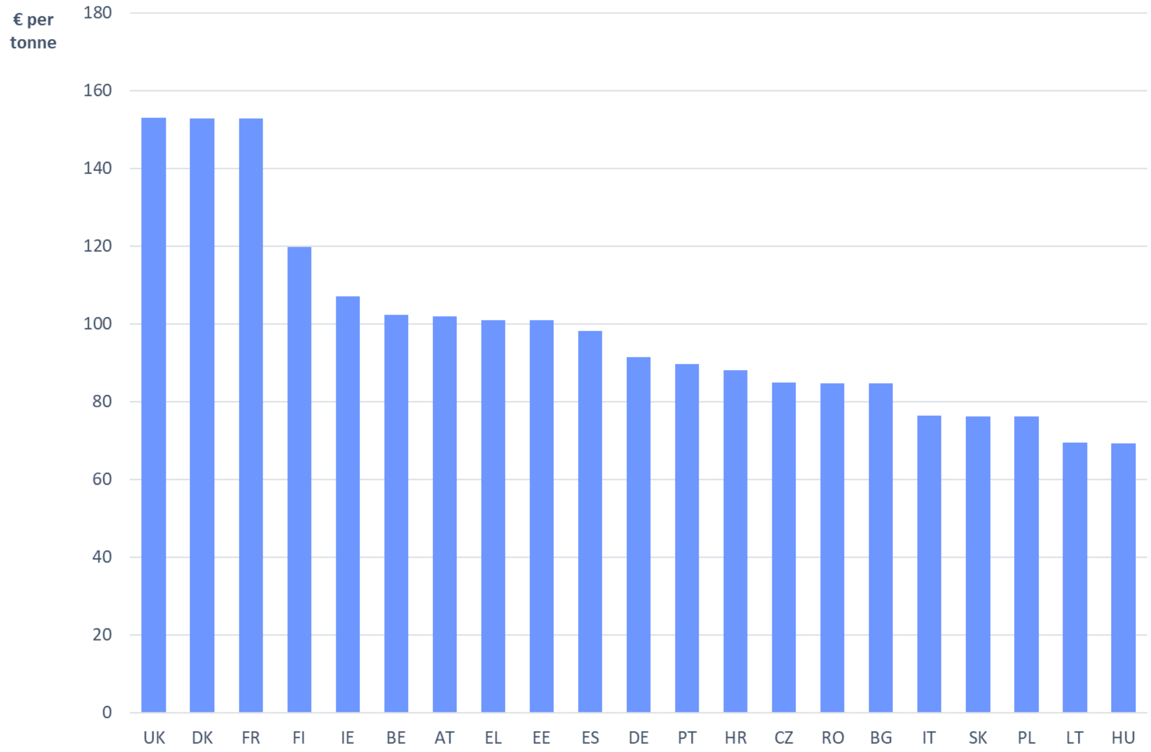
Notes:
a. Zero sold production of 'Portland* cement' indicated for CY, LU, MT;
b. Data for 'Portland* cement' unavailable for LV, NL, SE, SI;
c. Zero sold production of 'Other hydraulic cement' indicated for CY, CZ, DK, EE, EL, FI, LT, LU, LV, MT, PT, RO, SE, SK;
d. Data for 'Other hydraulic cement' unavailable for AT, BE, BG, HR, HU, IE, NL, SI.

Source: Ecorys based on Eurostat Prodcom

2.4.3 Price (unit value) profile of EU cement production

The figures below show estimates of unit values for Portland* cement – which can be interpreted as an indicator of average factory gate prices. These data show substantial variation across the EU, with the average unit value in the UK, France and Denmark more than 50% above the EU28 average unit value, and Lithuania and Hungary some 30% below. In fact, there appears to be a segmentation of markets, with a few countries with particularly high unit values (e.g. UK, France, Denmark and, to a lesser extent Finland) and then most of the remaining countries with similar unit values and limited variation across countries.

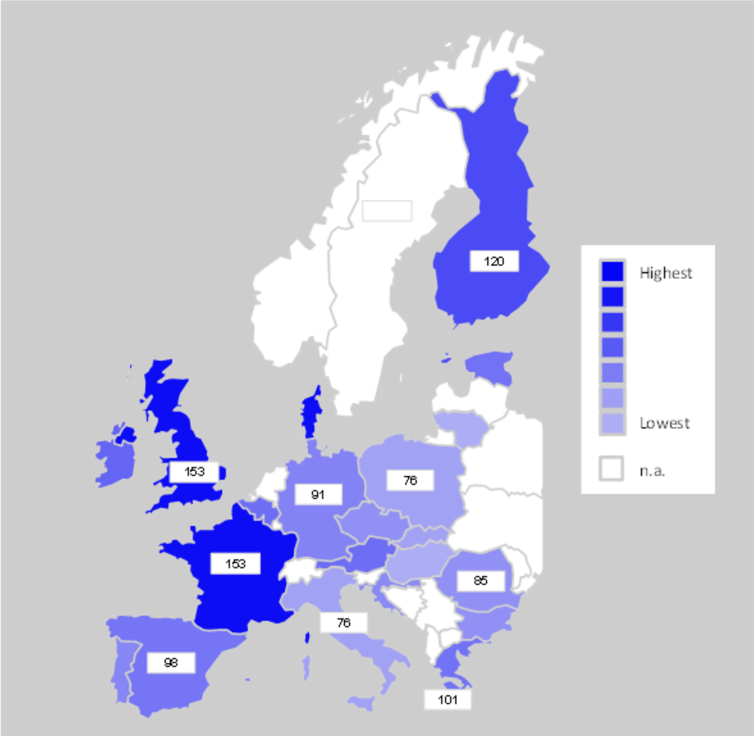
Figure 13: Portland* Cement - average unit value per tonne of sold production by type and country in 2016 (index, EU28=100)



Notes:
a. Zero sold production of 'Portland* cement' indicated for CY, LU, MT;
b. Data for 'Portland* cement' unavailable for LV, SE, SI;

Source: Ecorys based on Eurostat Prodcom

Figure 14: Portland* cement - mapping of average unit values in 2016 (index, EU28=100)



Source: Ecorys based on Eurostat Prodcom

Note: Some caution should be exercised when comparing and assessing average unit prices at a country level. The high value in some countries may be attributable to many reasons, e.g. higher material, transport, labour, and energy costs. Furthermore, prices refer to those sold on the market – which is only a part of overall production.

2.5 Size, structure and performance of the EU cement manufacturing industry

2.5.1 Comment on available structural business statistics

Eurostat data from the Structural Business Statistics (SBS) database are available for NACE 2 class 23.51 (Manufacture of cement). This NACE class covers the- manufacture of clinkers and hydraulic cements, including Portland, aluminous cement, slag cement and supersulphate cements. It excludes, however, the manufacture of articles of cement and other cement based products such as concrete which are reported elsewhere in NACE Rev. 2.[31]

It should be noted that SBS classifies enterprises based on their principal economic activity. This means that when an enterprise is active in more than one economic activity, then the value added and turnover that it generates, the persons it employs, and the values of all other variables will be classified under the enterprise's principal activity; the principal activity is normally the one that generates the largest amount of value added. This is one potential explanation for differences between aggregate production values based on product data (e.g. Prodcom) and those based on enterprise data (e.g. Structural Business Statistics).

[31] See Annex A for details of the NACE classification of cement and cement based products.

2.5.2 Overview of the cement manufacturing industry

In 2015, the most recent year of available comparative data, the cement manufacturing industry in the EU represented an estimated €15 billion turnover and €4.8 billion in value added and offers employment to 47 thousand persons in the EU in around 350 enterprises[32].

Box 4: Multiplier effects of cement and concrete production

According to a 2015 study by Le BIPE for the Concrete Initiative[33], the cement and concrete industries directly generated around €20bn in value added and 384 thousand jobs in the EU28 in 2012. However, through its purchases and the spending of its direct and indirect employees, the combined cement and concrete industry generates a total value added of €56bn in the EU28 and generates over 1.1 million jobs. This corresponds to a multiplier effect of 2.8; i.e. each €1 value added generated in the cement and concrete industries, results in the generation of €2.8 in the overall economy. Within the context of this study it was not possible to verify this claim, but it is more or less in line with Eurostat calculations for the construction sector (multiplier of 2.1).[34]

2.5.3 Time profile of the EU cement manufacturing industry

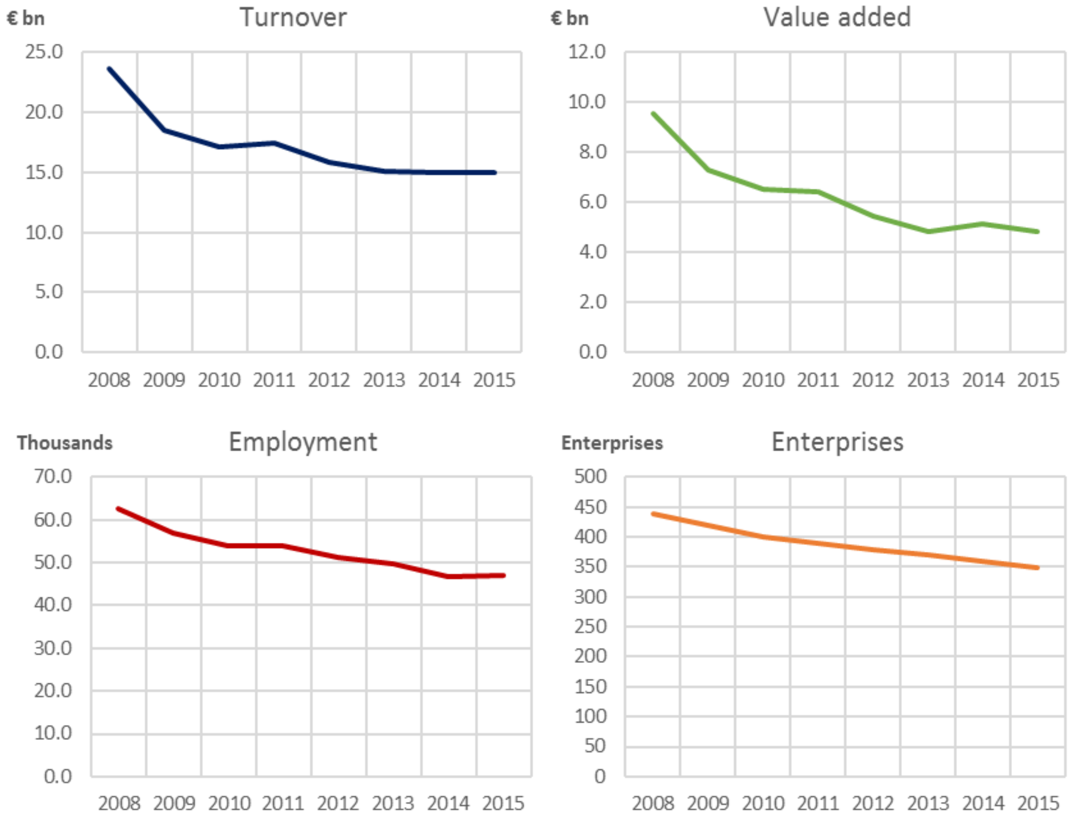
The figure below shows the recent evolution of key headline variables for the EU cement manufacturing industry from 2008 to 2015. A sharp decline in all headline variables is evident; between 2008 and 2015, turnover declined by 37%, value added by 49%, employment by 25% and the number of enterprises by 20%.

[32] Eurostat SBS data for 2014

[33] Source: https://www.theconcreteinitiative.eu/newsroom/publications/143-cement-and-concrete-industry-multiplier-effect-on-the-economy-and-their-contribution-to-a-low-carbon-economy

[34] Eurostat, 'Output multipliers for the EU', 2015; the calculated output multiplier for the construction sector is 2.1; for industrial products (except construction) approximalty 2.2. See: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consolidated_supply,_use_and_input-output_tables.

Figure 15: EU28 cement manufacturing – evolution of key variables 2008-2015



Source: Ecorys based on Eurostat SBS

These declines were substantially more pronounced than for EU manufacturing as a whole, which evolved over the same period as follows: turnover +2%, value added +11%, employment -9%, and the number of enterprises -2%.

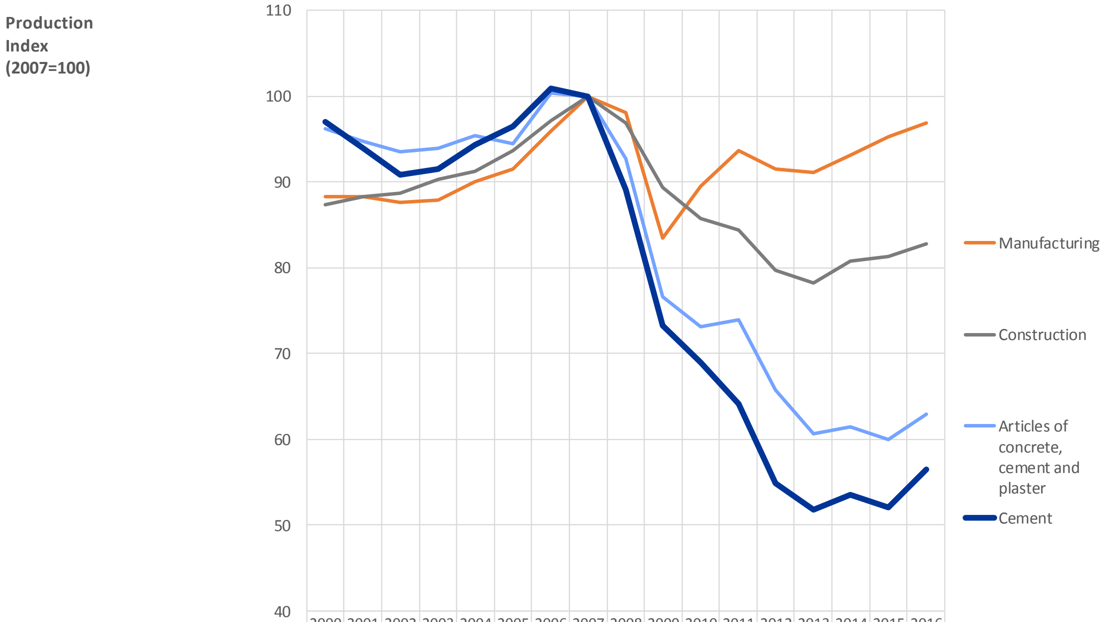
A broader perspective on production (volumes) is provided by the Eurostat short-term business statistics (STS), as shown in the figure below[35]. These data allow a comparison with other key sectors of the economy, notably the important intermediate customer sector of 'articles of concrete, cement and plaster' and the main end-used sector of construction. These data show that between 2002 and 2006, cement production was on a stable and positive growth trajectory. Production then declined dramatically, falling by a half between 2007 and 2013. After stabilising somewhat between 2013 and 2015, there is evidence of some limited improvement between 2015 and 2016. It appears that the modest improvement in construction activity since 2013 is slowly feeding through to production volumes for 'articles of concrete, cement and plaster' and, in turn, cement production.

[35] Note, Eurostat STS data use a base year of 2010 (=100). These data have been 'mechanically' rebased to 2007, which was the peak production year, so as to highlight the relative impact of the economic and financial crisis.

Box 5: Developments in the structure of demand for cement

In general, although industry sources report that demand has been heavily affected by the crisis, there are some positive signs for the future. Limited investment in infrastructure due to gaps in public funding remains a problem in certain regions, but demand in the residential building sector appears to be increasing. Also, demand for low carbon or more environmentally friendly products is increasing, as well as the demand for high-quality products. However, current demographic trends and weak economic growth prospects are a source of uncertainty for the future.

Figure 16: EU28 cement – volume index of production 2000-2016

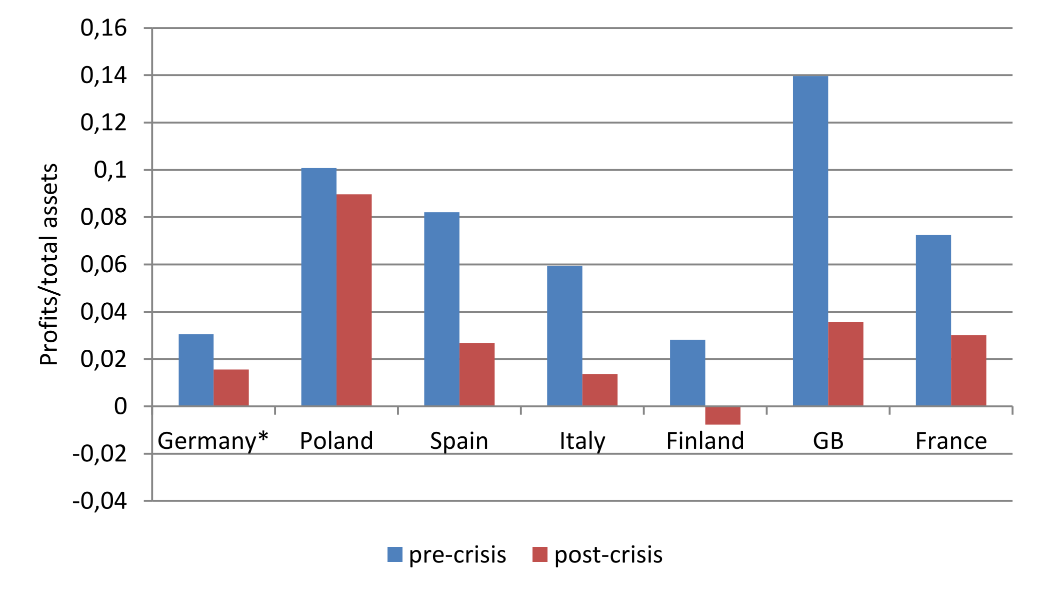


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Manufacturing	88.4	88.4	87.6	87.9	90.1	91.5	96.0	100.0	98.1	83.4	89.5	93.6	91.6	91.1	93.1	95.3	97.0
Construction	87.4	88.3	88.8	90.3	91.3	93.7	97.2	100.0	96.9	89.5	85.8	84.5	79.8	78.3	80.8	81.4	82.8
Articles of concrete, cement and plaster	96.2	94.7	93.5	94.0	95.4	94.4	100.4	100.0	92.7	76.6	73.2	73.9	65.8	60.6	61.5	60.0	63.0
Cement	97.0	93.9	90.8	91.6	94.3	96.6	100.9	100.0	89.1	73.3	68.9	64.1	54.9	51.8	53.5	52.0	56.5

Source: Ecorys based on Eurostat STS

Drawing attention to the financial performance of the cement industry, the next figure shows profitability in the manufacture of cement sector (23.51) for selected countries, as calculated from Amadeus data. In sector 23.51, a decrease can be observed in the return on the total assets after 2007, across all countries. The countries that show the largest drops in profitability include Great Britain, Spain, Italy and France. Profitability was lower in Germany and Finland and has not experienced such large decreases in the aftermath of the recession. Finland is the only country where the profitability is below zero in the post-crisis period, but cautious is needed as there are only few Finnish companies in the Amadeus database. Profitability of Polish companies in Sector 23.51 worsened only lightly in response to the financial crisis.

Figure 17: Profitability in the manufacture of cement sector (23.51)

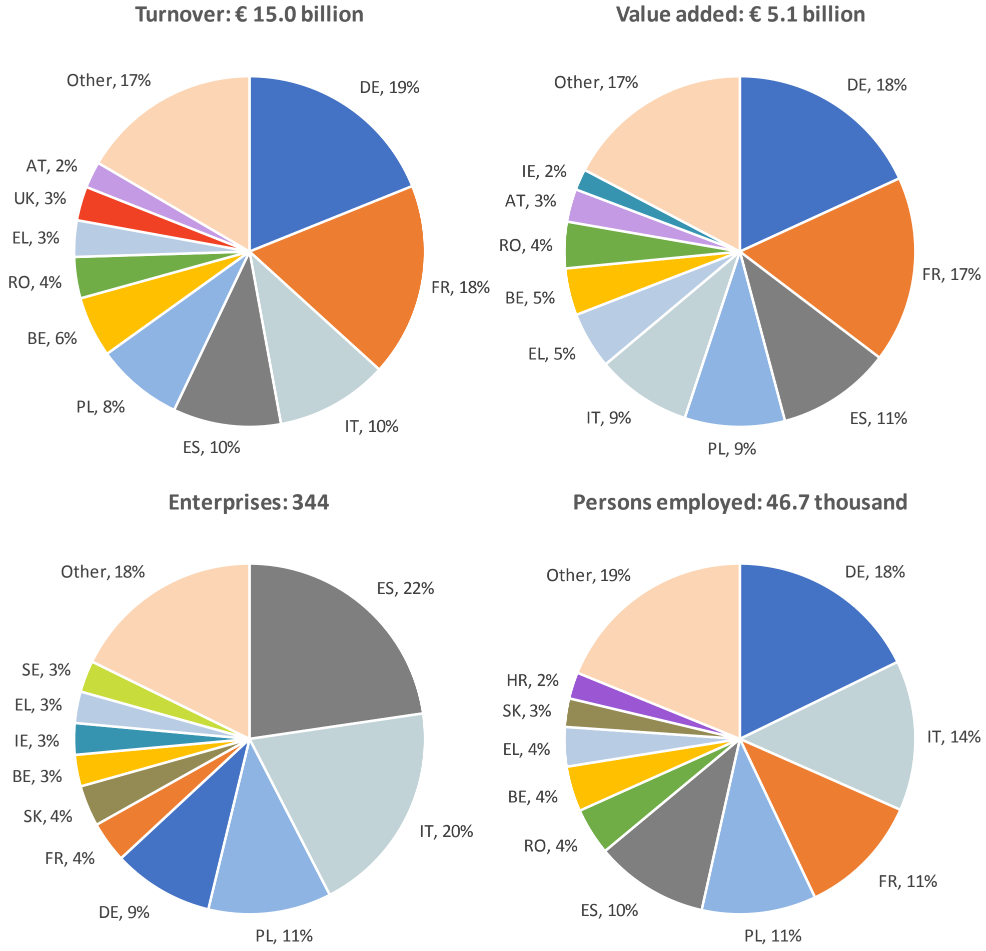


Source: Amadeus database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

2.5.4 Geographical profile of the EU cement manufacturing industry

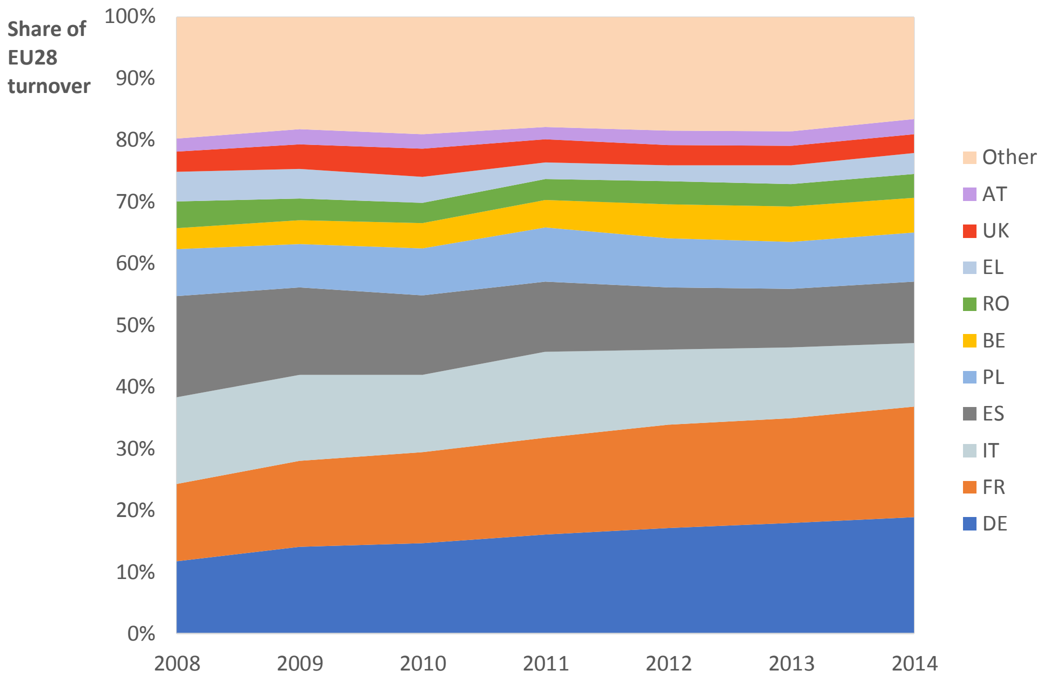
In 2014, Germany, France, Italy, France, Spain, Poland and Belgium together account for 71% of EU's turnover, 68% of EU's value added, 70% of EU's enterprises and 68% of EU's employment in the cement sector; see the figure below. Since 2008, Italy and Spain have seen the most significant decline in their share of total EU cement manufacturing turnover, which has fallen by 6.5 and 3.6 percentage points (p.p.), respectively; see the figure below. Germany (+7.2 p.p.) and France (+5.2 p.p.) have seen the largest increases in their share of EU turnover, while the collective share of 'other' smaller cement manufacturing countries is estimated to have fallen by 3.2 percentage points. Within the context of the overall decline in EU cement industry turnover, which fell by 37%, these changes are to a large extent driven by different cycles of construction in the Member States.

Figure 18: EU28 cement manufacturing - breakdown of turnover, value added, number of enterprises and number of persons employed in the EU by country (2014)



Source: Ecorys based on Eurostat SBS

Figure 19: EU28 cement manufacturing - breakdown of EU28 turnover by country (2008-2014)

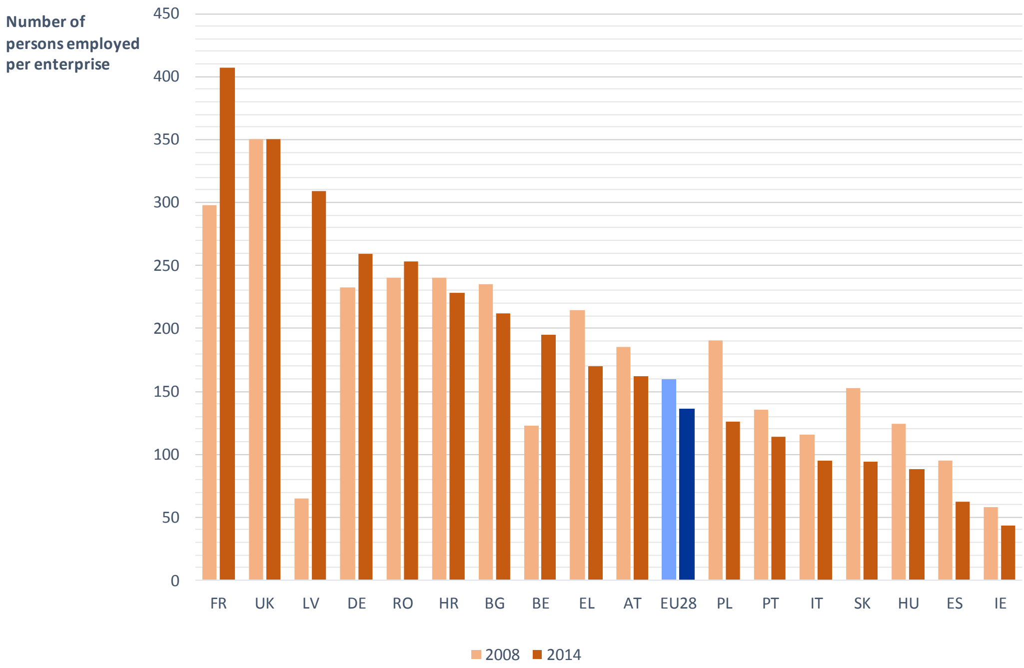


Source: Ecorys based on Eurostat SBS

2.5.5 Enterprise size of the EU cement manufacturing industry

In 2014, the average number of employees per enterprise for the EU was 137 persons. However, for individual countries, this number varied from above 400 in France to less than 50 in Ireland. Most countries have seen a contraction in the average size of enterprises since 2008 but the development varies across countries, with the average number of employees increasing, for example, in France, Germany, Belgium. There are offsetting factors at play: contraction of demand/production pushing reductions in employment within firms, while consolidation (mergers and acquisition) within the sector has pushed in the opposite direction.

Figure 20: EU28 cement manufacturing - average enterprise size by country (2008, 2014)



Notes:
a. No data available for CY, CZ, DK, EE, FI, LT, LU, MT, NL; SE, SI
b. PT data for 2008 and 2012
c. FR and SK data for 2010 and 2014
Source: Ecorys based on Eurostat SBS

The Amadeus sample shows similar results in terms of the average size of the cement manufacturing industry to that obtained from Eurostat's SBS. The average size of the EU cement sector in 2014 (NACE 23.51) was 142 employees, which is relatively similar to the SBS data already shown. This is considerably higher than the average size in lime and plaster manufacturing (NACE 23.52) with 37 employees, or manufacture of articles of concrete and cement (NACE 23.6) with 26 employees). In the cement sector the largest average size in 2014 was found in France (243 employees), Germany (297), Croatia (285), Slovakia (371), Great Britain (199). The lowest average size is found in Spain (45), and also Hungary (60), and Portugal (93).

Our Amadeus analysis[36] also finds that the manufacture of cement market is consolidated. Countries with highest level of concentration are Great Britain and France. The countries with the lowest levels of concentration are Spain and Italy. In Spain we see an increase in the level of consolidation after the financial crisis.

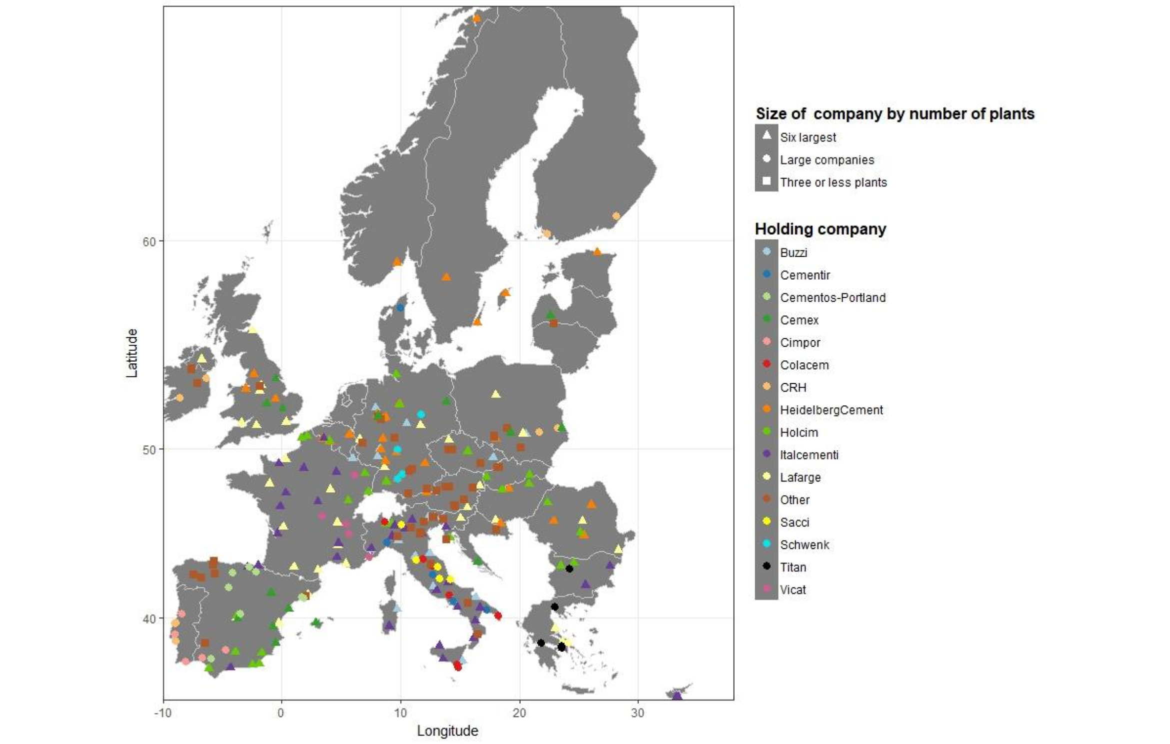
[36] See Annex D, Section D3

Box 6: Structural characteristics of European cement manufacturing enterprises

The European cement market is characterised by the presence of a handful of large vertically integrated companies (LafargeHolcim, HeidelbergCement, Cemex, Buzzi Unicem). Mergers and acquisitions between the largest companies (e.g. merger of Lafarge and Holcim in 2015, HeidelbergCement's acquisition of Italcementi in 2016) form part of a continuous trend towards an increasingly consolidated ownership pattern within the industry at the European level. Interviews with industry representatives have indicated that the European situation reflects a worldwide tendency, partially due to the economic situation during the past years, which favours larger companies and makes it harder for smaller ones to compete.

Mergers and acquisitions in Europe occurred throughout the 1990s and early 2000s, partially driven by political developments, such as the collapse of communist regimes in Central and Eastern Europe and the ensuing privatisation of state-owned companies and German reunification. The years following the 2008 financial crisis were marked by a restructuring and rationalisation process within the industry, as well as further horizontal integration. Companies develop diversified geographic portfolios as a way of limiting risks and increasing their potential for growth. The figure below shows the geographical distribution of cement plants by holding companies in or around 2014.[37] It demonstrates that even before 2015, a small number of companies controlled more than half of the plants located in the EU and Norway. However, as a result of the recent mergers, this number has been further reduced.

Figure 21 Geographical distribution of cement plants in Europe by holding company



Source: Ecorys based on F. Branger (2015)

Despite a consolidated ownership pattern within the European industry, the continued presence of smaller local/regional companies implies that differences exist in industry structure at national level. Moreover, due to the low value to weight ratio of cement, cement is usually supplied within a close geographical proximity to location of production, typically within a maximum radius of 150 to 250 km. Consequently, cement markets are local and geographically segmented, with competition occurring at a local/regional level. Thus,

[37] Source: F. Branger (2015) EUTL Cement dataset; available at https://hal-enpc.archives-ouvertes.fr/hal-01183725. Note, the presented analysis contains updates that may not be directly available from the quoted source.

increased concentration at a European level may not directly result in changes in competition conditions at a local/regional level. Furthermore, regulations on competition aimed at protecting cement customers from the negative effects of high concentration and preserving competitive markets, including those from the European Commission, limit possibilities for more horizontal integration.

2.5.6 Labour productivity of the EU cement manufacturing industry

In 2015, the cement manufacturing industry generated turnover of €15.2 billion with a workforce of less than 47 thousand, resulting in an average turnover per person employed of €320 thousand; this compares to an estimated average for manufacturing as a whole of €238 thousand. The average EU figure for the cement manufacturing industry masks very wide divergence across countries. For example, turnover per employee in Ireland is estimated at €580 thousand compared to €165 thousand in Bulgaria; see the figure below (as well as the note of caution*).

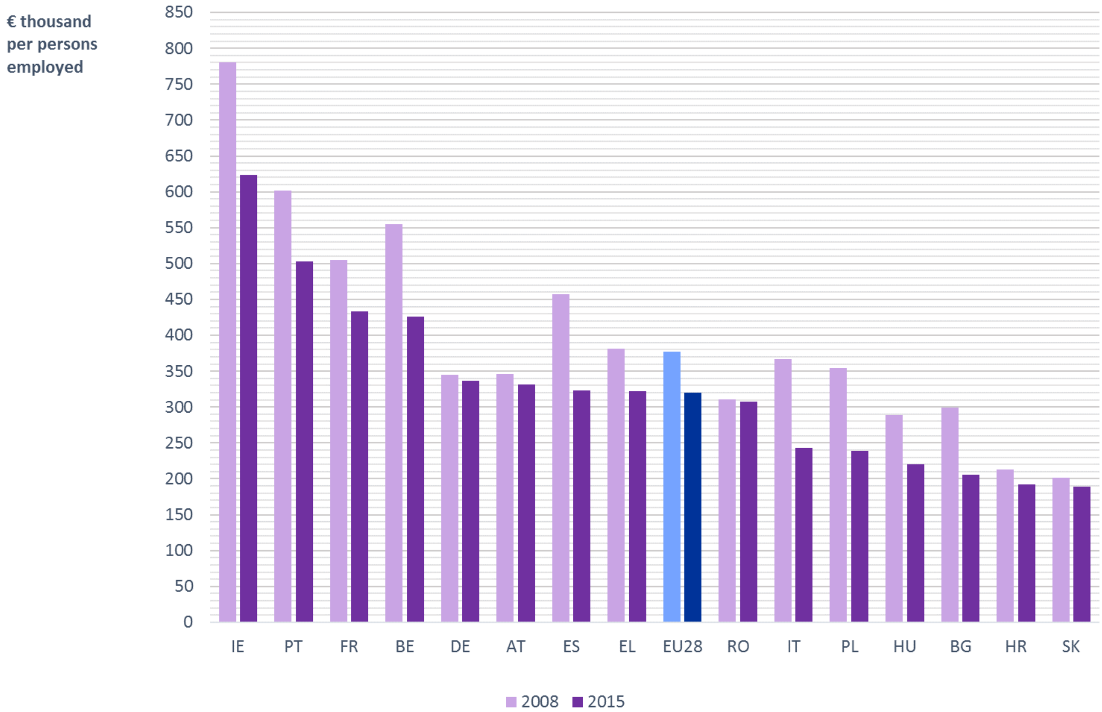
A similar picture of across country divergence exists for apparent labour productivity – measured by value added per person employed. In 2015, average apparent labour productivity of the cement manufacturing industry in the EU was €110 thousand, compared to €57 thousand for the manufacturing sector as a whole. Nominal labour productivity is highest in Ireland, France, Portugal and Germany; see the figure below. However, whereas (nominal) apparent labour productivity in manufacturing grew at an average annual rate of 1.9% between 2008 and 2015, for cement manufacturing it fell at an average rate of -5.4%. Overall, (nominal) labour productivity in cement manufacturing fell by 28% between 2008 and 2015.

The Amadeus analysis shows that the level of apparent labour productivity in the manufacturing of cement sector (23.51) in 2014 is estimated to be around €150 thousand constant PPP, falling to just over €100 thousand in 2015. Overall, we see that the level of apparent labour productivity has fallen in the EU since 2008, by over 30%. The level of apparent labour productivity has not decreased to the same extent in the manufacturing of lime and plaster sector (23.52%) or the manufacturing of articles of concrete, cement and plaster (23.6%).

Across countries, we also observe differences. The level of apparent labour productivity has deteriorated to a larger extent in Spain and Italy. There is more heterogeneity in cross-country performance in manufacturing of cement (23.51%) than in the other sectors, namely, manufacturing of lime and plaster (23.52%) and manufacturing of articles of concrete, lime and plaster (23.6%).

Note (*): *Some caution should be exercised when comparing and assessing turnover and value added per employee at a country level. The high value in some countries (e.g. Ireland) may be partly attributable to turnover reported by corporate headquarter enterprises capturing turnover from (foreign) affiliates. This may arise, for example, through corporate headquarters charging for goods and services provided to (foreign) affiliate companies. Thus, turnover data (and consequently value-added) may overstate turnover directly generated within the domestic market.*

Figure 22: EU28 cement manufacturing - turnover per person employed by country (2008, 2015)



Notes:

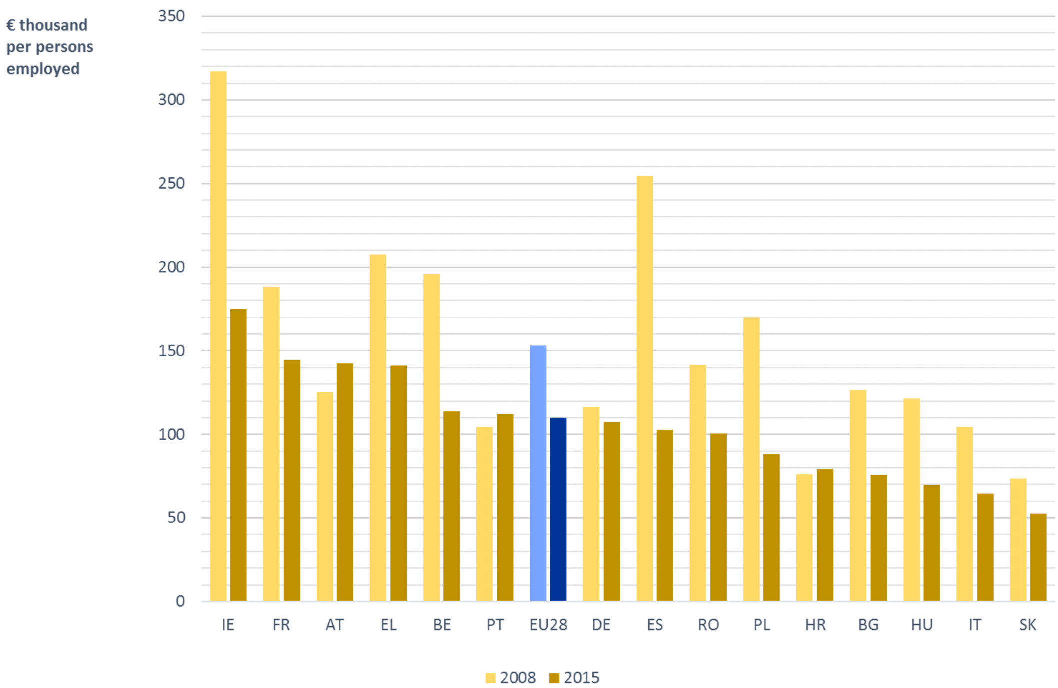
a. No data available for CY, CZ, DK, EE, FI, LT, LU, MT, NL; SE, SI, UK (2008 only, not shown)

b. PT data for 2008 and 2012

c. FR data for 2010 and 2014

Source: Ecorys based on Eurostat SBS

Figure 23: EU28 cement manufacturing – apparent labour productivity by country (2008, 2015)

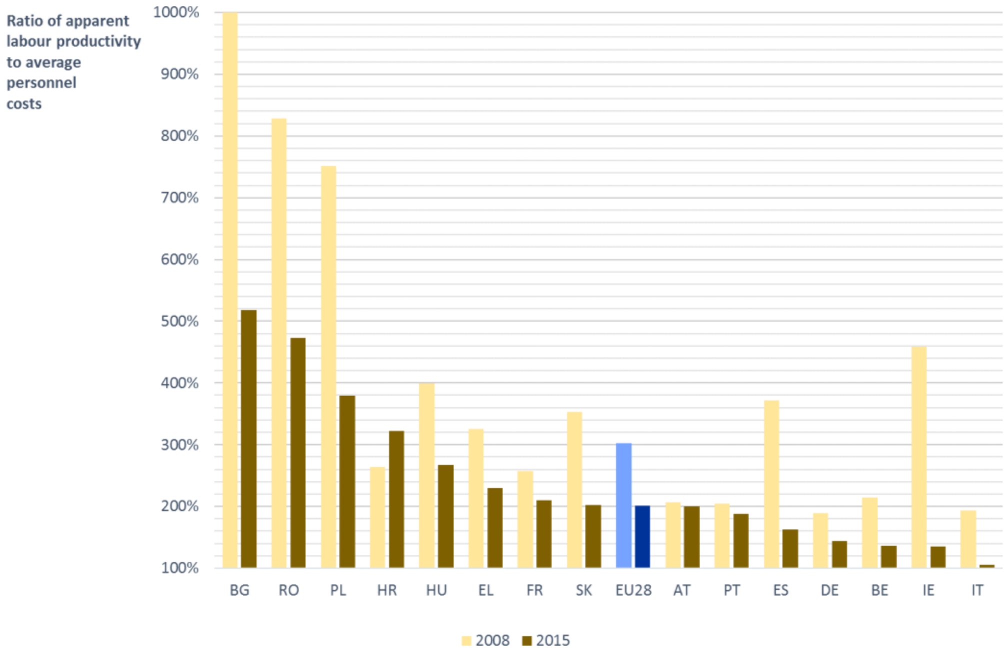


Notes:
d. No data available for CY, CZ, DK, EE, FI, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)
a. PT data for 2008 and 2012
b. FR data for 2010 and 2014

Source: Ecorys based on Eurostat SBS

The divergence across countries in turnover and value added per worker (person employed), can be the result of multiple possible causes. These can be differences in production efficiency (i.e. volume of output per worker) but also reflect differences in costs and market prices for cement products, which in turn reflect differences in overall economic development and factor costs. An indicator that partly corrects for these differences is the wage-adjusted labour productivity ratio, which is measured by apparent labour productivity divided by average personnel costs (expressed as a ratio in percentage terms). The figure below shows the wage-adjusted labour productivity ratio, for available countries, in 2008 and 2015. In 2015, for the whole EU, value added generated in the cement industry was on average around twice the cost of labour (201%). This represents a significant decline from 2008, when value added was on average around three times the cost of labour. The wage adjusted labour productivity ratio is typically higher in central and eastern European countries and lowest in some of the countries with the largest cement industries (e.g. Italy, Germany, Spain and Belgium).

Figure 24: EU28 cement manufacturing – wage adjusted labour productivity ratio by country (2008, 2015)



Notes:
a. No data available for CY, CZ, DK, EE, FI, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)
b. PT data for 2008 and 2012
c. FR data for 2010 and 2014

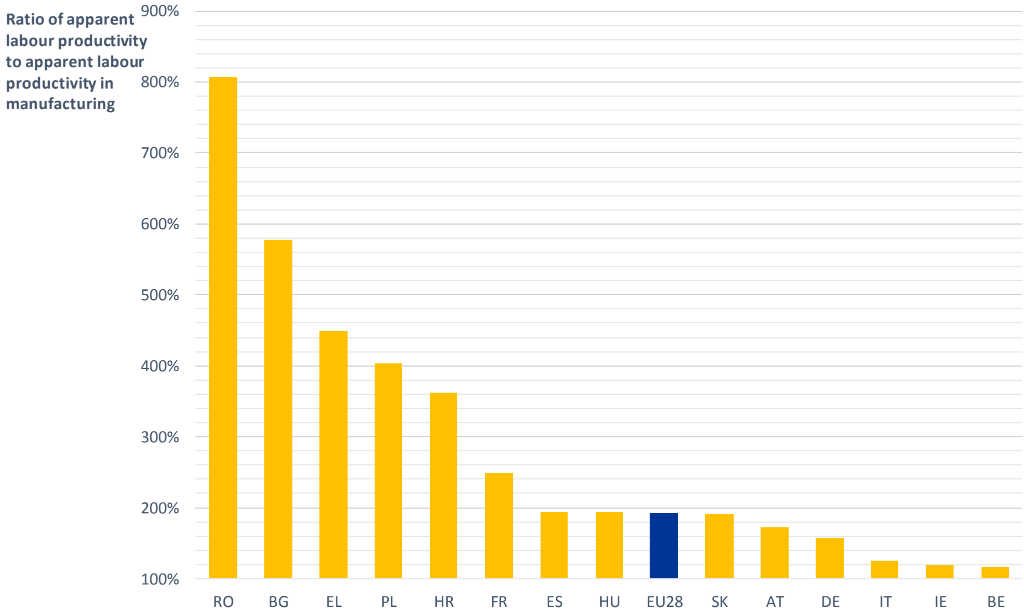
Source: Ecorys based on Eurostat SBS

An alternative approach is to compare apparent labour productivity in the cement manufacturing industry with that for manufacturing as a whole. This is shown in the figure below, which indicates that apparent labour productivity in cement manufacturing for the EU as a whole is nearly twice (193%) above the average of all manufacturing. The highest ratios are observed in Romania and Bulgaria, where apparent labour productivity in the cement sector is, respectively, 8-times and nearly 6-times above the average value added per worker of total manufacturing in the country. In Belgium, Ireland and Italy, apparent labour productivity in the cement sector exceeds that in manufacturing as a whole by less than 25%.

Box 7: Explanations of differences in industry performance

Interviews with industry representatives offer some explanations for the observed divergence in industry performance across Member States. While the overall technical and environmental performance of European producers is quite similar when compared to other areas of the world, regional differences – even within the same country – may reflect local cement demand conditions that are largely determined by the level of development and the local economic situation. The utilisation rate of existing production capacities also influences economic performance. The age of the installations is another important factor, as older plants are not always up to Best Available Technology (BAT) standards and are therefore less efficient. Local energy costs (which may be influenced by regulations), the availability of raw materials, the level of competition between producers and the skill of workforce further define the performance of cement manufacturers.

Figure 25: EU28 cement manufacturing – ratio of apparent labour productivity of cement manufacturing to apparent labour productivity of total manufacturing (2015)



Notes:
a. No data available for CY, CZ, DK, EE, FI, LT, LU, LV, MT, NL; PT, SE, SI, UK

Source: Ecorys based on Eurostat SBS

2.6 Production costs in the EU cement manufacturing industry

2.6.1 Breakdown of the production cost (main cost components)

Absolute level of the production costs

According to industry representatives, the average selling price of cement at the end of 2017 was around €60 per tonne (ex-factory price)[38], although this may vary significantly. Due to confidentiality restrictions, market players could not share actual levels of production cost with the research team. However, various public sources exist in this domain.

[38] This is a rough estimate, as sales prices are confidential and vary significantly across the EU.

In 2016, the JRC published a comprehensive analysis of the production costs for various energy-intensive industries in the EU, including the cement industry.[39] The report is based on 2011-2012 data and found that the average EU production costs for cement was around €48 per tonne.[40] Within the sample, the costs per tonne range within the EU from €35 (minimum) to €73 (maximum).

Other estimations on the production costs of cement are in the same range as the JRC-report (see box below). Please note that these estimations differ from each other in terms of scope and methodology.

Box 8: Estimates of absolute cement production costs

Various efforts, with differences in scope and approach, have been made to estimate cement production costs. IEA (2010) estimates the average costs of a conventional plant (without any carbon capture) at around €66 per tonne, but underlines that costs are difficult to assess due to varying context (kilns, used technology, inputs, etc.).[41] The costs for plants with CCS techniques like post-combustion or oxy-combustion lie much higher (respectively €129 and €82 per tonne of cement). Cost estimates based on a sample of eight cement plants in Scandinavia found the average production cost to be around €58 per tonne (ex-factory, so excluding transport costs).[42] Information collected by Ecorys as part of the present study, indicated a within country range for one producer of between €30 to €45 per tonne (ex-factory) depending on the plant, while other estimates pointed rather to an average production costs of around €55 per tonne.

Breakdown of production costs

Various sources present information on the breakdown of the production costs of cement. These are briefly discussed in the following paragraphs. The following sources are briefly discussed:

- Estimations from the **Joint Research Centre (JRC, 2016)** on the production costs for energy intensive industries;
- Data from **Eurostat** (Structural Business Statistics) on the composition of the production value;
- Other estimations. For example by **Ecofys (2016)** and **Rootzen and Johnson (2016)**;
- Findings from the **company survey carried out within the context of this study**.

The various sources show a large variety in the breakdown of cost components as percentage of the actual production costs. Most likely this is mainly related to the differences in scope and methods for data collection and data analysis.

The already mentioned **JRC-study (2016)**[43] makes a distinction between four main cost components: (i) raw material, (ii) energy, (iii) maintenance and (iv) labour and other costs. Based on 2011 and 2012 data the JRC estimates that the overall production costs lie around €46 (2011) to €48 per tonne (2012). In the next figure the estimated breakdown is presented, with specific attention paid to the various energy costs. The figure shows that the used energy

[39] JRC (2016): Production costs from energy-intensive industries in the EU and third countries, see especially annex B (p. 68-85). This data is also used in: SWD(2016) 420 Energy Prices and Costs in Europe. http://ec.europa.eu/energy/sites/ener/files/documents/swd2.pdf.

[40] The JRC based the assessment on data from the Global cement database. For the EU, this database contained 303 plants, which is approximately 94% of the total EU population. These plants fall under the NACE 23.51 classification ("manufacture of cement").The plants have a joined capacity of 317 Mt of cement production. The data refers to 2011 and 2012, which is the most recent data in the database. The costs include (i) energy costs, (ii) the cost of raw materials and (iii) other costs like maintenance, operating labour, administration and overhead, etc.

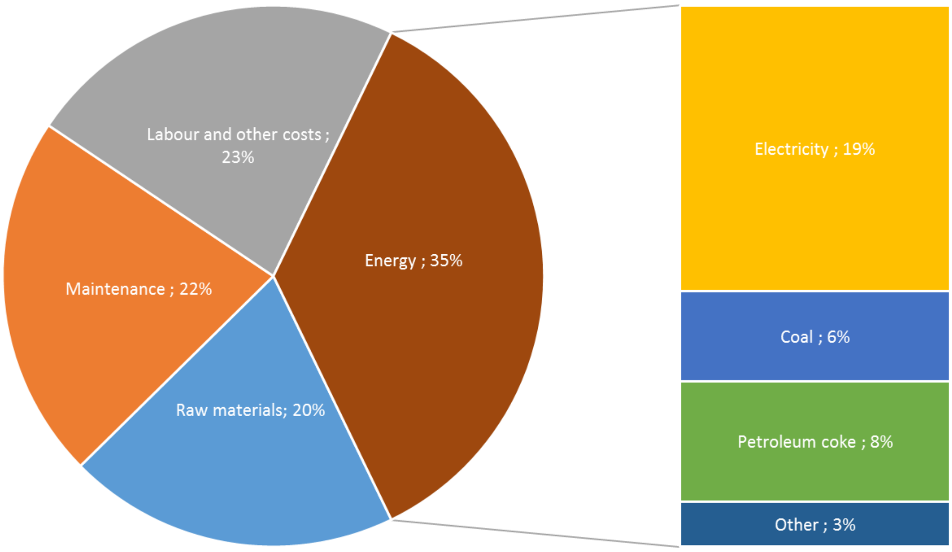
[41] IEA Energy Technology Network, Technology Brief 'Cement', June 2010.

[42] Rootzén, J. ; Johnsson, F. (2016) "Managing the costs of CO2 abatement in the cement industry". Climate Policy pp. Page 1-20.

[43] JRC (2016): Production costs from energy-intensive industries in the EU and third countries, see especially annex B (p. 68-85).

is the major cost component, followed by labour and other costs (e.g. insurance, overhead, etc.).

Figure 26: Estimated cement production costs (% of total, average 2011/2012, EU28)

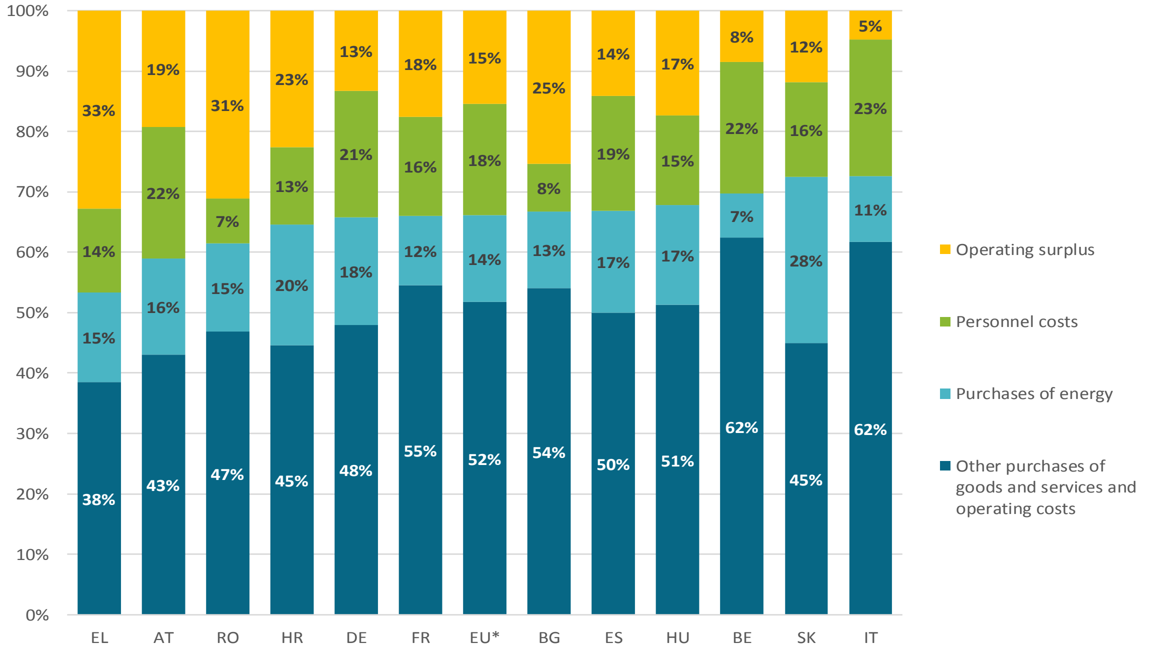


Source: JRC (2016), based on 2011-2012 data.
Note: The JRC estimated the production cost per tonne of cement to be approximately €46 in 2011 and €48 in 2012. In their analysis the JRC presents per cost category various estimations (e.g. low, average or high). Where applicable (e.g. for energy cost and maintencance costs) we used the 'average' estimation. With regard to the energy costs the JRC makes a distinction between various types of energy costs, e.g. electricity, coal, petroleum coke, etc. In the figure the category 'other' refers to biomass, natural gas and (residual) fuel oil. The use of alternative 'fuel waste' is seen as a negative costs. i.e. a payment for the producers. This is taken into account in the calculations, but not visible.

Eurostat SBS[44] data provides only partial information on the composition of production costs but, nonetheless, it can be used to calculate estimates of the breakdown of the value of production by broad items as shown in the figure below. The value of production of cement manufacturing is composed of four element: 'operating surplus' and 'personnel costs', which combined equate to value added, 'energy cost' and 'other costs' covering purchases of other goods and services and other operating costs (and incomes). As explained after the figure, there are serious doubts whether these figures present a realistic breakdown.

[44] Eurostat Structural Business Statistics (SBS). Please note that this data can not directly be compared with the data presented en used in Chapter 5 in the context of the ADAGIO-model. The data used in Chapter 5 comines several data sources, including Eurostat Structural Business Statistics.

Figure 27: EU28 cement – estimated breakdown of production value by component (2014)



Notes:

a. EU* is a production weighted average of the individual countries shown in the figure

Source: Ecorys based on Eurostat SBS.

In the countries for which data are available, the share of value added[45] in production varies from 27% in Italy, up to 47% in Greece. Within this bandwith, there is considerable variation in the share of operating surplus in production costs, from only 5% in Italy to 33% in Greece and 31% in Romania. Similarly, the share of labour costs in the production value ranges from 7% in Romania, up to 23% in Italy and 21-22% in Germany, Belgium and Austria. Energy costs, which are particularly important for the industry due to its high energy intensity, are estimated to amount to 14% of the value of production on average for the EU (based on countries for which data are available). However, there appears to be considerable variation across countries, with energy purchases amounting to only 7% of the value of production in Belgium to 28% in Slovakia. Based on the interviews with industry representatives and other public sources (especially the JRC-study), this share of energy costs seems unrealistic.

There are a few other studies which asses (or refer to) the cost components. **Ecofys (2016)** calculates an average 20% energy share for the aggregate sector '*cement, lime and plaster*' in the period 2008-2013, with observations ranging from 13% to 36%.[46] The **Rootzén, & Johnsson (2016)** study on the Scandinavian cement production indicates a production cost breakdown of 16% for raw materials, 29% for the costs of fuel and electricity, while the fixed operational and capital costs add up to 55%.[47] The **Commission Communication (2014)** for a European Industrial Renaissance indicates (without a specifc source/explanation) that energy costs represent 30% of the overall production cost for cement.[48] The **IEA (2010)**[49] provides estimates of the production cost breakdown for a conventional cement plant (with different cost

[45] Measured by the sum of 'operating surplus' and 'personnel costs'.

[46] Ecofys (2016), 'Prices and costs of EU energy', p. 121. This data is also used in: European Commission, 'Energy Prices and Costs in Europe', SWD(2016) 420; web link: http://ec.europa.eu/energy/sites/ener/files/documents/swd2.pdf

[47] Rootzén, J. ; Johnsson, F. (2016) "Managing the costs of CO2 abatement in the cement industry". Climate Policy pp. Page 1-20. Please note that the sample (eight plants) is much smaller than in the JRC-study.

[48] SWD(2014) 14. *State of the Industry, Sectoral overview and Implementation of the EU Industrial Policy.* Page 50 http://ec.europa.eu/DocsRoom/documents/4103/attachments/1/translations/en/renditions/pdf

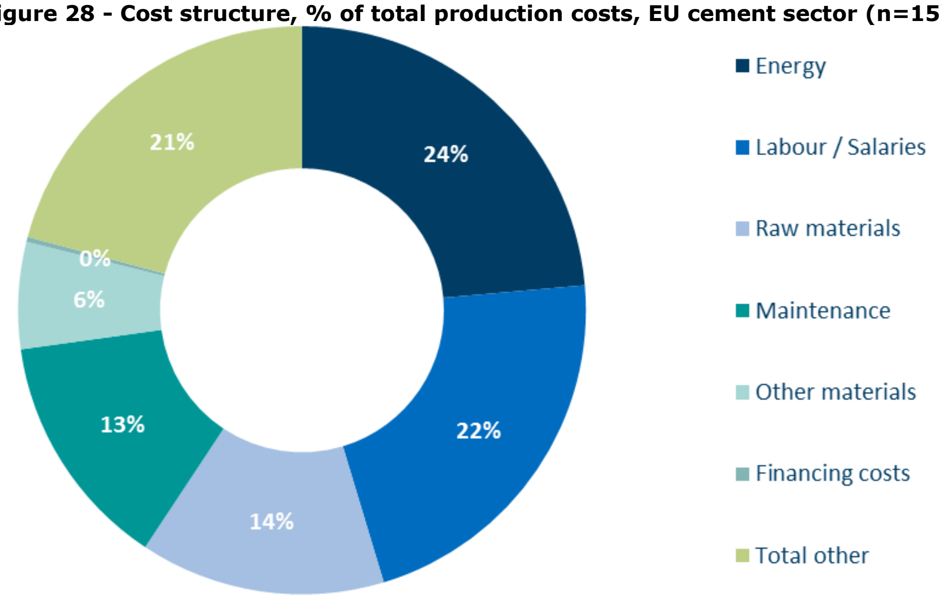
[49] IEA Energy Technology Network, Technology Brief 'Cement', June 2010.

components). The combined share of fuel costs and electrical power for a conventional plant is assessed to be 16%.[50]

As part of the present study, **a survey among cement (and lime) companies** has been undertaken to collect additional data and opinions on industrial competitiveness; Annex B contains more details on the followed approach. The survey included questions on the breakdown of production costs, for which the findings are reported in the following paragraphs.

The following figure shows the breakdown of average cement production costs obtained for a sample of 15 European cement companies.[51] Among the different cost categories, costs of energy appear as the largest item in the reported cost structure of cement companies, constituting 24% of total costs on average. This figure includes both the expenses incurred for electricity and for the fuel used during the production process (e.g. in the burning operations). However, there is a significant variation across the responding companies considered, with energy cost shares ranging from roughly 14 to almost 45% of total costs.[52] Please note that this figure of 24% is higher than the Eurostat SBS data, but lower than the JRC-estimations.

Figure 28 - Cost structure, % of total production costs, EU cement sector (n=15)



Source: Ecorys company questionnaire; see annex B for more details. Note: in the company questionnaire also the category 'transport cost' was included. This category is left out here to increase the comparability.

The cost of labour (including social security contributions) accounts for the second largest item in the cost structure, amounting on average to one fifth (22%) of total costs. Raw materials are the third largest cost component (14% on average), which is substantially lower than the JRC estimate of 35%. The average estimate hides, however, considerable variation across companies, with some reporting costs below 10% and others indicating a share of up to 30%. Raw materials considered include primary items such as limestone, clay, shale, marl, while secondary additions in the production process such as gypsum, anhydrite, minerals are computed separately (6.0%). Costs of maintenance and financing costs account for 13% and 6% respectively on average. Under the residual 'other costs' category, reporting companies mention the costs of packing operations, rental costs, depreciation and amortisation.

[50] Other cost components are: capital charges (45%), variable operational costs (9%), fixed operational costs (29%).

[51] These 15 cement companies represent approximately 30% of the European industry, both in terms of employment and turnover. For this check, we used 2014 company data as available in the Amadeus company database.

[52] The response with the lowest energy share was double-checked. This specific respondent indicates that energy costs (as share of total production costs) are the fourth cost component.

For transport costs (not shown in the figure), companies report widely different cost shares, which is understood to reflect different business structures as well as varying accounting processes. Some of the companies interviewed do not consider transport costs as a technical item of cost of their production but as a cost which is charged differently to different type of sales (e.g. domestic sales or exports). Some companies opt to outsource transport operations, while others handle transport internally, including in some cases railway transportation to the client.

Breaking down the survey estimates into three regional subgroups, strong similarities can be observed between the cost structure indicated by companies operating in the Northwestern countries (Germany and Belgium) and those operating in Southern ones (Spain and Italy). Secondary materials such as gypsum or mineral additions tend to be more costly for companies in Northwestern Europe, while energy costs are relatively lower.[53]

The overview of the various sources shows that there is quite some variety in the assessed breakdown of cost components. In the next box we briefly explain how we dealt with it in the remainder of the report.

Box 9: How are the varying estimations on cost components taken into account?

Industry representatives interviewed for the study indicate that the estimates of the average share of energy in production cost indicated by Eurostat SBS data, at 14% of production value, is (far) below their own estimates. This view is confirmed by the survey among cement companies and the JRC-study (2016). The reason for the large difference between Eurostat and both other sources is not immediately apparent. One explanation for the differences lies in the fact that Eurostat includes 'operating surplus' as a cost item, whilst other sources do not. Yet another difference may be due to the scope of energy sources included in the Eurostat definition of energy costs. Specifically, it is not clear whether Eurostat data count alternative energy source (e.g. waste materials) as part of energy costs or include them under 'other purchases'.

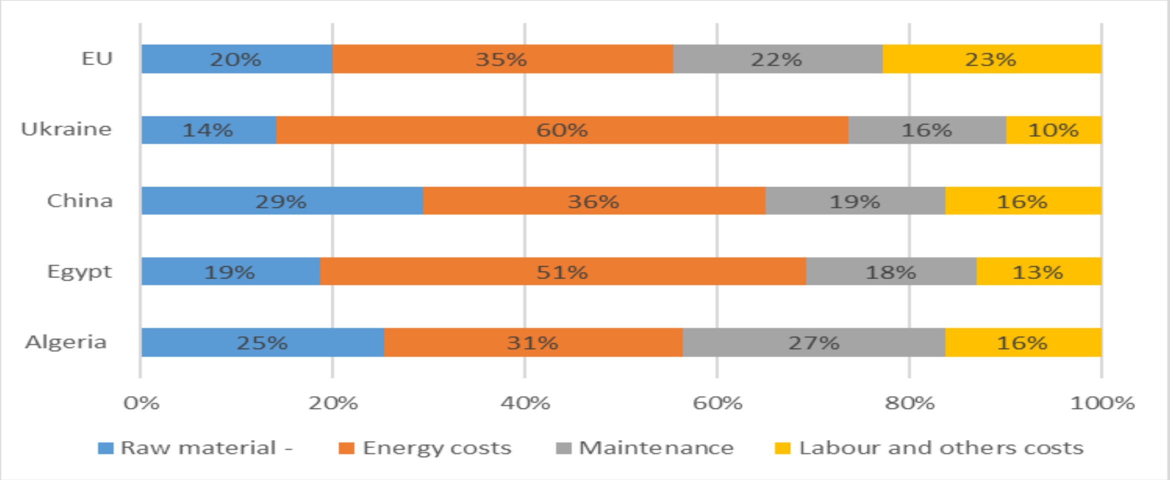
As the Eurostat SBS data is an important source for the ADAGIO-model used in the scenario projections (see chapter 5), specific assumptions (i.e. corrections on the too low energy factor share) have been made to the underlying dataset. As further explained in Chapter 5, the simulation model assumed an average factor share of 24% for energy in the cement industry. This percentage is primarily based on the results of our survey. Given their importance for the model simulation results, sensitivity analyses of the assumed energy factor shares have also been carried out; for example with a 30% energy factor share for cement (in scenario 1 and 2).

[53] Differences in energy costs are, to a large extent, related to the costs for electricity, which differ substantially within the EU. The JRC-report indicated that on average 55% of the energy costs is related to electricity. With regard to the sample it is important to note that the prices in southern countries like Italy (around 70€/MWh) are on average higher than Germany and Belgium- Wallonia (around 62-65€/MWh). See the following report for an overview of electricity prices: Ecofys (2016): Prices and costs of EU energy.

2.6.2 EU production costs in an international perspective

The JRC-study (2016) presents a limited comparison of the cost-breakdown for EU cement production with four international competitors: Algeria, China, Egypt and Ukraine. The analysis is primarily based on data from the Global cement database.[54] The JRC analysis finds large cross-country differences in the absolute cost of cement manufacturing, with production costs ranging from €37 per tonne of cement (Algeria and China) to €53 per tonne of cement (Ukriane). The breakdown of the costs for 2012 is presented in the figure (relative share).

Figure 29 Breakdown of production costs in 2012 in the EU and four other countries (as % of total)

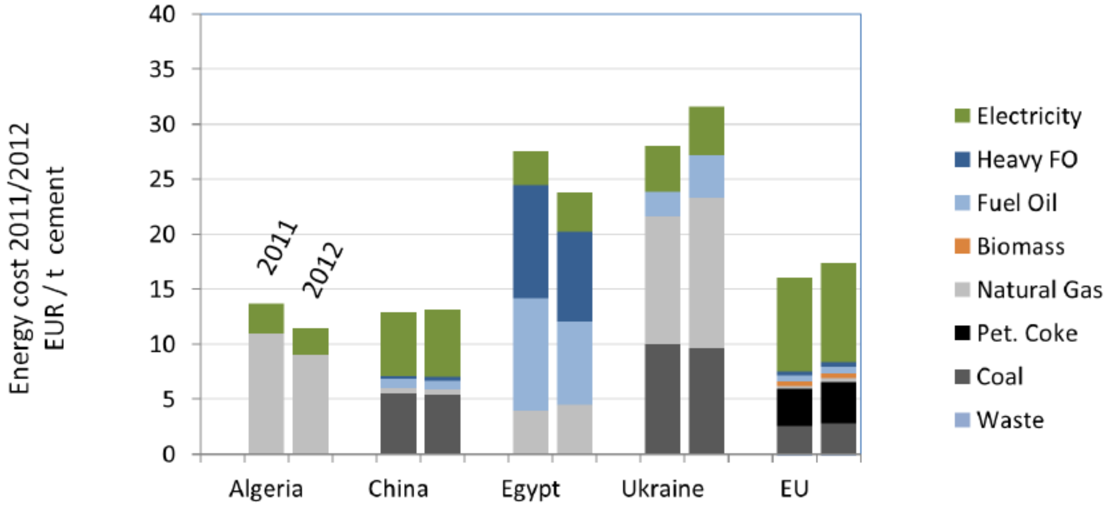


Source: JRC (2016), based on 2012 data.
Note: The JRC used the following absolute levels of production costs (per tonne of cement): Algeria and China: €37; Egypt: €47; EU: €48 and Ukraine €53. Industry representatives indicated that, to their knowledge, the costs in China are significantly lower (around 20-25 €/tonne in 2017). Where applicable (e.g. for maintencance costs) we used the 'average' estimation. With regard to the energy costs the JRC less types of energy costs are distinghuised (compared to the EU), i.e. electricity, coal, natural gas and (residential) fuel oil.

The differences between the countries are driven by difference in energy costs. In Algeria and China, the energy costs per ton of produced cement are much lower than in the EU, Ukraine and Egypt. The JRC-study shows that both the composition of fuels and overall cost levels per tonne of cement differ significantly across the countries. The share of electricity in the overall fuel mix is relatively high in the EU and China, while plants in Algeria and Ukraine use a high proportion of natural gas and coal is used heavily in China and Ukraine, and fuel oil in Egypt.

[54] In the analysis the JRC included: Ukraine (6 plants), China (78 plants), Egypt (10 plants), and Algeria (4 plants). The coverage in terms of plants included in the JRC-sample varies between 4% (China) to 60% (Egypt).

Figure 30: Energy costs of the fuel mix used in the cement industry in 2011/2012



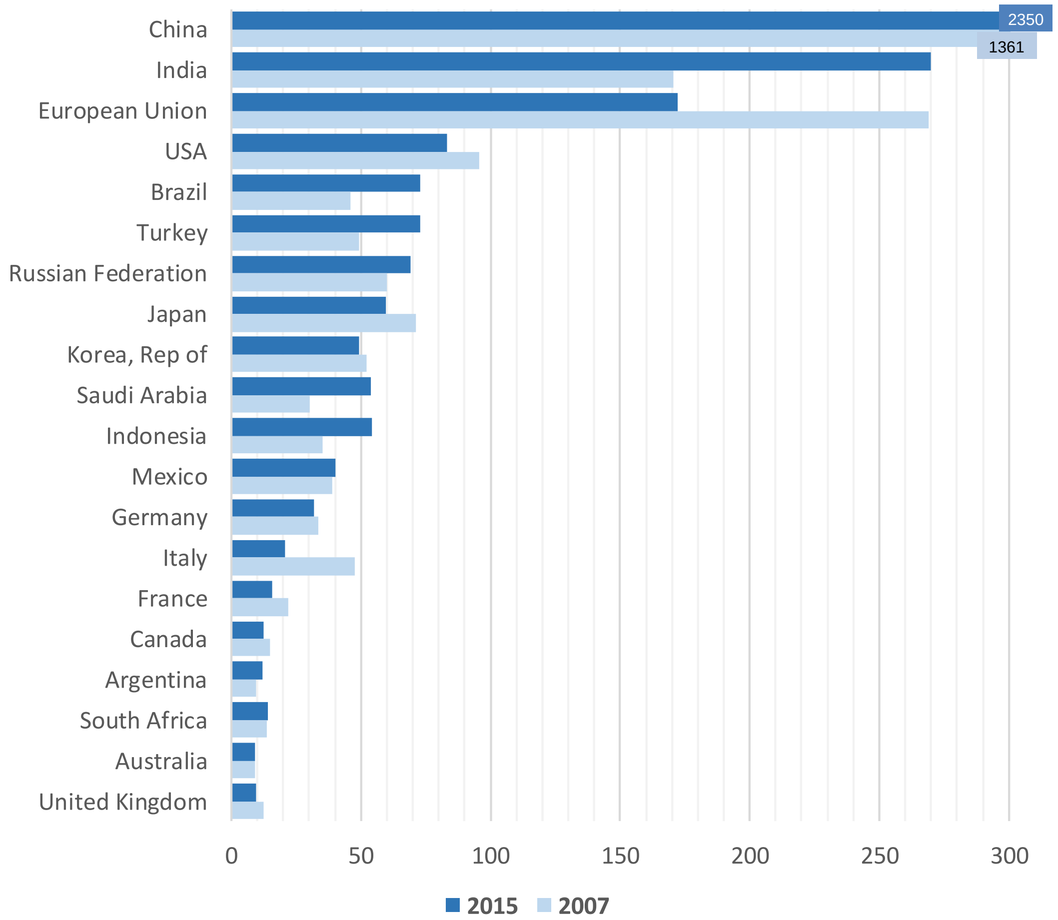
Source: JRC (2016).

2.7 Global production of cement

In 2015, according to CEMBUREAU,[55] cement production in the EU28 amounted to 167 million tonnes, representing 4% of global production, placing the EU as the third largest producer behind India with a production of 270 million tonnes. China dominates global production with an estimated volume of 2.35 billion tonnes representing 51% of global production in 2015.

[55] CEMBUREAU (2017), 'Activity Report 2016'.

Figure 31: Production levels of main world cement producers



Source: Ecorys elaboration on Cembureau data

2.8 International trade in cement

2.8.1 Trade data coverage

Table 4 provides the categorisation of trade codes from the Harmonized System (HS) classification. It should be noted that the trade product category 'cement clinker' (HS 25231000) does not distinguish between Portland cement clinker and clinker for other cement types. Further, the trade product category Portland* cement (HS 25232100 + HS 25232900) covers both Portland cement (CEM I) and Portland-composite cement (CEM II); for more details, see the 'Product overview' and the 'Note on the classification of cement in statistical data' at the beginning of this chapter (Section 2.1).

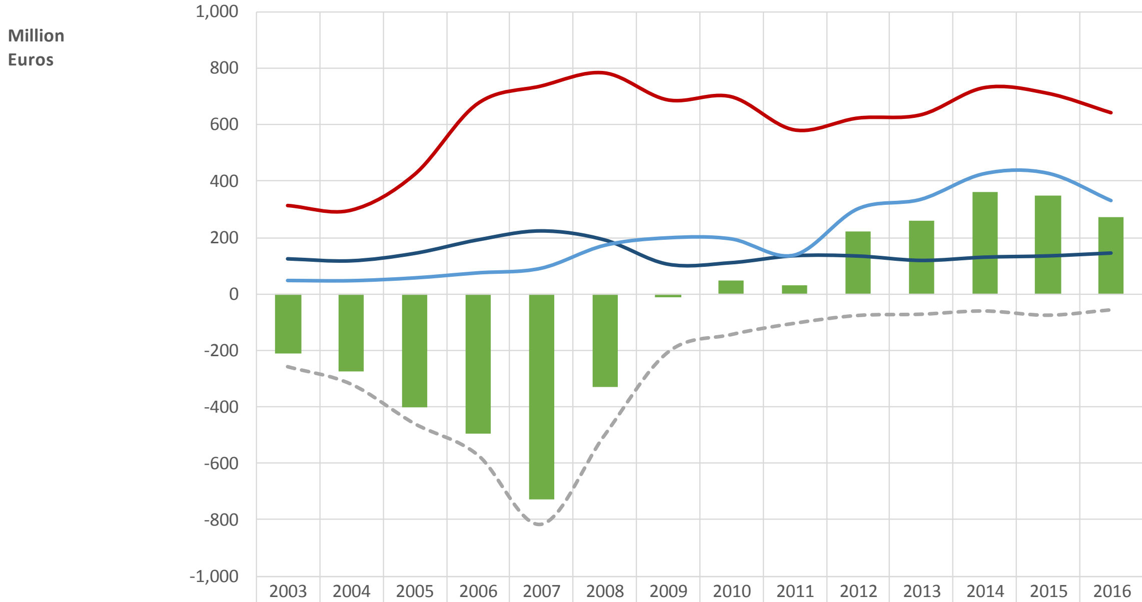
Table 4 Cement trade codes

Product category	HS code	HS code description
Cement clinker	25231000	Cement clinker
Portland* cement	25232100	White Portland cement, whether or not artificially coloured
	25232900	Portland cement (excl. white, whether or not artificially coloured)
Other hydraulic cement	25233000	Aluminous cement
	25239000	Cement, whether or not coloured (excl. Portland cement and aluminous cement)

2.8.2 Overall trade performance of cement clinker

There have been large shifts in the EU trade position for cement clinker over the past decade and a half (see the figure below). Prior to the economic crisis, the EU28 maintained a negative and increasing trade deficit. Since 2010, however, the EU has had a trade surplus in cement clinker, while intra-EU trade has remained relatively stable, hovering around €120 to 150 million per year. Since 2009, cement clinker has increasingly found its way to non-EU28 partners, leading to an extra-EU export value exceeding €400 million in 2014 and 2015, accounting for over half of the value of sold clinker production. This development can be attributed to a reorientation of production by EU cement manufacturers faced with large declines in domestic demand from domestic supply of cement to increased exports of cement clinker (see Box 3).

Figure 32 Trade pattern for cement clinker, for EU28 (in € million)

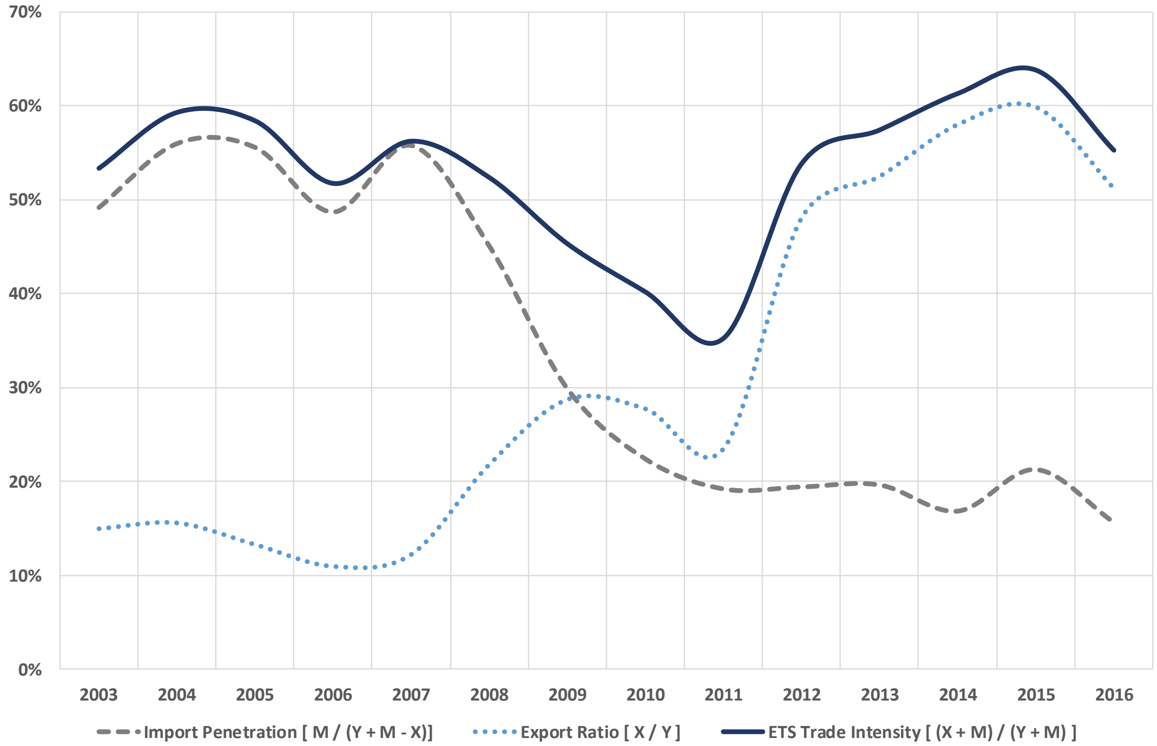


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU trade balance	-212	-274	-404	-497	-727	-332	-11	49	31	222	261	363	350	272
Sold production	315	299	425	676	739	785	690	701	583	625	637	733	713	644
Intra-EU trade (exports)	124	116	143	193	225	193	104	109	135	134	118	129	134	145
Extra-EU export	47	47	57	74	91	171	198	195	137	300	334	425	427	330
Extra-EU [-] imports	-259	-321	-460	-571	-817	-503	-209	-146	-106	-78	-74	-62	-77	-58

Source: Eurostat Comext for trade data, Prodcom for production data. Ecorys calculations.

The figure below shows key trade indicators (import penetration, export intensity, trade intensity) for cement clinker based on the value of sold production and extra-EU trade flows. These demonstrate the overall high trade intensity for cement clinker, which remains an important indicator for the sector due to its role in determining whether a sector is deemed to be at risk of carbon leakage for the purposes of the EU's greenhouse gas Emissions Trading System (EU ETS). The figure also reveals a switch from a high trade intensity driven by imports to a high trade intensity driven by exports; between 2007 and 2015 the EU import intensity for cement clinker fell by 35 percentage points, while exports rose from 12% to 60% of sold production.

Figure 33 Extra-EU trade indicators for cement clinker, EU28 (based on sold production value)

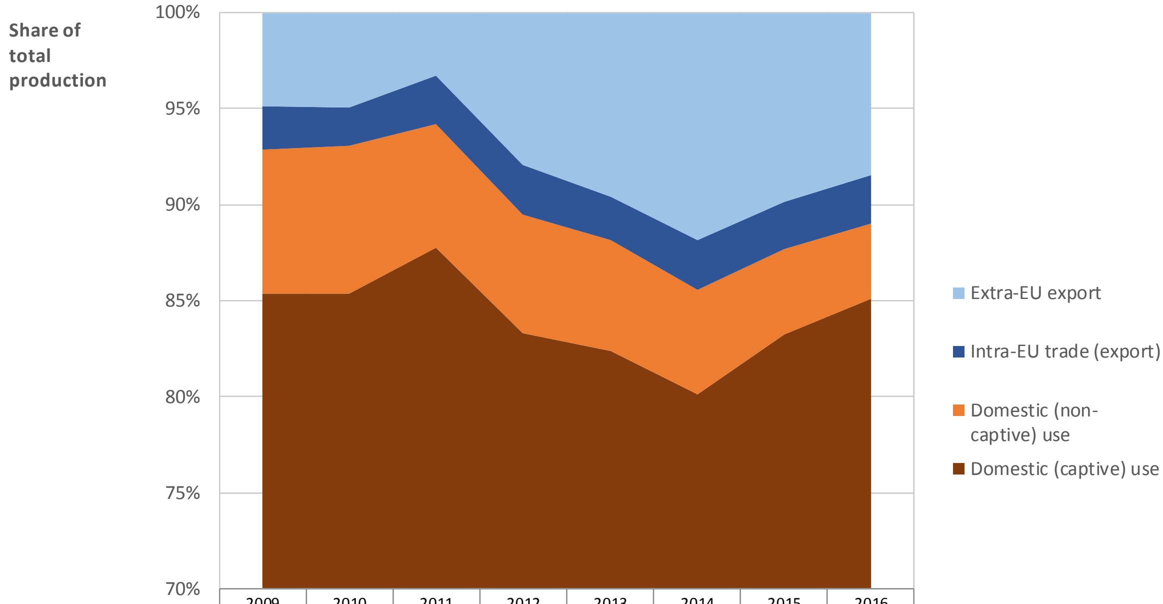


Source: Eurostat Comext for trade data, Prodcom for production data. Ecorys calculations.

In evaluating the EU's trade performance for cement clinker, it is relevant to recall that most cement clinker goes directly into the production of cement, with the calcination process (clinker production) and subsequent grinding and blending (cement production) usually integrated within the same production plant location. Consequently, as previously described in Section 2.3, only a small proportion of total clinker production reaches the market, either sold domestically or exported. Eurostat Prodcom data, which provide data on the total volume (tonnes) of cement clinker production only since 2009 (under NACE Rev. 2), indicate that around 85% of production is used directly ('captive' production). Of the remaining 15%, as shown in the figure below, over recent years around two-thirds (10% of total production) has gone to extra-EU exports. Although, as noted in Section 2.3, production data from industry sources - Cement Sustainability Initiative (CSI)[56] – indicate higher total production of cement clinker, which would suggest that the share of extra-EU exports could be lower than 10% of total clinker production (by weight).

[56] The Cement Sustainability Initiative (CSI), is an industry-led grouping – under the umbrella of the World Business Council for Sustainable Development (http://www.wbcsd.org/) – comprising 23 major cement producers commanding around 30% of global production (www.wbcsdcement.org). Part of this initiative is the CSI Global Cement Database "Getting the Numbers Right" (GNR), which includes industry data on cement production, and CO_2 and energy performance information. Data are supplied by CSI members and are subject to partial independent verification.

Figure 34 EU28 cement clinker production - breakdown by domestic use and trade destination 2009-2016 (million tonnes)

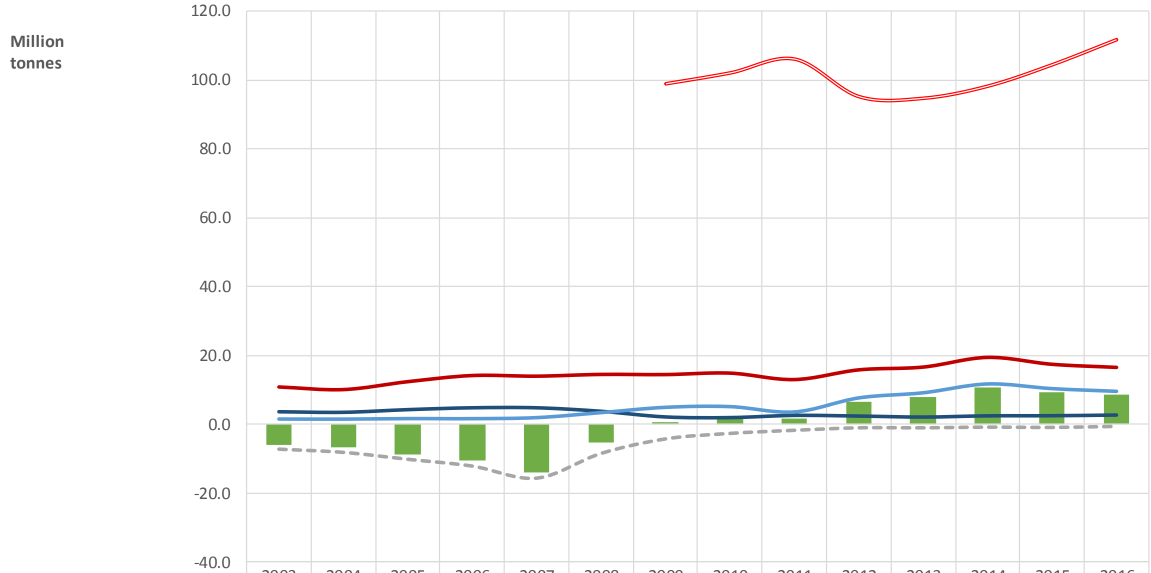


	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU export	4.8	5.0	3.5	7.6	9.1	11.6	10.3	9.5
Intra-EU trade (export)	2.2	2.0	2.7	2.5	2.2	2.5	2.6	2.8
Domestic (non-captive) use	7.4	7.9	6.9	5.8	5.5	5.4	4.7	4.4
Domestic (captive) use	84.5	87.2	93.1	79.4	78.1	78.7	87.0	95.1

Source: Ecorys based on Eurostat Prodcom.

The figure below shows the evolution of EU cement clinker production (total and sold production) together with extra-EU trade in volume (tonnes of cement clinker). Similarly to the value of trade described previously, the figure shows a trade deficit up until 2008 and a surplus for the years thereafter. However, by looking at total production as opposed to sold production, cement clinker appears as a much less traded product. This is further evidenced by the subsequent figure, which compares trade indicators (import penetration, export intensity, trade intensity) for cement clinker, based on both sold production volumes (Y) and total production volumes (Y*). While the trade indicators based on sold production volumes show a very similar pattern to those described earlier, the trade intensity for cement clinker is much lower when evaluated on the basis of total clinker production. For the latter, the overall trade intensity of cement clinker is only around 10% for the period since 2009; this is driven mostly by exports, with import penetration (extra-EU imports over apparent consumption) having fallen below 2% since 2011.

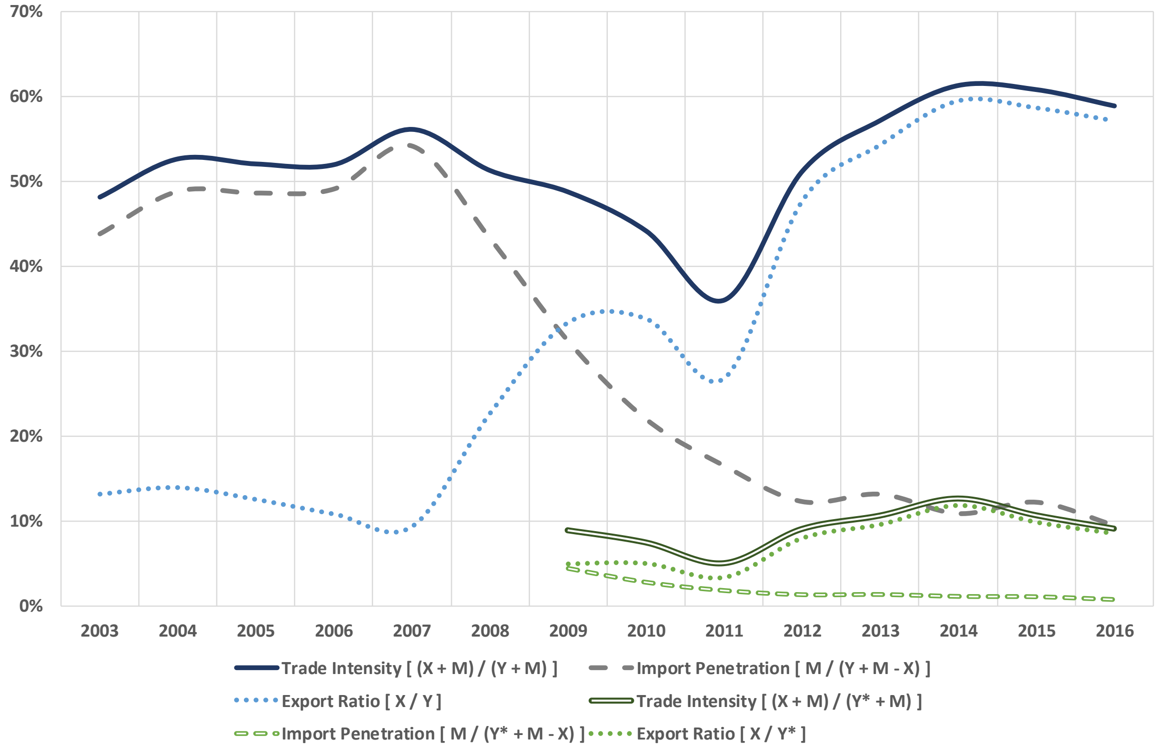
Figure 35 Trade pattern for cement clinker, for EU28 (in tonnes)



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU trade balance	-5.9	-6.8	-8.7	-10.7	-13.8	-5.2	0.5	2.3	1.6	6.4	7.9	10.7	9.2	8.8
Sold production	10.8	10.1	12.4	14.2	14.0	14.5	14.5	14.9	13.0	15.9	16.7	19.6	17.5	16.6
Intra-EU trade (exports)	3.7	3.6	4.4	4.9	4.9	3.9	2.2	2.0	2.7	2.5	2.2	2.5	2.6	2.8
Extra-EU export	1.4	1.4	1.6	1.5	1.8	3.3	4.8	5.0	3.5	7.6	9.1	11.6	10.3	9.5
Extra-EU [-] imports	-7.3	-8.2	-10.2	-12.2	-15.7	-8.5	-4.4	-2.8	-1.9	-1.2	-1.1	-1.0	-1.0	-0.7
Total production							99.0	102.2	106.1	95.3	94.8	98.3	104.5	111.8

Source: Eurostat Comext for trade data, Prodcom for production data. Ecorys calculations.

Figure 36 Extra-EU trade indicators for cement clinker, EU28 (based on sold production (Y) and total production (Y*) in volume)

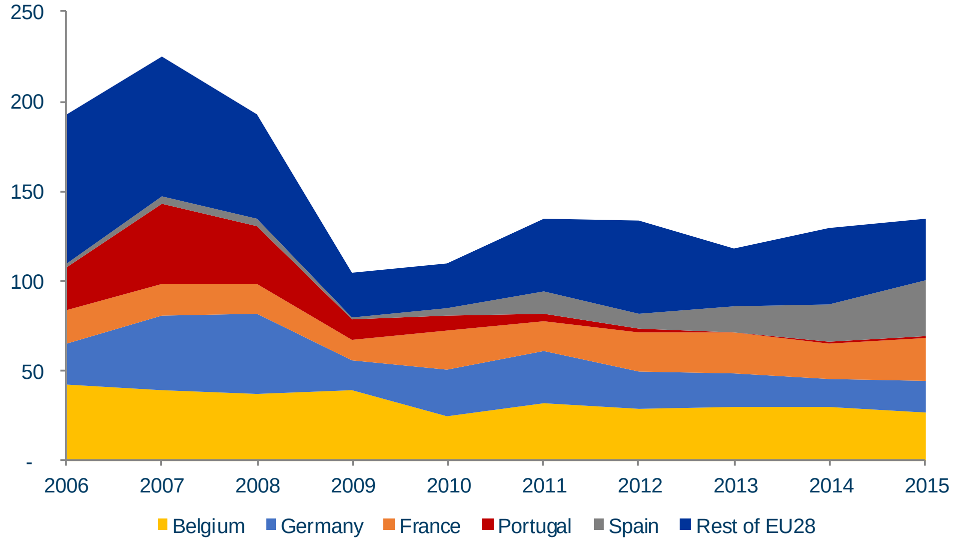


Source: Eurostat Comext for trade data, Prodcom for production data. Ecorys calculations.

2.8.3 Export performance of cement clinker

The figure below shows the trade patterns within the EU Internal Market in the last decade. Belgium, Germany and France are consistently among the largest traders in cement clinker. The market share of Portugal in intra-EU trade declined, arguably to the benefit of Spain, which was a marginal player in 2006, but was the largest trader to other EU MS in 2015.

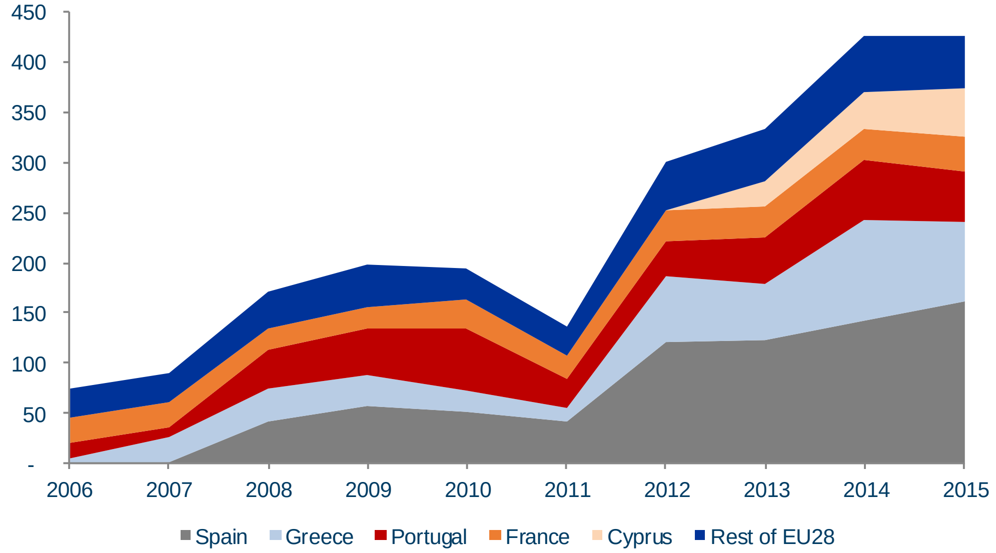
Figure 37 Intra-EU exports in cement clinker, per EUMS (in million EUR)



Source: Eurostat Comext, Ecorys calculations.

The figure below displays a similar picture as far as exports to third countries are concerned. The five largest exporters are all located in the periphery of the EU, which facilitates the shipment of cement clinker to third countries. The increase of Spanish exports to third markets over the last decade is remarkable and therefore subject to more detailed analysis (see box in next section).

Figure 38 Extra-EU exports in cement clinker, per EUMS (in million EUR)



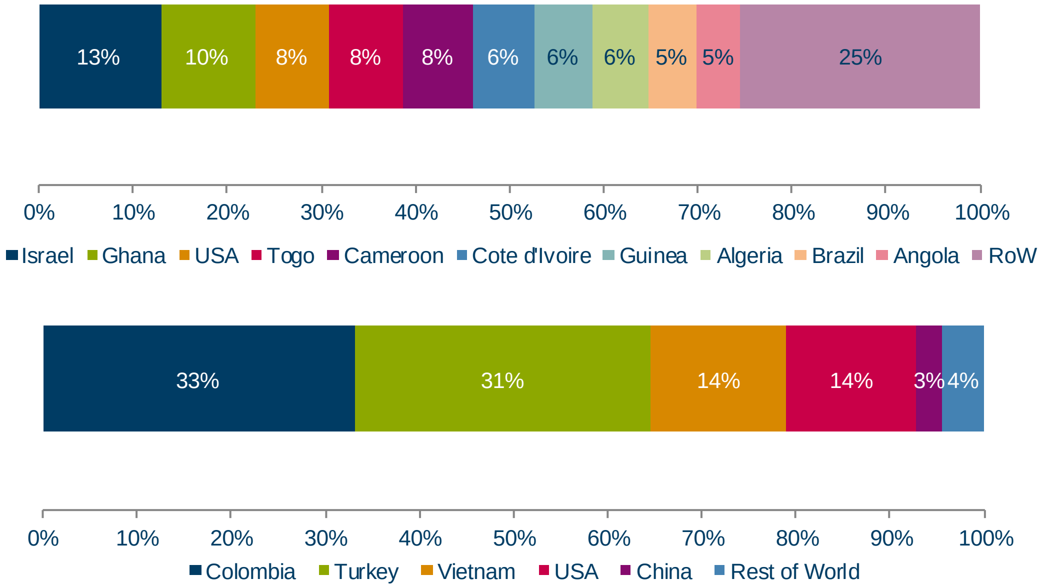
Source: Eurostat Comext, Ecorys calculations.

2.8.4 EU main international trade partners for cement clinker

The largest export destinations of cement clinker from the EU28 are shown in the figure below.

Israel, the USA and Brazil are the only countries that make it to the top 10 outside of the African continent. Import sources are much less diversified, with Colombia and Turkey accounting for two thirds of EU cement clinker imports.

Figure 39 Extra-EU export (upper panel) and import (lower panel) partners , 2015



Source: Eurostat Comext, Ecorys calculations.

The five largest export and import partners in 2015 are shown in the table below, this time with their absolute trade value reported. Especially Israel is an upcoming export market, as the export value was only €1.5 million in 2012.[57] The three African countries showed a substantial increase in export value after 2011.[58] The import patterns are much more stable.

Table 5 Largest export and import partners, 2015

Rank	Export destination	€ Million	Import source	Million EUR
1	Israel	55.2	Colombia	25.6
2	Ghana	42.8	Turkey	24.3
3	USA	34.0	Vietnam	11.1
4	Togo	32.9	USA	10.6
5	Cameroon	32.1	China	2.1
	Rest of the World	229.7	Rest of World	3.5

Box 10: Change in the Spanish cement clinker industry between 2006 and 2015

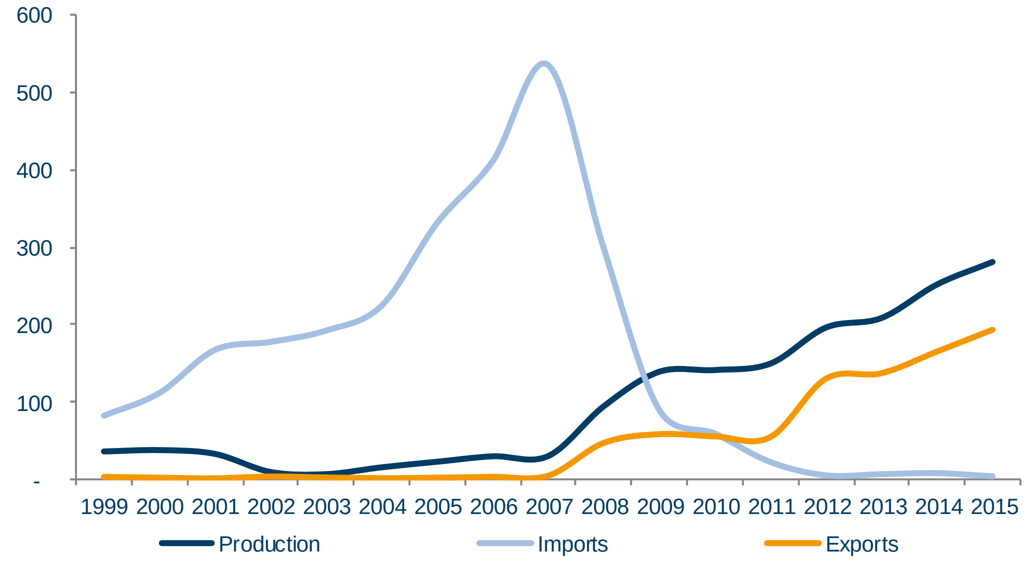
The production and total trade flows in cement clinker for Spain are depicted in the first figure below**.** Prior to the 2008 crisis (and the subsequent collapse of the Spanish construction sector), Spain recorded hardly any sold cement clinker production, while its imports reached a value of more than half a billion euros in 2007. Some two thirds of these imports came from China in the years 2006, 2007, and 2008. After 2011, exports started to increase rapidly and have kept pace with the growth of sold production. The Spanish exports performance can be related to the overcapacity that resulted after the collapse of the Spanish construction sector. The fact that Spanish cement clinker production capacity is predominantly located close to the coastline facilitated exports through shipping. Spanish

[57] In 2013 en 2014 the value increased to respectively €21million and €34 million.

[58] In 2011 their combined export value was €16 million; in 2012 this increased to €74 million and in 2015 it was €108 million.

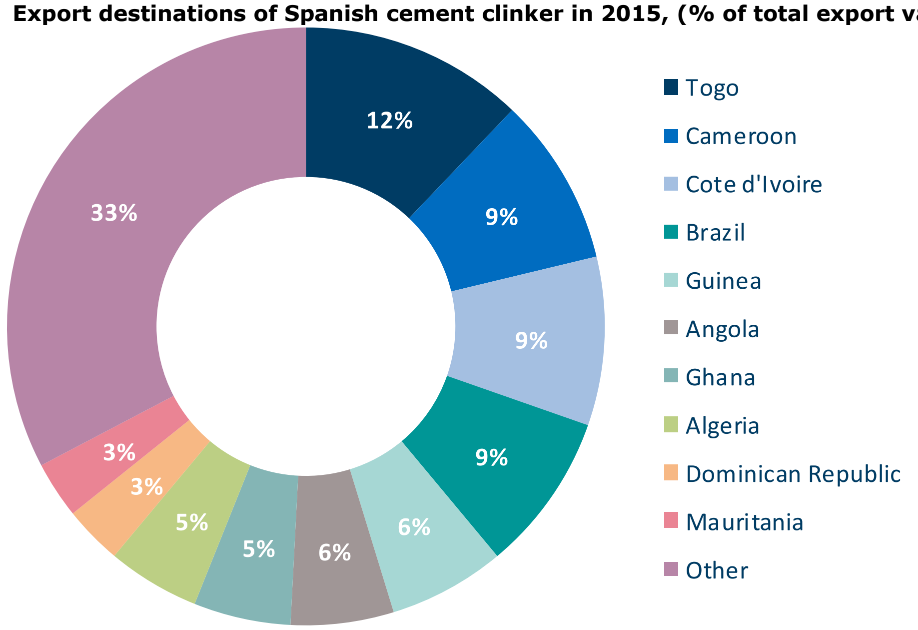
cement clinkers mainly found their way to non-EU partners. As shown in the second figure below, none of the 10 largest export partners of Spain in 2015 are EU MS. Eight of the ten largest export destinations are African countries, with Brazil and Dominican Republic making up the other top-10 export destinations.

Figure 40 Spanish cement clinker industry (in million EUR)



Source: Eurostat Comext (for trade flows) and Prodcom (for production), Ecorys calculations

Figure 41 Export destinations of Spanish cement clinker in 2015, (% of total export value)

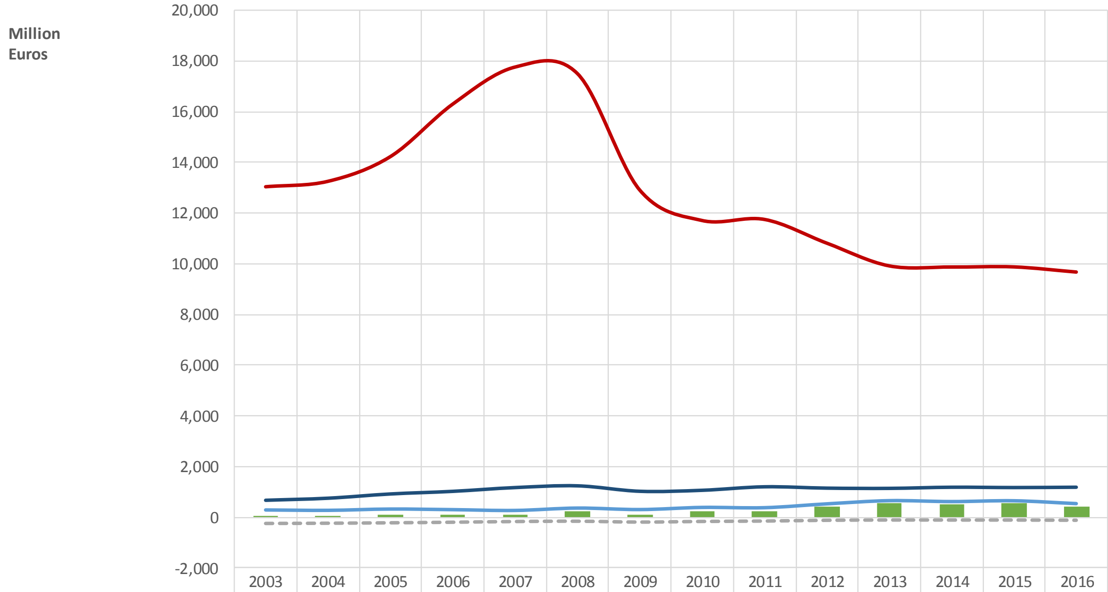


Source: Eurostat Comext, Ecorys calculations.

2.8.5 Portland* cement

The value of Portland* cement production[59] decreased drastically over the last decade, though it has been rather stable since 2013 at some €10 billion per year. Internal EU-trade, on the other hand, has been relatively stable at some 10% of the sold production, while extra-EU exports have been half that level. As there is hardly any import from non-EU countries, the trade balance with the rest of the world, the EU maintains a positive trade balance with the rest of the world

Figure 42 Trade pattern for Portland* cement, for EU28 (in € million)



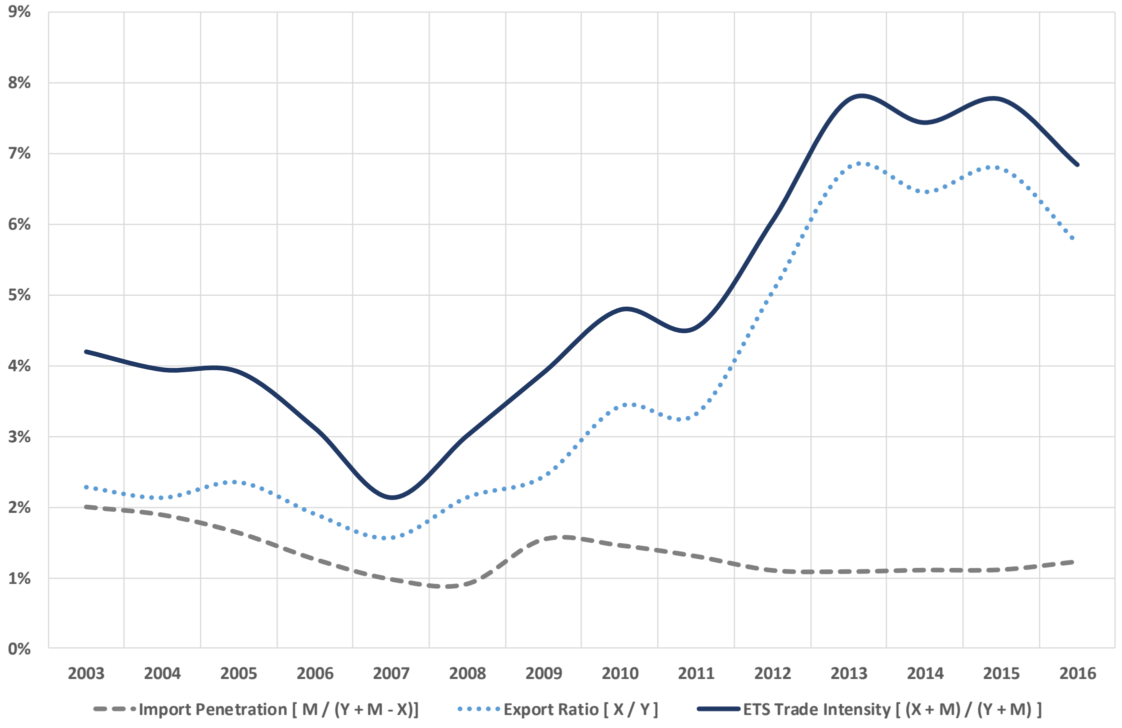
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU trade balance	38	34	104	107	107	217	117	235	241	432	575	535	568	443
Sold production	13,042	13,256	14,227	16,290	17,747	17,491	12,911	11,715	11,757	10,825	9,932	9,887	9,891	9,690
Intra-EU trade (exports)	685	764	926	1,027	1,171	1,238	1,029	1,067	1,201	1,150	1,141	1,184	1,172	1,185
Extra-EU export	298	283	335	311	279	375	315	402	391	546	676	639	672	556
Extra-EU [-] imports	-260	-250	-231	-204	-172	-158	-197	-167	-150	-115	-102	-103	-104	-113

Source: Eurostat Comext (for trade flows) and Prodcom (for production), Ecorys calculations

The figure below provide a picture of trade indicators for Portland* cement. Extra-EU trade intensity has increases from 2% in 2007 to nearly 8% in 2013 and 2015. This increase can be mainly attributed to increased exports to non-EU partners, as the export intensity increases in similar fashion. Imports remain at around 1% of apparent domestic consumption.

[59] The Eurostat Prodcom code 23511210 (and corresponding HS trade codes 25232100 and 25232900), referred to as 'Portland* cement', covers Portland cement (CEM I) and Portland composite cements (CEM II).

Figure 43 Extra-EU trade indicators for Portland* cement, EU28

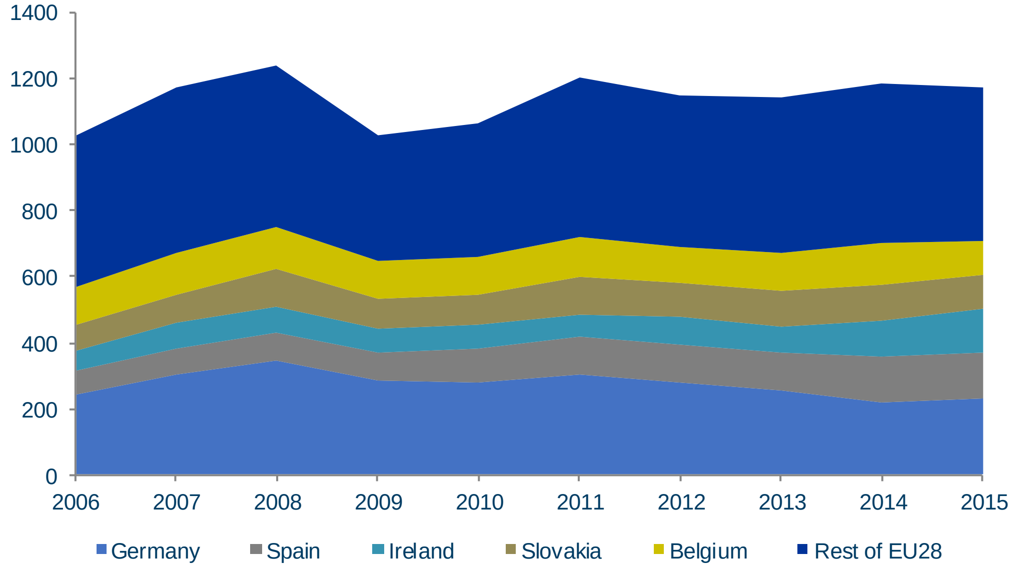


Source: Eurostat Comext (for trade flows) and Prodcom (for production), Ecorys calculations.

2.8.6 Export performance of cement

The intra-EU trade in Portland* cement is shown in the figure below. A comparison with the five largest producers (Spain, Italy, France, Poland, the UK) in the figure below, shows that only Spain is also an active trading nation in Portland* cement. In Italy, France, Poland and the UK, a large share of the national production appears to be consumed domestically. In terms of intra-EU shares, there are no marked patterns in terms of country shares and evolution that stand out.

Figure 44 Intra-EU exports in Portland* cement, per EUMS (in € million)

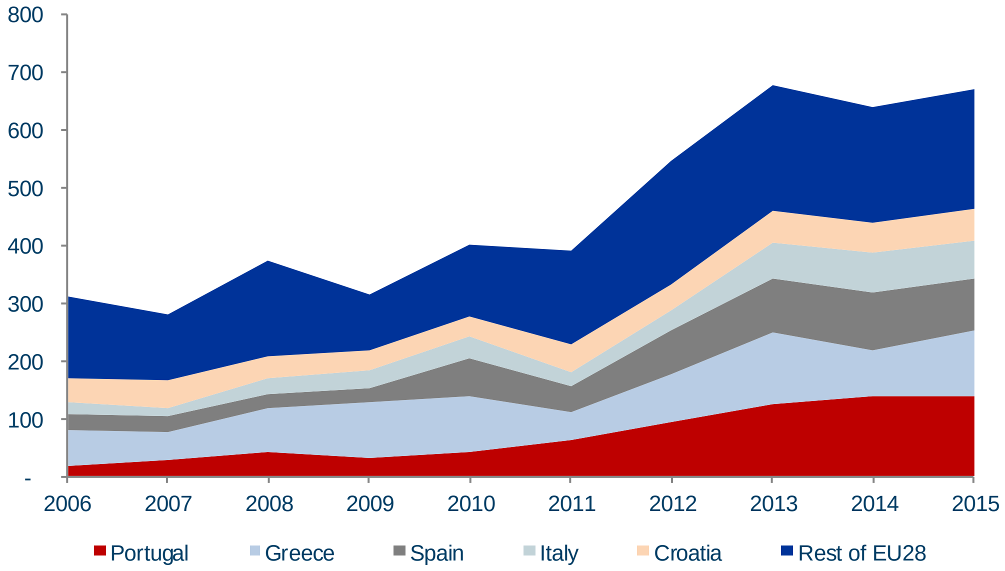


Source: Eurostat Comext, Ecorys calculations.

Trade to non-EU partners has been steadily increasing over time, from 2011 to 2015, extra-EU exports increased by almost 75%. Portugal, Greece and Italy are the main sources of this increase in exports. Croatia is the fifth largest exporter of Portland* cement, which is remarkable due to its economic size. It is therefore likely that the Portland* cement of Croatia is shipped across the border to their Balkan neighbours.

Concerning foreign direct investment, the most relevant element in a decision to invest is the potential for growth of consumption, while stable governance and a level playing field with local competitors are also desirable qualities of potential target areas. While smaller companies interviewed did not report significant FDI activities, larger ones already possess a diversified geographical portfolio, and are present in emerging markets offering favourable conditions (i.e. Africa, Asia, Latin America and the MENA region). Because of the decline in consumption of cement in Europe since the 2008 economic and financial crisis and the poor prospects for growth, the EU is not considered to be very attractive for investors, as other regions offer better return on capital.

Figure 45 Extra-EU exports in Portland* cement, per EUMS (in € million)

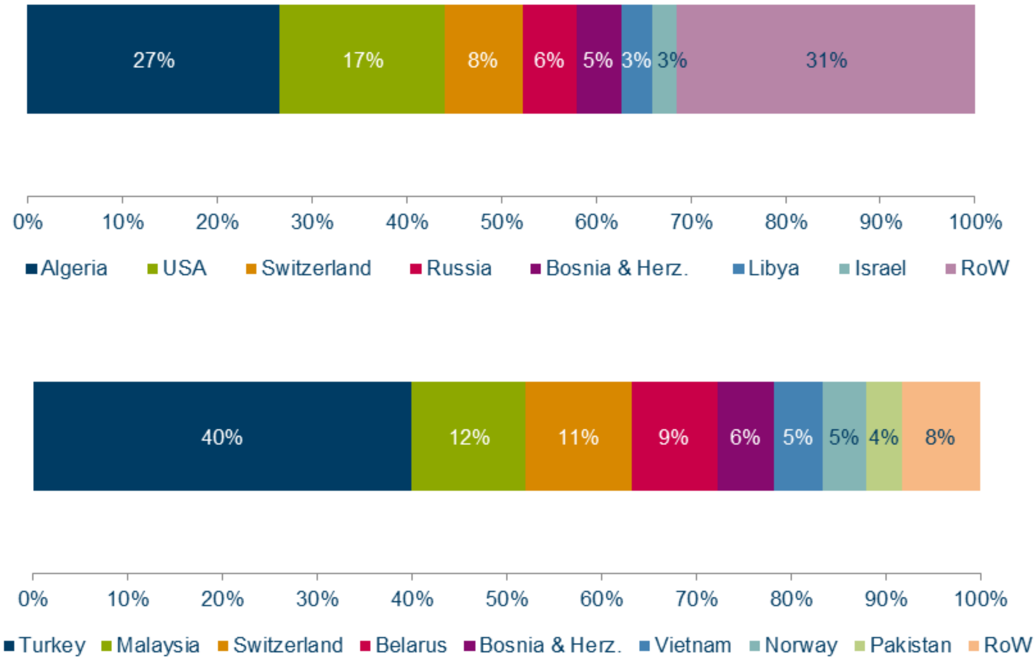


Source: Eurostat Comext, Ecorys calculations.

2.8.7 EU main international trade partners for cement

In 2015, Algeria is the main export destination, accounting for a little over a quarter of the total EU exports in Portland* cement. Other than second-placed USA, all countries in the top 10 border EU MS by land or sea. Imports are predominantly sourced from neighbouring Turkey and Switzerland (more than half of the imports).

Figure 46 Extra-EU export (upper panel) and import (lower panel) partners , 2015



Source: Eurostat Comext, Ecorys calculations.

Table 6 Largest export destinations

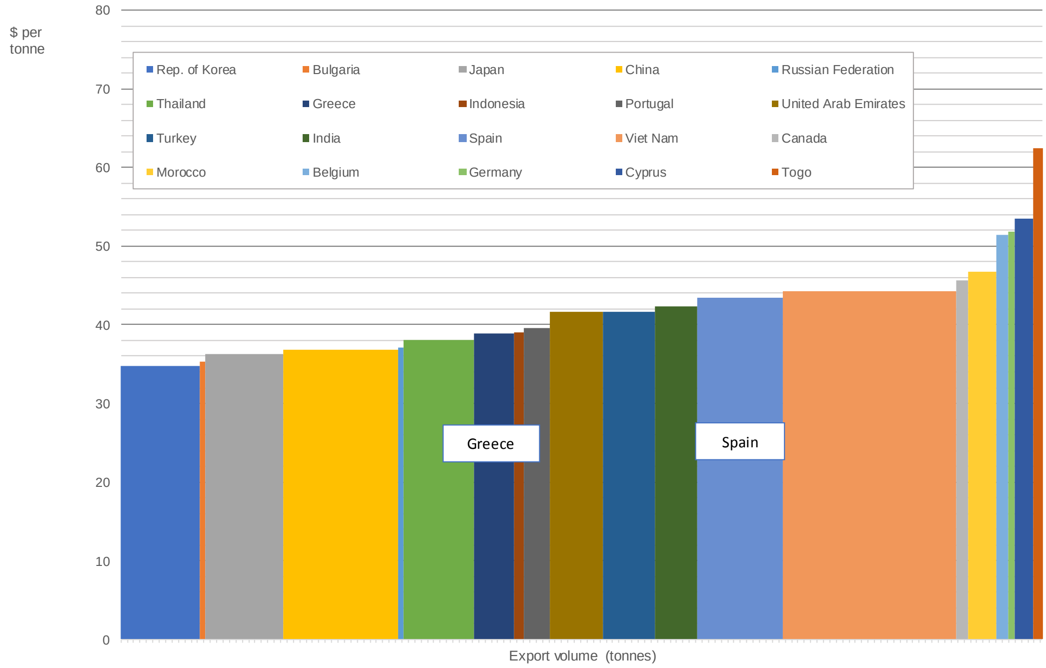
Rank	Export destination	€ Million		Import source	€ Million
1	Algeria	179.0		Turkey	41.5
2	USA	116.8		Malaysia	12.4
3	Switzerland	55.2		Switzerland	11.6
4	Russia	38.2		Belarus	9.4
5	Bosnia & Herz.	31.6		Bosnia & Herz.	6.2
	Rest of the World	251.0		Rest of the World	22.6

2.8.8 EU trade in a global perspective

Trade in clinker cement accounts for a relatively small proportion of total European cement clinker production but, nonetheless, has a combined trade value of some €600 million in 2015. Total global trade in 2015 amounted to roughly USD 2.5 billion, such that European producers accounted for a quarter of global trade. The largest 20 global exporters of cement clinker (in volume) in 2015 are represented in the figure below [60] These countries are responsible for almost 93% of total world exports (including intra-EU trade). Only two EU Member States make it to the top-10 list of largest exporters on the global scale (Spain – 3rd, and Greece – 10th). They find themselves in between Asian countries only. Expressed in unit value (USD per tonne), there is not much variation between the countries, with Togo being the exception – where cement clinker exports average over $ 60 a tonne.

[60] Countries are positioned according to the average unit value of their lime exports.

Figure 47: 20 largest global exporters of cement clinkers by weight – volume and average unit value of exports (2015)

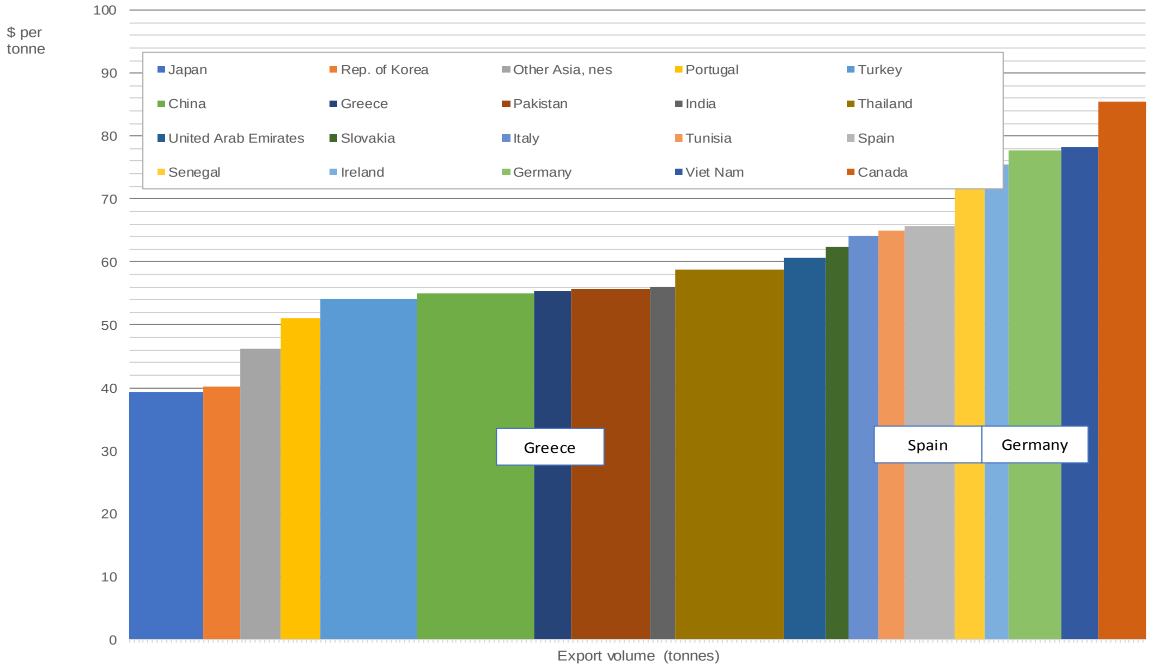


	KR	BG	JP	CN	RU	TH	GR	ID	PT	UE	TU	IN	ES	VN	CA	MO	BE	DE	CY	TG
Netweight (Mln tonne)	4.5	0.4	4.4	6.6	0.4	4.0	2.3	0.6	1.5	3.1	2.9	2.4	4.9	9.9	0.7	1.6	0.7	0.4	1.0	0.6
Trade Value (US$ million)	156	13	160	241	13	154	88	22	59	127	122	102	213	440	31	77	35	19	54	36
Unit Value ($ per tonne)	35	35	36	37	37	38	39	39	40	42	42	42	44	44	46	47	51	52	54	62

Source: Ecorys based on UN Comtrade

Portland* cement is a commodity that is traded in much larger volumes (both in terms of value and weight). Global trade amounts to USD 7 billion, of which a third is exported by the EU MS (including intra-EU trade). In terms of volume, however, exporters such as Thailand, China and Turkey are much larger than EU Member States.

Figure 48: 20 largest global exporters of Portland* cement by weight – volume and average unit value of exports (2015)



	JP	KR	OA	PT	TU	CN	GR	PA	IN	TH	UE	SK	IT	TU	ES	SN	IE	DE	VN	CA
Netweight (Mln tonne)	5.8	2.9	3.2	3.1	7.6	9.1	2.9	6.1	2.0	8.5	3.2	1.9	2.3	2.1	3.9	2.3	1.9	4.1	2.9	3.7
Trade Value (US$ million)	227	116	146	158	412	502	162	342	110	501	194	116	148	135	255	174	145	320	226	316
Unit Value ($ per tonne)	39	40	46	51	54	55	55	56	56	59	61	62	64	65	66	75	75	78	78	85

Source: Ecorys based on UN Comtrade

Box 11: Perceptions on trade vulnerability

Cement producers interviewed for the study feel that the EU market is quite vulnerable to imports from third countries. The cost impact of more stringent environmental and safety regulations, as well as higher production costs are viewed as the main factors having a negative effect on relative competitiveness, along with the long-term uncertainty stemming from the ETS. Coastal regions - especially in Southern Europe – are perceived to be the most threatened ones, but countries sharing a border with non-EU Member States are also exposed to foreign competition. According to interview responses, Turkey, Morocco, Algeria and Egypt seem to pose the biggest threat, but the potential reduction in demand for cement in China makes it another likely competitor. Changes in transport costs are among the most important factors in determining actual trade vulnerability. With regard to environmental and climate issues, Interviewees highlighted that EU-producers are in the lead with a lower environmental footprint as compared to other regions[61]. They tend to be more efficient (productive), and can build on higher and more reliable product quality. However, in competition with imports higher there exists no opportunity to set a price for sustainability.

[61] The most recent data from GNR on CO2 emissions confirms this. More information: http://www.wbcsdcement.org/GNR-2014/index.html

2.9 Product substitution

Product substitution is an important topic, and a highly relevant aspect for the competitiveness analysis of the sector. Product substitution can occur at three different stages of the cement supply chain. The first two – namely clinker and cement substitution – are part of the cement and concrete manufacturing process, and are aimed at reducing energy use and CO2 emissions resulting from the burning process. Both clinker and cement can be blended with various alternative materials. For instance, clinker can be replaced by fly ash in cement, while silica fume can be added to the concrete mix instead of cement (for more details and examples, see the section on R&D below). There is, however, a limit to the extent to which clinker and cement can be substituted, as the use of other constituents has an impact on the performance of concrete. The third stage means the replacement of concrete with other products. According to results from the interviews, cement producers believe wood and steel to be the primary competitors for concrete products in the construction sector, also mentioning bricks, asphalt, glass and aluminium.

As concrete is currently the most widely used construction material, it is nearly impossible to completely replace it with other materials. This is particularly so for civil engineering works (bridges, tunnels, etc.), as well as foundations. Concrete has a large number of advantages: it is relatively cheap, flexible, durable and resilient. It also has excellent thermal and noise dampening qualities, while its local availability makes it more accessible than some other materials. Nevertheless, concrete as a sustainable building material has been challenged due to its association with the CO_2 inherent in the production of cement, despite cement only accounting for 10-12% of the composition of most concrete. Interview respondents report that wood appears to be increasing its market share, partly because of the introduction of new policies favouring its use in some Member States, but also due to changes in lifestyle (wood being more popular) or new techniques making it possible to build better buildings also made out of other materials than concrete. Existing studies show different outcomes concerning LCAs depending on the methodology and scope of the study (see box below).

Box 13 LCAs relevant to the sector

The cement industry believes that the environmental footprint of construction materials should be evaluated on the basis of comprehensive life cycle assessments (LCAs) – a yardstick which leads however to some ambivalence. According to several papers from the cement and concrete industry, as well as a study[62] conducted by the Massachusetts Institute of Technology (MIT), life cycle emissions for concrete buildings are lower than emissions for wood or steel. The Boston Consulting Group's calculations, based on the MIT study, show this difference, which ranges from 3% to 8% in emissions. However, there are other studies which have reached a different conclusion. A paper[63] undertaking a life cycle assessment (LCA) for three office buildings with load bearing systems made of reinforced concrete, steel and timber did not find any of the techniques preferable only on the basis of LCA. A 2014 study[64] using an LCA for reinforced concrete and wooden structures demonstrate an overall better environmental performance of the latter, albeit with somewhat contradictory results in different impact categories. Although not all above studies have equal weight and authority, there appears to be still an insufficient evidence basis for drawing overarching conclusions about the performance of cement vis-à-vis other building materials on the basis of LCAs. Clearly, the number of variables in terms of building standards, applications and local contexts are

[62] Ochsendorf et al. (2011) Methods, Impacts, and Opportunities in the Concrete Building Life Cycle, MIT

[63] Passer et al. Life Cycle Assessment of buildings comparing structural steelwork with other construction techniques

[64] Guardigli (2014) Comparing the environmental impact of reinforced concrete and wooden structures, In: Eco-efficient Construction and Building Materials: Life Cycle Assessment (LCA), Eco-Labelling and Case Studies, F. Pacheco-torgal, L. Cabeza, J. Labrincha and A. De Magalhaes (ed.), pp. 407-433

sheer endless.

As sustainability is concerned the results of the studies shown in the box are ambiguous and provide no clear facts for policymakers to introduce new environmental regulation dedicated to support alternative building products.

Cement/concrete does not only compete with other building products, it also has complementarities with other types of building products. Steel is an important complementary product to concrete, especially in its use in reinforced concrete, while the industry also sees opportunities in combining concrete with glass-, carbon- and steel fibres. Furthermore, the use of 3D printing will allow much more flexible combinations with other building materials. Additives play a crucial (an increasingly important) role, as they can give various qualities to concrete, ensuring its workability, durability, etc.

2.10 Research, development and innovation in the cement industry

Research and innovation is present throughout the European cement and concrete supply chain and, according to several publications coming from industry associations, prioritises efforts to reduce the sector's environmental footprint. The European cement industry is claimed to be the second after North America in terms of R&D and innovation, but ahead of other regions. [65] The five areas for R&D activities commonly mentioned are resource and energy efficiency, carbon sequestration and reuse, product efficiency and downstream initiatives. The first three are mostly related to **production process innovation**, while the other two focus on **product innovation**.[66]

The industry founded in 2003 a platform to organise its research activities. The **European Cement Research Academy (ECRA)** consists of over 47 leading cement producers worldwide. Its aim is to accelerate and facilitate innovation. In their R&D activities, cement producers are typically engaged with universities, research institutes, customers, equipment suppliers and even start-ups. However, individual cement companies also invest in research and innovation.

Carbon sequestration and use is in the focus of several projects[67]:

- **CEMCAP** is a H2020 project of €10 million (with a €8.8 million contribution from the EU) which prepares the ground for large-scale implementation of CO2 capture in the European cement industry. The most important partner in the project is HeidelbergCement (and companies owned by it, namely Italcementi and Norcem);
- **LEILAC[68]** (Low Emissions Intensity Lime And Cement) is a European Union Horizon 2020 research and innovation project which aims to develop a carbon capture technology to enable a reduction in CO2 emissions for both the cement and lime industries without significant energy or capital penalty[69]. With a budget of €20.8 million (EU contribution €11.9 million) and a wide participation from both lime and cement companies (Lhoist, Heidelberg, Cemex, CRH) it is one of the most important innovation projects for both sectors. HeidelbergCement's Lixhe plant hosts the pilot project to demonstrate the potential for capturing 95% of process CO2 emissions;

[65] The Boston Consulting Group's paper for Cembureau estimates Europe's contribution to R&D in cement and concrete technology, measured as the number of references to each innovation cited in subsequent investigation works.

[66] Cembureau (2017) "Innovation in the Cement Industry"

[67] Other projects: CO2 for algae cultivation (CEMEX+HeidelbergCement), CO2 Capture by Calcium Looping (CEMEX), CO2Capture by Redesigning of Calciner (CEMEX), CO2 to methane or other transport fuels (HeidelbergCement)

[68] Also mentioned in the chapter on innovation in the lime sector

[69] Leilac, 2016, LEILAC Project Overview, https://www.sintef.no/contentassets/d0556618d34a4563a89e8e681f781419/3-presentation_adam_vincent.pdf

- HeidelbergCement's Norcem cooperates with ECRA to test different carbon capture technologies in its plant in **Brevik** (post-combustion technologies);
- LafargeHolcim's project, finished in 2014, tested oxy-combustion at the calciner.

Use of alternative fuels: According to a 2017 Ecofys publication on co-processing of waste in EU cement plants, alternative fuels represent as much as 41% of the fuel mix of the cement industry[70]. However, there are large differences between Member States concerning the current rate of alternative fuel use – ranging from just 7% in Greece to 65% in Germany – and future prospects as well. Much depends on the characteristics and age of the plants concerned, with newer plants allowing for higher rates of alternative fuels. Another paper by Ecofys[71] finds that there are examples which demonstrate that it is both economically and technologically feasible to increase this rate as high as 95%. There are, nevertheless, barriers to achieve this substitution rate, as it would require further investment from the industry. In addition, there are also market distortions in some of the Member States – such as the inclusion or non-inclusion of carbon price for different energy recovery options – which hinder uptake. Ecofys estimates that a 60% rate could be achievable in the medium term[72].

Clinker substitution is another way the industry intends to reduce process emissions resulting from cement production.

- **Nanocem** attracts wide participation from the industry: HeidelbergCement, LafargeHolcim, CRH, Cementir are taking part in it, as well as BASF and SIKA from the admixtures sector. Using advanced techniques like atomic force microscopy, X-ray diffraction and transmission electron microscopy, the research aims to gain a better understanding of concrete and to explore options for new replacement materials, as well as potential improvements in the use of existing ones;
- Project **Aether,** run by LafargeHolcim, received funding from LIFE+ (€2.3 million out of a total of €5.9 million), and its goal was to develop a new, innovative class of clinkers, with a lower environmental footprint. The project led to the development of a new generation of cement, which requires much less energy and a lower temperature in the kiln, while the performance characteristics are similar to that of Portland cement. The Aether project trials were successful and lead to a reduction of 25-30% during the production process[73].
- Another LIFE project is 'ECO TILES' that demonstrates the possibility to produce fully recycled (up to nearly 70%) pre-casted cement-based products (Terrazzo tiles) using recycled glass from urban and industrial waste, ceramic and Construction & Demolition Waste (CDW). The production will have a substantial lower (-20%) environmental impact than the production process of traditional tiles and achieves the manufacture of high-grade pre-casted products.

The sector also invests in **product innovation**. This includes new binder and concrete technologies, such as the following:

- **ECO-Binder** runs under H2020 and involves participants from the industry as well (Lafarge, HeidelbergCement, Vicat). Its purpose is to replace Ordinary Portland Cement (OPC) and OPC based concrete products with new, low-CO2 binders and to develop a new generation of concrete based construction materials with lower energy needs;
- R&D developments from other industries can also help the sector reduce its emissions. **Silica fume**, a by-product of the production of silicon metal or ferrosilicon alloys is a highly pozzolanic concrete additive, which can significantly enhance the mechanical properties of

[70] Ecofys (2017) Status and prospects of co-processing of waste in EU cement plants, p.4
[71] Ecofys (2016) Market opportunities for use of alternative fuels in cement plants across the EU
[72] Ecofys (2016), p. 31-32
[73] Aether project, funded by LIFE+. http://www.aether-cement.eu/

concrete. Research by the non-ferrous metal industry, driven by stringent national and EU regulations on dust emission limit values, resulted in filters capable of capturing 300 000 tonnes of dust in Europe every year. It is estimated that this could replace 600 000 tonnes of cement, leading to 341 400 – 454 800 tonnes of CO2 emission reduction.[74];

- Schwenk Zement's **Celitement** is a new hydraulic binder with up to 50% lower CO2 process emissions;
- Some examples for **innovative concrete products** are pervious concrete (allowing rainwater to penetrate the underlying soil), translucent concrete (transmits light through the structure) or high performance concrete (unique mechanical properties: mechanical strength, modulus of elasticity and durability;
- **C³** is a new material compound from carbon and concrete. The aim is to exchange corrodible reinforced concrete by carbon concrete. Since carbon does not rust and there is therefore no need to use additional concrete to protect steel from corroding, this can lead to a more efficient use of concrete.

The industry is also investing in research in construction waste management and concrete recycling. **ECO-CEMENT** was an FP7 funded project finished in 2015 aimed at reducing GHG emissions and construction waste. **C2CA**'s (another FP7 project) goal was to develop three innovative technologies for recycling end-of-life concrete.

In addition to the areas mentioned above, results from interviews suggest that cement producers are interested in the potential role of the Digital Agenda, Industry 4.0 (metadata, big data), performance based standards and 3D printing in cement and concrete production.

[74] Bipro and ICF, 2017, EU, processing of non-ferrous metals: Use of silica fume – development and use of a new product resulting from exhaust gas treatment

3 EU lime industry profile

3.1 Introduction

This chapter gives an overview of information, based primarily on publicly available statistical data, describing the structure, performance and development of the EU lime industry. The European lime industry is a provider of a key ingredient to a diverse range of products and applications. Lime is derived from limestone which is geographically present throughout Europe. When heated, limestone transforms into quicklime, which forms the basis of all lime products available on the market. Due to its particular chemical characteristics, lime is a fundamental raw material used for a multitude of industrial processes and different economic activities.

Manufacturers of lime can be categorised in two segments.

- Captive manufacturing undertaken by a dedicated end-user (e.g. a sugar plant) and where lime products do not enter the market; only limited data and information on the captive segment of the industry is available;
- Non-captive manufacturing, which is the segment of production that is covered by this study. Hereafter, unless otherwise stated, the **analysis in this chapter relates to non-captive manufacturing of lime.**

Unfortunately data are not available that would allow reliable estimation of the relative share of ‘captive’ and ‘non-captive’ shares of total lime production.

3.2 Product overview

3.2.1 Product categories

The main categories of lime products relevant for the analysis presented in this chapter are:

- **Quicklime**, which is produced by heating (calcining) materials containing calcium carbonate ($CaCO_3$), typically limestone, to release carbon dioxide (CO_2) and leave quicklime (CaO - calcium oxide);
- **Hydrated or Slaked Lime,** which is obtained when quicklime is mixed (slaked) with water to produce calcium hydroxide ($Ca(OH)_2$)[75];
- **Hydraulic Lime,** which is a general term for varieties of quicklime or slaked lime used to make lime mortars which set through hydration (i.e. hardens when in contact with water)[76].

Other products that may be referred to in this chapter are:

- **Dolime** (CaO.MgO), which is produced by calcining dolomitic limestone ($CaMg(CO_3)_2$), also called dolomite, a limestone containing a certain proportion of magnesium;
- **Milk of lime (Lime milk)**, which is a suspension of hydrated lime in water;
- **Lime putty**, which is a hydrated lime which has been slaked with sufficient water to form – possibly after evaporation – a thick paste.

[75] Quicklime is not stable and will revert to calcium carbonate as it reacts with CO_2 in the air unless slaked/hydrated with water.

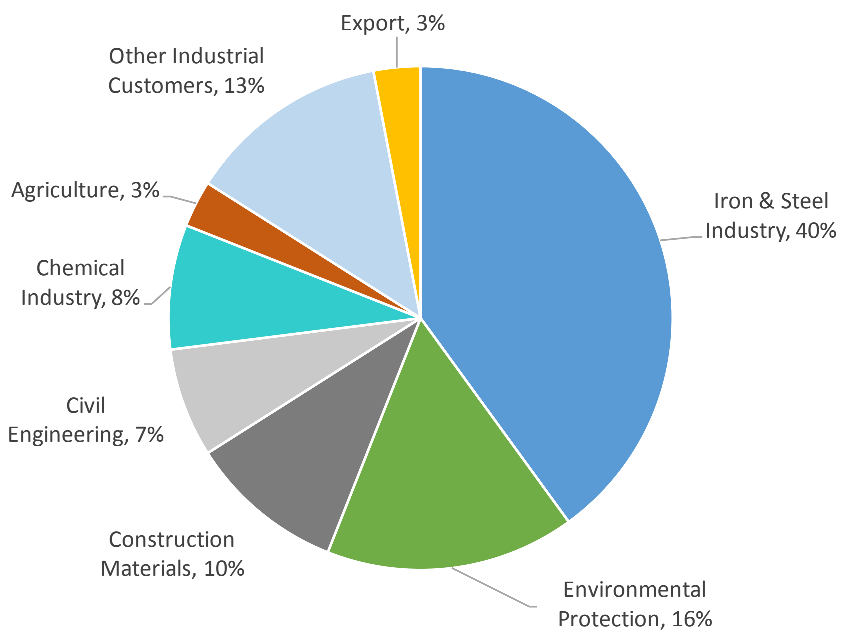
[76] Hydraulic limes can be classified as natural or artificial. Natural hydraulic lime does not require other materials to be added to limestone to create hydraulicity, Artificial hydraulic lime is created by adding hydraulic and/or pozzolan materials either before or after burning in a lime kiln; added materials include Portland cement, blast furnace slag, fly ash, and limestone filler.

3.2.2 Product applications and markets[77]

Lime products have a wide range of industrial applications across multiple sectors, as shown in the figure below. Examples include:

- **Iron & steel.** The Iron and Steel industry is the most important customer for lime products, where quicklime and dolime are used as flux to remove impurities – aluminates, phosphorus, silicates, sulphur, etc.;
- **Environmental protection.** Lime products are used in *water treatment* to remove impurities, adjust pH levels and water hardness, eliminate undesirable organic matters and metallic trace elements. Lime is used in *flue gas treatment* to capture SO2 and other acid gases and other harmful elements (e.g. mercury and dioxins / furans), notably for flue gas desulphurisation in power plants, waste incineration plants and industrial plants. Lime is also used for the neutralisation of effluent in sewage treatment plants, the treatment of effluent and sludge, and remediation of contaminated sites;
- **Construction & civil engineering.** Lime products are used extensively as a filler and bonding agents in building materials; e.g. lime based mortars and sand lime bricks have good thermal and acoustic insulation capabilities. Lime products are also important for soil stabilisation and as an additive to asphalt for road surfacing;
- **Chemical industry.** Lime is used as a neutralising agent (chemical base) in the petrochemical, cosmetics, pharmaceutical, animal feed and tanning industries. High purity lime is the base for the manufacture of Precipitated Calcium Carbonate (PCC) used in paints and PVC components. Calcium carbide, created by reacting lime with carbon, is used in the production of welding gas, and pig iron and steel as well as in agriculture and chemicals;
- **Agriculture.** Lime products are used in different mixtures to correct soil acidity and as part of fertilisers to add nutrients.

Figure 49 Breakdown of lime customer markets (2014)



Source: EuLA (2016)[78]

[77] Sources: EuLA (2014) A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe (Lime Roadmap), p. 7-8; EuLA (2014): Lime factsheet, p. 1-2; Ecofys: A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe (Lime Roadmap) – Presentation, 2014, http://www.eula.eu/documents/competitive-and-efficient-lime-industry-cornerstone-sustainable-europe-lime-roadmap, accessed March 2017.

[78] EuLA (2016), Activity Report 2015-2016, p. 7

Box 12: Lime product substitutes

Industry representatives interviewed for this study have indicated that there is only limited scope to replace lime with substitute products. This is especially true for steel production, the largest market segment for lime products. Nonetheless, there are possibilities for competition in specific markets; for example, from chemical products in the environmental market, from crude limestone and dolomite in agriculture, from kaolin-based products in papermills, etc. In the construction sector – especially with regards to building materials – cement is a competing product, currently favoured over the more traditional lime mortars, mostly because of its quick setting time.[79]

Generally, the lime industry is more concerned about the possible disappearance of certain market segments than competition from other products. In particular, the potential relocation of steel production to locations outside of the EU and replacement of European production by imported steel, which would have severe repercussions for the lime sector, is a major concern. A more positive perspective is offered by the shift to a circular economy and increasing demand for environmental applications – especially for water and flue gas treatment – that create new opportunities for the lime industry. There are also several applications where lime is combined with other types of products to increase efficiency or quality. For instance, lime can be combined with fly ash, cement or slag for soil stabilisation or in mortars, and is used with nitrogen, phosphorus and potassium (NPK) fertilisers to improve nutrient uptake.

3.2.3 Production Process

Lime is derived from naturally occurring limestone, almost entirely composed of calcium carbonate ($CaCO_3$)[80]. The lime production process is a complex operation consisting of various stages, typically these are:

- **Extraction.** The first phase of the process begins at the limestone quarry. After the removal of the upper layers of earth, vegetation or rock – referred to as the overburden – limestone is extracted through blasting. Dislodged rock is then loaded onto dumpers by excavators and transported to crushers;
- **Processing.** Crushers use compression and impact to break the rocks. Depending on the type of kiln used, rock is separated based on its size. For instance, the bigger ones go to shaft kilns, whereas the smaller are calcinated in rotary kilns[81]. Some of the stone may be washed to remove any remaining clay particles. The stone, once crushed, is taken to the kilns by conveyors;
- **Calcination.** The lime burning process – or calcination – takes place in the kiln and requires sufficient heat to decompose limestone and to form quicklime (calcium oxide). This reaction takes place at 900 °C, but temperatures around 1000 °C are usually used to speed up the process;
- **Additional Processing.** After calcination in the kiln, lime still requires additional processing. Lime refining is undertaken to deliver differentiated end products and at ensuring that they fit the quality and property requirements for specific application fields. Additional processing might include crushing or the use of ball mills or high-pressure mills.[82] Quicklime can also be

[79] On the other hand, lime has several advantages, for instance its resistance to cracking and its plasticity. Lime-based mortars might also have a bigger role in the future because their recyclability.; Naktode et al. (2014) Evaluation of Lime for Use in Mortar, p. 70

[80] EuLA (2017) What is air lime?, http://www.eula.eu/sites/default/files/publications/files/What%20is%20lime_EN_2xA4_2016%2006%2028%20a-1.pdf, p.2

[81] EuLA website, Production, http://www.eula.eu/production

[82] EuLA (2014) Competitive and Efficient Lime Industry, p.15, Llhoist website, From quarry to customer, http://www.lhoist.com/quarry-customer

reacted with water to form slaked or hydrated lime, which can be supplied as fine dry powder, a thick paste called lime putty, or a liquid suspension known as milk of lime[83].

Box 13: Potential for improved energy efficiency of lime production

EuLA's Lime Roadmap estimates the potential for future improvements to the energy efficiency of lime production process. The paper concluded that there is only a limited potential for energy efficiency improvements, due to the inherent need to produce enough heat for calcination to take place and the fact that current lime kilns operate close to the thermodynamic minimum (i.e. the minimum energy necessary to achieve calcination given the characteristics of the production system). The sector expects to achieve an 8% reduction in fuel intensity by 2030, while full implementation of existing technologies combined with future innovations could lead to a reduction of 16% by 2050 [84].

3.2.4 Supply chain

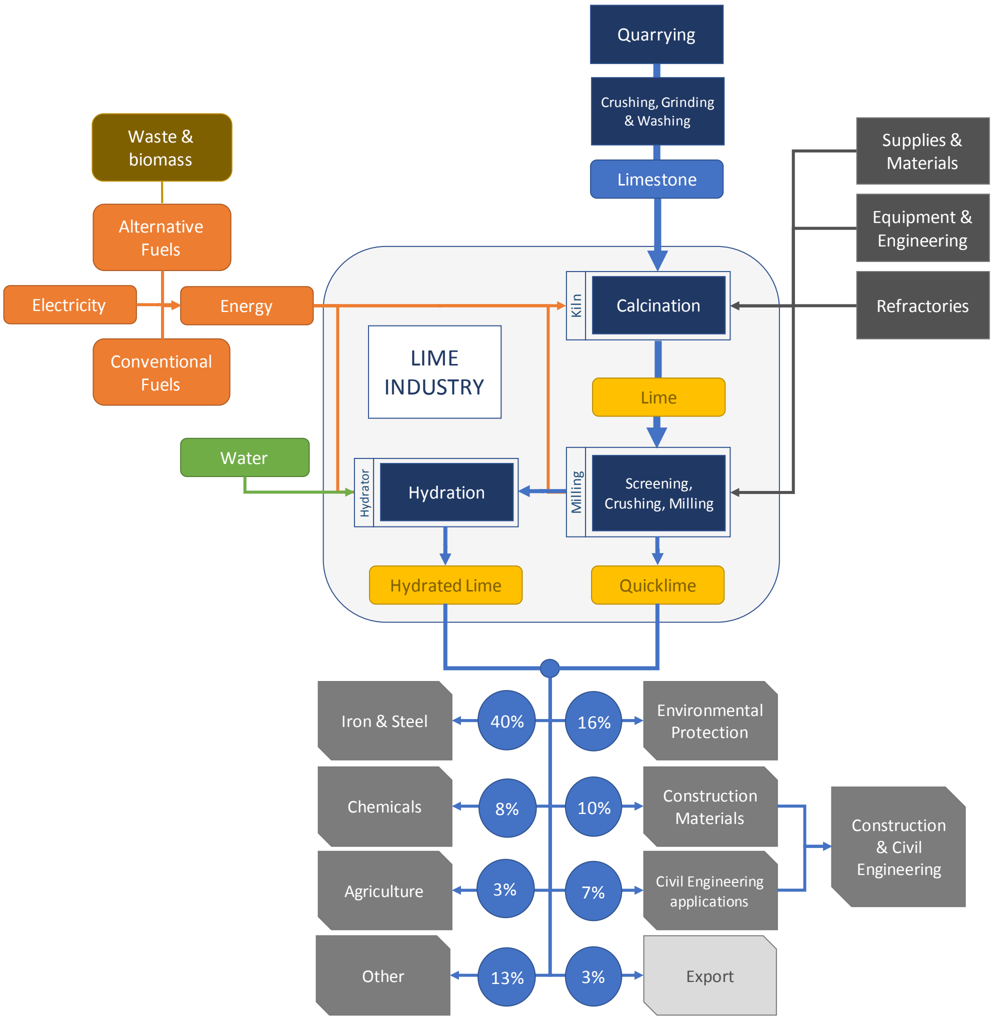
The figure below offers a simplified representation of the supply chain for lime products. In most cases, quarrying and lime production activities are integrated, with production plants situated close to quarrying sites. Typically lime producers will own the quarrying site, although quarrying activities may be contracted out to a separate specialist company. For historical reasons, in some Central and Eastern European countries, the quarry may be owned by another company, requiring lime manufacturers to purchase their raw material or to buy a license to acquire access.[85] The quality of available raw material together with the specific requirements of downstream clients, influence the types of final lime products that are produced.[86]

To minimise transport costs, lime production sites are situated close to sources of raw material (i.e. limestone quarries). The business case for proximity of production to quarrying is reinforced by the significant weight reduction that occurs during the lime production process.[87] Even for final products, their low value to weight ratio combined with high costs of transport mean that most final products are delivered within a distance of less than 200km.[88] Proximity to downstream clients is, therefore, a factor influencing the location of production sites. Equally, transport costs costs can act as a barrier that strongly influence the geographical scope of competition, whether at a local level or in terms of international trade in lime products.

Lime production is highly energy intensive, while carbon dioxide (CO2) is an inevitable by-product of the calcination process. Together, these characteristics help explain the sensitivity of the sector to conditions affecting energy supply and emissions (not only CO2). In contrast to cement production processes, lime production has limited flexibility in use of alternative fuels, due to the impact of energy sources on the purity and cleanness of final products.

[83] EuLA (2017)
[84] EuLA (2014), A competitive an deficient lime industry (Lime Roadmap 2015)
[85] It was common in these countries to have cement and lime factories under one umbrella. After the fall of communist regimes, quarries were mainly allocated to the larger cement factories. The still existing lime manufacturers hence had to acquire licenses from the owners to still access the quarries.
[86] Based on interviews with EuLA and national lime associations.
[87] Quicklime is much less dense than limestone. The removal of carbon dioxide during calcination results in a (theoretical minimum) weigh reduction of 43-44%.
[88] Based on interviews with EuLA and national lime associations.

Figure 50: Illustrative supply chain of the lime industry



Source: Ecorys; market breakdown based on EuLA (2016)[89]

Box 14: Vertical integration of European Lime manufacturing enterprises

A secure supply of raw materials (e.g. limestone) is essential for lime production, which is why lime manufacturers usually integrate upstream quarrying activities[90] and also why they may also be involved in the supply of limestone and aggregates. Conversely, it is unusual for non-captive lime manufacturers to integrate downstream production activities. Some lime manufacturers do, however, use the provision of support and advisory services to customers as a means to increase their influence over downstream markets. Conversely, some downstream market segments that require large and secure supplies of lime products, such as steel plants, may integrate lime production facilities within their activities.[91] Unfortunately data are not available that would allow to estimate the relative share of 'captive' and 'non-captive' shares of total lime production.

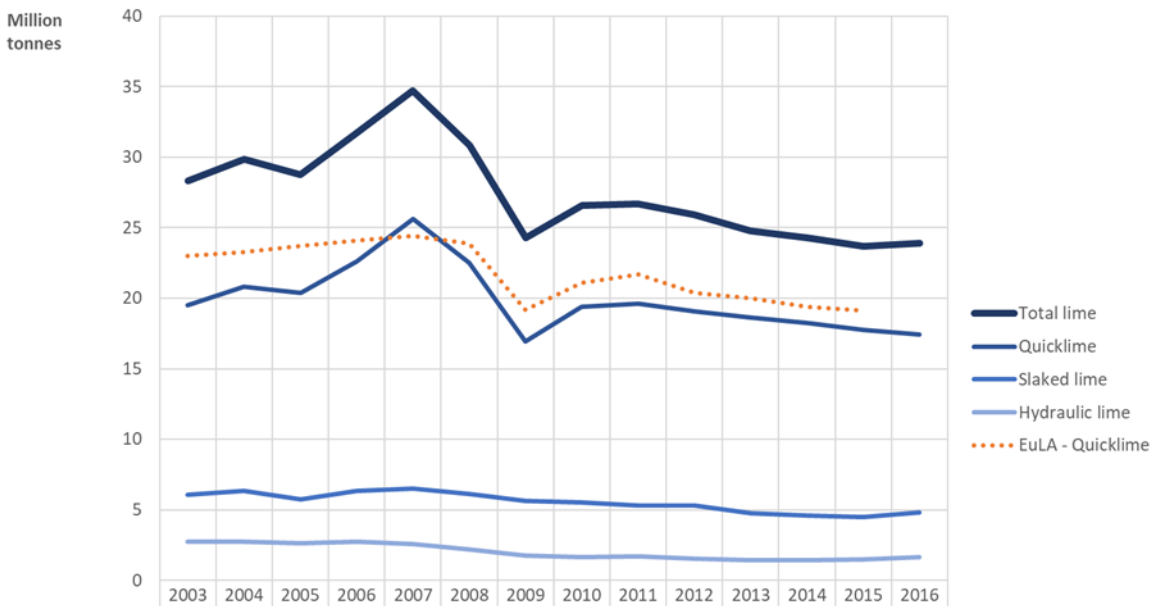
[89] EuLA (2016), Activity Report 2015-2016, p. 7
[90] According to information obtained from industry associations and company interviews; there is, however, some variation in the extent to which lime producers have integrated quarries in their activities depending on the region. For example, there is a lower level of vertical integration in Central and Eastern Europe due to historical reasons.
[91] According to information obtained from industry associations and company interviews.

3.3 Production profile

3.3.1 Time profile of EU lime production

Eurostat production data indicate that EU28 total production of lime products amounted to an estimated 23.9 million tonnes in 2016, with a value of € 2.0 billion[92]. These amounts compare with a peak production volume of 34.7 million tonnes in 2007 and sales value of € 2.4 billion in 2008; see figures below. Within these totals, quicklime accounts for three-quarters (75%) of total sales volumes and values in 2016, slaked lime accounts for a further fifth (20%) of sales, and hydraulic lime around 5%. Eurostat production estimates are broadly comparable with European Lime Association (EuLA) data, which show quicklime production by the Association’s members of just below 19 million tonnes in 2015; as the EuLA membership does not correspond to EU28 and, as EuLA is not permitted to provide country level data, a direct comparison with Eurostat data is not possible[93].

Figure 51: EU28 lime – quantity of sold production 2003-2016



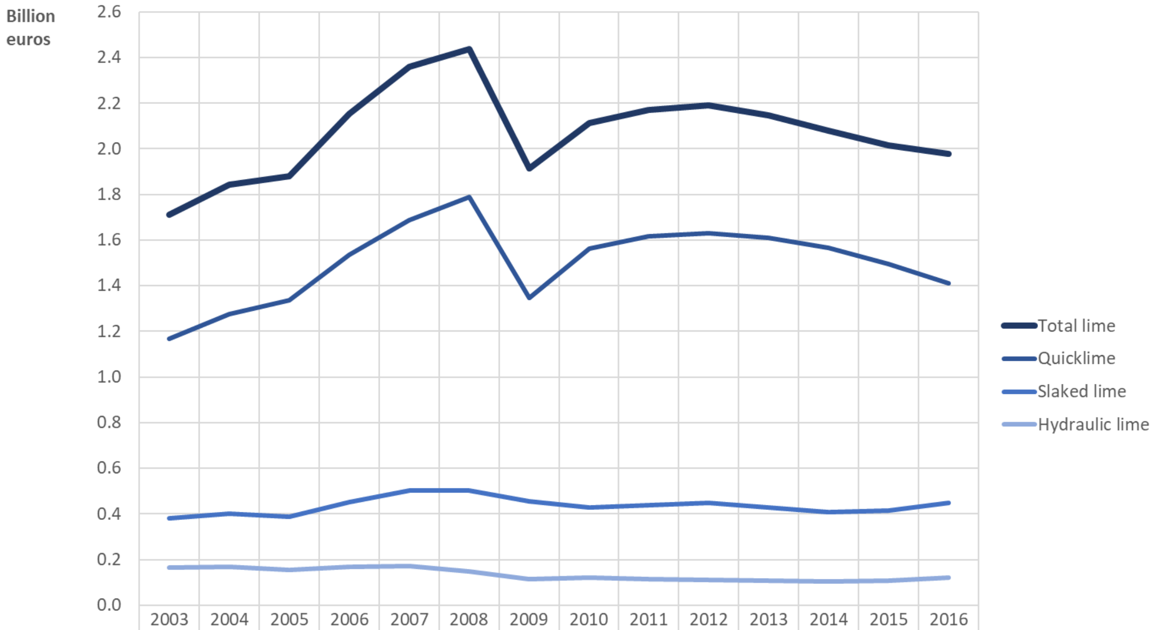
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total lime	28.3	29.9	28.7	31.7	34.7	30.9	24.3	26.6	26.7	25.9	24.8	24.3	23.7	23.9
Quicklime	19.5	20.8	20.4	22.6	25.6	22.5	16.9	19.4	19.6	19.1	18.6	18.2	17.7	17.4
Slaked lime	6.1	6.3	5.7	6.3	6.5	6.1	5.6	5.5	5.3	5.3	4.7	4.6	4.5	4.8
Hydraulic lime	2.8	2.7	2.6	2.8	2.6	2.2	1.7	1.7	1.7	1.5	1.4	1.4	1.5	1.7
EuLA - Quicklime	23.0	23.3	23.7	24.1	24.4	23.9	19.2	21.1	21.7	20.4	20.0	19.4	19.1	

Source: Ecorys based on Eurostat Prodcom and EuLA.

[92] Prodcom values are based on the ex-work selling price. The ex-works price should include charges only up to the seller's factory or premises. All further charges, such as delivery, distribution, and commissions, should not be reflected in the ex-works price.

[93] EuLA membership covers 19 EU Member States (AT, BE, BG, CZ, DE, DK, EE, EL, ES, HU, IE, IT, FI, FR, PL, PT, SE, SK, UK) and 2 non-EU countries (CH, NO).EuLA estimates that its members are responsible for 95% on non-captive lime production in Europe. For 2011, the Association estimated that its members made a contribution to GDP of € 2.5 billion.

Figure 52: EU28 lime – value of sold production 2003-2016



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total lime	1.71	1.84	1.88	2.15	2.36	2.44	1.91	2.11	2.17	2.19	2.15	2.08	2.02	1.98
Quicklime	1.17	1.28	1.34	1.54	1.69	1.79	1.35	1.56	1.62	1.63	1.61	1.57	1.49	1.41
Slaked lime	0.38	0.40	0.39	0.45	0.50	0.50	0.45	0.43	0.44	0.45	0.43	0.41	0.41	0.45
Hydraulic lime	0.16	0.17	0.16	0.17	0.17	0.15	0.11	0.12	0.11	0.11	0.11	0.10	0.11	0.12

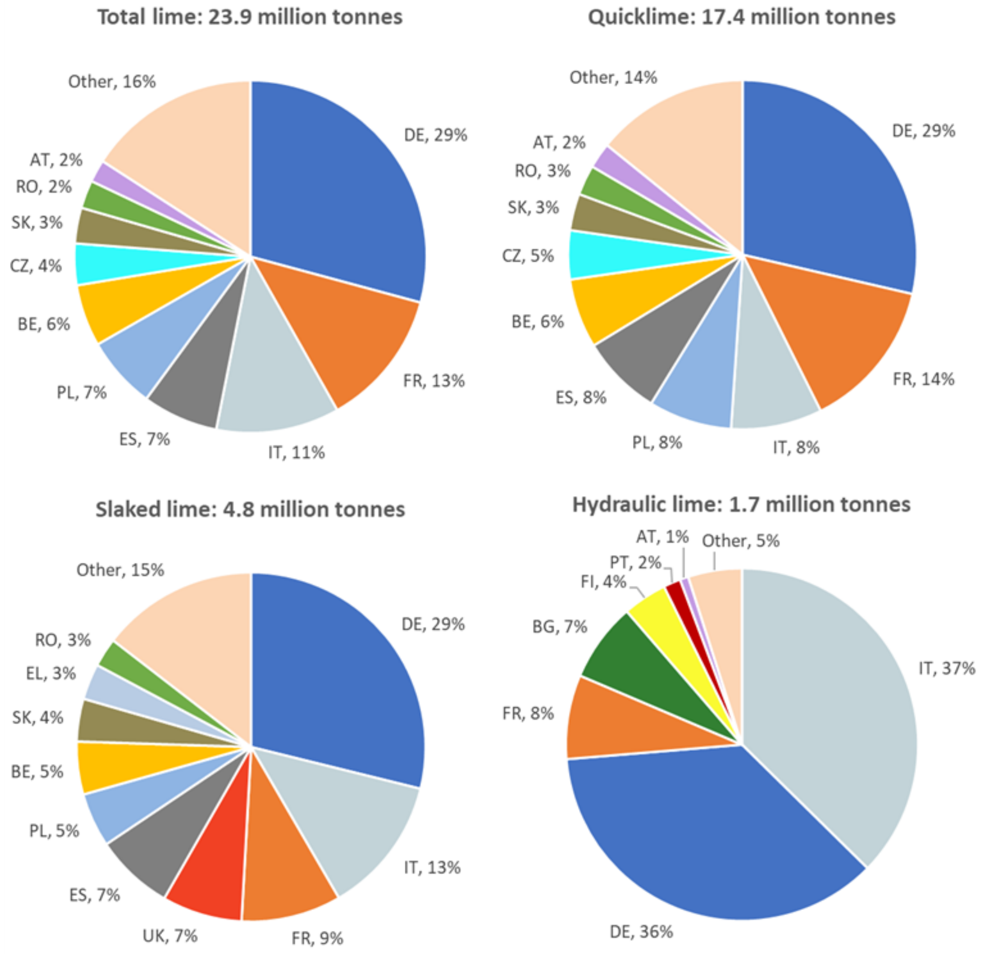
Source: Ecorys based on Eurostat Prodcom

3.3.2 Geographical profile of EU lime production

In terms of the geographical distribution of lime production, as shown in the figure below, the largest EU producer is Germany (29% of total lime production by weight), followed by France, Italy, Spain, Poland, and Belgium). The Eurostat database does not contain full production data for the UK, but national sources place it as the next largest producer with a share of around 5% of total EU lime production[94].

[94] Mineral Products Association, "*The Mineral Products Industry at a Glance*" (2016 Edition) indicates UK sales of lime in 2015 of 1.2 million tonnes. http://www.mineralproducts.org/documents/Mineral_Products_Industry_At_A_Glance_2016.pdf

Figure 53: EU28 Lime sold production quantity - breakdown by type and country in 2016



Notes:

a. Zero sold production of 'Quicklime' indicated for CY, LU, MT, NL;
b. Data for 'Quicklime' unavailable for HU, IE, LV, SI, UK;
c. Zero sold production of 'Slaked lime' indicated for CY, EE, LU, LV, MT, NL;
d. Data for 'Slaked lime' unavailable for HU, IE, PL, PT, SE, SI;
e. Zero sold production of 'Hydraulic lime' indicated for BE, CY, DK, EE, EL, HR, HU, LT, LU, LV, MT, NL, RO, SE, SI, SK;
f. Data for 'Hydraulic lime' unavailable for CZ, ES, IE, PL, UK;

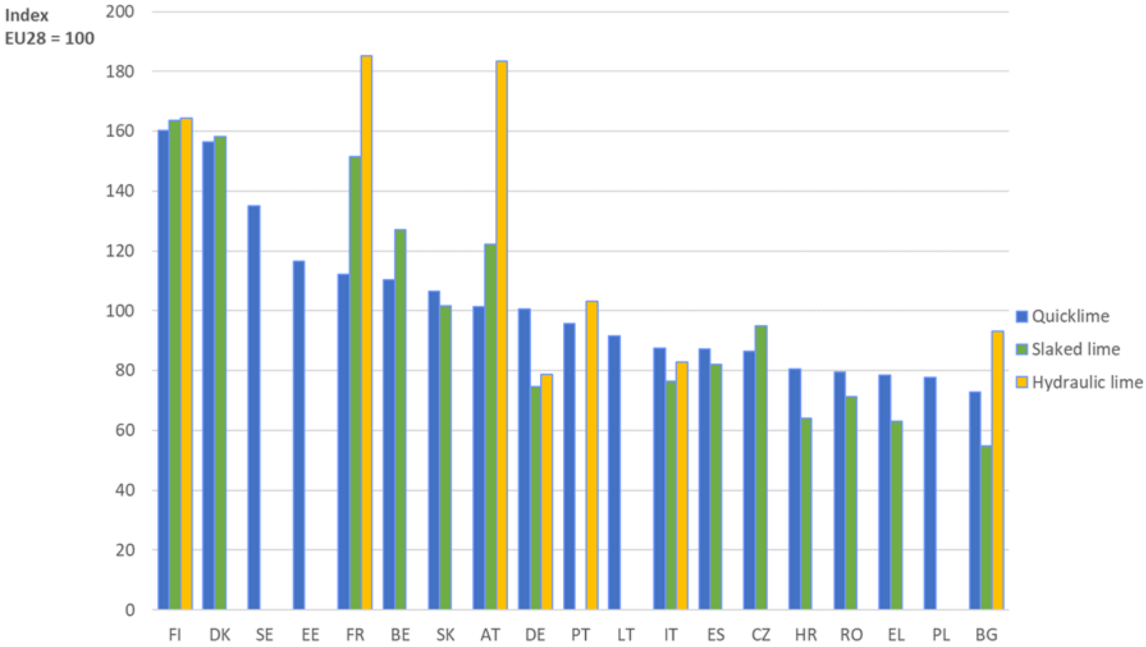
Source: Ecorys based on Eurostat Prodcom

3.3.3 Price (unit value) profile of EU lime production

Data on the price of lime products are not available from industry sources and, accordingly, it is necessary to rely on public data. Estimates of unit values of lime products based on Eurostat data – which can be interpreted as an indicator of average factory gate prices[95] – show considerable variation across Europe; as shown in the figures below. Unit values are typically highest in northern EU Member States (i.e. Scandinavia and Baltic States) than in more southern countries. In the case of quicklime, the average unit value in Finland is virtually double the unit values from the south east of the EU (i.e. Bulgaria, Croatia, Greece, Romania).

[95] Prodcom values are based on the ex-work selling price. The ex-works price should include charges only up to the seller's factory or premises. All further charges, such as delivery, distribution, and commissions, should not be reflected in the ex-works price.

Figure 54: EU28 lime sold production - average unit value per tonne by country in 2016 (index, EU28=100)

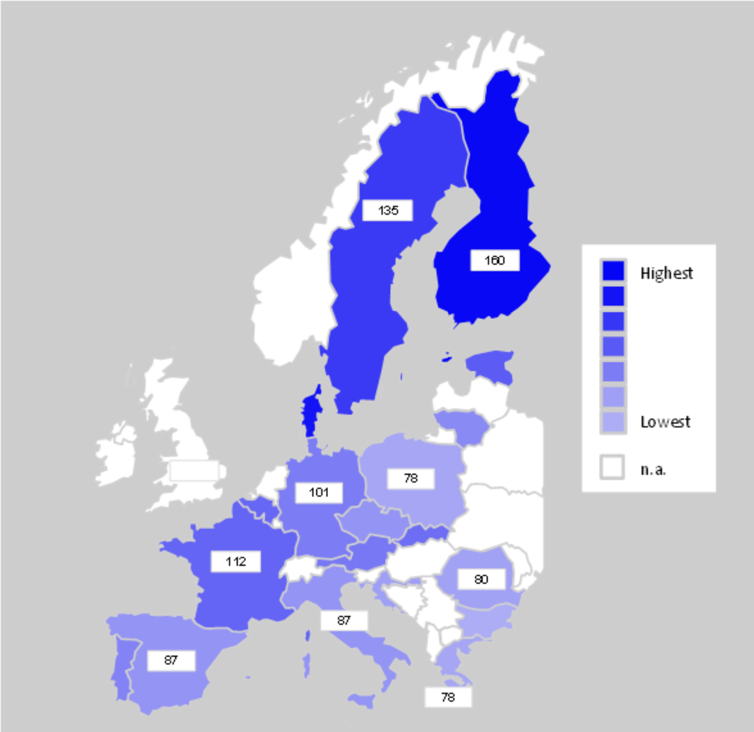


Notes:

a. Zero sold production of 'Quicklime' indicated for CY, LU, MT, NL;
b. Data for 'Quicklime' unavailable for HU, IE, LV, SI, UK;
c. Data for 'Quicklime' SE refers to 2015
d. Zero sold production of 'Slaked lime' indicated for CY, EE, LU, LV, MT, NL;
e. Data for 'Slaked lime' unavailable for HU, IE, PL, PT, SE, SI;
f. Zero sold production of 'Hydraulic lime' indicated for BE, CY, DK, EE, EL, HR, HU, LT, LU, LV, MT, NL, RO, SE, SI, SK;
g. Data for 'Hydraulic lime' unavailable for CZ, ES, IE, PL, UK.

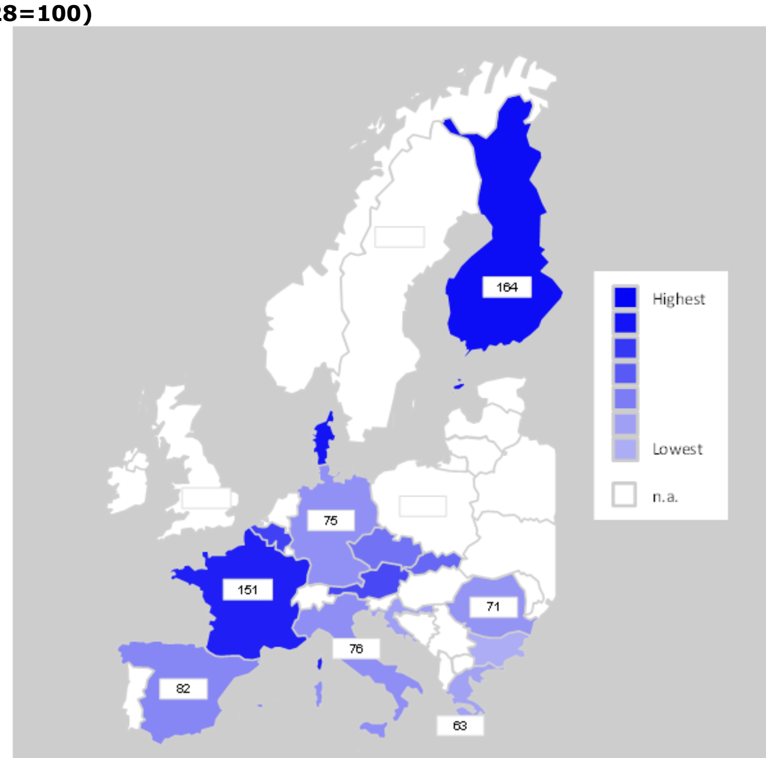
Source: Ecorys based on Eurostat Prodcom

Figure 55: EU28 quicklime sold production – mapping of average unit values in 2016 (index, EU28=100)



Source: Ecorys based on Eurostat Prodcom

Figure 56: EU28 slaked lime sold production – mapping of average unit values in 2016 (index, EU28=100)



Source: Ecorys based on Eurostat Prodcom

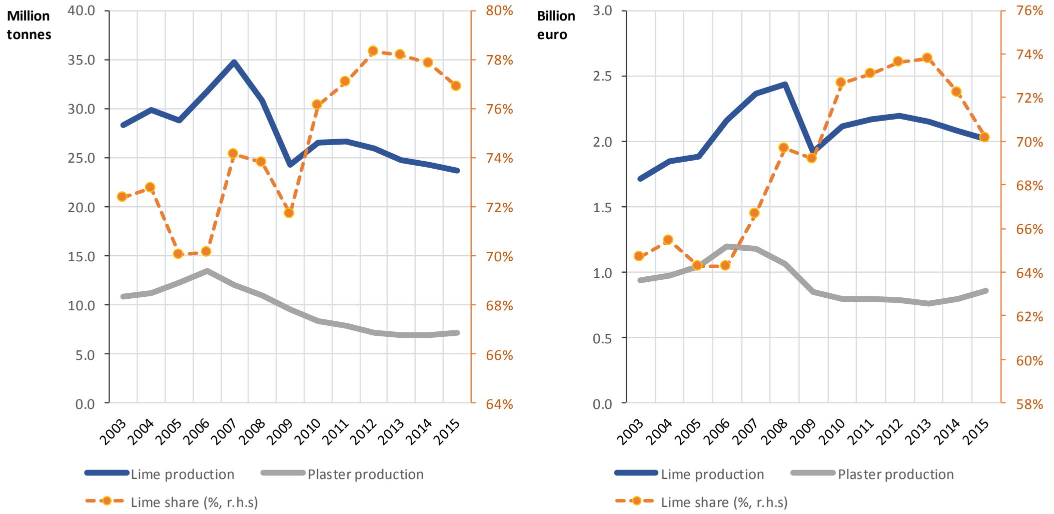
3.4 Size, structure and performance of the EU lime and plaster manufacturing industry

3.4.1 Comment on available structural business statistics

Eurostat's Structural Business Statistics (SBS) database does not allow for a separation between lime and plaster manufacturing, which are combined under the NACE 2 class 23.52 (Manufacture of lime and plaster)[96]. Consequently, in the absence of data specific to the lime industry, the following subsections present and describe data for combined lime and plaster manufacturing activities. As such, these data are only partially indicative of the structure and performance of the lime industry, as they are obviously also influenced by the part of plaster in the combined lime and plaster manufacturing activities. However, it represents the best available data source to give indications of the structure and performance of lime production. Where possible the data is cross-checked with available industry sources.

It can be noted, however, that in terms of overall size – as measured by volume (tonnes) and value of production – the EU lime manufacturing industry is much larger than the plaster manufacturing industry. This can be demonstrated using Eurostat Prodcom data that separately provide information on the volume and value of EU production of lime and plaster[97], as shown in the figure below. In 2015, for example, the value of lime production is estimated at €2.1 billion while plaster production is estimated at only €0.8 billion, implying that lime accounts for 72% of the combined production value[98]. Accordingly, as lime is the dominant sub-sector, it would appear reasonable to suggest that the data on combined lime and plaster manufacturing used in following subsections offer a reasonable proxy for assessing the general structure and performance of the EU lime manufacturing industry.

Figure 57: EU28 comparison of lime and plaster production 2003-2015



Source: Ecorys based on Eurostat Prodcom

[96] NACE 2 class 23.52 (Manufacturer of lime and plaster) covers both the manufacture of lime products (quicklime, slaked lime and hydraulic lime, together with calcined dolomite), alongside the manufacture plasters of calcined gypsum or calcined sulphate. It excludes, however, the manufacture of articles of plaster (e.g. plaster articles for use in construction, such as plaster boards, sheets and panels).

[97] PRCCode: 23522000 Plasters consisting of calcined gypsum or calcium sulphate (including for use in building, for use in dressing woven fabrics or surfacing paper, for use in dentistry)

[98] This estimate is corroborated by industry representatives from the study 'Mirror Group', who indicate that the estimate up to 70% of the value of the combined NACE 2 class 23.52 (Manufacturer of lime and plaster) is accounted for by the lime sector.

In addition, it should be noted that SBS classifies enterprises based on their principal economic activity. This means that when an enterprise is active in more than one economic activity, then the value added and turnover that it generates, the persons it employs, and the values of all other variables will be classified under the enterprise's principal activity; the principal activity is normally the one that generates the largest amount of value added. This is one potential explanation for differences between aggregate production values based on product data (e.g. Prodcom) and those based on enterprise data (e.g. Structural Business Statistics).

3.4.2 Overview of the lime and plaster manufacturing industry[99]

In 2015, the most recent year of available comparative Eurostat data, the lime and plaster manufacturing industries in the EU represented an estimated €4.2 billion turnover and €1.4 billion in value added, with 592 enterprises offering employment to 14.7 thousand persons in the EU. These values imply that, in 2015, the EU lime and plaster manufacturing industries accounted for 0.06% of the total manufacturing turnover in the EU, 0.08% of value added and 0.05% of employment (persons employed). The box shows that there are also estimation from the industry, but with a different scope.

Box 15: Size estimate from European industry association

The European Lime Association (EuLA), the main industry association of non-captive lime producers in Europe, which is understood to cover 95% of European non-captive lime production (including associated quarrying activities), estimates the value of its members' production at €2.5 billion, with 11 thousand direct employees[100].

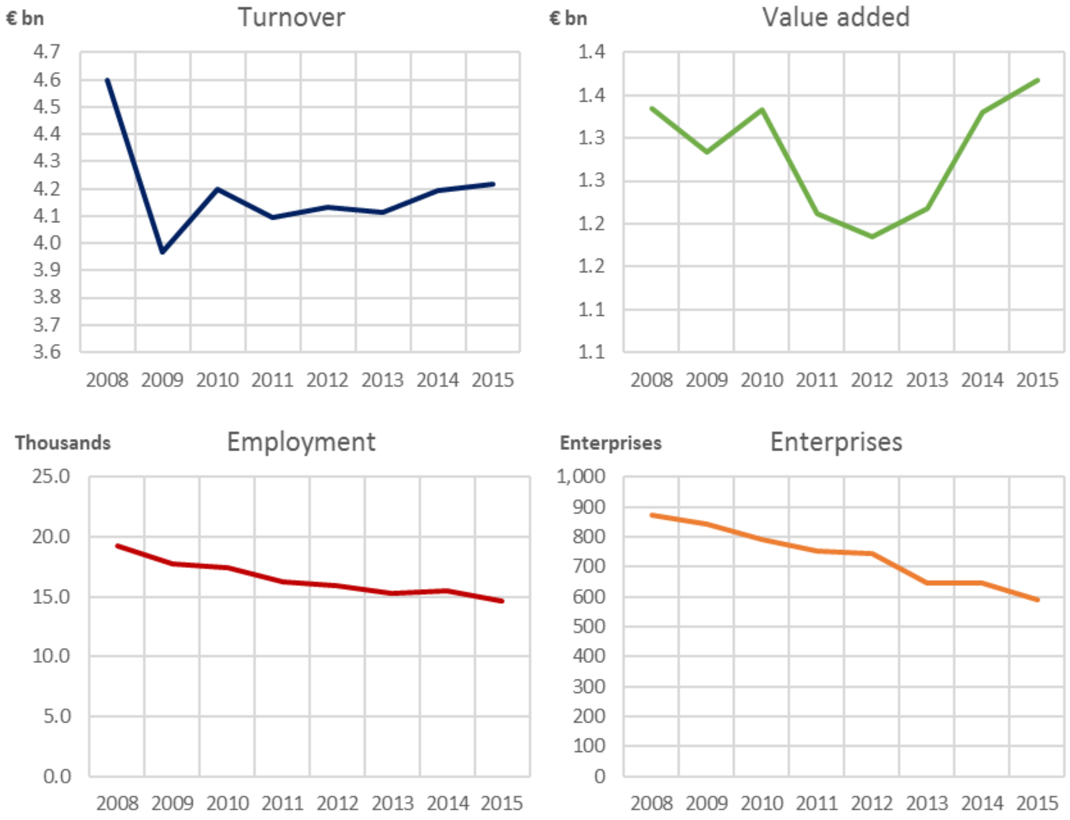
Eurogypsum, the representative body of European manufacturers of gypsum products, estimates that the gypsum and hydrite industry has a turnover of €7.5 billion and directly employs 28,000 persons.[101] These figures are, however, not directly comparable with Eurostat data on lime and plaster manufacturing (NACE 2 class 23.52) as, in addition to plaster manufacturing, they also cover some quarrying activities, together with manufacture of plaster-based products such as plasterboard, plaster blocks and gypsum fibreboards, which are reported elsewhere in the NACE nomenclature.[102]

3.4.3 Time profile of EU lime and plaster manufacturing industry

The figures below show the recent evolution of key headline variables for the lime and plaster manufacturing industry from 2008 to 2015. A sharp decline in turnover between 2008 and 2009 is evident, with a fall of around 14%, followed by a slight rebound in 2010. It has remained relatively stable thereafter at around 90% of its 2008 level. Value added generated by the industry shows a more persistent decline that continued until 2012 but that appears to have been strongly reversed in 2013 -2015. By contrast, both employment (measured by the number of persons employed) and number of enterprises show a persistent decline (this development is also visible in Amadeus data, see Annex D), with possible levelling off between 2013-2015; between 2008 and 2015, employment is estimated to have fallen by 24%, to around 14.7 thousand, while the number of enterprises contracted by 32%.

[99] NACE class: 23.52 Manufacture of lime and plaster
[100] EuLA (2014), "A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe!
[101] Eurogypsum website: http://www.eurogypsum.org/about-gypsum/the-european-plaster-and-plasterboard-industry/the-european-industry-overview/
[102] See Annex A for details of the NACE classification of lime and plaster based products

Figure 58: EU28 lime and plaster – evolution of key variables 2008-2015



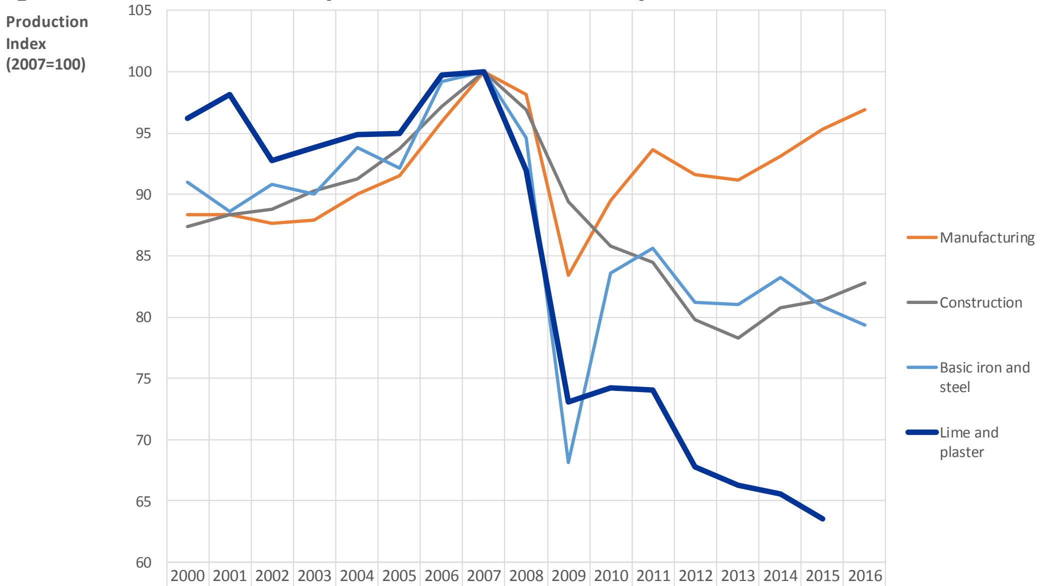
Source: Ecorys based on Eurostat SBS

These declines were substantially more pronounced than for EU manufacturing as a whole, which evolved over the same period as follows: turnover +2%, value added +11%, employment -9%, and the number of enterprises -2%.

A broader perspective on production (volumes) is provided by the Eurostat short-term business statistics (STS), as shown in the next figure.[103] These data allow a comparison with other key sectors of the economy, notably important customer sectors such as iron and steel, and construction. These data show that between 2002 and 2006, lime and plaster production was on a stable and positive growth trajectory. Production then declined, falling by a quarter between 2007 and 2009. After stabilising in 2010 and 2011, production continued to decline between 2012 and 2015, the latest year for which data are available. It is notable that despite some improvement in production volumes for construction (and manufacturing) since 2013, and an apparent rebound in iron and steel production in 2010 and 2011 following the slump in the previous two years, lime and plaster production has endured a more persistent decline than that of its main clients. Overall, it appears that the improvement in production volumes in key customer markets following the financial and economic crisis has not been sufficient to reverse the decline in the volume of lime and plaster production. Therefore, the lime sector appears to be subject to structural rather than cyclical forces.

[103] Note, Eurostat STS data use a base year of 2010 (=100). These data have been 'mechanically' rebased to 2007, which was the peak production year, so as to highlight the impact of the economic and financial crisis.

Figure 59: EU28 lime and plaster – volume index of production 2000-2016



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Manufacturing	88.4	88.4	87.6	87.9	90.1	91.5	96.0	100.0	98.1	83.4	89.5	93.6	91.6	91.1	93.1	95.3	97.0
Construction	87.4	88.3	88.8	90.3	91.3	93.7	97.2	100.0	96.9	89.5	85.8	84.5	79.8	78.3	80.8	81.4	82.8
Basic iron and steel	91.0	88.6	90.8	90.1	93.8	92.1	99.2	100.0	94.7	68.1	83.5	85.6	81.2	81.0	83.2	80.9	79.4
Lime and plaster	96.2	98.1	92.8	93.8	94.9	95.0	99.7	100.0	92.0	73.1	74.2	74.0	67.8	66.3	65.6	63.5	

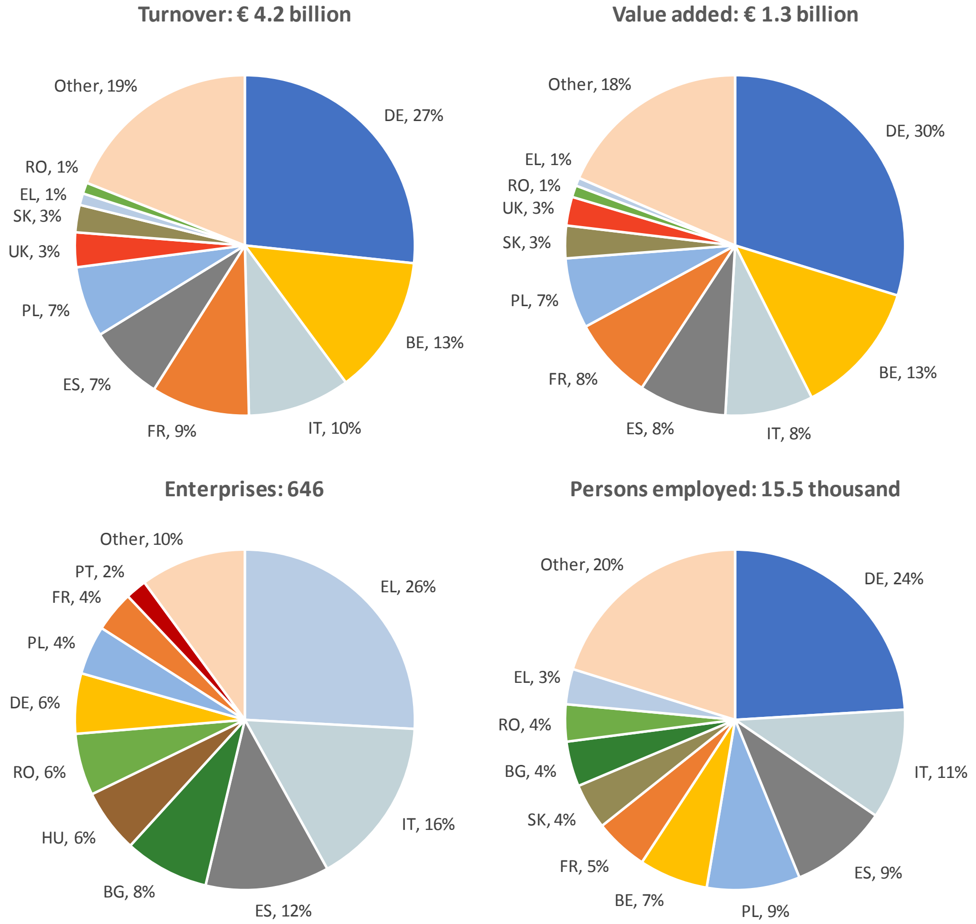
Source: Ecorys based on Eurostat STS

3.4.4 Geographical profile of EU lime and plaster manufacturing industry

In 2014, Germany, Belgium, Italy, France, Spain and Poland together accounted for 76% of total EU turnover of lime and plaster manufacturing, 74% of value added, 64% of employment but only 43% of enterprises; see figure below. Germany alone accounts for 27% of turnover and 30% of value added and, although it accounts for nearly a quarter (24%) of employment, it represents only 6% of enterprises. By contrast, Greece accounts for over a quarter (26%) of enterprises but only 3% of employment and only 1% of turnover and value added.

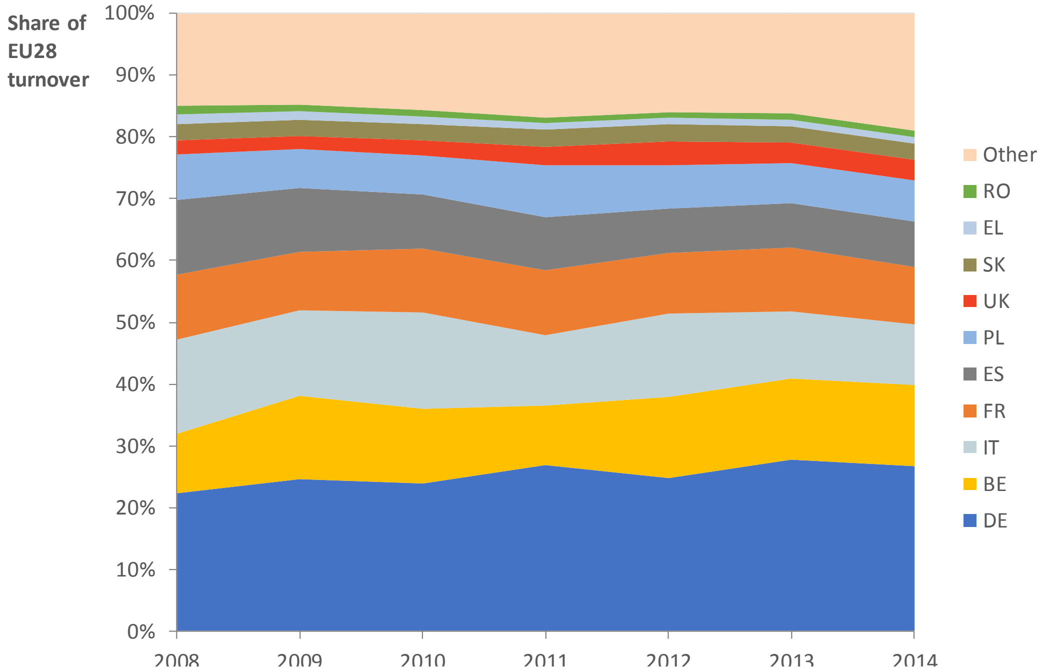
In terms of the evolution of turnover, as shown above, following a sharp decline in 2009, total EU28 turnover has remained relatively stable at around €4.1 to 4.2 billion. Since 2008, Italy and Spain have seen the most significant decline in their share of total EU lime and plaster manufacturing turnover, which has fallen by 5.6 and 4.8 percentage points (p.p.), respectively; see figure below. Germany (4.3 p.p.) and Belgium (3.6 p.p.) have seen the largest increases in their share of EU turnover, while the collective share of 'other' smaller lime and plaster manufacturing countries is estimated to have increased by 4.1 percentage points.

Figure 60: EU28 lime and plaster manufacturing: breakdown of turnover, value added, number of enterprises and number of persons employed in the EU by country (2014)



Source: Ecorys based on Eurostat SBS

Figure 61: EU28 lime and plaster manufacturing: breakdown of EU28 turnover by country (2008-2014)

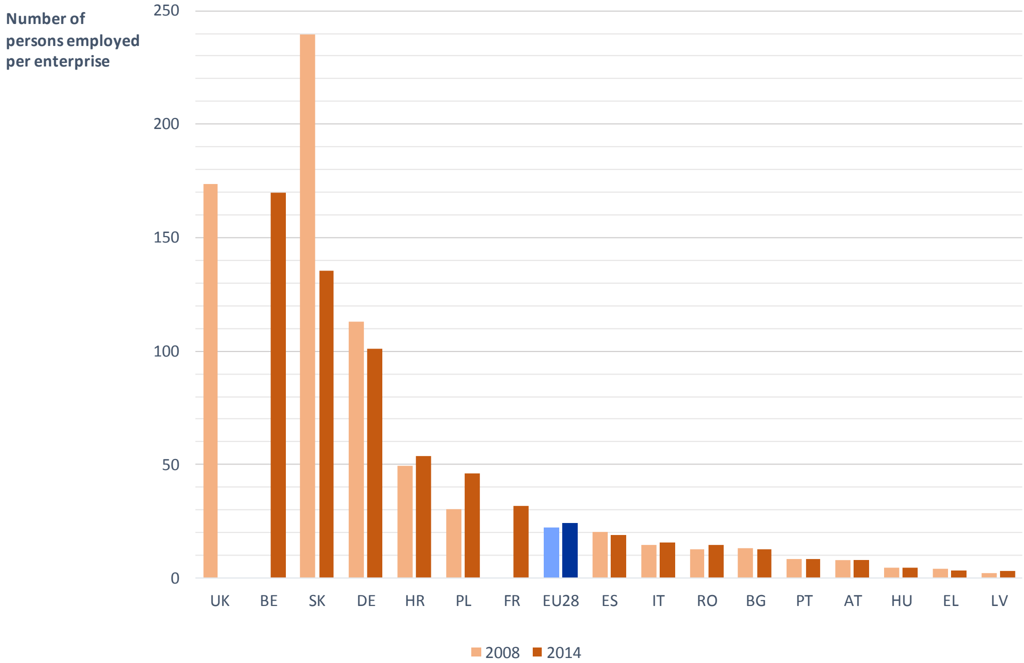


Source: Ecorys based on Eurostat SBS

3.4.5 Enterprise size of EU lime and plaster manufacturing industry

As suggested by the comparison of the relative shares of employment and enterprises mentioned above, there are significant differences in the average size of enterprises (measured by employee numbers) across the EU. In 2014, the average number of employees per enterprise for the EU was 24 persons, indicating the small size of the majority of EU lime and plaster companies. The available data indicates that average enterprise size is largest in the UK, Belgium, Slovakia and Germany, while it is lowest in Austria, Hungary, Greece and Latvia.

Figure 62: EU28 lime and plaster – average enterprise size by country (2008, 2014)



Notes:
a. No data available for CY, CZ, DK, EE, FI, IE, LT, LU, MT, NL; SE, SI
b. PT data for 2008 and 2012

Source: Ecorys based on Eurostat SBS

Box 16: Structural characteristics of European lime manufacturing enterprises

The majority of lime manufacturing enterprises are small and medium sized firms, often single plant family owned, operating at a local level. Nonetheless, the EU lime industry also has a limited number of large companies that are recognised as global leaders. The largest EU lime producers are Carmeuse, Lhoist, CRH, Nordkalk, Schäferkalk and Calcino. Some of them, like Carmeuse and Lhoist also have production operations outside the EU.

Historically, over the last three decades large conglomerates disinvested their lime activities into smaller and more numerous specialised companies.[104] Over recent years, and with differences in local situations, the European lime industry has witnessed increasing concentration over recent years. This has occurred through a combination of merger and acquisition activities (M&A) and through firms exiting the market. This may be partly attributed to general economic conditions that, in addition to forcing some firms out of the market, has also led to plants being closed or 'mothballed'. Companies also report that increasing environmental protection costs together with administrative requirements (burden) related, among other things, to land use (for quarrying) make it more difficult for smaller enterprises to set-up and run lime production facilities.[105] It needs to be noted that those costs are

[104] EuLA (2014), "A Competitive and Efficient Lime Industry - Cornerstone for a Sustainable Europe"
[105] According to information obtained from industry associations and company interviews.

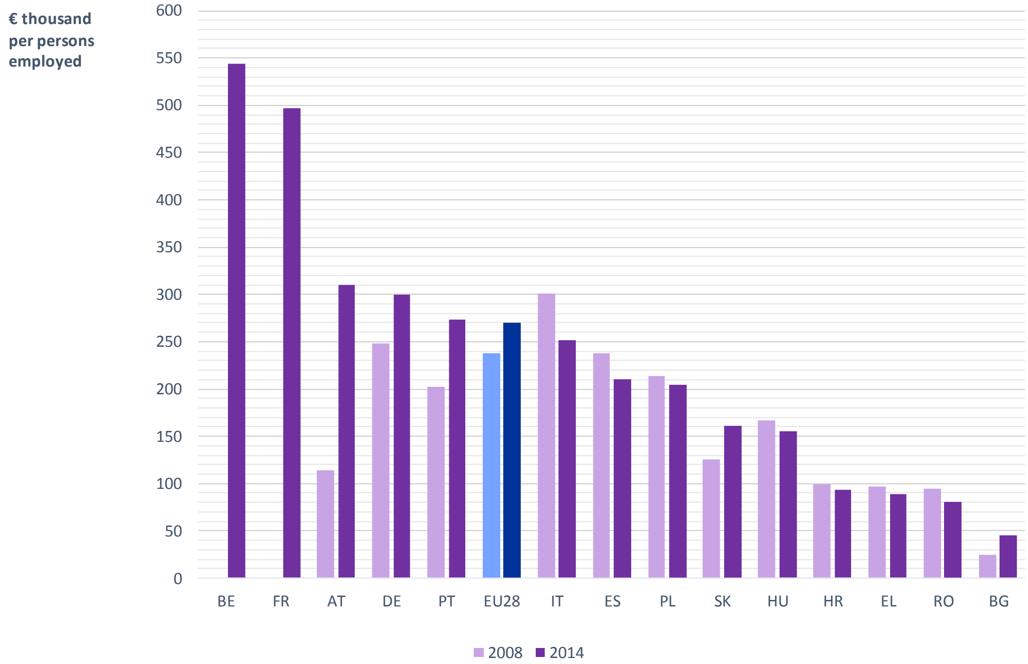
balanced, if not outweighed, by the benefits, e.g. access to the free allocation of emissions allowances within the framework of the EU ETS

The size of individual production plants usually reflects local demand conditions, including the sectoral composition of demand; for example, whether production is directed towards downstream clients (e.g. for sugar production) or for more diverse low volume clients (e.g. agriculture). The number of workers directly employed in production activities is limited, reflecting the capital intensive and automated nature of production. A high proportion of workers may be engaged in transport related activities (from quarries to production plants), along with production supervisory and administrative functions.[106]

3.4.6 Labour productivity of EU lime and plaster manufacturing industry

Eurostat SBS data for 2014 indicate that the lime and plaster manufacturing industry generated turnover of €4.2 billion with a workforce of less than 16 thousand, resulting in an average turnover per person employed of €270 thousand. This compares to an estimated average for manufacturing as a whole of €238 thousand. The average EU figure for the lime and plaster manufacturing industry masks very wide divergence across countries. For example, turnover per employee in Belgium is estimated at €544 thousand, over 10 times greater than the corresponding amount for Bulgaria at only €45 thousand per person employed; see figure below.

Figure 63: EU28 lime and plaster – turnover per person employed by country (2008, 2014)



Notes:
a. No data available for CY, CZ, DK, EE, FI, IE, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)
b. PT data for 2008 and 2012

Source: Ecorys based on Eurostat SBS

A similar picture of across country divergence exists for apparent labour productivity – measured by value added per person employed. In 2014, average apparent labour productivity of the lime and plaster manufacturing industry in the EU was €86 thousand, compared to €57 thousand for the manufacturing sector as a whole. Nominal labour productivity is highest in

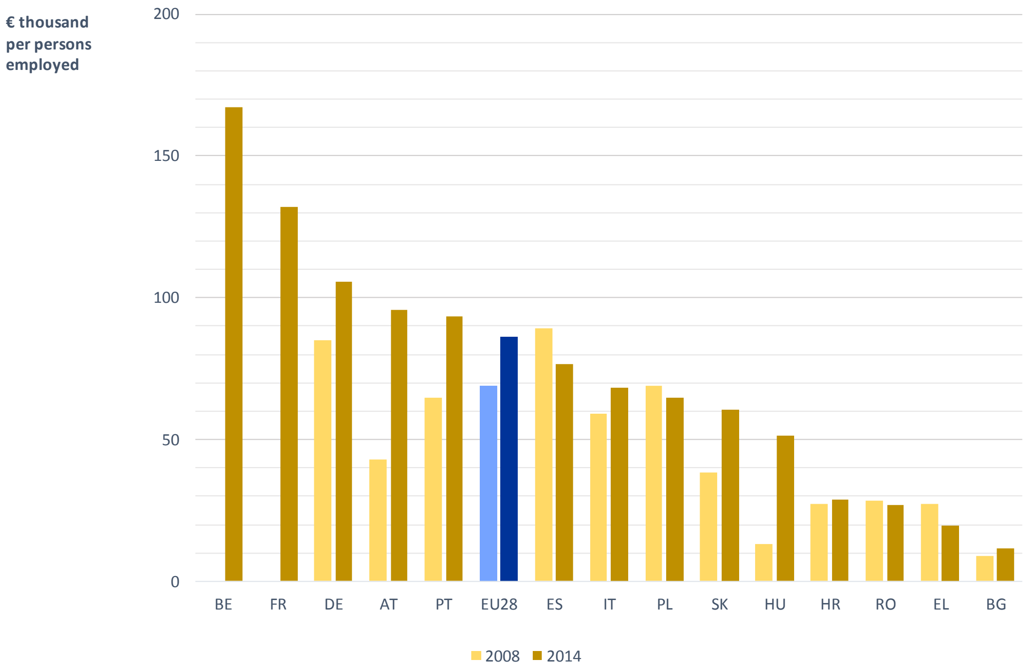
[106] Idem.

Belgium, France and Germany, and lowest the south east of the EU (i.e. Bulgaria, Croatia, Greece, Romania); see figure below.

It can be noted that between 2008 and 2014 apparent labour productivity in the EU lime and plaster manufacturing industry grew in nominal terms at an average annual rate of 3.7%, exceeding that of total EU manufacturing (1.9%). This implies that (nominal) apparent labour productivity grew by 25% over the six-year period, though this figure mask significant differences across countries; (nominal) apparent labour productivity grew particularly strongly in Hungary (+292%), Austria (+124%) and Slovakia (+58%), whilst large falls were recorded in Cyprus (-38%), Greece (-28%) and Spain (-14%).

<u>Note:</u> Some caution should be exercised when comparing and assessing turnover and value added per employee at a country level. The high value in some countries (e.g. Belgium) may be partly attributable to turnover reported by corporate headquarter enterprises capturing turnover from (foreign) affiliates. This may, arise, for example, through corporate headquarters charging for goods and services provided to (foreign) affiliate companies. Thus, turnover data (and consequently value-added) may overstate turnover directly generated within the domestic market.

Figure 64: EU28 lime and plaster – apparent labour productivity by country (2008, 2014)

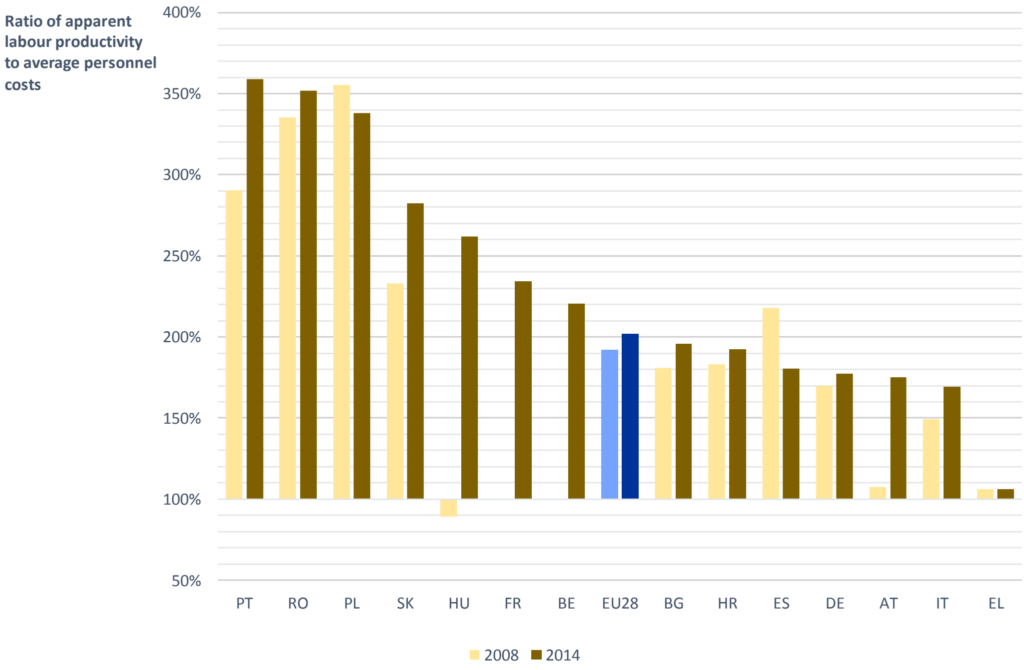


Notes:
a. No data available for CY, CZ, DK, EE, FI, IE, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)
b. PT data for 2008 and 2012

Source: Ecorys based on Eurostat SBS

The wide divergence across countries in turnover and value added per worker (person employed), can be the result of multiple possible causes. These can be differences in production efficiency (i.e. volume of output per worker) but also reflect differences in costs and market prices for lime and plaster products, which in turn reflect differences in overall economic development and factor costs. An indicator that partly corrects for these differences is the wage-adjusted labour productivity ratio, which is measured by apparent labour productivity divided by average personnel costs (expressed as a ratio in percentage terms). The figure below shows the wage-adjusted labour productivity ratio, for available countries, in 2008 and 2014. In 2014, for the EU as a whole, value added generated in the industry was around twice the cost of labour (202%). Interestingly, in addition to Portugal and Romania, there is a concentration of high value added to labour cost ratios in central EU countries, namely Poland, Slovakia and Hungary. By contrast, alongside Greece for which value-added per worker is barely above labour costs, Italy, Austria, Germany and Spain are all towards the bottom-end of wage-adjusted labour productivity.

Figure 65: EU28 lime and plaster – wage-adjusted labour productivity ratio by country (2008, 2014)



Notes:

a. No data available for CY, CZ, DK, EE, FI, IE, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)

b. PT data for 2008 and 2012

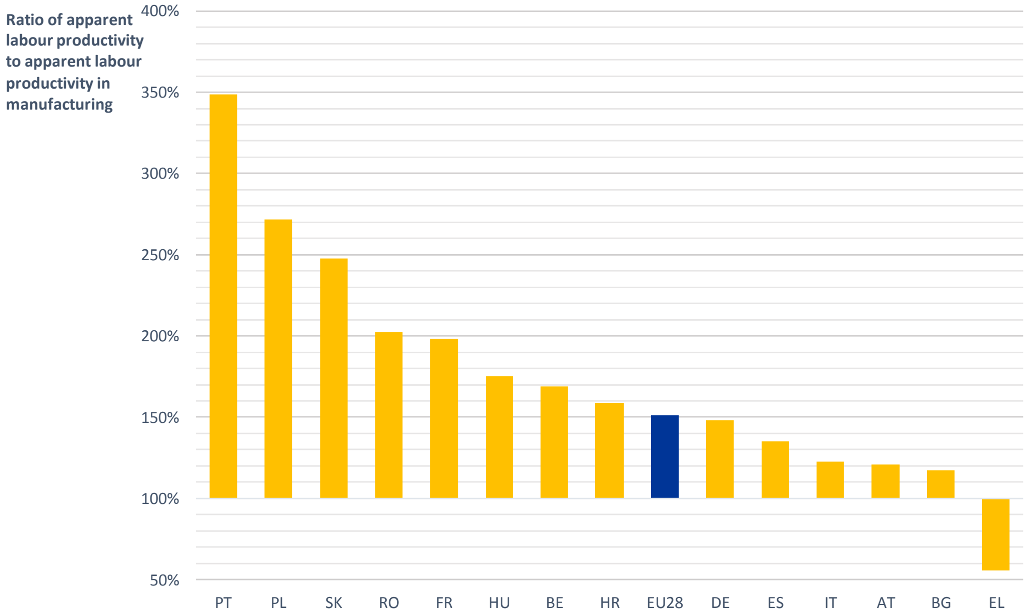
Source: Ecorys based on Eurostat SBS

An alternative approach is to compare apparent labour productivity in the lime and plaster manufacturing industry with that for manufacturing as a whole. This is shown in the figure below, which indicates that apparent labour productivity in lime and plaster for the EU as a whole is 50% above the average of all manufacturing. Again, Portugal has the highest value (349%), indicating that the lime and plaster sector generates 3.5 times the average value added per worker of total manufacturing in the country. As with the wage-adjusted labour productivity indicator, Poland, Slovakia, and Romania are among the countries with the highest ratio relative to total manufacturing. Greece is the only country where apparent labour productivity in the lime and plaster manufacturing industry is below the average for total manufacturing. Again, Germany, Spain, Italy and Austria are all positioned towards the bottom-end of apparent labour productivity (relative to total manufacturing).

The Amadeus analysis reveals that the apparent level of productivity in this sector is below that of the manufacture of cement. In 2014 it was about 85 million euro. By countries, labour productivity by employee in Germany, Spain, and the United Kingdom were similar to the EU average. France stands out because of its comparative higher value and Italy for showing lower level than the other remaining countries.

As in the case of the cement industry, the lime and plaster sector shows a high level of consolidation. In Germany, United Kingdom, France Finland and Sweden the concentration is very high and has not significantly changed with the crisis, whereas in Italy, and particularly in Spain, the industry is less concentrated.

Figure 66: EU28 lime and plaster – ratio of apparent labour productivity of lime and plaster to apparent labour productivity of total manufacturing by country (2014)



Notes:
a. No data available for CY, CZ, DK, EE, FI, IE, LT, LU, LV, MT, NL; SE, SI, UK (2008 only, not shown)
b. PT data for 2008 and 2012

Source: Ecorys based on Eurostat SBS

Box 17: Factors influencing relative performance

Representatives of companies interviewed for the study point to several factors that might have an impact on the relative performance of the lime industry in different Member States. Differences in the cost of production factors (e.g. labour, energy, raw materials) are clearly important; the breakdown of production costs is described in the following section). Access to raw materials and sources of alternative fuels are also highlighted as a potential issue for some geographical areas. The regulatory environment (including national legislation) is frequently mentioned by lime companies as affecting relative performance of different Member States; for example, due to difference in the transposition and application of EU directives and regulations or national and local environmental policies. In addition some industry representatives indicate that uncertainty of longer-term policy developments, such as ETS, put the EU lime sector at a disadvantage compared to non-EU producers.

3.5 Production costs in the EU lime and plaster manufacturing industry

3.5.1 Breakdown of the production cost (main cost components)

Absolute level of the production costs

The information on the absolute level of production costs is limited and originates from the same source. In a study for the European Lime Association (EuLA), Ecofys[107] indicated that the average production costs vary between €55 and €70 per tonne of lime, depending on the type of kiln used and variations in the main cost elements (energy, raw material, etc.). Ecofys based this cost indication on a 2008 study by NERA.

The calculations in the NERA study[108] are based on non-public 2006 data from lime manufacturers.[109] NERA made a distinction between four types of kilns. The results show an average production cost of €55 per tonne for PFRKs (Parallel Flow Regenerative Kilns, the most used kilns) and €72 per tonne for LRKs (long rotary kilns).[110] The authors emphasise that there is a high variation in cost by company and kiln type. For PFRKs the actual costs can be €10 per tonne higher or lower than the average. Based on the provided data, NERA calculate the weighted costs for a 'representative EU lime producer'; these are total long-term production costs around €59 per tonne (for 3 mm lime, excluding any emissions costs).

According to industry representatives, at the end 2017 lime had an average (ex-factory) selling price around € 80 to € 100 per tonne, although this may vary significantly.[111]

Breakdown of production costs: evidence from publicly available data and literature

There are various sources, which present a breakdown of the production costs of lime. These are briefly discussed.

The **Eurostat SBS data[112]** provides only partial information on the composition of production costs but, nonetheless, can be used to calculate estimates of the breakdown of the value of production by broad items as shown in the figure below. The figure breaks the value of production of lime and plaster manufacturing into four headings: 'operating surplus' and 'personnel costs', which combined equate to value added, 'energy cost' and 'other costs' covering purchases of other goods and services and other operating costs (and incomes).

[107] Ecofys (2014), "technical report: A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe", This technical report was accompanied by: EuLA (2014), "A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe (Lime Roadmap)"

[108] NERA (2008), "*Potential Impacts of the EU ETS on the European Lime Industry*";

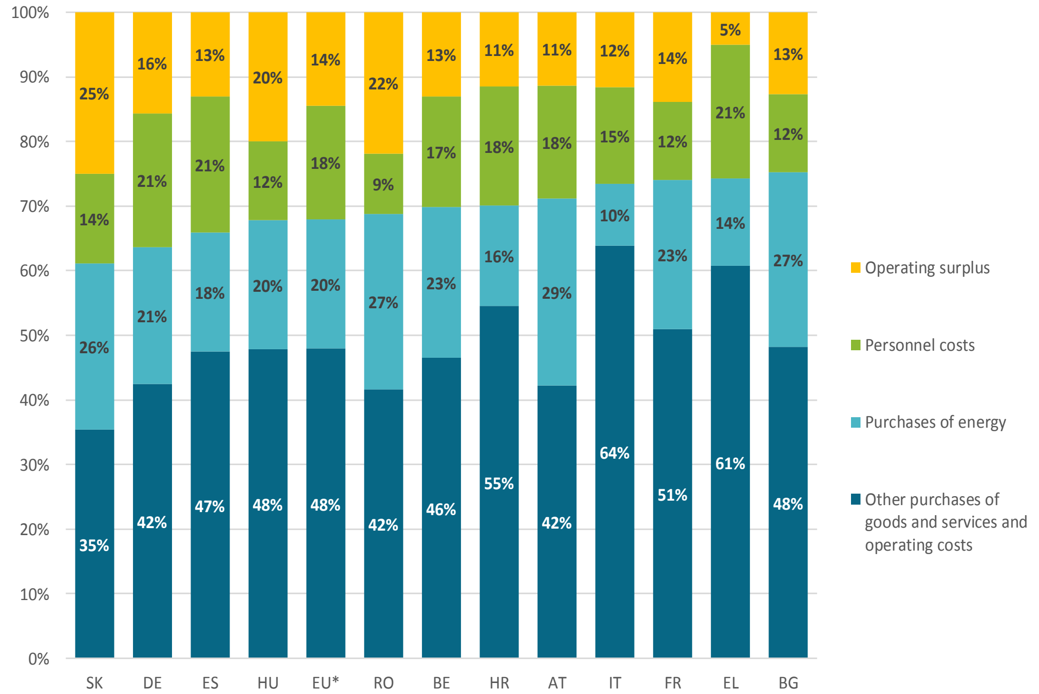
[109] NERA indicates that the obtained data comes from EuLA member companies. The data is from 2006 and covers in total 16 Mt of lime production. The data refers to 3 mm lime and "does not include dolime, nor other grades of lime that reflect additional processing".

[110] The distinction is based on the BREF-documents; the two other mentioned types are 'annular shaft kilns' (ASK) and 'other kilns' (OK).

[111] This is a rough estimate, as sales prices are confidential and vary significantly across the EU.

[112] Eurostat Structural Business Statistics (SBS). Please note that this data can not directly be compared with the data presented en used in Chapter 5 in the context of the ADAGIO-model. The data used in Chapter 5 comines several data sources, including Eurostat Structural Business Statistics.

Figure 67: EU28 lime and plaster – estimated breakdown of production value by component (2014)



Source: Ecorys based on Eurostat SBS
Notes: EU* is a production weighted average of the individual countries shown in the figure.

For the countries for which data are available, the share of value added in production varies from close to 40% in Slovakia down to 25% in Bulgaria. Within these amounts there is considerable variation in the share of operating surplus in production costs, from only 5% in Greece to 22% in Romania and 25% in Slovakia. Similarly, the share of labour costs in the production value ranges from 9% in Romania, up to 21% in Germany, Spain and Greece. Energy costs, which are of particular importance for the industry due to its high energy intensity, are estimated to amount to 20% of the value of production on average for the EU (based on countries for which data are available). However, there appears to be considerable variation across countries, with energy purchases amounting to only 10% of the value of production in Italy to 29% in Austria (depending on the actual product manufacturing).

The Eurostat data appear to provide a conservative estimate on the share of energy costs. Information collected by this study from lime companies points to higher shares of energy costs, on average 31% (see next section). Possible difference with the Eurostat sources may lie in the fact that the variable purchase of energy may not always include all types of energy (fuel, natural gas, coal, petcoke, alternative fuels). Furthermore, it is crucial to underline that Eurostat data refer to both lime and plaster, whilst plaster production is considerably less energy intensive than lime production.

In the already mentioned reports of 2014, **EuLA and Ecofys**[113] indicate that the most important cost component of the lime production process is energy with a 40% share, followed by raw materials (17%) and capital/depreciation costs (7%). The broadly defined "other costs" (37%) category contains items such as operation and maintenance, labour costs, and company overheads. Again, this breakdown is based on the 2008 study by NERA. The next table presents

[113] Ecofys (2014), "technical report: A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe", This technical report was accompanied by: EuLA (2014), "A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe (Lime Roadmap)"

this detailed breakdown of the (absolute) production costs for the four kiln types, as well for the 'representative EU lime producer' (last column).

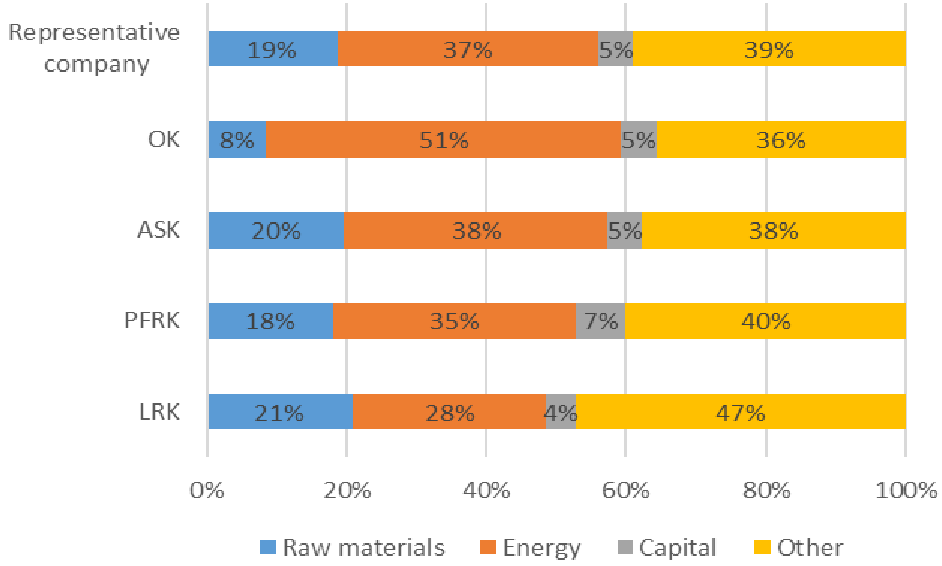
Table 7: Production cost per kiln type & representative manufacturer (2006 data, in €/tonne)

	LRK	PFRK	ASK	OK	Representative company
Raw materials	15	10	12	5	11
Energy	20	19	23	30	22
Capital	3	4	3	3	3
Other	34	22	23	21	23
Total	72	55	61	59	59

Source: NERA (2008), "Potential Impacts of the EU ETS on the European Lime Industry";
Note: the abbreviations stand for: long rotary kilns (LRKs), Parallel Flow Regenerative Kilns (PFRKs), annular shaft kilns (ASK) and other kilns (OK).

In the next figure we present the cost categories as a percentage of the total costs. These percentages differ from the previous presented Eurostat data, but are more in line with the information collected by this study from lime companies (see next section).

Figure 68: Production cost per kiln type & representative company (2006 data, in % of total)



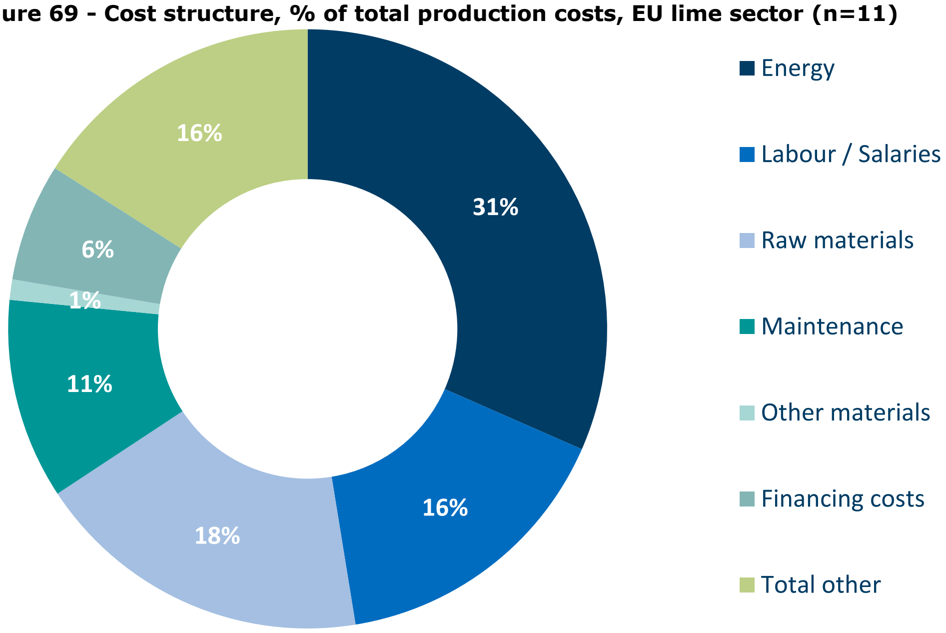
Source: NERA (2008), "Potential Impacts of the EU ETS on the European Lime Industry".
Note: the abbreviations stand for: long rotary kilns (LRKs), Parallel Flow Regenerative Kilns (PFRKs), annular shaft kilns (ASK) and other kilns (OK).

The Best Available Techniques (BAT) Reference Document from the European Commission's Joint Research Centre also highlights the importance of energy for lime production, which are indicated to account for 30-60% of the total production costs.[114]

Within the context of this study we launched a survey among lime (and cement) companies in order to collect additional data for the overall industrial competitiveness analysis. Here we present the results on the cost breakdown; Annex B contains more details on the followed approach. The findings of our data collection among lime producers are presented in the next figure. These results cover the whole sample.

[114] JRC (2013) Best Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide, p.178.

Figure 69 - Cost structure, % of total production costs, EU lime sector (n=11)



Source: Ecorys company questionnaire; see annex B for more details. Note: in the company questionnaire also the category 'transport cost' was included. This category is left out to increase the comparability.

Our estimates indicate that costs of energy amount to roughly 31% on average of total production costs. The figure varies sensibly, however, across the companies surveyed, being in some cases slightly less of half of total costs, while being around 15% in others. This figure is more or less in line with the figure mentioned by NERA (37% for the representative company). Raw materials (e.g. cost of limestone) account for an high share, reaching almost one fifth of total costs (18%) and therefore constituting the second largest item of the cost structure. The NERA-study reported 19% for the representative company in 2006. Costs of labour represent on average 16% of total costs, ranging across companies between less than one tenth of total costs and more than one fourth. Maintenance- and financing costs account for a similar share, being on average around 10% each (11% and 6% respectively). Residual cost items can refer to depreciation costs or other outsourcing costs. Other materials used in the production process (e.g. mineral additives, gypsum) cost indicatively around 1% of total production costs.

The geographic breakdown of the sample findings highlights differences primarily in the cost of limestone and other primary raw materials, which correspond to more than one-fifth of total production costs for companies operating in North-Eastern Europe, while they amount to roughly 15% for those companies in North Western Europe. Energy constitutes instead a relatively low share of costs for the former companies, as compared to the latter one. There is a sensible difference also in the relative weight of labour costs. The 'other costs' category is considerably higher for NEE, it is no direct explanation for that.

There is quite some variety in the assessed breakdown of cost components, as the overview of the various sources shows. In the next box we briefly explain how we dealt with it in the remainder of the report.

Box 18: How are the varying estimations on cost components taken into account?

Industry representatives interviewed for the study indicate that the estimates of the average share of energy in production cost indicated by Eurostat SBS data, at 20% of production value, is (far) below their own estimates. This view is confirmed by the survey among lime companies and the (EuLA commissioned) reports from NERA and Ecofys. As explained in the context of cement it is not immediately clear why there is a large difference between Eurostat and other sources.

As the Eurostat SBS data is an important source for the ADAGIO-model used in the scenario projections (see chapter 5), specific assumptions (i.e. corrections on the too low energy factor share) have been made to the underlying dataset. As further explained in Chapter 5, the simulation model assumed an average factor share of 32% for energy in the cement industry. This percentage is primarily based on the results of our survey. Given their importance for the model simulation results, sensitivity analyses of the assumed energy factor shares have also been carried out; for example with a lower energy factor share for lime (in scenario 1 and 2).

3.5.2 EU production costs in an international perspective

The cost structure of the EU lime industry can also be put in the perspective of competing third countries. The aforementioned 2008 NERA study[115] undertook a comparison of European production costs with those of former Soviet Union and North African countries. As indicated, EU lime production costs, based on 2006 data, are estimated to vary from €55 to €70 per tonne depending on the type of kiln used and variations in the cost factors mentioned above. By comparison, production costs in former Soviet Union and North African countries are estimated to range from €32 to €47 per tonne, with an additional €3-5 with the inclusion of capital costs. According to the estimates of the 2008 NERA study, non-EU producers have a cost advantage of €10-20 on average (not accounting for emission costs). The paper argues that four factors contribute to lower prices in the regions studied, namely the significantly lower labour and energy prices, lower raw material costs and less stringent regulations. NERA (2008) estimates that transport prices for dry bulk goods – such as lime – are around €12-20 per tonne for short distances, around €20-25 per tonne for medium length routes, and €33-45 per tonne for the long range[116].

Taking transport costs into account, NERA (2013)[117] provides estimates for two scenarios.[118] The "central" case concludes that lime kilns in Western Russia could be competitive with kilns in North Eastern European countries (e.g. Finland). Similarly, Eastern European countries might experience competition from Ukraine and Belarus, while kilns in the Mediterranean regions might have to compete with production in the Maghreb. In an "increased threat" scenario – assuming higher carbon emission prices, and lower transport and non-EU fuel costs – this potential threat of foreign competition extends to production from Turkey and Egypt, as well as parts of the Middle East. At this moment tariffs on neighboring countries (Belarus, Ukraine, Maghreb) are at either 0% or 1.7% depending if still classified as "third country rule" or "preferential". [119] This amount is not compensating for lower production costs.

[115] NERA (2008), "Potential Impacts of the EU ETS on the European Lime Industry", p. 56; see also EuLA (2014), "A Competitive and Efficient Lime Industry, Cornerstone for a Sustainable Europe (Lime Roadmap)", p. 27.

[116] NERA (2008), "*Potential Impacts of the EU ETS on the European Lime Industry*", p. 2.

[117] NERA (2013), 'Energy and transport cost comparison of the EU lime industry to 10 non-EU regions'.

[118] The central scenario assumes that each country or region produces lime with the average fuel mix used for industrial production in that country or region, and a carbon price of €5/tCO2. The increased threat scenario assumes €15 for carbon price, as well as lower transport and non-EU fuel costs. The analysis is not historical, it only considers the situation as it was at the time of publication.

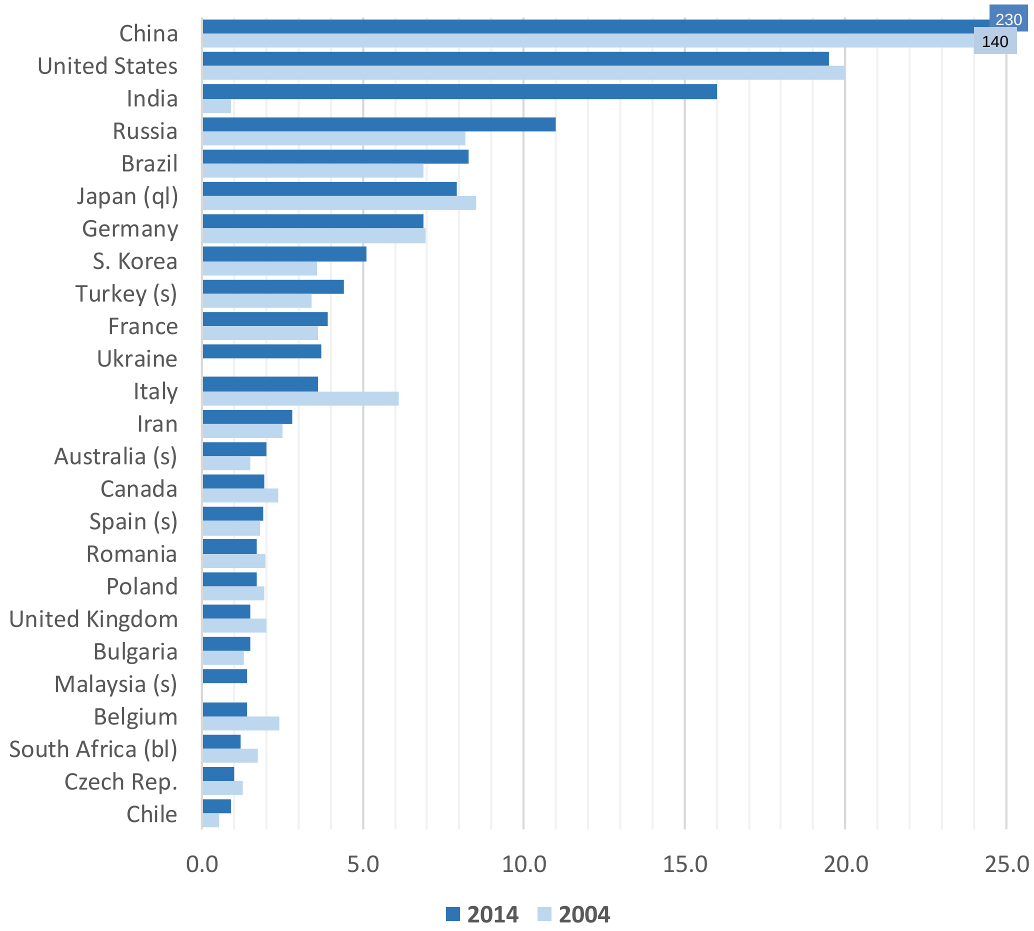
[119] TARIC database 2017

To explain why differences in production costs do not result in significant trade and the flows are rather limited, the EuLA "Lime Roadmap" mentions other factors besides transport costs: "differences in quality, the value of the long-term business relationships, the lack of available spare production capacity, and/or concerns about the stability of cost differences, which might make foreign producers reluctant to invest in "dedicated" export capacity"[120].

3.5.3 Global production of lime products

Data from the US Geological Survey (USGS), which is also reported by the International Lime Association, reveals that China completely dominates global lime production, producing an estimated 230 million tonnes in 2014; an increase of 64% since 2004. The largest increase indicated by these data is for India, which show a near 17-fold increase since 2004, although most of this increase occurred prior to 2010. Countries with the highest estimated growth rates over recent years (2009 to 2015) are Russia, Malaysia and South Korea.

Figure 70: Global lime production, selected countries in million tonnes (2004, 2014)



Notes:
a. s = sales; ql = quicklime only; bl = burnt lime
b. United States includes Puerto Rico

Source: USGS

[120] EuLA (2014) p. 23

3.6 International trade in lime products

3.6.1 Trade data coverage

This section introduces the EU trade performance in lime products. The analysis covers the following categories of lime products:

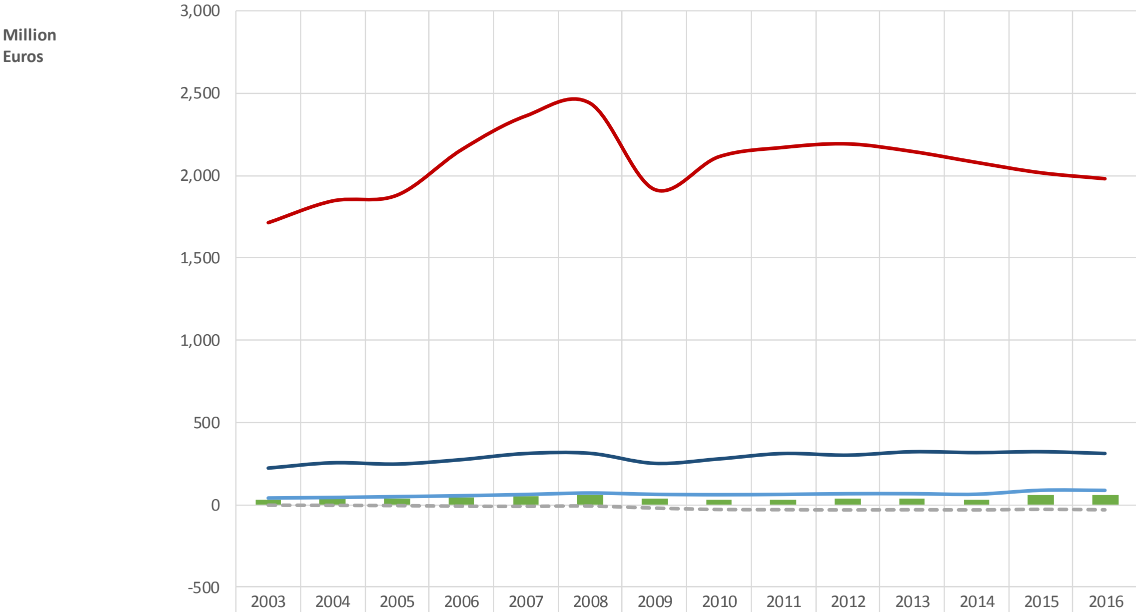
Table 8: Lime database codes

HS Code	Definition
2522.10.00	Quicklime
2522.20.00	Slaked lime
2522.30.00	Hydraulic lime (excl. pure calcium oxide and calcium hydroxide)

3.6.2 Overall trade performance

The figure below shows the evolution of EU production and trade values of lime products since 2003. As described earlier, production levels peaked in 2007-2008 at above €2.4 billion but sharply declined to €1.9 billion in 2009, rising to €2.2 billion in 2011, and the declining to €2.0 billion thereafter. International trade in lime is limited relative to EU production. This applies to both trade within the EU (intra-EU trade) as well as the exports out of the EU (extra-EU exports). Trade within the EU fluctuates between €230 and €320 million and exports to partners outside the EU between €39 and €86 million. The EU has a small trade surplus in lime, which peaked at €60 million in 2008.

Figure 71: Production and trade values of the lime subsector (€ million)

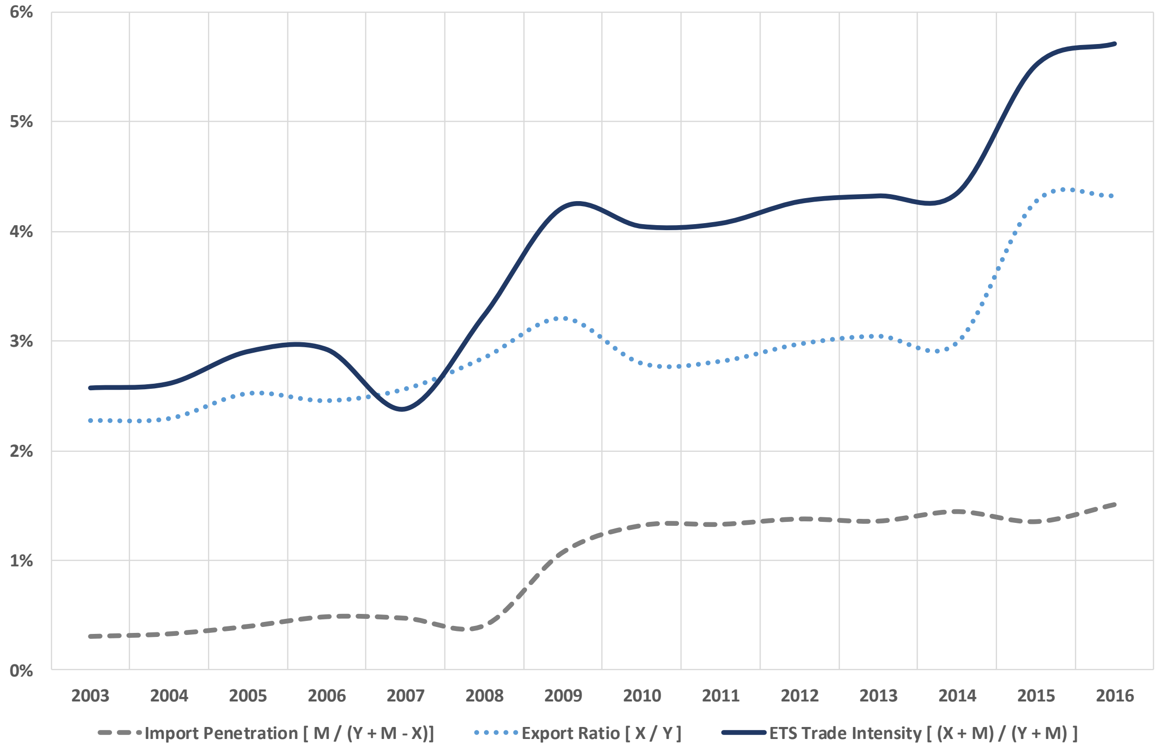


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU trade balance	34	36	40	42	49	60	41	31	33	35	37	32	60	57
Sold production	1,712	1,844	1,879	2,155	2,361	2,438	1,914	2,113	2,170	2,191	2,145	2,079	2,016	1,979
Intra-EU trade (exports)	227	257	250	275	310	311	254	279	310	301	320	315	320	310
Extra-EU export	39	42	47	53	60	69	61	59	61	65	65	62	86	86
Extra-EU [-] imports	-5	-6	-7	-10	-11	-10	-20	-28	-28	-30	-29	-30	-27	-29

Source: Eurostat Comext (for trade flows) and Prodcom (for production), Ecorys calculations.

The low value of cross border trade can be seen in the figure below. Imports from non-EU sources (import penetration) account for less than 2% of the value of EU apparent consumption, whereas only about 3% of EU production is exported outside the EU Internal Market, although this rose to above 4% in 2015 and 2016. Overall, the trade intensity of EU lime production is also rather low, though an upward trend can be identified over the last decade.

Figure 72 **Trade indicators for lime, EU28**

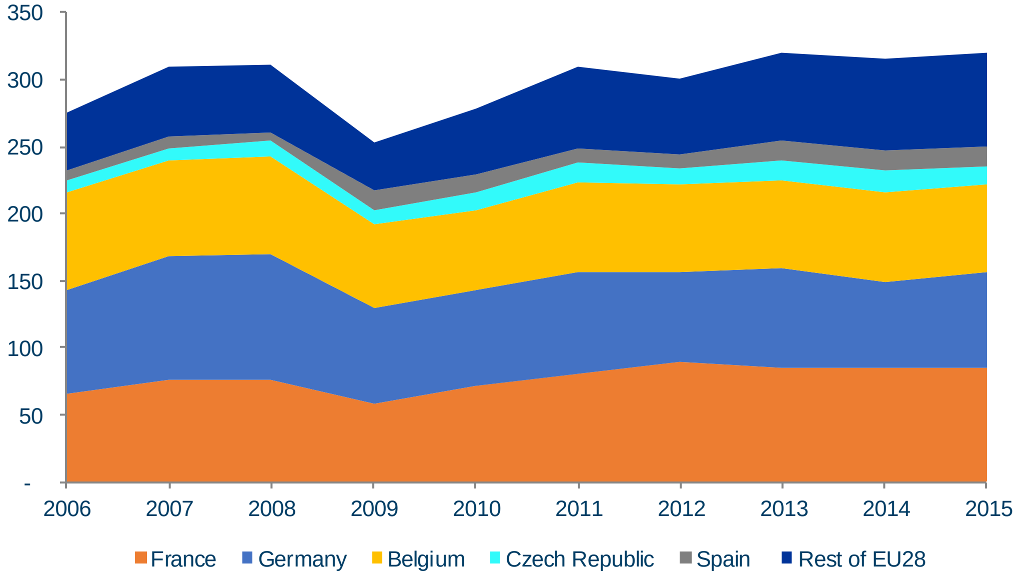


Source: Eurostat Comext (for trade flows) and Prodcom (for production), Ecorys calculations.

3.6.3 Export performance

A breakdown of intra-EU trade by country over the last decade is presented in the figure below. The main cross-border suppliers within the Internal Market are France, Germany and Belgium; in 2015, France, Germany and Belgium together accounted for more than two-thirds (69%) of intra-EU trade (exports), revealing a higher concentration than for production.

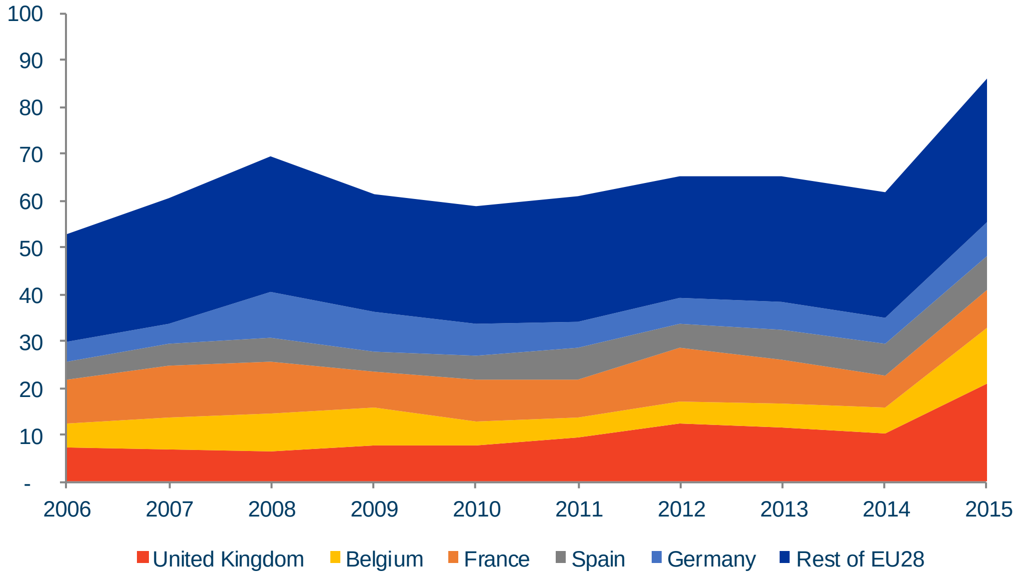
Figure 73 Intra-EU exports in lime products by country (€ million)



Source: Ecorys based on Eurostat Comext.

Extra-EU exports in lime are spread among a number of Member States, with the five largest exporters representing 65% of the total (see Figure below). The economic crisis did not heavily affect extra-EU exports but the latest available data for 2015 show rapid growth compared to 2014, increasing in total from €62 to €82 million. This growth was not driven by one individual country, with both the large producers as well as the rest of EU28 having similar growth trends in this year. In light of these results it is interesting to note that lime industry representatives report very limited opportunities for EU producers to increase their exports. Aside from high regulatory, labour and transport costs for the EU industry, there are other factors that might hinder further growth in exports, for instance exchange rate policies (e.g. in Russia or Turkey).

Figure 74 Extra-EU exports in lime products by country (€ million)



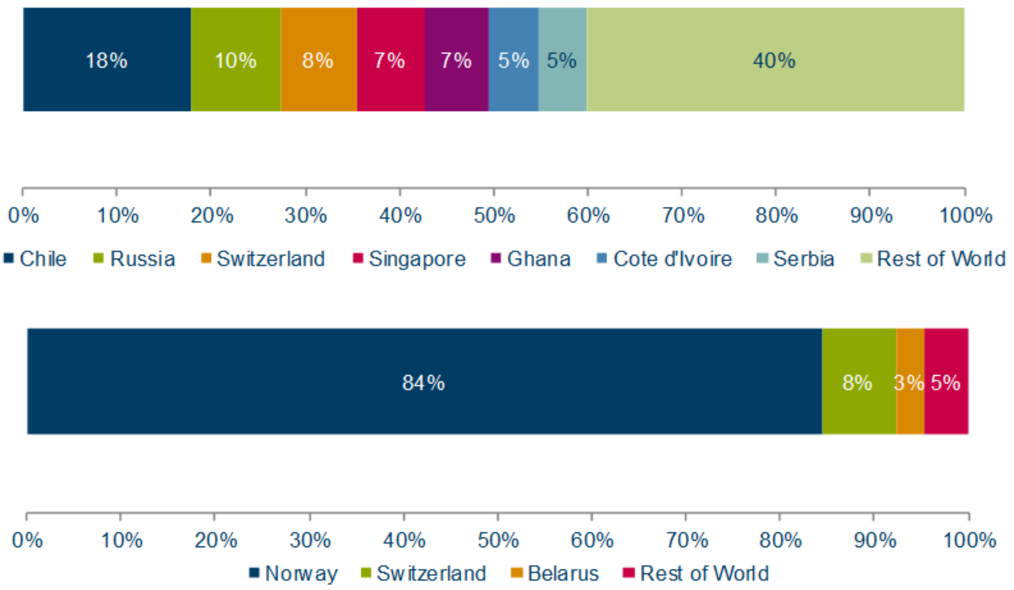
Source: Ecorys based on Eurostat Comext.

3.6.4 EU main international trade partners

The destinations of extra-EU exports and sources of extra-EU imports in 2015 are shown in the figure below; corresponding data are shown in the table thereafter. The destination of EU exports is highly diversified, with the four largest importers of EU lime coming from different geographical regions. In 2015, Chile was the largest export market, accounting for with 18% of total EU lime exports; Chile's status among the largest importer of EU lime is a new development, however, with exports having increased rapidly over the last five years (see table below). Over recent years, the main export destinations for EU lime exports have been Russia, Switzerland, Ghana and Singapore.

Norway is the main source of EU imports of lime, accounting for 84% of all imports sourced from outside the EU. Switzerland and Belarus, which together account for 11% of imports, are the next largest suppliers of lime to the EU market. These countries, together with Bosnia and Herzegovina, have consistently been the main external suppliers to the EU over the past five years (see table below).

Figure 75 Extra-EU export (upper panel) and import (lower panel) partners (2015)



Source: Ecorys based on Eurostat Comext.

Table 9: EU largest export and import partners (2015)

Rank	Export destination	€ million	Import source	€ million
1	Chile	15.4	Norway	22.4
2	Russia	8.2	Switzerland	2.1
3	Switzerland	6.9	Belarus	0.8
4	Singapore	6.3	Bosnia and Herzegovina	0.7
5	Ghana	5.9	South Africa	0.1
	Rest of the world	43.4	Rest of the world	0.4

Source: Eurostat Comext.

Table 10 Annual rank of largest export destinations for EU28 lime exports (from 2011 to 2015)

	2011	2012	2013	2014	2015	Average annual export value (€ million)
Russia	1	1	1	1	2	7.7
Ghana	3	3	2	2	5	6.0
Singapore	2	2	4	4	4	5.6

	2011	2012	2013	2014	2015	Average annual export value (€ million)
Switzerland	5	5	3	3	3	5.5
Norway	4	4	5	5	8	4.0
Chile	73	26	30	26	1	3.3
Serbia	6	11	8	6	7	3.1
South Africa	8	7	6	7	10	3.1
Ukraine	7	6	9	8	9	3.0
Cote d'Ivoire	15	8	7	9	6	2.5

Source: Eurostat Comext.

Table 11: Annual rank of largest source country of EU28 lime imports (from 2011 to 2015)

	2011	2012	2013	2014	2015	Average annual export value (€ million)
Norway	1	1	1	1	1	23.8
Switzerland	3	3	2	2	2	1.6
Bosnia and Herzegovina	2	2	4	3	4	1.3
Belarus	4	4	3	4	3	0.6
South Africa	6	5	5	5	5	0.3
Turkey	5	8	8	6	7	0.2
Egypt	8	7	10	8	9	0.1
China	9	9	6	7	6	0.1
Russia	7	6	24	16	21	0.1
USA	10	10	9	9	8	0.1

Source: Eurostat Comext.

3.6.5 EU trade in a global perspective

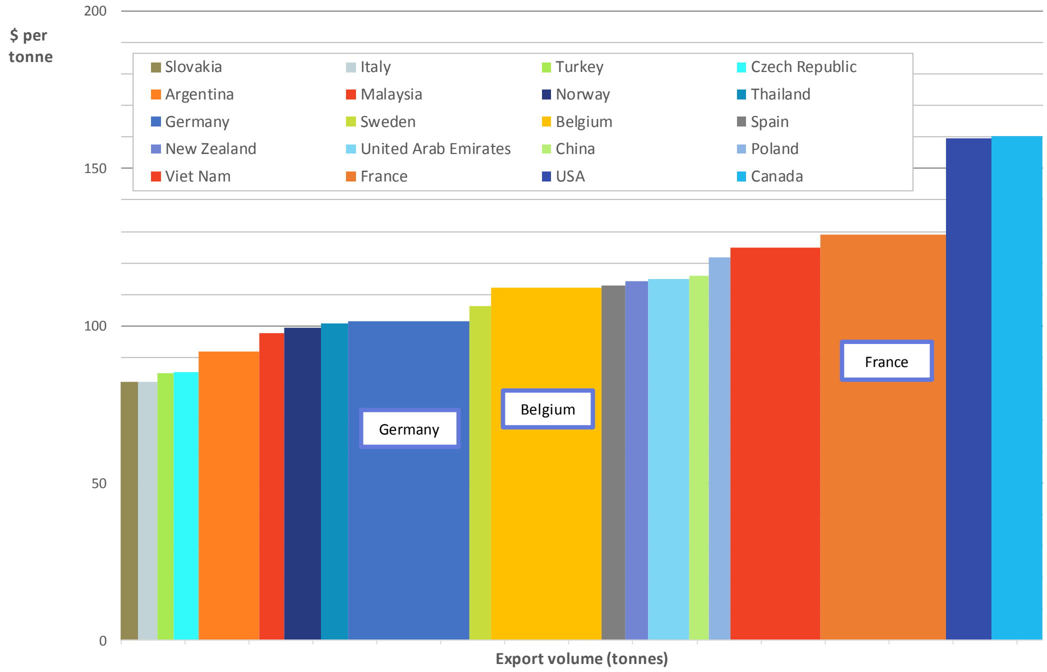
As noted previously, international trade in lime products is limited as the wide geographical availability of raw materials (i.e. limestone) and the low value to weight ratio means that lime is typically produced close to markets and is not transported over long distances. Data from UN Comtrade indicate that around 6.2 million tonnes of lime was traded internationally in 2015[121], with an export value of around $710 million (€640 million). These data suggest an average global price (unit value) for internationally traded lime products of around $115 (€104) per tonne.

The figure below shows the largest 20 global exporters of lime (in volume)[122] in 2015 which collectively accounted for around 85% of total world exports. France, Germany and Belgium are the largest exporters, accounting for a third of world trade (including intra-EU trade). The largest non-EU exporters of lime products (by volume) are Vietnam, Argentina, Canada, USA and the United Arab Emirates; among these countries, both Vietnam and Argentina have seen their share of global exports increase over the last decade. The average unit values of US and Canadian exports indicate a noticeable price 'premium' on lime exports from these countries, amounting to around $30 (€27) per tonne compared to France that has the highest average unit among the main EU exporting countries.[123] Otherwise, average unit values for EU exports are

[121] This figure includes intra-EU trade.
[122] Countries are positioned according to the average unit value of their lime exports.
[123] Export values are (in principle) recorded as FOB (Free on Board) and include, therefore, the transaction value of the goods and the value of services performed to deliver goods to the border of the exporting country.

not systematically different from those for other leading global exporters; Slovakia, Italy and the Czech Republic have average unit values that are among the lowest observed, while the average unit value of Vietnam's exports – the largest non-EU exporter – are only marginally lower than those of France.

Figure 76: 20 largest global exporters of quicklime by weight – volume and average unit value of exports (2015)



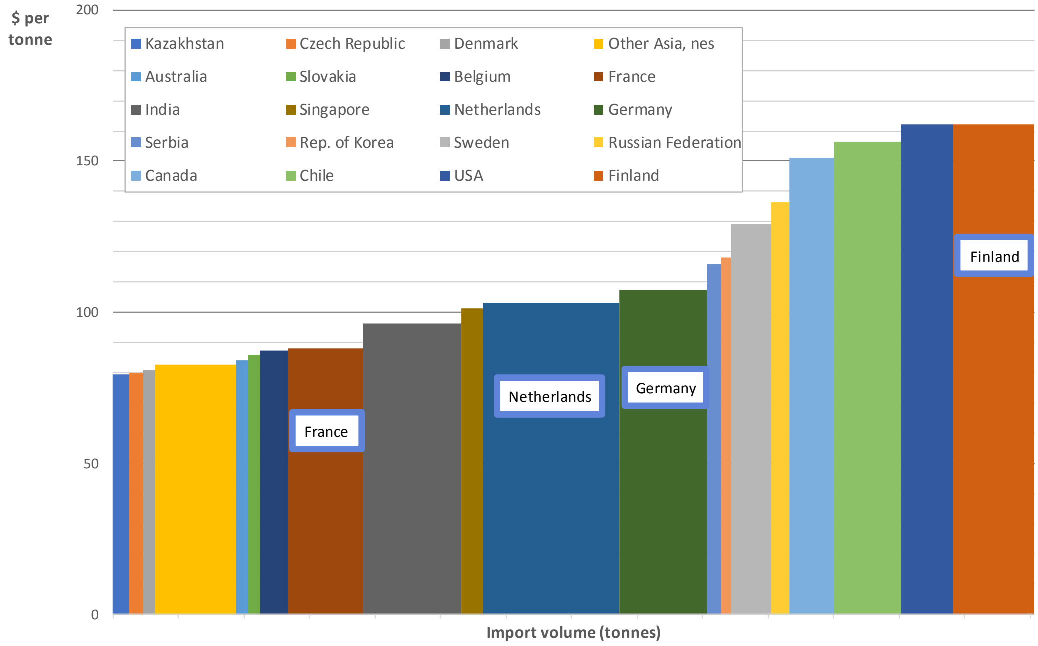
	SK	IT	TR	CZ	AR	MY	NO	TH	DE	SE	BE	ES	NZ	AE	CN	PL	VN	FR	US	CA
Netweight (1000 tonne)	100	112	93	137	351	138	211	158	689	126	631	137	125	236	114	119	515	716	259	292
Trade Value (US$ million)	8	9	8	12	32	13	21	16	70	13	71	15	14	27	13	15	64	92	41	47
Unit Value ($ per tonne)	82	82	85	85	92	98	99	101	101	106	112	113	114	115	116	122	125	129	160	160

Source: Ecorys based on UN Comtrade

In terms of imports, as shown in the figure below[124], the Netherlands is the largest importer of lime products, followed by India, Germany, other Asia NES[125], Finland and France. These data indicate the continuing importance of the EU in international trade flows for lime, although this primarily concerns intra-EU trade flows. However, looking over time (not shown), it is evident that Asian markets – most notably India – are of growing importance as an importer of lime products. Among the leading importers of lime products, unit values are highest for Finland, followed by the US, Chile and Canada.[126] The apparent high value paid for lime imports in Finland ($162/€145 per tonne) mirrors the high production unit values identified earlier in this chapter.

[124] Countries are positioned according to the average unit value of their lime imports.
[125] Not elsewhere specified: this covers exports for which the partner designation is unknown to the country or if an error was made in the partner assignment.
[126] Imports are recorded as a CIF-type value (Cost, Insurance and Freight), which include the transaction value of the goods, the value of services performed to deliver goods to the border of the exporting country and the value of the services performed to deliver the goods from the border of the exporting country to the border of the importing country.

Figure 77: 20 largest global importers of quicklime by weight – volume and average unit value of imports (2015)



	KZ	CZ	DK	Other Asia	AU	SK	BE	FR	IN	SG	NL	DE	RS	KR	SE	RU	CA	CL	US	FI
Netweight (1000 tonne)	87	82	67	450	69	61	162	414	550	119	761	491	77	56	222	101	248	376	293	450
Trade Value (US$ million)	7	7	5	37	6	5	14	37	53	12	78	53	9	7	29	14	37	59	48	73
Unit Value ($ per tonne)	79	80	81	83	84	86	87	88	96	101	103	107	116	118	129	137	151	156	162	162

Source: Ecorys based on UN Comtrade

3.7 Research, development and innovation in the lime sector [127]

The lime industry R&D&I investments are mostly directed towards **improvements in production process**, **innovative new products or applications** and **increased energy efficiency**. One of the key cross-cutting focuses is on the reduction in the environmental footprint of the industry, for instance by cutting GHG emissions. Findings from the interviews indicate that in some cases – especially with regards to CO2 emissions reduction technologies – research is too expensive for single companies. R&D in these areas therefore involves a broad range of stakeholders, including the International Lime Association, EuLA, national lime associations, competitors, universities, research institutes or even customers.

Innovation in the production process starts at the **quarry.** For example, Nordkalk's project to repurpose lime by-products in Finland intends to optimise waste flows to extend the lifetime of quarries. Because of the difficulties faced by some producers with regards to access to quarries, this is an important area of research for the industry.

[127] EuLA (2017) Innovation in the Lime Sector, http://www.eula.eu/sites/default/files/publications/files/Innovation_report_EuLA_2017%2006%2007%20web_0.pdf; ECRA: CCS - Carbon Capture and Storage, https://ecra-online.org/research/ccs/; CEMBUREAU: Innovation in the cement industry, http://www.Cembureau.be/innovation-cement-industry, Buzzi Unicem: Annual Report 2015, http://www.buzziunicem.it/online/download.jsp?idDocument=2799&instance=1, p.44; The Boston Consulting Group: The Cement Sector: A Strategic Contributor to Europe's Future, http://www.Cembureau.eu/sites/default/files/documents/The%20Cement%20Sector%20-%20A%20Strategic%20Contributor%20to%20Europe%27s%20Future.pdf, p.25

Process emissions mitigation is in the focus of innovation activities in the lime sector. Recent and ongoing projects include:

- **CARINA** (Carbon Capture by Indirectly Heated Carbonate Looping Process) was a €2.5 million (EU contribution €1.6 million) FP7 project finished in 2014 promising higher plant efficiency and lower emissions than other CO2 capture technologies;
- **CAPSOL** (Design Technologies for Multi-scale Innovation and Integration in Post-Combustion CO2 Capture: From Molecules to Unit Operations and Integrated Plants) was another programme funded under FP7 and finished in 2014 aimed at developing a solvent based post-combustion CO2 capture technology – among others – for the quicklime production process;
- **BIOXYSORB** (Biomass co-combustion under both air- and oxy-fuel conditions), finished in 2016 (total funding €2.1 million, EU contribution €1.3 million), intended to assess the possibilities of economic low carbon power production and emissions control for biomass co-fired power stations;
- **SCARLET** (Scale-up of Calcium Carbonate Looping Technology for Efficient CO2 Capture from Power & Industrial Plants) was finished in March 2017, and had a budget of €7.3 million (of which €4.7 million was provided by the EU). One of its major goals was to perform tests using Calcium Carbonate Looping (CCL), a low-cost post combustion CO2 capture technology;
- **LEILAC** (Low Emissions Intensity Lime And Cement) is a European Union Horizon 2020 research and innovation project which aims to develop a carbon capture technology to enable a reduction in CO2 emissions for both the cement and lime industries without significant energy or capital penalty. [128] With a budget of €20.8 million (EU contribution €11.9 million) and a wide participation from both lime and cement companies (Lhoist, HeidelbergCement, Cemex, CRH) it is one of the most important innovation projects for both sectors;
- Individual companies are also investing in new production process technologies. For instance, the application of **sensors,** which capture a more granular level of operational data and can operate more reliably under harsh process conditions (i.e. a combustion chamber) has become possible through 3d printing[129];
- JRC's BAT Reference Document mentions four emerging techniques in lime production. These are mostly focusing on **reducing emissions** (carbon monoxide, NOx, SO2) or on **enhancing heat recovery from kilns**.

The industry also intends to improve its **energy efficiency**. Some of the relevant projects are:

- **ADIREN4LIME**: This project, finished in 2015 (total funding €11.9 million), was aimed at reducing energy costs by using an Anaerobic Digester, which breaks down organic biomass in anaerobic conditions and generates biogas. This can be used to produce electricity or fuel for lime kilns;
- **ECOLOOP**: Started in 2015, the project's objective is to assess the generation of gas from synthetic waste as an energy surplus.

Because of the wide range of uses, innovations in lime applications include several areas as well. Carmeuse's **HEMPCRETE** project targeted increased energy efficiency in buildings by using hemp-lime based construction materials. **ULCOS** (Ultra-Low CO2 Steel Making), an FP6 project with a budget of €35.3 million and an EU contribution of €20 million, was finalised in 2010 and included – among others – Lhoist as a partner. Its main priority was to reduce CO2 emissions in

[128] Leilac, 2016, LEILAC Project Overview, https://www.sintef.no/contentassets/d0556618d34a4563a89e8e681f781419/3-presentation_adam_vincent.pdf

[129] Dr. Carlo Cella, Dr. Francesco Cella and Edoardo Cella: Driving Innovation in Product Design and Manufacturing Using 3D Printing, January 2017, https://www.iiconsortium.org/news/joi-articles/2017-Jan-Driving-Innovation-Product-Design-Manufacturing-3D-Printing.pdf, accessed March 2017, p.2

the steel industry. Fels' **low-dust compacted mortar pellets** is another product in development. It is intended to reduce workers' exposure to dust on building sites, and therefore to facilitate compliance with Occupational Exposure Limits (OEL).

Innovation at end of life also covers diverse areas. Carmeuse is one of the partners working on a plasma metal recovery project called **PLASMETREC**, providing its expertise in flue gas treatment. Lhoist took part in **PLD**, a €13 million project (of which €4.9 million is EU funded, under LIFE+) ended in 2015 and aimed at de-oiling oily steelmaking by-products.

Analysis of patents filed by European lime producers also gives an insight into some of the most important areas for innovation. Between 2005 and 2011, the top 5 applicants patented approximately 83 inventions. These inventions are mainly related to water and sludge treatment, construction and flue gas treatment.[130]

In addition to the above, findings from interviews point to **phosphorous looping** and **desulphurization in sea vessels** as interesting research areas for the industry.

Results from interviews point out that the industry is trying to promote the use of lime in the treatment of wastewater and to enhance environmental applications for lime. Research is conducted on new applications of lime as a construction material as well. Another important strategy for lime companies is to try to increase exports, because of the limited size of their domestic market.

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[130] EuLa, 2014, Technical Report: A Competitive and Efficient Lime Industry, https://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwi1mP6s9OTSAhXEliwKHYLeAHMQFggvMAI&url=http%3A%2F%2Fwww.eula.eu%2Ffile%2F477%2Fdownload%3Ftoken%3DG4HAme1u&usg=AFQjCNGdgI1k7QyB7xmnxYzIMIWGQzVfFQ&sig2=JVG7Djf0EQRfMK4adMUWXA&bvm=bv.149760088,d.bGg&cad=rja, accessed March 2017

4 Regulatory and other framework conditions

This chapter gives an overview and selection of key regulatory framework conditions, while also evaluating their impact and influence on the performance of the sectors concerned.

4.1 Introduction

4.1.1 Regulatory and other framework conditions and their impact on competitiveness

Each company and industry acts within a setting that it cannot or only partially influence. This setting is defined by exogenous factors such as Climate Change or economic crises as well as the policy and regulatory framework or institutional set-up providing rules, defining minimum standards, guarantees and limits to businesses[131].

While exogenous conditions cannot be directly changed, framework conditions, be they of regulatory nature or non-regulatory nature, are being defined by governments. The Policy Framework (both EU and Member State level) allows for the design and implementation of regulatory and non-regulatory policies that have a bearing on the framework conditions and to a greater or lesser degree on market and exogenous conditions. At the EU-level, a set of wider policies driven by the Europe 2020 Strategy and policies beyond 2020 are of key relevance to the performance of industry, including competition policy, climate policy, consumer policy, trade and international regulation, infrastructure policy, standardisation (both industrial and markets), energy policy, environmental policy and regional policy.

Within the broader Europe 2020 Strategy, the Integrated Industrial Policy[132] forms a specific policy response to the needs of EU-industry. It focuses on industrial innovation, the skills base, resource-efficiency and a targeted industrial policy. This integrated industrial policy approach is clearly embedded within the broader Europe 2020 Strategy, and it interacts with a wide range of other policies and Flagships (including, for instance, the Innovation Union and better regulations for innovation-driven investment at EU level[133] and a Resource-efficient Europe[134]). At the same time, industrial policy needs to comply with the 'polluter pays' principle as set out in Article 191 of the TFEU[135]. It is equally important for the Integrated industrial policy to be linked to initiatives at national and regional level – for instance, in the area of capacity building, investment, education and training. Coherence, coordination and integration of policies can only take place through involvement of multiple levels of governance.

[131] JRC (2016): Assessment of Framework Conditions for the Creation and Growth of Firms in Europe, see: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103350/jrc103350.pdf

[132] COM (2010) 614 final: An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0614:FIN:EN:PDF

[133] RTD (2016): SWD Better regulations for innovation-driven investment at EU level, see: http://ec.europa.eu/research/innovation-union/pdf/innovrefit_staff_working_document.pdf#view=fit&pagemode=none

[134] EREP (2013): Action for a Resource Efficient Europe, see: http://ec.europa.eu/environment/resource_efficiency/documents/action_for_a_resource_efficient_europe_170613.pdf

[135] TFEU (2012): Article 191 (2), see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT , states: *"Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. In this context, harmonisation measures answering environmental protection requirements shall include, where appropriate, a safeguard clause allowing Member States to take provisional measures, for non-economic environmental reasons, subject to a procedure of inspection by the Union."*

All framework conditions can affect industries' competitiveness in a positive or negative way. The main forms are:

- **Defining the level playing field**: framework conditions define the level playing field for all companies. They define the conditions under which companies operate and compete, what they are allowed to do and what not and to what extent competitors from outside the same regulatory and policy background are allowed to enter the local market;
- **Guaranteeing minimum societal standards**: minimum safety or environmental standards guarantee compliance of industries with societal ambitions. This aspect addresses the daily lives of workers, but also society as a whole in terms of use of nature and natural resources;
- **Targeting skills shortage**: education and training policies address skills shortages of private companies;
- **Influencing transformation and modernisation of industries through innovation**: industrial policies support the transformation processes towards modern industries and as such influence the competitiveness of the industries in the future;
- **Causing administrative costs and limiting flexibility**: compliance with legislation requires companies to spend time and efforts on such compliance activities and limits them in their flexibility of operating their businesses.[136]

To what extent the competitiveness of industries is affected in either way also depends on their response capacity.

Before assessing regulatory and other framework conditions in further detail, it is important to underline that the various types of legislation vary significantly in terms of scope and character, especially with regard to the legal jurisdiction. Within the context of the European Union, an important part of the national legal system finds its origin in the EU primary and secondary legislation[137], but this is not necessarily the case and differs per policy field. Besides that, the Member States often have a broad discretionary power with regard to the implementation of legislation, especially in the case of EU directives. This implies that EU legislation as such has multiple dimensions and that a clear distinction needs to be made with regard to the legal authority for the legislation (i.e. European or national authorities or even local authorities).

4.1.2 Cost and benefits of regulation

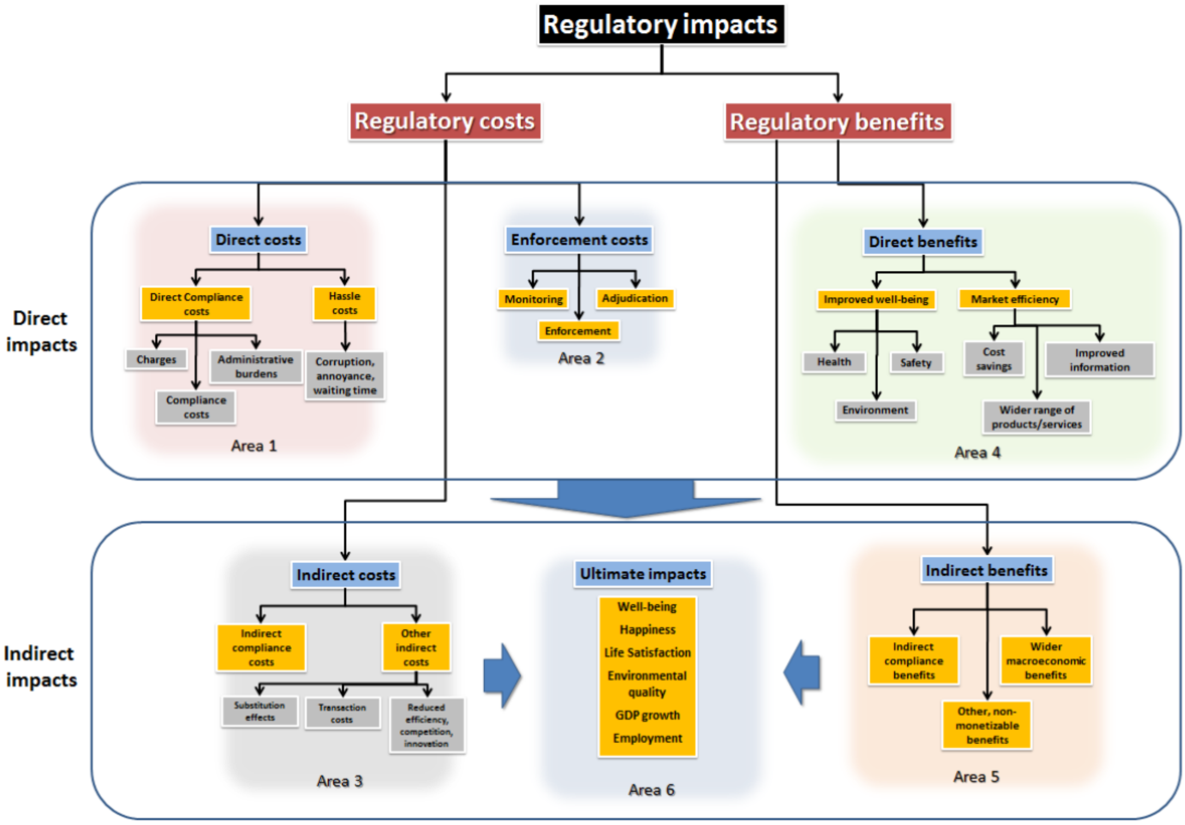
Next to their primary regulatory targets, regulatory framework conditions should also be aligned to support the overall business environment. While it is acknowledged that such a framework contributes to "business conduct cost" of firms while also creating benefits to the industries and particularly societies, it is difficult to quantify the specific costs and benefits.[138]

Other (non-regulatory) framework conditions (such as skills policy initiatives, support of access to finance, development of infrastructure) are generally perceived by industries mainly as a benefit[139] and its cost are covered by the society (through tax contributions). Regulatory framework conditions can however cause to industries both, costs and benefits. Benefits usually coincide with the reasons why legislative acts have been implemented. Costs on the other hand are often caused unintentionally. According to a classification by CEPS (2013), both costs and

[136] OECD (1997): Regulation and Industrial Competitiveness: A Perspective for Regulatory Reform, see: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD(97)133&docLanguage=En
[137] EU primary legislation refers to the EU treaties; EU secondary legislation refers to the regulations, directives and decisions.
[138] OECD (1997): Regulation and Industrial Competitiveness: A Perspective for Regulatory Reform, see: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD(97)133&docLanguage=En
[139] Ecorys based on sector interviews

benefits can be further divided into direct and indirect costs/benefits. An additional cost factor occurs in the form of enforcement costs.[140] The figure hereunder provides a further breakdown of cost and benefit categories.

Figure 78 Categories and sub-categories of regulatory impacts



Source: CEPS (2013): Assessing the Costs and Benefits of Regulation, see: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf

To quantify costs of regulation, the most common method is to apply the Standard Cost Model (SCM) or modified versions of it. The SCM allows to break legislation down into obligations and to assess their net cost imposed by legislation[141].

Box 19: Standard Cost Model (SCM)

The core equation of the Standard Cost Model is: Administrative cost = Σ P x Q. P represents the costs of all obligations and Q the number of occurrences of the obligation. To be able to quantify the total administrative cost it is therefore necessary to identify individual obligations (such as filling in forms, understanding requirements etc.), the cost of conducting them (such as the wage of persons implementing them or copy cost) and how frequent they are being implemented (once a year, once a week, one a week etc.). An additional factor of complication is that the SCM compares the situation to what is called the "Business as Usual"(BaU) situation. The BaU is defined as an absence of any legislation.

Even though benefits of regulation are mainly represented in the fulfilment of the policy ambition and hence the reason for developing a specific legislation, their quantification in the form of 'one number' is difficult, as benefits are more challenging to be compared and cannot be

[140] CEPS (2013): Assessing the Costs and Benefits of Regulation, see: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf

[141] EC (2017): Revised Better Regulation Toolbox, TOOL #60. THE STANDARD COST MODEL FOR ESTIMATING ADMINISTRATIVE COSTS, see: http://ec.europa.eu/smart-regulation/guidelines/toc_tool_en.htm

presented in the form of monetary values. The quantification of benefits therefore needs to focus on providing a set of indicators illustrating the diverse benefits.[142]

Costs of regulation for industries

Types of costs usually assessed focus on direct cost categories including administrative, compliance costs and charges.[143] The impacts of such costs on industries are debated. A study from the US argues, while not quantifying the actual cost of regulation, that increased regulatory pressure on the cement industry would make imports more likely as it reduces the competitiveness of local production in comparison to international competitors[144]. At an EU level the ambition in recent years was therefore to improve the understanding of such costs. Existing studies to assess the cumulative cost of EU legislation on several other similarly structured industries aim to therefore aggregate such regulatory costs and to express them in the form of ratios €/tonne, as shares of production cost or as shares of turnover. The four cumulative cost assessments (CCA) indicate that the interpretation of the costs of regulation depend on the way of measurement, e.g. in €/tonne, in %/costs or in % of EBIT or EBITDA. Regulatory costs can be higher when expressed in the latter ways, especially so in years where profits are small or negative.

The CCA for the steel and aluminium industries showed that for the assessed sectors the average costs generated by EU rules represented 8% (and never more than 10%) of total production costs[145]. The CCA on chemicals estimated the costs to be at about 2% of the turnover of the industry[146], for forest based industries the estimate is at 1.3% of their turnover[147], for the ceramic sector between 1.2% and 5.4% of production cost depending on sub-sector and year and for glass 1.5% - 4.7% of production cost[148]. In this context two specific topics are important to mention (see boxes).

Box 20: Gold-plating as a factor of complexity

A methodologically challenging factor in assessing regulatory cost is the identification of source of cost. So-called 'Gold-plating' (meaning that national authorities add additional requirements to EU Directives, which were not intended by the Directives) has particularly been observed in Structural Funds[149]. However, also industrial stakeholders raise concerns that the form of national implementation of EU Directives is often stricter and more demanding than what is requested.[150] Reasons for this can be e.g. previously higher national standards or specific policy priorities. Consequently, cost quantifications of EU Directives risk to be upward biased by national implementation decisions. Moreover, additional national rules can cause differences in treatment for the same activity in different Member States. EU Regulations are hence seen as more efficient solutions.[151]

[142] CEPS (2013): Assessing the Costs and Benefits of Regulation, see: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf and EC (2017): Revised Better Regulation Toolbox, TOOL #59. Methods to Assess Costs And Benefits
[143] CEPS (2013): Assessing the Costs and Benefits of Regulation, see: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf
[144] SMU COX(2010): Economic Impacts of Cement Industry Regulations: The Proposed Portland Cement NESHAP Rule, see: http://cement.org/newsroom/SMU/09%20SMU%20Study%20on%20Impact%20of%20EPA's%20NESHAP.pdf
[145] CEPS, EA (2013): Assessment of Cumulative Cost Impact for the Steel and the Aluminium Industry, see: https://www.ceps.eu/system/files/final-report-aluminium_en.pdf
[146] Technopolis (2016): Cumulative Cost Assessment for the EU Chemical Industry
[147] Technopolis (2016): An assessment of the cumulative cost and impact of specified EU legislation and policies on the EU forest-based industries
[148] CEPS, Economisti Associati, Ecorys (2017): Cumulative Cost Assessment for the Ceramics and Glass Industries
[149] See: Spatial Foresight (2017): Research for REGI Committee - Gold-plating in the European Structural and Investment Funds, or Ecorys (2015): Gold-plating in the EAFRD, To what extent do national rules unnecessarily add to complexity and, as a result, increase the risk of errors?
[150] Interviews with industry representatives
[151] Interviews with industry representatives

Box 21: Cost pass-through reducing the burden for the industry

Cost pass-through refers to the increase of the price a customer pays because of an increase in a company's costs[152]. This can be particularly observed in sectors with high market power and low substitution of their products, meaning that customers will also have to buy products of higher prices. The higher the possibility to pass through costs for an industry, the lower is the regulatory cost impact on them (as they can pass the costs on to their customers). On this topic various studies have been published, showing a different result on whether or not cost pass-through in the cement and lime industries exists and to what extent it exists:

- The study by CE Delft and Oeko-Institut (2015, a study for the EC)[153] states that "*the literature offering empirical estimates of the pass-through of carbon costs for industrial products remains relatively scarce. (….) when comparing the results of these studies in more detail, it becomes apparent that the quantified cost pass-through rates vary substantially across studies. Clearly, the exact extent to which costs are estimated to be passed through is highly dependent on the methods chosen and the data used*." The study then estimates pass-through rates of 35-40% in clinker for France, Germany and Poland, 90-100% in Portland cement in the Czech Republic and Poland and 20-40% in total cement in France and Germany.
- The Walker (2006) study estimates the cement cost pass-through in France and Germany at below 30% and Italy below 10%[154]
- The Alexeeva-Talebi (2010) study estimates the pass-through for cement, lime, plaster at 73%[155].
- Cost pass-through is also an important factor in NERA's analysis of the potential impact of ETS. The paper concludes that a complete pass through of costs of CO2 emissions for lime producers is unlikely under ETS without risking market share loss and long-term profits, as this would expose them to being undercut by non-EU suppliers.[156]

The variety of results across studies shows that it is difficult to name one definite and everywhere applicable cost-pass through rate. Both sectors working largely in markets with limited trade in-flows this result is however not surprising. The individual cost-pass through capability depends on the number of factors, but particularly on the market power a company has towards its clients. In regional markets with high concentration, higher cost-pass through can be expected and vice-versa.

Benefits of regulation for industries and citizens

Direct benefits of regulation can be additional citizens' utility, welfare or satisfaction and improved market efficiency. Indirect benefits include spill over effects related to third-party compliance with legal rules, wider macroeconomic benefits or other non-magnetisable benefits[157]. Attempts of such assessments in an aggregated form have been conducted. The study assessing the benefits of chemicals legislation on human health and the environment for example, developed a list of indicators demonstrating the improvement for society[158].

[152] http://dictionary.cambridge.org/dictionary/english/pass-through

[153] CE Delft and Oeko-Institut (2015): Ex-post investigation of cost pass-through in the EU ETS. An analysis for six sectors, see: https://ec.europa.eu/clima/sites/clima/files/ets/revision/docs/cost_pass_through_en.pdf

[154] Walker, N. (2006), Concrete Evidence? An empirical approach to quantify the impact of EU Emissions Trading on cement industry competitiveness, Working Paper PEP 06/10, School of Geography Planning and Environmental Policy, University College Dublin.

[155] Alexeeva-Talebi (2010): Cost Pass-Through in Strategic Oligopoly: Sectoral Evidence for the EU ETS, see: ftp://ftp.zew.de/pub/zew-docs/dp/dp10056.pdf

[156] NERA (2008), p. 57

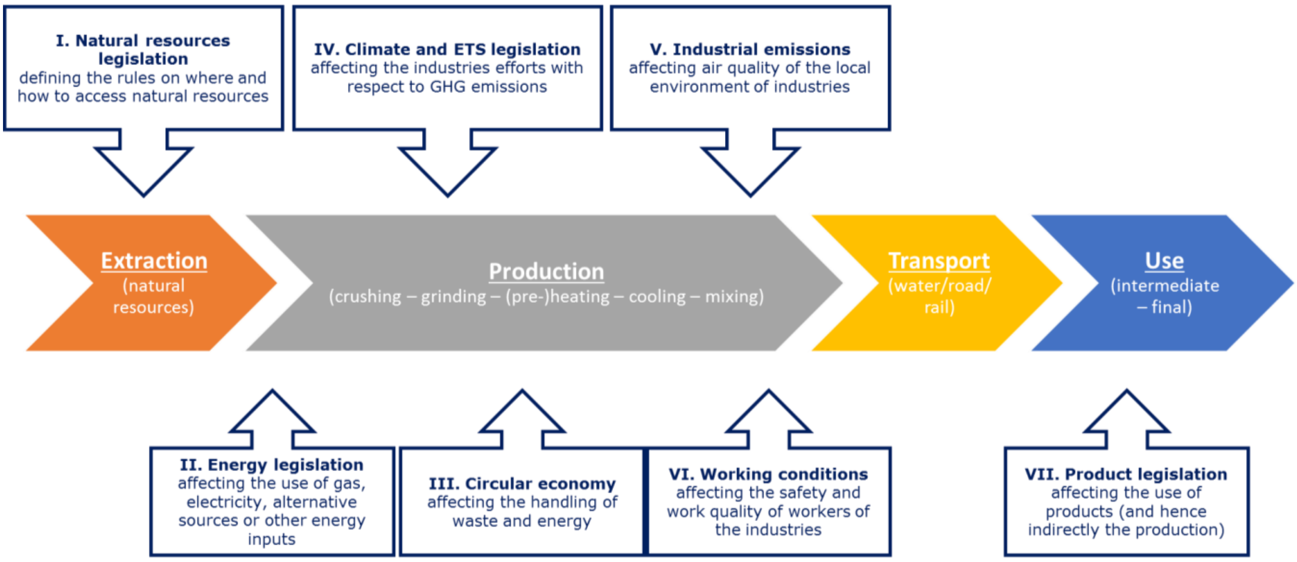
[157] CEPS (2013): Assessing the Costs and Benefits of Regulation, see: http://ec.europa.eu/smart-regulation/impact/commission_guidelines/docs/131210_cba_study_sg_final.pdf and EC (2017): Revised Better Regulation Toolbox, TOOL #59. Methods to Assess Costs And Benefits

[158] RPA, DHI (2016): Study on the calculation of benefits of chemicals legislation on human health and the environment, see: http://ec.europa.eu/environment/chemicals/reach/pdf/study_final_report.pdf

4.1.3 Identification of key regulatory themes affecting the industries

The operation of cement and lime companies is affected by a set of rules defining standards and form of production, their location and output. This study focuses on EU rules and hence only touches upon national specificities or laws where they are in a direct relationship with EU legislation. EU rules affecting the industries can be grouped into a set of themes leading from the extraction of natural resources, to production, transport and use of the product.

Figure 79 Overview of key legislative themes



Source: Ecorys

The themes are affecting the different steps in the production process in the following way:

- **Extraction of natural resources**:
  - Theme I: Natural resources legislation defining the rules on where and how to access natural resources;
- **Production of cement and lime including crushing, grinding, (pre-)heating, cooling and mixing of raw materials:**
  - Theme II: Energy legislation affecting the use of gas, electricity, alternative sources or other energy inputs;
  - Theme III: Circular economy affecting the handling of waste and energy;
  - Theme IV: Climate and ETS legislation affecting the industries efforts with respect to GHG emissions;
  - Theme V: Industrial emissions affecting air quality of the local environment of industries;
  - Theme VI: Working conditions affecting the safety and work quality of workers of the industries;
- **Use:**
  - Theme VII: Product legislation affecting the use of products (and hence indirectly the production).

Based on desk research and the feedback from scoping interviews with industry associations, feedback from the study Mirror Group and the company survey (see annex B for more details), the following list of key legislative acts have been identified per Theme:

Table 12 Key EU legislative acts for each of the 7 identified themes

Key EU legislative acts per Theme
Theme I: Natural resources
• Natura 2000 and Biodiversity - Birds Directive 2009/147/EC and Habitats Directive 92/43/EEC • Mining Waste Directive 2006/21/EC **Raw material supply** • Water Framework Directive 2000/60/EC • Waste water treatment directive 91/271/EEC of 21 May 1991 • Waste Shipment Regulation 1013/2006/EC Directive 2008/98/EC on waste (Waste Framework Directive)
Theme II: Energy legislation
• Internal market gas and electricity (Directive 2009/72 and 73 /EC) • Cross border transmission gas and electricity (Regulation 714 and 715/2009) • Renewable Energy Directive (Directive 2009/28/EC) • Energy Efficiency Directive (Directive 2012/27/EC) • Energy Taxation Directive (Directive 2003/96/EC)
Theme III: Circular Economy
• Circular Economy Action Plan Package (COM/2015/0614 final) • Waste to Energy Communication - Waste Shipment Regulation 1013/2006/EC - Directive 2008/98/EC on waste (Waste Framework Directive) • Energy Efficiency of Buildings Directive (Directive 2010/31/EC) • Heating and cooling strategy 2016
Theme IV: Climate and ETS legislation
ETS and GHG emissions: • Carbon leakage list (Decision *2014/746/EU*) • ETS-trading scheme (Directive 2003/87/EC) • 3rd phase of ETS (Directive 2009/29/EC) • Transitional Union-wide rules for harmonised free allocation of emission allowances (Decision 2011/278/EU)
Theme V: Industrial emissions
• Industrial Emissions Directive (Directive 2010/75/EU) + Best Available Techniques Reference Document (BREF) documents • Ambient air quality Directives (2008/50/EC and 2004/107/EC) • National Emission Ceilings Directives (2016/2284/EU) as the instrument of the Clean Air Programme
Theme VI: Working conditions
• Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) • Carcinogens or Mutagens Directive (2004/37/EC) • Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work • Directive 89/656/EEC on the Use of Personal Protective Equipment • Vibration Directive (Directive 2002/44/EC) • Legislation dealing with chemical hazards/risk at work (Directive 98/24/EC)
Theme VII: Product legislation
• Regulation EU/305/2011 on Construction products

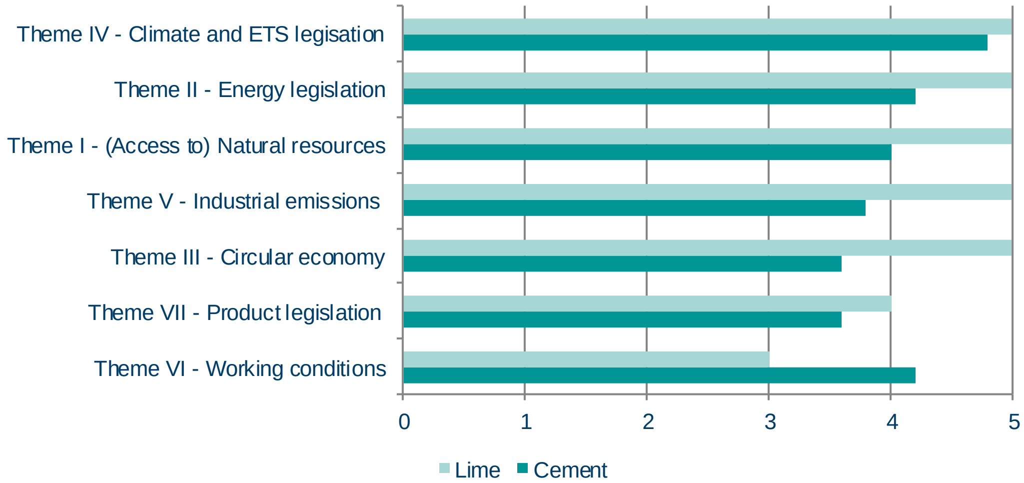
4.2 Analysis of key regulatory framework conditions

Building on the identification of relevant regulatory themes and other framework conditions, surveys amongst (i) eight national associations representing the cement and lime industries in a selection of the most important (and most representative) EU Member States and (ii) the company survey with cement and lime companies in the same Member States have been carried out in the context of this study (for more details see Annex B). They allow the identification of key policy areas of interest for the industries and set the base for further in-depth analysis of them.

4.2.1 Prioritisation of key regulatory Themes and other relevant framework conditions

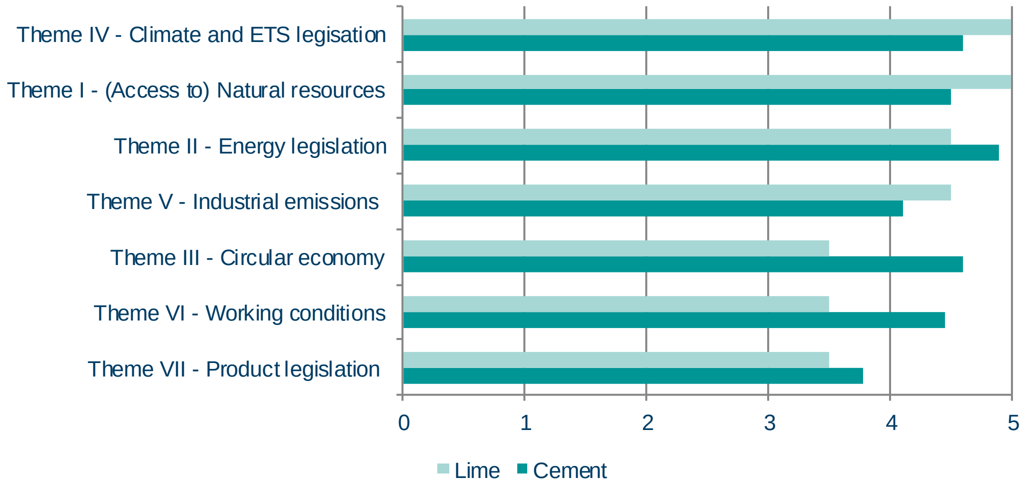
As a starting point for the prioritisation, those public policy areas were listed which (a priori) were assessed to be important for the lime and cement industries[159]. This selection is presented in the next figure, and covers the seven themes introduced above. The national associations have scored these legislative areas on a 0-5 scale, with 5 indicating a most pressing issue. Most of the themes are considered to be 'important' or 'very important', with Climate and energy legislation, as well as access to natural resources, as most relevant regulatory topics.

Figure 80 National associations- ranking regulatory drivers, lime and cement



Source: Ecorys industry survey (n=8, in 5 different countries)

Figure 81 Companies – ranking regulatory drivers, lime and cement



Source: Ecorys industry survey (n=19, in 6 different countries)

The four most pressing issues identified by the companies are the same as the ones by the industry associations. Climate and ETS, (access to) natural resources, energy legislation and industrial emissions are seen as the most important legislative areas.

[159] This listing was primarily based on the insights from previous competiveness studies and the reports on cumulative costs which were published in the recent years for various industries (see section 4.2).

Analysis of prioritised regulatory Themes

The analysis of Themes provides for each of them (a) an introduction in the key Theme and (b) insights on how it influences the industry competitiveness (based on the definition outlined in chapter 1). The analysis presented hereafter is then based on this prioritisation:

1. Theme IV: Climate and energy legislation/ETS;
2. Theme I: Natural resources;
3. Theme II: Energy legislation;
4. Theme V: Industrial emissions;
5. Theme VI: Working conditions;
6. Theme VII: Product legislation;
7. Theme III: Circular Economy.

4.2.2 Climate and ETS legislation

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by four legislative acts:

- **Carbon leakage list** (Decision 2014/746/EU)[160]: providing a list of industries assessed to be at risk of carbon leakage and therefore need to be protected of financial burdens, which might cause their moving to cheaper non-EU production locations;
- **ETS-trading scheme** (Directive 2003/87/EC)[161]: establishing a scheme for GHG emission allowance trading within the EU;
- **3rd phase of ETS** (Directive 2009/29/EC)[162]: modifying the ETS-trading scheme and defining its functioning and parameters for the period 2013-2020;
- **Transitional Union-wide rules for harmonised free allocation of emission allowances** (Decision 2011/278/EU)[163]: providing further clarification and harmonisation for the free allocation of emission allowances for the ETS system.

In line with the 'polluter pays' principle as set out in Article 191 of the TFEU, and with the aim to implement the most efficient form to reduce GHG emissions and meet its international commitments, the EU established the world's first major carbon market, the EU Emissions trading system[164]. The EU ETS is a cap-and-trade system that sets a limit (cap) on the total amount of emissions and allows under this limit for the trading of emission allowances between companies. By setting a cap, the EU ETS puts a price on carbon emissions and internalizes the societal costs related to emissions. This cap reduces over time in order to stimulate further emission reduction.

[160] Decision 2014/746/EU, determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage, for the period 2015 to 2019, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014D0746&from=EN

[161] Directive 2003/87/EC, establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0087&from=EN

[162] Directive 2009/29/EC, amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF

[163] Decision 2011/278/EU, determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:130:0001:0045:EN:PDF

[164] UN (1998): Kyoto Protocol to the United Nations Framework Convention on Climate Change

The EU ETS has been in place since 2005 and is now in its third phase[165] (2013 to 2020) which brought an EU-wide approach (as opposed to the national approaches used in the first two phases) through an EU-wide cap and harmonised rules for free allocation[166] of allowances to industry. While auctioning is meant as the default method for companies to get emission allowances (57% of all emissions are traded through these auctions), free allocation is still given out to companies. In July 2015 the EC has tabled a legislative proposal to revise the EU ETS for its fourth phase (2021 – 2030) to ensure the EU is on track to achieve its objective of reducing emissions by 40% by 2030, as compared to 1990 levels[167]. The legislative process regarding the revision is on-going (currently advanced discussions in the context of "trilogues"). A number of industrial sectors and sub-sectors are part of the so-called "Carbon Leakage" list[168], which includes (sub-)sectors that are deemed to be exposed to a significant risk of carbon leakage as they have to compete with companies from third countries with no/limited comparable climate policies. Sectors on the list therefore receive a higher share of free emission allowances. Both the cement and lime industry are on this list based on their high emission intensity. In 2016 the verified emissions (of stationary installations) in the EU-28 were approximately 1,750 Mt of CO_2 equivalents.[169] In 2016 the verified emissions for the cement and lime industries were respectively 115 Mt of CO2 equivalents (7% of total) and 31 Mt of CO2 equivalents (2% of total). Based on the current proposals being discussed in the context of the ETS revision for phase IV, it seems likely that both sectors will remain on the carbon leakage list, however this is subject to the final decision by Council and European Parliament.

Impact on competitiveness

Even though currently protected by the carbon leakage list, the potential future impact of the ETS system may cause increased cost for the industries and at the same time (under certain conditions) increase their incentive to innovate in the field of GHG reduction.[170]

As indicated above both the cement and lime industries currently receive a share of free allowances (based on benchmarks) as they are on the carbon leakage list. Figure 82 shows the emissions, allowances and the surplus of allowances accumulated by the cement clinker industry under the EU ETS since 2005. Between 2009 and 2012, arguably due to the economic crisis, the allowances the cement clinker industry received exceeded their actual emissions, while in the third phase this surplus was much smaller. The level of free allowances is closer to their emissions.

[165] Directive 2009/29/EC amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community

[166] Decision 2011/278/EU determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council

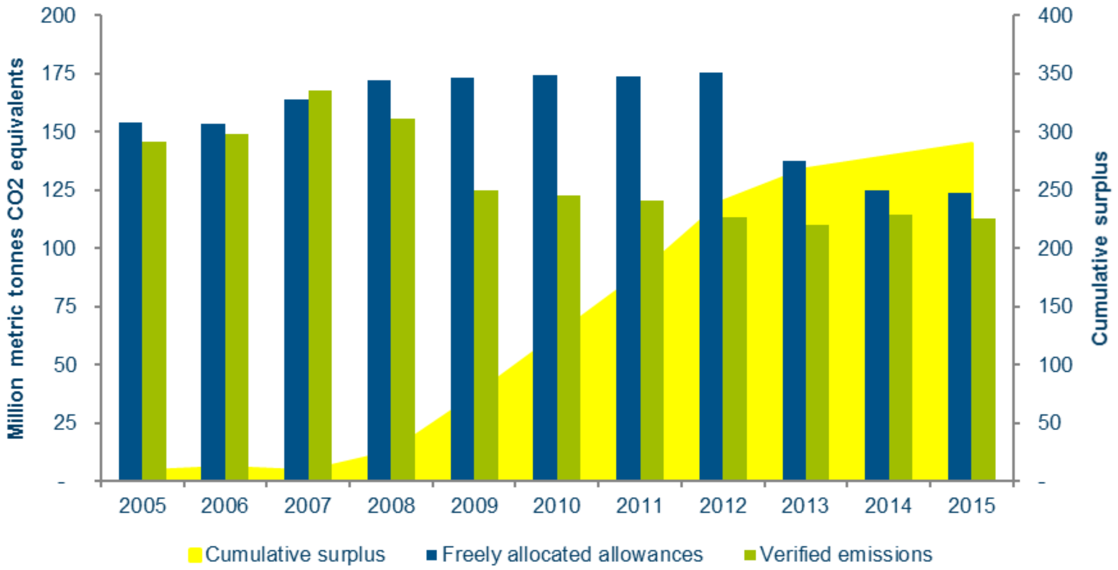
[167] https://ec.europa.eu/clima/policies/ets_en

[168] European Commission, Decision 2014/746/EU determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage, for the period 2015 to 2019.

[169] EU Emissions Trading System (ETS) data viewer. This covers all stationary installations. The categories 'aviation' and 'combustion of fuels' are not included.

[170] Interviews with national associations and companies. This trade-off depends on the circumstances and the potential of investments to reduce specific costs.

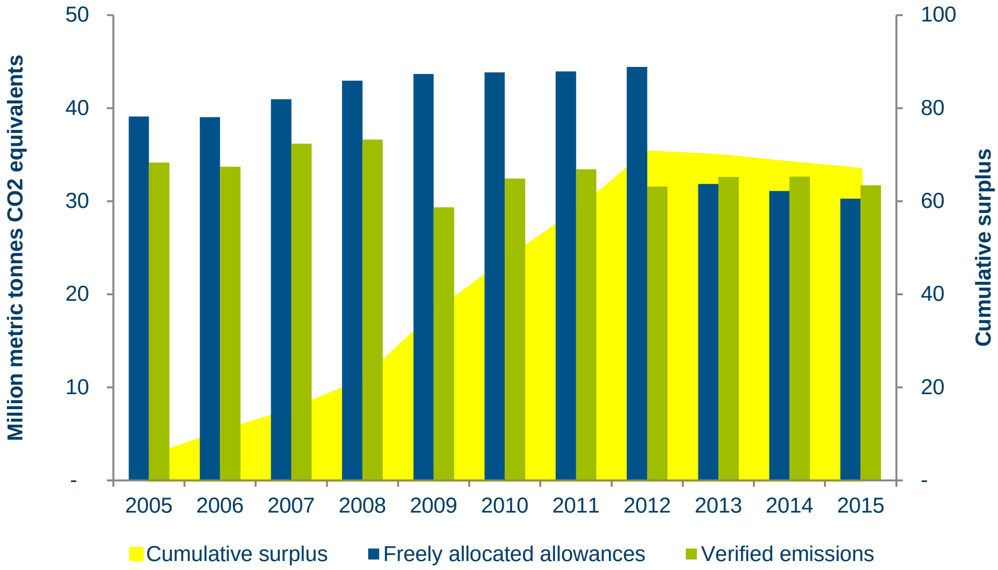
Figure 82 Emissions, allowances, surplus in the EU ETS for cement clinker, 2005-2015 (in million metric tonnes CO2 equivalents)



Source: European Environmental Agency data, Ecorys calculations.

The next figure presents the same information for the lime industry. In the years between 2005 and 2012, the lime industry consistently received more allowances than its emissions, which led to a significant accumulation of excess allowances. Since 2013, the lime sector has on average higher emissions than the allowances it receives, but is able to utilise its accumulated surplus to avoid carbon costs.

Figure 83 Emissions, allowances, surplus in the EU ETS for lime production, 2005-2015 (in million metric tonnes CO2 equivalents)



Source: European Environmental Agency data, Ecorys calculations

While the two figures present the aggregated situation for the European industry, the situation for individual companies can be different. Due to the set-up of the system to allocate the free allowances based on a benchmark of the average emissions per produced tonne of the 10% best performers in the industry in a certain period, less efficient companies will have to buy allowances, whereas the top performers receive more allowances than they need. For the underperformers, this constitutes a cost driver which however also represents an incentive to innovate and reduce emissions. Currently this impact on the industries is rather limited, mainly because a large share of allowances is still 'free', the sectors are using the accumulated surplus, whilst the current carbon price is low. However, the majority of the industry operators stated that they were concerned about substantial future cost increases[171]. Such potential cost increases are directly related to the question to what extent the industries are able to pass-on cost changes to their downstream clients.

With regard to the future, given their high emissions and long-term use of capital investments (e.g. investments for each adjustment of technology amount to several million euro[172] and is therefore intended to be used for many years - a kiln's lifetime is between 30-50 years[173]), the industries therefore perceive potential policy changes in the ETS segment as a risk for business operations and thus call for long-term policy stability[174].

An increase of EU production costs could also increase the risk of production being shifted towards non-EU countries. The current data (see chapters 2 and 3), however do not indicate strong trade intensity for cement and lime, especially given that the products of the two sectors are mainly locally consumed. This is also confirmed by the assessment conducted by the European Commission in the context of establishing the current carbon leakage list.[175] However, as discussed in Section 2.8.2, following the EU ETS trade intensity indicator, cement clinker has a high trade intensity.

The fourth ETS phase (2021-2030) is currently being negotiated. While each new ETS phase has so far been longer than the previous one, and the issue of free allocation is settled at the beginning of each phase to ensure predictability to the maximum extent possible, the duration of ETS phases remain shorter than the investment horizon of many companies and therefore might influence investment decisions[176].

[171] Based on company interviews
[172] JRC (2013): Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide, see: http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_Published_def.pdf
[173] See for cement: http://lowcarboneconomy.cembureau.eu/index.php?page=thermal-energy-efficiency and for lime: http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_Published_def.pdf
[174] WBCSD (2015): Cement industry calls for long-term policy certainty as it aspires to reduce CO2 emissions by 20-25% by 2030, see: https://www.wbcsdcement.org/pdf/20151208_press%20release_LCTPi%20Cement.pdf
[175] European Commission (2014), Impact Assessment accompanying the document Commission Decision determining, pursuant to Directive 2003/87/EC of the European Parliament and the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage for the period 2015-2019.
[176] See for cement: http://lowcarboneconomy.cembureau.eu/index.php?page=thermal-energy-efficiency and for lime: http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_Published_def.pdf

4.2.3 Natural resources

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by six types of legislative acts:

- **Natura 2000 and Biodiversity** (Directives 2009/147/EC and 92/43/EEC)[177] [178]: providing the largest network of protected areas in the world[179], conserving wild birds and natural habitats and wild fauna;
- **Mining Waste** (Directive 2006/21/EC)[180]: amending the Directive on environmental liability concerning environmental damage (Directive 2004/35/EC)[181] providing guidance and measures to prevent or reduce adverse effect on the environment;
- **Water** (Directive 2000/60/EC)[182]: establishing a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater;
- **Waste water treatment** (Directive 91/271/EEC)[183]: protecting the environment from the adverse effects of waste water discharges;
- **Waste Shipment** (Regulation 1013/2006/EC)[184]: establishing procedures and control regimes for the shipment of waste, depending on the origin, destination and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination;
- **Waste** (Directive 2008/98/EC)[185]: lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use.

Since 1997, it is a requirement under the EC Treaty, that "environmental protection requirements must be integrated into the definition and implementation of the Community policies"[186]. Thus, environmental concerns are considered in the activities and decisions of all sectors. The European environmental policy rests on the principles of precaution, prevention and rectifying pollution and source and on the 'polluter pays' principle (as set out in Article 191 of the TFEU). In light of this, a number of legislative acts have been developed throughout time to preserve and strengthen the environment. Those which limit the access or form of access to raw materials are the most relevant for the cement and lime industries[187]:

- The Habitats Directive , which was adopted in 1992, aims to promote the maintenance of biodiversity taking into account economic, social, cultural, and regional requirements. It established the Natura 2000 ecological network of protected areas and forms the cornerstone of Europe's conservation policy along with the Birds Directive. Under the directive, over 1000 animal and plant species and 200 habitat types are protected in various ways including

[177] Directive 2009/147/EC, on the conservation of wild birds, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:0025:en:PDF
[178] Directive 92/43/EEC, on the conservation of natural habitats and of wild fauna and flora, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043&from=EN
[179] http://ec.europa.eu/environment/nature/natura2000/index_en.htm
[180] Directive 2006/21/EC, on the management of waste from extractive industries and amending Directive 2004/35/EC, see: http://eur-lex.europa.eu/resource.html?uri=cellar:c370006a-063e-4dc7-9b05-52c37720740c.0005.02/DOC_1&format=PDF
[181] Directive 2004/35/EC, on environmental liability with regard to the prevention and remedying of environmental damage, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0035&from=En
[182] Directive 2000/60/EC, establishing a framework for Community action in the field of water policy, see: http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF
[183] Directive 91/271/EEC, concerning urban waste water treatment, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31991L0271&from=EN
[184] Regulation 1013/2006/EC, on shipments of waste, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R1013&from=en
[185] Directive 2008/98/EC, on waste and repealing certain Directives, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN
[186] http://ec.europa.eu/environment/integration/integration.htm
[187] Based on sector interviews

designating Sites of Community Importance (SCIs), strict protection regimes, and ensuring that their use is compatible with maintaining them in a good conservation status.

- **Natura 2000**[188] is a European-wide network that stretches over 18% of the EU land area and almost 6% of its marine territory. Its aim is to ensure the long-term survival of Europe's most valuable and threatened species and habitats that are listed under the Birds and Habitats Directive. It was set up under the Habitats Directive and is considered to be the largest coordinated network of core breeding and resting sites for rare and threatened species, and rare natural habitats. The network is not only a system of strict nature reserves, but also of privately owned land. The approach to conservation is centred on the idea of people working with nature rather than against it. Member States must ensure that the sites are managed in an ecologically and economically sustainable manner. The selection procedure of sites depends on the Birds and Habitats Directives. Under the Habitats Directive (Art. 3 and 4), Member States ensure the conservation of each habitat type and species by first proposing list of Sites of Community Importance (pSCIs). Once sites have been adopted, Member States designated them as Special Areas of Conservation (SACs) within six years and adopt conservation measures. Under the Birds Directive (Art. 4), Special Protection Areas (SPAs) are designated for 194 threatened species and all migratory bird species. In general, Member States are responsible for establishing the methods for implementing the Directives and for achieving the conservation objectives of the Natura 2000 sites.
- **The Birds Directive**[189], which dates back to 2008, aims to protect all of the 500 wild bird species that occur naturally in the EU. The directive establishes SPAs that are included in the Natura 2000 ecological framework; it outlines guidelines on bird hunting and trading; and it promotes research to aide in the protection, management, and use of all species under the directive. All Member States have to report on the status and the trends in bird populations (article 12) and as well as report on derogations (article 9) that they may apply to the directive's obligations;
- **The Mining Waste Directive** [190] lays down minimum requirements to minimise the environmental and health risks related to the waste from extractive industries (e.g. coal or limestone). The Directive forbids for example that a waste facility can operate without a permit. This permit is consequently linked to the presence of a waste management plan "for the minimisation, treatment, recovery and disposal of extractive waste". Besides that, operators are amongst others required to have a major-accident prevention policy.

Impact on competitiveness

The main impact of legislative acts in the area of natural resources concerning the competitiveness of the cement and lime industries arises from the limiting or regulating of access and use of natural resources.

The EU harmonised approach internalises the externalities and creates a level playing field on how operators deal with externalities related primarily to the environmental risks of extraction, but also to health and safety risks.

[188] DG ENV- Natura 2000 (http://ec.europa.eu/environment/nature/natura2000/index_en.htm)
[189] Birds Directive- Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. (http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm)
[190] Mining Waste Directive - Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries.

However, it causes compliance costs and opportunity costs for cement and lime companies in the form of limited access to raw materials. According to interviewees and survey respondents, one of the main impacts of the presented legislative acts on such companies is that the access to land and/or raw material (e.g. limestone) is regulated by the Habitats and Birds Directive. This affects the current business operations, by regulating the access to new land or the further use of acquired land. Especially new quarry areas can be affected by (for example) Natura 2000. This does not mean that economic activities are forbidden in those areas, but rather that they are managed in a both ecologically and economically sustainable manner.

Particularly important in this context is that the relevant directives give the Member States (within certain boundaries) room for very diverse forms of implementing the national, regional or local legislation. This implies that there are not only differences in the form of implementation between the various Member States or regions, but also in the extent (restrictiveness) of such directives. Specific examples from company interviews refer to: (i) the differences in the transposition of the Mining Waste Directive in Germany, France, Belgium and the UK, and (ii) the introduction of an additional tax on the use of water in lime stone pits in Poland. Such differences allow on a national or local level to increase environmental protection, but at the same time risk to create administrative burdens and reducing the level-playing field across MSs. The 2016 fitness check on the Birds & Habitats Directive states that the administrative burdens of compliance are significant and that the burdens are often caused by inefficient implementation at national, regional and local level.[191] This finding is also in line with the findings of the recent study on the legal framework for mineral extraction (MINLEX)[192], which emphasised that the administrative burden depends on the legal framework of the MS, as well as on the phase of the cycles and where the investment is planned, as well as the extraction method[193].

Furthermore, in some MS, regulatory uncertainty exists for operators. The time horizon for investments may be up to 20 years to break-even. Interviewees indicated that the whole procedure to develop a new area may take 10-15 years and that the outcome is not always certain.[194] This creates uncertainty in terms of the long term business planning of the operators and limits the willingness to invest. The MINLEX-study states that "*complex and unpredictable permitting procedures undermine the investment attractiveness in a country/region*" and refers to two main observations: (i) large differences in the time needed to receive a permit, and (ii) the fact that in some countries the original permits are not reliable and changed after law suits[195]. Besides that, the Birds & Habitats fitness check refers to the fact that a high number of cases was brought to national and EU courts, resulting in some risk-averse decision-making at national and local level on permits for projects and socio-economic activities[196].

[191] Milieu, IEEP and ICF, 'Evaluation Study to support the Fitness Check of the Birds and Habitats Directives', March 2016, p. 15-16.
[192] MINLEX, 'Study on the legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU', 2016, see: http://www.bmgk-bg.org/web/Library/EMBF2016/PresentationsENG/Blazena%20Hamadova%20-%20MINLEX%20-%20Study%20of%20the%20Legal%20Framework%20-%20EMBF2016%20-%20ENG.pdf
[193] The following key factors are mentioned: the legal framework, the number of involved authorities, the phase of the mining cycle and the extraction method.
[194] Based on company interviews
[195] MINLEX, 'Study on the legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU', 2016, see: http://www.bmgk-bg.org/web/Library/EMBF2016/PresentationsENG/Blazena%20Hamadova%20-%20MINLEX%20-%20Study%20of%20the%20Legal%20Framework%20-%20EMBF2016%20-%20ENG.pdf
[196] Milieu, IEEP and ICF, 'Evaluation Study to support the Fitness Check of the Birds and Habitats Directives', March 2016, p. 15-16.

4.2.4 Energy legislation

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by five types of legislative acts:

- **Internal market gas and electricity** (Directives 2009/72/EC and 2009/73/EC)[197] [198]: establishing common rules for the generation, transmission, distribution and supply and storage of electricity and gas, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EU and the organisation and functioning of the natural gas sector;
- **Cross border transmission gas and electricity** (Regulation 714/2009 and 715/2009)[199] [200]: setting fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal market in electricity and non-discriminatory rules for access conditions to natural gas transmission systems taking into account national characteristics;
- **Renewable Energy** (Directive 2009/28/EC)[201]: establishing a common framework for the promotion of energy from renewable sources including mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy;
- **Energy Efficiency** (Directive 2012/27/EC)[202]: establishing a common framework of measures for the promotion of energy efficiency within the EU to ensure the achievement of the 2020 20 % headline target on energy efficiency and to pave the way for further energy efficiency improvements beyond that date;
- **Energy Taxation** (Directive 2003/96/EC)[203]: defining taxation standards for energy products and electricity to be imposed by Member States.

The manufacturing of cement and lime is highly energy intensive, particularly in heating the kilns (heating and cooling) and the grinding process. As described in sections 2.6 and 3.5 various estimations exists with regard to the costs of energy as share of the production costs. Besides the use of 'traditional' energy sources (coal/lignite, gas) to heat the kilns, operators particularly in the cement segment also use alternative fuels. Alternative fuels vary from tyres to grinded residual waste ("fluff") and chemical residuals (e.g. old paint). For the grinding procedure(s) operators often use electricity, which can originate from fossil fuel sources (gas, coal) or renewable sources (solar, wind, etc.)[204]. For lime production, the use of alternative fuels is restricted as it affects the pureness of the final product.[205]

[197] Directive 2009/72/EC, concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072&from=en
[198] Directive 2009/73/EC, concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0094:0136:en:PDF
[199] Regulation 714/2009, on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0015:0035:EN:PDF
[200] Regulation 715/2009, on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0036:0054:en:PDF
[201] Directive 2009/28/EC, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN
[202] Directive 2012/27/EC, on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF
[203] Directive 2003/96/EC, restructuring the Community framework for the taxation of energy products and electricity, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:283:0051:0070:EN:PDF
[204] PMT-Zyklontechnik GmbH: Alternative Fuels in the Cement-Industry, see: http://www.coprocem.org/documents/alternative-fuels-in-cement-industry.pdf
[205] Based on interviews with sector associations and companies in the lime industry

Energy policy is a shared competence between the EU institutions and the Member States. Three main pillars determine the EU's energy policy: security, affordability and sustainability.[206] The Energy Union strategy is the overarching vehicle through which these objectives are addressed at the EU level:

- **Objective 1: A secure energy supply, with reliable provision of energy for all.**
  Through the Energy Security Strategy, the EU aims to enhance the cooperation among Member States and diversification of energy sources, to prepare for potential exogenous shocks to the supply of energy[207]. As all industrial sectors combined consume some 25% of the EU28 final energy consumption, this strategy has an impact on industrial operations as well;
- **Objective 2: An environment for energy providers to compete, to ensure affordable energy prices.**
  Through three consecutive Energy Packages, the gas and electricity markets in the EU were liberalized, allowing flexibility in the choice of supplier for business and individuals alike. The creation of a cooperation body for energy regulators (ACER) also facilitated the development of the EU internal energy market[208];
- **Objective 3: A sustainable energy consumption, with the aim to lower emissions, pollution and fossil fuel dependence.**
  A series of renewable energy, emission reduction, and energy efficiency targets are the backbone of three energy strategies for 2020, 2030, and 2050 respectively[209]. The 2020 Strategy strives for a 20% reduction for all three targets, gradually increasing to a 40% reduction in greenhouse gas emissions, and 27% reductions for the other two targets by 2030.

The objectives in the segment of energy policy are hence of high importance for the EU from a strategic point of view and from the industries in terms of influence on one of their main production cost drivers. The objectives have thus been framed into a set of relevant legislation regulating the functioning and taxation of markets (Directives 2009/72/EC[210] and 2009/73/EC[211], Regulations 714/2009[212] and 715/2009[213], Directive 2003/96/EC[214]) and incentivising the development and use of renewables and more energy efficient solutions (Directives 2009/28/EC[215] and 2012/27/EC[216]). Besides that, there exist more aggregate legislative acts on the functioning of markets (antitrust rules, price setting) and the conditions for the provision of state aid, though these are not specifically related to the field of energy.

[206] COM(2010) 639 final: Energy 2020 A strategy for competitive, sustainable and secure energy, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010DC0639&from=EN
[207] Energy Security Strategy. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/energy-security-strategy
[208] Fact Sheet on the Internal Energy Market. http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_5.7.2.html
[209] 2020 Energy Strategy. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2020-energy-strategy
2030 Energy Strategy, https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2030-energy-strategy
2050 Energy Roadmap, https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-energy-strategy
[210] Directive 2009/72/EC, concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072&from=en
[211] Directive 2009/73/EC, concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0094:0136:en:PDF
[212] Regulation 714/2009, on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0015:0035:EN:PDF
[213] Regulation 715/2009, on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0036:0054:en:PDF
[214] Directive 2003/96/EC, restructuring the Community framework for the taxation of energy products and electricity, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:283:0051:0070:EN:PDF
[215] Directive 2009/28/EC, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN
[216] Directive 2012/27/EC, on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF

Impact on competitiveness

The broad set of energy legislation could influence the level retail prices of energy products which in turn impact the costs of companies for procuring energy. The efect on competitiveness is more pronounced in energy intensive sectors such as cement and lime. Another important channel of influence of the energy legislation is the increased potential for the use of alternative fuels. The extent to which energy legislation impacts the industries hence depends on the legislation itself, its transposition into national law as well as on their ability to pass-through such costs (See Box 19) to their downstream clients.

The Internal Market legislation (Directives 2009/72/EC[217] and 2009/73/EC[218], Regulations 714/2009[219] and 715/2009[220]) aims to improve the functioning of the internal market for energy; it sets common rules for the markets of electricity and the markets of natural gas; it also enhances cross-border cooperation. The Renewable Energy Directive[221] sets rules for the EU to achieve its 20% renewable target by 2020.

From the perspective of energy intensive end users, including companies from the cement and lime iindustries, the energy legislation could exhert both positive and negative pressure on prices of energy products and associated costs. For example, connecting increasing variable renewable electricity generation to the grid requires significant upgrades to existing infrastructure[222]. On the other hand, increasing renewable power generation tends to displace costlier power generation technologies from the merit order and thus results in lower wholesale prices.

Existing CCAs assess the regulatory cost impact of EU legislation on similar sectors such as the ceramics and glass industries. This assessment shows that the impact of EU legislation on costs is higher per tonne for electricity (€2.25-€7.06/tonne) than for gas (€0.45-€4.00/tonne). Most of the costs can be classified as direct charges and some as indirect regulatory costs (coming from passed-through costs on electricity and gas suppliers)[223]. This suggests that regulatory costs occur particularly where policy aims to steer change (in the case of energy such change can be more efficient use of energy, more use of renewables etc.).

The specific impact of EU legislation on energy costs also depends on the supply strategies chosen by industries. Energy-intensive industries have two supply strategies that ordinary industrial users and private individuals cannot access: they can produce their own energy, or they can procure it in specific deals with energy providers[224]. In case of the former, companies are faced with high investments costs and long-payback periods, but they can also enjoy a level of price stability and no network charges. In case of the latter, their absolute demand levels generate a strong position vis-à-vis the suppliers in long-term contract negotiations. Electricity prices tend to be inversely related to consumption, which yields additional benefits to the energy-intensive industries. However, the ability to smoothen the consumption of energy during

[217] Directive 2009/72/EC, concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072&from=en

[218] Directive 2009/73/EC, concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0094:0136:en:PDF

[219] Regulation 714/2009, on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0015:0035:EN:PDF

[220] Regulation 715/2009, on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0036:0054:en:PDF

[221] Directive 2009/28/EC, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN

[222] CEPS, Economisti Associati, Ecorys (2017): Cumulative Cost Assessment for the Ceramics and Glass Industries

[223] CEPS, Economisti Associati, Ecorys (2017): Cumulative Cost Assessment for the Ceramics and Glass Industries

[224] Ecofys (2016). Prices and costs of EU energy. https://ec.europa.eu/energy/sites/ener/files/documents/report_ecofys2016.pdf

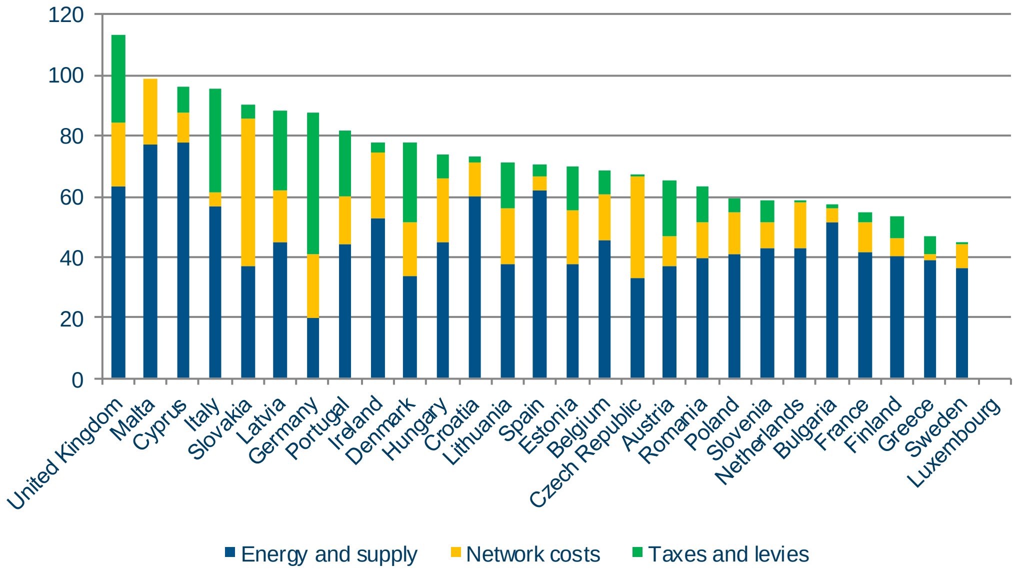
all moments of the day, as well as the eligibility for national subsidies creates variation among different firms within the same Member States.

Differences in energy costs between Member States

Energy legislation could have a large impact on production costs through the various components of the retail price of energy products. In a series of reports by Ecofys[225], CEPS[226], and the JRC[227], (heavy) industrial energy costs across Member States are broken down in specific subcategories; energy, network, and taxes & levies. As shown in the Figures below, network costs, and taxes and levies make up a larger share of the total price for electricity than for gas (except for gas in the Scandinavian countries). However, exemptions and special arrangements (within the framework of the State Aid Guidelines of the EC) can sometimes lead to significantly lower energy prices than depicted here, the following discussion should therefore be assessed with this in mind[228].

Electricity prices for industrial players with an annual consumption between 70 GW and 150 GW are depicted in the figure below. The spread in prices between the MS is relatively large, with electricity in Greece and Sweden at around half the UK price per MWh. There is a large variation between the cost components in each Member State. For instance, in Germany the energy supply is about a quarter of the total price, whereas it makes up some 90% of the electricity price in Spain. Network costs differ greatly among the Member States, and are the largest component for Slovakia, whereas they barely exist in Italy. Therefore, the regulatory conditions in the electricity market within in each MS are a main driver for intra-EU competitiveness differences.

Figure 84 Electricity prices components for industrial consumers in EUR/MWh (band IF), 2016-S2



Source: Eurostat table; nrg_pc_205_c. Band IF denotes an annual electricity consumption range between 70 GW and 150 GW. Information for Luxembourg is classified; Greece data is 2015-S2 data.

[225] Ecofys (2016). Prices and costs of EU energy. https://ec.europa.eu/energy/sites/ener/files/documents/report_ecofys2016.pdf

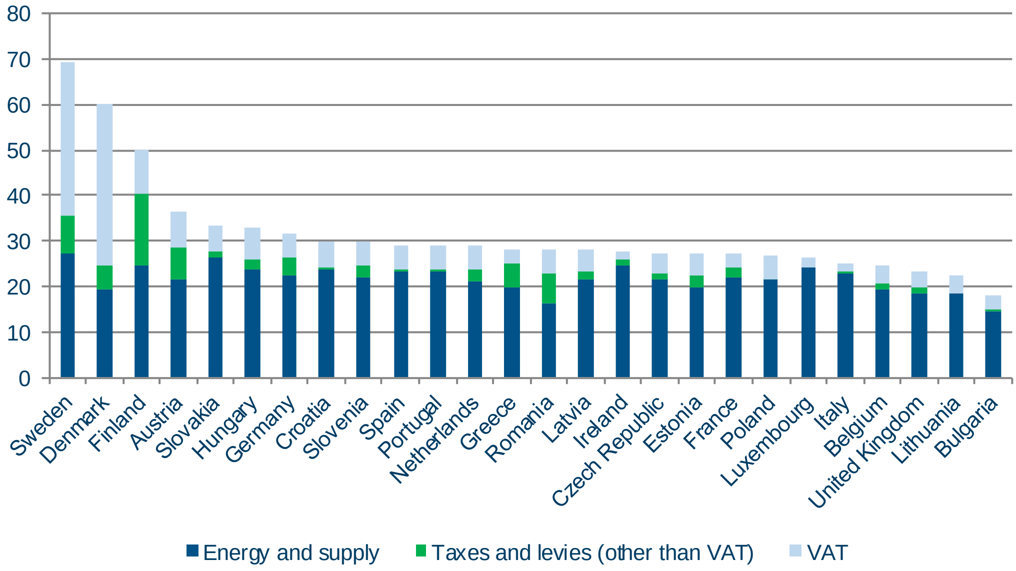
[226] CEPS et al. (2017). Composition and drivers of energy prices and costs: Case studies in selected energy-intensive industries. https://www.ceps.eu/publications/composition-and-drivers-energy-prices-and-costs-case-studies-selected-energy-intensive

[227] JRC (2016), Production costs from energy-intensive industries in the EU and third countries.

[228] For an overview of these reductions and exemptions in taxes and levies, see Ecofys (2016).

The dispersion of gas price components is much smaller across Europe, with the exception of Sweden, Denmark and to a certain degree Finland. For the other MS, gas prices per MWh range between 18 and 35 euro. If VAT is removed from the price component (as is often the case for industrial consumers), the differences across Member States are much less pronounced. However, as the raw energy supply costs represent such a large share of the total gas price, the impact of changes to the regulatory environment regarding gas is expected to be much smaller than for electricity.

Figure 85 Gas prices components for industrial consumers in EUR/MWh (band I4), 2016-S2



Source: Eurostat table; nrg_pc_203. Band I4 denotes an annual gas consumption range between 100 TJ and 1000 TJ. Information for Malta and Cyprus not available.

Differences in energy costs in an international perspective

A breakdown of costs per type of energy costs per tonne cement produced for a number of extra-EU competitors is already presented in section 2.6. Both Egypt and Ukraine had higher energy costs per tonne of cement produced than the EU in 2012, whereas costs are lower for Algeria and China. These findings mainly depend on the composition of the energy use in the production of cement. For instance, Algeria mainly uses its domestically sourced, cheap natural gas, whereas Egypt has to resort to fuel oils that are more expensive. China and Ukraine, on the other hand, use a lot of cheaper coal compared to the other regions depicted here. Alternative fuels led to a decrease in energy costs in EUR per tonne cement in the EU[229].

The EC finds that 2015 average industry electricity prices in the EU are roughly at par with China and Turkey, lower than Japan and Brazil, but higher than Mexico, the US, Korea and Russia. As for gas prices, the US, Russia, and Turkey have lower gas prices, China and Japan higher ones[230]. However, differences in energy intensity lead Ecofys to conclude that energy costs in the cement, lime and plaster industry are higher in the US than they are in the EU[231].

[229] JRC (2016), Production costs from energy-intensive industries in the EU and third countries. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC100101/ldna27729enn.pdf

[230] European Commission SWD(2016) 420. *Energy prices and costs in Europe*. http://ec.europa.eu/energy/sites/ener/files/documents/com_2016_769.en_.pdf

[231] Ecofys (2016). Prices and costs of EU energy. Page 139. https://ec.europa.eu/energy/sites/ener/files/documents/report_ecofys2016.pdf

Increased potential for the use of (cheaper) alternative fuels

The creation of a 'waste hierarchy' within the European Union has resulted in more emphasis on the final use of waste. The landfilling of waste is more and more discouraged which creates opportunities for alternative usage, for example as alternative fuel in kilns. In a recent study for CEMBUREAU, Ecofys found that that the co-processing rate of alternative fuels (waste) varies between 7% and 65% within the EU. Key aspects that determine the potential for alternative fuels include: 'a mature waste management system, smooth permitting procedures, a modern cement industry and high prices for carbon and fossil fuels'[232]. Examples on the use of alternative fuels show that while the quantity of used fuel increases when switching to alternative fuels, the costs of production decrease (sometimes drastically)[233]. This has also been confirmed by some interviews. However, with increasing demand for such alternative fuels, also their prices are expected to increase[234]. The European lime industry indicated that the need for product purity limits the potential use of alternative fuels in their industry.

4.2.5 Industrial emissions

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by three types of legislative acts:

- **Industrial Emissions** (Directive 2010/75/EU)[235] and Best Available Techniques Reference Document (BAT)[236]: laying down rules on integrated prevention and control of pollution arising from industrial activities and providing an overview on the best available technologies to keep industrial emissions at a minimum level;
- **Ambient air quality** (Directives 2008/50/EC and 2004/107/EC)[237] [238];
- **National Emission Ceilings** (2016/2284/EU)[239] **as the instrument of the Clean Air Programme**[240]: laying down measures for ambient air quality to avoid, prevent or reduce harmful effects on human health and environment, assessing air quality and obtaining information about it as well as ensuring that such information is public. Promoting increased cooperation between MS in reducing air pollution.

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[232] Ecofys (2017). *Status and prospects of co-processing of waste in EU cement plants.* Report for CEMBUREA. https://cembureau.eu/media/1612/2017-05-11_ecofys_publication_alternativefuels_report.pdf

[233233] EPA, Energy Star (2013): Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making, see: https://www.energystar.gov/sites/default/files/buildings/tools/ENERGY%20STAR%20Guide%20for%20the%20Cement%20Industry%2028_08_2013%20Final.pdf

[234234] EPA, Energy Star (2013): Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making, see: https://www.energystar.gov/sites/default/files/buildings/tools/ENERGY%20STAR%20Guide%20for%20the%20Cement%20Industry%2028_08_2013%20Final.pdf

[235] Directive 2010/75/EU, on industrial emissions (integrated pollution prevention and control), see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF

[236] JRC (2013): Best Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide, see: http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_Published_def.pdf

[237] Directive 2008/50/EC, on ambient air quality and cleaner air for Europe, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0050&from=en

[238] Directive 2004/107/EC, relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:023:0003:0016:EN:PDF

[239] Directive 2016/2284/EU, on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016L2284&from=EN

[240] COM(2013) 918 final: A Clean Air Programme for Europe, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0918&from=EN

The Industrial Emission Directive (IED)[241] is the main piece of EU legislation in the area of industrial emissions. It aims to prevent and control pollution into air, water, and land[242]. The Directive, which came into force in 2011, replaces seven directives including the IPPC Directive[243], the Large Combustion Plants Directive[244], the Waste Incineration Directive[245], the Solvents Emissions Directive[246] and three Directives on Titanium Dioxide[247].

The IED requires operators of installations for certain types of industrial activities above certain production thresholds (as defined in Annex I of the IED), to obtain and renew an integrated environmental permit to operate. The permit sets Emission Limit Values (ELVs) based on the so-called Best Available Techniques (BAT). The BAT and the associate emission levels (the so-called BAT-AELs) are specified in technical documents, the so-called BAT Reference Documents (BREF), whose conclusions are formally adopted by the Commission through an Implementing Decision (the so-called BAT Conclusions). These technical documents are progressively drafted and updated for the various sectors falling in the scope of the IED by the Commission and the industry stakeholders. The BREFs/BAT conclusions are drafted via an inclusive and transparent decision making process in which Member States representatives, industry stakeholders and NGOs all take part[248]. This 'Sevilla process' guarantees that BAT conclusions that are adopted are technically and economically viable. This process is coordinated by the JRC, under the IED regime.

Finally, the IED includes provisions on monitoring and compliance, mandating emission levels to be monitored and environmental inspections to be carried out by the competent authorities at different intervals depending upon the level of risk. The competent authorities shall regularly visit each site, the frequency being decided upon a systematic appraisal of the environmental risks of the installations concerned; in any case, the period shall not exceed one year for installations posing the highest risks and three years for installations posing the lowest risks[249].

Other relevant legislative acts relate to the quality of the air and emission ceilings (e.g. providing uniform measurement standards, monitoring rules and reduction targets). More specifically these include the Ambient Air Quality Directive[250] and the National Emission Ceilings Directive[251] which sets targets for MS. The ambient air quality directive is one of the key measures outlined in the 2005 thematic strategy on air pollution and it set standards and targets for reducing concentrations of fine particles PM2.5. Furthermore, it is the result of

[241] Directive 2010/75/EU, on industrial emissions (integrated pollution prevention and control), see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF

[242] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

[243] Directive 2008/1/EC, concerning integrated pollution prevention and control, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0001&from=EN

[244] Directive 2001/80/EC, on the limitation of emissions of certain pollutants into the air from large combustion plants, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0080&from=EN

[245] Directive 2000/76/EC, on the incineration of waste, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0076&from=en

[246] Directive 1999/13/EC, on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999L0013&from=EN

[247] Directive 2006/33/EC, amending Directive 95/45/EC as regards sunset yellow FCF (E 110) and titanium dioxide (E 171), see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0033&from=EN , Directive 92/112/EEC, on procedures for harmonising the programmes for the reduction and eventual elimination of pollution caused by waste from the titanium dioxide industry, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0112&from=EN , Directive 78/176/EEC, on waste from the titanium dioxide industry, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31978L0176&from=en

[248] http://eippcb.jrc.ec.europa.eu/about/who_is_who.html

[249] Directive 2010/75/EU, on industrial emissions (integrated pollution prevention and control), see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF

[250] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[251] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

merging four directives and one council decision into a single directive[252]. The National Emissions Ceiling Directive is the main legislative instrument to achieve the 2030 objectives of the Clean Air Program. The directive sets maximum limits on five major pollutants (Sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and fine particulate matter)[253].

Impact on competitiveness

The legislative framework regarding emissions impacts the Cement and Lime Industry's competitiveness by providing harmonised requirements that are technically and economically viable for industry in order to improve their environmental performance, and creating a level playing field and harmonising costs and benefits within the EU. Towards outside EU competitors, these requirements can lead to differences in production costs.

The key emissions to air for cement and lime sector are NOx, Sox, and Dust (PM10)[254]. The various legislative acts, which aim to regulate and reduce these and other emissions to air, land, and water result in an EU wide harmonisation of various national legislative regimes. This system ensures that the various Member States use (a more or less) uniform approach, which creates a level-playing-field for the market operators across the EU.

Instead of having 28 different legislative regimes, there is one single harmonised regime thus saving and avoiding costs. The legislative framework Member States had permitting regimes in place prior to the introduction of the EU legislative acts, which also generated (national) costs for industry. Costs arose by complying with the requirements from a wide array of national permitting regimes. Consequently the IED reduced the wide array of national permitting regimes.

The costs of implementing the BAT conclusions for the IED for the Cement and Lime industry are seen as high, but do not seem to be a major concern for the various interviewees like ETS is. It is seen as necessary and in essence unavoidable.[255] The BAT conclusions for the Cement and Lime industry that were adopted in 2013[256] were agreed in cooperation with industry stakeholders (including CEMBUREAU[257], EuLA[258], EUROMINES[259], EURITS[260]) and were labelled technically feasible while being economically viable. As the implementation deadline for new BAT conclusions is four years, the BAT conclusions for the Cement and Lime sectors will gradually take effect between 2013 and 2017. The 2013 impact assessment (covering a broad set of industries) shows that the impact on the economy is neutral and that most affected sectors are Medium Combustion Plants (MCPs) and the agricultural sector.[261]

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[252] http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm
[253] http://ec.europa.eu/environment/air/pollutants/ceilings.htm
[254] https://circabc.europa.eu/sd/a/44aaf4c4-d716-4f02-91ab-a526b07ee6b7/Final%20report_20150501.pdf
[255] Based on company interviews
[256] JRC (2013): Best Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide, see: http://eippcb.jrc.ec.europa.eu/reference/BREF/CLM_30042013_DEF.pdf
[257] https://cembureau.eu/about-cembureau/who-are-we/
[258] http://www.eula.eu/about-us
[259] http://www.euromines.org/who-we-are
[260] http://www.eurits.org/about-eurits
[261] European Commission (2013), Impact assessment accompanying a revised EU Strategy on Air Pollution, a proposal for amending Directive 2001/81 on national emission ceilings for certain atmospheric pollutants, and a proposal for a Directive regulating air emissions from Medium Combustion Plants, SWD(2013)531. see: http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52013SC0531

4.2.6 Working conditions

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by seven types of legislative acts:

- **Safety and health of workers at work** (Directive 89/391/EEC)[262]: introducing measures to encourage improvements in the safety and health of workers at work;
- **Registration, Evaluation, Authorisation and Restriction of Chemicals** (REACH) (Regulation (EC) No 1907/2006)[263]: ensuring a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation;
- **Carcinogens or Mutagens** (Directive 2004/37/EC)[264]: aiming to protect workers against risks to their health and safety, including the prevention of such risks, arising or likely to arise from exposure to carcinogens or mutagens at work, by laying down particular minimum requirements including limit values;
- **Personal Protective Equipment** (Regulation 2016/425)[265]: laying down requirements for the design and manufacture of personal protective equipment, which is to be made available on the market, in order to ensure protection of the health and safety of users and establish rules on the free movement of such equipment;
- **Use of Personal Protective Equipment** (Directive 89/656/EEC): laying down minimum requirements for personal protective equipment (PPE) used by workers at work.
- **Vibration** (Directive 2002/44/EC)[266]: laying down minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to mechanical vibration;
- **Chemical hazards/risk at work** (Directive 98/24/EC)[267]: laying down minimum requirements for the protection of workers from risks to their safety and health arising, or likely to arise, from the effects of chemical agents that are present at the workplace or as a result of any work activity involving chemical agents.

The industrial processes related to the extraction of raw material and the manufacturing of cement and lime (products) as well as their transport and distribution impose health and safety risks on the employees involved.[268] The most significant occupational health and safety risks occur during the operational phase of manufacturing and include dust, heat, noise and vibrations, physical hazards, chemical hazards and other industrial hygiene issues[269].

[262] Directive 89/391/EEC, on the introduction of measures to encourage improvements in the safety and health of workers at work, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31989L0391&from=EN

[263] Regulation (EC) No 1907/2006, concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1907-20140410&from=EN

[264] Directive 2004/37/EC, on the protection of workers from the risks related to exposure to carcinogens or mutagens at work (Sixth individual Directive within the meaning of Article 16(1) of Council Directive 89/391/EEC), see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF

[265] Regulation 2016/425, on personal protective equipment and repealing Council Directive 89/686/EEC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0425&from=EN

[266] Directive 2002/44/EC, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), see: http://eur-lex.europa.eu/resource.html?uri=cellar:546a09c0-3ad1-4c07-bcd5-9c3dae6b1668.0004.02/DOC_1&format=PDF

[267] Directive 98/24/EC, on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0024&from=EN

[268] https://cembureau.eu/cement-101/worker-protection/

[269] International Finance Corporation (2007): Environmental, Health, and Safety Guidelines for Cement and Lime Manufacturing, see: http://www.ifc.org/wps/wcm/connect/f74848804951d04eb75cb719583b6d16/Final+-+Cement+and+Lime+Manufacturing.pdf?MOD=AJPERES

While automation of processes and technical and safety improvements in plants have reduced the exposure of workers to risks over time, EU legislation has put the issue on its agenda already in the 1980s, namely with the Framework Directive on Workers' Safety[270]. The Directive serves as a corner stone for the overall EU policy on this field and stimulates (to take measures in relation to) the overall health and safety conditions of EU workers. Other important legislative acts relate to all relevant risk factors such as the minimum criteria for Personal Protective Equipment[271] and minimum protection measures for different types of risks (e.g. noise, chemical substances, etc.)[272].

Impact on competitiveness

The impacts of legislation regarding the health and safety of workers are hard to measure. The key impacts of this type of legislation mainly affect the overall well-being of the workers in both industries via the introduction and enforcement of high health and safety standards. However, the logical causal chain between a legislative act, the well-being of workers and the competitive position of a company or industry cannot be quantified. Furthermore, despite causing cost (e.g. purchase of specific equipment, safety trainings etc.), previous experiences[273] show that some elements of these costs would most likely also exist if there were no (more) EU legislation, meaning that industry could be willing to make the same or similar expenditures also in absence of such legislation. Moreover, before EU harmonisation, some national requirements existed. Companies tend to set high health and safety standards, as it increases productivity (including reduced sick leave of staff) and enhances reputation. EU health and safety legislation also provides clarity of the legal framework and the setting up of a common level playing field of minimum requirements across the EU.

Higher costs on health and safety within the EU in comparison to non-EU producers appear not to be a main concern of EU industries. Instead, industry aims to reduce impacts of safety lacks.

Data from CEMBUREAU (see table below), for example measures the loss in working hours due to accidents. Please note that these safety indicators can not be directly compared to non-EU countries, as definitions and used methodologies vary.

Table 13 Safety indicators in the EU cement industry (2009 – 2015)

Safety Indicators	2009	2010	2011	2012	2013	2014	2015
Lost day Severity Rate Directly Employed (per million man hours) working days basis	196	230	170	149	164	151	150
LTI[274] frequency rate directly employed (per million man hours)	12.6	11.7	8.2	8.9	8.2	8.1	7.2

Source: CEMBUREAU (2017), see: https://cembureau.eu/cement-101/worker-protection

EuLA started in 2013 an accidents prevention strategy which aims to reach zero injuries in 2020. In the table below the monitoring results for two safety indicators are shown. Again, it should be noted that these safety indicators can not be directly compared to non-EU countries, as definitions and used methodologies vary.

[270] Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work.
[271] Directive 89/686/EEC on personal protective equipment.
[272] See for example: Directive 98/24/EC on chemical hazards/risk at work and Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).
[273] E.g. CEPS, Economisti Associati, Ecorys (2017): Cumulative Cost Assessment for the Ceramics and Glass Industries
[274] Zero fatalities and lost time injuries

Table 14 Safety indicators in the EU lime industry (2009 – 2015)

Safety Indicators	2010	2011	2012	2013	2014	2015
Lost Time Incident frequency rate	20,4	19,8	19,3	14,5	16,4	10,5
Fatalities	3	1	0	1	0	2

Source: information received from EuLA, based on the EuLA database (90% coverage)

4.2.7 Product legislation

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by legislation on Construction products (Regulation EU/305/2011)[275]. The Construction Products Regulation (CPR), which lays down harmonised rules on the performance of construction products became effective in 2013. It presents "*conditions for the placing or making available on the market of construction products by establishing harmonised rules on how to express the performance of construction products in relation to their essential characteristics and on the use of CE marking on those products*" (article 1). Key elements of the Regulation are (1) the 'declaration of performance' in which the manufacturer expresses that his products meets the essential requirements of the Directive and (2) the application of the CE marking, which provides a quality signal to the final users. Designated 'product areas' under the regulation are for example precast concrete products (area 1), cement, building limes and other hydraulic binders (area 15) and reinforcing and prestressing steel for concrete (area 16).

Impact on competitiveness

For both industries (but especially cement) CPR represents a set of rules they need to follow and as such creates compliance cost (and takes time to follow the administrative procedure). At the same time it creates a level playing field and asks competitors outside the EU to comply with EU rules.

4.2.8 Circular Economy

Introduction

The EU regulatory framework for cement and lime industries under this theme is defined mainly by four types of legislation:

- **Waste to Energy Communication**
  - Waste Shipment (Regulation 1013/2006/EC)[276]: establishing procedures and control regimes for the shipment of waste, depending on the origin, destination and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination;
  - Waste Framework (Directive 2008/98/EC)[277]: laying down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use;

[275] Regulation EU/305/2011, laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0305&from=NL
[276] Regulation 1013/2006/EC, on shipments of waste, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R1013&from=EN
[277] Directive 2008/98/EC, on waste and repealing certain Directives, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

- **Circular Economy Action Plan Package** (COM/2015/0614 final)[278]: sets out a concrete and ambitious EU mandate to support the transition towards a circular economy covering the aspects of production, consumption, waste management, from waste to resources, five specific priority areas, innovation, investment and other horizontal measures;
- **Waste-to-energy** (COM(2017) 34 final)[279]: setting out the principle that waste-to-energy processes can play a role in the transition to a circular economy provided that the EU waste hierarchy is used as a guiding principle and that choices made do not prevent higher levels of prevention, reuse and recycling;
- **Energy Efficiency of Buildings** (Directive 2010/31/EC[280]): promotes the improvement of the energy performance of buildings within the Union, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness;
- **Heating and cooling** (COM(2016) 51 final)[281]: identifies, building on the existing base in EU legislation, areas where update or reform is needed to become future-proof and deliver on the Energy Union objectives.

The EU legislative framework for waste has a broad coverage, providing overall waste management frameworks and targeting particular waste streams with separate Directives, regulating the streams' management and setting (often) recycling and recovery targets.[282] Since the revision of the legal framework in 2008 more emphasis is laid on the 'product life cycle' which covers the steps from generation to disposal. Via the introduction of the 'waste hierarchy' emphasis is on waste prevention, reuse, recycling and recovery, before waste disposal (e.g. on a landfill).

In line with the focus on the 'product life cycle' and the (re)use of waste as a resource, the Commission emphasised in the last couple of years the need for a 'circular economy'.[283] In essence, these regulatory actions focus on the transition to the 'circular' or extended use of resources. Of further relevance is the aspect of energy efficiency with respect to downstream clients of the industry. This plays (especially) in cement an important role in the future shift towards (more) climate-neutral buildings. Key legislative acts in this field are the Energy Performance of Buildings Directive[284] and the Energy Efficiency Directive[285]. Both directives aim to reduce the energy consumption of new and existing buildings, for example via the requirement that Member States must set minimum energy performance requirements for new buildings and the requirement that Member States come up with a list of national financial measures to improve the energy efficiency of buildings.

A recent communication of high relevance was published in January 2017 on 'waste to energy'[286]. In essence, it clarifies the position of different waste-to-energy processes in the overall waste hierarchy.

[278] COM/2015/0614 final: Closing the loop - An EU action plan for the Circular Economy, see: http://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF
[279] COM(2017) 34 final: The role of waste-to-energy in the circular economy, see: http://ec.europa.eu/environment/waste/waste-to-energy.pdf
[280] Directive 2010/31/EC, on the energy performance of buildings, see: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:en:PDF
[281] COM(2016) 51 final, An EU Strategy on Heating and Cooling, see: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v14.pdf
[282] Key regulations in this field are Directive 2008/98/EC on waste (Waste Framework Directive) and Regulation 1013/2006/EC on waste shipments. Beside that efforts were done to determine criteria whether 'waste' is still a valuable resource or not.
[283] See for example the Circular Economy Action Plan Package (COM/2015/0614 final)
[284] Directive 2010/31/EU on the energy performance of buildings.
[285] Directive 2012/27/EU on energy efficiency.
[286] Communication, 'The role of waste-to-energy in the circular economy', COM (2017) 34 final.

Impact on competitiveness

The above legislative acts, communicates and stimulates innovation in the cement and lime sector as well as the renovation and upgrade of the old stock of plants in Europe. They promote 'industrial symbiosis' and synergies within the sectors, but also with other sectors (e.g. energy companies, utilities, waste collectors as well as downstream sectors). This creates important business opportunities for the future, particularly for cement where the opportunities to use alternative fuels are sheer unlimited (e.g. tyres, animal corps, paint waste, biomass, etc).

4.3 Analysis of other framework conditions

In addition to the regulatory framework conditions, there are other framework conditions of non-regulatory nature, which impact the performance and competitiveness of the cements and lime industries. The five key framework conditions identified are:

- international trade and a level playing field on the global market;
- access to knowledge, research and technology;
- access to labour, skills, and employment;
- access to finance and investment; and
- access to infrastructure, transport and land.

Each of the five is further elaborated upon hereafter.

4.3.1 International trade: level playing field

The long-term competitiveness of the cement and lime industries is partly depending on the development of the global market, where demand shocks in the home market (EU28) can be mitigated. If the EU industry is cost competitive from a global perspective, excess production could be sold to non-EU partners. This is then a sign of strength for the cement and lime industries in the long-run.

In this context the EU trade policy is strongly supporting open international trade and plays a crucial role to fight against protectionism and to ensure a level playing field in trade. The European Commission implements the EU Market Access Strategy[287], the enforcement pillar of the EU trade policy, to address all kind of trade and investment barriers through appropriate actions. EU trade policy is especially active in negotiations of trade agreements and in the removal of non-tariff measures in order to reduce unnecessary trade obstacles, such as technical barriers. The EU stands firm against unfair trade practices through anti-dumping and anti-subsidy measures and is one of the main users of trade defence[288] instruments (anti-dumping, anti-subsidy, safeguards[289]). This is necessary to uphold the EU's commitment to open markets.

However, a number of recent main events in the area of international trade can be identified and may impact the future competiveness of the cement and lime industries. This includes the global move towards protectionism[290]; the troubled relations with Russia[291]; and the future of

[287] European Commission: Global Europe. A Stronger Partnership to Deliver Market Access for European Exporters, see: http://trade.ec.europa.eu/doclib/docs/2007/april/tradoc_134591.pdf

[288] http://ec.europa.eu/trade/policy/accessing-markets/trade-defence/actions-against-imports-into-the-eu/

[289] European Commission: Introduction to trade defence policy, see: http://trade.ec.europa.eu/doclib/docs/2013/april/tradoc_151014.pdf

[290] EP (2017): The 2016 elections in the United States: Effects on the EU-US relationship, see: http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/578030/EXPO_IDA(2017)578030_EN.pdf

[291] Gros, Daniel, Mustilli, Federica (2016): The Effects of Sanctions and Counter-Sanctions on EU-Russian Trade Flows, see: https://www.ceps.eu/publications/effects-sanctions-and-counter-sanctions-eu-russian-trade-flows

the steel industry in the EU[292]. Geopolitical events in 2016, notably the election of Donald Trump[293] as President of the United States and the Brexit referendum result in the United Kingdom, have shifted the focus in the international trade arena from liberalised cross-border transactions towards protectionism. Trading of certain goods may become more difficult, including industries related to the cement and lime sectors. An important example here is the steel industry, which is of vital importance for the lime industry (and to a lesser extent to the cement industry). This sector is among the most protected sectors in terms of international trade,[294] and recent moves in the direction of more protection may therefore pose a threat in the future.

In addition to increased protectionism tendencies, developments on the Eastern and Southern borders of the EU also potentially pose a threat to the EU cement and lime industries[295]. While not supported by hard evidence, state aid for cement producers in Belarus and other support measures for Ukrainian producers are said to tackle the market in the Eastern Member States.

4.3.2 Access to finance and investment

The availability of funds for investments has taken a hit during the economic and financial crisis in 2008/2009 and the Eurozone crisis in the years after.[296] The risk-averse investment climate still shapes the market today. Overall, cement and lime companies – many of them existing for long periods of time already – tend to be less dependent on financial institutions when compared to other sectors. Indeed, access to finance did not arise as an important concern in the company survey. Nevertheless, access to funds that are used to industrialise pilot findings of innovative projects (in TRL – technology readiness levels 6-9) remains an issue of vital importance for the sector[297]. This point is emphasized by CEMBUREAU, which indicates there is a general need for a 'one-stop-shop' for the financing of breakthrough technology.

4.3.3 Access to knowledge, research and technology

Technological innovation in the cement and lime sectors is supported through a number of channels. Access to knowledge, research and technology has therefore not been identified as a problem in the sector[298], as there are multiple areas in which innovation is pursued. The three main areas of innovation are thus related to the main regulatory areas, being the reduction of GHG emissions by increasing the use of alternative fuels, replacing clinker in cement (w or slag for instance), and innovation in the field of carbon capture and storage/re-use (CCS). More details on the mentioned projects are integrated in the chapters 2 and 3.

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[292] European Commission (2017): The Future of European Steel, Innovation and sustainability in a competitive world and EU circular economy, see: https://publications.europa.eu/en/publication-detail/-/publication/f5a82742-2a44-11e7-ab65-01aa75ed71a1

[293] https://www.economist.com/blogs/freeexchange/2016/11/global-economy

[294] COM (2013) 407 final, Action Plan for a competitive and sustainable steel industry in Europe, see: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0407&from=EN

[295] Based on company interviews

[296] Kolev, Atanas (2013): Factors influencing investment during the financial crisis and deep economic recession: the European experience since 2008, IN: EIB (2013): Investment and Investment Finance in Europe, see: http://www.eib.org/attachments/efs/investment_and_investment_finance_in_europe_en.pdf

[297] EuLA (2017). Innovation in the Lime Sector. http://www.eula.eu/documents/innovation-report-eula-2017

[298] Based on company interviews

4.3.4 Access to labour, skills and employment

The labour and employment dynamics within the cement and lime industries make them stand out from other manufacturing industries. German figures show that the average age of labour force is on average 45.5 years, and that the average job tenure is around 20 years.[299] While these figures may be country specific, other countries show a higher than average age for workers in the cement industry as well[300]. There has also been a move towards higher skilled workers, which is the direct result of more automation in the production process. The supply of apprenticeship applications is therefore of vital importance for the renewal of the workforce in the coming years. This is identified by a number of interviewees as a potential hurdle, highly skilled workers are hard to come by. Moreover, the cement and lime production sites are usually located in rural regions, which makes these sectors an important indirect employer for a larger group of workers[301].

Employment in the cement and lime sectors is sometimes hazardous, as the occasional fatal accident occurs in all production countries. There are four large sources of cause of health hazards, ranging from skin contact with the intermediate inputs, through to dust and high temperatures on-site. In the Cement Sustainability Initiative (CSI), the aim is to achieve "Zero fatalities and lost time injuries (LTI)". In the last 15 years, the number of fatalities has decreased by 33%, while the incidence rate of injuries has halved[302]. The European lime industry tries to achieve this "Zero injuries" target by 2020[303].

4.3.5 Access to infrastructure, transport and land

Due to the geographical limitations of the sectors (e.g. the quarry needs to be closely located to the production plant), issues related to infrastructure and transport are limited. Transport of finished cement and lime products is usually done by players in the downstream market, even though these activities may be part of the vertically integrated companies. Access to infrastructure has not been mentioned as an issue by interviewees, whilst the access to land legislation is discussed in the section 4.2.3 above.

4.4 Concluding remarks

The analysis shows that, despite the fact that many regulatory themes are relevant for these industries, there are a few themes which stand out with regard to industrial competitiveness, specifically energy and climate legislation and the access to natural resources. The described regulatory and other framework conditions tend to change over time. Changes in the regulatory framework of outstanding importance have been taken as a basis for the future scenarios which are presented in chapter 5.

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[299] German cement association VDZ. Jobs and apprenticeships in the cement industry. https://www.vdz-online.de/en/cement-industry/cement-sector/jobs-and-apprenticeships/

[300] European data is not available, but the US reports that workers in the "Cement, concrete, lime, and gypsum product manufacturing" sector are on average 5 years older than the average worker in the economy.

[301] German cement association VDZ. Jobs and apprenticeships in the cement industry. https://www.vdz-online.de/en/cement-industry/cement-sector/jobs-and-apprenticeships/

[302] Cement Sustainability Initiative – Employee Health and Safety. http://www.wbcsdcement.org/index.php/key-issues/health-safety

[303] European Lime Association – Target Zero Injury http://www.eula.eu/topics/target-zero-injury

5 Assessment of industry competitiveness and scenarios for the future

5.1 Future drivers of competitiveness

The analysis provided in this report points to the cement and lime industries as mature industries, which are vital for a range of downstream industries, products and services. Over the last 10 years, both sectors have witnessed major downturns, and future prospects are less than certain. Additional analysis has pointed to a sharp decline in profitability over the period 2007-2009 for both sectors, followed by some recovery since 2010. Firms in Italy and Spain seem to be those that struggled the most regarding their financial performance. Both EU cement and lime production are limited in size in a global perspective, with China being by far the largest producer. However, despite their commonalities in terms of input materials (lime stone), energy intensity, value chain and production characteristics, the two sectors are quite distinct and an assessment of industry competitiveness for the cement industry is very different from that for the lime sector.

Box 22: Analysis of Total Factor Productivity

For a better understanding of the competitiveness of the sectors, key findings from the research have been triangulated with the analysis of the Amadeus database that constitutes the basis for the calculation of Total Factor Productivity (TFP) in the cement and lime industries (see, Annex D and E for full details on the latter).

The question is now how these sectors will shape up in the future, and what will be their drivers for future competitiveness.

Being part of the civil engineering and construction value chain, the **EU cement sector** is highly cyclical. Demand fluctuates with activity in those sectors and this is expected to be the same in the future. The sector peaks at the height of construction booms – but shrinks in times of economic and financial crisis. Evidently, the sector suffers much more so in countries heavily affected by a crisis than elsewhere in the EU. Cement is usually sold in relatively close geographical proximity to the production site, which explains the differences in cyclicality, industry structure at national and even regional level. Such focused regional markets are explained by the low price-weight-ratio of cement and lime, which may hinder exploitation of economies of scale or reduce capacity utilisation rates, regulatory barriers to market entry and asset specificity (cement production assets cannot be easily transferred to alternative use).

In the future, producers can shift some capacity from production for the domestic cement market to exports of cement clinker – as has happened in Spain during the crisis. This shows the export potential of European cement clinker under current domestic and global market conditions. As of today, extra-EU trade in cement is limited; although the export share has been increasing over recent years, it remains below 10% of total production. Although the trade position of clinker points to a low penetration of extra-EU imports, there are signals that clinker has the potential to travel – due to the higher value/weight ratio - and increasing export intensity.

However, the fact that clinker can travel also has a ‘flipside’: a slowdown in global demand, in particular in markets with large cement clinker production capacity (China), or an increase in production costs in the EU relative to global competitors could see a reversal of the recent trade trends, with an increase in the penetration of imported clinker in the EU market.

The cement industry has proven to be internationally competitive by increasing exports. This success has been driven by poor domestic demand. Surplus production has been exported based on marginal cost calculation. The trade balance has become positive in recent years, in spite of higher fixed costs in the EU than in many neighbouring countries. The current situation is price sensitive and trade flows will be strongly impacted by changes in relative prices.

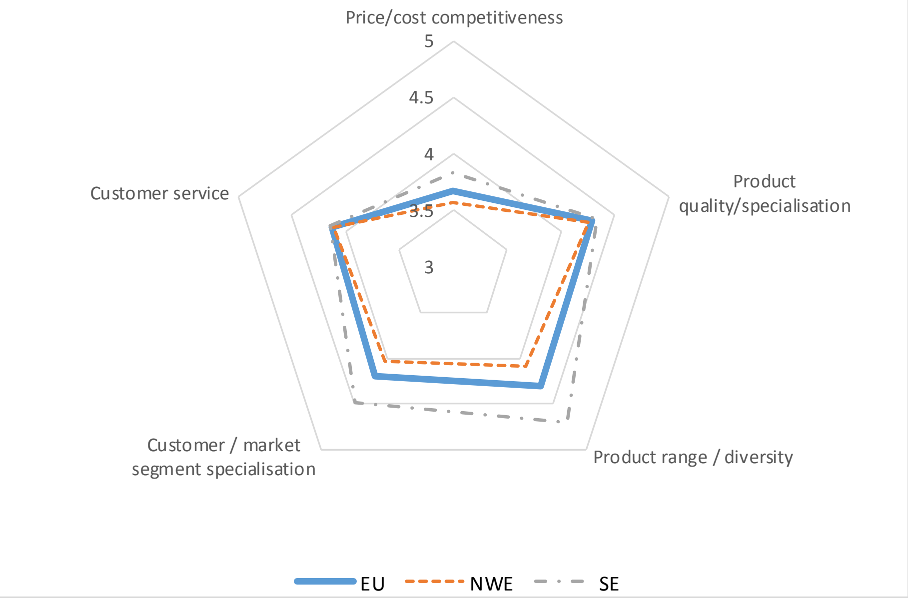
What now will be the drivers for future competitiveness in the cement industry? In the next box we present the views of the cement companies which participated in the survey. The results underline that especially energy costs and raw material supply are seen as crucial drivers for the future.

Box 23. Survey insights on the competitiveness drivers for the cement industry

In our survey we asked 15 cements companies across the EU representing about one third of EU cement turnover and employment to indicate main drivers of their competitive position and areas, which can be improved. Companies could provide a score on each of the areas offered, ranging from 1 (being "very poor") to 5 (being "very good"). In the analysis, where confidentiality thresholds allow, we can distinguish also between regional specificities.

For the question on their **current market position** companies prove to be rather confident (see next figure). This is particularly the case concerning the quality of their product and range of product variety they provide to customers.

Figure 86 – Current market competitiveness position of cement sector

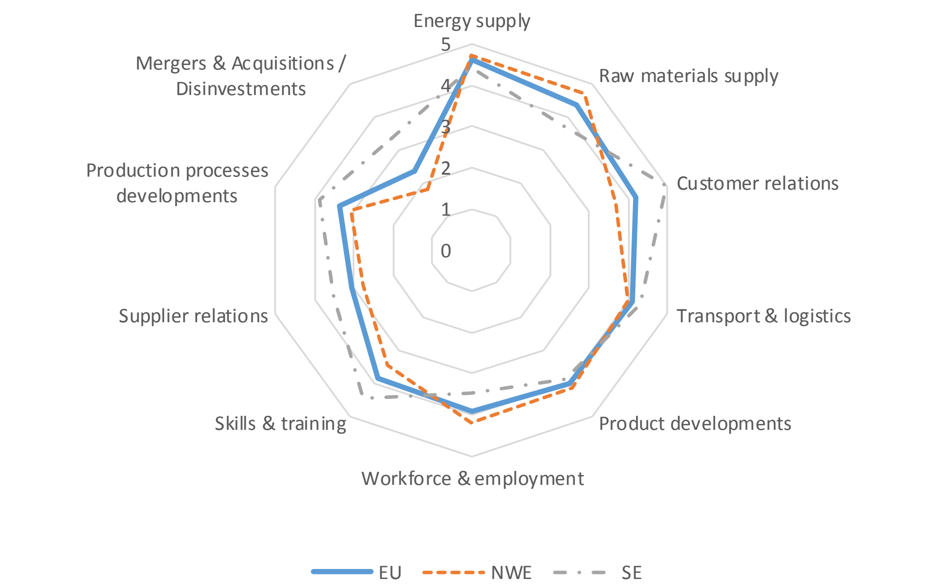


Note: Score ranges from 1=very poor to 5=very good (scale of the axis starts from 3)

Product range was however one of the areas which revealed the highest variance of replies, with some companies indicating to have a poor competitive position relatively to the diversity of their product lines. This variance is also captured by the different average scores outlined by the regional subgroups, with Southern European companies showing a higher confidence in their product range, as opposed to their North Western counterparts. Conversely companies feel to have the relatively poorest performance when it comes to the price of their products.

When asked about what areas they deem to be important to improve their competitive position (see next figure), companies rank energy supply as the primary element, followed by the access to raw materials and the development of relations with customers. Energy supply is an essential area to improve to secure a competitive position, for all companies across our sample. The access to raw materials tends instead to be a more pressing issue for companies in North Western countries, than those in Southern Europe. Mergers and acquisitions receive a relatively lower score, from the companies in our sample. Replies to this extent display nevertheless a high variance: some companies in Southern Europe tend to attribute a higher importance to this dimension. Access to labour and the level of skills of the workforce are graded similarly by European companies. However, behind the average aggregated figures for Europe, one can see that Southern European companies tend to stress more the importance of improving their competitive position via the training of their employees. Conversely, companies in North Western Europe give relatively more attention to securing the access to workforce.

Figure 87 – Importance of areas to improve market position of cement producers



Note: Score ranges from 1=not important to 5=absolutely essential

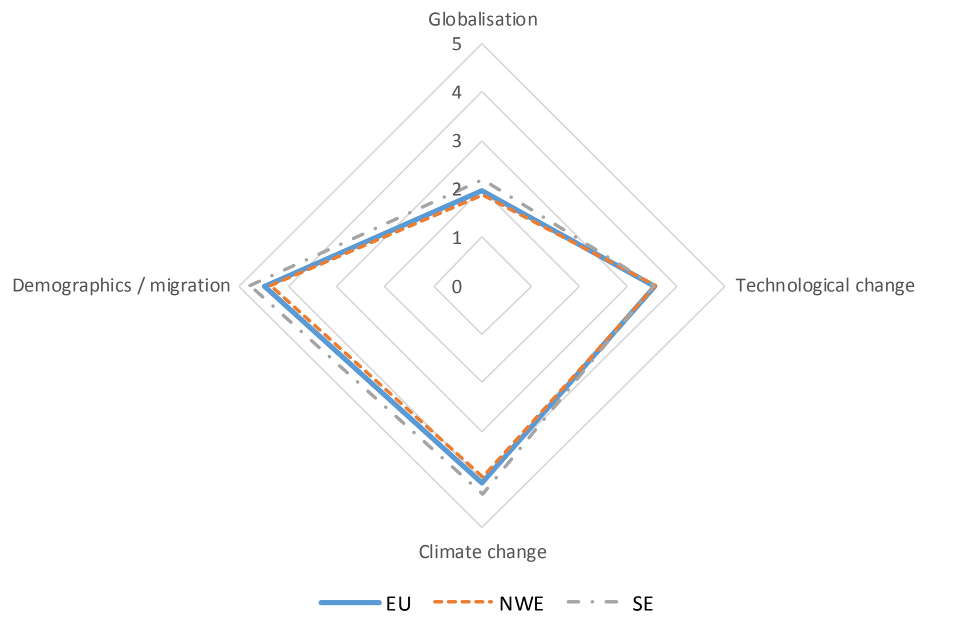
Similarly, we inquired the perception about drivers of change affecting the competitiveness of the EU sector as a whole. It is not globalisation what concerns cement companies, with many of those surveyed attributing limited importance to this phenomenon. Demographic trends and migration are instead seen as very important, and the same can be said for climate change policies, and, to a lesser extent, for changes in technology.

Cost of energy is again on top of cement companies' priorities, also when the focus is shifted from their microeconomic perspective to the broader picture of the EU sector. Access to raw materials and land are also seen as key issues, the latter dimension being of essential importance to companies in Northern and Western Europe. Companies in Southern Europe are in general more worried about the poor market demand conditions in the EU market and in the external one.

Changes in the size of companies and in the structure of the industry are the most important driver affecting competitiveness, among those investigated about the conditions of the sector. The developments in the value chain and in the supply chain are also considered of high importance.
In terms of general framework conditions, it is the access to infrastructure what it is more important for the competitiveness of the sector, followed by the access to knowledge, while finance is not seen as a primary issue

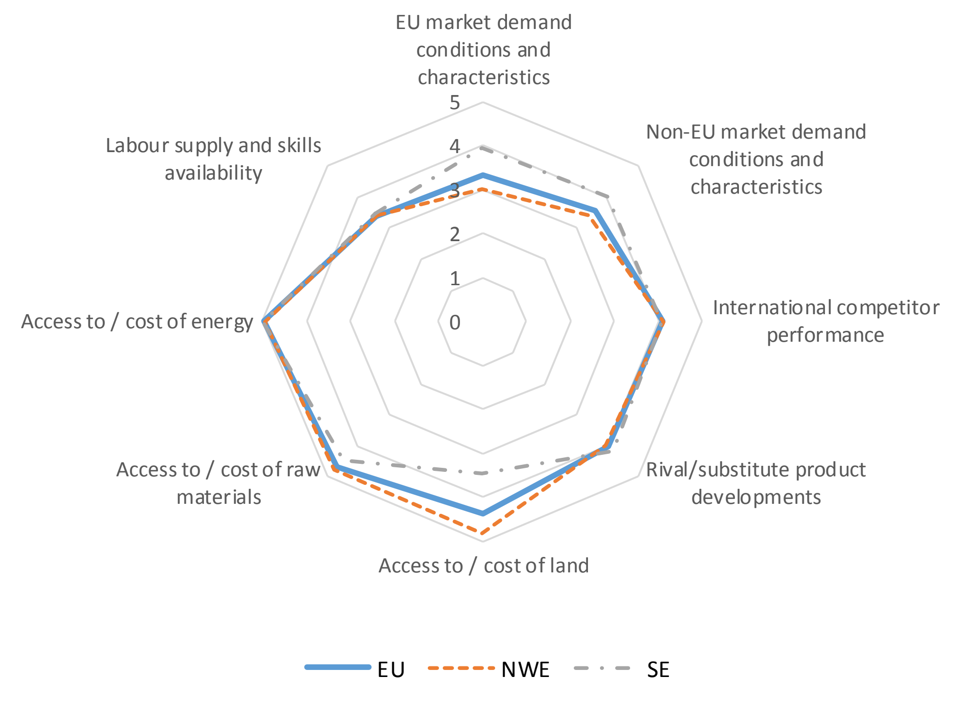
Regarding the regulatory environment, legislative changes involving the access to natural resources and energy supply are of crucial importance. Policy regarding ETS, climate and circular economy also tend to be among the relevant drivers identified by companies. On the other side of the scale, industry and fiscal policy are relatively less important for the competitiveness of the sector.

Figure 88 - Factors affecting the competitiveness of the European cement sector: exogenous conditions



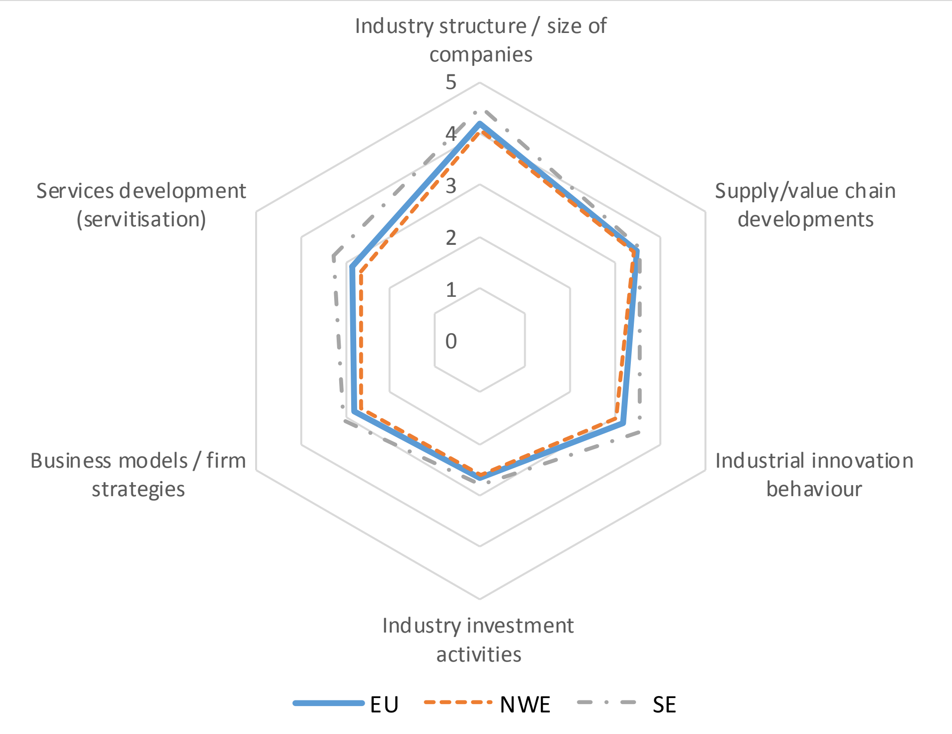
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 89 - Factors affecting the competitiveness of the European cement sector: market conditions



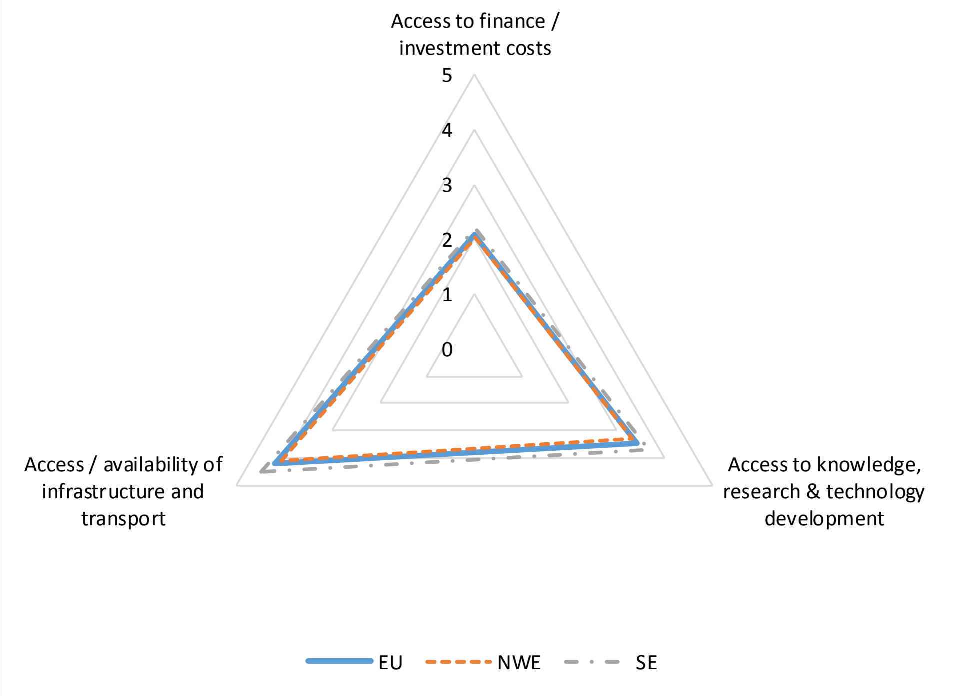
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 90 - Factors affecting the competitiveness of the European cement sector: industry conditions



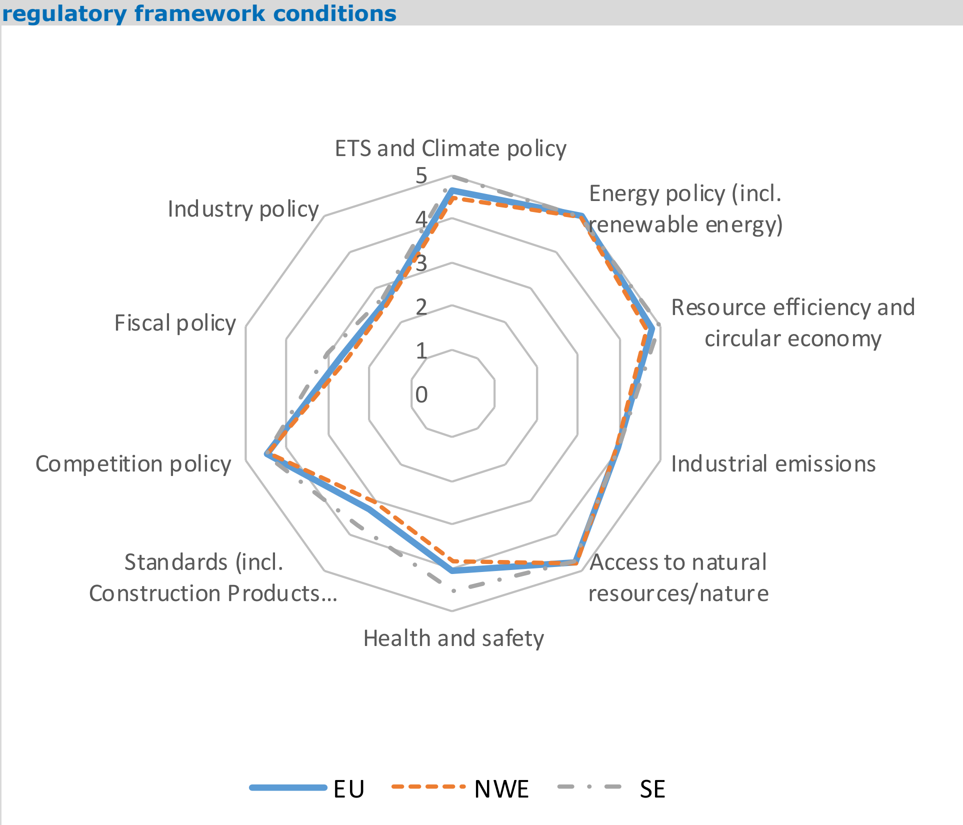
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 91 – Factors affecting the competitiveness of the European cement sector: general framework conditions



Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 92 – Factors affecting the competitiveness of the European cement sector: regulatory framework conditions



Note: Average scores, score ranges from 1=negligible to 5=very important

With regard to the **EU lime industry,** a somewhat different picture emerges. The sector is on a downward trend in terms of production, employment and productivity. The lime sector sells mostly to the iron & steel sectors (40%), accompanied by a wide range of other downstream sectors, including environmental protection, the chemical sector, construction materials, civil engineering, agriculture as well as others. Therefore, the structural decline in the EU industrial basis (particularly steel industry) is expected to have a profound impact on the EU lime sector. The majority of lime manufacturing enterprises are small and operating at a local level, although a limited number of large producers [304] have production operations throughout the EU or beyond. A concentration trend can also be witnessed amongst the industry's downstream clients, such as in in steel and environmental protection. Lime prices vary fairly strongly within the EU, underlining the wide divergence in terms of productivity, as well as limited trade intensity due to the rather unfavourable value/weight ratio.

What now will be the drivers for future competitiveness in the cement industry? In the next box we present the views of lime companies which participated in the survey. The results show (again) that energy costs and access to raw material are seen as important future drivers, but also the future market demand is seen as crucial driver.

[304] Notably Lloist, Carmeuse, CRH, Nordkalk, Schäferkalk and Calcinor.

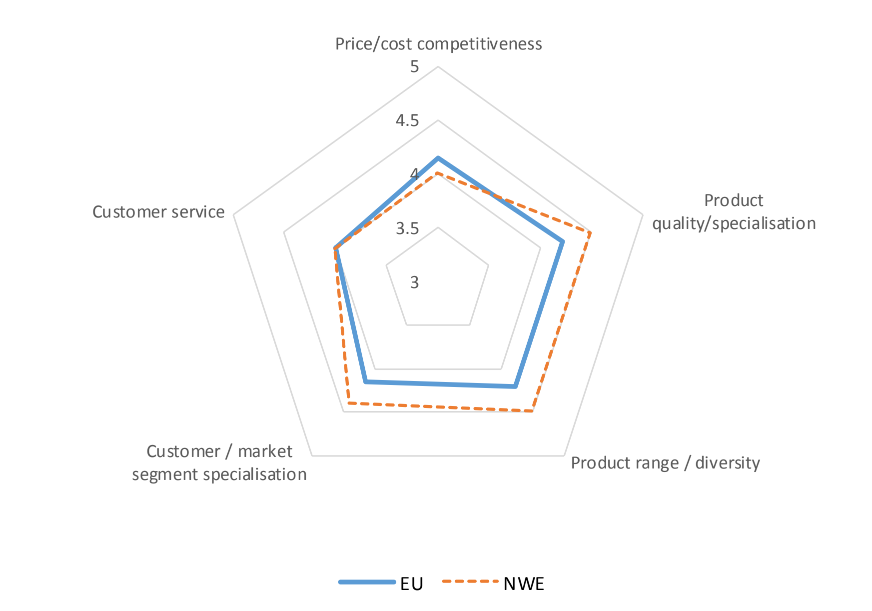
Box 24. Survey insights on the competitiveness drivers for the lime industry

As for the cement industry, in our survey we asked 11 lime companies across the EU representing almost one third of EU lime turnover and a bit more than a quarter of EU lime employment to indicate main drivers of their competitive position and areas, which can be improved. Companies could provide a score on each of the areas offered, ranging from 1 (being "very poor") to 5 (being "very good"). In the analysis, where confidentiality thresholds allow, we can distinguish also between regional specificities.

With respect to their assessment of their overall market position, lime companies believe they possess a positive position on all the areas considered, with differences across the average scores being limited. Lime firms responses indicate that in their opinion they have a solid position when it comes to the quality of their products, as well as to the diversity of product sold. They tend to perceive their competitive position as good also in terms of cost competitiveness.

Dispersion of individual replies within each dimension is marginal, with companies in North Western Europe considering to have a stronger position in products (both in quality and range), as well as in the targeting of their market segment.

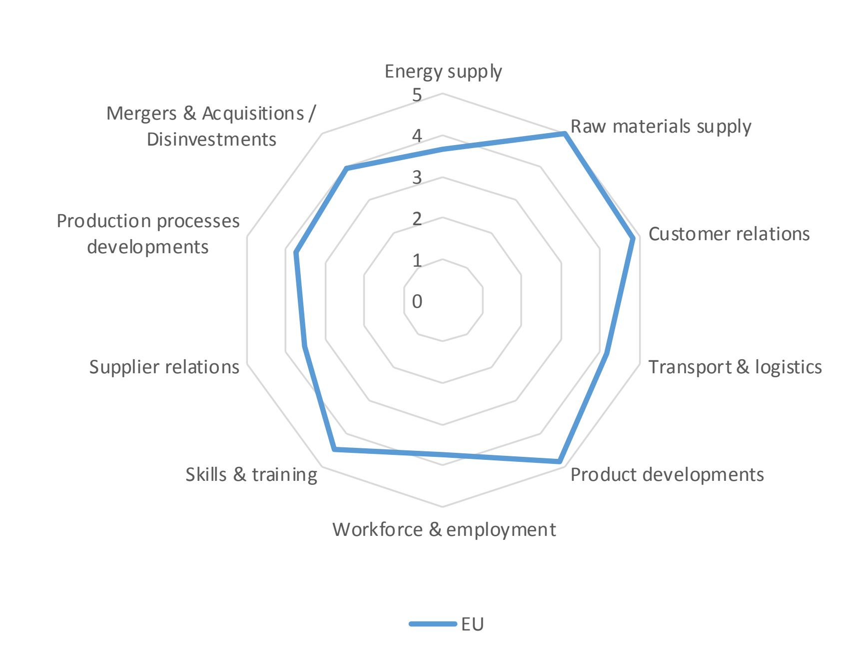
Figure 93 – Current market competitiveness position of lime sector



Note: Score ranges from 1=very poor to 5=very good (scale of axis starts from 3)

When asking about how to secure the market position, the supply of raw materials was mentioned as a crucial issue. Developments in the products as well as improvements in the relations with customers are also of high importance.

Figure 94 – Importance of areas to improve market position of lime producers



Note: Score ranges from 1=not important to 5=absolutely essential

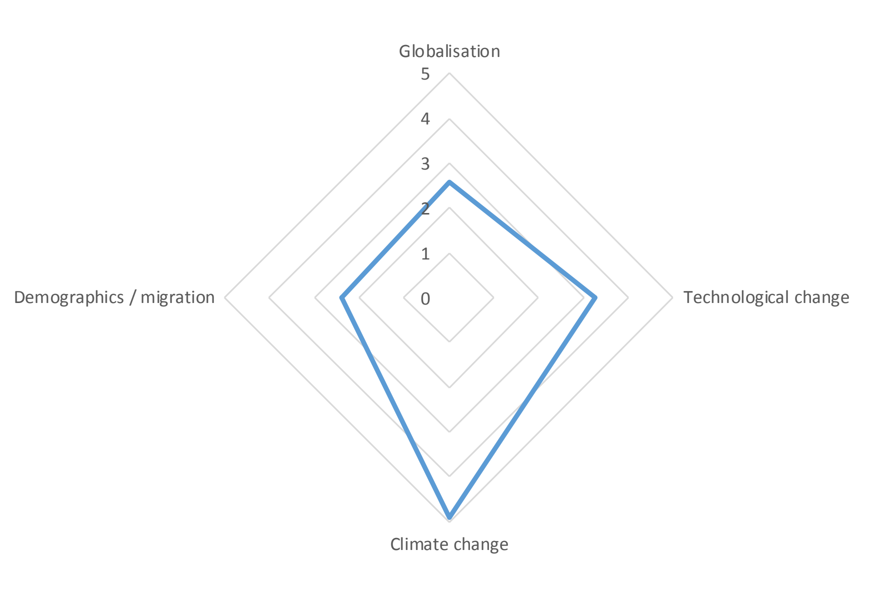
We additionally analysed the perception of companies concerning factors affecting the competitiveness of the EU lime sector, on several dimensions, ranging from exogenous conditions, and conditions specifically related to the lime market, to the aspects of the business strategies and of the regulatory environment. Climate change is systematically indicated as an important exogenous driver affecting the competitiveness of the EU lime sector, according to the companies surveyed. Globalisation, demographics trends and changes in technology, will play a role, but to a lesser extent.

Access and cost of energy, and land and raw materials are indicated as important drivers of competitiveness for the EU sector, followed by developments of substitute products that could potentially affect the demand of lime. Performance of international competitors is also seen as a relevant driver, while labour supply and the conditions of the EU and non-EU demand are seen as having a relatively lower impact.

The different drivers analysed under the heading of "industry conditions" tend to receive the same level of attention by lime companies. The development in the supply chain and the value chain and the trends of changes in the structure of the sector and the size of the company have a lower impact to competitiveness, according to the replies of our sampled companies.

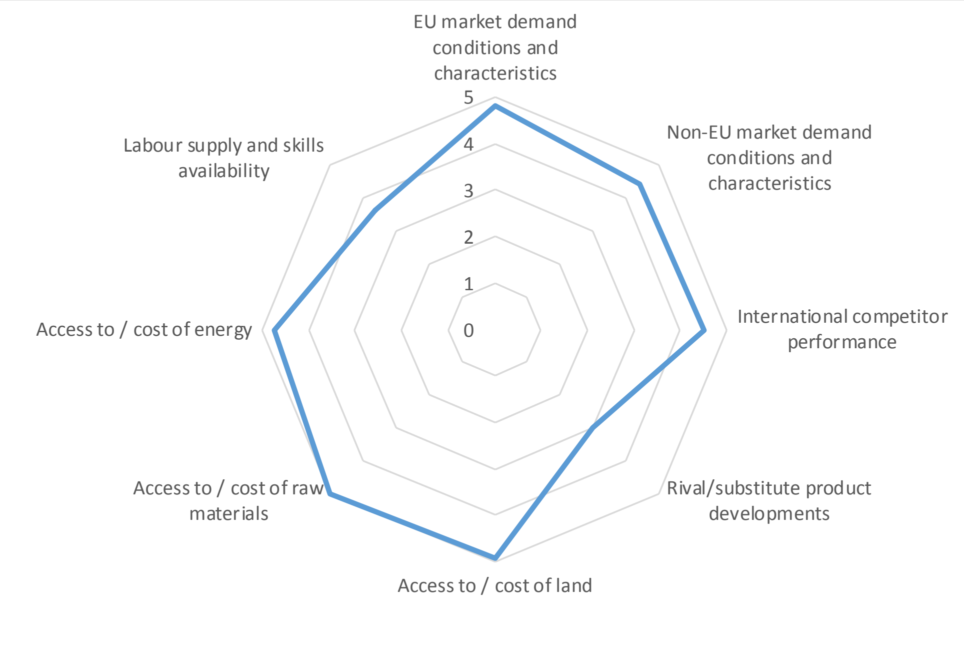
ETS and climate legislation are one of key aspects to consider, when analysing the regulatory framework, as well as the regulation affecting access to natural resources.

Figure 95 - Factors affecting the competitiveness of the European lime sector: exogeneous conditions



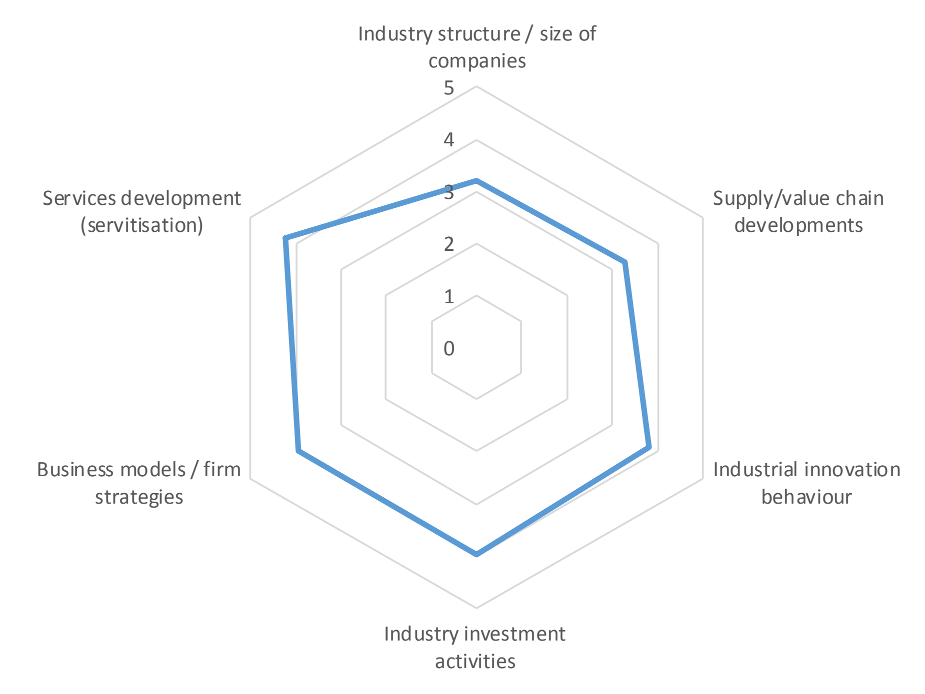
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 96 - Factors affecting the competitiveness of the European lime sector: market conditions



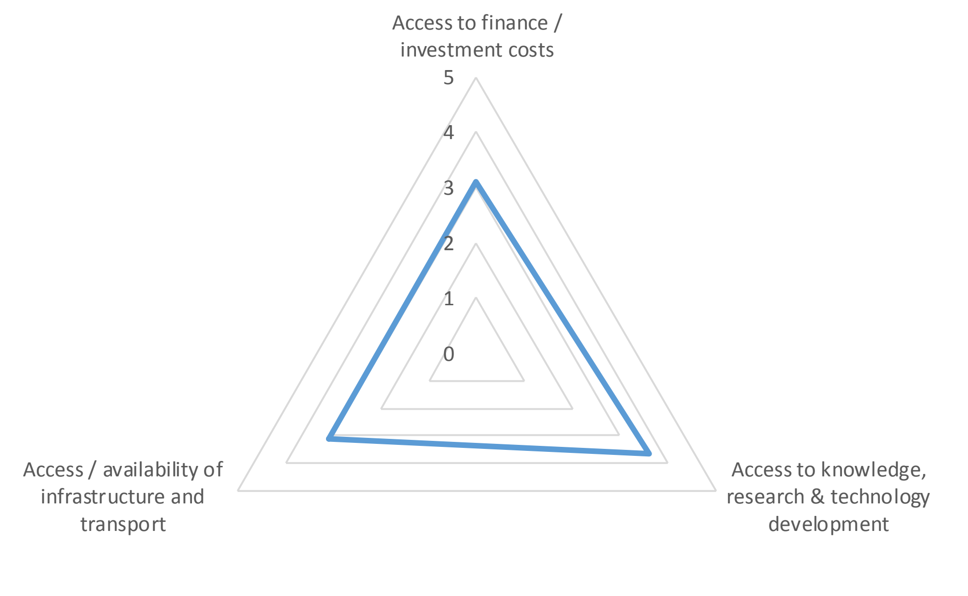
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 97 - Factors affecting the competitiveness of the European lime sector: industry conditions



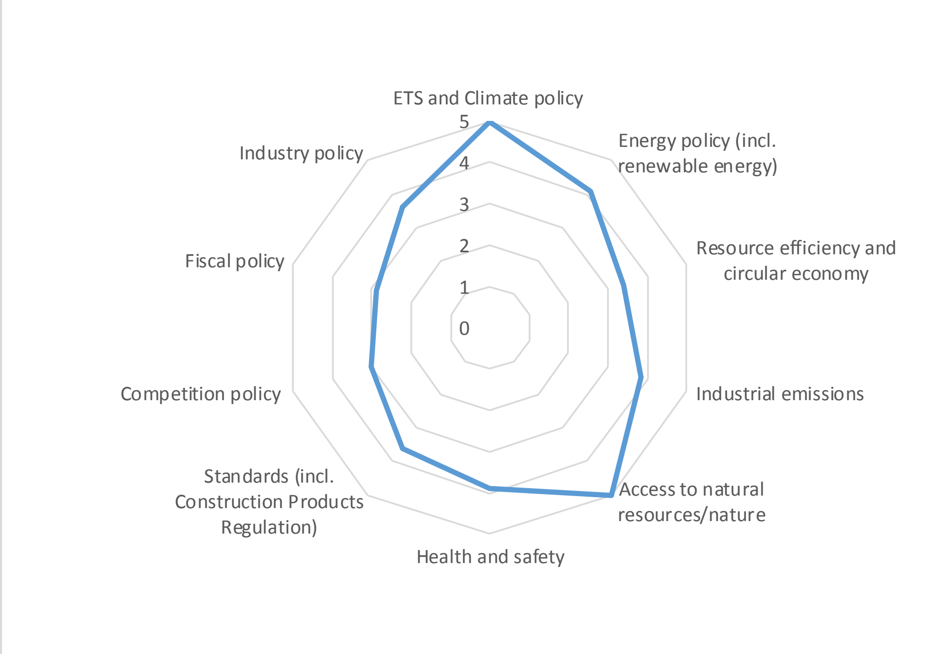
Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 98 – Factors affecting the competitiveness of the European lime sector: general framework conditions



Note: Average scores, score ranges from 1=negligible to 5=very important

Figure 99 – Factors affecting the competitiveness of the European lime sector: regulatory framework conditions



Note: Average scores, score ranges from 1=negligible to 5=very important

Key patterns as described in the boxes above are as follows:

- **Current market position:** the overall (average) situation in terms of product quality and range, and customer/market specialisation and services is largely satisfactory (good) for both industries. However, cement companies attribute a lower evaluation of price/cost competitiveness compared to their counterparts in the lime sector;
- **Areas to improve market position:** generally, both industries attach a high level of importance to all areas listed in the survey. Lime companies appear to attach greater importance to 'raw materials supply' and 'customer relations' than is case for cement companies. Also, cement companies attach a lower importance to mergers and acquisitions, which may be a reaction to the relatively recent major consolidation that has occurred in the industry;
- **Exogenous trends:** demographics and migration are seen as a more important factor for future competitiveness by surveyed cement companies than by lime companies. This may be attributable to the potential impact of migration and demographics on future construction activity levels and, hence, demand for cement, both within the EU and globally;
- **Market conditions:** access to energy, raw materials and land play a key role in shaping the future competitiveness, according to both the cement and lime companies surveyed. The demand trends in the EU and in the non-EU markets are particularly stressed by lime companies, which, conversely, foresee the importance of future developments in substitute products to a lesser extent than cement companies. Overall, it seems that the lime industry is more focused on competition from other producers (e.g. see also on international competitor performance), while the cement industry directs its attention towards the potential competition arising from outside the sector, from rival products;
- **Industry conditions:** generally, surveyed lime companies attach a higher importance to innovation behaviour, investment activities, business strategies, and service development than their counterparts from the cement industry. By contrast, industry structure and company size is seen as more important for future competitiveness by cement companies than by lime companies. This seems to reflect a view that larger cement companies are in a better competitive position than smaller rivals, again as reflected by the recent major consolidation that has occurred in the industry;
- **Regulatory conditions:** both cement and lime companies rank regulatory conditions

concerning access to natural resources (and biodiversity) and ETS and climate change as very important for the future competitiveness of the sector. Energy policy and resource efficiency and the circular economy are scored more highly by cement companies than by lime companies, which may reflect a combination of the cement sectors greater potential for use of alternative fuels and the dependence of demand on the construction industry, for which circular economy developments and sustainability characteristics of construction products are important. Finally, competition policy is rated as more important by cement companies than by lime companies.

5.2 Scenarios for the future

5.2.1 Context for the scenarios

A key issue for both the cement and lime sectors and, in turn, for policy makers, is to better understand how resilient are the sectors when responding to external shocks, changes in demand, technology developments, as well as regulatory reforms and new initiatives (at EU, national, regional and local levels). Research suggests that the cement and lime industries are susceptible and sensitive to developments in many areas that could potentially affect their business environment and lead to changes in key parameters determining each industry's competitive position and performance. Consequently, there is a high level of uncertainty surrounding the future development of these industries and, accordingly, proposing a single projection (scenario) for the future appears somewhat inappropriate.

Cement is expected to remain a vital product for future civil engineering and construction projects and, as in the past, will remain susceptible to fluctuations in economic cycles through their impact on European construction demand. At the same time, there is concern – particularly from within the cement industry – that EU production is potentially quite vulnerable to imports from third countries, particularly so for clinker. For example, the cost impacts of more stringent environmental regulations, or other developments that cause higher production costs (including taxes), are viewed among the main factors that could have a negative impact on relative competitiveness of European cement production. Furthermore, uncertainty over the long-term direction and application of regulation in Europe, or arising from the transposition of EU legislation into national or regional legislation, is viewed as hindering investment decision-making and, therefore, a source of additional costs for European producers.

According to interview responses as well as the analysis provided in the previous chapters, coastal regions - especially in Southern Europe – and those regions sharing a land border with non-EU countries are most exposed to competition from imported cement products, including imported cement clinker. Turkey, Morocco, Algeria and Egypt currently pose the biggest potential threat. However, with its massive domestic production capacity, a downturn in Chinese cement demand could lead producers there to look for export markets too, which could pose a major challenge to EU production. Similarly, changes in transport costs could be expected to have an impact on the EU industry's trade volatility.

In terms of competition from non-cement products, the situation is complex as cement and other construction products (e.g. wood, steel) can be both substitutes and complements to each other. Where they are substitutes, their relative merits in terms of performance, particularly in terms of sustainability and full life-cycle resource use are not well understood, and there is a need for these to be better evaluated (e.g. through Life-cycle Cost Assessment (LCA).

With regard to the prospects for the EU lime industry**,** although there is some potential to replace lime and lime based products, the scope for product substitution is generally considered to be limited. This is especially true for the use of lime in steel production, the largest market segment for lime products. Nonetheless, there are possibilities for competition in specific markets; for example, from chemical products in the environmental market, from crude limestone and dolomite in agriculture, from kaolin-based products in papermills, etc. In the construction sector – especially with regards to building materials – cement is a competing product, currently favoured over the more traditional lime mortars, mostly because of its quick setting time. More important, however, is the concern that the lime industry will see the disappearance of certain market segments altogether. In particular, lime producers are concerned about the potential relocation of steel production to locations outside of the EU, and report that imports from China have already increased in recent years. The disappearance of its biggest market could have severe repercussions for the lime sector. Conversely, the shift to a circular economy and increasing demand for environmental applications – especially for water and flue gas treatment – creates new opportunities for the lime industry.

Both sectors are characterised by high energy intensity, high levels of CO2 emissions, high capital intensity and long investment cycles; for example, a new kiln's lifetime is between 30-50 years and can cost up to € 100 million, while investments for major up-grading kiln technology can amount to several € million and need to be amortized over many years. These characteristics, combined with recent weak market growth performance and prospects, imply that both industries are susceptible to changes in regulatory frameworks – particularly in relation to climate change and energy policy, but also access to raw materials – that have the potential to impact on the return on investment. Uncertainty over future policy developments is a challenge for long-term investment planning and underlies industry calls for greater clarity of direction and stability of application of regulatory frameworks.

Given the current situation, both cement and lime industries in the EU express a willingness to invest in cleaner, more energy efficient and better performing plants and installations, as a response to evolving global challenges and policy frameworks. But, at the same time, ask for a greater level of long term stability and certainty of EU, national and regional regulatory frameworks (beyond 2030). If not, a combination of increasing production costs (caused by regulation or otherwise, such as changing market conditions) and uncertain investment conditions, could undermine competitiveness of EU production and result in greater penetration of imports, possibly from countries with inferior environmental performance than EU production. In this context, the following sub-sections will present and explore the potential impact of a variety of types of potential policy changes on the cement and lime industries and on the EU's trade position in these products.

5.2.2 Description of the scenarios

In the context of this study, a number of scenarios were developed to explore the potential impact of a variety of potential exogenous as well as policy changes on the cement and lime industries and on the EU's trade position in these products. The scenarios were developed with the aim to test the 'resilience' of the EU cement and lime industries vis-à-vis exogenous as well as policy-driven changes. The scenarios and their underlying assumptions have been developed on the basis of exchanges with the European Commission and industry representatives accompanying this study. The scenarios have been constructed around fictive possible future changes each of them intersecting distinct points in the value chain. These fictive policy interventions are not to be confused or compared with the development of real EC policy initiatives - which would require a systematic and formal impact analysis [305]. However they are considered informative as the scenarios produce distinct reactions in terms of outputs, imports/exports and employment. Nevertheless, when interpreting the results of a model it should always be borne in mind that it will always paint a simplied situation of the reality, and that other factors outside the model may play a role in the business reality as well. The results of this model exercise can therefore only be indicative.

Further details on the 'shocks' that have been modelled in each scenario are provided below:

- **Scenario I: Targeted energy prices**: The cement and lime sectors are confronted with a change in energy costs. The main scenario assumes a tax increase on their energy inputs amounting to 25% (or10%) of previous energy costs. A sensitivity analysis is made for a 10% decrease of prices as well. This change in energy costs is expected to lead to a change in cement and lime output price (factor prices), input prices for downstream industries (particularly construction, iron and steel, but also that for the chemical industries, as the most important users of cement and lime). Via the further transmission of prices, all relative prices will be influenced, resulting in economy-wide changes to the structure of demand. As the change in energy prices is assumed to be limited to the EU28, price differentials between the EU and the Rest-of-the-world will change as well, which will result in trade effects for potentially all commodities;
- **Scenario II: Blanket energy prices**: all economic sectors are confronted with an energy tax increase equivalent to 10% of energy costs. For this particular scenario, it will be assumed that energy prices for oil, gas and coal in the EU will increase due to a tax increase. It is expected that such a price shock will affect different industries to different extents. As a particularly energy-intensive sector, however, cement and lime will be affected more severely than most other sectors. In consequence, cement and lime output prices will change more, leading to an increase in input prices for downstream industries (particularly construction, iron and steel, but also the chemical industries, as the most important users of cement and lime). As in the previous case, all relative prices will be influenced, resulting in economy-wide changes to the structure of demand. These changes are expected to be less intense than in the previous scenario;

  Scenario III: Product tax: A product tax of 25% is levied on cement and lime. Changes in legislation do not affect the cement industry directly, but rather the users of their output, e.g. implementation of tax on the use of cement. As such, the tax applies to both domestic production and imports. The effects will work mainly through price-induced changes in the demand for cement and lime; in so far as cement and lime enters into production processes, however, output prices of cement and lime using industries will be affected as well;
- **Scenario IV: Production tax:** The cement and lime sector is faced with new legislation whose implementation raises production costs by 5%. This implies that, contrary to the former scenario, non-cement and non-lime industries will not be directly affected. Several sources could lie at the origin of such an increase, e.g. changes in (future) energy and/or climate legislation, raw material taxes (e.g. limestone), etc. Irrespective of the source of these taxes, the cement and lime sectors will face indirect (and induced) effects, as users of cement and lime output. Construction will be among the sectors that will bear the immediate (and possibly strongest) effect of the mentioned shock;

[305] For example with the help of dedicated energy models such as PRIMES, the European Commission is developing analysis tools in the areas of energy, climate and transport. It allows policy-makers to analyse the long-term economic, energy, climate and transport outlook based on the current policy framework. It is not designed as a forecast of what is likely to happen in the future, but it provides a benchmark against which new policy proposals can be assessed. Detailed results on the 2016 Reference Scenario and EUCO scenarios are available under the following links:
https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf
https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf

- **Scenario V: Delocalisation of downstream industries (lime only):** The steel industry, a major customer of the lime industry, continues its exodus from the EU. For this 'pure delocalization' scenario the main assumption is that domestic output in the mentioned downstream industries is reduced by 10%. This scenario will provide additional insights in the case of the lime industry.

5.2.3 Assumptions

An overview of the main assumptions that have been adopted for each scenario is provided in the table below. All these scenario settings and assumptions are based on literature review, analysis of secondary data sources and the knowledge gathered so far during the project. The scenario settings and the results from the model simulations have been validated in workshops with industry representatives.

Table 15 Assumptions

Scenario	Scenario settings and assumptions
General assumptions (for all scenarios)	The simulation is comparative-static, and is not based on a forecast of possible future time paths. Therefore, all simulated interventions are assumed to be introduced on top of the current state of the economy. The simulation setup does not include reactions of final demand. Specifically, any new taxes that might be raised by the simulation assumption are not recycled into the economy. The simulations only reflect production-related economic linkages (between all sectors in all model regions). The most important assumptions for the model pertain to the elasticities of demand: own-price elasticities for cement and lime are assumed to be in the range of -0.5 (low estimate) to -1.5 (high estimate). Cross-price reactions to the price of cement and lime for the following commodities are implemented: - wood products (C16) with elasticity +0.2; - building materials (C23.10; for example, bricks) with elasticity +0.2; - steel (part of C24) with elasticity -0.2.[306, 307308]

[306] The reasoning is the following: all three products, wood, other building materials, and steel are both substitutes for cement (in the form of buildings made from wood, steel or bricks, for example) and complements (steel reinforcement, wooden casing, ingredients and additives of concrete, etc.). The chosen elasticities assume steel to be more of a complement (if demand for concrete drops, so does demand for steel, but in a dampened way), while other building materials and wood are assumed to be more like substitutes (again assuming a dampened reaction)

[307] In all scenarios, cement and lime prices are assumed to increase, so an increase in the demand for 'wood products' (C16) and 'other building materials' (C23.10) is expected; demand for steel (C24) should decrease. In the simulations, the changes in demand for these commodities are assumed to pose no problems for the sectors producing them. This should be a very innocent assumption in the case of steel, where demand from construction amounts to only 6% of total demand in the EU. For wood products, the share of construction-related demand is a third of the total, so a substantial increase in demand might pose some problems; the simulation results, however, are not expected to be more than a few percent. Similar reasoning pertains to other building materials (C23.10): for these, the construction sector is naturally the most important customer. Also, use of C23.10 roughly equals use of cement and lime plus concrete products. Nevertheless, capacity problems in the production of C23.10 are assumed to be of minor importance, again based on the argument that the expected percent changes in necessary supply are moderate (also, some additional demand will be met by imports).

[308] The choice of the cross price elasticities is certainly not an uncontentious one; however, for the main purpose of the simulation exercises, to estimate the effect of the scenario assumptions on the production volumes of cement and lime & plaster, the specific value of these cross-price elasticities is of very minor importance; even appreciably different values would not materially influence those results. Their main purpose is to show the influence of the cement-and-lime relevant

Scenario	Scenario settings and assumptions
	The simulation model assumes factor shares for energy in the cement industry of (on average) 24% and for the lime & plaster industries 31%[309]; results for different energy share will be presented in sensitivity scenarios.
Targeted Energy prices	The costs of energy for the cement sectors are increased by 25% (10%) by introducing a targeted commodity tax (or reduced by 10%).
Blanket Energy prices	The costs of energy are increased by 10% for all sectors through the EU by introducing a targeted commodity tax.
Product tax	An additional commodity tax on cement and lime equivalent to 25% (10%) of current use prices is introduced (over and above already existing commodity taxes). The new tax applies to both domestic products and imports.
Production tax	The intention is to simulate, the 'costs of regulation'. In this case, this is Implemented as an increase in output prices by 5%. Demand for other factors (capital, labour, energy, materials) is not directly influenced; so, the regulation is considered as an additional 'factor of production'.
Relocation	A decrease of steel output by 10%. The regional distribution follows current production patterns, so that steel production is reduced by 10% in each EU member state.

5.2.4 Description of the ADAGIO model

Although ADAGIO[310] is a dynamic model, for this project, the model as been set up in **a 'comparative-dynamic' way**, i.e. the results were simulated over a period of 20 years to allow all economic variables to adapt to the respective simulation setup and settle into the new (dynamic) equilibria. However, the **baseline** solution **is not a 'real forecast'**, instead **it is steady-state baseline solution**. The reason for this was a pragmatic one: producing a real (and sensible) forecast for a highly disaggregated model like ADAGIO is problematic in itself. Additionally, the sectoral disaggregation of C23 into the cement and lime relevant subsectors (which was also mirrored on the commodity side) was essentially based on the 2011-2014 averages of EUROSTAT's Structural Business Survey SBS. In other words, it represents a (weighted) point in time, which could not (and cannot) feasibly be turned into a time series of observations. Therefore, any 'forecast' of the output of the cement and lime sectors (as well as the demand for their commodities) could not be based on historical periods of meaningful length – any 'forecast' would essentially be without historical information. Therefore, we decided to run the simulations in the aforementioned 'comparative-dynamic' way. As a result, the interpretation is essentially a contemporaneous one: what would the current situation be, *if the simulated changes had already been implemented a (sufficiently) long time ago*. Most results, however, will be presented as percentage changes *vis-a-vis* the steady-state base run anyway – they would not be much different had they been simulated vis-a-vis a 'forecast' base run.

assumptions on these (related) sectors, in order to allow some plausibility checks in a broader feasibility context ("would those related industries be able to deliver the products necessary to compensate for the decrease in C&L output?").

[309] In the disaggregation of Sector C23 into the sub-sectors C23.51 (Cement) and C2352 (Lime & Plaster) (plus other sub-sectors), extensive use was made of the Structural Business Survey (SBS), on which, among other variables, the factor share of energy for the sub-sectors was based. In the case of the cement sector, the factor share thus estimated was in good agreement with results from the survey (21% respectiviley 24%). in the case of lime, however, the SBS-share proved too low (at around 22% versus 31% in the survey). The main reason seems to be the fact that even at the 4-digit level, "lime" cannot be separated from "plaster" – thus the less energy intensive plaster production exerts a downward bias on the combined sector's energy share. As the simulations did not affect demand or supply of plaster, we re-calibrated the energy intensity of the lime & plaster sector to reflect the higher energy demand of lime production.

[310] See, Annex F for technical details of the ADAGIO model.

The **simulations** will be of **'Type I'** – i.e. they will estimate the direct and indirect effects of the scenario assumptions on the production side of the economy (the effects on the directly involved sectors, their suppliers, the suppliers of those suppliers, etc.). However**, induced effects will not be covered**. Induced effects are those that are linked to changes in value added and consist of, for example, changes in household consumption (induced by income changes) or changes in public consumption (following changes in tax revenue). The reasoning is as follows. Most of the scenarios (in fact all of them, except for the steel scenario) involve price changes which are implemented as changes in the tax regime (a 25% increase in energy taxes, or a 10% increase in commodity taxes on cement). A full (Type II) simulation – covering intermediate as well as final demand effects – would necessitate far-reaching assumptions about the way these new taxes are recycled – are they used to cut income taxes? or corporate taxes? or social security contributions? are they simply spent by the government, or (just maybe) used to retire public debt? The consequences for the simulations would be extremely different. To avoid discussions on this issue, and of course for its own merits, it was to concentrate on the immediate production-related effects. However, we will come back to this issue in the discussion of the respective scenario results, where appropriate. It also has to be stressed that **international trade linkages**, imports and exports, **do react to changes in relative prices**; exports, although notionally a component of final demand, do therefore react.

Box 25: the determination of prices in the ADAGIO model

For every sector, output prices are determined together with the factor shares. The production function used is of type Translog and distinguishes 5 factors of production: Capital. Labour, Energy, imported materials and domestic materials (KLEMmMd). As usual, the production function is not estimated directly, but rather via its dual, the cost function. This formulates factor shares as well as the output price as a function of factor prices; the equations for all factors depend on all prices (i.e. own price and cross prices), as does the equation for the output price (So, the output price is not a (simple) weighted average of factor prices). To approximate "technical progress", linear and non-linear time trends are included. The equations for the factor shares and output price are determined via system estimation.

The (sectoral) output prices, which are basic prices (i.e. the price "at the factory door") are then converted into commodity prices using the sectoral market shares matrix. Adding user-specific trade and transport margins as well as taxes less subsidies on commodities yields purchaser prices – the price a user has to pay for the product. The purchaser price for exports constitutes the price at the border of the exporting country, it is the fob-price. Adding international trade and transport costs results in the cif-price for the importing country (i.e. the price at the border of the importing country, before tariffs as well as margins and commodity taxes of the importing country).

As for the factor prices: the prices of imported and domestic materials are directly calculated as the weighted user price of intermediate products. wages (the "price of labour") are endogenously linked to inflation (i.e. the weighted average of the purchaser prices of the user "private households") and productivity; the capital price is linked to the endogenous price of investment (the weighted average of the prices of investment goods) and the exogenous rate of interest. Energy prices are linked to the endogenous prices of fuels. In this vein, all prices in ADAGIO are endogenously derived from the output price.[311]

[311] Except for the Rest-of-the-World, i.e. the (roughly) 15-20 % of the world economy not covered by ADAGIO: not being included in the model, the RoW's prices cannot be determined endogenously, but have to be exogenously provided. In concrete model application, however, their development is usually linked to the (average) price paths of the 5 model countries BRA, IDN, IND, MEX.

Although ADAGIO works at the level of individual countries, **results will be presented mainly for 4 regional aggregates**: EU-South (Portugal, Spain, Italy, Greece); West (France, Ireland, Belgium, Luxembourg, the Netherlands and the United Kingdom); East (Poland, Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Romania) and, finally, Central-North (Sweden, Finland, Denmark, Germany and Austria). However, key results will be shown at the level of individual member states.

Moreover, **results will be presented for sectors, but mainly for commodities** – i.e., most results will deal with a percentage change in production of commodity C23.51, say, and not output of sector C23.51. The reason has to do with classification and statistics. More specifically, a firm is classified according to its main output. Therefore, a firm whose output consists of 51% pf C23.51 (cement) and 49% of C24.52 (lime) will be classified as belonging to sector C23.51; cement, then, will be its 'typical' product, lime an 'atypical' product. This example is chosen for a reason: it seems that especially lime is often an 'atypical' product of otherwise classified firms (C23.51 or C23.10). Additionally, the full disaggregation into the 5 sub-sectors C23.10, C23.51, C23.52, C23.61, C23.63 was not possible for all countries; in some, only C23.10, C23.51 and C23.6 were feasible, for a few others, no disaggregation was possible at all. For both reasons, the presentation of results at the commodity level seems much more appropriate than sectoral results. If genuinely 'sectoral' variables are presented, e.g. employment, they will be derived from sectoral results using the commodity share of output as weights. For example, if commodity C23.52 (lime) represents 10% of the output of the cement sector C23.51, then we assume that 10% of the workers in the cement sector C23.51 are employed for its (atypical) production of lime.

Table 16 Relevant sector/industry codes

Code	Description
B05	Mining of coal and lignite
B06	Extraction of crude petroleum and natural gas
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C19	Manufacture of coke and refined petroleum products
C23	Manufacture of other non-metallic mineral products
C23.10	Manufacture of glass and glass products
C23.5	Manufacture of cement, lime and plaster
C23.51	Manufacture of cement
C23.52	Manufacture of lime and plaster
C23.6	Manufacture of articles of concrete, cement and plaster
C23.61	Manufacture of concrete products for construction purposes
C23.63	Manufacture of ready-mixed concrete
C24	Manufacture of basic metals
C24.1	Basic iron and steel and ferro-alloys
D35	Electricity, gas, steam and air conditioning supply
F (includes F41-F43)	Constructions and construction works
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport

Besides production effects, we **report the effect on international trade** (imports and exports), aggregated to intra- and extra-EU trade. We also present results for closely connected sectors. In particular, the construction sector (F) as the most important user of cement and lime, but sometimes also at wood products (C16) and basic metals (C24). Both of these sectors are complements and substitutes for cement and cement products – substitutes as construction materials (houses can be built from concrete, steel, bricks, but also from wood), complements as compound materials (steel in reinforced concrete) and casing materials (wood as molds for ready-mix concrete). This difficulty was solved by choosing rather low elasticities of substitution between cement and lime on the one hand and wood and steel on the other (of -0.3).

We are aware that these elasticities are somewhat ad-hoc – on the other hand, their value has only very minor repercussions on the main topic of this report (cement as well as lime & plaster), because their use is driven predominantly by their own- price elasticities (the prices of the potentials substitutes are nit changes exogenously). The main purpose of including elasticities of substitution between wood/steel in the one hand and cement/lime on the other is to get a feeling for the order of magnitude that price changes in ceme nt/lime could exert on the demand for wood and steel. The simulations will show that these are not dramatic, and should not pose unsurmountable challenges on those sectors.

As for the demand elasticities for cement and lime/plaster, the following **elasticities of substitution** have been used. The own-price elasticity of cement and lime products was set at -0.6.[312] As attempts at estimating this elasticity from the WIOD data base yielded rather inconclusive results, this value was chosen from the moderate end of the range of estimates **found in the literature** (see, Röller and Steen, 2006; Meunier et al., 2014).

A word of caution concerning the interpretation of the results: As stated above, the simulation setup assumes that final demand (except for exports) is fixed. The simulations pertain only to intermediate production linkages, i.e. 'Type I' simulations. In addition, and specifically, we assume that any tax revenues will not be recycled. Therefore, the simulation setup contains a 'big' *ceteris paribus* assumption.[313] In other words, the numbers cannot be interpreted as a forecast of what will be the development in the respective scenarios – rather, they are indications of what opportunities or risks the scenario framework would pose for the different sectors of the economy. Recycling of the tax revenues would lead to markedly different results, depending on the manner of recycling (e.g. income tax reduction, social security reduction, etc.). Using the tax proceeds to finance a reduction in labour costs, for example, might well neutralise or even reverse the detrimental effect of energy taxes on output prices). Thus, even if in the following pages words like "losses", "drops", etc. are used, they are used mostly for 'flavour'.

5.2.5 Scenario I: Targeted Energy Prices

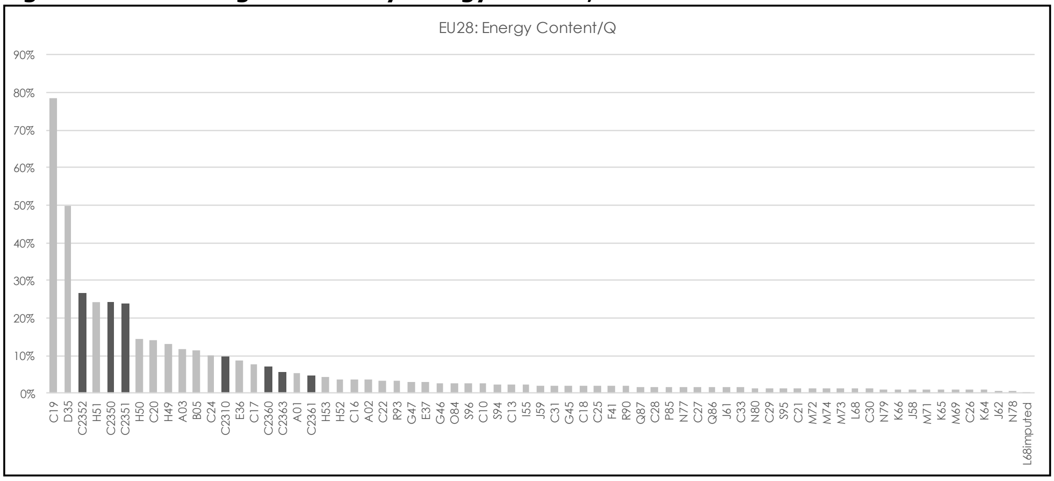
A. Key assumptions

The cement and lime sectors are very energy intensive. As shown in the figure below, in a ranking of sectors by their energy costs (total energy inputs divided by turnover), the cement and lime industries are in the forefront, ranked behind only the energy sectors C19 (petroleum refineries) and D35 (Electricity and Gas), and at a par with the transport sectors H49-H51.

[312] If the price of cement and lime goes up by 1%, its nominal demand will drop by 0.6%

[313] *Ceteris paribus* assumption: All other things being equal.

Figure 100 Ranking of sector by energy content, 2011[314]



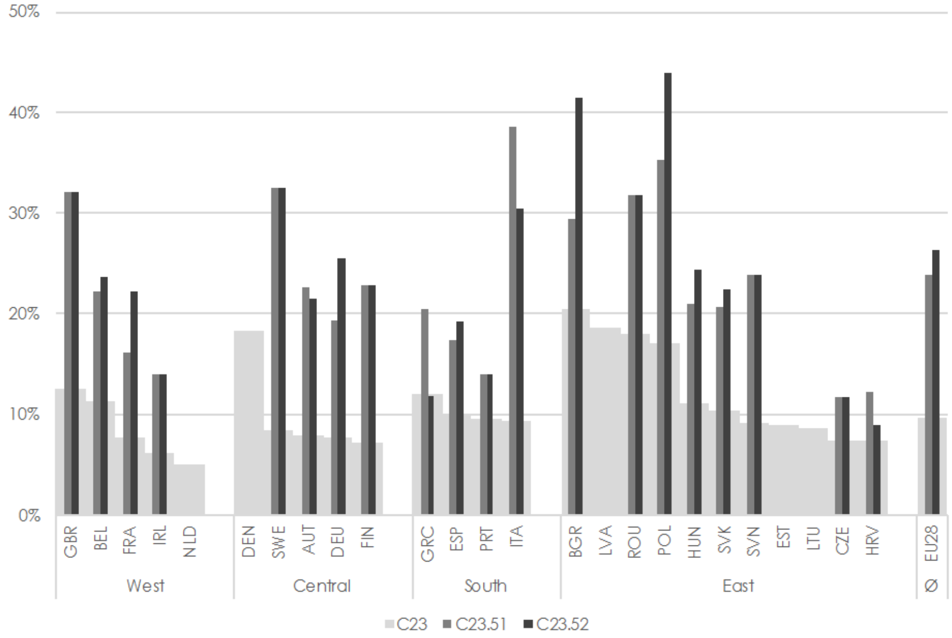
Source: IO database (WIOD, EUROSTAT).

Therefore, energy costs in the C23 sector are high, but not uniformly so across the Member States. The share of energy costs in output roughly follows a regional rich-poor pattern (energy costs are relatively more important when labour costs are lower, for example). Of course, energy prices vary substantially between countries also due to the energy mix and the energy efficiency of the capital. Moreover, energy costs for the two sub-sectors cement (C23.51) and lime (C23.52) are appreciably higher than the average energy costs for the aggregate sector C23 (see Figures 101 and 102). These two facts imply that increases in energy costs, either by a rise in energy prices or taxation, will affect the cement and lime industry disproportionately hard.

This scenario as well as the next one will examine this in more detail: by raising energy prices only for the cement and lime industries, the present scenario (Scenario I ‘Targeted energy prices’) will focus more on regional differences, while Scenario II ‘Blanket energy prices’ will look more at relative effects at the sectoral level by raising energy taxes uniformly. In Scenario I, the rise in energy tax amounts to 25% of the current user cost of energy (i.e., it raises energy taxes by an amount equal to 25% of what users already pay for their energy, over and above existing taxes); while in Scenario II, the increase will be a more moderate (and probably more realistic) 10%.

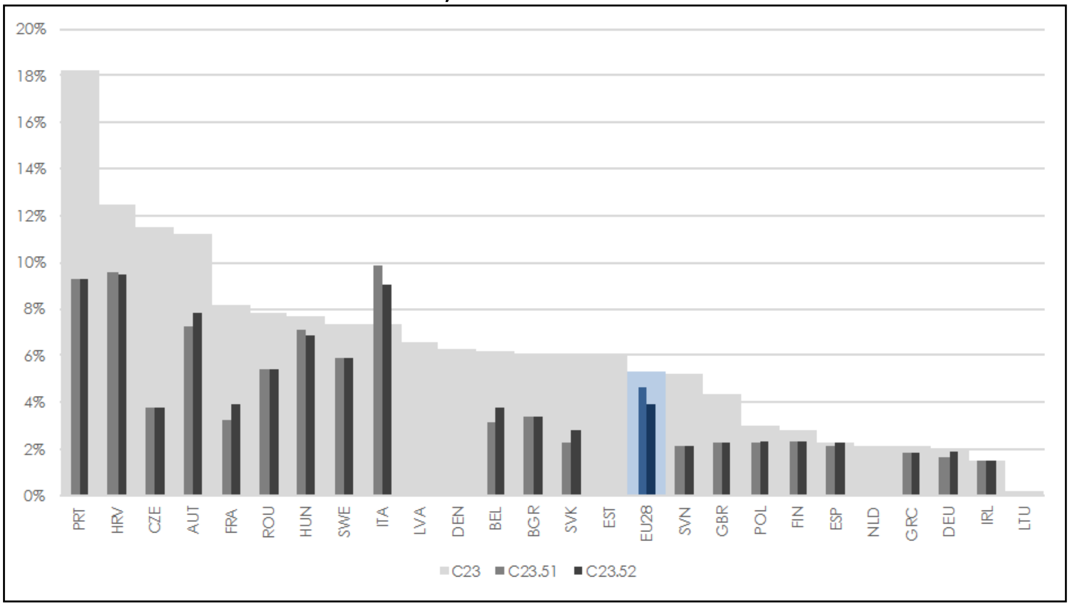
[314] The year 2011 refers to the base year of the IO database WIOD. The disaggregation is based on SBS data averaged over 2011-2014.

Figure 101 Ranking of countries by cement and lime (Sector C23.51 and C23.52) energy costs as a share of output, 2011[315]



Source: SBS; WIOD; own calculations.

Figure 102 Ranking of countries by the share of commodity taxes on the energy costs of the cement and lime sectors, 2011[316]



Source: WIOD; EUROSTAT; own calculations.

The technical implementation in ADAGIO is quite straightforward. For the cement and lime sectors only, commodity taxes on the energy goods B05 (coal), B06 (oil), C19 (petroleum refinery products) and D35 (electricity and gas) are increased by an amount equivalent to 25% of their initial use prices. This increase, therefore, comes above already existing energy and commodity taxes – it is the use price of energy for the C&L sectors (product price plus trade- and transport margins plus taxes) that increases by 25% (in short, energy becomes more

[315] The year 2011 refers to the base year of the IO database WIOD. The disaggregation is based on SBS data averaged over 2011-2014.

[316] The year 2011 refers to the base year of the IO database WIOD. The disaggregation is based on SBS data averaged over 2011-2014.

expensive by a quarter). Reiterating the general introduction on the simulation setup, any proceeds (if any) from this new tax are not recycled; instead, the results solely show the direct and indirect effects on the production side of the economy only.

B. Main results

In this scenario, as a result of the 25% (additional) energy tax, commodity prices for cement are estimated to rise by 4.3% on average; lime and plaster prices rise by 3.3% (Table 17). This feeds forward into the price of concrete products and ready-mix (simulated to rise by 0.5 resp. 0.8%), and further to the price of construction work, which, however, responds with very dampened price increases of around 0.1%. The general price level also rises, but by less than half of a percent (a bit more in the East and the South, a bit less in the West and Central-North part of the EU).

Table 17 Impact on prices

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.2%	5.9%	4.5%	0.8%	1.3%	0.9%	0.1%	0.0%	0.0%	**0.0%**
West	0.1%	3.6%	3.5%	0.3%	0.7%	0.7%	0.0%	0.0%	0.0%	**0.0%**
East	0.4%	5.8%	7.2%	1.1%	1.8%	1.4%	0.2%	0.1%	0.1%	**0.1%**
CentralNorth	0.1%	4.2%	4.4%	0.4%	0.6%	0.7%	0.1%	0.0%	0.0%	**0.0%**
EU28	**0.2%**	**4.7%**	**4.5%**	**0.6%**	**1.0%**	**0.9%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

Whereas nominal output rises slightly (Table 18), the price increases lead to a drop in the quantity demanded (and, hence, quantity produced) of cement and lime products (of -4.0% respect to -3.3% for cement and lime). The induced price increases in the concrete and, further on, the construction sector (as well as in the whole economy) lead to (very slight) losses. More specifically, the volume output of concrete products contracts by around 0.5% (following price increases of 0.6%). In the construction sector, both price increases and output losses are already much dampened. Throughout the economy, real output does contract, but by less than half a percent (Table 19).

Table 18 Impact on nominal commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.1%	0.2%	1.2%	0.1%	0.4%	0.2%	0.0%	0.0%	-0.1%	**0.0%**
West	0.1%	0.8%	0.8%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	**0.0%**
East	0.0%	0.4%	1.5%	0.1%	0.5%	0.2%	0.0%	0.0%	-0.1%	**0.0%**
CentralNorth	0.1%	0.4%	1.0%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.1%**	**0.5%**	**1.0%**	**0.1%**	**0.3%**	**0.2%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

Table 19 Impact on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-0.1%	-5.4%	-3.1%	-0.7%	-0.9%	-0.8%	-0.1%	0.0%	-0.1%	**-0.1%**
West	-0.1%	-2.6%	-2.6%	-0.2%	-0.5%	-0.5%	0.0%	0.0%	-0.1%	**0.0%**
East	-0.3%	-5.2%	-5.4%	-0.9%	-1.3%	-1.2%	-0.2%	-0.1%	-0.2%	**-0.1%**
CentralNorth	-0.1%	-3.7%	-3.3%	-0.3%	-0.5%	-0.6%	-0.1%	0.0%	-0.1%	**0.0%**
EU28	**-0.1%**	**-4.0%**	**-3.3%**	**-0.5%**	**-0.7%**	**-0.7%**	**-0.1%**	**0.0%**	**-0.1%**	**0.0%**

Source: Own calculations.

As the whole price system will change (actually, all prices will rise in response to the tax hike in the energy input of the cement and lime sectors, at least marginally), international competitiveness will change as well due to terms-of-trade deterioration: extra-EU imports will become relatively cheaper, exports dearer. The consequences are shifts in international trade. More specifically, exports to outside the EU will decrease, extra-EU imports will increase (at least in relative terms). The effect of intra-EU trade is more complex and depends on relative energy intensities and initial energy costs. The fall in demand, however, proves to be large enough so that intra-EU trade almost uniformly drops in absolute terms (see Table 20).

Table 20 Impact on real imports and exports

Imports	**C2310**	**Other C23**	**C2351**	**Cement**	**C2352**	**Lime & Plaster**	**C2361**	**Concrete Products**	**C2363**	**Ready-Mix**	**F**	**Construction**
Region	**extraEl**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**
South	0.3%	-0.1%	7.5%	-1.3%	4.8%	-2.2%	0.9%	-0.3%	1.9%	-0.5%	0.0%	-0.2%
West	0.2%	-0.1%	4.3%	-4.8%	6.3%	-5.3%	0.4%	-0.5%	0.5%	-1.1%	0.0%	-0.2%
East	0.5%	0.1%	5.1%	-3.9%	7.2%	-2.5%	0.6%	-0.3%	1.3%	-0.5%	0.0%	-0.1%
CentralNorth	0.2%	-0.1%	4.6%	-3.0%	5.4%	-2.4%	0.5%	-0.5%	0.6%	-0.8%	0.0%	-0.2%
EU28	**0.3%**	**-0.1%**	**5.3%**	**-3.8%**	**6.0%**	**-3.8%**	**0.6%**	**-0.5%**	**0.8%**	**-0.8%**	**0.0%**	**-0.2%**

Exports	**C2310**	**Other C23**	**C2351**	**Cement**	**C2352**	**Lime&Plaster**	**C2361**	**Concrete Products**	**C2363**	**Ready-Mix**	**F**	**Construction**
Region	**extraEl**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEl**	**intraEU**	**extraEU**	**intraEU**	**extraEl**	**intraEU**
South	-0.2%	-0.1%	-6.0%	-5.1%	-4.5%	-3.3%	-0.8%	-1.0%	-1.3%	-1.5%	-0.1%	-0.1%
West	-0.1%	0.0%	-2.8%	-3.1%	-2.6%	-4.0%	-0.3%	-0.2%	-0.6%	-0.9%	-0.1%	-0.1%
East	-0.2%	-0.3%	-4.8%	-3.6%	-5.2%	-3.9%	-0.8%	-0.9%	-1.4%	-1.4%	-0.3%	-0.3%
CentralNorth	-0.1%	0.0%	-3.8%	-4.1%	-3.9%	-3.4%	-0.3%	-0.2%	-0.6%	-0.5%	-0.1%	-0.1%
EU28	**-0.1%**	**-0.1%**	**-4.4%**	**-3.8%**	**-4.0%**	**-3.8%**	**-0.5%**	**-0.5%**	**-0.8%**	**-0.8%**	**-0.2%**	**-0.2%**

Source: Own calculations.

As shown in Table 20, with decreasing demand and output, demand for labour will drop as well. In the cement and lime industries, around 1 200 jobs are affected. On the whole, rather more jobs are linked to this scenario: some 65 000 throughout the whole economy[317]. Interestingly,

[317] this might seem a lot as a consequence of price increases in two sectors which are not very labour intenisve, together employing around 80,000 persons. However, it has to be born in mind that the price increases in these two sectors

the sector which is most affected is agriculture with some 6 500 jobs. The reasons are multiple: Mostly, because agriculture is one of the larger sectors. Also, lime is an input for Agriculture, which means that the induced price effect is higher than in other sectors of the economy, and, the elasticity of substitution between imports and domestic for agricultural products is comparatively high, so price increases have larger negative effects on trade. In the construction sector, 1 600 jobs are at stake, a similar number as in the metal sector. Due to drops in trade, the trade and transport sectors will together lose around 10 000 jobs.

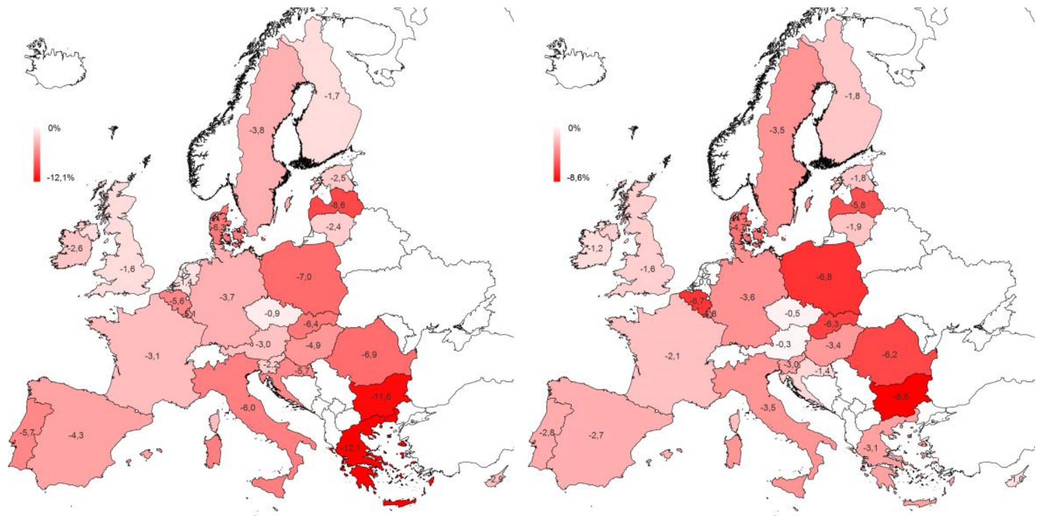
Table 21 Impact on employment

	Employment: absolute [1000 persons]										relative [%]		
	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic metals	**Economy**	C23 total	Construction	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**C16**	**C24**	**Total**	**C23**	**F41**	**Total**
South	0	-0	-0	0	-0	-0.2	-0.9	0.0	-0.3	**-16**	0.0%	0.0%	0.0%
West	0.2	-0.1	0.0	0.1	0.0	-0.3	-0.2	0.0	-0.1	**-8**	-0.1%	0.0%	0.0%
East	0.0	-0.7	-0.1	-0.0	0.1	-1.0	-0.5	-0.3	-0.9	**-32**	-0.2%	0.0%	-0.1%
CentralNorth	0.1	-0.2	-0.0	0.1	0.0	0.0	-0.0	-0.0	-0.2	**-9**	0.0%	0.0%	0.0%
EU28	**0.4**	**-1.1**	**-0.1**	**0.2**	**0.1**	**-1.4**	**-1.6**	**-0.3**	**-1.5**	**-65**	**-0.1%**	**0.0%**	**0.0%**

Source: Own calculations.

The regional differences of the impact on cement and lime production are shown in the figure below.

Figure 103 Changes in volumes of cement (C23.51, left) and lime (C23.52, right)



Source: Own calculations.

In all Member States, the effect of the energy price increase is a negative one, with higher effects in the Eastern (and, les pronounced, Southern) countries. The patterns for cement (left) and lime & plaster (right) are similar; declines in lime & plaster ouptut, however, seem to be somewhat more concentrated in the north-eastern parts of Europe.

feedback and forward into virtually all prices; with world prices remaining much less affected, the terms-of-trade of all European products worsen with respect to extra-EU countries – exports of all products will drop (even if only so lightly), imports will rise. As a consequence, the economy will shrink – the 65,000 jobs related to this scenario amount to some 0.03% of the EU's total employment.

Apart from and additional to affecting demand and trade, a further consequence of the rise in energy costs is that cement and lime firms try to reduce their use of energy. In nominal terms, this does not look very successful: as a result of the price increase, the factor share of energy actually rises by around 12% in the cement and 8% in the lime & plaster industry - but only in nominal terms. So, even if they pay more for their energy input, less energy is consumed in real terms ('volumes' of energy); a reduction of 10% in cement and 15% in lime production.

The model results suggest that taxing energy inputs can be a possible way to encourage (even enforce) a more frugal use of energy. However, it should be noted that the technical possibility to partially substitute energy by other production factors (i.e. labour and capital) coming from the model relies on historically based estimates of substitution parameters. Industry representatives from the cement industry consider that the type of gains achieved by past efforts to increase energy efficiency in production, will be much harder to achieve in the future, without a major technological breakthrough. Thus, the 10% increase in energy efficiency predicted by the model is considered too optimistic. With respect to lime, industry representatives indicate a similar situation but suggest that with an appropriate combination (depending on individual plant conditions) of technology switching for optimization of energy input and optimization of mineral input, it would be difficult but possible to achieve a 15% reduction in energy consumption.

There is, however, a further issue arising from the use of taxes on energy that results from their asymmetric impact on domestic production and imported products. The simulated taxes applies to domestic production, and implies a deteriorations in the terms-of-trade for EU products, leading to a partial replacement of domestic production by imports; in the simulated scenario EU imports of cement rise by 5.3% and lime & plaster by 6.0%. To the extent that imports come from higher energy intensive production, the positive impact from lower energy use (and emissions) of EU production will be dampened from a global perspective (carbon leakage').

C. Sensitivity analysis

Various sensitivity analyses have been carried out, which are presented here.

Sensitivity 1: lower Energy share – Lime & Plaster

As stated in the introduction to the scenarios, we used average energy intensities of 24% (Cement) and 31% (Lime) for the simulations; this is higher than what would be inferred from SBS data, which indicate 21% (Cement) and 22% (Lime) at the EU-average[318]. Using the lower shares, the effect on prices and volumes would be more subdued, especially for lime & plaster:

[318] as discussed, this discrepency for lime is most probably due to not being able to separate lime and plaster at even the 4-digit NACE level.

Table 22 **Impact on prices in [%]**

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	Economy
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**Econon**
South	0.1%	4.9%	3.2%	0.9%	1.0%	0.8%	0.1%	0.1%
West	0.1%	3.5%	2.9%	0.3%	0.5%	0.6%	0.0%	0.0%
East	0.3%	5.8%	6.0%	0.9%	1.7%	1.3%	0.2%	0.1%
CentralNorth	0.1%	3.5%	3.0%	0.3%	0.5%	0.6%	0.1%	0.0%
EU28	**0.1%**	**4.3%**	**3.4%**	**0.5%**	**0.8%**	**0.7%**	**0.1%**	**0.0%**

Source: Own calculations.

The main difference is in lime & plaster: due to the lower energy intensity, the effect of the 25% increase in energy prices on output price is lower, at 3.4 vs. 4.5%. As a consequence, the decrease in real production volumes is more subdued as well, with real volumes dropping by 2.6% (against 3.3% in the standard scenario). For cement, the differences are minor, as would have been expected, given that the energy intensities in the standard and sensitivity scenario are very similar.

Table 23 **Impact on real commodity output in [%]**

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	Economy
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**Economy**
South	0.0%	-4.9%	-2.4%	-0.6%	-0.7%	-0.7%	-0.1%	-0.1%
West	0.0%	-2.9%	-2.1%	-0.1%	-0.3%	-0.3%	0.0%	0.0%
East	-0.4%	-5.3%	-4.6%	-0.7%	-1.2%	-1.1%	-0.2%	-0.1%
CentralNorth	0.0%	-3.0%	-2.2%	-0.1%	-0.3%	-0.4%	-0.1%	0.0%
EU28	**0.0%**	**-3.9%**	**-2.6%**	**-0.3%**	**-0.5%**	**-0.6%**	**-0.1%**	**-0.1%**

Source: Own calculations.

Sensitivity 2: higher Energy share – Cement

In contrast to the first sensitivity scenario, in this section we assume a higher energy cost share for the cement industry. The reason is that although SBS and survey results are very similar (indicating average energy costs in the cement sector of around 21 and 24%, respectively), there are indications that energy costs are higher and similar to the ones in the lime sector, at around 30%. Therefore, keeping regional variations as indicating in the SBS data, we raised the EU-wide average for energy costs to 30%, and re-ran the energy price scenario. As expected, this higher energy share leads to appreciably higher effects on prices and quantities:

Table 24 **Impact on prices in [%]**

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy Total**
South	0.2%	7.6%	4.9%	1.1%	1.6%	1.1%	0.1%	0.1%	0.0%	**0.0%**
West	0.1%	4.5%	3.9%	0.4%	0.9%	0.9%	0.1%	0.0%	0.0%	**0.0%**
East	0.4%	7.3%	7.9%	1.3%	2.2%	1.7%	0.2%	0.1%	0.1%	**0.1%**
CentralNorth	0.1%	5.4%	4.6%	0.5%	0.8%	0.9%	0.1%	0.0%	0.0%	**0.0%**
EU28	**0.2%**	**5.9%**	**4.8%**	**0.7%**	**1.2%**	**1.1%**	**0.1%**	**0.0%**	**0.0%**	0.0%

Source: Own calculations.

Whereas the price effect in the main scenario was +4,7 and 4.5% for cement and lime & plaster, respectively, the increase in cement output prices is now estimated at +5.9% (the difference in the case of lime is only modest, as expected). Downstream prices are higher, too: price fro ready-mix goes up by +1.2%, vs +0.9% in the main scenario. Similarly higher effects are simulated for demand and domestic supply: the drop in real cement output, which was estimated at -4.0% in the main scenario, now amounts to -5.0%. Output of lime falls by -3.5%, similar to the main scenario's -3.3%.

Table 25 Impact on real commodity output in [%]

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy Total**
South	-0.1%	-6.8%	-3.4%	-0.9%	-1.1%	-0.9%	-0.1%	0.0%	-0.1%	**-0.1%**
West	-0.1%	-3.3%	-2.8%	-0.3%	-0.6%	-0.6%	-0.1%	0.0%	-0.1%	**0.0%**
East	-0.4%	-6.3%	-5.9%	-1.2%	-1.6%	-1.4%	-0.2%	-0.1%	-0.2%	**-0.2%**
CentralNorth	-0.1%	-4.6%	-3.5%	-0.3%	-0.6%	-0.7%	-0.1%	0.0%	-0.1%	**0.0%**
EU28	**-0.1%**	**-5.0%**	**-3.5%**	**-0.6%**	**-0.9%**	**-0.8%**	**-0.1%**	**0.0%**	**-0.1%**	**-0.1%**

Source: Own calculations.

Sensitivity 3: lower energy price increase

To demonstrate the sensitivity of results with respect to the increase in energy prices, this sensitivity scenario uses a 10% increase instead of the 25% of the standard scenario.

Table 26 Impact on prices in [%]

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy** Total
South	0.1%	2.4%	1.9%	0.3%	0.5%	0.4%	0.0%	0.0%	0.0%	**0.0%**
West	0.0%	1.5%	1.5%	0.1%	0.3%	0.3%	0.0%	0.0%	0.0%	**0.0%**
East	0.1%	2.4%	3.0%	0.4%	0.8%	0.6%	0.1%	0.0%	0.0%	**0.0%**
CentralNorth	0.0%	1.7%	1.8%	0.1%	0.3%	0.3%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.1%**	**1.9%**	**1.8%**	**0.2%**	**0.4%**	**0.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

As expected, the effect on prices is lower, in a roughly linear fashion: an increase in energy prices of 25% lead to an increase in output prices of around 4.6%, while now a 10% increase is passed on as a 1.8% increase in output prices. Similarly, real output now contracts by around 1 ½ %, while with the higher energy price increase, the contraction amounted to -4% (cement) and -3.3% (in the case of lime), again a roughly proportional difference.

Table 27 Impact on real commodity output in [%]

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy** Total
South	0.0%	-2.3%	-1.4%	-0.3%	-0.4%	-0.3%	0.0%	0.0%	0.0%	**0.0%**
West	0.0%	-1.1%	-1.1%	-0.1%	-0.2%	-0.2%	0.0%	0.0%	0.0%	**0.0%**
East	-0.1%	-2.2%	-2.3%	-0.4%	-0.5%	-0.5%	-0.1%	0.0%	-0.1%	**-0.1%**
CentralNorth	0.0%	-1.5%	-1.4%	-0.1%	-0.2%	-0.2%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.0%**	**-1.7%**	**-1.4%**	**-0.2%**	**-0.3%**	**-0.3%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

Sensitivity 4: Energy price decrease

So far, the scenario assumed rising energy prices for the C&L industry. To assess the reaction of demand for C&L products following a fall in energy prices[319], this sensitivity scenario assumes a 10% reduction.

Table 28 Impact on prices in [%]

[319] This sensitivity scenario can also serve as a proxy for technological progress in the C&L industry which would reduce energy demand by 10%. Especially in the case of cement production, it also might involve an increase in (cheaper) waste as a source of energy.

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy** Total
South	-0.1%	-2.5%	-1.9%	-0.3%	-0.5%	-0.4%	0.0%	0.0%	0.0%	**0.0%**
West	-0.1%	-1.5%	-1.5%	-0.1%	-0.3%	-0.3%	0.0%	0.0%	0.0%	**0.0%**
East	-0.2%	-2.5%	-3.1%	-0.4%	-0.8%	-0.6%	-0.1%	0.0%	0.0%	**0.0%**
CentralNorth	-0.1%	-1.8%	-1.9%	-0.2%	-0.3%	-0.3%	0.0%	0.0%	0.0%	**0.0%**
EU28	**-0.1%**	**-2.0%**	**-1.9%**	**-0.2%**	**-0.4%**	**-0.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

The lower energy prices feed a reduction in output prices by around 2%, which leads to falling output prices in the concrete sector: ready-mix would be around 0.4% cheaper in this scenario. Demand for cement and lime would rise by between 1.5 and 1.9%, as would the real production of concrete products and ready-mix. The effect on construction prices, however, would be too small to lead to more visible demand for construction services.

Table 29 Impact on real commodity output in [%]

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy** Total
South	0.1%	2.5%	1.4%	0.3%	0.4%	0.4%	0.0%	0.0%	0.0%	**0.0%**
West	0.1%	1.2%	1.2%	0.1%	0.2%	0.3%	0.0%	0.0%	0.0%	**0.0%**
East	0.2%	2.4%	2.6%	0.4%	0.6%	0.6%	0.1%	0.0%	0.1%	**0.1%**
CentralNorth	0.1%	1.7%	1.5%	0.1%	0.2%	0.3%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.1%**	**1.9%**	**1.5%**	**0.2%**	**0.3%**	**0.3%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

D. Summary of main assumptions and sensitivity

The following figure compares the (EU-wide) results of main scenario with those of the sensitivity modifications:

Table 30 Sensitivity of C&L sector results to different changes in energy prices

		1 - C&L Energy price **+25%**	1.1 - C&L Energy price **+25%**, **lower E-share in Lime&Plaster**	1.2 - C&L Energy price **+25%**, **higher E-share in Cement**	1.3 - C&L Energy price **+10%**	1.4 - C&L Energy price **-10%**
Cement	Output Price	4.7%	4.3%	5.9%	1.9%	-2.0%
	real Output	-4.0%	-3.9%	-5.0%	-1.7%	1.9%
	extraX	-4.4%	-3.7%	-5.5%	-1.8%	1.9%
	extraM	5.3%	4.1%	6.9%	2.2%	-2.2%
	Employment [1000]	-1.1	-0.4	-0.8	-0.5	0.6
Lime&Plaster	Output Price	4.5%	3.4%	4.8%	1.8%	-1.9%
	real Output	-3.3%	-2.6%	-3.5%	-1.4%	1.5%
	extraX	-4.0%	-2.8%	-4.9%	-1.7%	1.8%
	extraM	6.0%	4.8%	-4.9%	2.4%	1.7%
	Employment [1000]	-0.1	-0.1	-0.1	-0.1	0.1

Source: Own calculations.

The model reactions are roughly linear with respect to the size of the shock, as well as roughly symmetric with respect to the sign of the shock. Using the original energy shares as derived from the SBS data results in less pronounced effects, especially in the case of lime & plaster – this was to be expected, as the discrepancy in the cost share for energy between survey and SBS was especially pronounced in this sector. Although for the cement industry, survey and SBS were much more in line, we performed sensitivity analysis with a *higher* energy cost share, to accomodate the notion about the cement energy content being too low after all; with a 30% cost share, the reactions on prices and, therefore, demand and production turned out stronger as a result.

5.2.6 Scenario II: Blanket Energy Prices

A. Key assumptions

This scenario is similar to Scenario I 'Targeted energy prices', except that increased energy taxes are imposed on all economic sectors (see, Scenario I for a description of the existing situation).

The technical implementation of this scenario is similar to Scenario I, except that commodity taxes on energy goods are increased for all sectors, by 10% of the initial use price of the respective energy good (again, it is a 10% increase over and above total energy costs including energy and commodity taxes already in place). However, the tax increase is not applied to all energy goods, but only to fossil fuels (coal, oil and oil products, gas). The rationale behind it is that this represents a CO_2-tax. So, D35 (electricity) is not taxed directly, but incurs indirect taxation to the extent that fossil fuel is used in its generation. Moreover, it is assumed that the petrochemical industry C19 do not to pay taxes on their input of crude oil. Instead, to mimic emission (CO_2) taxes, it has been assumed that petrochemical products are taxed at an additional 10%.

B. Main results

As already shown in the last scenario, cement and lime are among the most energy intensive industries. Accordingly, the simulated impact on prices is markedly higher than in other sectors.

Overall, the average price increase is estimated at around 1.4%, compared to 1.8% and 1.9% in the cement and lime industries (Table 31).

Table 31 Impact on prices

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	1.3%	1.9%	1.9%	1.1%	1.3%	1.4%	0.8%	1.0%	1.2%	**1.2%**
West	1.2%	1.4%	1.4%	1.0%	1.1%	1.2%	0.7%	0.9%	1.1%	**1.1%**
East	2.2%	2.7%	3.4%	2.0%	2.2%	2.2%	1.7%	1.6%	2.4%	**2.4%**
CentralNorth	1.3%	1.8%	2.0%	1.1%	1.2%	1.3%	0.9%	1.0%	1.4%	**1.4%**
EU28	**1.4%**	**1.8%**	**1.9%**	**1.2%**	**1.3%**	**1.4%**	**0.9%**	**1.1%**	**1.4%**	**1.4%**

Source: Own calculations.

Increasing prices imply that a moderate effect on nominal output of around -0.6% overall translates into real production volume which is lower by around -1.5% for the whole economy. Again, both nominal and real output losses are above-average in the cement and lime industries, where real output volumes are estimated to drop by around -2.5% (see Tables 32 and 33).

Table 32 Impact on nominal commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-0.9%	-1.1%	-0.7%	-0.7%	-0.5%	-0.8%	-0.3%	-0.6%	-0.9%	**-0.7%**
West	-0.6%	-0.9%	-0.6%	-0.4%	-0.3%	-0.5%	-0.3%	-0.5%	-0.8%	**-0.5%**
East	-1.5%	-1.7%	-1.4%	-1.3%	-1.0%	-1.4%	-0.6%	-1.7%	-2.8%	**-1.2%**
CentralNorth	-0.6%	-0.9%	-0.6%	-0.6%	-0.5%	-0.6%	-0.3%	-0.6%	-1.2%	**-0.6%**
EU28	**-0.8%**	**-1.1%**	**-0.7%**	**-0.7%**	**-0.5%**	**-0.7%**	**-0.3%**	**-0.8%**	**-1.2%**	**-0.6%**

Source: Own calculations.

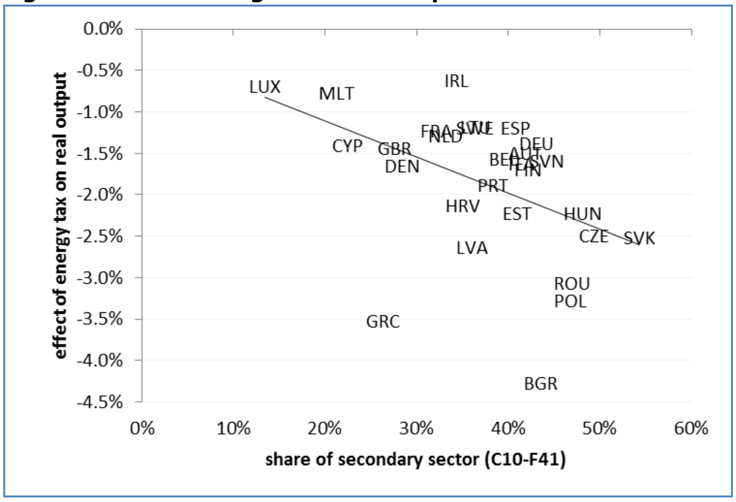
Table 33 Impact on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-2.2%	-3.0%	-2.5%	-1.8%	-1.8%	-2.1%	-1.1%	-1.6%	-2.1%	**-1.6%**
West	-1.8%	-2.3%	-2.0%	-1.3%	-1.3%	-1.7%	-0.9%	-1.4%	-1.9%	**-1.3%**
East	-3.6%	-4.3%	-4.7%	-3.2%	-3.2%	-3.5%	-2.3%	-3.3%	-5.1%	**-2.8%**
CentralNorth	-1.8%	-2.6%	-2.5%	-1.6%	-1.7%	-1.9%	-1.2%	-1.6%	-2.6%	**-1.4%**
EU28	**-2.1%**	**-2.8%**	**-2.6%**	**-1.8%**	**-1.8%**	**-2.1%**	**-1.2%**	**-1.8%**	**-2.6%**	**-1.5%**

Source: Own calculations.

As shown in Table 33, in the East region, real output in cement and lime/plaster is estimated to drop by around 4.5%. This is so due to more energy-intensive production, as well as cheaper labour costs, which additionally raise relative energy costs. However, in the West and Central-North regions, the decrease of real cement and lime volume is simulated at around 2 ½ %, while in the South this is in the range of -2.5 to -3%. In addition, the detrimental effect of the energy tax correlates (roughly) with the weight of the manufacturing sector: the higher its share, the higher the negative effects of the energy tax (see Figure 104).

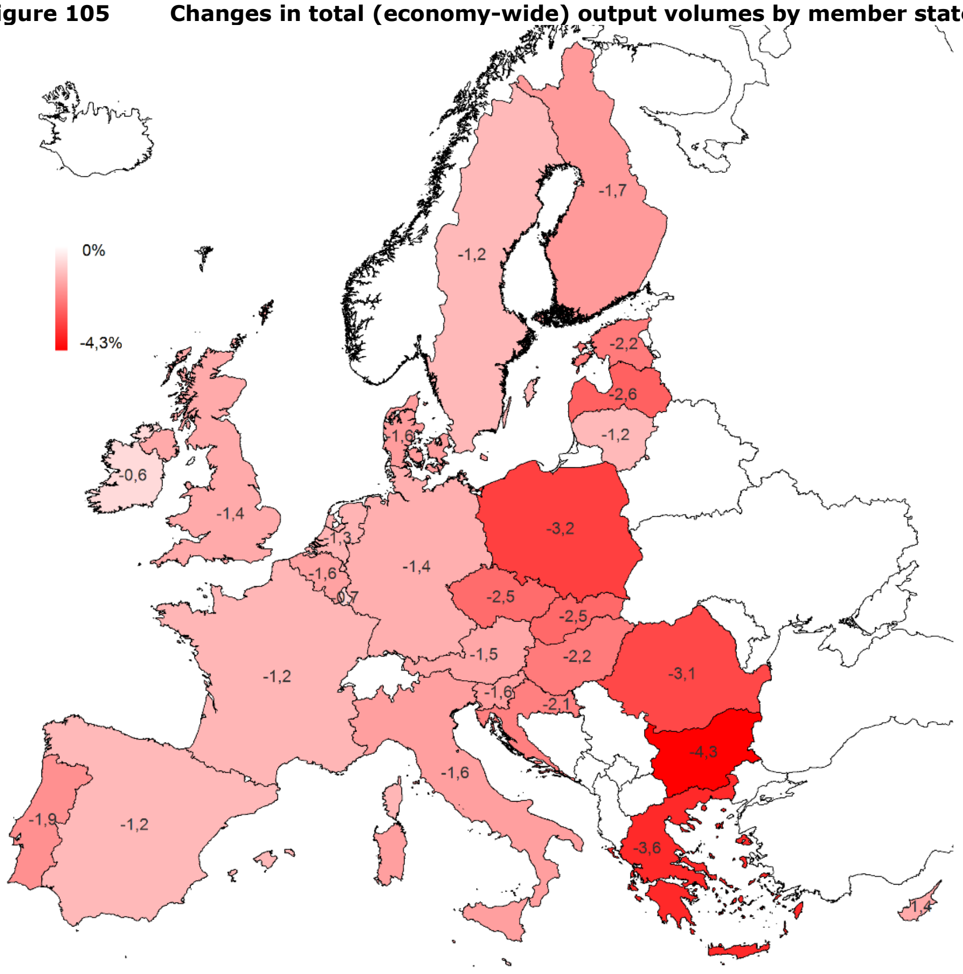
Figure 104 Changes in total output volumes vs. share of secondary sector



Source: Own calculations.

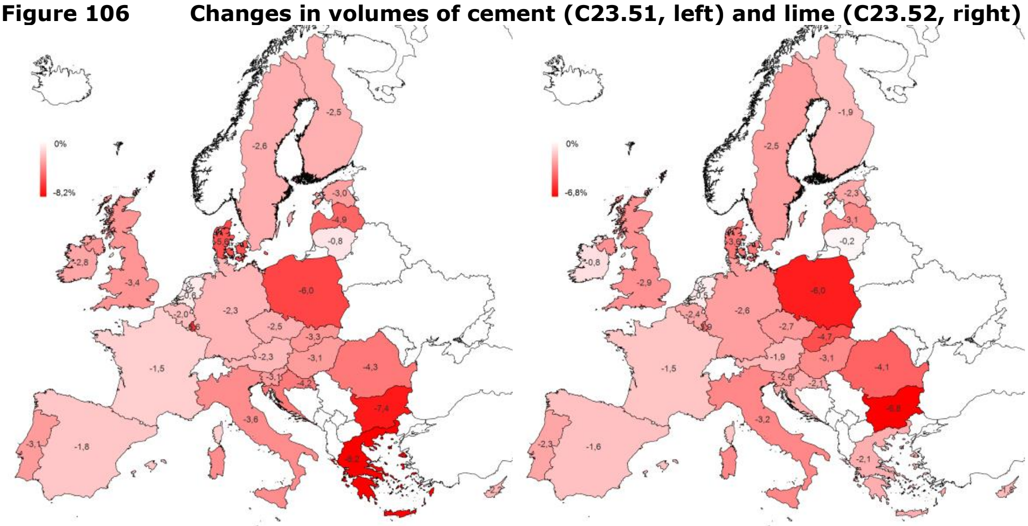
Figure 105 shows the regional differences on total economic output volume at the level of Member States, while Figure 106 provides an overview of changes in the volumes of cement and lime by Member State.

Figure 105 Changes in total (economy-wide) output volumes by member state



Source: Own calculations.

Figure 106 Changes in volumes of cement (C23.51, left) and lime (C23.52, right)



Source: Own calculations.

Table 34 displays the impact on real imports and exports. An important explanatory reason for the decline in output is international trade. With deteriorating terms-of-trade vis-a-vis the world outside the EU, extra-EU exports drop by around 1.5-2.5%, while extra-EU imports rise by around 1-2%.

Table 34 Impact on real imports and exports

Imports	C2310 Other C23		C2351 Cement		C2352 Lime & Plaster		C2361 Concrete Products		C2363 Ready-Mix		F Construction	
Region	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU
South	0.5%	-2.1%	1.2%	-2.2%	1.7%	-1.9%	0.7%	-1.7%	1.5%	-1.5%	0.6%	-1.2%
West	0.8%	-1.9%	0.8%	-2.4%	1.7%	-2.2%	0.8%	-1.4%	1.4%	-1.5%	-0.1%	-2.2%
East	0.7%	-2.3%	0.5%	-3.0%	1.4%	-2.7%	0.6%	-2.1%	1.0%	-1.7%	-0.4%	-2.2%
CentralNorth	0.8%	-2.1%	0.5%	-2.4%	1.5%	-1.5%	0.6%	-2.0%	0.8%	-1.8%	0.0%	-1.8%
EU28	**0.7%**	**-2.1%**	**0.8%**	**-2.5%**	**1.6%**	**-2.0%**	**0.7%**	**-1.7%**	**0.9%**	**-1.6%**	**0.0%**	**-2.1%**

Exports	C2310 Other C23		C2351 Cement		C2352 Lime&Plaster		C2361 Concrete Products		C2363 Ready-Mix		F Construction	
Region	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU
South	-1.2%	-1.9%	-1.9%	-2.4%	-1.8%	-1.9%	-1.0%	-1.6%	-1.2%	-1.8%	-0.9%	-1.0%
West	-0.9%	-1.6%	-1.0%	-1.9%	-1.1%	-1.6%	-0.7%	-1.2%	-0.7%	-1.2%	-1.0%	-1.2%
East	-1.8%	-3.2%	-2.3%	-3.2%	-2.6%	-3.3%	-1.6%	-2.8%	-1.7%	-2.6%	-2.8%	-2.9%
CentralNorth	-1.1%	-1.8%	-1.5%	-2.7%	-1.7%	-2.6%	-0.8%	-1.5%	-0.9%	-1.5%	-1.3%	-1.7%
EU28	**-1.1%**	**-2.1%**	**-1.6%**	**-2.5%**	**-1.7%**	**-2.0%**	**-0.9%**	**-1.7%**	**-1.0%**	**-1.6%**	**-1.8%**	**-2.1%**

Source: Own calculations.

Drawing attention to employment, Table 35 shows that more than 1.2 million jobs are linked to the changes in economic output, equivalent to 0.5% of existing employment. In the cement and lime industries, 1 600 jobs are at risk, 2 % of its base line employment. At an economy-wide level, averaging half a percent, losses are estimated to be appreciably higher in the East (-1.3%).

Table 35 Impact on employment

	Employment: absolute [1000 persons]										relative [%]		
	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic metals	**Economy**	C23 total	Construction	**Economy**
Region	C2310	C2351	C2352	C2361	C2363	C23	F41	C16	C24	Total	C23	F41	Total
South	-6	-0	-0	-1	-1	-9	-16	-4	-4	**-220**	-1.7%	-0.5%	-0.3%
West	-2.7	-0.1	-0.0	-0.5	-0.4	-5	-36	-1	-3	**-184**	-1.5%	-0.8%	-0.2%
East	-8.4	-0.5	-0.1	-2.3	-0.8	-13	-66	-14	-9	**-632**	-3.3%	-1.9%	-1.3%
CentralNorth	-3.0	-0.2	-0.1	-1.0	-0.4	-5	-29	-3	-7	**-224**	-1.7%	-0.9%	-0.4%
EU28	**-20.6**	**-1.3**	**-0.3**	**-5.0**	**-2.2**	**-32**	**-147**	**-22**	**-23**	**-1,260**	**-2.1%**	**-1.0%**	**-0.5%**

Source: Own calculations.

When interpreting this scenario (even more so than in the other ones), it is important to bear in mind the results are not a forecast of what would happen, if energy taxes rose by 10% of costs. Rather, they are a simulation of what might be the consequences if *only* energy taxes would rise, but the framework of final demand would not be affected – neither private households, nor public households would react to the changes in energy taxes (only their import propensity react to the new price system). More specifically, the simulations abstract from the question of how the new taxes might be recycled – for example, to finance cuts in income tax, or corporate tax, to increase transfer payments, or retire debt. These possibilities would have vastly different implications. For example, in terms of the price system, if it were to finance a (possibly revenue-neutral) reduction in labour-related costs, this might well result in a mitigation or even reversion of the energy tax-induced price increases (at least in sectors which are less energy-intensive). Although the simulations presented here cannot be interpreted in this "encompassing" way, their chief intention is to highlight the extent to which the different parts of the economy would be affected by the scenario assumptions.

C/D. Summary of main assumptions and sensitivity

Like in the first scenario, sensitivity analyses were made for the energy cost share: lower share for lime & plaster (24% instead of 32% as well as a higher share in the case of cement production (30% instead of 24%). The direction of the sensitivity is as expected: less pronounced when energy cost shares are lower for lime & plaster; more pronounced with higher energy cost shares for cement. The results diverge less from the main scenario due to the encompassing nature of the energy price increase, which causes output prices to rise markedly in all sectors. As a consequence, the prices of all inputs rise, resulting on the one hand in (much) higher price increases in C&L, but in the other in relatively lower decreases in the use of energy (in real terms) – when all inputs become more expensive, the substitution of energy is less pronounced, and the price effect less driven by the pure energy price hike. A 10% increase in blanket energy scenario, therefore, results in a roughly 2% price increase in the cement and lime production, accompanied by output losses of around 2.5 – 3%.

Table 36 Sensitivity of C&L sector results to different changes in energy prices (for all sectors)

		2 - All Energy prices +10%	2.1 - All Energy prices +10%, **lower E-share in Lime&Plaster**	2.2 - All Energy prices +10%, **higher E-share in Cement**
Cement	Output Price	1.8%	1.7%	2.1%
	real Output	-2.8%	-2.7%	-3.1%
	extraX	-1.6%	-1.5%	-1.9%
	extraM	0.8%	0.7%	1.1%
	Employment [1000]	-1.3	0.9	-1.1
Lime&Plaster	Output Price	1.9%	1.7%	2.0%
	real Output	-2.6%	-2.4%	-2.7%
	extraX	-1.7%	-1.4%	-1.7%
	extraM	1.6%	1.3%	1.7%
	Employment [1000]	-0.3	0.5	-0.3

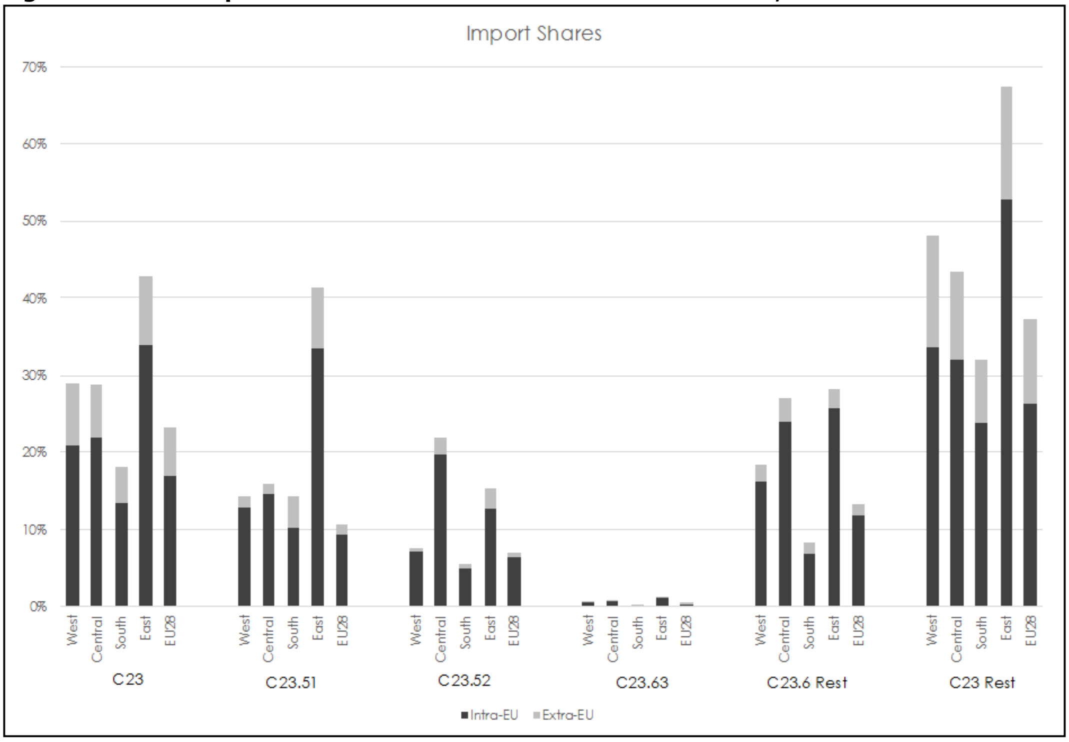
5.2.7 Scenario III: Product Tax

A. Key assumptions

Scenario III 'Product tax' simulates an additional use tax on cement and lime commodities. In contrast to the scenarios that simulate an increase in energy prices, which could reach domestic producers only, this tax applies to both domestic and imported cement and lime products. Therefore, it should result in less substitution between domestic and imported cement and lime.

The simulation assumes that the tax is fully implemented on all domestic production and imports, without any illegal importation that escapes imposition of tax.

Figure 107 Import shares of C23 commodities C2310-C2363, 2011[320]

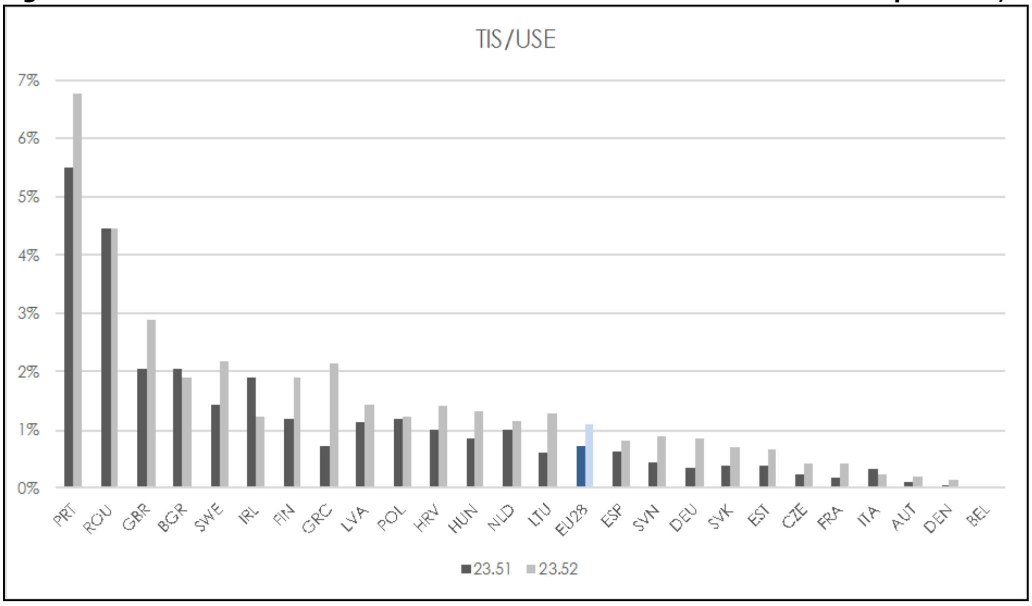


Source: WIOD; SBS; EUROSTAT; own calculations.

Figure 108 provides additional information on the existing taxation on intermediate use of cement and lime products. As shown in the mentioned figure, initial taxes on cement and lime products, as used in the ADAGIO model, on the intermediate use of cement and lime are low, averaging some 1% of purchaser prices, albeit with marked regional differences.

[320] The year 2011 refers to the base year of the IO database WIOD. The disaggregation is based on SBS data averaged over 2011-2014.

Figure 108 **Product taxes on the intermediate use of cement and lime products, 2011**



Source: IO-database.

For the purpose of this simulation scenario, product taxes will rise substantially, i.e. by 25% of user prices (which will imply, on average, a more than tenfold increase of the commodity tax rate). This rate increase will come, as in the case of energy taxes (Scenarios I and II), on top of existing taxes. We examine the reaction of the model under two assumptions:

- a low price elasticity of demand of -0.5; and
- as a sensitivity analysis, a high elasticity of -1.5, corresponding to estimates of short- and long-run elasticities, respectively.

B. Main results

Table 37 focuses on the impact of nominal commodity outputs. A price increase of a quarter is substantial, especially if it is perceived as a sustained increase (rather than mere volatility, which could be waited out). Accordingly, the impact on demand and supply of cement and lime is larger than in the previous scenarios. As shown in Table 37, cement and lime production in the EU is simulated to contract by more than a tenth in nominal terms. Moreover, in nominal terms, output of concrete and products thereof actually rises, by around 1% – construction rises as well, but only marginally.

Table 37 Impact on nominal commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.3%	-10.5%	-10.8%	0.7%	1.7%	-0.5%	0.0%	0.1%	-0.2%	**0.0%**
West	0.2%	-10.9%	-10.2%	0.7%	1.5%	-0.8%	0.0%	0.3%	-0.2%	**-0.1%**
East	0.0%	-11.0%	-9.8%	0.3%	1.2%	-0.9%	0.0%	0.0%	-0.4%	**-0.1%**
CentralNorth	0.2%	-11.2%	-9.9%	0.6%	1.1%	-0.8%	0.0%	0.1%	-0.2%	**-0.1%**
EU28	**0.2%**	**-10.9%**	**-10.2%**	**0.6%**	**1.4%**	**-0.7%**	**0.0%**	**0.1%**	**-0.2%**	**-0.1%**

Source: Own calculations.

This, however, is without taking into account any induced price increases (Table 38). Although the commodity tax does not affect output prices of cement and lime industries directly, it does influence the price that a cement and lime - using industry has to pay – therefore, whenever cement and lime products are used in a production process, the costs of inputs will increase and, as far as these additional costs can be passed on to the buyer, output prices will increase as well. Via this sequence, the prices of ready-mix and concrete products (both heavy users of cement and lime) will rise by more than 4% resp. 3%; construction prices will also go up, by around 0.4%. The input costs (and output prices) for the cement and lime sector also rise – not as a direct consequence of the commodity tax on output prices (this does not affect the output price of the sector directly), but again as an indirect effect of the cement and lime industries being not only producers, but also users of cement and lime products (an obvious case would be a cement factory buying cement clinker from a different firm).

Table 38 Impact on prices

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.4%	2.7%	1.6%	4.6%	4.6%	1.7%	0.4%	0.2%	0.2%	**0.2%**
West	0.4%	2.3%	1.7%	2.6%	3.7%	1.7%	0.3%	0.1%	0.1%	**0.1%**
East	0.5%	2.0%	1.3%	3.0%	3.4%	1.6%	0.5%	0.2%	0.2%	**0.2%**
CentralNorth	0.4%	2.5%	1.5%	2.4%	3.5%	1.5%	0.3%	0.2%	0.1%	**0.1%**
EU28	**0.4%**	**2.5%**	**1.6%**	**3.1%**	**3.8%**	**1.6%**	**0.4%**	**0.2%**	**0.1%**	**0.1%**

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.5%	1.6%	1.1%	3.2%	4.6%	1.6%	0.4%	0.2%	0.2%	**0.2%**
West	0.6%	1.8%	1.4%	3.0%	4.9%	2.1%	0.3%	0.1%	0.1%	**0.1%**
East	0.6%	1.6%	1.1%	3.7%	4.0%	1.9%	0.5%	0.2%	0.2%	**0.2%**
CentralNorth	0.6%	1.7%	1.2%	2.5%	3.5%	1.5%	0.3%	0.2%	0.1%	**0.1%**
EU28	**0.6%**	**1.7%**	**1.2%**	**3.0%**	**4.3%**	**1.8%**	**0.4%**	**0.2%**	**0.1%**	**0.1%**

Source: Own calculations.

Combining both the effects on nominal output and prices, we obtain the changes in real production volumes that are reported in Table 39. More specifically, in real terms, the output of concrete (products) drops by around 2.5%, while construction output falls by half of a percent. The effect on cement and lime output is more dramatic, simulated to drop by more than a tenth.

Table 39 Impact on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-0.2%	-11.9%	-11.8%	-2.5%	-2.8%	-2.1%	-0.4%	-0.1%	-0.4%	**-0.2%**
West	-0.5%	-12.5%	-11.5%	-2.2%	-3.2%	-2.9%	-0.4%	0.1%	-0.4%	**-0.2%**
East	-0.5%	-12.4%	-10.8%	-3.3%	-2.7%	-2.7%	-0.5%	-0.2%	-0.6%	**-0.4%**
CentralNorth	-0.4%	-12.6%	-11.0%	-1.9%	-2.4%	-2.3%	-0.3%	-0.1%	-0.3%	**-0.2%**
EU28	**-0.4%**	**-12.3%**	**-11.3%**	**-2.3%**	**-2.8%**	**-2.5%**	**-0.4%**	**-0.1%**	**-0.4%**	**-0.2%**

Source: Own calculations.

Table 40 presents the effects that have been simulated in terms of employment. Together, some 6 000 jobs are lost in cement and lime production, along with 7 000 in the construction sector. Interestingly, the model comes up with an ambivalent result in the concrete industry, slight losses in concrete products, slight employment increases in ready-mix – ostensibly, the increase in the price of factor 'materials' leads to substitution by the – now relatively (much) cheaper – factor 'labour' by more than the decline in (real) output. The employment in the metal sector decreases by 5 000 persons, driven mainly by the drop on construction volumes, but also by the price increase in an intermediate product, lime. Wood remains largely stable – the negative effect of the decline in construction is balanced by wood substituting for cement and concrete in construction works.

Table 40 Impact on employment

	Employment: absolute [1000 persons]										relative [%]		
	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic metals	**Economy**	C23 total	Construction	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**C16**	**C24**	**Total**	**C23**	**F41**	**Total**
South	0	-2	-0	-0	-0	-2.3	-4.2	0.1	-0.9	**-47**	-0.4%	-0.1%	-0.1%
West	-0.6	-0.9	-0.2	0.0	0.2	-6.3	-1.2	0.3	-0.8	**-61**	-1.7%	0.0%	-0.1%
East	-0.4	-1.1	-0.2	-0.2	0.2	-2.4	-1.9	-0.6	-2.3	**-86**	-0.6%	-0.1%	-0.2%
CentralNorth	-0.1	-1.1	-0.3	-0.2	0.2	-1.7	0.4	0.0	-1.2	**-49**	-0.6%	0.0%	-0.1%
EU28	**-1.0**	**-4.8**	**-1.1**	**-0.5**	**0.5**	**-12.7**	**-6.9**	**-0.2**	**-5.3**	**-242**	**-0.8%**	**0.0%**	**-0.1%**

Source: Own calculations.

Table 41 presents an overview of the simulated effects concerning real imports and exports. As shown in the table, with the commodity tax indirectly increasing output prices of the cement and lime industry as well (vie the aforementioned channels of intermediate inputs), exports outside the EU suffer, although the simulated changes of -1.4 and -2.1% for lime and cement are moderate compared to the changes in both imports and output volumes (moreover, extra-EU exports account for a very small share of domestic production only). As relative user prices of domestic output and imports remain largely unchanged[321], the fall in imports is first and foremost demand driven.

[321] Use prices of domestic poduction do go up a bit more, as the commodity tax on cement, lime and plaster feeds through to somewhat higher domestic output prices via intermediate use of these commodities.- see above

Table 41 Impact on real imports and exports

Imports	C2310 Other C23		C2351 Cement		C2352 Lime & Plaster		C2361 Concrete Products		C2363 Ready-Mix		F Construction		C24 basic Metals	
Region	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU
South	0.5%	-0.4%	-13%	-18%	-10%	-14%	3.6%	-1.9%	9.1%	-0.4%	-0.1%	-0.8%	-0.1%	-0.4%
West	1.1%	-0.1%	-15%	-18%	-13%	-15%	3.9%	-2.1%	4.8%	-2.5%	0.2%	-0.6%	-0.1%	-0.4%
East	0.8%	-0.4%	-14%	-16%	-15%	-15%	3.2%	-2.2%	3.2%	-3.4%	0.1%	-0.6%	-0.2%	-0.5%
CentralNorth	0.9%	-0.4%	-13%	-16%	-12%	-14%	3.2%	-3.3%	4.4%	-2.5%	-0.1%	-0.7%	0.0%	-0.3%
EU28	**0.9%**	**-0.3%**	**-14%**	**-17%**	**-13%**	**-15%**	**3.6%**	**-2.5%**	**4.4%**	**-2.5%**	**0.1%**	**-0.6%**	**-0.1%**	**-0.4%**

Exports	C2310 Other C23		C2351 Cement		C2352 Lime&Plaster		C2361 Concrete Products		C2363 Ready-Mix		F Construction		C24 basic Metals	
Region	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU	extraEU	intraEU
South	-0.5%	0.0%	-1.4%	-19%	-1.0%	-15%	-2.9%	-2.8%	-4.3%	-2.7%	-0.7%	-0.6%	-0.3%	-0.4%
West	-0.5%	-0.5%	-1.4%	-17%	-1.3%	-15%	-2.3%	-1.8%	-4.1%	-2.5%	-0.5%	-0.5%	-0.3%	-0.4%
East	-0.6%	-0.3%	-1.5%	-16%	-1.3%	-15%	-3.9%	-5.0%	-4.4%	-4.5%	-0.8%	-0.7%	-0.4%	-0.6%
CentralNorth	-0.5%	-0.2%	-1.5%	-17%	-1.2%	-15%	-2.3%	-1.3%	-3.2%	-2.1%	-0.5%	-0.4%	-0.2%	-0.4%
EU28	**-0.5%**	**-0.3%**	**-1.4%**	**-17%**	**-1.2%**	**-15%**	**-2.6%**	**-2.5%**	**-3.7%**	**-2.5%**	**-0.6%**	**-0.6%**	**-0.3%**	**-0.4%**

Source: Own calculations.

C. Sensitivity analysis

Various sensitivity analyses have been carried out, which are presented here.

Sensitivity analysis 1: lower increase in product tax

Not surprisingly, using a more moderate product tax, equivalent to 10% of base line prices instead of the main scenario's 25% tax, the model comes up with more moderate effects on output and prices (and consequently, employment): real output of cement and lime is simulated to fall by around 5%. Though output prices of C&L do not rise significantly (they rise by around half of a percent only, for the same reasons as was explained above), user prices do increase due to the non-deductible 10% product tax. As a result, the price of concrete products rises by around 1.2%, the price of ready-mix by 1.7%, triggering price increases of construction services of 0.2% - which in turn depresses demand for those by 0.2%.

Table 42 Impacts on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-0.1%	-5.3%	-5.2%	-1.0%	-1.2%	-0.9%	-0.2%	0.0%	-0.1%	**-0.1%**
West	-0.2%	-5.5%	-5.0%	-0.9%	-1.3%	-1.2%	-0.1%	0.1%	-0.1%	**-0.1%**
East	-0.2%	-5.5%	-4.7%	-1.4%	-1.1%	-1.2%	-0.2%	-0.1%	-0.2%	**-0.2%**
CentralNorth	-0.2%	-5.6%	-4.8%	-0.8%	-1.0%	-1.0%	-0.1%	0.0%	-0.1%	**-0.1%**
EU28	**-0.2%**	**-5.5%**	**-5.0%**	**-1.0%**	**-1.2%**	**-1.1%**	**-0.2%**	**0.0%**	**-0.1%**	**-0.1%**

Source: Own calculations.

Sensitivity analysis 2: long-run price elasticity of demand

Rössler and Steen (2006) estimate both short- and long-run elasticities for cement and lime products. Their estimate of -0.5 for the short run corresponds to the elasticity that we have assumed so far in our analysis. However, in the long run, they estimate this elasticity being around -1.5, implying that a sustained 1% increase in the price of cement and lime eventually reduces the demanded quantity by 1.5%, when users increasingly find substitutes for cement and lime. Plugging this (much) higher value into the ADAGIO model yields the impact on real outputs shown in Table 43.

Table 43 Impacts on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.1%	-24.5%	-31.0%	-3.3%	-2.5%	-3.6%	-0.4%	0.4%	-0.4%	**-0.2%**
West	-0.1%	-26.9%	-29.5%	-1.6%	-2.3%	-3.9%	-0.3%	0.8%	-0.4%	**-0.2%**
East	-0.3%	-23.6%	-27.4%	-2.5%	-2.1%	-3.7%	-0.4%	0.3%	-0.6%	**-0.3%**
CentralNorth	-0.2%	-26.4%	-28.5%	-1.8%	-2.2%	-3.9%	-0.3%	0.4%	-0.3%	**-0.2%**
EU28	**-0.1%**	**-25.6%**	**-29.3%**	**-2.2%**	**-2.3%**	**-3.8%**	**-0.3%**	**0.5%**	**-0.4%**	**-0.2%**

Source: Own calculations.

Compared with the status quo, demand for cement and lime is down by more than a quarter (double the reduction as compared with the lower elasticity). The impact on the construction sector (F) is slightly smaller than in the short run, due to construction being able to substitute for cement and concrete. The impact on concrete, however, is, like the impact on cement and lime, stronger than in the short run, mostly because cement cannot easily be substituted in the production of both concrete and products thereof. Demand for wood products now actually rises, driven by substitution for cement and concrete. Similarly, demand for basic metals drops due to its role as a companion of cement in reinforced concrete, but in dampened way as steel substitutes for concrete in structural applications.

5.2.8 Scenario IV: Production Tax

A. Key assumptions

Scenario IV 'Production tax' simulates an increase in production costs of 5%. The reason for the increase is not specified, and could, for example, be brought about by compliance costs induced by work-related regulations, costs for operating permits, etc. In fact, it could be any costs which cannot be tied to the cost of the factors of production which are distinguished by the TRANSLOG production model (i.e., capital, labour, energy, domestic respect to imported materials).

B. Main results

To begin with, we focus on the impact of prices that it is associated to the implementation of the tax mentioned above (Table 44). The 5% increase in production-related costs translates into a 4.2% (Cement) and 3.0% (lime) increase in output prices, which feed forward into higher concrete prices (0.5%-0.8%) and moderately higher construction prices (+0.1%).

Table 44 Impact on prices

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.1%	4.5%	3.0%	0.6%	1.0%	0.7%	0.1%	0.0%	0.0%	**0.0%**
West	0.1%	3.8%	2.8%	0.3%	0.7%	0.7%	0.0%	0.0%	0.0%	**0.0%**
East	0.2%	4.4%	3.9%	0.7%	1.2%	1.0%	0.1%	0.0%	0.0%	**0.0%**
CentralNorth	0.1%	4.1%	2.9%	0.3%	0.6%	0.6%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.1%**	**4.2%**	**3.0%**	**0.5%**	**0.8%**	**0.7%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

As shown in Tables 45 and 46, although nominal demand for and output of cement and lime products increases by half of a percent, the price hike implies that volume production of cement drops by -3.5%, of lime by -2.3% (see Table 6.3).

Table 45 Impact on nominal commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.0%	0.2%	0.8%	0.1%	0.3%	0.1%	0.0%	0.0%	0.0%	**0.0%**
West	0.0%	0.7%	0.6%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	**0.0%**
East	0.0%	0.0%	0.8%	0.1%	0.3%	0.1%	0.0%	0.0%	-0.1%	**0.0%**
CentralNorth	0.0%	0.8%	0.7%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.0%**	**0.5%**	**0.7%**	**0.1%**	**0.2%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

Table 46 Impact on real commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	-0.1%	-4.1%	-2.1%	-0.5%	-0.7%	-0.6%	-0.1%	0.0%	-0.1%	**0.0%**
West	-0.1%	-3.0%	-2.1%	-0.3%	-0.5%	-0.6%	0.0%	0.0%	0.0%	**0.0%**
East	-0.2%	-4.2%	-3.1%	-0.7%	-0.8%	-0.9%	-0.1%	-0.1%	-0.1%	**-0.1%**
CentralNorth	-0.1%	-3.2%	-2.2%	-0.3%	-0.4%	-0.5%	0.0%	0.0%	0.0%	**0.0%**
EU28	**-0.1%**	**-3.5%**	**-2.3%**	**-0.4%**	**-0.6%**	**-0.6%**	**-0.1%**	**0.0%**	**-0.1%**	**0.0%**

Source: Own calculations.

Moving onto the analysis of employment (Table 47), the number of jobs in the cement and lime industries is simulated to fall by around 2 000 persons. In total, the sector C23 loses 4.8 thousand employees (1% of workers). Construction sheds some employees as well, the number of fewer than 1 000 jobs, however, is barely visible in a workforce of more than 3.5 million.

Table 47 Impact on employment

	Employment: absolute [1000 persons]										relative [%]		
	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic metals	**Economy**	C23 total	Construction	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**C16**	**C24**	**Total**	**C23**	**F41**	**Total**
South	0	-1	-0	0	0	-1.1	-0.6	0.0	-0.2	**-12**	-0.2%	0.0%	0.0%
West	0.1	-0.4	-0.1	0.1	0.0	-2.3	-0.2	0.0	-0.1	**-9**	-0.6%	0.0%	0.0%
East	-0.0	-0.7	-0.1	0.0	0.1	-1.0	-0.2	-0.2	-0.5	**-20**	-0.3%	0.0%	0.0%
CentralNorth	0.1	-0.5	-0.2	0.1	0.0	-0.5	0.0	0.0	-0.2	**-7**	-0.2%	0.0%	0.0%
EU28	**0.3**	**-2.5**	**-0.6**	**0.2**	**0.1**	**-4.8**	**-0.9**	**-0.1**	**-1.0**	**-47**	**-0.3%**	**0.0%**	**0.0%**

Source: Own calculations.

As shown in Table 48, as the production tax applies to domestic industries only, domestic cement and lime are put at a clear disadvantage with respect to imports (which, contrary to the product tax scenarios, cannot be reached by the production tax) – as a result, imports from outside the EU increase by a around 4% (although from a low base: extra-EU import shares for cement and lime are less than 2% for the EU28). Additionally, intra-EU trade decreases, by around 1-3%, which is less than the extra-EU increase in relative terms, but involves much higher volumes (10% of domestic demand in the case of cement). Extra-EU exports, on the other hand, decline by 3% due to higher prices against the (more or less) unchanged cement prices outside the EU.

Table 48 Impacts on real imports and exports

Imports	**C2310**		**C2351**		**C2352**		**C2361**		**C2363**		**F**		**C24**	
		Other C23		**Cement**		**Lime & Plaster**		**Concrete Products**		**Ready-Mix**		**Construction**		**basic Metals**
Region	**extraEl**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**
South	0.2%	-0.1%	5.4%	-2.7%	3.2%	-0.7%	0.8%	-0.3%	1.3%	-0.3%	0.0%	-0.1%	0.0%	-0.1%
West	0.2%	-0.1%	4.8%	-3.4%	6.0%	-2.3%	0.4%	-0.4%	0.6%	-0.7%	0.0%	-0.1%	0.0%	-0.1%
East	0.3%	0.0%	3.4%	-3.8%	4.2%	-2.0%	0.5%	-0.3%	1.1%	-0.5%	0.0%	-0.1%	0.0%	-0.1%
CentralNorth	0.2%	-0.1%	4.9%	-3.3%	3.4%	-1.7%	0.4%	-0.5%	0.5%	-0.6%	0.0%	-0.1%	0.0%	0.0%
EU28	**0.2%**	**-0.1%**	**4.6%**	**-3.4%**	**4.3%**	**-2.0%**	**0.5%**	**-0.4%**	**0.7%**	**-0.6%**	**0.0%**	**-0.1%**	**0.0%**	**-0.1%**

Exports	**C2310**		**C2351**		**C2352**		**C2361**		**C2363**		**F**		**C24**	
		Other C23		**Cement**		**Lime&Plaster**		**Concrete Products**		**Ready-Mix**		**Construction**		**basic Metals**
Region	**extraEl**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**	**extraEl**	**intraEU**
South	-0.1%	0.0%	-4.1%	-3.8%	-2.8%	-1.6%	-0.5%	-0.8%	-0.8%	-0.8%	-0.1%	-0.1%	-0.1%	-0.1%
West	-0.1%	-0.1%	-3.1%	-3.3%	-2.4%	-2.1%	-0.3%	-0.3%	-0.6%	-0.7%	-0.1%	-0.1%	0.0%	0.0%
East	-0.2%	-0.2%	-3.9%	-3.9%	-3.3%	-3.3%	-0.6%	-0.8%	-1.0%	-1.0%	-0.2%	-0.2%	-0.1%	-0.1%
CentralNorth	-0.1%	0.0%	-3.7%	-2.9%	-2.7%	-1.4%	-0.3%	-0.2%	-0.6%	-0.4%	-0.1%	-0.1%	0.0%	-0.1%
EU28	**-0.1%**	**-0.1%**	**-3.7%**	**-3.4%**	**-2.7%**	**-2.0%**	**-0.4%**	**-0.4%**	**-0.7%**	**-0.6%**	**-0.1%**	**-0.1%**	**0.0%**	**-0.1%**

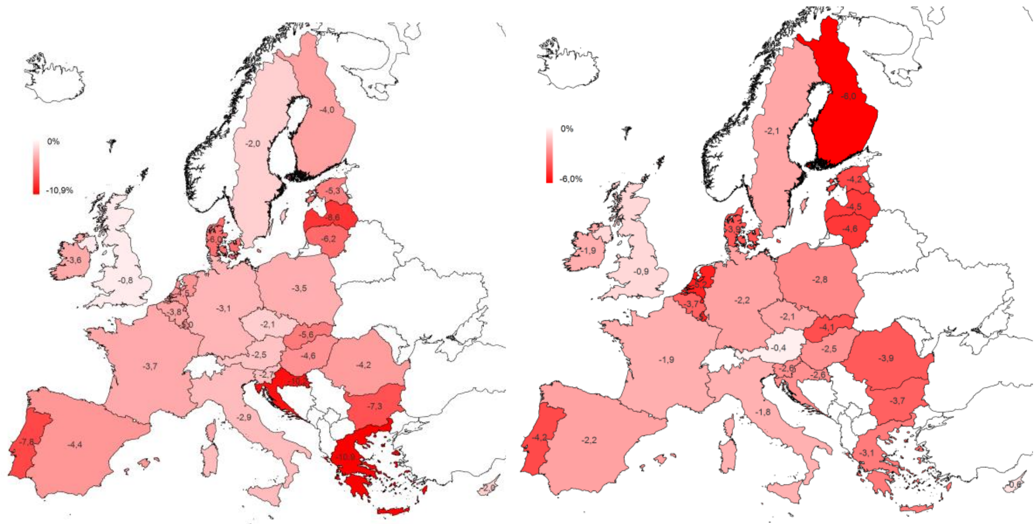
Source: Own calculations.

As in Scenario I 'Targeted Energy Prices', in most Member States, the effect of the energy price increase is a negative one, with higher effects in the Eastern (and, les pronounced, Southern) countries. A few countries are simulated with increases in real output. These (rather small) increases are mainly the result of intra-EU trade diversion between Member States with differing energy intensities (or, rather, different cost shares for energy products) in their respective cement and lime industries.

In addition, as in Scenario I 'Targeted Energy Prices', regulation-induced increases in production costs pose the problem of asymmetric impact, as regulation can work on domestic production only; if, as a result of a deteriorations in the terms-of-trade, domestic production is (partially) replaced by imports, any favourable impact of the domestic regulation (on emissions, say) might be much dampened at the global level.

Further information on the changes in volumes of cement and lime that have been simulated is provided in the figures below.

Figure 109 Changes in volumes of cement (C23.51, left) and lime (C23.52, right)



Source: Own calculations.

C. Sensitivity analysis

Various sensitivity analyses have been carried out, which are presented here.

Sensitivity analysis: "negative" Production Tax

The main scenario investigates the effect of a 5% increase in production costs – it was termed "tax" to highlight the non-specificity of the rise in production costs. Here, we look at a fall in production costs of 5%; again, the reasons for this could be manifold, from an actual production subsidy to falling compliance costs etc.

Table 49 Impact on prices

	Other C23	Cement	Lime&Plaster	Concrete Products	Ready-Mix	C23 total	Construction	wood products	basic Metals	**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F**	**C16**	**C24**	**Total**
South	0.1%	4.5%	3.0%	0.6%	1.0%	0.7%	0.1%	0.0%	0.0%	**0.0%**
West	0.1%	3.8%	2.8%	0.3%	0.7%	0.7%	0.0%	0.0%	0.0%	**0.0%**
East	0.2%	4.4%	3.9%	0.7%	1.2%	1.0%	0.1%	0.0%	0.0%	**0.0%**
CentralNorth	0.1%	4.1%	2.9%	0.3%	0.6%	0.6%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.1%**	**4.2%**	**3.0%**	**0.5%**	**0.8%**	**0.7%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy Total**
South	-0.1%	-4.5%	-3.2%	-0.7%	-1.0%	-0.7%	-0.1%	0.0%	0.0%	**0.0%**
West	-0.1%	-3.9%	-2.9%	-0.4%	-0.7%	-0.8%	0.0%	0.0%	0.0%	**0.0%**
East	-0.2%	-4.5%	-4.0%	-0.7%	-1.2%	-1.0%	-0.1%	0.0%	0.0%	**0.0%**
CentralNorth	-0.1%	-4.2%	-3.0%	-0.4%	-0.6%	-0.7%	0.0%	0.0%	0.0%	**0.0%**
EU28	**-0.1%**	**-4.3%**	**-3.1%**	**-0.5%**	**-0.8%**	**-0.8%**	**-0.1%**	**0.0%**	**0.0%**	**0.0%**

Source: Own calculations.

The effect on prices is dampening: output prices of cement and lime & plaster drop by -4.3 and -3.1% respectively. Downstream industries face falling cost pressure as well, resulting in prices for concrete (products) which are almost 1% lower than in the base scenario. The effect in construction prices is already much lower, however, due to a combined cost share of only around 4-5% for cement, lime & plaster and concrete products. Overall, the effect of the 5% drop in production costs is roughly symmetric to the effect of rising production costs.

This symmetry is somewhat weaker with respect to real output: the ensuing rise in cement output volumes, at +4.1%, is proportionally higher than the -3.5% drop following the 5% tax increase of the main scenario. This asymmetry is not very pronounced, however, and seems to be mostly a result of a higher increase in extra-EU exports, combined with a proportional drop in extra-EU imports.

Table 50 Impacts on real commodity output in [%]

Region	Other C23 C2310	Cement C2351	Lime&Plaster C2352	Concrete Products C2361	Ready-Mix C2363	C23 total C23	Construction F	wood products C16	basic Metals C24	**Economy Total**
South	0.1%	4.7%	2.3%	0.6%	0.7%	0.7%	0.1%	0.0%	0.1%	**0.0%**
West	0.2%	3.5%	2.4%	0.3%	0.5%	0.6%	0.0%	0.0%	0.0%	**0.0%**
East	0.3%	4.8%	3.4%	0.7%	0.9%	1.0%	0.1%	0.1%	0.1%	**0.1%**
CentralNorth	0.1%	3.7%	2.4%	0.3%	0.4%	0.6%	0.0%	0.0%	0.0%	**0.0%**
EU28	**0.2%**	**4.1%**	**2.5%**	**0.4%**	**0.6%**	**0.7%**	**0.1%**	**0.0%**	**0.1%**	**0.0%**

Source: Own calculations.

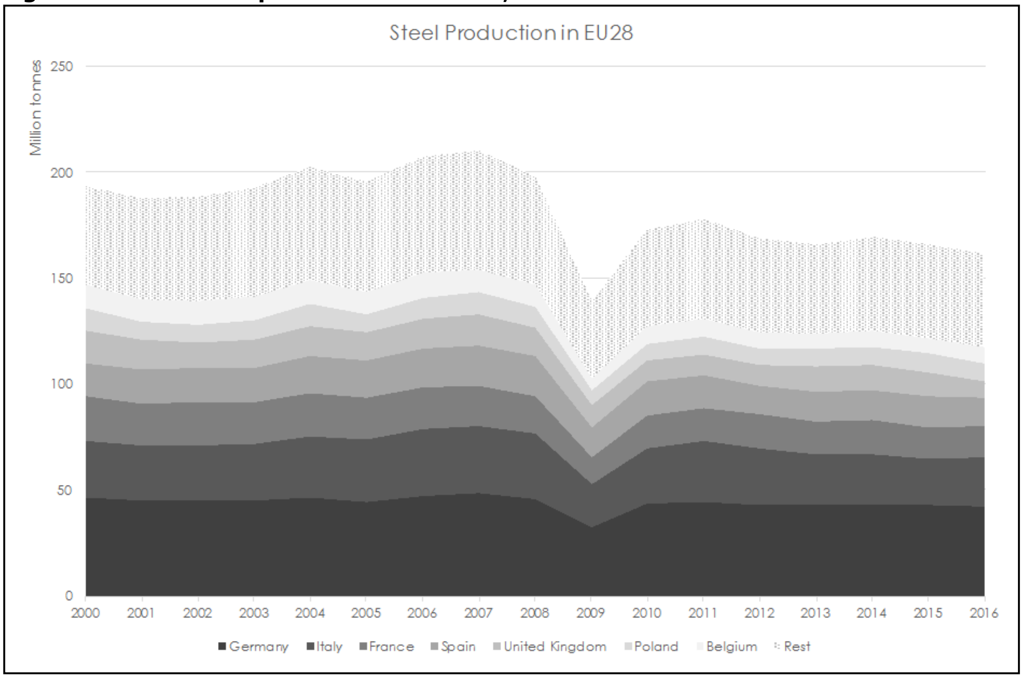
5.2.9 Scenario V: Delocalisation of downstream industries (lime only)

A. Key assumptions

In the past, European steel output has declined markedly, For example, between 2007 and 2014, output volume has dropped from 210 million tons to 170 million tons, even as world output has increased from 1.35 to 1.67 billion tons over the same period.[322]

[322] see https://en.wikipedia.org/wiki/List_of_European_countries_by_steel_production

Figure 110 Steel production in the EU, 2000-2016

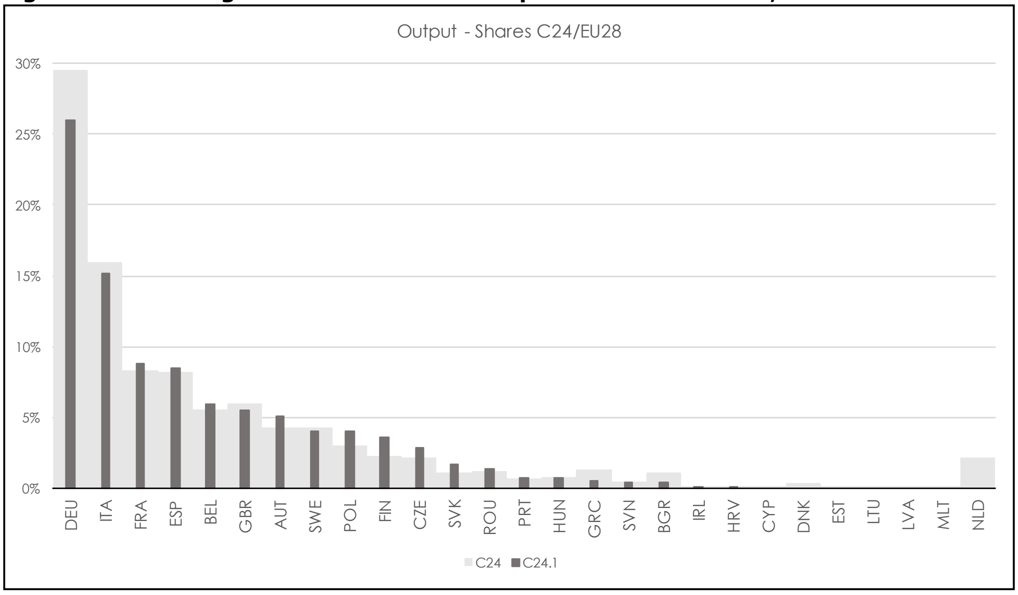


Source: World Steel Association.

The steel industry is a major customer for the lime sector, accounting for around 40% of lime sales (which totaled around €2 billion in 2015). Routinely, steel producers threaten to relocate even more of their capacities outside the European Union.

This scenario tries to capture the influence of steel production on the cement and lime sectors (as well as other sectors) by simulating a 10% reduction in steel output. The regional distribution of this reduction follows the regional distribution of production, which according to the SBS averaged to around 180 billion € per year in 2011-14 (the steel sector, C24.1, accounts for more than 40% of the "basic metal" sector C24). Figure below shows this regional distribution.

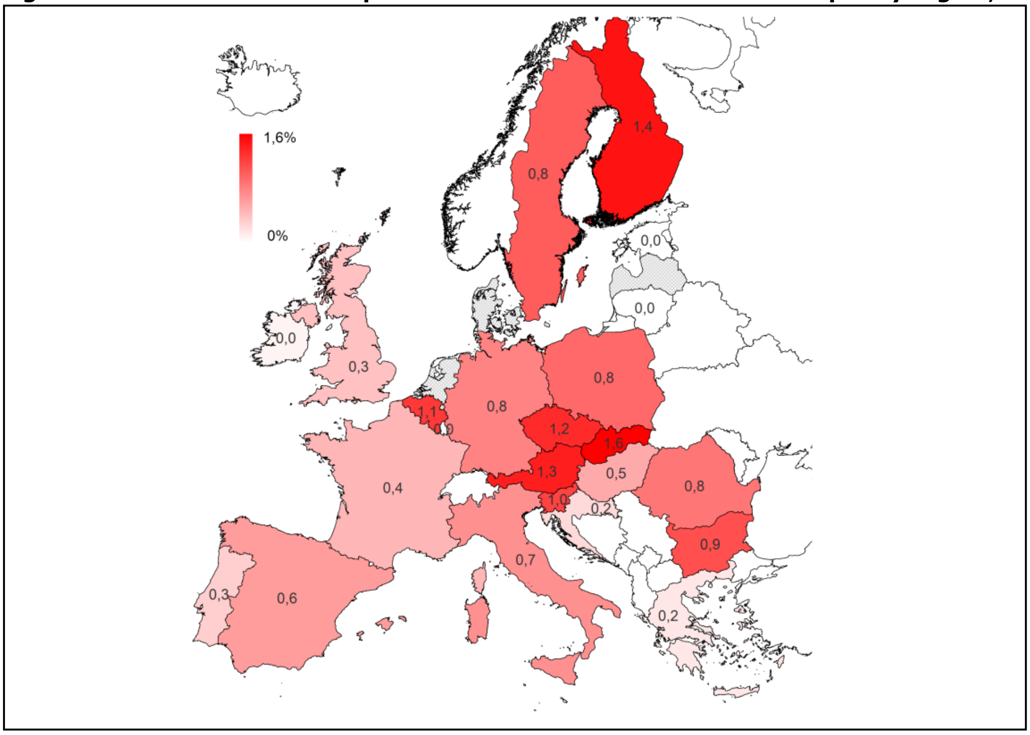
Figure 111 Regional distribution of output of C24 and C24.1, 2011-14



Source: SBS, Own calculations.

As shown in the figure below, European steel production very roughly follows economic size, although tradition (typically based on the availability of ore and coal) still plays an important role (in this way, Austria, for example, still has one of the most largest steel industries outside the Eastern regions, relative to economic size).

Figure 112 Share of steel production C24.1 in total economic output by region, 2011-14



Source: SBS; WIOD; own calculations.

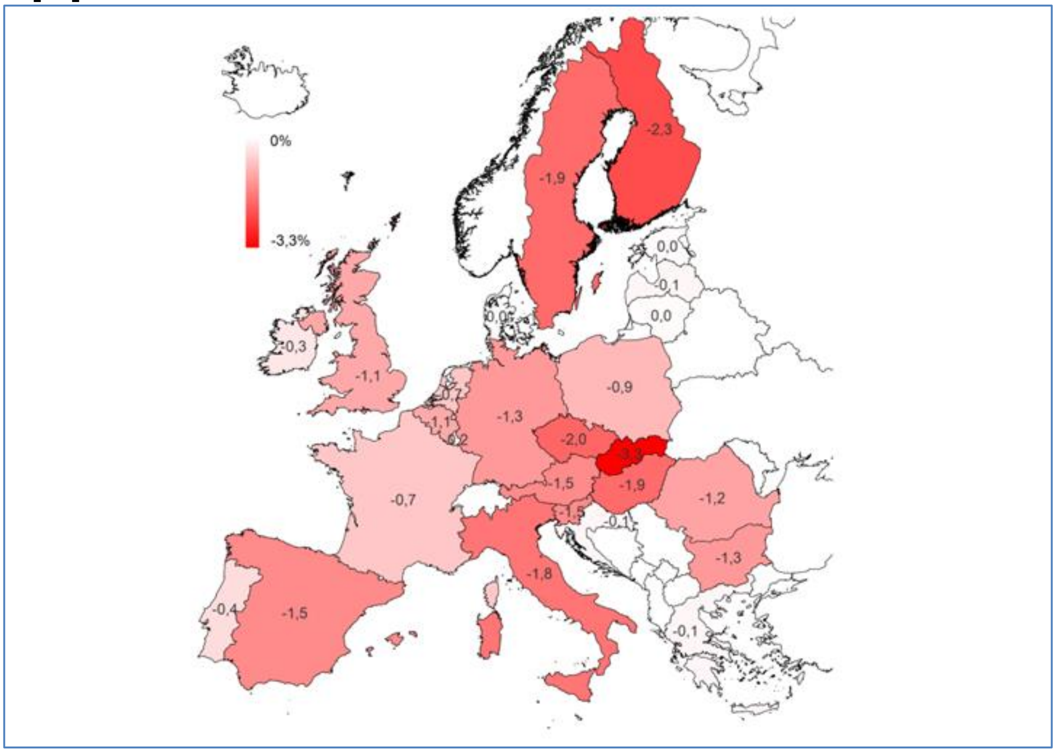
For the purpose of this simulation exercise, the reduction in steel output is implemented as two separate (but simultaneous) shocks:

- **Shock 1:** In ADAGIO, the steel sector C24.1 is part of the 2-digit sector C24 (Basic Metals). Unlike the disaggregation of C23 into its subsectors, this disaggregation was not feasible for the metal sector C24. Therefore, the output of C24 in each country was reduced by 10% of its respective output of C24.1, as reported by the SBS.
- **Shock II:** The problem is that the input structure of C24 reflects <u>all</u> basic metals, not only the one of steel production– this means that lime as an input (and as recorded in the IO database) plays a (much) smaller role for C24 than for C24.1 – by simply reducing the 'average metal sector C24', the reduction in lime demand would therefore be underestimated. The 'missing' demand reduction was therefore implemented as a second and separate shock in the specific demand for lime.

B. Main results

The regional pattern of steel's impact on national lime production, as expected, reflects the regional pattern of the importance of steel for the total economy, As shown in the next figure, the largest effects are simulated for Slovakia, Finland, Sweden, followed by Czech Republic, Hungary and Austria.

Figure 113 Impact on output of commodity C23.52 (lime and plaster) by EU member state, in [%]



Source: Own calculations.

Focusing on the impact on nominal commodity output (see table below), the largest impact, of course, is simulated for C24 (basic metals), with an order of magnitude expected in the 4% range (because the steel sector C24.1 accounts for around 40% of C24, which is then reduced exogenously by 10%). The simulated effect, however, is somewhat larger at more than 5%, which is brought about by the steel sector using output of other C24 firms as inputs. This is an indirect effect, which drives the effects on all other sectors of the economy: on average, 1% of the economy is linked to the production of steel. In principle (and probably in some roundabout way), all economic sectors are linked to steel production. For lime and plaster producing firms, the 10% drop in steel would imply a 1.2% drop in output – again not unexpectedly, as lime accounts for around 30% of total lime and plaster production, and the steel industry accounts for 40% of lime sales.

Table 51 Impact on nominal commodity output in [%]

	Other C23	Cement	Lime&Plaster	Concrete Produ	Ready-Mix	C23 total	Construction	basic Metals	Economy
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**C24**	**Economy**
South	-0.2%	-0.1%	-1.4%	-0.1%	0.0%	-0.2%	0.0%	-5.0%	-0.1%
West	-0.2%	-0.1%	-0.9%	0.0%	0.0%	-0.2%	0.0%	-5.7%	-0.1%
East	-0.2%	-0.1%	-1.1%	-0.1%	0.0%	-0.2%	0.0%	-6.5%	-0.1%
CentralNorth	-0.2%	-0.1%	-1.3%	-0.1%	0.0%	-0.2%	0.0%	-5.6%	-0.1%
EU28	**-0.2%**	**-0.1%**	**-1.2%**	**-0.1%**	**0.0%**	**-0.2%**	**0.0%**	**-5.5%**	**-0.1%**

Source: Own calculations.

Since the effect on prices in this scenario is only marginal, the changes in real output are very similar to the changes in nominal output (and, therefore, not shown separately).

In terms of employment, the production linkages translate into around 225 thousand employees, which are connected to the production of 10% of European steel – 87 thousand in the steel industry itself, the rest in supply industries. In the lime and plaster industries, only around 300 persons are simulated as being affected by the decrease in steel production (see table below).

Table 52 Impact on employment

	Other C23	Cement	Lime&Plaster	Concrete Product	Ready-Mix	C23 total	Construction	wood products	basic metals	**Economy**	C23 total		**Economy**
Region	**C2310**	**C2351**	**C2352**	**C2361**	**C2363**	**C23**	**F41**	**C16**	**C24**	**Total**	**C23**	**F41**	**Total**
South	-0.3	-0.0	-0.1	-0.0	-0.0	-0.4	-0.8	-0.3	-18	**-50**	-0.2%	0.0%	-0.1%
West	-0.2	-0.0	-0.1	-0.0	-0.0	-0.3	-0.7	-0.0	-15	**-45**	-0.2%	0.0%	-0.1%
East	-0.4	-0.0	-0.1	-0.0	-0.0	-0.6	-1.8	-0.6	-27	**-66**	-0.2%	-0.1%	-0.1%
CentralNorth	-0.2	-0.0	-0.1	-0.0	-0.0	-0.3	-1.4	-0.1	-27	**-64**	-0.2%	0.0%	-0.1%
EU28	**-1.1**	**-0.0**	**-0.3**	**-0.1**	**-0.0**	**-1.5**	**-4.7**	**-1.1**	**-87**	**-225**	**-0.2%**	**0.0%**	**-0.1%**

Source: Own calculations.

The effect on international trade, again, is as expected (see table below). Exports are only marginally affected since price reactions are low, while reductions in imports are caused by the reduction in demand from the steel industry.

Table 53 Impact on real imports and exports

Imports	**C2310**	**Other C23**	**C2351**	**Cement**	**C2352**	**Lime & Plaster**	**C2361**	**Concrete Products**	**C2363**	**Ready-Mix**	**F**	**Construction**
Region	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**
South	-0.3%	-0.3%	-0.1%	-0.1%	-0.6%	-0.5%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%
West	-0.2%	-0.2%	-0.1%	-0.1%	-0.4%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
East	-0.4%	-0.4%	-0.1%	-0.1%	-0.9%	-1.0%	-0.1%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%
CentralNorth	-0.3%	-0.3%	-0.1%	-0.1%	-1.2%	-1.1%	-0.1%	-0.1%	0.0%	0.0%	-0.1%	-0.1%
EU28	**-0.3%**	**-0.3%**	**-0.1%**	**-0.1%**	**-0.8%**	**-0.7%**	**-0.1%**	**-0.1%**	**0.0%**	**0.0%**	**-0.1%**	**-0.1%**

Exports	**C2310**	**Other C23**	**C2351**	**Cement**	**C2352**	**Lime&Plaster**	**C2361**	**Concrete Products**	**C2363**	**Ready-Mix**	**F**	**Construction**
Region	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**	**extraEU**	**intraEU**
South	0.0%	-0.2%	0.0%	-0.1%	0.0%	-0.5%	0.0%	-0.1%	0.0%	0.0%	0.0%	-0.1%
West	0.0%	-0.3%	0.0%	-0.1%	0.0%	-0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
East	0.0%	-0.3%	0.0%	-0.1%	0.0%	-1.1%	0.0%	-0.1%	0.0%	-0.1%	0.0%	-0.1%
CentralNorth	0.0%	-0.3%	0.0%	-0.1%	0.0%	-0.8%	0.0%	-0.1%	0.0%	0.0%	0.0%	-0.1%
EU28	**0.0%**	**-0.3%**	**0.0%**	**-0.1%**	**0.0%**	**-0.7%**	**0.0%**	**-0.1%**	**0.0%**	**0.0%**	**0.0%**	**-0.1%**

Source: Own calculations.

5.2.10 Summary of Scenario Results

The effects of the five scenarios on output prices and production volumes are presented below. When compared, They show that Scenario I, an increase of energy prices of 25% only for the Cement & Lime sectors, is expected to have the highest impact on prices, with an increase of 4.7% in cement and 4.5% in lime & plaster, followed by Scenario IV, a production tax f 5% of turnover on cement & lime, causing an increase of 4.2% in cement and 3% in lime & plaster and Scenario III, a product tax of 25% on Cement and Lime, has the strongest impact on the volumes of production, causing a decrease of -12.3% for cement and -11.3% for lime & plaster.

Table 54 Impact on output prices - CEMENT

Cement: effect on prices	Sc1: Energy Prices +25% in the Cement & Lime sectors	Sc 2: Energy Prices +10% in all sectors	Sc 3: Product Tax of 25% on Cement and Lime	Sc 4: Production Tax of 5% of Turnover on Cement & Lime	Sc 5: De-localisationi of Steel production
Eastern EU member states	5.9%	1.9%	1.6%	4.5%	0.0%
Southern EU member states	3.6%	1.4%	1.8%	3.8%	0.0%
Western EU member states	5.8%	2.7%	1.6%	4.4%	0.0%
Central-North member states	4.2%	1.8%	1.7%	4.1%	0.0%
EU28	**4.7%**	**1.8%**	**1.7%**	**4.2%**	**0.0%**

Source: Own calculations.

Table 55 Impact on output prices – LIME AND PLASTER

Lime & Plaster: effect on prices	Sc1: Energy Prices +25% in the Cement & Lime sectors	Sc 2: Energy Prices +10% in all sectors	Sc 3: Product Tax of 25% on Cement and Lime	Sc 4: Production Tax of 5% of Turnover on Cement & Lime	Sc 5: De-localisationi of Steel production
Eastern EU member states	4.5%	1.9%	1.1%	3.0%	0.0%
Southern EU member states	3.5%	1.4%	1.4%	2.8%	0.0%
Western EU member states	7.2%	3.4%	1.1%	3.9%	0.0%
Central-North member states	4.4%	2.0%	1.2%	2.9%	0.0%
EU28	**4.5%**	**1.9%**	**1.2%**	**3.0%**	**0.0%**

Source: Own calculations.

Table 56 **Impact on production volumes - CEMENT**

Cement: effect on volumes of prodcution in	Sc1: Energy Prices +25% in the Cement & Lime sectors	Sc 2: Energy Prices +10% in all sectors	Sc 3: Product Tax of 25% on Cement and Lime	Sc 4: Production Tax of 5% of Turnover on Cement & Lime	Sc 5: De-localisationi of Steel production
Eastern EU member states	-5.4%	-3.0%	-11.9%	-4.1%	-0.1%
Southern EU member states	-2.6%	-2.3%	-12.5%	-3.0%	-0.1%
Western EU member states	-5.2%	-4.3%	-12.4%	-4.2%	-0.1%
Central-North member states	-3.7%	-2.6%	-12.6%	-3.2%	-0.1%
EU28	**-4.0%**	**-2.8%**	**-12.3%**	**-3.5%**	**-0.1%**

Source: Own calculations.

Table 57 **Impact on production volumes – LIME AND PLASTER**

Lime & Plaster: effect on volumes of prodcution	Sc1: Energy Prices +25% in the Cement & Lime sectors	Sc 2: Energy Prices +10% in all sectors	Sc 3: Product Tax of 25% on Cement and Lime	Sc 4: Production Tax of 5% of Turnover on Cement & Lime	Sc 5: De-localisationi of Steel production
Eastern EU member states	-3.1%	-2.5%	-11.8%	-2.1%	-1.5%
Southern EU member states	-2.6%	-2.0%	-11.5%	-2.1%	-0.9%
Western EU member states	-5.4%	-4.7%	-10.8%	-3.1%	-1.3%
Central-North member states	-3.3%	-2.5%	-11.0%	-2.2%	-1.3%
EU28	**-3.3%**	**-2.6%**	**-11.3%**	**-2.3%**	**-1.2%**

Source: Own calculations.

Scenario 1: Targeted Energy Prices - Increasing the energy costs by 25% (e.g. by implementing new energy taxes) would result in output prices rising by around 4.7% for cement and 4.5% for lime & plaster. This upward pressure on output prices would apply to resident firms, but leave import prices unchanged. This leads to a disadvantage for domestic production, which would drop by around 3-4% in volume terms, while imports from outside the EU would increase by 5.3% for cement and 6% for lime. An intended (favourable) impact would therefore be substantially dampened ("carbon leakage" in the case of emissions). According to the model, the results are roughly linear with respect to the increase in energy prices – a doubling of the increase would have around double the effect on output prices, and double the effect on real production volumes.

Scenario 2: Blank Energy Prices - The economy-wide effect of a 10% increase in energy costs would according to the model lead to an increase of 1.8% in cement prices and 1.9% of lime & plaster. This would lead further to a reduction of real output of 2.6% for lime & plaster and 2.8% for cement. The cement and lime sectors being among the most energy intensive ones, the impact on prices and real output is markedly above average. Price increases lead to even higher reductions in output (partially compensated by higher import volumes). This (partial) substitution of domestic production by imports might dampen the (favourable) impact on the energy content of cement and lime demand ('carbon leakage').

Scenario 3: Product tax – According to the model, there is a substantial impact on demand driven by the price increase for cement and lime users. The price increase combines both an indirect impact that results in an increase in output prices (+1.7% cement, +1.2% lime & plaster) and the 25% tax, such that user prices increase by 26.7% for cement and 26.2% for lime & plaster. Assuming short-run price elasticity of -0.5, the demanded quantity is simulated to fall by more than a tenth; if a long-run elasticity of -1.5 is used, the drop in demand and output would rise to a quarter. In contrast to Scenarios I, II, and IV, the product tax applies to all products, domestic and imported. This would avoid trade distortions and "unintended consequences" ('carbon leakage' in the case of emissions).

Scenario 4: Production tax - A fictive (unspecified) regulation adding 5% to the costs of production would result in output prices rising by around 3% for lime and 4.2% for cement. This upward pressure on output prices applies to resident firms, but they leave import prices unchanged. This leads to a disadvantage for domestic production, which would drop by around 2.3% for lime and 3.5% for cement. In parallel strong import would increase of 3.5 to 4% can be expected. Any intended (favourable) impact would therefore be substantially dampened ("carbon leakage" in the case of emissions).

Scenario 5: De-localisation of downstream industries (lime only) - This scenario focuses on steel production which has high regional variability, which implies, naturally, high regional variability of demand for lime from this source. Thus, the importance of the steel industry for its European suppliers is sizable. The lime industry, however, represents only a small part of these interlinkages in absolute numbers. A drop of steel output by 10% would lead to a drop of lime by 1.2%. The full closure of steel plants however, would lead to the complete drop of all business of various lime plants.

6 Conclusions and policy recommendations

The purpose of this study is to assess the competitiveness of the EU cement and lime industries. The analysis covers the assessment of current competitive situation of each industry, including description and analysis of their value chains, sector-specific features (e.g. performance, market structure, processes and inputs), and competitive position in relation to main competitors both inter-sectorial and global scale. Further, the competitiveness analysis covers public policy and other aspects of importance to the industries, including trade threats, innovation and technological constraints and opportunities. Finally, the study offers an outlook on the competitive position of the sectors, relying on economic modelling and simulations of different policy scenarios that may affect the competitiveness of the sectors in the future.

The study has approached "competitiveness" from three angles[323]:

- **Intra-EU competitiveness**, which looks at the relative competitive situation of industry at the level of EU Member States;
- **Extra-EU (international) competitiveness**, which looks at the competitive situation of EU industry relative to international (non-EU) competitors and the ability of EU industry to compete in global markets, including in the face competition from international players in the EU market;
- **Inter-sectorial competitiveness**, which looks at the competitive situation of cement and lime products relative to rival (substitute) products, and their position in downstream customer markets.

The study builds on a combination of analysis of secondary information (e.g. academic studies, business literature, and publicly available statistical data) and primary data collected in the context of this study. The latter includes information obtained through a survey of companies (capturing 26 companies, representing about 30% of employment and turnover in both sectors). In parallel, interviews with downstream industry associations were held. Moreover, interviews with representatives from relevant Directorate Generals of the European Commission were conducted to better understand the EU-level regulatory situation. In total, approximately 40 stakeholders were involved. The analysis is complemented by the use of scenario modelling, implemented using a specifically developed variant of the ADAGIO input-output model.

The remainder of chapter highlights some key findings from the analysis, draws conclusions, and outlines policy recommendations for each sector, structured according to the three competitiveness aspects described above.

6.1 Overall conclusions

Cement and lime play a vital role in the European economy. Both are essential for the construction industry, while lime products are particularly important inputs for steel production, the chemicals industry, agriculture, environment protection, and other sectors. As such, cement and lime production are not stand-alone industries, but are intertwined in the supply chains of many downstream sectors; this interconnectedness is confirmed by the findings from the

[323] Ketels, Christian (2016): Review of Competitiveness Frameworks, see: http://www.hbs.edu/faculty/Publication%20Files/Review%20of%20Competitiveness%20Frameworks%20_3905ca5f-c5e6-419b-8915-5770a2494381.pdf , as well as Ecorys competitiveness studies for the European Commission, see: http://www.sectorcompetitiveness.com/

scenario modelling conducted by the study. Demand for cement and lime is strongly linked to the overall economic cycle and production levels in major customer industries. Following a period of strong growth, both industries were hit hard by the economic crisis that began in 2008; this was particularly the case in those countries most heavily affected by the crisis (e.g. Greece, Ireland, Italy, Portugal, and Spain).

Due to a combination of low value-to-weight ratios and widespread geographical presence of raw materials, production of cement and lime tends to be locally-based, with most product supplied within a radius of less than few hundred kilometres from the production site. Historically, these conditions enabled the development of many small, often family owned businesses, serving local and regional markets. Over time, however, both industries have seen the emergence of a handful of major European groups owning multiple production sites within Europe and, increasingly, outside of Europe. The trend towards greater industry concentration has been reinforced in the aftermath of the 2008 economic crisis, through a combination of mergers and acquisitions and businesses leaving the market. Nonetheless, regional variations persist, particularly in the lime sector where there are still many relatively small independent producers.

Although international (extra-EU) trade is relatively limited, there is evidence of growing international trade intensity for cement and, especially, for cement clinker (an intermediate product in cement production with lower density than cement). This is evidenced by increased exports by EU countries that were particularly adversely affected by the crisis. This development demonstrates that, even if cement (and lime) is generally considered to have low 'tradability', international trade can take place under certain conditions: e.g. excess capacity relative to domestic demand, and a combination of (international) differences in production costs – or other conditions, such as access to raw materials – and low transport (shipping) costs.

The two industries have many characteristics in common: a dependence on the availability of raw materials (e.g. limestone), high capital intensity and long-term investment cycles, asset specificity (i.e. production assets cannot be easily transferred to alternative use), highly energy intensive production processes, and high levels of CO_2 emissions inherent to the chemical processes involved in their production. These characteristics imply that both industries are susceptible to public policy developments on several fronts: climate change, energy and resource efficiency, environment, land use and biodiversity, etc. Both industries perceive potential risks, not just from the general direction of policy reforms that may increase production costs and reduce profitability but, equally, from uncertainty over specific regulatory measures that makes long-term investment planning more difficult. In particular, and most notably for the cement sector, there is concern that divergence between (more stringent) EU regulatory regimes and those for international competitors, could undermine European production and lead to an influx of imports.

The scenario modelling exercise tends to support the argument that EU cement and lime production is potentially volatile vis-a-vis imports as a consequence of policy reforms – or other causes – that raise production costs in the EU relative to imports (and of competing suppliers in international export markets). Where this is the case, there are implications not only for production and employment in the EU cement and lime industries but, also, in downstream sectors. There is an obvious challenge for policy-makers' ambitions to steer EU industries towards greater sustainability, while avoiding delocalisation and, specifically, carbon leakage. At the same time, a predictable long-term policy environment – whether at EU, national and local level – is important for encouraging the necessary investments to achieve greater sustainability but may lie beyond the time horizon of policy-makers and regulators.

The following sub-sections present a number of building blocks that can contribute to reflection by business and policy makers on the future of the cement and lime industries.

6.2 The EU Cement industry

General situation

In 2015, Eurostat data indicate that the EU produced around 105 million tonnes of cement clinker and 162.5 million tonnes of cement. The value of cement production is estimated at more than € 12 billion in 2015, with the cement industry employing 47 thousand persons, in around 350 companies. Most cement clinker is produced in vertically integrated production plants and goes directly into production of cement. However, volumes of sold clinker have been increasing over time, from 11 million tonnes in 2003 to 17.5 million tonnes in 2015. This increase is explained by an increase in the export intensity of EU clinker production that came as a response to the collapse in demand for cement in some EU Member States.

Demand for cement depends on activity levels in the construction and civil engineering sectors. Cement production peaked during the height of the construction boom but almost halved in the aftermath of the economic and financial crisis: between 2008 and 2015, turnover is estimated to have declined by 38%, employment by 27%, and value added by 47%. These developments were accompanied by falls in profitability as well as labour productivity. Only very recently, in line with the revival of construction and civil engineering markets, the first signs of recovery have appeared.

Intra-EU competitiveness

Cement production in the EU is characterised by limited variation in basic production technologies and relatively homogeneous outputs, with defined European standards for most widely used cement types. Within the EU, cement can be economically transported only over limited distances, and production and consumption occur almost entirely in fairly close proximity. High costs of transport relative to product value reduce opportunities for customers to engage in spatial price arbitrage and, as a result, cement markets in Europe display signs of significant geographical segmentation. Even where intra-EU cross border trade takes place, it typically reflects proximity of production facilities in neighbouring countries, rather than differences in relative (cost) competitiveness of supply at a national (Member State) level.

When cement clinker is taken into consideration, the above described situation is more nuanced. Cement clinker is considered to be more tradeable than cement, making international trade and competition – both intra-EU and extra-EU – of greater relevance. This applies particularly for production locations and demand markets accessible to maritime and inland shipping. The analysis of unit values for cement clinker sales in Europe, and from international trade data, suggests much lower price variation for cement clinker than for cement.

Overall, demand and supply conditions for cement production reflect local situations. From the supply side, these include the availability, quality and cost of raw materials and production factors (e.g. labour, energy, etc.), alongside the intensity of competition between rival suppliers. Further, despite EU-level common internal market regulatory frameworks, differences in national and local-level regulations can have an important influence on local supply and demand conditions. Difference in local situations are reflected in wide dispersion in performance indicators across Member States, that may also mask further variation at regional and local levels. Similarly, despite common basic production technologies, the analysis points to variation across Member States in the cost breakdown of production which, it is to be supposed, at least partially reflect differences in the relative costs of raw materials and production factors within and between Member States.

The scenario modelling exercises highlight intra-EU variations in the impact of potential policy measures, in terms of changes in output and employment. In general, EU-wide policy measures have more pronounced impacts in Southern and Eastern European regions. This can be attributed to a combination of factors, notably higher production cost shares of energy and greater exposure (proximity) to competition from non-EU neighbouring countries (e.g. Ukraine, Belorussia) or those with maritime access to EU markets (e.g. North Africa, Turkey).

Policy recommendation C1: be attentive to regional impacts of EU policy changes
EU policy reforms and new initiatives should consider possible variation in impacts resulting from differences in factor costs (e.g. energy prices) and differences in exposure to international competition (imports), which may result in strong differences in the impact on the competitiveness of EU production at a regional, or even, highly localised level.

Extra-EU competitiveness

Collectively, the EU28 is the third largest global producer of cement after India (second largest) and China, which dominates global production, with an estimated share of more than 50% of global production. Since 2010, the EU has had a positive net trade balance in cement clinker, with an extra-EU export value of €400 million in 2014 and 2015. However, the export intensity of cement clinker is low, particularly if it is assessed in relation to total clinker production rather than the much lower level of clinker that is sold in the open market. The success of some EU producers in carving out a position as exporters of cement clinker (and cement) in response to a collapse in domestic demand shows, however, that the EU itself may be vulnerable to imports, should there be a fall in domestic demand in other important cement producing countries or regions, notably China.

Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario (nr. 3) points toward a level playing field between the EU industry versus non-EU players.

Policy recommendation C2: active monitoring of neighbouring countries and transport costs

To support a level playing field, and to reduce risk of production delocalisation to nearby non-EU countries, policy makers should actively monitor regulatory decisions as well as cost developments (e.g. energy prices, labour costs etc.) in these countries, and in international shipping markets. Specifically, policy makers need to be attentive to the evolution of international transport costs and implications for the 'tradability' of cement products.

Policy recommendation C3: retaining an international 'level playing field'

Building on the monitoring, policy initiatives taken outside the EU should be assessed in relation to their impact on the competitiveness of non-EU producers relative to EU production, and whether the policy initiative constitutes a distortion of fair competition. If so, remedial of offsetting EU policy actions should be considered.

Policy recommendation C4: addressing the problem of carbon leakage for all industries without changing level playing field for EU manufacturers in international competition

The EU as an economy, globally in the lead with environmental and climate policies, is faced with the problem of carbon leakage for other industries too. It is suggested to launch an initiative laying the basis for public policies dedicated to further sustainability without changing the level playing field for EU manufacturers in international competition without violating WTO rules.

The attractiveness of the EU as a location for long-term investments in cement productions is affected by the predictability and long-term stability of relevant policy and regulatory conditions. Uncertainty over future policy and regulatory regimes reduces the attractiveness of the EU as a production location, particularly if demand prospects are more positive in other global regions. This is relevant in the context of future rules for the fourth ETS phase and, looking beyond to the post-2030 situation.

Policy recommendation C5: promote investments and innovation into the sector by providing long-term policy stability and certainty for investment

To secure the long-term investments – both in R&D&I and production facilities – necessary for improved sustainability of cement production, greater clarity in required on the direction of future policy developments that will affect the viability and return of industry investments. In the short-term, the position of the industry on the carbon leakage list should be clarified. And, in general, a longer-term strategy and policy approach for the industry should be determined.

Inter-sectorial competitiveness

Looking at the future, cement is expected to remain a vital product for future civil engineering and construction projects. Being the most widely used construction material, it has several advantages: it is relatively cheap, flexible, durable and resilient. It has excellent thermal and noise dampening qualities, while it is more accessible than some other materials. However, cement production is associated the high CO2 emissions, which has been associated with the promotion of other materials as a more sustainable and benevolent alternative (e.g. wood, steel).

Interviews indicated a certain substitution of concrete by wood and steel. This development is driven on the one hand by lifestyle and contemporary aesthetic such as in the use of wood and on the other hand by upcoming new techniques and procedures providing advantages against steel in some areas of applications. However, the potential for a wider dissemination in construction and civil engineering are limited. As for instance, a noteworthy dissemination of wood only takes place in residential buildings, in family homes but not in multi-family dwellings.

This said for all of the cement industry the substitution of concrete by wood will be of lesser importance under the current regulatory system. This assessment is supported by the simulations.

In general, when assessing the competitiveness between cement and other products, it needs to be stated that cement and steel as well as cement and wood are both substitutional and complementary goods. While steel is needed when constructing high buildings out of concrete, wood is needed for example when building roads. This is also shown in the model exercises, where input/output relations point to a mutual interdependency of these building materials. Even wooden houses need a concrete floor, whilst steel and wood are also needed for concrete.

Policy recommendation C6: take into account the complementarity of building products, too

While choice of building products can be presented as an either-or decision, there can be an important level of complementarity between products (e.g. cement, steel, wood) for building and infrastructure projects. Policy measures or initiatives that target specific product types – either promoting or discouraging their use – should be assessed both from substitution and complementarity perspectives.

The EC has recently launched a framework that allows the measurement of sustainability at the level of buildings. [324] Measuring sustainability on the basis of Life Cycle Assessments is part of this framework. The assessment of the overall sustainability of building products is one important area of activity. However, this should not be determined on the basis of its production process only, but rather as part of the overall life cycle of buildings. Existing LCAs differ in their methodology and scope and hence provide no clear result.

Policy recommendation C7: develop a comprehensive LCA including the construction product and the building to address the ambivalence of cement as a construction product in relation to other building materials

There is a need to better understand the lifecycle costs of building materials not only in terms of their production, but also in relation to their use during the lifetime of a building or infrastructure project. It is evident that cement production impose high costs when, for example, CO_2 emissions are factored in, but this may be offset by greater durability during its use, which will also depend on local situations and characteristics of buildings. A widely-accepted robust and comparable methodology for comprehensive LCA of construction materials and products is required, and that is transparent and based on harmonised underlying assumptions.

Policy recommendation C8: material neutrality in policy making in absence of uniformly accepted LCA approaches

In the absence of a comprehensive LCA methodology (as recommended above), a cautious approach should be adopted when making or influencing choices over competing construction materials and products, to avoid favouring materials and products when information is inconclusive or contradictory. A default position, could be to apply absolute material neutrality to avoid introducing potential market distortions. For example, product taxes or other measures, should aim to be neutral across different categories of building products rather than focussing on specific products (or inputs/outputs).

[324] http://ec.europa.eu/environment/eussd/buildings.htm

In addition, the sector burns a wide array of waste (e.g. paint, animal residues, tyres, etc.) that would otherwise not be easy to process. In so far it is part of a circular economy and can build on the Circular Economy Action Plan Package (COM/2015/0614 final) as a business model. A study of Ecofys[325] finds that the current share of "waste fuel" can be increased by a certain amount of investment and the abolition of some administrative market barriers.

Policy recommendation C9: consider the role of the cement sector as part of the circular economy

Increasing use of alternative fuels, which are otherwise defined as waste justifies considering the role of the cement sector as part of the circular economy. As such, policy discussions and developments should take this role of cement production into consideration as it can create benefits for the sector in terms of costs of fuel and for the environment in re-using waste.

Seeing cement, despite its high CO2 emissions as a fundamental part of construction industries, does not mean by definition having to accept negative environmental impacts. Admittedly, even large amounts of investments will allow only for a partial reduction of CO2 emissions. Already now however, cement companies are making large investments in regeneration of old quarries.

Policy recommendation C10: Enable 'out of the box' and cost-effective solutions to address CO2 emissions

In light of the Paris Agreement, more will be needed to reduce the CO2 emissions of the sector. Thereto, 'out of the box' but cost-effective solutions to address CO2 emissions will need to be developed in the years to come, taking into account a full supply chain approach. These need to be enabled and facilitated through dialogue and cooperation between industry and government.

6.3 The EU lime industry

General situation

The EU lime industry has seen a decline in terms of production, employment and productivity. Based on Eurostat data, total lime production has fallen from an estimated 34.7 million tonnes (€2.4 billion) in 2007 to 23.7 million tonnes (€2 billion sales value) in 2015. This downward trend appears to be structural, and signs of recovery have not been recorded yet. The lime sector sells mostly to the iron & steel sectors (40%), accompanied by a wide range of other downstream sectors, including environmental protection, the chemical sector, construction materials, civil engineering, agriculture as well as others. Therefore, the structural decline in the EU industrial basis (particularly steel industry) has had a profound impact on the EU lime sector. The majority of lime manufacturing enterprises are small and operate at a local level, although a limited number of large producers[326] have production operations throughout the EU and/or beyond. A concentration trend can also be witnessed amongst the industry's downstream clients, such as in steel and environmental protection. Lime prices vary fairly strongly within the EU, underlining the wide divergence in terms of productivity, as well as limited trade intensity due to the rather unfavourable value/weight ratio. Nevertheless, an upward trend can be identified in both export and import intensity of lime.

[325] Ecofys (2016) Market opportunities for use of alternative fuels in cement plants across the EU

[326] Notably Lloist, Carmeuse, CRH, Nordkalk, Schäferkalk and Calcinor.

Intra-EU competitiveness

Trade within the EU fluctuates between €250 and €320 million. The main cross-border suppliers within the Internal Market are France, Germany and Belgium. In 2015, these three countries accounted for more than 69% of EU trade (exports), revealing a higher concentration than for production. The most cost-competitive Member States are however, Hungary, Romania and Slovakia, all being in border regions of the EU facing strong price competition from outside the EU. Competitiveness between EU Member States is hence affected by impacts of regional policy measures, but also proximity to outside EU competition. The model exercises point to more pronounced impacts of policy measures to Southern and Eastern European regions: changes in output and employment are stronger, whilst exposure to imports is higher as well. This is due in part to the fact that lime production is more energy intensive in those regions, but also to foreign trade, particularly reflected through the proximity to cheap non-EU production sites (e.g. Ukraine, Belorussia) and/or access through sea (e.g. North Africa, Turkey) and the fragility of the concerned economies.

> **Policy recommendation L1: be attentive to regional impacts of EU policy changes**
> When preparing adjustments to EU policies, regional specificities such as differences in energy prices and their proximity to neighbouring competitors need to be taken into consideration as they have an impact also on the intra-EU competitive position of companies.

Extra-EU competitiveness

International trade in lime is limited relative to EU production. EU exports to third countries fluctuate between €50 and €80 million. The EU has a small trade surplus in lime, which peaked at € 60 million in 2008. Imports from non-EU sources account for about 1% of the value of EU apparent consumption, mainly arriving from Norway. A total of 3% of EU production is exported outside the EU. The EU lime industry's main exporting countries are the United Kingdom, Belgium, France, Spain and Germany. France, Germany and Belgium are the largest exporters, accounting for a third of world trade (including intra-EU trade). The trade intensity of EU lime has been increasing over the last decade. Export destinations include countries as different as Russia, Switzerland, Ghana, Singapore and recently Chile. However the potential for future export growth is considered limited, in light of the high cost base for EU producers in terms of labour, transport and regulatory costs. Exchange rate fluctuations (e.g. with Turkey or Russia) play a role as well. Overall the current development is hence driven by sluggish domestic demand in the EU. Low transport costs (particularly sea transport) support the EU manufacturers activities to export surplus production based on a marginal cost calculation. The foreign trade balance is fragile and remains vulnerable to changes in price differentials, induced by changes in input costs, taxes or duties.

Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario (nr. 3) points toward a level playing field between the EU industry versus non-EU players.

Policy recommendation L2: active monitoring of neighbouring countries and transport costs

To be able to guarantee a level playing field and to reduce the risk of shifting production to non-EU neighbouring countries, policy makers should actively monitor regulatory decisions as well as cost developments (e.g. energy prices, labour costs etc.) in these countries.

Policy recommendation L3: retaining a level playing field between EU and non-EU producers

Price sensitivity of the fragile balance in foreign trade suggests to a cautious stance for policymakers. Most environmental and climate policies will impact costs and market prices of domestic manufacturers and provide advantages to imports (carbon leakage). Only the taxation of products will maintain a level playing field for all competitors. However, the introduction of such a policy might be challenging with regard to the necessity to stay committed to WTO provisions.

Policy recommendation L4: addressing the problem of carbon leakage for all industries without changing level playing field for EU manufacturers in international competition

The EU as an economy, globally in the lead with environmental and climate policies, is faced with the problem of carbon leakage for other industries too. It is suggested to launch an initiative laying the basis for public policies dedicated to further sustainability without changing the level playing field for EU manufacturers in international competition without violating WTO rules.

As for the cement industry, also for lime a specific aspect affecting long-term investments in the existence of long-term stability of policy and regulatory requirements. Companies do not yet see stability for the time post-2030. Such perceived instability might hamper investments.

Policy recommendation L5: promote investments and innovation into the sector by providing long-term policy stability and certainty for investment

The most urgent issue for the industry is to provide clarification if the industry will be removed from the carbon leakage list or not. In general, the longer the time frame of policy decisions can be, the better it is for the sector. The pursuit of environmental and climate policies with a long-term perspective, permanently communicated with stakeholders of the industry, and – if necessary – only gradual changes is recommended.

Inter-sectorial competitiveness

With regard to the future, lime products are not easy to be substituted. This is especially true for steel production, the largest market segment for lime products. While steel producers have tried to reduce the lime needed by substituting it with specific chemicals, substantial further reductions are not to be expected.

Chemicals can in general represent some form of substitute in specific markets such as environmental protection or agriculture; from crude limestone and dolomite in agriculture, from kaolin-based products in paper mills, etc.

Cement has the potential to be a substitutional good in some forms in the construction sector, but this is not a noteworthy threat.

While lime appears not having to fear substitute goods in the near future, its dependence on downstream industries such as steel is of more importance. If steel companies relocate, outside the EU and/or get replaced by imports e.g. from China (which have already increased in recent years), this could have strong impacts on the lime sector. The steel sector has high regional variability, and has been undergoing a restructuring for decades. It is struggling in international competition and is not only affected directly by environmental and climate policies, but by input prices above the world market level. The scenario V on delocalization of downstream industries only captures this effect partially as the model is not able to take into consideration the closure of factories.

Policy recommendation L6: consider impact on up- and downstream industries in policy making

All public policies with an impact on input prices for the steel industry should be taken into account for an assessment of its competitiveness, among them lime. The multiple effects of price changes in the value-chain must not be forgotten.

In addition, the lime industries experience a stronger concentration of their downstream clients, particularly in steel. Such concentration of market power, can increase the price pressures on the lime industries.

Policy recommendation L7: be attentive to concentration activities in downstream industries

Competition policy should be very attentive with respect to potential monopoly developments of downstream industries, to avoid price setting power towards their dependent upstream lime providers.

The shift towards a circular economy driven by public policies - and increasing demand for environmental applications – especially for water and flue gas treatment – creates new opportunities for the lime industry. The lime sector is prepared to invest in innovation and renewal of production capacities, however, requires a stable policy framework to do so. Frequent policy changes are detrimental even for investments in technologies such as carbon capture etc.

Policy recommendation L8: consider potential for circular economy contribution by lime industry through long-term policy stability

Lime as a product can contribute to environmental applications, but also the production process itself may be further improved through innovations. Such innovations depend however on large-scale investments, which companies are only willing to make, if long-term regulatory and policy stability is guaranteed.

Even more than for the cement industries, lime production has its limitations in reducing CO2 emissions. On the one hand side this is due to an unavoidable extraction of CO2 from the raw material in the production process. On the other hand it is due to the high energy intensive burning of fossil fuels (particularly natural gas). While in cement, increasing use of alternative fuels can be observed, this is only possible to a limited extent for lime as the choice of the fuel affects the purity of the final product. Depending on its application, the fuel hence needs to be defined (with gas being the 'cleanest' in terms of its impact on the final product). As for the cement industries, also lime companies however already invest e.g. in environmental regeneration of quarries to reduce the environmental impact of their business. Similar ‘compensation’ investments are possible.

Policy recommendation L9: Enable ‘out of the box’ and cost-effective solutions to address CO2 emissions

In light of the Paris agreement, more will be needed to reduce the CO2 emissions of the sector. Thereto, ‘out of the box’ but cost-effective solutions to address CO2 emissions will need to be developed in the years to come, taking into account a full supply chain approach. These need to be enabled and facilitated through dialogue and cooperation between industry and government.

Annex A: Sector classifications

1. Manufacture of cement (NACE 23.51)

Manufacture of cement (NACE 23.51), which covers the manufacture of clinkers and hydraulic cements, including Portland, aluminous cement, slag cement and superphosphate cements. Using common classifications, the following product categories are covered:

PRCCode[a]	Description	HS/CNCode[b]	Description
23511100	Cement clinker	25231000	Cement clinkers
23511210	Portland cement	25232100	White Portland cement, whether or not artificially coloured
		25232900	Portland cement (excl. white, whether or not artificially coloured)
23511290	Other hydraulic cements	25233000	Aluminous cement
		25239000	Cement, whether or not coloured (excl. portland cement and aluminous cement)

[a] Product code under the European statistical classification of manufactured products (Prodcom)
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade

2. Manufacture of lime (part of NACE 23.52)

Manufacture of lime (part of NACE 23.52), which covers the manufacture of quicklime, slaked lime and hydraulic lime. Using common classifications, the following product categories are covered:

PRCCode[a]	Description	HS/CNCode[b]	Description
23521033	Quicklime	25221000	Quicklime
23521035	Slaked lime	25222000	Slaked lime
23521050	Hydraulic lime	25223000	Hydraulic lime (excl. pure calcium oxide and calcium hydroxide)

[a] Product code under the European statistical classification of manufactured products (Prodcom)
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade

3. Manufacture of articles of concrete and cement (NACE 23.61, 23.63, 23.65, 23.69)

Manufacture of articles of concrete and cement (NACE 23.61, 23.63, 23.65, 23.69), which covers manufacture of concrete products for construction purposes, manufacture of ready-mixed concrete, manufacture of mortars, manufacture of fibre cement, and manufacture of other articles of concrete, plaster and cement. Using common classifications, the following product categories are covered:

PRCCode[a]	Description	HS/CNCode[b]	Description
23611130	Building blocks and bricks of cement, concrete or artificial stone	68101110	Building blocks and bricks, of light concrete with a basis of crushed pumice, granulated slag, etc.
		68101190	Building blocks and bricks of cement, concrete or artificial stone, whether or not reinforced (excl. of light concrete with a basis of crushed pumice, granulated slag, etc.)
23611150	Tiles, flagstones and similar articles of cement, concrete or artificial stone (excluding building blocks and bricks)	68101900	Tiles, flagstones, bricks and similar articles, of cement, concrete or artificial stone (excl. building blocks and bricks)
23611200	Prefabricated structural components for building or civil engineering, of cement, concrete or artificial stone	68109100	Prefabricated structural components for building or civil engineering of cement, concrete or artificial stone, whether or not reinforced

		68 10 99 00	Articles of cement, concrete or artificial stone, whether or not reinforced (excl. prefabricated structural components for building or civil engineering, tiles, paving, bricks and the like)
23631000	Ready-mixed concrete	38245010	Concrete ready to pour
23641000	Factory made mortars	38245090	Non-refractory mortars and concretes (excl. concrete ready to pour)
23651100	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips, particles, sawdust or other waste of wood, agglomerated with cement, plaster or other mineral binders	68080000	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips, particles, sawdust or other waste of wood, agglomerated with cement, plaster or other mineral binders (excl. articles of asbestos-cement, cellulose fibre-cement or the like)

[a] Product code under the European statistical classification of manufactured products (Prodcom)
[b] Product code under the Harmonised System (HS) / Combined Nomenclature (CN) of goods in trade

Annex B: Followed methodology

B1. General methodology

The general methodology applied in this study consists of the collection and combination of primary and secondary sources, whereas the data collection and analysis phases were conducted in an iterative process continuously further deepening and triangulating the findings. Starting point of the work was the review of academic and business literature combined with scoping interviews with sector associations and plant visits and the analysis of publically and privately available data sources. To set the basis for assessing the regulatory conditions, a set of legislative acts were reviewed. The analysis was then deepened through the implementation of a national association and a company survey. In parallel, interviews with downstream industry associations and representatives from relevant Commission services were held. The data was then analysed using quantitative and qualitative analysis tools. In parallel, an analysis of the total factor productivity was conducted and five different scenarios for the sectors modelled using the ADAGIO input-output model. The process of validating and analysing data and assumptions for modelling was guided by a Mirror Group. On the basis of the analysis, conclusions for the Cements and Lime industries were drawn and policy recommendations drafted. The following sections provide further details on each of the methodological components.

B2. Followed approach: data collection

Secondary data collection

Literature review

A wide range of academic and business sources have been exploited and reviewed (for the list of used sources, see Annex G – Bibliography). The collected literature covers all the key thematic areas which are needed as a basis to describe the cement and lime sectors and markets. Relevant aspects identified in the literature are directly fed into the respective chapters and as such represent one of the key pillars of data and information triangulation. In order to keep balance, we have aimed to identify a broad set of literature. However, the number of sources especially on the lime sector is limited as this sector is not as well documented as the cement industry. A full list of documents reviewed can be found in the bibliography enclosed (Annex G).

Data sources reviewed

Starting point for the data analysis was the collection of publically available and private secondary data from Eurostat SBS, Eurostat STS, Eurostat PRODCOM, Eurostat COMEXT, AMADEUS as well as industry data provided by sector representatives and identified online. The data was used to provide a clear assessment of the sectors including indicators such as turnover, number of persons employed, labour productivity, imports, exports, comparative advantages etc.

Primary data collection

The primary data collection built on the secondary information collected, aimed at validating findings and completing data gaps. It was conducted in the form of three types of data collection:

- Extended sector scoping;
- Survey (with associations and companies);
- Mirror Group sessions.

Extended sector scoping

Scoping interviews have been held with sector representatives throughout the study, to…

…improve our understanding of the sector in terms of:

- Industry structure and organisation;
- Industry performance and prospects;
- Key legislation and regulations as well as the regulatory environment and associated costs and benefits for industry;

…discuss approach for data collection with companies to…

- Assess the feasibility of different interview/survey formats;
- Understand the key confidentiality requirements;
- Align the next steps towards successful primary data collection.

Building on the preliminary understanding of the sectors (through CEMBUREAU and EuLa), further interviews with the following related European sector associations were conducted to capture all relevant aspects of their value chains: ERMCO (European Ready Mixed Concrete Organization), BIBM (Bureau International du Béton Manufacturé - European Federation of the Precast Concrete Industry), UEPG (Union Européenne des Producteurs de Granulats - European Aggregates Association), ECOBA (European Coal Combustion Products Association).

Survey

The survey was conducted at two levels, national associations and companies. For both types of stakeholders a base questionnaire was developed, which was then further adjusted for the specific category and sector (see Annex C). In addition a plant level questionnaire was developed.

A set of final questionnaires and sampling strategy were developed including various rounds of feedback and testing. The final set of questionnaires consisted of a company questionnaire, national associations questionnaires and plant level questionnaires. The questionnaires were piloted with industry and validated and commented on by different Commission services. The final questionnaires were shared with the targeted sample and discussed in the form of face-to-face or phone interviews.

Note: The original attempt of collecting also information on cost structures at plant level could not be implemented. The reason for this lies in the inability of companies to provide the necessary data on production volumes, turnover, production costs and production capacity at plant level. This type of data is highly sensitive from the perspective of competition policy, as it would allow companies to derive the profitability levels of their competitors (given the limited number of variables that determine the profit levels in these sectors). Neither plant managers nor national management are allowed to provide this data unless receiving official clearance from corporate legal departments. Legal departments consulted refer in this context to the Guidelines provided by DG COMP.[327] Representatives at the Mirror Group meeting confirmed in the meeting of 13th July 2017 that they are not able to provide answers to the plant level questionnaire as they perceive the risk of losing control over their data being too high. In the Steering Committee of 7th and the Mirror Group of 13th July alternative approaches to circumvent this limitation were discussed.

[327] EC (2011) "Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal co-operation agreements (201/C11/01), paragraph 55-110.

Sampling strategy

The sampling strategy took into consideration the different levels of stakeholders and their capacity to answer the questions of this study. The focus and purpose of interviews with stakeholders was therefore tailored for each group:

- **EU associations**: help to identify issues at stake, support the targeting and validation of work and the identification of suitable further information sources. Support to improve the understanding of the 'broader' competitiveness picture and potential for strengthening the industrial EU policy. Capture the downstream situation representing companies manufacturing cement products and also the construction sector;
- **National associations**: entry point to companies in the Member State, which allow to provide a better overview of national and geographical specificities across the EU;
- **Companies**: fill data gaps in secondary data and to assess the competitive situation of EU industry;
- **Plants**: for the assessment of (regulatory) costs, some information at plant level is needed. Such information was intended to be collected through companies or directly from plants.

For a classic competitiveness study, the combination of association interviews with a random sample of company interviews across the EU is sufficient to get an understanding of the situation for companies and to assess their overall competitive position. In contrast, for the assessment of regulatory costs, a more thorough selection of the sample is needed. An additional requirement is that, if company confidential data is to be collected, the sample size needs to be large enough (representing at least 5 plants from 3 different companies). Therefore, the plant level information intended to be collected largely affected the overall sampling strategy.

Another aspect taken into consideration were concerns of the Mirror Group about the length of the base questionnaire. Thus, to conduct successfully the primary data collection, information was always collected at the highest possible level of aggregation. This means that where possible, European associations answered instead of national associations, national associations instead of companies and companies instead of plants.

European associations

For interviews at a European level the following sector associations were approached.

Table B.1. Associations part of the sampling strategy

Association	Website	Description
Already involved in the study		
Cembureau (European Cement Association)	http://www.Cembureau.be/	Cembureau is the representative organization of the cement industry in Europe. It has members from 27 countries (25 MSs).
EuLa (European Lime Association)	http://www.eula.eu/	EuLa is the sector based representation for the European lime industry. It represents 17 MSs.
Considered for further interviews		
EMO (European Mortar Industry Organisation)	http://www.euromortar.com	EMO is the representation of the interests of the European mortar and thermal insulation composite systems (ETICS) industry in the EU. It's members come from 13 European countries (11 MSs).
BIBM	http://www.bibm.eu/	European Federation for Precast Concrete

Association	Website	Description
ERMCO (European Ready Mixed Concrete Organization)	http://www.ermco.eu/	ERMCO is the representation of the interests of ready mixed concrete industries in the EU. It has 25 members organizations including those of 14 EU MSs.
UEPG (European Aggregates Association)	http://www.uepg.eu/	UEPG promotes the interests of the European aggregates industry by representing its Members on economic, technical, health & safety and environmental policy. It has members from 27 countries and 22 MSs
EFCA	http://www.efca.info/	EFCA is a partnership of 11 National Admixture Associations (8 EU MS), formed in 1984 in order to represent the interests of the industry.
CCA-Europe (European calcium carbonate and dolomite producers)	http://www.cca-europe.eu/	CCA-Europe is a non-profit association, whose Members cooperate on scientific and legislative issues of common interest related to the mineral calcium carbonate. Its membership comprises 48 companies from 11 EU Member States as well as Norway and Switzerland

National associations

Eurostat data shows that the relevant industries for the manufacturing of cement and lime are concentrated in a small number of Member States. Furthermore, similarities between Member States (e.g. in terms of technological development) from similar geographic areas have been confirmed by European industry associations. The recommendation from the Mirror Group was therefore to focus interviews with national associations on a sample of Member States identified as covering a large share of markets and being typical[328] in representing different geographic areas. The conclusion of the Mirror Group was that large markets such as Germany and Spain represent well the Northern/Southern Member States. Poland as the biggest Eastern Member State providing a good example and Sweden/Finland to represent the Nordic situation. In addition, based on the specificities of lime (Belgium) and cements (Italy), also two more Member States were added. The sample strategy thus provided a large market coverage as well as geographic diversity. The following table provides further reasons for addressing these Member States:

Table B.2 Member State focus of primary data collection

Member State	Reasoning for selection
Germany	Germany is the member state with the highest turnover in both cement and lime sectors, accounting for 19% and 28% respectively. Germany is also the largest contributor in terms of employment in both sectors, as it represents 18% of the employment in the EU cement industry and 24% of the employment in the EU lime industry.
Spain	Spain is the 4th EU MS in terms of turnover in the cement sector and 5th in the lime sector representing 10% and 7% of EU's turnover in the cement and lime sectors respectively. Spain is also one of the main contributors in terms of employment in the sectors as it represents 10% and 9% of employment in the cement and lime industries respectively.
Poland	Poland is also one of the largest contributors of EU's cement and lime industries, accounting for 8% of EU's turnover in the cement sector and 7% of EU's turnover in the lime sector. It

[328] Typical is to be understood as a Member State that is representing well the market and company structures of several other neighboring Member States. The judgement is based on the discussion with the Mirror Group.

Member State	Reasoning for selection
	is also on of the main contributors in terms of employment as it represents 11% and 9% of the total EU employment in the cement and lime industries respectively.
Belgium	Belgium is the 6th largest contributor in terms of turnover in EU's cement industry and 2nd in EU's lime industry. It accounts for 6% of EU's turnover in the cement sector and 13% of EU's turnover in the lime sector. It is also on of the main contributors in terms of employment as it represents 4% and 7% of the total EU employment in the cement and lime industries respectively.
Sweden/ Finland	The MG suggests that the Nordic dimension should be covered by the sample. Eurostat does not provide data on individual Member States, but both Sweden and Finland have been identified as typical countries by the Mirror Group. It will have to be decided whether to include both or one of the Member States, depending on willingness to cooperate and the identification of potential companies/plants in the two MS.
Italy	Italy was added to the sample on request from the cements sector as it represents a major market in Southern Europe. The addition will allow to provide an even broader coverage of the EU.

Companies

The focus in terms of company selection was on companies having a base in the selected Member States above.

Data collection and confidentiality

To improve the willingness of companies to participate in the data collection, a specific approach of three steps was applied:

1. **Confidentiality statement**: We will provide all stakeholders to be interviewed with a confidentiality statement providing information about our confidentiality rules and how we will treat data;
2. **Individual confidentiality agreements**: We expect companies to request individual confidentiality agreements to be signed between Ecorys and the company at stake, which we will do;
3. **Data protection**: We will follow strict data protection processes which cover the full anonymisation of data in integrated files (numbering of companies and matching files of numbers and companies in other protected folders), secured access to folders used only for the project team and password protected files (questionnaires and calculation files).

The target of companies was to interview at least three cement and three lime companies present in Germany and Poland and two (each) in Spain and Italy. In the smaller Member States such as Belgium and Sweden/Finland at least two companies in each of them should have been covered. Furthermore, SMEs should have been sufficiently represented in the sample of companies. Across Member States, companies could (but should not always) be part of the same holding company. Guiding principle of sampling was to target:

- Interviews with some of the largest players dominating the competitive position of the industry;
- Focused entry point on Member States selected by the MG capturing about 60% of the markets;
- Divided Member States into similar geographical areas (in terms of their political and economic environment e.g. North-West-Europe, Southern Europe, Central and Eastern Europe);
- Divided the sample into large companies and SMEs[329].

[329] This aspect seems to be more relevant for the lime industry than for the cement industry where a stronger concentration can be observed.

In total, we targeted for cement and lime the following number of companies:

Table B.3 Target number of companies to be interviewed for primary data collection

Company size	Cement	Lime
Large company	7	10
SME company	3	6-7
Total	10	16-17
Representing	5-6 Member States	5-6 Member States

Primary data has been collected in the form of national association interviews and company interviews. Based on the sampling strategy cement and lime associations as well as companies from Belgium, Germany, Italy, Spain, Poland, Finland and Sweden have been approached for interviews. State of play at report resubmission on interviews was as follows:

- 5 national cement associations were interviewed (DE, BE, ES, IT, PL);
- 3 national lime associations were interviewed (BE, DE, ES);
- 29 cement manufactures were approached, of which 15 have been interviewed to date;
- 18 lime manufacturers were approached, of which 11 have been interviewed.

Further interviews are under preparation and being held before the summer.

Sample composition

All targeted national associations (5 national cement associations from DE, BE, ES, IT, PL and 3 lime associations from BE, DE, ES) were interviewed. Furthermore, for the quantitative analysis we were able to use a sample of questionnaires from 15 cement and 11 lime companies. The companies included into the aggregate sample account to approximately one third of the total turnover and employment of the EU cement sector. In the case of the lime sector the total number of people employed by the companies in our sample amounts to a similar share of the EU total, and the same can be said in terms of coverage of total EU turnover.

Table B.4 General Sample coverage

	Cement	Lime
Share of total EU28 sector employment (2014)	30%	27%
Share of total EU28 sector turnover (2014)	33%	29%

Source: total EU28 employment and turnover estimates for cement and lime sectors are based on Eurostat

We considered as individual entries in our dataset, the figures provided by each business entity, investigating for aggregated estimates at company level, whenever confronted with firms having their production operations in more than one plant. While the definition of relevant business entity is straightforward in the case of smaller firms with a limited number of geographically concentrated plants, the target become less defined in case of international industrial groups. The juridical structure and corporate strategy of groups differ, with some opting for example for a unified and coordinated corporate structure, maintaining the plants in all countries under the same company, while others implement a degree of flexibility in the way each sub-entity is recognized and operate.

We decided to consistently restrict our focus to the existing legal entities at national level, as we aimed to capture the patterns of the different markets for cement and lime in the EU Member

States. Therefore, when contacting industrial groups, we considered the national legal entities as separate individual companies, and hence treated their replies as separate data entries. Nevertheless, when disclosing our elaborations we take care of ensuring that they are based at least on three different single data entries, provided by business entities belonging to at least three different groups. This was done to respect the confidentiality of the data shared by companies interviewed.

Figures of cost structure may sensibly differ across MS, while elements about the R&D investments are rather treated at the parental level of holdings. In gathering our data, we tailored our approach to specific business strategy of the groups we interviewed.

The table below outlines the composition of our sample in terms of firms size, type of ownership structure and geographical composition. With regards to the geographical composition we will present results aggregated in three macro-geographical areas, namely:

- North-Western Europe (NWE), which includes companies operating in Germany and Belgium;
- North-Eastern Europe (NEE), which includes companies operating in Poland, Finland and Sweden;
- Southern Europe (SE) which includes companies operating in Spain and Italy.

Table B.5 Sample composition

	Cement	Lime
Number of firms	15	11
Geographic composition		
BE	0	2
DE	7	3
IT	2	0
ES	4	2
FI	0	1
SE	0	1
PL	2	2
Macro areas		
North Western Europe	7	5
North-Eastern Europe	2*	4
Southern-Europe	6	2*
Firm size		
SME	3	2
Large firm	12	9
Corporate structure		
Part of a group	11	8
Independent	4	3

Note: * indicates data sub-groups for which data cannot be disclosed due to confidentiality reasons

Mirror Group inputs and validation

The establishment of a Mirror Group to this study was used to allow for a regular exchange with industry representatives on the basis of interim results so to identify and explain outliers of data or to assess the validity of interpretations. Members of the Mirror Group were representatives from CEMBUREAU and EuLa, but also representatives of selected individual firms (as recommended by the associations) and in selected Mirror Group meetings also representatives from downstream industries. The Mirror Group met after the Kick-off Meeting, after the Inception Report, after the Preliminary Report, after the draft scenario analysis was conducted and after the submission of the Draft Final Report.

B3. Followed approach: data analysis (overall)

Analysis of quantitative survey data

We elaborated averages for the European industry, by using as weights the shares of turnover and number of employees provided by companies for 2016. Companies provided in most cases figures for the latest three available years (often for the 2014-2016 period). We employed the average rates of variation of the sample, to produce reliable figures to complement missing information for a given year observation. We additionally referred to the Amadeus database for the limited cases in which the entire data series for employment or turnover was entirely missing. Averages presented below are based on turnover. Nevertheless, estimations appear robust when compared with averages based on number of employees. Regional averages are also elaborated based on shares of turnover of 2016.

Throughout the report we disclose data depending on the rate of replies from companies on each single quantitative item, notably only if there are sufficient responses provided (at least 3 different companies). The aspect of confidentiality is of particularly importance concerning cost structure data. Namely, we are able to disclose data on cost structure for companies operating in North Western Europe and Southern Europe, in the cement sector, and for companies in North Western Europe and North Eastern Europe for the lime sector. For the remaining quantitative items investigated in the questionnaires (e.g. evaluation of drivers of competitiveness or assessment of the market position) we often limited the presentation of the data for the lime sector to the EU average, while for the cement sector we apply the same disclosure of regional averages than the one used for cost structure.

Analysis of qualitative survey information

For a structured analysis of qualitative information, we used the analysis software Atlas to structure questions according to key reoccurring topics. We thus first tagged key messages to have some sort of first quantification of issues, (e.g. how many times do they talk about energy costs, transport costs, vertical integration, etc.), and then specifically looked at what respondents were specifically referring to in those cases. The in-depth synthesis of response was then conducted on a question by question basis and used to validate findings and particularly to substantiate quantitative response.

Assessment of regulatory groups

Based on the insights from the scoping interviews and the literature review, a first assessment of the 'importance' of the various regulatory groups was made and discussed both with the Steering Committee and the Mirror Group. This assessment was used as input to the draft questionnaire. Furthermore, the regulatory assessment was substantiated based on further literature sources, interviews with representatives of the relevant European Commission DGs (notably DG CLIMA. DG ENV etc.) and national associations and companies.

Analysis of quantitative secondary data

The analysis of quantitative secondary data was conducted in the form of an iterative process, starting with a first presentation and assessment of available Eurostat and other publically available data. The results were then cross-checked with industry data and industry representatives and further substantiated with data identified in other sources.

Analysis of total factor productivity (TFP)

The Amadeus database contains balance sheet information, as well as other firm-specific information.

Our approach also relies on the methodology developed by Gal (2013). Further details are provided below:

- Value added (VA). An important limitation of the Amadeus database is that a large proportion of firms do not report VA. Gal (2013) proposes a twofold procedure to impute VA, using other available information. First, an internal imputation procedure using Amadeus information only (e.g. staff costs, EBITDA). Second, an external imputation procedure, drawing from additional sources such as Eurostat's National Accounts database to estimate labour costs for those firms that did not provide that information.
- Labour input (L). In the context of Amadeus, employment is defined as the number of employees. The shares of labour costs to value added (sL) are calculated by using information from Eurostat NA.
- Capital input (K). Capital is calculated according to the Perpetual Inventory Method (PIM). For this purpose, we relied on the available Amadeus data on the book value of tangible fixed assets (TFAS), and the book value of depreciation (DEPR); as well as the Gross Fixed Capital Formation (GFCF) deflator at the industry level which is available at Eurostat National Account database.

To ensure the comparability over time and across countries, original currency-real values of each variable were transformed into international comparable 2010 PPP. As proposed by Gal (2013), sampling weights were introduced to minimise the under representativeness of small firms present in Amadeus. These weights were calculated by using information from the Eurostat Structural Business Statistics (SBS) database. A sampling weight was assigned for each firm-year observation to mimic the true structure of firms. A time-varying re-sampling weight was assigned to each firm in the sample. The sampling weights, which were created for each firm for which TFP was to be calculated, replicated the number of employees by country, industry, year and firm-size class. The data reported by SBS was used as the benchmark when constructing the individual re-sampling weights.

Quantitative analysis and customisation of the ADAGIO model

For the scenario analysis, the ADAGIO model, A DynAmic Global Input Output model, was used. It is part of a family of regional models with a common modelling philosophy; a philosophy which might be described as "Dynamic New Keynesian": although not "General Equilibrium" in the usual sense, this model type (which might be called "EIO" – econometric Input Output modeling – or "DYNK" – Dynamic New Keynesian) shows important aspects of equilibrium behaviour. The dynamic aspect differentiates from the static CGE long-term equilibrium. This feature is most developed in the consumption block, where a dynamic optimization model of households is applied. But it equally applies to the equilibrium in the capital market as well as to the macroeconomic closure via a well-defined path for the public deficit.

The ADAGIO model is an input-output model in the sense that it is inherently a demand-driven model. However, it is a much more powerful model for impact assessment than the static IO quantity and price models due to the following features:

- The price and the quantity side of the input-output model are linked in different ways, demand reacts to prices and the price of labour reacts to demand.
- Prices in the model are not identical for all users as in the IO price model, but user-specific due to its proper account of margins, taxes and subsidies, and import shares that are different for each user.
- Consumption, investment and exports (i.e. the main categories of final demand) are endogenous and not exogenous as in the IO quantity model, explained by consumer

behaviour (demand system), regional import demand (differentiated by intermediate and final use) and producer behaviour (K,L,E,M model with M split up into domestic and imported).
- Aggregates of the column of IO coefficients (total intermediates, energy goods, value added components) are endogenous and explained in the K,L,E,M model, whereas in the IO price model they are taken as exogenous.

While this approach shows several similarities with computable general equilibrium (CGE) models, it also deviates from specifications in CGE models in some important aspects. Output is demand driven and the supply side is represented with the help of a cost function that also comprises total factor productivity (TFP). The growth of TFP is the most important long-term supply side force in that sense in the DYNK model. Contrary to some CGE applications, exports are also fully demand driven via foreign demand in the DYNK approach (demand for imports in one country corresponds to demand for exports in other countries).

B4: Followed approach: production cost breakdown

Within the context of this study we launched a survey among cement (and lime) companies in order to collect additional data for the overall industrial competitiveness analysis. In this section we present the approach on the cost breakdown.

Sample composition (cement and lime)

Our estimates are aggregated on a sample of 15 cement companies and 11 lime companies. The companies included in the aggregated sample account to more than one fourth of the total turnover and employment of the EU cement sector. In the case of the lime sector the total number of people employed by the companies in our sample amounts to roughly one fifth of the EU total. The same applies in terms of coverage of total turnover of the EU lime sector.

Table B.6 General Sample coverage

	Cement (n=15)	Lime (n=11)
Share of total EU28 sector employment (2014)	30%	27%
Share of total EU28 sector turnover (2014)	31%	29%

Source: total EU28 employment and turnover estimates for cement and lime sectors are based on Eurostat

In the case of groups of companies, we requested data at the level of national legal entities, which we treated as separate individual companies. The table below outlines the composition of our sample in terms of (i) geographical composition, (ii) firm size, and (iii) type of ownership structure. With regard to the geographical composition we will present results aggregated in three macro-geographical areas, namely:
- North-Western Europe (NWE), which includes companies operating in Germany and Belgium;
- North-Eastern Europe (NEE), which includes companies operating in Poland, Finland and Sweden;
- Southern Europe (SE) which includes companies operating in Spain and Italy.

Table B.7 Sample composition

	Cement	Lime
Number of firms	15	11

Geographic composition		
BE	0	2
DE	7	3
IT	2	0
ES	4	2
FI	0	1
SE	0	1
PL	2	2
Macro areas - grouping		
North Western Europe (NWE)	7	5
North-Eastern Europe (NEE)	(2*)	4
Southern-Europe (SE)	6	(2*)
Firm size		
SME	4	2
Large firm	11	9
Corporate structure		
Part of a group	11	8
Independent	4	3

Note: * indicates data sub-groups for which data cannot be disclosed due to confidentiality reasons

Out of this sample, a subset of 11 cement companies and 10 lime companies disclosed data on their cost breakdown. The table below reports the geographic composition of these subsets. To respect the confidentiality of company data, we agreed to disclose only figures based on (i) data from at least 3 different companies, and (ii) belonging to more than 3 distinct groups. This implies that we cannot disclose information on North-Eastern Europe for cement and Southern-Europe for lime.

Table B.8 Sample composition specifically regarding replies on cost structure

	Cement	Lime
Number of firms	11	10
Geographic composition		
BE	0	2
DE	7	3
IT	0	0
ES	4	1
FI	0	1
SE	0	1
PL	0	2
Macro areas - grouping		
North Western Europe	7	5
North-Eastern Europe	(0*)	4
Southern-Europe	4	(1*)

Note: * indicates data sub-groups for which data cannot be disclosed due to confidentiality reasons

Methodology (cement and lime)

We asked companies to provide an indicative breakdown of their cost structures, expressing single cost components as shares of total production costs. We specifically addressed the following cost categories:

- Raw materials (e.g. limestone, clay, shale, marl, etc.)
- Other materials (e.g. gypsum, anhydrite, mineral additions)

- Energy (i.e. including fuel and electricity)
- Transport
- Maintenance
- Labour / Salaries (incl. social security contributions)
- Financing cost

We elaborated averages for the European industry, by using as weights the shares of turnover and number of employees provided by companies for 2016. Companies provided in most cases figures for the latest three available years (often for the 2014-2016 period). We employed the average rates of variation of the sample, to produce reliable figures to complement missing information for a given year observation. We additionally referred to the Amadeus database for the limited cases in which the entire data series for employment or turnover was entirely missing. Averages presented below are based on turnover. Nevertheless, estimations appear robust when compared with averages based on number of employees. Regional averages are also elaborated based on shares of turnover of 2016. We disclose only figures based on at least three different observations coming from at least three different companies.

Annex C: Questionnaires - primary data collection

Different questionnaires have been used for the primary data collection, which have been shared with and commented by different stakeholders to the study. The base **questionnaire for companies** was then adjusted to the two sectors and to national associations. Hereafter we add the base questionnaire for cement companies. Other questionnaires differ mainly at the level of completeness and rewording.

Introduction: context, objectives and approach of the study

Context – The European cement and lime industries are significant contributors to the EU economy in terms of GDP, employment and other variables. They play an essential role in the supply of necessary inputs for other downstream sectors (e.g. the construction industry, especially for cement, and the steel manufacturing sector for lime). Further, due to the energy intensive nature of their production processes they are notable for their significant energy footprint. The combination of these diverse aspects of the cement and lime industries means that they are of potentially crucial elements to be considered for achieving EU policy objectives in several areas. At the same time, these sectors face various challenges that could severely impact on their competitiveness, such as the cost and availability of inputs (raw materials or energy), developments in environmental, climate change, and health and safety regulations, as well as competition from third country producers. Against this background, the European Commission (DG GROW) has commissioned a study on the *Competitiveness of the EU cement and lime sectors,* that will be implemented by a consortium of research and consultancy organisations of which Ecorys is a partner. The study is to be carried out over the period January 2017 – December 2017.

Study objectives – The main objective of this study is to provide a clear and up-to-date assessment of the competitive position and performance of the EU cement and lime sectors. The study will also consider these sectors in the light of their role within the wider supply/value chain. It will notably assess the relations with the downstream segments of the cement industry, such as those companies using **cement** as input for their production process (e.g. concrete and other cement-based products).

The study should deliver a diagnosis of both the current competitiveness and future development prospects for each sector, thereby giving the European Commission necessary information and evidence to engage with the sector on future policy developments. In terms of this study, 'competitiveness' has 3 dimensions: (i) international competitiveness, i.e. EU cement and lime sectors vis-à-vis their international competitors; (ii) inter-sectorial competitiveness, i.e. competitiveness of cement and lime products vis-à-vis alternative (substitute) products; and (iii) macroeconomic competitiveness, i.e. in terms of the contribution of the cement and lime sectors to the economic welfare (e.g. value added, employment, etc.).

The assessment should encompass both non-regulatory and regulatory aspects and determinants of competitiveness; with the regulatory assessment focusing on those public policy areas identified as most important for the competitiveness of each sector.

Results and contact – The results of this study will give DG GROW insights on the competitiveness of the EU cement and lime sectors, on their prospects for the future, and provide appropriate recommendations for policy-makers.

Request to participate – *Consultation and interaction with companies and sector representatives is a vital element supporting the analysis and achieving the main aims of the study. The cooperation of industry and other stakeholders is needed for the collection of data and other information relevant for the assessment of the performance and competitive position of each sector. For this reason, we are approaching your organisation with the request to participate to an in-depth interview. The topics and questions for this interview are outlined in the accompanying questionnaire.*

For contact with the research team, please contact the following persons:

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Confidentiality commitment

This questionnaire indicates the topics we would like to discuss with you and/or your organisation. The research team acknowledges that some of these topics can be commercially sensitive. Accordingly, a signed confidentiality statement by Ecorys (on behalf of the research team) will be provided. If this is considered insufficient by the interviewee, a specific agreement can be entered into. Furthermore, data will be saved in a protected location on Ecorys´ servers to which only the core team of the project will have access. Questionnaires will be password protected and we will ensure that any files aggregating and elaborating data will report companies information associated only with an anonymous identification number. Correspondence between identification numbers and univocal information as company names and VAT will be stored in a separate environment.

In addition, a concise write-up of issues discussed at the interview and the information obtained will be shared with the interviewee(s). Thus, giving an opportunity to correct, revise or complement information. Interviewees will have the explicit possibility to declare certain information as 'confidential' and not suitable for further use or publication.

The outputs of the study (e.g. reports, presentations, etc.) will not disclose any individual company information unless prior approval has been received. All potentially sensitive quantitative information and data will only be presented in an aggregated form that preserves the anonymity of individual companies and/or production plants, and in such a way to prevent any possibility to trace the information or data back to the company or plant.

How to use/fill this questionnaire

The questionnaire consists of 10 modules covering different aspects important for the assessment of the competitive position of the sectors. Interviewees are asked to fill all modules relevant for their organisation. If certain modules cannot be filled, we would encourage the interviewees to nevertheless fill the other modules and provide an explanation why a module was dropped. Interviews will take place either in person or by phone. Interviewees are encouraged to pre-fill the questionnaires to the extent possible before the talk. Our team is ready to provide assistance and clarity where/if needed.

Section A: Company Information
Section B: Product and Product Information
Section C: General Market Information
Section D: Market Information – Supply Conditions & Competition (within industry)
Section E: Market Information – Competitive Position & Performance (within industry)
Section F: Market Information – Competition with other products
Section G: Business Development & Strategies
Section H: Research, Technology Development, and Innovation
Section I: Public policy and regulatory environment
Section J: Current and future drivers

In addition to the company questionnaire, companies receive a specific plants questionnaire annex, which focuses on regulatory costs and benefits. The annex questionnaire is intended to be filled for one or several plants of the company. The exact number of plants is to be agreed between the research team and the company.

Section A: Company Information

Please provide the following information on your company

A1	**Company Name**	
	Company Location (Main Office)	
	Contact Person / Interviewee	

A2	**Is your company a subsidiary / affiliate of another company / group?**		☐ NO ☐ YES
	If YES:	***Indicate the name/identity of the controlling company***	

A3	**Does your company own or control subsidiary / affiliate companies?**		☐ NO ☐ YES
	If YES:	***Indicate the name/identity of the subsidiary / affiliate company and its main type of business (sector of activity)*** ***[List the 5 most important ones]***	
		Company name	**Type of business**
	1		
	2		
	3		
	4		
	5		

A4	**How many persons does your company employ?** **[Please give details for the last 3 years available. If exact data is unavailable please provide your best estimate]**		Measure of employment used: ☐ Headcount ☐ Full Time Equivalents (FTE)
	Year	**Number of Persons**	**Type of business**

> If available: please supply any additional information you have on the workforce: e.g. by employee category; qualification/skill levels; gender; etc.

A5	**Does your company supply products (or services) as well as cement products?**	☐ NO ☐ YES

If YES:	***What are the main products and services produced by your company?*** ***[For non-cement products, list the 5 most important and indicate their share (%) of total production value (or turnover). If exact data is unavailable please provide your best estimate]***	
	Product or service	**Production share (%)**
-	**CEMENT**	
1		
2		
3		
4		
5		

A6	**What is the total turnover (operating revenues) of your company? And, if different, what is your total turnover (operating revenues) from the production of cement?** **[Please give details for the last 3 years available. If exact data is unavailable please provide your best estimate]**

Year	Currency	Total Turnover	EU share (%) of the turnover	Cement Production Turnover

A7	**Discussion topic: Supply chain integration**
	To what extent is the company vertical integrated in the supply chain (e.g. upstream: quarrying; downstream: cement based products including concrete)? What are the business reasons for this choice of integration?

A8	**Discussion topic: Intra-industry integration (M&A / brownfield investment)**

	To what extent has the company pursued a strategy of horizontal integration (i.e. mergers and acquisitions) of other companies / businesses involved in the production of cement in the last 20 years? What are the business reasons for this choice of integration? [Please distinguish between local/regional market, in other EU countries, in other regions of the world]

A9	**Discussion topic: Foreign investment in new (greenfield) production capacity outside the EU** ***[note: it is important for the purpose of the study to understand whether a company is already operating outside the EU, both in terms of their business models as well as knowledge of the conditions of operating outside the EU]***
	To what extent has the company pursued a strategy of foreign investment in new cement production capacity in countries/regions outside the EU in the last 20 years? What are the business reasons for this choice of integration?

Section B: Product and Production Information

Please provide the following information regarding your cement products and production.

B1	What types/categories of cement products does your company produce? [List the 5 most important types/categories and indicate their share (%) of total cement production volume and value. If exact data is unavailable please provide your best estimate]		
	Product type/category	Production share (%)	
		Volume (tons)	Value (EUR)
1	Clinker		
2	Portland cement		
3			
4			
5			
-	Other		

B2		
	How many cement production sites does your company operate in Europe?	
	How many cement kilns does your company operate in Europe?	
	How many cement production sites does your company operate outside Europe[330]?	
	How many cement kilns does your company operate outside Europe[331]?	
	Europe = EU28 + EFTA (Iceland, Liechtenstein, Norway and Switzerland)	

[330] To understand the relative presence and strength of the company inside vs outside the EU
[331] idem

B3	What is your installed/permitted production capacity of cement per country of your operations? *[If possible, indicate the number of production sites, capacity and production volume (latest year) in each location. If exact data is unavailable please provide your best estimate]*

	Country	Production sites (number)	Installed capacity (so-called nameplate capacity)	Production volume (tons)
1				
2				
3				
4				
5				
-	Other			

B4	What are the main categories of costs incurred by your company for its production of cement products? [List a maximum of the 10 most important types/categories of costs and indicate their share (%) of total cement production costs. If exact data is unavailable please provide your best estimate. Please make sure that costs for which EU or national subsidies and/or state aid have been granted are excluded.]

	Cost type/category	Share of production costs (%)
1	Raw materials (e.g. limestone, clay, shale, marl, etc.)	
2	Other materials (e.g. gypsum, anhydrite, mineral additions)	
3	Energy	
4	Transport	
5	Maintenance	
6	Labour / Salaries (incl. social security contributions)	
7	Financing cost	
8	Other (please specify):	
9	Other (please specify):	
10	Other (please specify):	

B5	What subsidies did your company receive for lowering the energy consumption or

minimising the environmental impact of the production of its cement products?

[List a maximum of the 5 most important types/categories of subsidies and indicate their share (%) of total cement production costs. If exact data is unavailable please provide your best estimate].

	Subsidy type/category	Share of production costs (%)
1		
2		
3		
4		
5		

B6 **Did your company receive any subsidy or other types of public support to reduce its energy costs?**

[List a maximum of the 5 most important types/categories of subsidies and other types of public support measures and indicate their share (%) of total cement production costs. If exact data is unavailable please provide your best estimate].

	Subsidy type/category of public support	Share of production costs (%)
1		
2		
3		
4		
5		

Section C: General Market Information

Please provide the following information regarding the market for your cement products.

C1	Does your company supply cement products for 'own use' within the company or to other subsidiaries or affiliated companies in the same Group?	☐ NO ☐ YES
If YES:	*Indicate the proportion of total cement production volume that is for own use and to affiliated companies. [If exact data is unavailable please provide your best estimate]*	
		Share of total production (%)
1	Own-use (i.e. within the same company)	
2	Supply to subsidiaries of the company	
3	Supply to affiliated companies within the same group	
-	Total supply to subsidiaries and affiliates	

C2	Does your company supply cement products directly to end-user customers (rather than through third-party distributors)?	☐ NO ☐ YES
If YES:	*What proportion of the company's total cement production is supplied directly to end-user customers?* *[If exact data is unavailable please provide your best estimate]*	***Share of total production (%)***
If YES:	*What are the main end-user customer types for your company's cement products?* *[List the 5 most important customer types/categories and indicate their share (%) of total direct sales to end-user customers. If exact data is unavailable please provide your best estimate]*	
	Customer type/category or sector	**Share of total direct sales (%)**
1		
2		
3		
4		
5		
-	**Other**	

C3	Do your company's production plants supply cement products beyond their local regional markets?	☐ NO ☐ YES

If YES:	***Do your company's EU production plants export cement products to markets outside the EU?***	☐ NO ☐ YES
If YES:	***What proportion of the company's EU cement production is exported to markets outside the EU?*** ***[If exact data is unavailable please provide your best estimate]***	**Share of total production (%)**
If YES:	***What are the most important export markets outside the EU for your company's cement products?*** ***[List the 5 most important export markets and their share of total extra-EU exports of cement products. If exact data is unavailable please provide your best estimate]***	

	Export market (country or region)	Share of total extra-EU exports (%)
1		
2		
3		
4		
5		

C4	**Discussion topic: EU Market Demand Conditions**
	What do you view as the most important demand trends shaping conditions in the EU cement market?

C5	**Discussion topic: Market Demand Conditions Outside The EU** ***[note: it is important for the purpose of the study to understand whether a company is facing different demand trends outside the EU]***
	What do you view as the most important demand trends shaping conditions in cement markets outside the EU?

Section D: Market Information – Supply Conditions & Competition (within industry)

Please provide the following information regarding the competition conditions within the market for cement products.

D1	**Who (what types of producers) are the main direct competitors for your cement products?** **[For companies operating in multiple EU countries, indicate the general situation in EU markets. Please rank competitors: 0 = not relevant; 1 = most important competitor; 2 = 2nd most important producer; etc.]**	
	Category of competitors	**Rank**
	Other local / national producers	
	Producers from other EU countries (imports from other EU countries)	
	Producers from countries outside the EU (imports from non-EU countries)	
	Other [specify]:	

D2	**Do you face competition from cement products imported from outside the EU?**	☐ NO ☐ YES

If YES:	***What countries/regions from outside the EU are the main competitors for your company's cement products?*** ***[List the 5 most important non-EU countries/regions supplying competing products]***	
	Source country (non-EU) of competing products	**Countries (EU) where products are competing with your products**
1		
2		
3		
4		
5		

D3	**Discussion topic: Market Supply Conditions**
	In your opinion, what are the most important supply trends shaping conditions in your cement market?

D4	**Discussion topic: EU Market Barriers**
	In your opinion, what are the most important barriers/obstacles to greater integration of the cement market in the EU? Are you facing barriers in selling/buying across borders in the EU?

In your opinion, what are the most important facilitators of greater integration of the cement market in the EU? What is facilitating trade across borders within the EU?

D5	**Discussion topic: Non-EU Market Barriers**
	In your opinion, what are the most important barriers/obstacles to (or facilitators of) greater integration of the EU cement industry in (global) international markets? Are you facing barriers in selling/buying across international borders?

Section E: Market Information – Competitive Position & Performance (within industry)

Please provide the following information regarding relative competitiveness in the cement industry.

E1	**Discussion topic: Relative Competitiveness of cement Production Within the EU**
	What factors do you think are most important in determining the difference in the performance of the cement industry in different parts of the EU? For example, in terms of production efficiency, productivity, and overall cost competitiveness.

E2	**Discussion topic: Relative Competitiveness of cement Production in the EU compared to other countries/regions**
	What factors do you think are most important in determining the difference in the performance of the EU cement industry compared to countries/regions outside the EU? What are the relative strengths and weaknesses of the EU cement industry compared to countries/regions outside the EU? For example, in terms of public policy and regulatory environment, production efficiency, productivity, and overall cost competitiveness.

E3	**Discussion topic: Vulnerability of the EU Market to increased imports**
	In your opinion, how vulnerable is the EU market to increased imports of cement products from outside the EU? What factors are (or will be) most important in determining the vulnerability of the EU market? Which non-EU countries/regions pose the biggest potential threat of increased imports into the EU? Could you provide some evidence? Which EU Member States are most vulnerable to increased imports Penetration?

E4	**Discussion topic: Opportunities for increased EU exports to markets outside the EU**
	In your opinion, what opportunities are there to increase EU exports of cement products to markets outside the EU? What factors are (or will be) most important in determining if these opportunities can be exploited? Which countries/regions offer the biggest potential opportunities for increasing EU exports?

E5	**Discussion topic: Inward Foreign Investment (FDI) in EU Production** **[note: it is important for the purpose of this study to assess the extent to which EU production is connected with international players]**
	In your opinion, what do you consider to be the possibilities for increased foreign direct investment in EU cement production? What factors are (or will be) most important in determining whether such investments are realised? Which non-EU countries/regions have the most potential for investments in EU cement production?

E6	**Discussion topic: Outward Foreign Investment (FDI) by EU Producers** **[note: it is important for the purpose of this study to assess the extent to which EU companies are connected to international production]**
	In your opinion, what do you consider to be the possibilities for increased foreign direct investment by EU cement producers in markets outside the EU? What factors are (or will be) most important in determining whether such investments are realised? Which non-EU countries/regions have the most potential for EU investments cement production?

Section F: Market Information – Competition with other products

Please provide the following information regarding competition between cement products and other (substitute/rival) products.

F1	**Discussion topic: Competition with other products**
	In your opinion, what are (or will be) the most important rival or substitute products for cement products? What are the main advantages and disadvantages of cement products vis-à-vis rival or substitute products? What do you view as the most important trends influencing the relative competitive position of cement products vis-à-vis rival or substitute products?

F2	**Discussion topic: Complementarity with other products**
	In your opinion, are there potential opportunities to exploit synergies / complementarities between cement products and other types of products? What are (or will be) the most important trends / factors determining whether such synergies / complementarities are realised?

Section G: Business Development & Strategies

Please provide the following information regarding business development and business strategies of your company.

G1	**Discussion topic: Market Position**		
	How would you characterise the market position of your company in terms of the following characteristics? [Please select a reply from the scale provided]		
	Price / cost competitiveness	☐ 5. Very good ☐ 4. Good ☐ 3. Neutral ☐ 2. Poor ☐ 1. Very poor	Comment:
	Product quality / specialisation	☐ 5. Very good ☐ 4. Good ☐ 3. Neutral ☐ 2. Poor ☐ 1. Very poor	Comment:

Product range / diversity	☐ 5. Very good ☐ 4. Good ☐ 3. Neutral ☐ 2. Poor ☐ 1. Very poor	Comment:
Customer / market segment specialisation	☐ 5. Very good ☐ 4. Good ☐ 3. Neutral ☐ 2. Poor ☐ 1. Very poor	Comment:
Customer service	☐ 5. Very good ☐ 4. Good ☐ 3. Neutral ☐ 2. Poor ☐ 1. Very poor	Comment:
Other [specify]		
Other [specify]		

G2 **Discussion topic: Improvements to market position / competitiveness**

Which of the following areas do you consider important for improving the competitive position of your company? What actions is your company taking in these areas?

[Please provide a score according to importance for your company: 1=not important; 2=of little importance; 3=important; 4=very important; 5=absolutely essential]

Area	Score (1 to 5)	Comments on actions
Product developments		
Production processes developments		
Raw materials supply		

Energy supply		
Customer relations		
Supplier relations		
Transport & logistics		
Workforce & employment		
Skills & training		
Mergers & Acquisitions / Disinvestments		
Other [specify]		

Section H: Research, Technology Development, and Innovation (RTD&I)

Please provide the following information regarding research, technology development and innovation.

H1	**Discussion topic: RTD&I trends (Industry level)**
	In your opinion, what are the most important RTD&I trends and developments (now and in the future) affecting the cement industry? [Distinguish between trends/developments within the cement industry itself, and trends/ developments occurring outside the cement industry]

H2	**Discussion topic: RTD&I activities (Company level)**
	What are the most important RTD&I activities undertaken by your company in recent years and in the years ahead and where (country, plant) are they being implemented?

H3	**Discussion topic: RTD&I partnerships**
	What RTDI partnerships is your company engaged in? [Distinguish partnerships with other companies in the cement industry, with public sector (including academic / research organisations), with equipment suppliers, with customers/clients]

Section I: Public policy and regulatory environment

Please provide the following information regarding the public policy and regulatory environment.

I1

(a) Which are the main public policy and regulatory areas that are important for your company's production of cement products and the business environment?

(b) Can you give examples of specific legislation/regulations (EU or national)?

(c) What are the main issues and opportunities for your company within each policy area?

[List the 5 most important public policy and regulatory areas. Note: these can include public policy and regulatory areas with either a positive or negative impact]

Rank	Public Policy / Regulatory Area
1	(a)Policy area:
	(b)Examples:
	(c)Key issues and opportunities:
2	(a)Policy area:
	(b)Examples:
	(c)Key issues and opportunities:
3	(a)Policy area:
	(b)Examples:
	(c)Key issues and opportunities:
4	(a)Policy area:
	(b)Examples:
	(c)Key issues and opportunities:
5	(a)Policy area:
	(b)Examples:
	(c)Key issues and opportunities:

I2	(a)Which are the most important national or EU regulations (or other rules, standards, guidelines etc.) that affect your company's production costs of cement products? (b) Can you indicate the source of regulation (etc.)? (c) Can you give indication of the cost impacts of the regulation (etc.) on production costs of cement products? (e.g. share of total costs or per unit of production)? (d) Can you give indication of the benefits generated by the regulation (etc.) on production costs (e.g. share of total costs or per unit of production)? (e) What impact does the regulation (etc.) have on the competitiveness of your cement production and products? [List the 5 most important public policy and regulatory areas. Note: these can include regulations (or other rules, standards, guidelines etc.) with either a positive or negative impact on production costs][332]	
	Rank	**Public Policy / Regulatory Area**
	1	(a)Regulation etc.:
		(b)Source of regulation ☐ EU ☐ National transposition of EU legislation ☐ National level ☐ Subnational level (e.g. regional, local)
		(c)Cost impact:
		(d)Perceived benefit:
		(e)Competitiveness impact:
	2	(a)Regulation etc.:
		(b)Source of regulation ☐ EU ☐ National transposition of EU legislation ☐ National level ☐ Subnational level (e.g. regional, local)
		(c)Cost impact:
		(d)Perceived benefit:
		(e)Competitiveness impact:

[332] Main policy domains: ETS and Climate policy ; Energy policy (incl. renewable energy); Resource efficiency and circular economy; Industrial emissions; Access to natural resources/nature; Health and safety; Standards (incl. Construction Products Regulation); Competition policy, Fiscal policy, Industry policy..

3	(a)Regulation etc.:
	(b)Source of regulation ☐ EU ☐ National transposition of EU legislation ☐ National level ☐ Subnational level (e.g. regional, local)
	(c)Cost impact:
	(d)Perceived benefit:
	(e)Competitiveness impact:
4	(a)Regulation etc.:
	(b)Source of regulation ☐ EU ☐ National transposition of EU legislation ☐ National level ☐ Subnational level (e.g. regional, local)
	(c)Cost impact:
	(d)Perceived benefit:
	(e)Competitiveness impact:
5	(a)Regulation etc.:
	(b)Source of regulation ☐ EU ☐ National transposition of EU legislation ☐ National level ☐ Subnational level (e.g. regional, local)
	(c)Cost impact:
	(d)Perceived benefit:

	(e)Competitiveness impact:

Section J: Current and future drivers

Please provide an assessment (opinion) of the importance of following factors and conditions on performance and competitiveness of the EU cement industry.

J1 **Competitiveness drivers**

Which of the following areas do you consider important for 'drivers' of market conditions and business performance ('competitiveness) of European cement production activities?

Do you expect these to increase or decrease in importance in the medium-term future?

[Please rank according to importance for your company: 1=negligible; 2=limited; 3=modest; 4=important; 5=very important]

[Please rank change:"-"= decrease in importance; "0"=neutral/no change; "+"=increase in importance]

Area	Rank	Change	Additional remarks
Exogenous conditions			
Globalisation			
Technological change			
Climate change			
Demographics / migration			
Other [specify]			
Market conditions			
EU market demand conditions and characteristics			
Non-EU market demand conditions and characteristics			
International competitor performance			
Rival/substitute product developments			
Access to / cost of land			
Access to / cost of raw materials			

Access to / cost of energy			
Labour supply and skills availability			
Other [specify]			
Industry Conditions			
Industry structure / size of companies			
Supply/value chain developments			
Industrial innovation behaviour			
Industry investment activities			
Business models / firm strategies			
Services development (servitisation)			
Other [specify]			
General framework conditions			
Access to finance / investment costs			
Access to knowledge, research & technology development			
Access / availability of infrastructure and transport			
Other [specify]			
Regulatory framework conditions			
ETS and Climate policy			
Energy policy (incl. renewable energy)			
Resource efficiency and circular economy			
Industrial emissions			
Access to natural resources/nature			
Health and safety			

Standards (incl. Construc-tion Products Regulation)			
Competition policy			
Fiscal policy			
Industry policy			
Other [specify]			

Thank you very much for your cooperation!

Annex D: Analysis of economic and financial indicators for Sectors 23.51, 23.52 and 23.6

D1. Overview

This Annex covers four broad areas for analysing the performance of firms in NACE Industries 23.51, 23.52 and 23.6. In order to keep the information presented in this manageable, we have decided to focus on the most relevant areas instead of reporting indicators for the broad eight areas that were mentioned in the inception report. More specifically, we focus on the following dimensions of performance: profitability, efficiency, productivity performance and market structure.

The content on this Annex draws mainly from data from AMADEUS, i.e. information for all EU countries that have a significant presence in these sectors has been extracted. This analysis relies on the non-consolidated financial statements of companies, as the consolidated financial statements usually involve a less-precise definition of industry. We compute weighted means for a range of indicators of financial and economic performance on annual and country basis, as well as for the overall EU. Additionally, we use re-sampling weights so that we can replicate the employment figures by – available by size, year and country in Eurostat's Structural Business Statistics. We therefore compute these performance indicators making use of employment weights representative of the population of businesses in the EU. This is feasible only at 3 digit level, so any analysis at 4 digit relies on the Amadeus sample only, and does not accurately replicate the overall employment structure of the sectors.

D2. Further methodological considerations

As advanced in the inception report, we follow the methodology set out in Gal (2013)[333], in which sampling weights are introduced to minimize the under representativeness of small firms in AMADEUS. The weights are created using information from the Eurostat SBS database. A sampling weight is assigned for each of the firm-year observations, in order to mimic the true structure of European firms. A time-varying re-sampling weight (which is always greater or equal to one), is assigned to each firm in the sample; this ensures that all the firms present in AMADEUS are preserved. The sampling weights should replicate the SBS number of employees by country, industry (NACE 23.5 and 23.6), firm-size class and year. The mentioned sampling weights are created for each firm for which the measures of TFP are to be calculated.

At this stage, a **limitation of our analysis** should be raised. **Eurostat SBS does not offer information by size class and industry at the NACE 4-digit.** Therefore, **it is not possible to calculate the re-sampling weights for the industries 23.51 and 23.52**. This means that **we cannot fully ensure that the sample from AMADEUS drawn for these two 4-digits sectors is fully representative of the 'true' population of firms.** The representativeness is only guaranteed at three digits, i.e. Sectors 23.5 and 23.6.

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[333] Gal, P.N. (2013), "Measuring Total Factor Productivity at the Firm Level using OECD-ORBIS, Economics Department Working Papers Nº 1049, OECD.

D3. Description of the sample

The size of the overall AMADEUS sample is illustrated in Tables D.1 for Sectors 23.5 and 23.6, as well as in Tables D.2 and D.3 for the more detailed 23.51 and 23.52 sectors. We then restrict our sample to those companies for which we can calculate Total Factor Productivity (TFP) and proceed to compute a battery of economic and financial indicators.

For the manufacture of articles of concrete, cement and plaster sector (23.6), our full AMADEUS sample is considerably larger than that for Sector 23.5. The total number of firms is around 10,000 each year. There are 23 countries with presence in this sector.

The size of the sample in sector 23.6 widened during these years, from about 5,000 firms in 2003 to about 10,000, since 2010. Italy has the largest number of companies in this sector, around 1,500 companies, accounting for about 15-20% of the total sample. Spanish companies account for about 12-15% of the total number of firms, and Romanian firms for about 9-12% - although in the last few years the number of Romanian companies has seen a steady increase in the sample. With regards to other countries, the following each account for at least 5% of the total companies: Bulgaria, Germany, France, Great Britain and Hungary.

There are about 300 companies every year in Sector 23.51 in the whole of the EU; the number of companies in Sector 23.52 is only slightly lower. Spain accounts for the largest number of companies in the manufacture of cement sector (23.51). There are over 100 Spanish companies each year in this sector. The number of Italian companies in Sector 23.51 is between 40 and 50 approximately. Other countries that account for a sizable number of companies include Poland, France, Great Britain and Germany. The distribution of the total number of companies in Sector 23.52 is more even. Amadeus has around 65-70 Spanish companies every year, whilst Italy has between 45 and 55. Other countries such Bulgaria and Romania, have around 30-40 companies by the end of the period analysed; there are around 20 companies in France and Hungary each year.

A problematic issue with the industry information included in company accounts is that this is self-reported. This is an issue that may flaw the industry-based analyses as companies may erroneously fill the information on the industry of operation. We base this analysis on those companies that report the 23.51, 23.52 and 23.6 as their main activity. However, it is also possible that some companies have secondary operations in these industries. Table D.4 includes the number or companies that report 23.51 and 23.52 as their secondary activity. We see that the number of firms operating in these industries as a secondary activity is larger than the number of firms operating in these as their main activity. The number of firms in 23.51 is just over 1,000 while the number of firms in 23.52 is almost 2,000 towards the end of the sample.

The average size of a company in Sector 23.51 is significantly larger than that in Sector 23.52. One issue to bear in mind is that the Amadeus sample is not representative of the overall population of firms at 4 digit-sectors, hence we can only extract conclusions for the firms present in this sample. Given the nature of company accounts data, the larger companies are likely to be over-represented due to the lighter reporting requirements of smaller companies but we are not able to distinguish whether differences in the average size represent a `true' characteristic of the sectors or is a sampling issue.

The average size in our sample of EU companies went up from 86 employees in 2003 to 160 in 2015 (Table D.7). We have to bear in mind that given the nature of company accounts data, the larger companies are likely to be over-represented due to the lighter reporting requirements of smaller companies. There are also differences across countries in the average size of companies. The country with a smaller average size is Spain. The average size in 2015 is of 50 employees.

The average size of a EU company in Sector 23.52 ranges between 35 and 50 employees in the period of analysis (Table D.8). Here Italy is amongst the countries with smaller size. The size structure of the average firm in Sector 23.6 is not hugely different from that of Sector 23.6 at the European level, but is in general smaller. The average firm size ranges from 26 employees in 2003 to 34 in 2015. The AMADEUS employment coverage of Sectors 23.5 and 23.6 (Figures D.1 and D.2 respectively) is uneven across EU countries. We quantify the number of firms in each of the two sectors, on a country by country basis, from 2003 to 2015. There are between 500 and 700 companies in Sector 23.5 in the whole EU region, depending on the year considered. There are 21 countries with presence in this industry. Spain and Italy account for the largest share of companies. Spanish companies represent about 30% of the total number of companies, and Italian companies between 15% and 20% of the total sample. A number of countries have also a sizeable presence, each accounting for at least of 5% of the companies in this sector; these include Bulgaria, Germany, France, Great Britain and Romania.

Figure D.1 contains further details on the coverage of total employment in each sector –looking at one of the last the average of the last five years of the sample, 2014. This is done by comparing the total employment figures accounted for of the AMADEUS companies in these sectors with the sector information available at Eurostat on the actual size of the sectors. For the manufacture of cement, lime and plaster sectors we can see that the countries with a better employment coverage in 2014 are Slovenia, Czech Republic, Croatia, Croatia and Slovakia and Czech Republic, with more than 80% coverage of employment. This is illustrated in figure 1. In these countries we can also see the number of companies in our sample is around 10 or below. For these countries, we are confident that our Amadeus sample captures the majority of the companies in this sector. Spain, and Romania, France and Great Britain have a coverage about just below 50%, while the coverage of Italy's employment in this sector is below 30% (23% to be precise). There are some countries for which our Amadeus sample of companies accounts for less than 20% of the employment in the sectors. This is the case of Greece, Denmark Finland and Finland.

In sector 236, the Amadeus coverage in Spain, France and Romania is similar to that of sector 235, while the coverage of Italy's employment in this sector is significantly better (above 50%). The coverage of British companies is also below that of sector 235.

The AMADEUS coverage of German companies in both sectors is around 30%. The coverage of British companies in Sector 23.6 (just above 20%) is also significantly worse than the coverage of Sector 23.5. This is shown in Figures D.1 and D.2.

Table D.1A Number of firms in Sectors 23.5 2003-2014

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT		10	9	8	8	9	9	10	11	11	10	11	7
BE	12	12	10	11	10	12	12	12	12	12	13	13	13
BG	7	7	22	25	24	30	33	34	36	37	40	38	38
CZ	11	13	9	10	8	10	11	11	12	14	15	13	11
DE	7	14	36	39	35	38	39	40	43	40	40	41	13
DK									2	2	2	3	3
EE	1	1	2	2	2	3	3	3	3	3	3	3	3

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ES	235	234	160	171	165	165	170	172	173	182	200	195	177
FI	2	2	2	2	3	3	3	3	3	3	3	4	4
FR	27	32	25	30	26	32	34	35	33	34	32	32	29
GB	23	24	23	25	29	28	30	34	33	36	39	41	33
GR	21	22	10	13	12	13	13	13	13	12	13	12	6
HR	10	9	9	9	9	9	10	10	10	10	10	10	10
HU	5	22	14	9	11	10	17	18	23	27	28	29	28
IE	6	6	10	10	10	10	11	11	11	12	12	12	10
IT	82	113	79	75	102	104	106	106	110	112	116	113	102
LU	1	1	1	1	1	1	1	1	1	1	1	1	
LV	1	1	2	3	3	3	3	3	3	3	3	3	3
MT				1	2	2	1	2	2	2	3	1	1
NL	5	5	5	4	4	5	5	5	5	5	5	5	4
PL	18	19	14	23	24	24	32	34	33	39	37	34	22
PT	13	13	10	16	16	17	16	17	18	18	19	18	15
RO	26	33	35	28	37	39	34	36	39	41	49	49	49
SE	7	7	4	4	4	6	6	6	8	8	8	9	9
SI	5	5	4	4	4	4	4	5	6	6	6	6	6
SK	6	4	3	7	8	8	8	9	10	10	10	10	9
Total EU	531	609	498	530	557	585	611	630	653	680	717	706	605

Table D.1B Number of firms in Sectors 23.6 2003-2014

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT	13	105	108	190	214	221	214	231	254	262	264	268	227
BE	335	347	304	306	320	331	335	351	360	366	378	377	362
BG	36	38	220	234	281	308	333	358	376	394	431	434	429
CY			1	1	1	1	1		1	1	3	3	
CZ	104	123	151	154	174	191	209	224	234	250	260	249	187
DE	144	229	879	1043	1045	1109	1166	1182	1198	1198	1224	1111	535
DK									112	121	121	126	129
EE	37	41	40	31	46	53	54	58	61	66	70	69	67
ES	1301	1345	1117	1065	1039	1098	1148	1171	1208	1253	1326	1318	1167
FI	125	131	100	106	129	140	144	151	158	162	166	164	155
FR	628	659	617	588	611	644	677	711	735	773	776	685	548
GB	258	294	275	283	309	325	347	365	385	407	432	464	412
GR	182	190	151	141	142	143	150	155	161	166	172	171	95
HR	111	119	104	107	108	118	126	132	135	141	157	160	149
HU	101	322	277	163	247	249	357	359	394	444	476	490	494
IE	107	112	110	104	114	119	120	124	126	128	132	136	84
IT	1014	1405	1180	1131	1348	1420	1474	1544	1612	1702	1789	1799	1616
LT	13	13	16	21	30	30	31	33	33	35	38	26	13
LU	7	8	8	9	8	10	11	11	11	11	11	5	
LV	15	61	63	83	109	104	117	130	134	145	160	164	162
MT	3	3	3	3	3	7	8	8	8	6	7	5	2
NL	171	188	184	176	195	219	227	249	261	278	299	312	244
PL	132	140	154	249	307	376	462	477	504	541	550	528	368
PT	160	180	184	304	312	316	332	334	331	342	361	358	342

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
RO	452	542	629	528	744	765	775	811	893	964	1090	1138	1166
SE	135	142	129	127	135	138	138	145	155	162	174	189	187
SI	20	25	21	29	29	30	31	68	72	78	82	84	86

Source: AMADEUS database.

Table D. 2 Number of firms in Sector 23.51, 2003-2015

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT		8	7	6	5	6	6	7	7	7	6	7	4
BE	10	10	8	9	8	10	10	10	10	10	11	11	11
BG	3	5	4	5	5	5	5	5	5	5	5	5	5
CZ	5	6	4	4	3	4	4	4	4	4	4	4	4
DE	5	6	14	17	15	16	16	17	18	17	16	18	10
DK									1	1	1	2	2
EE	1	1	1	1	1	2	2	2	2	2	2	2	2
ES	163	163	98	105	101	100	105	104	108	114	129	124	114
FI	2	2	2	2	2	2	2	2	2	2	2	2	2
FR	8	10	5	9	8	10	12	12	11	11	11	13	11
GB	18	18	19	20	24	23	24	26	25	27	29	31	24
GR	3	3	1	1	1	1	1	1	1	1	1	1	1
HR	5	5	5	5	5	5	6	6	6	6	6	6	6
HU	2	4	3	3	3	3	5	5	4	6	6	6	6
IE	6	6	10	9	9	9	10	10	10	11	11	11	9
IT	35	49	34	30	50	48	48	48	49	51	52	52	43
LU	1	1	1	1	1	1	1	1	1	1	1	1	
LV	1	1	1	1	1	1	1	1	1	1	1	1	1
MT				1	2	2	1	2	2	2	3	1	1
NL	4	4	3	3	3	3	3	3	3	3	3	3	3
PL	12	12	8	12	13	14	20	21	20	23	22	22	14
PT	5	6	4	6	6	6	6	6	7	7	7	7	7
RO	4	4	4	5	6	8	8	8	10	10	10	8	9
SE	3	3	1	1	1	2	2	2	4	4	4	4	4
SI	2	2	2	2	2	2	2	2	2	2	2	2	2
SK	4	2		3	4	4	4	5	6	6	6	6	5
Total EU	302	331	239	261	279	287	304	310	319	334	351	350	300

Source: AMADEUS database.

Table D.3 Number of firms in Sector 23.52, 2003-2015

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT		2	2	2	3	3	3	3	4	4	4	4	3
BE	2	2	2	2	2	2	2	2	2	2	2	2	2
BG	4	2	18	20	19	25	28	29	31	32	35	33	33
CZ	5	4	5	6	5	5	6	6	5	6	6	5	5
DE	2	8	21	22	20	22	23	23	24	22	23	22	3
DK									1	1	1	1	1
EE			1	1	1	1	1	1	1	1	1	1	1
ES	72	71	62	66	64	65	65	68	65	68	71	71	63
FI					1	1	1	1	1	1	1	2	2
FR	19	22	20	21	18	22	22	23	22	23	21	19	18
GB	5	6	4	5	5	5	6	8	8	9	10	10	9

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GR	18	19	9	12	11	12	12	12	12	11	12	11	5
HR	5	4	4	4	4	4	4	4	4	4	4	4	4
HU	3	18	11	6	8	7	12	13	19	21	22	23	22
IE				1	1	1	1	1	1	1	1	1	1
IT	42	57	41	41	46	48	50	50	53	53	56	53	52
LV			1	2	2	2	2	2	2	2	2	2	2
NL	1	1	2	1	1	2	2	2	2	2	2	2	1
PL	6	7	6	11	11	10	12	13	13	16	15	12	8
PT	8	7	6	10	10	11	10	11	11	11	12	11	8
RO	22	29	31	23	31	31	26	28	29	31	39	41	40
SE	4	4	3	3	3	4	4	4	4	4	4	5	5
SI	3	3	2	2	2	2	2	3	4	4	4	4	4
SK	2	2	3	4	4	4	4	4	4	4	4	4	4
Total EU	223	268	254	265	272	289	298	311	322	333	352	343	296

Source: AMADEUS database.

Table D. 4 Number of companies with NACE as a secondary activity, 23.51 and 23.52

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2351	435	627	623	537	632	650	807	823	818	831	829	657
AT		1	2	2	2	2	2	2	2	2	2	1
BE	31	33	30	32	32	36	35	35	39	37	39	32
BG	2	1	6	8	8	7	8	9	9	9	9	9
CZ	5	5	8	10	9	13	15	15	13	10	6	3
DE	5	6	18	25	25	27	28	28	28	20	20	3
DK							1	1	1	1	1	
ES	279	278	243	258	256	260	273	275	276	269	254	136
FR									1	1	1	
GB	9	9	9	9	9	9	9	9	9	10	11	4
GR		1	1	1	1	1	1	1	1	1	1	1
HR	1	2	2	2	2	2	2	2	2	2	2	2
HU	61	250	247	133	218	225	348	353	347	379	390	375
NL	6	5	7	7	7	6	6	7	7	7	7	5
PL		1		1	1			1	1	1		
PT	9	10	10	12	15	15	15	15	13	15	15	14
RO	19	17	17	13	18	17	15	18	19	20	22	25
SE	1	1	1	1	1	1	1	1	1	1	1	
SK	7	7	22	23	28	29	48	51	49	46	48	47
2352	305	831	823	524	753	761	1083	1103	1117	1204	1212	1124
AT		3	2	3	3	2	2	3	3	2	2	
BE	9	9	9	9	10	10	10	10	11	11	11	9
BG	4	3	16	18	19	21	24	24	27	27	26	24
CZ	2	2	5	4	5	5	6	5	7	7	5	4
DE	3	7	15	21	21	22	22	23	23	22	19	3
DK								1	1	1	1	1
ES	84	86	83	86	84	86	89	92	92	90	85	57
FI	2	2	2	2	2	2	2	2	2	2	2	2
FR	2	2	2	2	2	2	2	2	2	3	2	2

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GB	8	8	8	8	8	9	10	10	11	11	11	7
GR	21	20	18	18	18	18	18	19	19	19	17	14
HR	5	6	5	6	4	5	6	6	6	6	6	5
HU	130	645	610	293	514	515	817	821	832	919	937	903
LV	2	2	1	1	1	1	1	1	1	1	1	1
PT	5	7	6	14	15	17	17	17	16	16	16	17
RO	25	25	27	24	28	26	22	29	32	34	37	41
SE	1	1	1	1	1	1	1	1	1	1	1	1
SK	2	3	13	14	18	19	34	37	31	32	33	33
Total	740	1458	1446	1061	1385	1411	1890	1926	1935	2035	2041	1781

Source: AMADEUS database.

Table D.5 Average size (employment) of companies in Sector 23.51

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BE	147	160	143	124	173	133	160	144	232	207	159	194	204
BG	49	66	297	310	343	350	249	247	207	155	205	155	278
CZ	372	411	307	302	339	425	356	288	315	288	288	315	405
DE				308	248	272	212	229	254	211	257	297	288
DK									27	26	26		27
ES	67	88	72	67	67	77	50	66	57	60	32	45	50
FI	3	3	3	2	2	2	2					1	1
FR	714	808	874	860	961	126	131	154	115	186	264	243	325
GB	29	39	43	40	46	45	48	54	51	315	340	199	706
GR	577	553	173	173	173	173	175	175	190	180	165	165	165
HR	409	330	319	320	401	414	430	354	326	308	324	285	286
HU					10	25	10	39	30	69	40	60	38
IT	126	221	159	142	140	117	134	137	187	112	155	135	148
NL	42	45											
PL	450	511	460	69	147	146	205	349	492	242	405		
PT				156	211	244	215	247	171	205	123	93	111
RO	964	927	623	322	250	304	393	312	153	569	201	160	145
SE		481			3	53	203	434	88	140	139	167	267
SI	363	341	323	248	209	197	189	176	159	126	65	118	198
SK	297	563		360	242	334	194	275	285	285	380	371	488
EU	86	98	78	68	96	141	119	138	156	149	140	143	160

Source: AMADEUS database.

Table D.6 Average size (employment) of companies in Sector 23.52

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BE	430	430	423	419	436	427	404	400	413	405	389	379	372
BG	153	109	234	293	20	34	21	268	7	25	25	13	39
CZ	122	188	151	135	137	150	161	25	120	113	113	113	113
DE				183	172	59	266	180	309	230	291	311	
DK									63	68		69	69
ES	40	61	24	58	57	74	38	43	56	36	20	27	31
FI					14	14	15	15	14		15	15	14
FR	8	26	29	25	27	32	15	14	45	40	43	54	57
GB	93	89	85	85	85	83	77	89	96	98	98	100	120
GR	20	23	36	31	31	30	33	39	31	18	20	15	65
HR	105	97	68	76	74	77	78	70	68	68	58	64	57
HU					52	55	33	25	22	8	18	10	15
IT	26	40	23	38	39	42	39	30	30	18	19	20	17
NL		2											
PL	125	139	99	92	109	131	75	127	110		188	146	
PT				11	15	17	12	9	10	12	29	22	15
RO	40	38	32	13	22	12	24	16	25	13	15	12	14
SE	8	1	1	1	1	36	78	81	78	80	83	54	43
SI	55	54	50	57	55	51	46	40	36	35	24	37	22
SK	191	191	330	285	285	170	157	285	124	135	179	159	225
EU	35	51	16	21	39	50	48	28	28	25	37	48	38

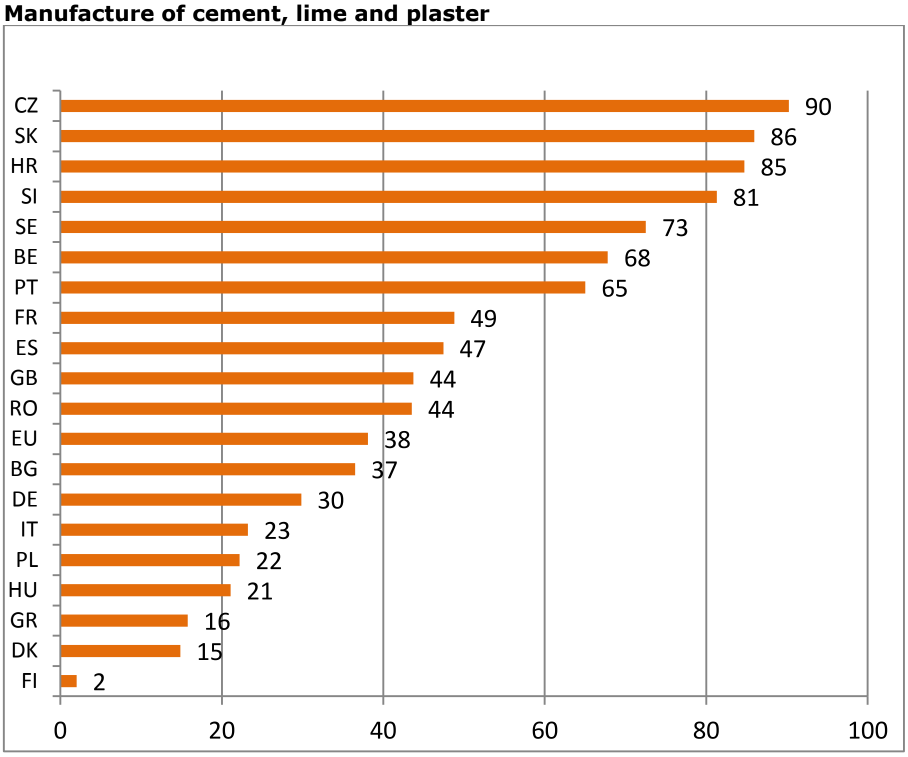
Source: AMADEUS database.

Table D.7 Average size (employment) of companies in Sector 23.6

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT								138	143	131	119	77	134
BE	29	41	32	33	38	39	26	38	41	40	43	41	47
BG	25	29	26	31	28	32	31	20	20	18	20	19	17
CZ	38	42	47	50	42	70	54	47	55	51	60	69	47
DE				42	36	40	37	36	36	27	41	62	164
DK									63	46	45	55	67
ES	24	23	24	28	24	22	19	21	16	17	10	10	15
FI	33	31	36	35	40	33	35	39	40	52	32	45	44
FR	37	39	43	45	31	26	24	27	31	31	29	43	39
GB	48	54	42	55	60	68	54	70	63	57	74	92	91
GR	19	19	14	16	16	12	13	13	11	11	12	12	13
HR	20	22	21	17	17	18	16	15	16	15	19	13	19
HU					22	32	21	22	25	23	14	13	14
IT	19	20	22	23	17	17	22	17	17	16	13	21	16
NL	30	26	63	37	32	64	65	70	59	59	58	83	91
PL	21	19	21	22	21	26	22	26	27	26	24	48	31
PT				23	20	22	21	19	19	17	22	22	17
RO	25	24	20	19	17	28	19	19	22	23	26	30	25
SE	38	54	56	30	50	40	48	46	51	46	50	33	46
SI	25	24	19	14	21	21	21	13	17	22	23	24	23
SK	27	31	25	25	23	25	34	25	30	22	21	22	27
UE	26	27	27	30	27	27	26	27	29	26	26	35	34

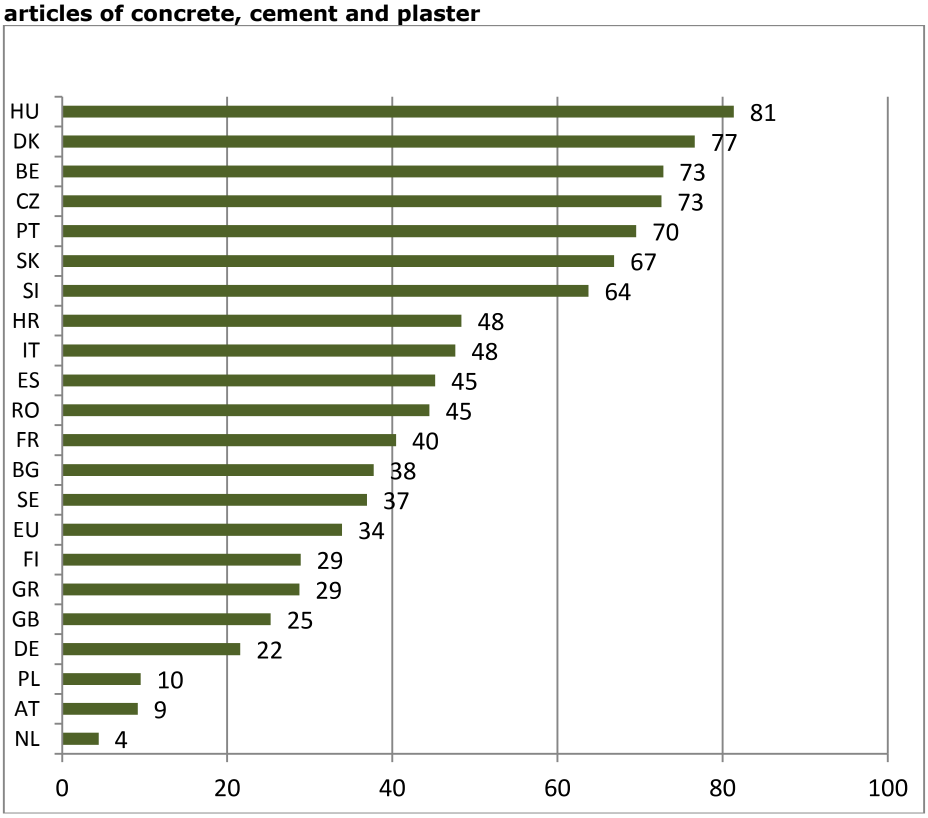
Source: AMADEUS database.

Figure D. 1 Coverage in terms of employment, average 2010-2015, sector 23.5 - Manufacture of cement, lime and plaster



Source: AMADEUS and Eurostat.

e D.2 Coverage in terms of employment, average 2010-2015, sector 23.6 - Manufacture of articles of concrete, cement and plaster



Source: AMADEUS and Eurostat.

Table D.8 Number of firms in the sample (TFP sample), Manufacture of cement, lime and plaster (Sector 23.5)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
AT								10	11	11	10	11	7	60
BE	12	12	10	11	10	12	12	12	12	12	13	13	13	154
BG	7	7	22	25	24	30	33	34	36	37	40	38	38	371
CZ	11	13	9	10	8	10	11	11	12	14	15	13	11	148
DE				39	35	38	39	40	43	40	40	41	13	368
DK									2	2	2	3	3	12
ES	235	234	160	171	165	165	170	172	173	182	200	195	177	2,399
FI	2	2	2	2	3	3	3	3	3	3	3	4	4	37
FR	27	32	25	30	26	32	34	35	33	34	32	32	29	401
GB	23	24	23	25	29	28	30	34	33	36	39	41	33	398
GR	21	22	10	13	12	13	13	13	13	12	13	12	6	173
HR	10	9	9	9	9	9	10	10	10	10	10	10	10	125
HU					11	10	17	18	23	27	28	29	28	191
IT	82	113	79	75	102	104	106	106	110	112	116	113	102	1,320
NL	5	5	5	4	4	5	5	5	5	5	5	5	4	62
PL	18	19	14	23	24	24	32	34	33	39	37	34	22	353
PT				16	16	17	16	17	18	18	19	18	15	170
RO	26	33	35	28	37	39	34	36	39	41	49	49	49	495
SE	7	7	4	4	4	6	6	6	8	8	8	9	9	86
SI	5	5	4	4	4	4	4	5	6	6	6	6	6	65
SK	6	4	3	7	8	8	8	9	10	10	10	10	9	102
Total	497	541	414	496	531	557	583	610	633	659	695	686	588	7,490

Source: AMADEUS database.

Table D. 9 Number of firms in the sample (TFP), Manufacture of articles of concrete, cement and plaster (Sector 23.6)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
AT								231	254	262	264	268	227	1,506
BE	335	347	304	306	320	331	335	351	360	366	378	377	362	4,472
BG	36	38	220	234	281	308	333	358	376	394	431	434	429	3,872
CY			1	1	1	1	1		1	1	3	3		13
CZ	104	123	151	154	174	191	209	224	234	250	260	249	187	2,510
DE				1,043	1,045	1,109	1,166	1,182	1,198	1,198	1,224	1,111	535	10,811
DK									112	121	121	126	129	609
ES	1,301	1,345	1,117	1,065	1,039	1,098	1,148	1,171	1,208	1,253	1,326	1,318	1,167	15,556
FI	125	131	100	106	129	140	144	151	158	162	166	164	155	1,831
FR	628	659	617	588	611	644	677	711	735	773	776	685	548	8,652
GB	258	294	275	283	309	325	347	365	385	407	432	464	412	4,556
GR	182	190	151	141	142	143	150	155	161	166	172	171	95	2,019
HR	111	119	104	107	108	118	126	132	135	141	157	160	149	1,667
HU					247	249	357	359	394	444	476	490	494	3,510
IT	1,014	1,405	1,180	1,131	1,348	1,420	1,474	1,544	1,612	1,702	1,789	1,799	1,616	19,034
LT	13	13	16	21	30	30	31	33	33	35	38	26	13	332
NL	171	188	184	176	195	219	227	249	261	278	299	312	244	3,003
PL	132	140	154	249	307	376	462	477	504	541	550	528	368	4,788

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
PT				304	312	316	332	334	331	342	361	358	342	3,332
RO	452	542	629	528	744	765	775	811	893	964	1,090	1,138	1,166	10,497
SE	135	142	129	127	135	138	138	145	155	162	174	189	187	1,956
SI	20	25	21	29	29	30	31	68	72	78	82	84	86	655
SK	25	31	89	102	115	117	203	220	240	256	265	295	291	2,249
Total	5,042	5,732	5,442	6,695	7,621	8,068	8,666	9,271	9,812	10,296	10,834	10,749	9,202	107,430

Source: AMADEUS database.

Table D.10 Number of firms in the sample (TFP sample), Manufacture of cement (Sector 23.51)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT								7	7	7	6	7	4
BE	10	10	8	9	8	10	10	10	10	10	11	11	11
BG	3	5	4	5	5	5	5	5	5	5	5	5	5
CZ	5	6	4	4	3	4	4	4	4	4	4	4	4
DE				17	15	16	16	17	18	17	16	18	10
DK									1	1	1	2	2
ES	163	163	98	105	101	100	105	104	108	114	129	124	114
FI	2	2	2	2	2	2	2	2	2	2	2	2	2
FR	8	10	5	9	8	10	12	12	11	11	11	13	11
GB	18	18	19	20	24	23	24	26	25	27	29	31	24
GR	3	3	1	1	1	1	1	1	1	1	1	1	1
HR	5	5	5	5	5	5	6	6	6	6	6	6	6
HU					3	3	5	5	4	6	6	6	6
IT	35	49	34	30	50	48	48	48	49	51	52	52	43
NL	4	4	3	3	3	3	3	3	3	3	3	3	3
PL	12	12	8	12	13	14	20	21	20	23	22	22	14
PT				6	6	6	6	6	7	7	7	7	7
RO	4	4	4	5	6	8	8	8	10	10	10	8	9
SE	3	3	1	1	1	2	2	2	4	4	4	4	4
SI	2	2	2	2	2	2	2	2	2	2	2	2	2
SK	4	2		3	4	4	4	5	6	6	6	6	5
Total EU	281	298	198	239	260	266	283	294	303	317	333	334	287

Source: AMADEUS database.

Table D.11 Number of firms in the sample (TFP sample), Manufacture of lime and plaster (Sector 23.52).

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AT								3	4	4	4	4	3
BE	2	2	2	2	2	2	2	2	2	2	2	2	2
BG	4	2	18	20	19	25	28	29	31	32	35	33	33
CZ	5	4	5	6	5	5	6	6	5	6	6	5	5
DE				22	20	22	23	23	24	22	23	22	3
DK									1	1	1	1	1
ES	72	71	62	66	64	65	65	68	65	68	71	71	63

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
FI					1	1	1	1	1	1	1	2	2
FR	19	22	20	21	18	22	22	23	22	23	21	19	18
GB	5	6	4	5	5	5	6	8	8	9	10	10	9
GR	18	19	9	12	11	12	12	12	12	11	12	11	5
HR	5	4	4	4	4	4	4	4	4	4	4	4	4
HU					8	7	12	13	19	21	22	23	22
IT	42	57	41	41	46	48	50	50	53	53	56	53	52
NL	1	1	2	1	1	2	2	2	2	2	2	2	1
PL	6	7	6	11	11	10	12	13	13	16	15	12	8
PT				10	10	11	10	11	11	11	12	11	8
RO	22	29	31	23	31	31	26	28	29	31	39	41	40
SE	4	4	3	3	3	4	4	4	4	4	4	5	5
SI	3	3	2	2	2	2	2	3	4	4	4	4	4
SK	2	2	3	4	4	4	4	4	4	4	4	4	4
Total EU	210	233	212	253	265	282	291	307	318	329	348	339	292

Source: AMADEUS database.

D4. Analysis of performance

A) Profitability

A number of measures can be used to assess the level of industry profitability. It can be defined as profit over operating revenue or also profit in relation to shareholder funds, as well as in terms of EBITDA over operating revenue. We focus here on the return on total assets, which is defined as the profit over the total assets of the company.

Figure D.3 illustrates profitability in the EU as a whole, in the manufacture of cement sector (23.51), the manufacture of lime and plaster sector (23.52) and the manufacture of articles of concrete, cement and plaster sector (23.6).

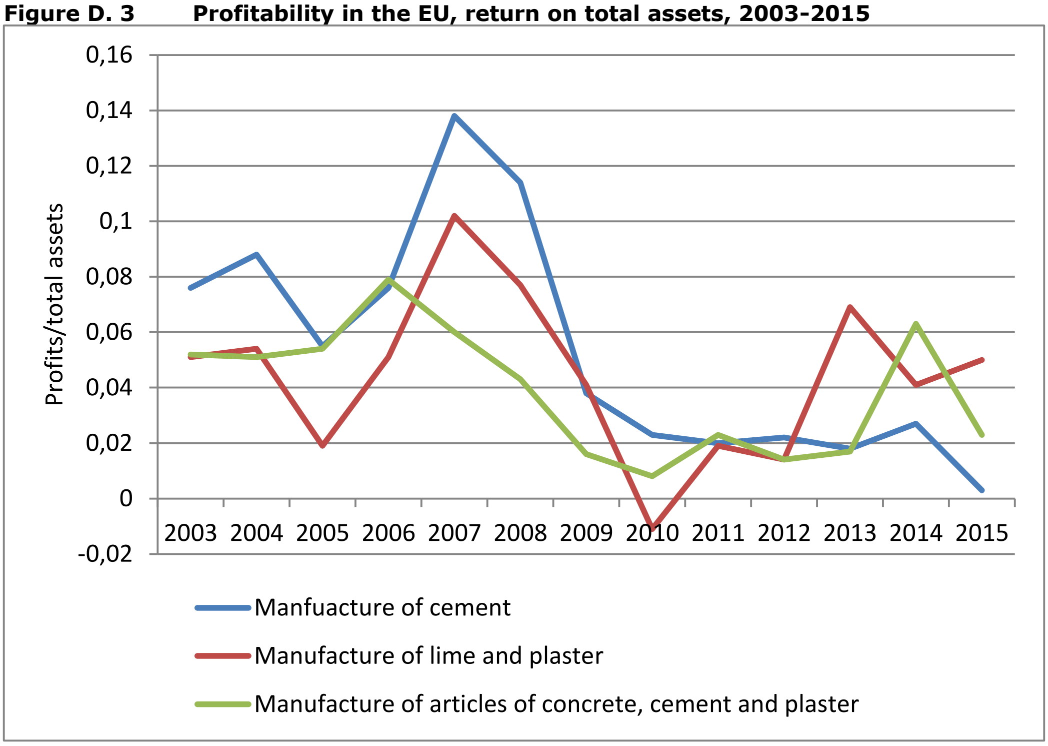
We see that prior to the 2007-2008 financial crisis, the profitability in the cement and lime and plaster sector rose rapidly in the EU. The levels of profitability in the cement sector were above those the lime and plaster sector. During that period, the increase in profitability in sector 23.6 - the manufacture of articles of concrete, cement and plaster- was more modest (Figures D.3 and D.6).

Since the crisis, profitability in the EU decreased rapidly in these sectors, in particular the cement and lime and plaster sectors. Profitability in these sectors was at lowest levels by 2010, it was even below zero in the lime and plaster industry. Since then, profitability has recovered to some extent, mainly in the manufacture of lime and manufacture of articles of concrete, cement and plaster, but remains below the pre-crisis levels. In the case of the cement sector, which is the largest sector, profitability does not show an improvement and has remained largely flat since 2010.

Figures D.4 and D.5 illustrate the profitability for a number of countries that are key in these sectors: Germany, Poland, Spain, Italy, Finland, Great Britain and France. In sector 23.51 we observe a decrease in the return on the total assets after 2007, across all countries. The countries that show the largest drops in productivity include Great Britain, Spain, Italy and France. Profitability was lower in Germany and Finland and has not experienced such large decreases in the aftermath of the recession. Finland is the only country where the profitability is below zero in the post-crisis period, but we need to be cautious as there are only few Finnish companies in AMADEUS. Profitability of Polish companies in Sector 23.51 worsened only lightly in response to the financial crisis. In Sector 23.52, we can also see that there was a substantial decrease in profitability in the majority of countries. Profitability worsened to a larger extent in France, as well as in Spain, Italy and Great Britain. The profitability of Polish companies experienced only a minor drop, as in Sector 23.51.

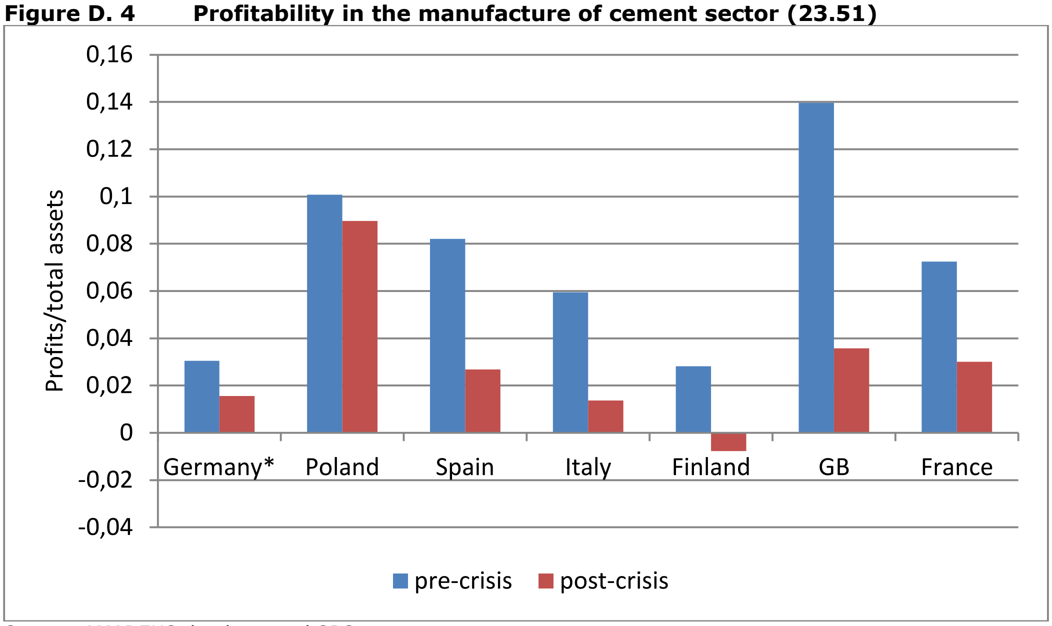
The profitability of the manufacture of articles of concrete, cement and plaster sector is generally lower than in Sector 23.52 and we see again the important deterioration of profitability across all the main countries as a result of the financial crisis. The decrease in profitability was of larger magnitude in Spain and also Poland. Profitability in Spain and Italy is negative, on average, since the crisis.

Figure D. 3 Profitability in the EU, return on total assets, 2003-2015



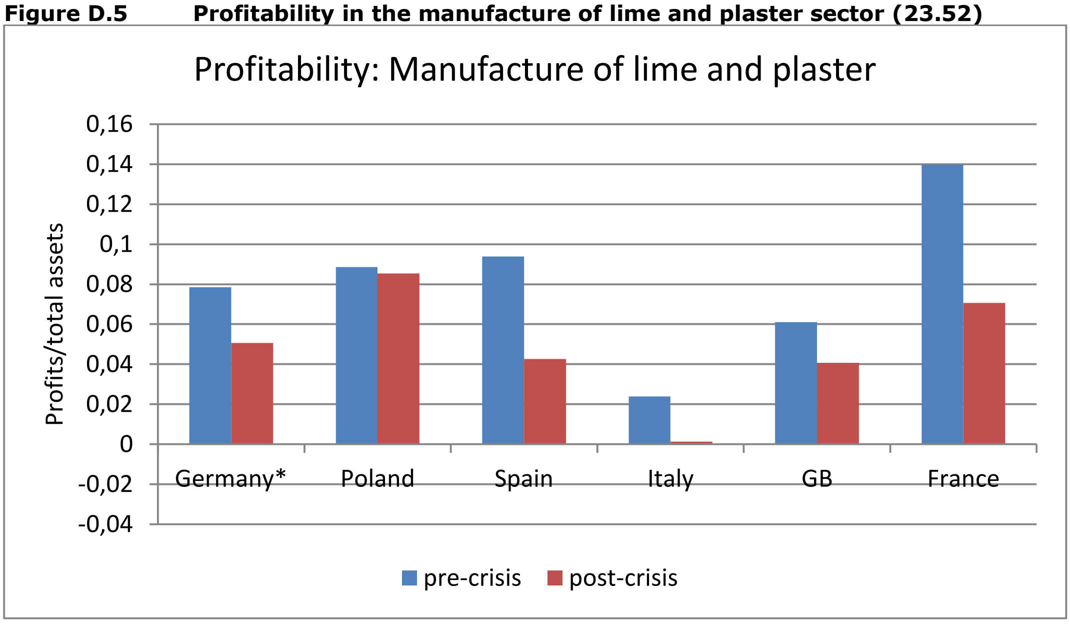
Source: AMADEUS database and SBS.
Note: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D. 4 **Profitability in the manufacture of cement sector (23.51)**



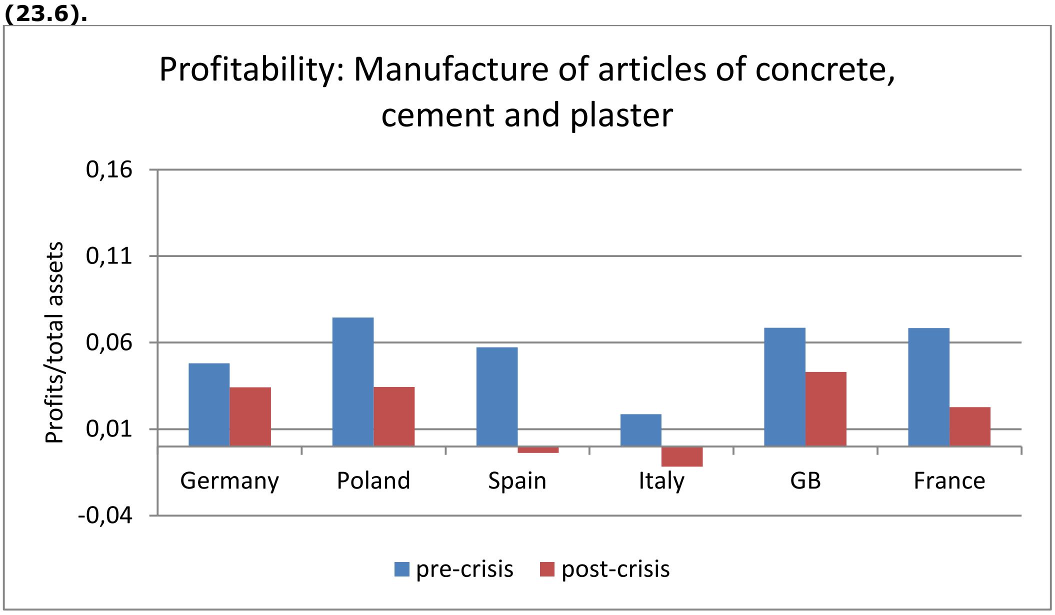
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.5 **Profitability in the manufacture of lime and plaster sector (23.52)**



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.6 Profitability in the manufacture of articles of concrete, cement and plaster sector (23.6).



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

B) Capital intensity and efficiency

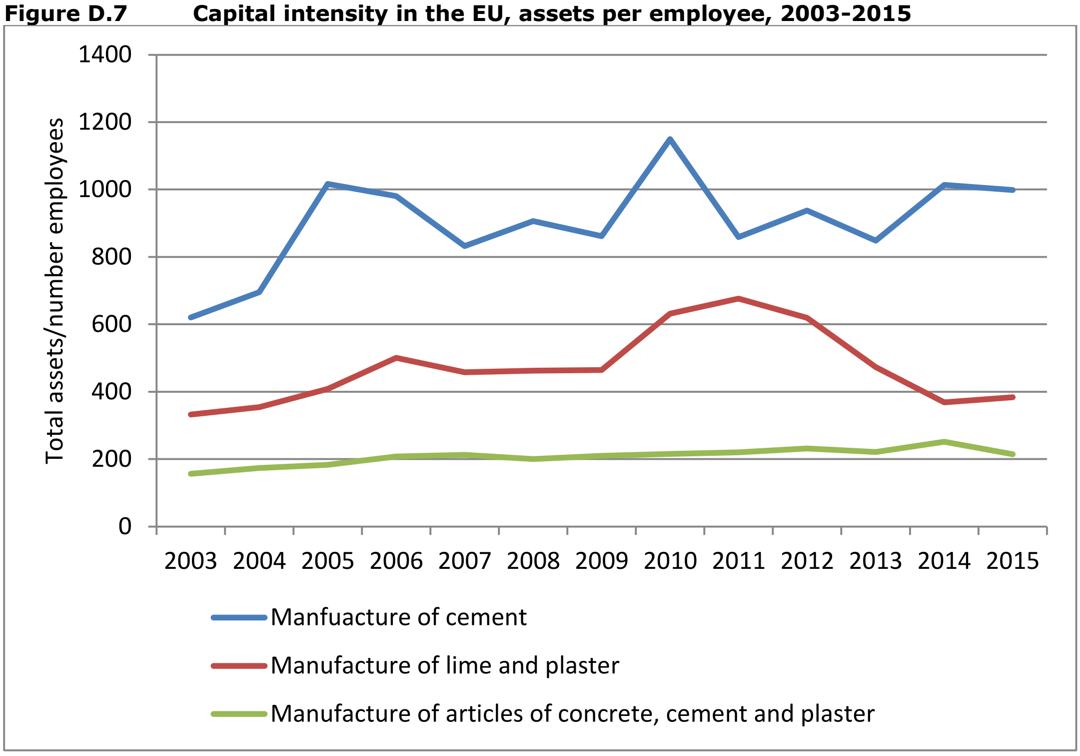
In this section, we illustrate how capital intensity of companies in Sectors 23.5 and 23.6 has evolved in the EU since 2003. We measure capital intensity in a particular company as the total value of its assets over its number of employees.

Figure D.7 illustrates the evolution of capital intensity in the whole of the EU in response to the financial crisis. The capital intensity is much higher in the manufacture of cement sector (23.51) than in the manufacture of lime and plaster (23.52) and in the in the manufacture of articles of concrete, cement and lime sector. These results show that Sector 23.5 is more capital intensive compared to Sector 23.6. Overall, the size of the total assets relative to the size of the workforce has experienced an increase in the manufacture of cement sector; this increment is above 50%. Furthermore, the increase has been continuous despite the effects of the crisis. The value in 2015 was 60% higher than in the initial years. In the manufacturing of lime and plaster capital intensity it also shows an increase up to 2011, year in which the upward trend began to reverse. This capital intensity in this industry is currently at slightly higher levels than prior to the crisis. In Sector 23.6, the fluctuations have been minimal, showing a slight upward trend.

By country, we observe that in Sector 23.51 capital intensity has reduced in some countries and has increased in others (Figure D.8). In general, the movements appear lower than in the case of the profitability. Spanish and Italian companies are, post-crisis, slightly less capital intensive. In contrast, German, British and French companies are slightly more capital intensive. The capital intensity of Polish companies has remained largely constant throughout this period.

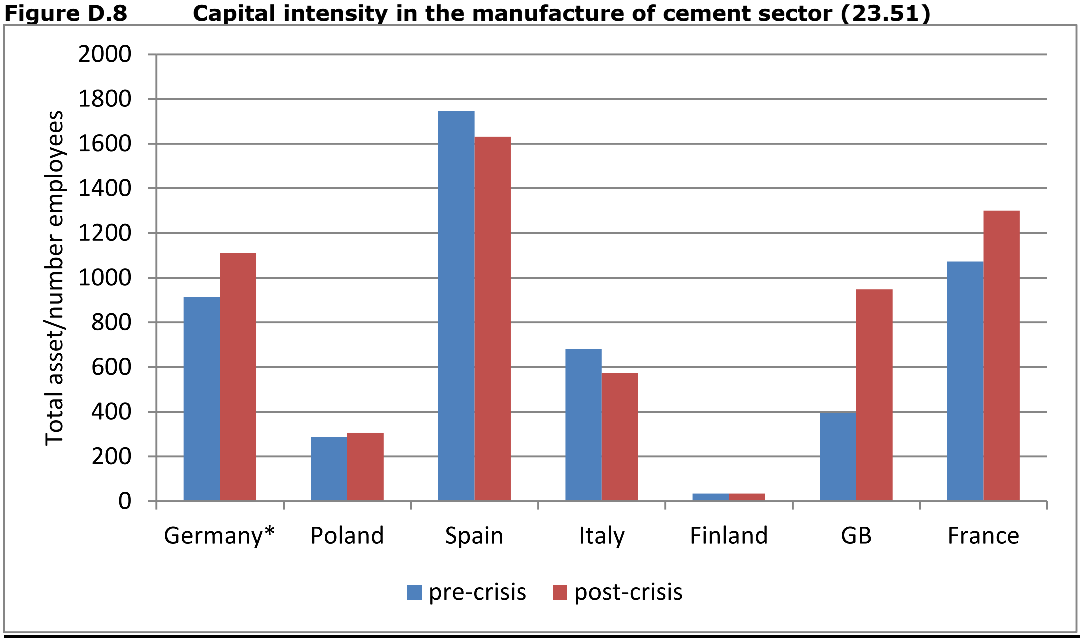
In Sectors 23.52 and 23.6 (Figures D.9 and D.10), capital intensity, that is the amount of capital that each worker has to work with, has instead increased in almost all the countries shown in the figures, including Spain, Italy, France and Poland.

Figure D.7 Capital intensity in the EU, assets per employee, 2003-2015



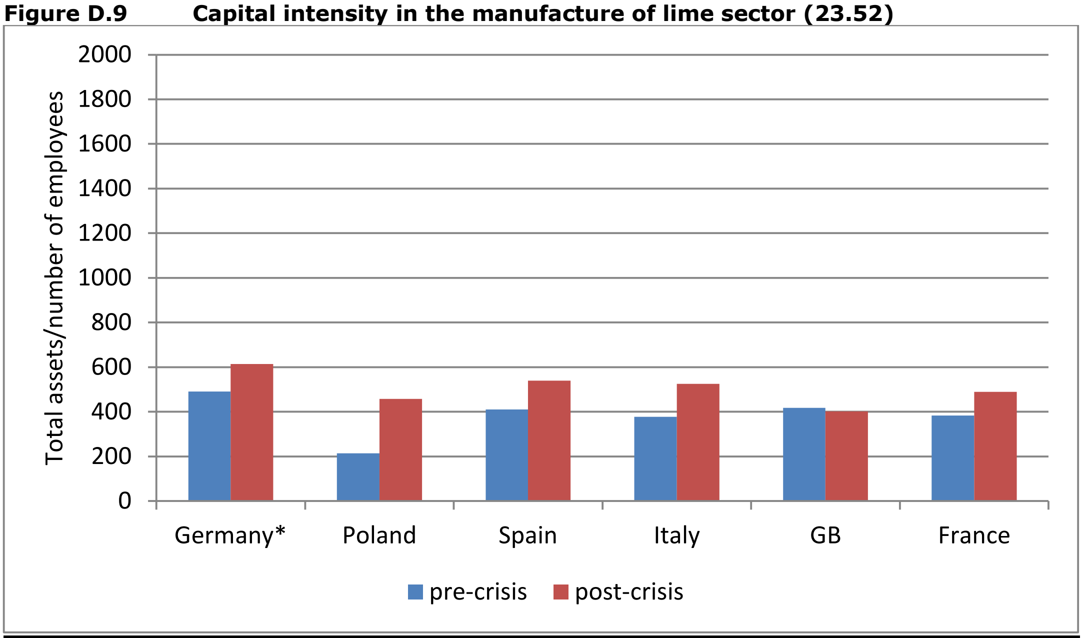
Source: AMADEUS database and SBS.
Note: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.8 Capital intensity in the manufacture of cement sector (23.51)



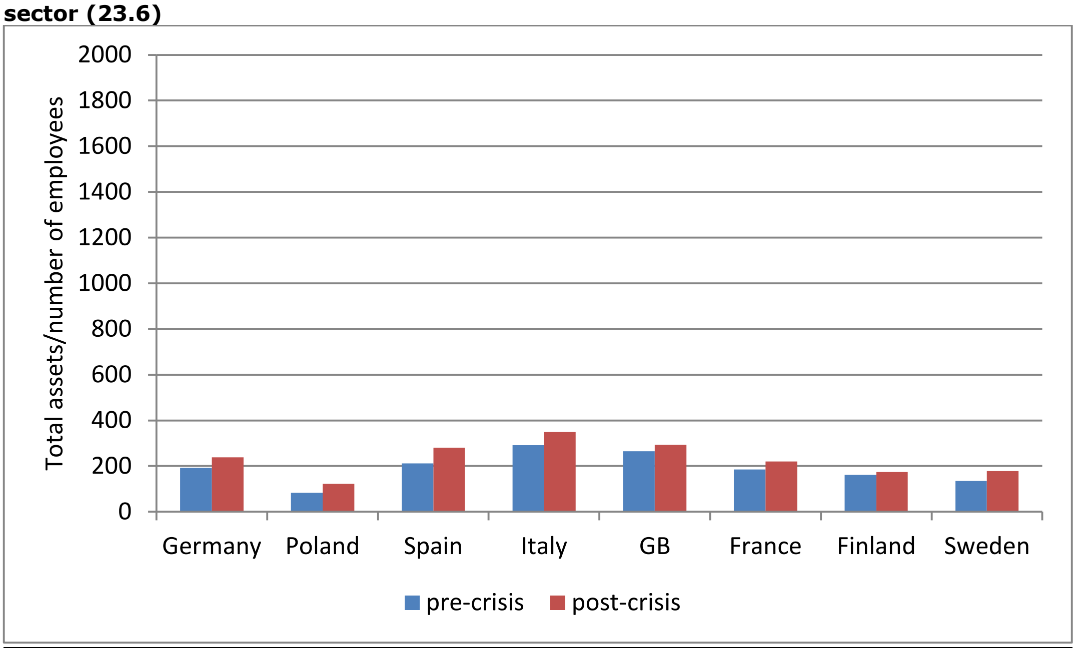
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.9 Capital intensity in the manufacture of lime sector (23.52)



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (2351 and 2352) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.10 Capital intensity in the manufacture of articles of concrete, cement and lime sector (23.6)



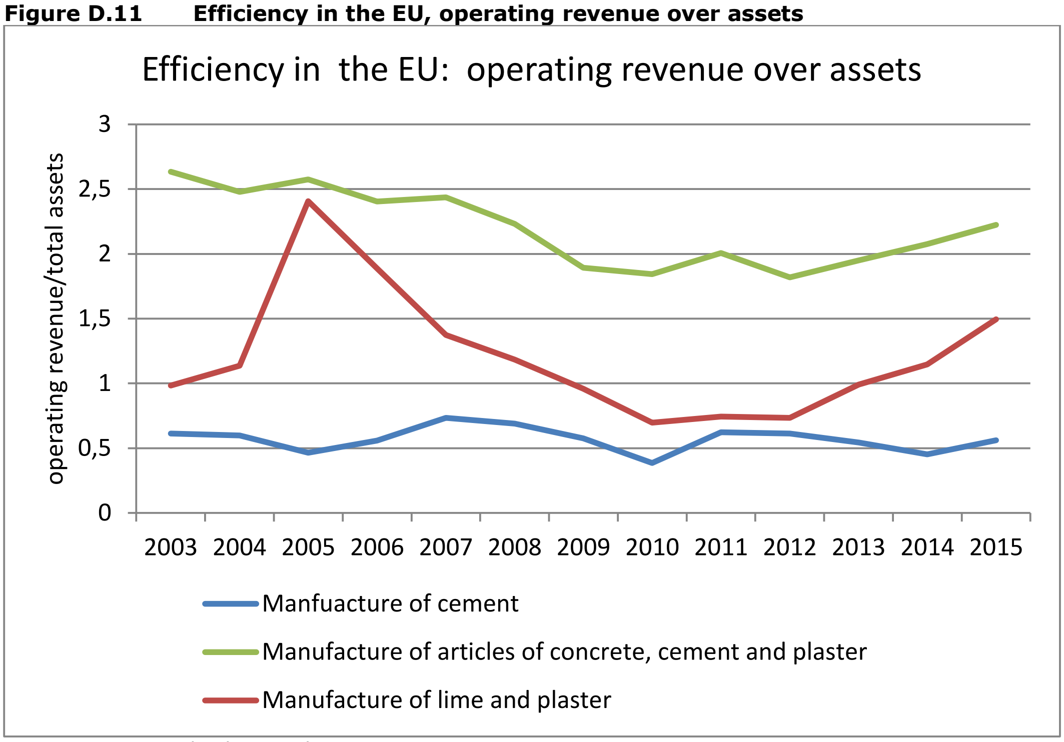
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

There are a number of measures we can use to analyse efficiency of companies in these sectors. The fixed assets turnover indicates the extent to which a firm can generate net sales from its fixed assets. It is defined as operating revenue over fixed assets. Figure D.11 illustrates how this ratio has evolved in the European Union during the period 2003-2015 in the three subsectors analysed. First of all, the manufacturing of cement sector stands out for its lower capacity to generate turnover, given the amount of fixed assets. This indicates that although this industry was more capital intensive than the other two (Sectors 23.52 and 23.6), its efficiency was significantly lower.

On the other hand, the manufacture of articles of concrete, cement and lime sector appear as the most efficient one, due to its higher capacity to generate net turnover (relative to the amount of fixed assets available for production). The level of efficiency has been deteriorating in the manufacture of lime and plaster sector, from prior to the crisis. Efficiency in cement has not changed greatly and in manufacturing of articles of concrete, cement and plaster this has decreased moderately.

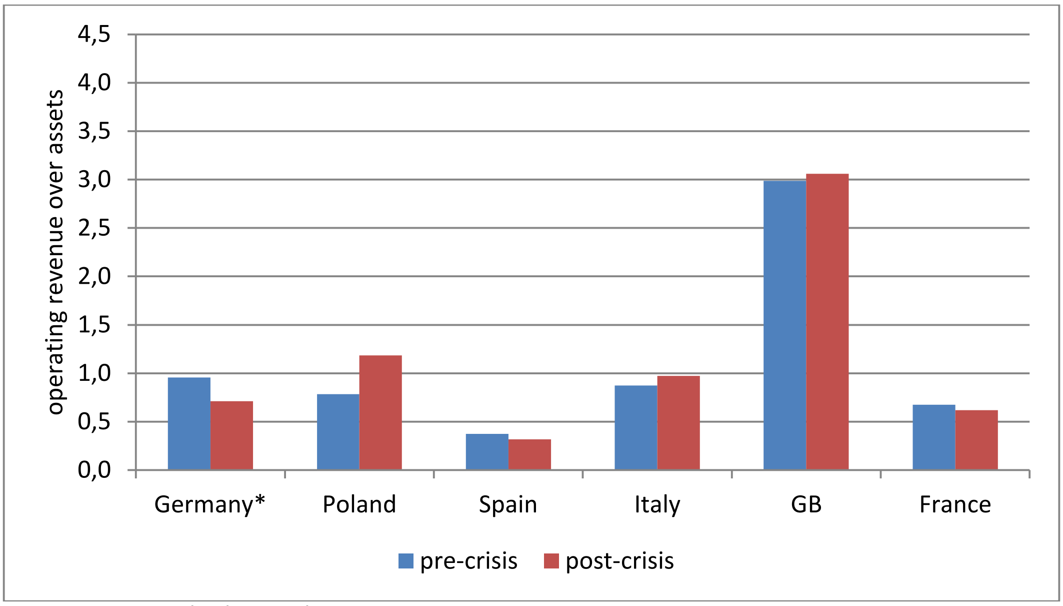
Across countries, there is significant heterogeneity. In Sector 23.51 (Figure D.12), Great Britain was the most efficient country, whereas the other give countries shown in figure 10 showed significant lower values. Furthermore, efficiency increased after the crisis in some countries (e.g. Poland) whilst in others decreased; the changes are generally quite small. In Sector 23.52 (Figure D.13), France, Great Britain and Italy were since before the crisis the more efficient sectors, considerably outperforming Spain, Poland and Germany. However, the efficiency advantage of the former group of countries was reduced with the crisis; the reduction of efficiency in Spain was also remarkable.
As for Sector 23.6 (Figure D.14) the comparison across countries reveals mixed results. France, Finland and Sweden appear to be the most efficient countries. The responses to the crisis were also different across countries. In some countries, efficiency improved (Germany, Poland, Finland, Sweden) whilst in others worsened. Spain and Italy experienced the largest decreases in efficiency levels.

Figure D.11 Efficiency in the EU, operating revenue over assets



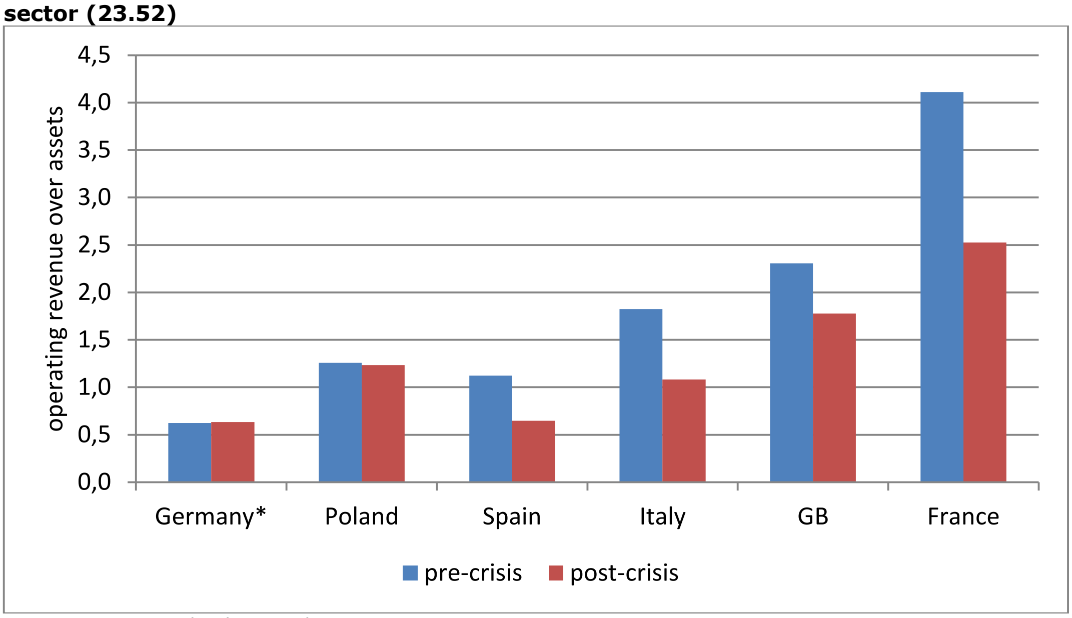
Source: AMADEUS database and SBS.
Note: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit.

Figure D.12 Efficiency, operating revenue over assets in the manufacture of cement sector (23.51).



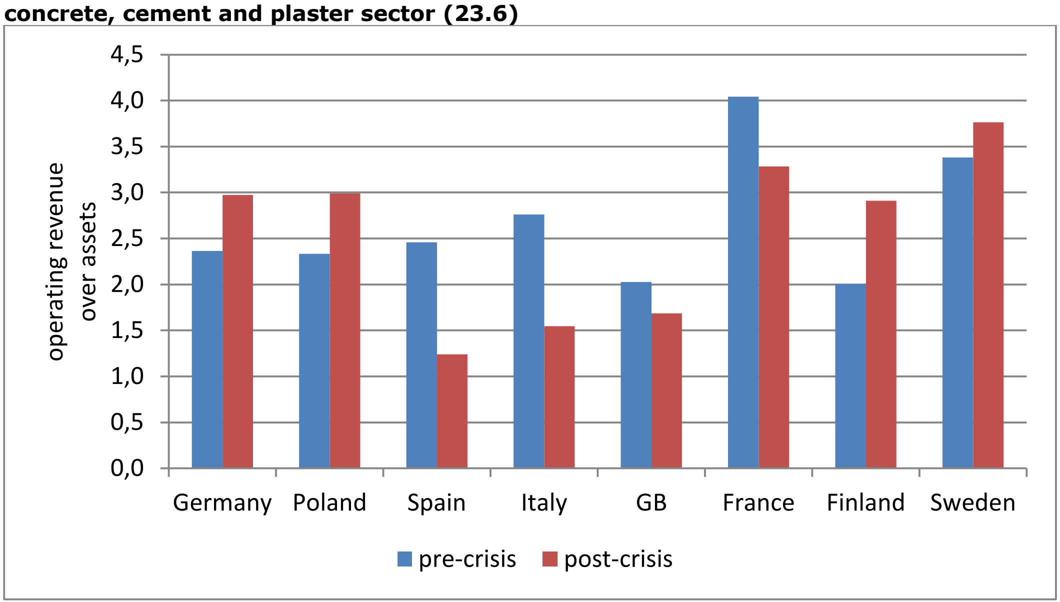
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.13 Efficiency –operating revenue over assets the manufacture of lime and plaster sector (23.52)



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4 digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.14 Efficiency –operating revenue over assets the manufacture of articles of concrete, cement and plaster sector (23.6)



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

C) Productivity

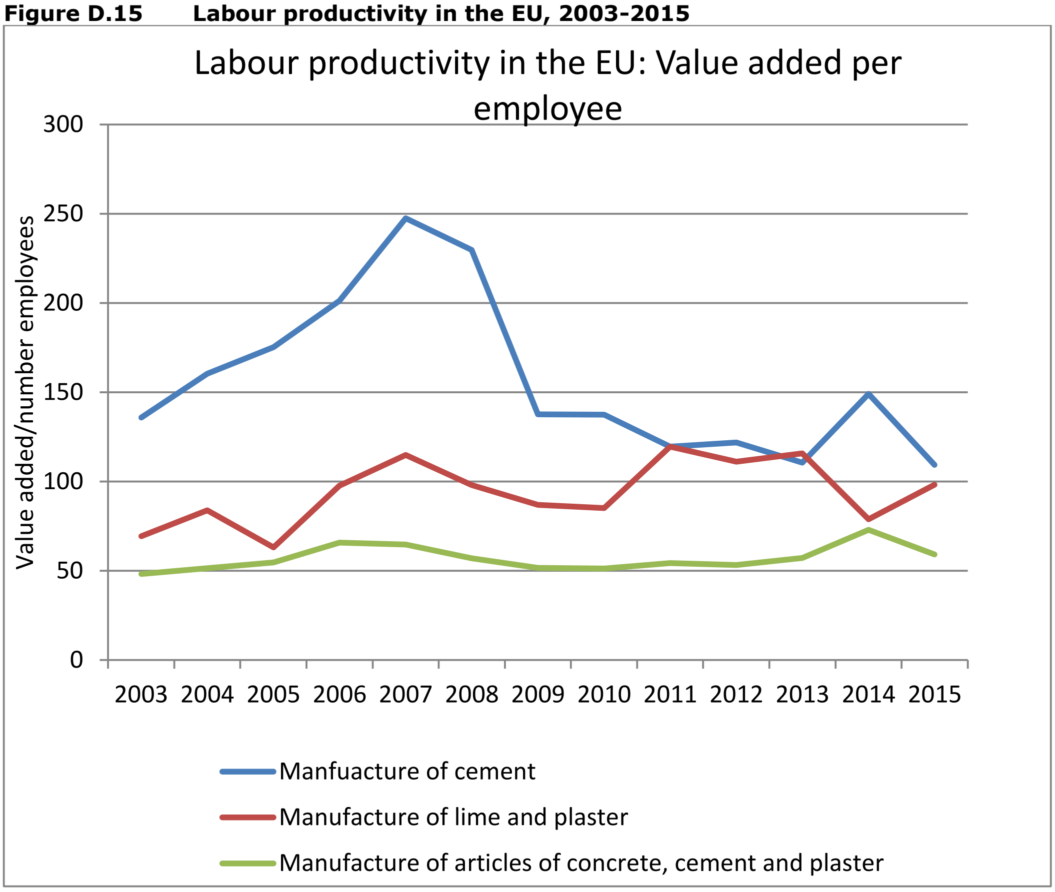
In terms of productivity, we have constructed a measure of labour productivity and a measure of total factor productivity. Labour productivity is defined as the ratio of value added in constant euro (PPPs) over employment.

As already defined, total factor productivity. Is the part of output growth not accounted by growth in production inputs. This variable is calculated according to the procedure described in the methodology section above.

Figure 13 shows how labour productivity has evolved in the EU in the manufacturing of cement, lime and plaster and articles of cement and concrete. On average for the EU, the level of labour productivity in the cement sector is above that of the lime and plaster sector and above that of articles of concrete, cement and plaster. This is consistent with our findings for differences in capital intensity across these sectors. In the cement sector, EU labour productivity increased rapidly in the years leading up to the recession, deteriorating quickly during the period 2007-2009. Since then, labour productivity has continued to slowdown but less rapidly that at the peak of the recession.

As for Sector 23.52, we observe that productivity has experienced some fluctuations but the level of productivity is at similar levels than it was before the crisis. As for the sector 23.6, productivity has also remained largely constant, although has seen a small increase. Therefore, the crisis has had a different impact on the labour productivity in the sub-industries. The higher pro-cyclicality of labour productivity in the cement industry (Sector 23.51) shows in the larger reduction experienced after the outburst of the crisis; instead Sectors 23.52 and 23.6 showed a more resilient profile during the economic downturn.

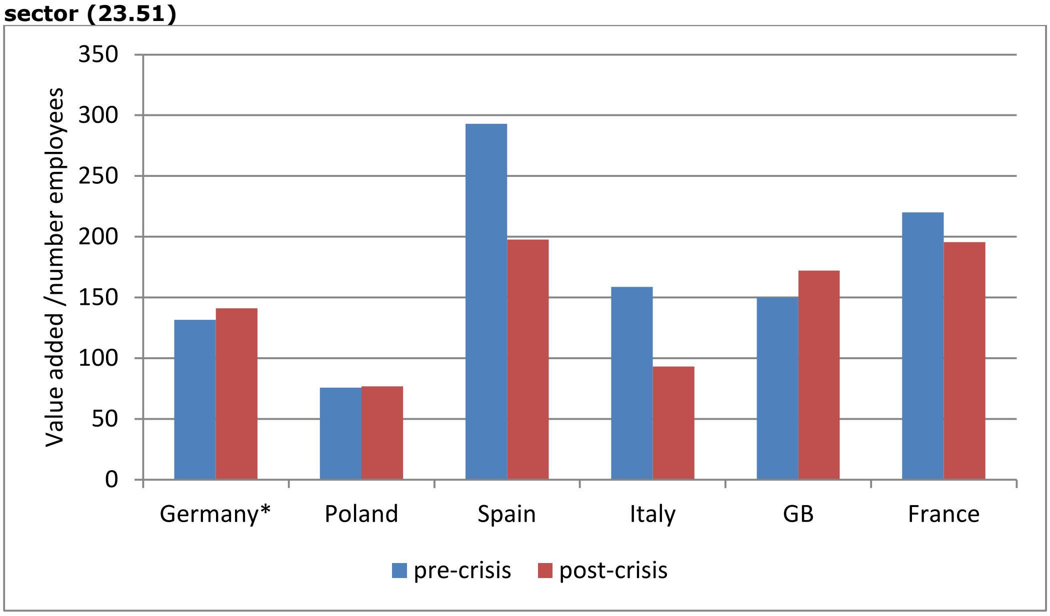
Figure D.15 Labour productivity in the EU, 2003-2015



Source: AMADEUS database and SBS.
Note: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

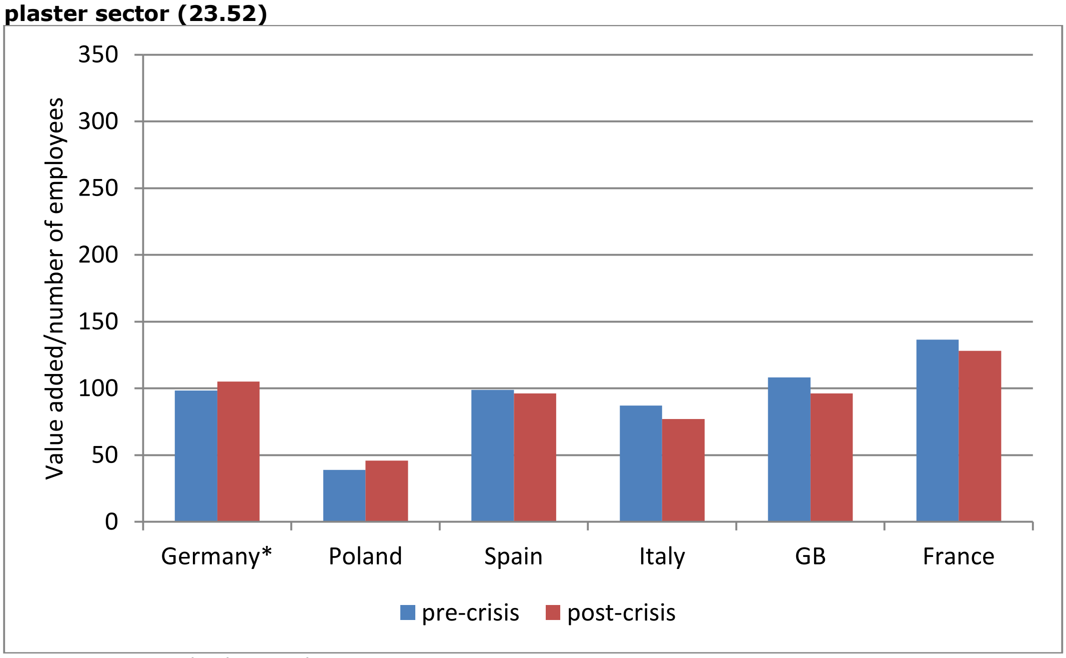
Figures D.16 and D.17 illustrate changes in labour productivity in several countries, in response to the recession. In the manufacturing of cement sector (23.51), labour productivity was higher in Spain although it showed the largest reduction with the crisis. The reduction was also important in Italy, and to a lesser extent in France. Productivity increased by a small margin in Great Britain, Germany and Poland. Figure D.17 shows that labour productivity in Sector 23.52 is lower than in Sector 23.51 and that countries are more homogeneous. Additionally, it can be seen that the manufacturing of lime and plaster sector (23.52) has not experienced large changes when looking at the sample of countries analysed. Labour productivity in the manufacturing of articles of concrete, cement and plaster sector industry (23.6) was also behaving more homogeneously than in the cement industry (23.51). Italy and Great Britain were the countries with lower productivity. In Germany, Poland and Spain labour productivity increased, whereas in the rest of countries it decreased.

Figure D.16 Labour productivity, value added per employee in the manufacture of cement sector (23.51)



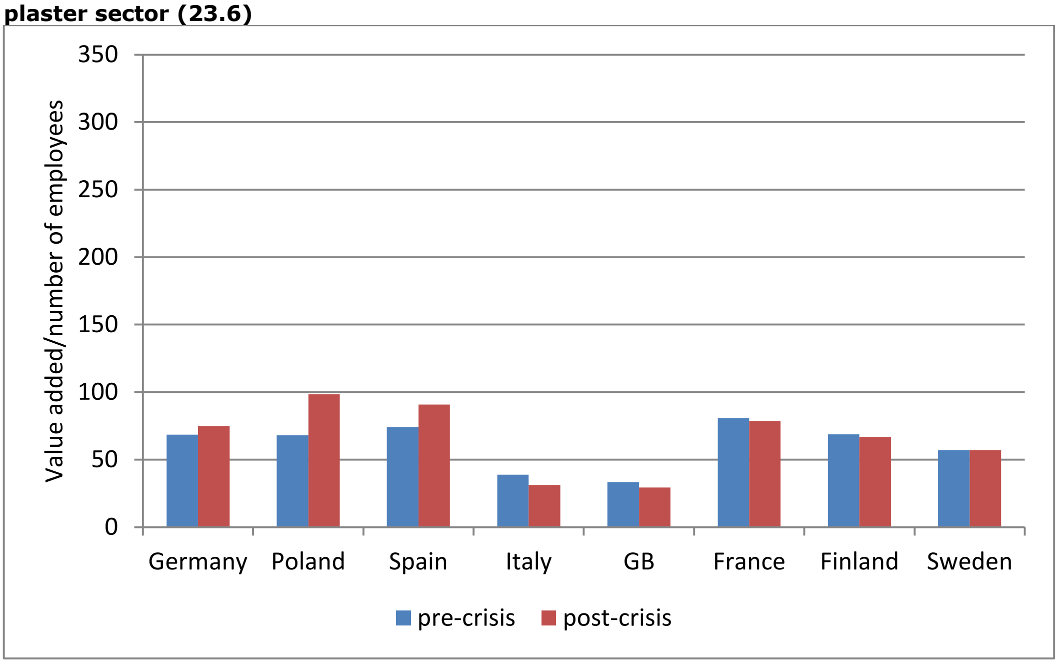
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D. 17 Labour productivity, value added per employee in the manufacturing of lime and plaster sector (23.52)



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.18 Labour productivity in the manufacture of articles of concrete, cement and plaster sector (23.6)



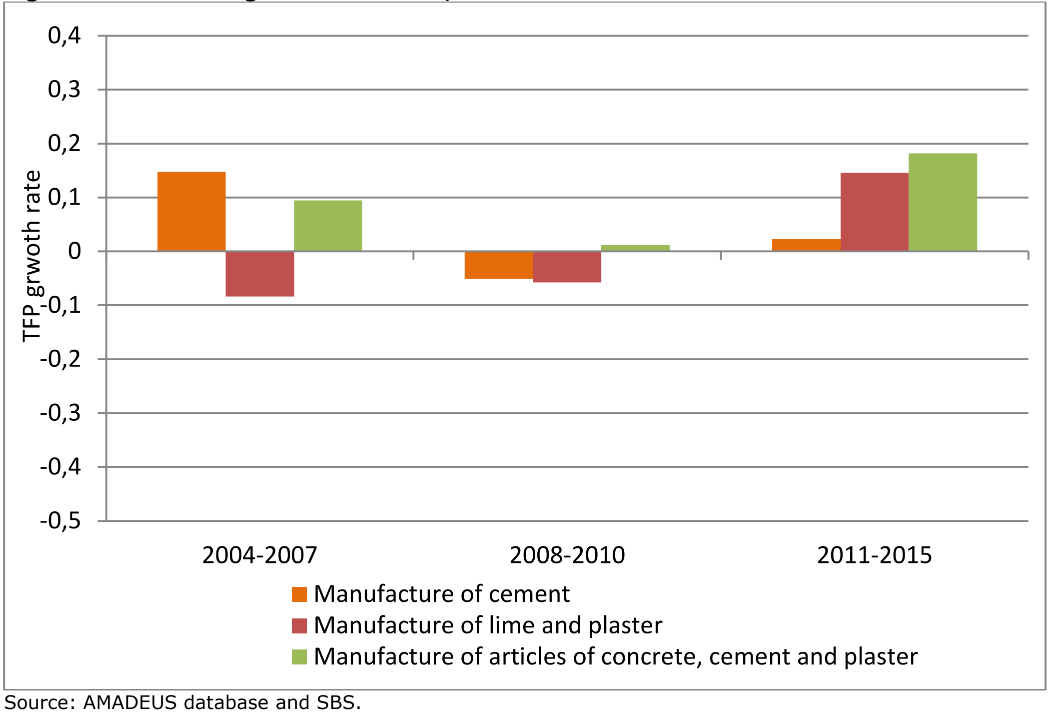
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Drawing attention to TFP, Figures D.19 to D.22 present the TFP growth performance of EU companies in Sectors 23.51, 23.52 and 23.6. Figure D.19 presents average TFP growth for three sub-periods: 2004-2007, 20008-2010 and 2011-2015. The manufacture of cement sector (23.51) experienced notable rates of growth in TFP in the years prior to the financial crisis in the whole of the EU. During the peak of the crisis, TFP growth collapsed and showed negative growth rates of -5% annually, on average. Since the last few years, TFP growth is again positive although well below growth rates achieved prior to the recession. This picture is not uniform across the rest of the sectors. TFP growth in the lime and plaster sectors was negative, on average during the period 2004-2010. In the last few years, growth has turned positive. The TFP performance of the articles of concrete, cement and plaster sector is to a certain extent similar to that in the cement sector: TFP growth was robust before the global economic crisis of 2007-2008, although lower than in the cement industry. It then fell sharply although growth remained positive, albeit very week. Since 2010, growth in the EU as a whole is again strong.

Figure D.20 illustrates TFP growth for a number of countries in the case of Sector 23.51. In the majority of countries TFP deteriorated since the recession, with the exception of Italy. Before the recession, TFP growth was negative in Italy and Germany, and it has somewhat improved since, although is still experiencing negative growth rates. In sector 23.52 (Figure D.21), we see a more heterogeneous behaviour across countries. Spain, and to a lesser extent France and Germany, are still experienced negative TFP growth rates. Italy and Great Britain have both seen a deterioration in TFP since 2008 whereas in Poland the opposite phenomenon is observed: strong TFP growth before the crisis that has continued since.

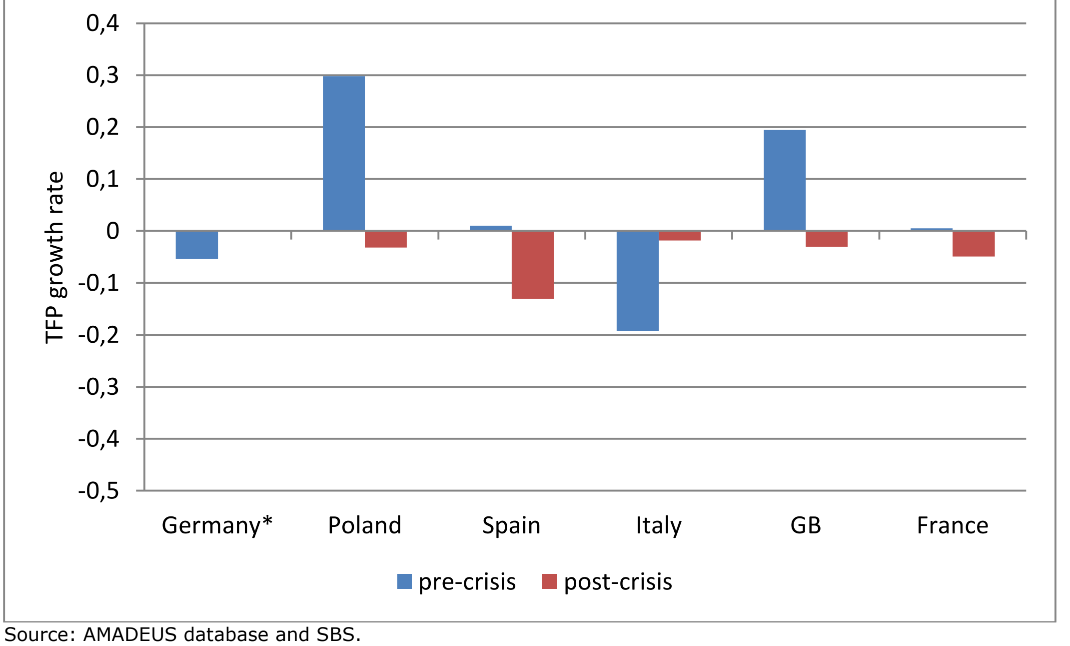
Figure D.22 focuses on Sector 23.6 and shows that TFP growth is in general higher than in the previous industries analysed. Additionally, TFP growth has accelerated in the post-crisis in comparison to the pre-crisis period in Spain, France, Germany and Great Britain, while in other countries TFP growth has been impaired (Italy and Poland).

Figure D.19 TFP growth in the EU, 2003-2015



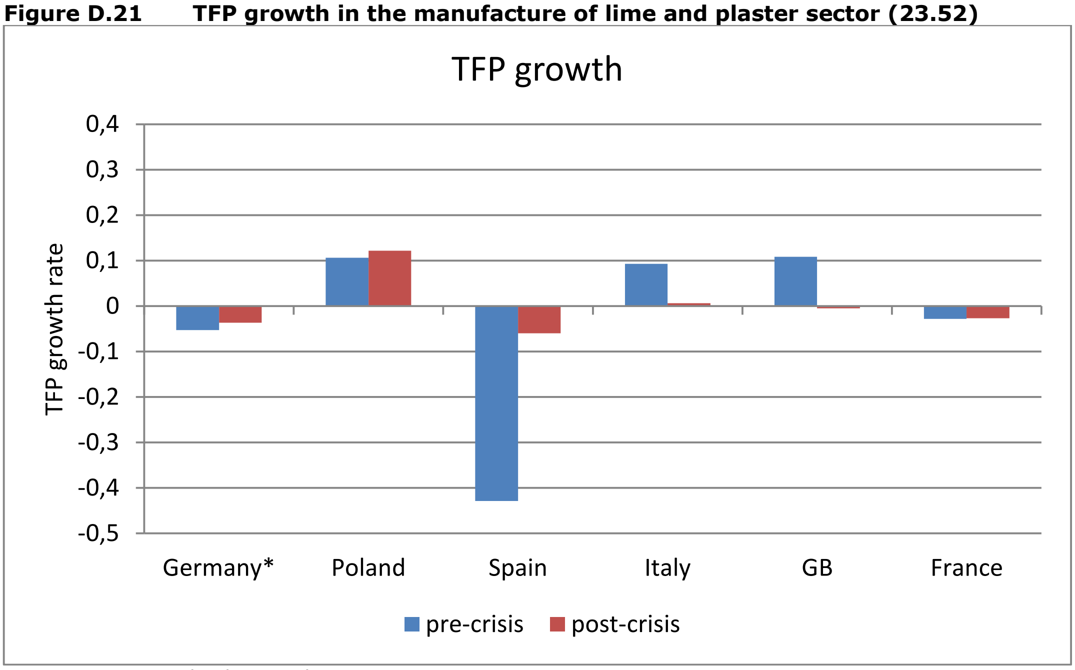
Source: AMADEUS database and SBS.
Note: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.20 TFP growth in the manufacture of cement sector (23.51)



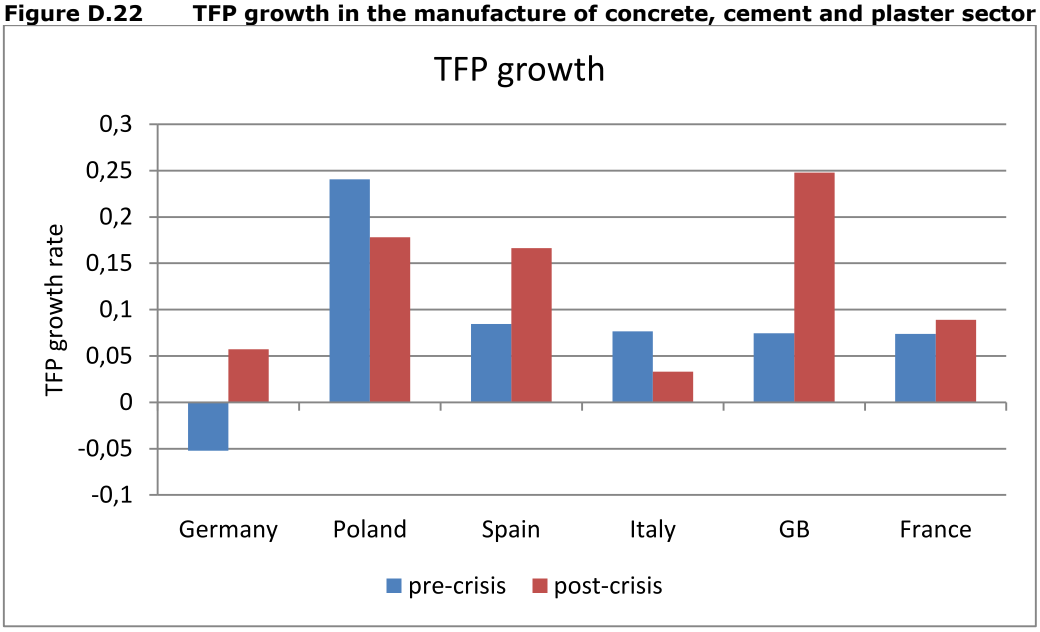
Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.21 **TFP growth in the manufacture of lime and plaster sector (23.52)**



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.22 **TFP growth in the manufacture of concrete, cement and plaster sector (23.6)**



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

D) Market structure

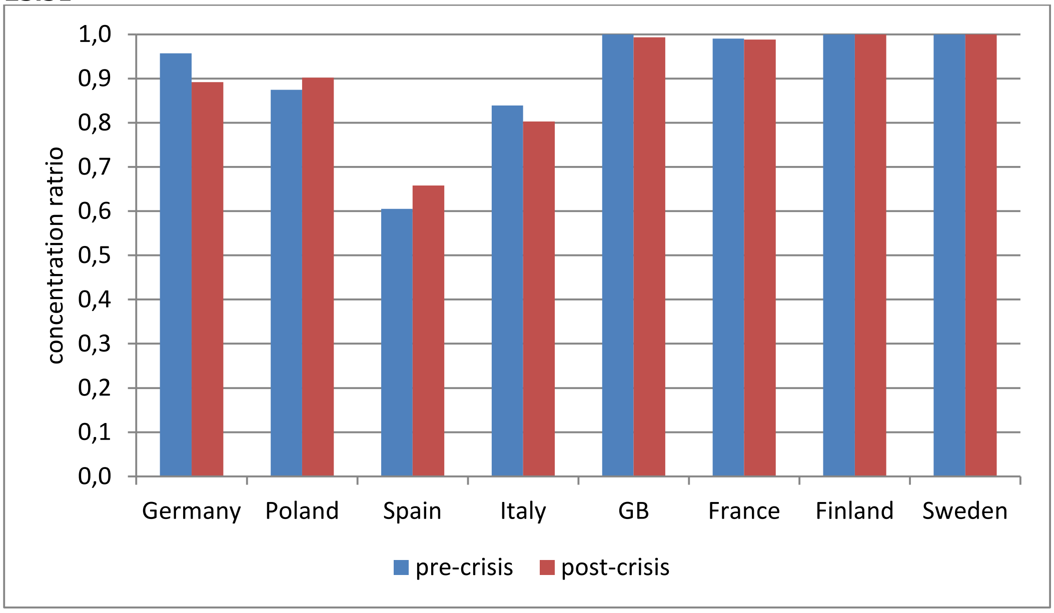
Analyses of market structure usually rely on two main measures to gauge the degree of concentration in an industry: concentration ratios and the Herfindahl-Hirschman (H-H) Index. Concentration ratios are a measure of the percentage market share in an industry held by the largest firms in that industry. Here we look at the combined market shares of the three and five largest companies in each market. A drawback of the concentration ratio is that it only captures a segment of activity in the market, and does not take into account all firms in the industry. The H-H index is considered a more accurate measure of concentration, as it includes all firms in an industry, and gives more weight to the largest firms. The higher is the market's level of concentration, the closer a market is to being a monopoly.

Drawing from AMADEUS we first compute a version of the concentration ratio, which captures the combined market share of the largest 5 firms in each market. We also report the Herfindahl-Hirschman Index, which is defined as the sum of the squared market shares of all firms in AMADEUS)[334].

Figure D.23 displays the values of the concentration ratios in Sector 23.51 for a number of countries. The figure shows that this market is highly concentrated. The countries with the highest levels of concentration are Great Britain, France, Finland, Sweden, with values close to 1. This result indicates that in these countries, the five largest firms account for almost all the activity of the industry. Moreover, we do not observe any major change throughout the period of analysis in the degree of concentration. Countries that present lower levels of concentration are Italy and Spain where we also see a small increase in the degree of concentration following the financial crisis. In Spain the five largest companies in the sector account for around 60 per cent of the total turnover. In the case of Italy these reach 80 per cent and experienced a small drop after the crisis.

Figure D.24 presents the values of the concentration for the lime and plaster sector (23.52). In this case, also Finland, Sweden and France present maximum levels of concentration in this sector. However, France shows lower levels of concentration, as similarly to Spain and Italy. In the case of Italy, the level of concentration is lower than in the post-financial crisis, as in the case of Sector 23.51. In the case of Sector 23.6 (Figure D.25) the picture is not very different to Sector 23.52 in terms of raking of countries; we observe an increase in concentration in the Spanish market and a decrease in the Italian. Overall, we see that the degree of concentration in the manufacture of articles of concrete, cement and plaster is significantly lower than the cement and lime.

Figure D. 23 Concentration ratio (five largest firms) in the manufacture of cement sector, 23.51

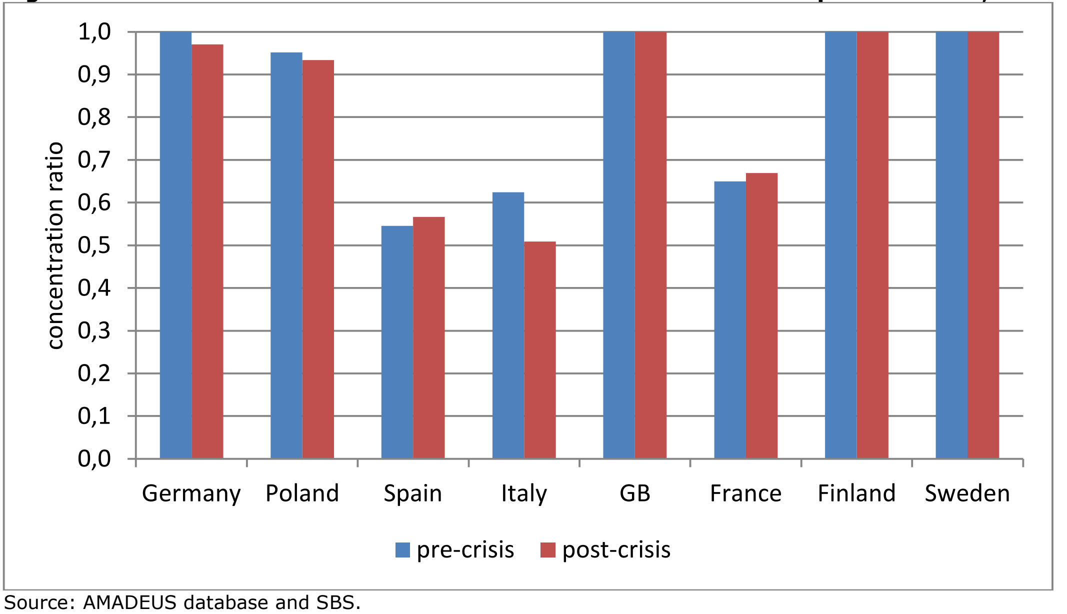


Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.
Note 3: The figures above should be considered carefully. Amadeus is not a fully representative database particularly when conducting the analysis at 4-digit level. Once again, we restate that population weights at 4-digit level could not be

[334] Information on the market share of multinational firms, subsidiaries or FDI, and internationalisation measures are not available to us (due to restriction in the AMADEUS license.

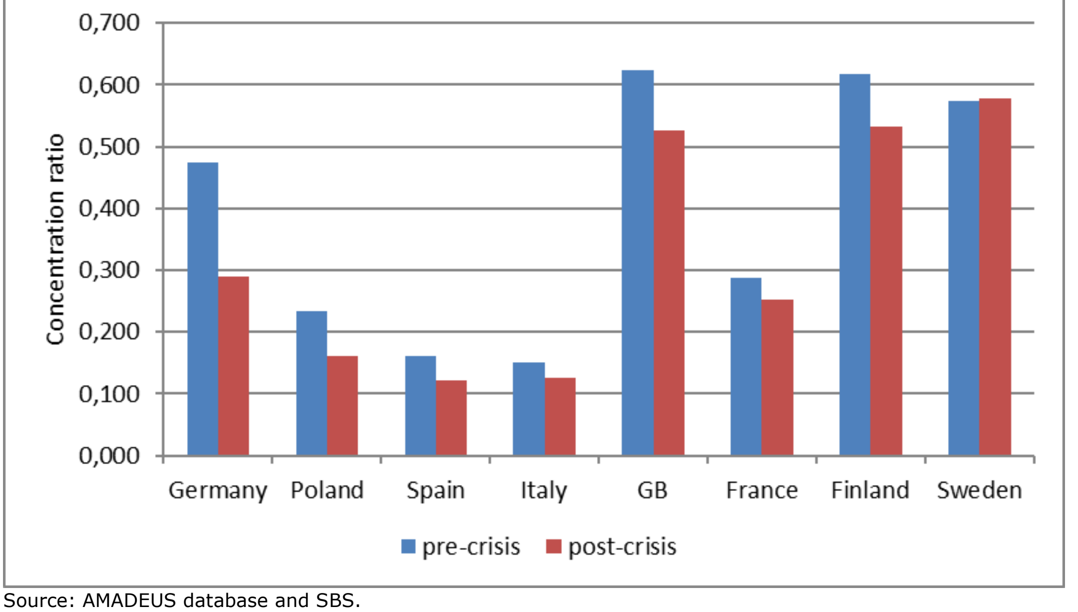
computed in order to improve representativeness. For example, in the German case only a few firms are included leading to a high concentration ratio of the five largest firms.

Figure D.24 Concentration ratio in the manufacture of lime and plaster sector, 23.52



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

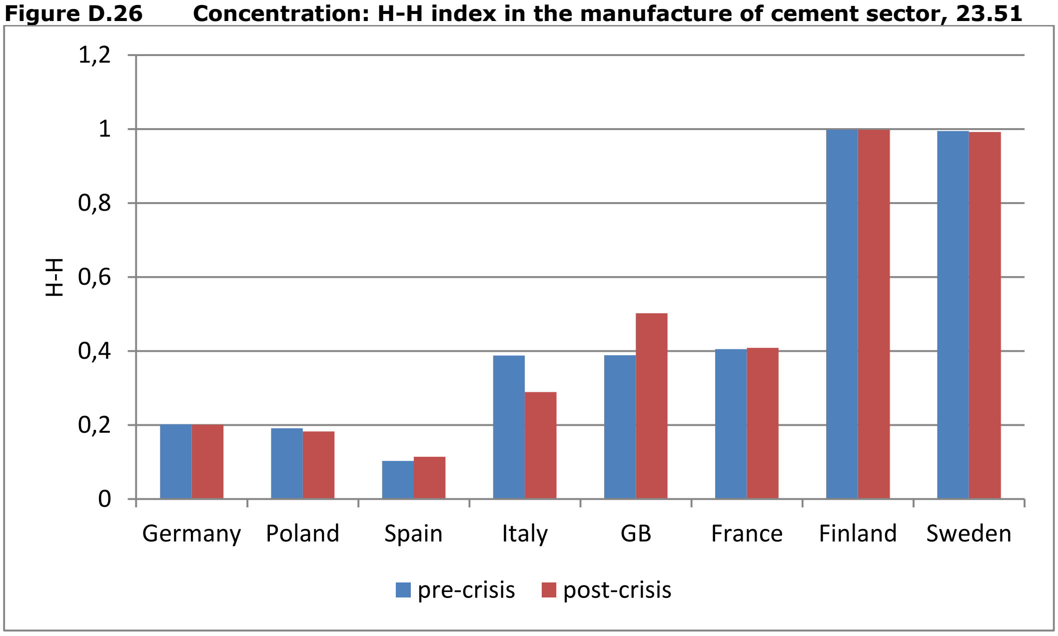
Figure D.25 Concentration ratio in the manufacture of articles of concrete, cement and plaster, 23.6



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

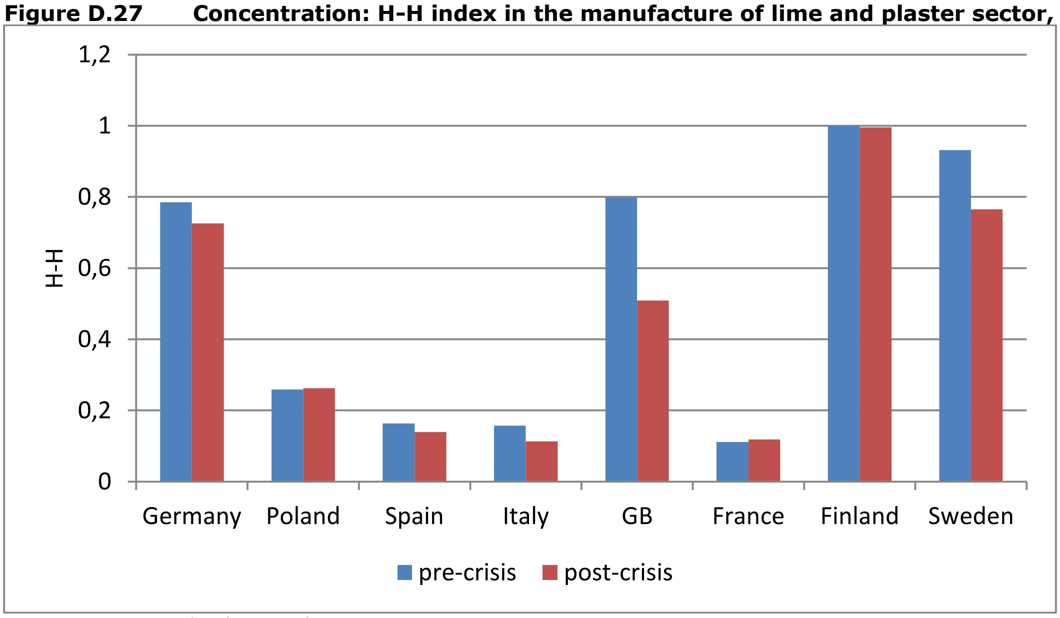
Figures D.26-D.28 presents evolution of the H-H index by country. According to this index, we observe that the countries with the higher levels of concentration in Sector 23.51 are Finland and Sweden, with values close to 1. This is reflecting that there are only few companies in our sample in these two countries. The H-H index also reveals that Great Britain and France are more highly concentrated than Spain and Italy. According to these indicators, however German and Polish are less concentrated, than what was suggested by the concentration ratios. This is because it considers operations by a larger spectrum of firms not only the largest ones. As in the results of the concentration ratio, we see that the concentration levels in Spain increased following the financial crisis while in Italy there was a slight decrease. This is consistent with the analysis of the concentration ratio. We also see Figure D.27 that the French market of 23.52 is much less concentrated than 23.51.

Figure D.26 Concentration: H-H index in the manufacture of cement sector, 23.51



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.
Note 3: Further clarification on the interpretation of the results is provided here. Let us focus on the German case. Despite it seems to be that there are only a handful of firms in this sector, their market share appears relatively distributed. Therefore, this affects the calculation of the H-H ratio. For example, there is only 4 industries in 2003 (so that the CR5 is 1), but the market shares are relative evenly distributed across these 4 firms, being the H-H index is relatively low.

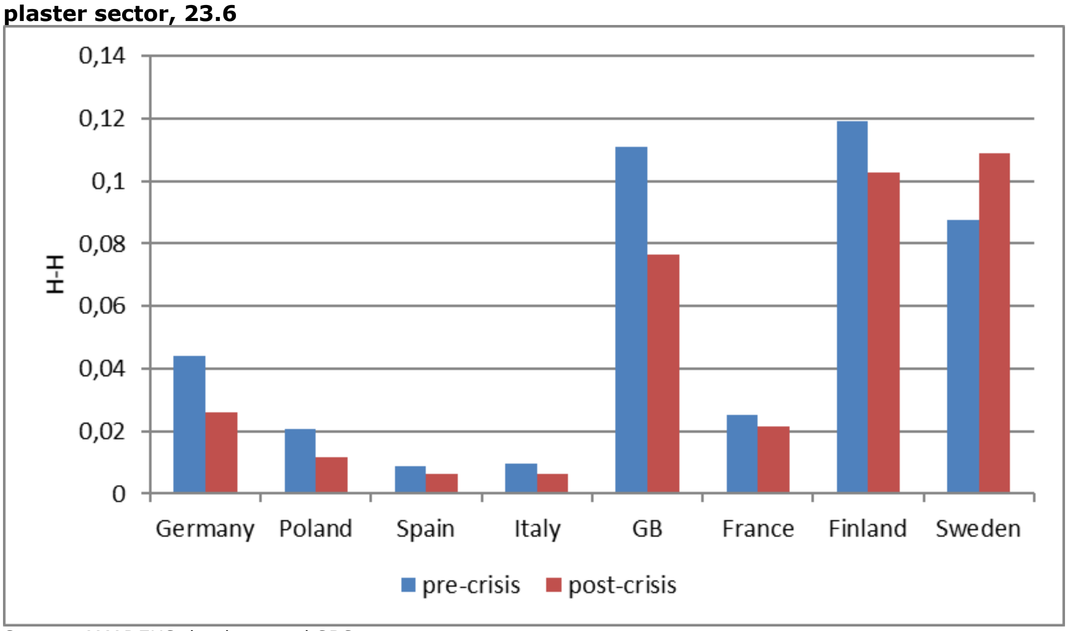
Figure D.27 Concentration: H-H index in the manufacture of lime and plaster sector, 23.52



Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-diigit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.28 Concentration: H-H index in the manufacture of articles of concrete, cement and

plaster sector, 23.6

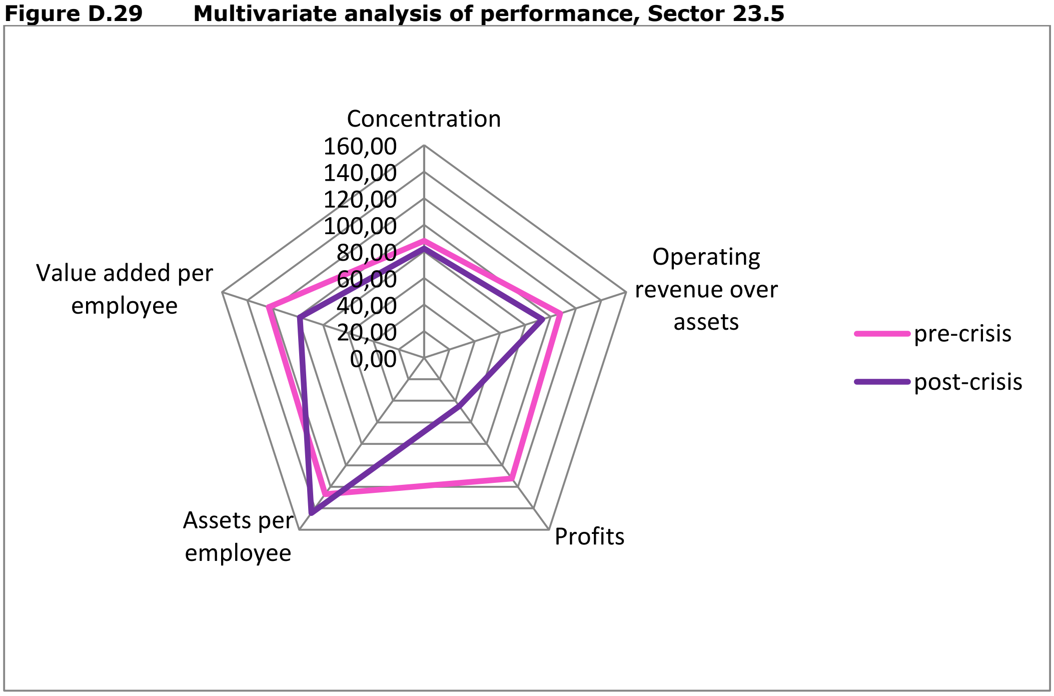


Source: AMADEUS database and SBS.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Finally, Figures D.29-D.32 provide an illustration of the relationship between some of the above variables using 'spider' or `radar' graphs. We have re-based each of the indicators using 100 as the benchmark for the initial year, 2013. This allows us to compare, using a common axis, the joint evolution of the variables over time. In the case of the manufacture of cement, lime and plaster –23.5 – (Figure D.29) all the indicators except for assets per employees reduced in the post crisis period. Therefore, the overall picture of the industry in terms of profitability, efficiency, productivity and concentration worsened. The level of concentration and efficiency, however experiences only small changes during this period. The figure reveals that the level of profitability is the variable experiencing the largest change, with an important drop after the 2007-2008 period.

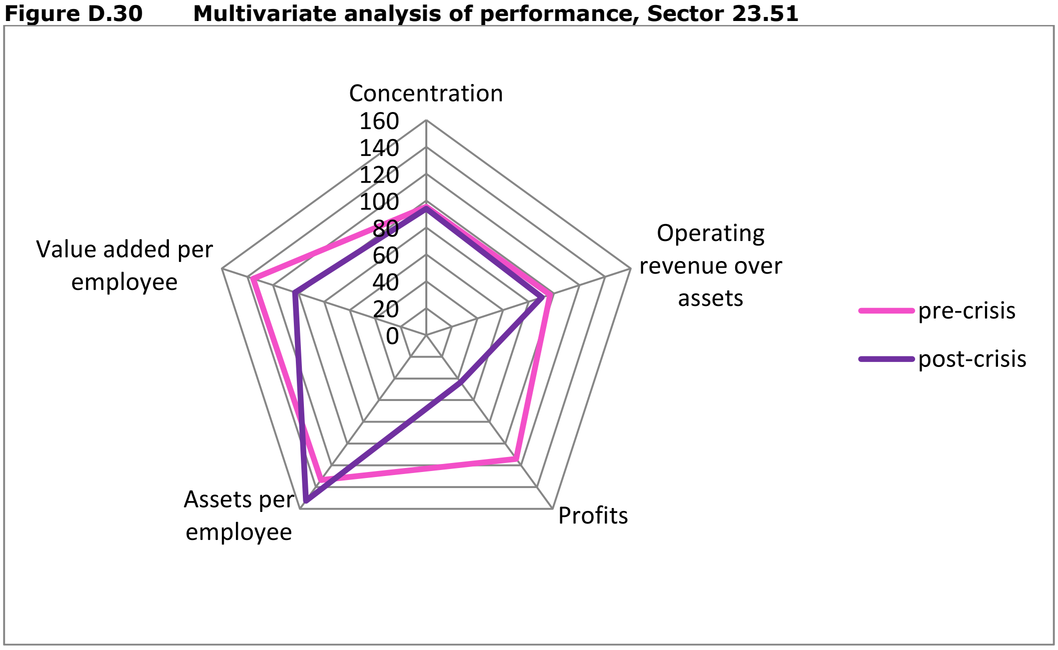
Figure D.30 represents a spider graph for Sector 23.51, that is, the manufacture of cement alone. We can see that this graph largely mirrors that for 23.5 as a whole. This is not surprising given this sector is the larger of the two sectors in 23.5. Figure D.31 illustrates the performance of these variables. Here we observe small improvements in labour productivity and capital intensity, but deterioration in efficiency. As in the case of the cement sector, the level of profitability has decreased but not to the same extent than in cement. In Sector 23.52 we also observe lower levels of concentration and improvement in terms of TFP. Finally, figure 29 presents a spider graph for Sector 23.6. The picture is more similar to Sector 23.52, but with less significant increase in productivity.

Figure D.29 Multivariate analysis of performance, Sector 23.5



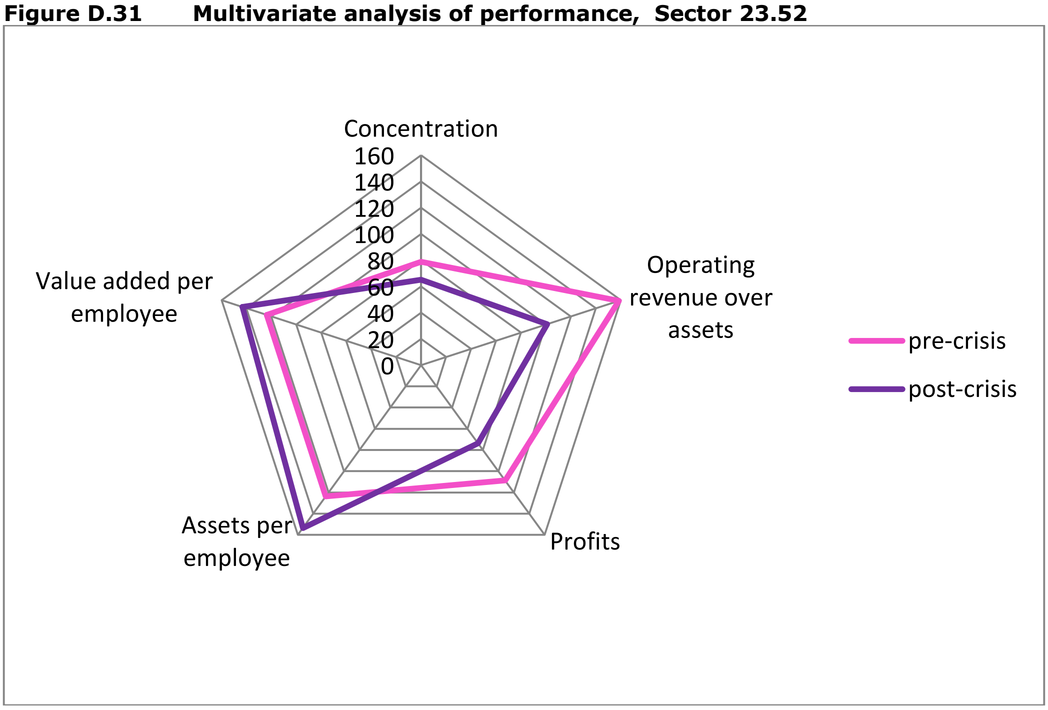
Base 2003=100.
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.30 Multivariate analysis of performance, Sector 23.51



Base 2003=100
Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.
Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.31 Multivariate analysis of performance, Sector 23.52

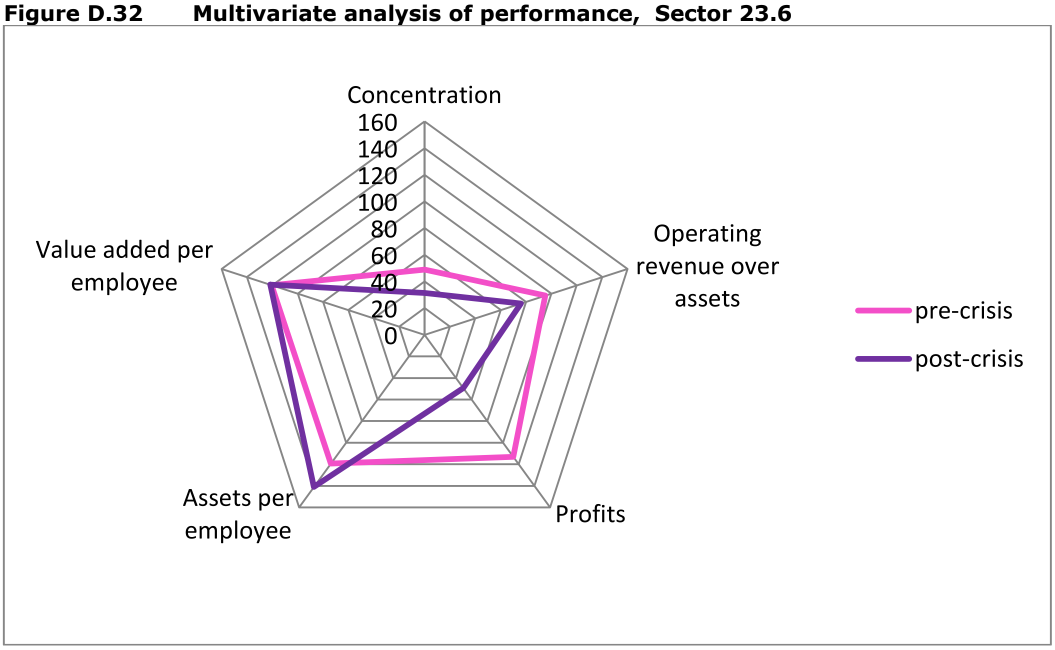


Base 2003=100

Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.

Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

Figure D.32 Multivariate analysis of performance, Sector 23.6



Base 2003=100

Note 1: Pre-crisis refers to the period 2003-2007; Post crisis refers to the period 2008-2015; in the case of Germany, the pre-crisis period only covers the years 2006 and 2007.

Note 2: Estimates at 4-digit level (23.51 and 23.52) are not weighted with population weights so caution is needed in interpreting the results. Eurostat's population weights are only available at 3-digit level.

D5. Summary of findings

For the purpose of this piece of research, we rely on the European company accounts data (AMADEUS database) in order to characterise the manufacture of cement sector (23.51), the manufacture of lime and plaster sector (23.52) and the manufacture of articles of concrete, cement and plaster sector (23.6) during the period 2003-2015. We have analysed a number of measures that allow us to describe these sectors in terms of the number, the size of firms and the concentration of the markets, as well as to analyse the dynamic performance of firms. More specifically, we have focused on variables such as productivity and profitability. An important observation to make is that, as a priori would be expected, there is a large degree of heterogeneity across EU countries.

Conclusions for a small number of key countries, as well as for the EU as a whole have been drawn. However, we generally need to be cautious in formulating conclusions at country level, as sample sizes are not uniform, and representativeness is problematic when looking at the industries at the more detailed 4-digit level.

In terms of the findings that have been identified, we have reported that the number of firms in the manufacturing of articles of concrete, cement and plaster (NACE 23.6) is considerably larger to the number of firms in the manufacturing of cement, lime and plaster sector (NACE 23.5). Within Sector 23.5, our sample contains a similar number of firms in 23.51 (manufacture of cement) and in 23.52 (manufacture of lime and plaster). This finding, however, does not reflect the true size of the sectors, as the average size in the manufacture of cement sector is considerably larger than that in the manufacture of lime and plaster sector, and then that in the manufacture of articles of concrete, cement and plaster sector. Spain and Italy have the largest number of firms in the cement sector whilst Italy and Spain have both the largest number of firms in lime and plaster. Spain has one of the smallest average sizes in Sector 23.51 and Italy in Sector 23.52. The levels of concentration are significantly lower in 23.6 compared to 23.5, as indicated by the larger population of firms. Unsurprisingly, we find that Spain and Italy are the countries showing the lowest levels of concentration, although the largest firms still account for a sizeable share of the total activity, particularly in Sector 23.5. Nordic countries have only a handful companies in these industries, therefore tend to present the highest levels of concentration.

Measures of labour and total factor productivity of firms, on an annual basis have been computed using data from AMADEUS and SBS. On average for the EU, the level of labour productivity in the cement sector is above that of the lime and plaster sector, and above that of the articles of concrete, cement and plaster sector. This is consistent with our findings for capital intensity. Labour productivity in the cement sector has deteriorated significantly since the crisis, and this is not observed in the same way in the other two sectors. In cement, EU labour productivity increased rapidly in the years leading up to the recession, deteriorating quickly during the period 2007-2009. Since then, labour productivity has continued to slowdown although less rapidly that at the peak of the recession. As for Sector 23.52, we observe that productivity has experienced some fluctuations but the level of productivity is at similar levels than it was before the crisis. As for the Sector 23.6, productivity has also remained largely constant, although has seen a small increase.

Another interesting finding is that TFP growth in the cement sector (and also the articles of cement, concrete etc.) largely mirrors the TFP performance of many EU economies as a whole. That is, TFP growth was strong before the 2007-2008 crisis, but collapsed with the advent of the financial crisis. In the last few years, some recovery has been registered, but TFP growth remains week. Our results therefore suggest TFP weakness is the main driver of the deteriorating labour productivity in the manufacture of cement sector. We do not find evidence that capital intensity has been reduced to any great extent or that the efficiency in the use of the fixed assets has been impaired. The worsening of TFP can reflect a number of factors, including a reducing in the rate of technological change and/or intangible investments, as well as the influence of measurement error.

Firms may be subject to adjustment costs, not only when changing the level of capital but also when hiring and firing workers, and they can respond to short-run fluctuations in demand by adjusting the intensity with which they use labour and capital. This would cause larger fluctuations in output than in capital and labour, and hence pro-cyclical movements in measured TFP growth. The average TFP performance in the manufacturing of lime and plaster sector is somewhat more positive and TFP growth has improved during the period of analysis. Across countries, our result also confirms the TFP weakness in these sectors since the crisis; the best performing sector in terms of TFP appears to be the manufacture of articles of concrete, cement and plaster. Many countries seem to present robust TFP growth rates since the crisis.

Finally, a comment on profitability is due. It has been identified that the deterioration of profitability for the firms under consideration is widespread across the EU. Profitability was growing rapidly before the financial crisis, in particular in the cement sector, but it has decreased rapidly since then in the vast majority of the countries that have been analysed.

Annex E: Econometric estimation of the 'technological frontier'

E1. Econometric Analysis

This Annex present the econometric analysis that has been carried out for the purpose of Task 3. The supplementary econometric exercise aims at analysing the productivity performance, as well as the TFP developments in the cement and limestone sector. The analysis can be used to explore in more depth the drivers of productivity performance, including the distance to the technological frontier.

We begin with an analysis of the determinants of TFP growth at firm level drawing from the AMADEUS database, for the period 2003-2015. AMADEUS does not contain a register of firms, and therefore does not allow us to track the same firms over the whole period of analysis. Despite having an unbalanced sample of firms, we are able to compute annual growth rates in TFP, as well as a number of explanatory variables, for a large number of companies.

We distinguish three separate industries: (i) Sector 23.51 – manufacture of cement; (ii) Sector 23.52 – manufacture of lime and plaster; and (iii) Sector 23.6 – manufacture of articles of cement, concrete and plaster. A distinction between the global (EU) frontier and the national frontier may also be an interesting element to consider as it can shed some light into the factors that enhance or hinder the mechanisms of knowledge transfer across firms, an issue currently of high policy relevance in the EU.

More specifically, our analysis involves the estimation of the following baseline equation:

$$\Delta \ln TFP_{it} = \alpha_1 \Delta \ln TFP_{F,t} + \alpha_2 GAP_{,i,t-1} + \beta' firm\ controls_{i,t} + country_c + sector_s + year_t + \epsilon_{i_t} \qquad (1)$$

where *i* denotes laggard firms and *F* denotes the frontier firm.

We identify what are the best-performing or frontier firms (in terms of total factor productivity) versus the non-frontier firms. We define two types of frontier. In the first case, we choose those firms, in each country, industry, year at the top 5% of the total factor productivity distribution. In the second case, we choose a fixed number of firms, in this case, the 10 most productive firms, again by country, industry and year.

As is standard in the literature, we assume the existence of a unique frontier, first at the national, level for each of the three sectors considered. The variable $GAP_{,I,t-1}$ refers to the distance of a typical firm *i* to the national frontier firm in each period, $GAP_{f=F,i}=\ln(TFP_F/TFP_i)$. Frontier firms are identified as those with the highest levels of TFP. 'Laggard' firms will be identified as those falling behind the frontier in terms of TFP levels. Frontier firms are identified on an annual basis and hence change over time. This specification rationalizes the idea that the diffusion of global technologies within countries is channeled through the adoption (and adaptation) by the national leaders, which make these technologies available to domestic companies. This part of the analysis aims to contribute to the emerging literature investigating the link between the productivity performance of laggards and the diffusion of existing technologies from national frontier firms. We test this model for the cement and limestone sectors.

Our baseline specification explains productivity advancements of the firm as a result of productivity growth experienced by the leading firms, that move the frontier outwards, as well as a result of the distance between the frontier and 'laggards' (in productivity terms). As well as TFP growth of leaders and the technological distance variables, specification (1) includes a number of control variables. Control variables include a set of firm characteristics (age, size), as well as indicators of financial conditions. Panel estimates include individual fixed effects to capture the impact of time-invariant firm heterogeneity, as well as country and industry dummies to capture the effect of common shocks (business cycle, etc.).

The results of estimating equation are contained in Table E.1. Columns (1) to (4) show the results when we define the frontier in terms of the 5% most productive firms. Columns (5) to (8) base the frontier on a fixed number of firms.

Starting with column 1, we test whether TFP growth depends on productivity growth of the frontier firms and on the gap of 'laggards' to productivity levels of the leading firms. We see that the contemporaneous rate of TFP growth of the frontier has a positive and significant direct effect on the TFP growth of 'laggard' firms. The coefficient is smaller, around 0.17-0.2. This finding highlights that firm productivity growth is significantly driven by leaders, which, by increasing their production efficiency, or moving the production possibility frontier outwards, create room for productivity growth of firms falling behind. A one-percentage point increase in the rate of TFP growth of the frontier firm at the national level induces a 0.2% increase in productivity growth of the laggards.

The gap is the distance between the productivity of a 'laggard' and the productivity of the frontier firms (constructed as an average). The sign of the gap variable is positive and significant; this indicates that the further a firm lies behind the frontier, the greater the potential for technology transfers. This result is in line with prior evidence based on company-accounts data (Andrews et al. 2015) as well as industry evidence (Griffith et al, 2004, Minniti and Venturini, 2017). The estimated coefficient is around 0.5.

We also see that these results are robust to the inclusion of a series of control variables in Table E.2 (column 2). We include a measure of size of the companies, in terms of number of employees, and a measure of age. We see that size has a negative and significant impact on TFP growth of firms. The results on the marginal effects suggest that smaller companies are more dynamic in terms of TFP than the larger ones. An increase in the size of the company by 10% ceteris paribus, is associated with 4% lower TFP growth. The variable age whilst mostly negative, is not statistically significant. In all eight specifications we include a measure of capital intensity. As we would expect, higher capital intensity is associated with higher TFP growth.

Columns (3) and (4) include other financial variables as well as interactions of some of these characteristics with the as well as the technology transfers enabled by certain firm characteristics (Griffith *et al*., 2004). We find that the variable debt, which is defined as debt (minus shareholder funds) over the total assets of the company, has a negative effect on TFP growth. However when we interact debt with the technology distance (gap) we find that this term is positive and significant. This result indicates that while debt has a negative influence on TFP growth, this is less so for firms far away from the frontier. This is consistent with the notion that 'laggard' firms benefit from having access to finance so that they can convergence catch up with leading firms.

$$\Delta \ln TFP_{it} = \alpha_1 \Delta \ln TFP_{F,t} + \alpha_2 GAP_{,i,t-1} + \beta_1' firm\ controls_{i,t} + \beta_1' firm\ financial_{i,t} * GAP_{,i,t-1} + country_t + sector_t + \epsilon_i \quad (2)$$

We conclude that the distance from the technological frontier is correlated with the potential for technology transfer. We establish the robustness of our results to the using alternative definitions of the frontier. This is represented by columns (5) to (8) where the frontier is represented by the 10 most productive firms in each industry, country and year.

Table E.2 shows the results of estimating equations (1) and (2) on the basis of the EU-wide frontier. The main difference with the results in Table E.1 is that as we would expect, the potential for technology transfer is lower from EU frontier firms to national laggard firms. The coefficient on the gap variable, which measures the distance between the productivity of the EU leader and the national laggard, is of the order of 0.2 (in the specification before this coefficient was around 0.5). Moreover, the contemporaneous effect that the growth of the TFP frontier has on a company's TFP growth rate is considerably lower, although still positive and statistically significant. The remaining control variables have similar interpretation that in case of the national frontier specification.

The results econometric exercise confirm the catching-up hypothesis for the cement and lime sectors; that is the further away firms are from technological excellence the higher the scope to experience faster TFP growth. However this process appears easier when considering the national frontier firms, as firms have more difficulties reaping the benefits of growth generated at the EU-wide firms. This should be a more problematic issue for those countries where national leaders are relatively far away from the global leaders. Removing restrictions to access knowledge generated by other firms, whether in same or distinct country should benefit laggards firms across a wide range of EU countries.

Table E.1 Total factor productivity growth and distance to national frontier, Fixed effect estimates 2003-2015

Dep. variable $\Delta lnTFP_{it}$	**Frontier: Top 5% of the TFP distribution**				**Frontier: 10 most productive firms**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
L. $gap_{N,i}$	0.574***	0.575***	0.576***	0.533***	0.554***	0.554***	0.555***	0.521***
	(0.00550)	(0.00550)	(0.00553)	(0.00726)	(0.00551)	(0.00550)	(0.00554)	(0.00707)
Δ $lnTFP_{N,F}$	0.173***	0.168***	0.168***	0.168***	0.150***	0.142***	0.142***	0.142***
	(0.00752)	(0.00753)	(0.00753)	(0.00752)	(0.00804)	(0.00802)	(0.00802)	(0.00801)
Age		-0.0775	-0.0772	-0.0810		-0.140	-0.140	-0.143
		(0.193)	(0.193)	(0.193)		(0.196)	(0.195)	(0.195)
Ln (Size)		-0.0383***	-0.0383***	-0.0336***		-0.0770***	-0.0772***	-0.0739***
		(0.0109)	(0.0109)	(0.0109)		(0.0110)	(0.0110)	(0.0110)
Ln(Capital intensity)		0.157***	0.157***	0.163***		0.129***	0.129***	0.134***
		(0.0109)	(0.0109)	(0.0109)		(0.0109)	(0.0109)	(0.0109)
Debt			-0.0198	-0.191***			-0.0239	-0.165***
			(0.0155)	(0.0243)			(0.0156)	(0.0241)
Debt* $gap_{N,i}$				0.0681***				0.0531***
				(0.00747)				(0.00689)
Constant	-0.803***	0.520	0.524	0.684	-0.962***	2.351	2.358	2.501
	(0.0160)	(5.311)	(5.311)	(5.304)	(0.0175)	(5.372)	(5.372)	(5.367)

Observations	38,805	38,166	38,166	38,166	38,954	38,303	38,303	38,303
R-squared	0.275	0.287	0.287	0.289	0.258	0.271	0.271	0.272
Number of unique firms	7,229	7,095	7,095	7,095	7,232	7,096	7,096	7,096

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note(s): FE estimation ;standard errors in parentheses. Dependent variable: annual TFP growth between; period 2003-2015. All estimates include country and two or three digit sector dummies; $\Delta \ln TFP_{N,F}$= TFP growth of the national frontier, $GAP_{N,i}$= productivity gap to the national frontier; Debt is measured as total assets minus shareholder funds over total assets. STATA is the econometric package used to produce the estimates shown in this Annex.

Table E.2 Total factor productivity growth and distance to EU frontier, Fixed effect estimates 2003-2015

Dep. variable $\Delta \ln TFP_{it}$	Frontier: Top 5% of the EU TFP distribution				Frontier: 100 most productive EU firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L. $gap_{EU,i}$	0.191***	0.190***	0.188***	0.155***	0.189***	0.188***	0.186***	0.154***
	(0.00356)	(0.00356)	(0.00357)	(0.00442)	(0.00365)	(0.00365)	(0.00365)	(0.00452)
$\Delta \ln TFP_{EU,F}$	0.0112***	0.0105***	0.0107***	0.0102***	0.0393***	0.0391***	0.0393***	0.0385***
	(0.00389)	(0.00389)	(0.00388)	(0.00387)	(0.00409)	(0.00409)	(0.00409)	(0.00408)
Age		-0.0190***	-0.0176***	-0.0196***		-0.0134***	-0.0118***	-0.0138***
		(0.00170)	(0.00170)	(0.00171)		(0.00173)	(0.00173)	(0.00174)
Ln (Size)		-0.0665***	-0.0661***	-0.0548***		-0.0371***	-0.0375***	-0.0269***
		(0.0128)	(0.0128)	(0.0128)		(0.0133)	(0.0132)	(0.0132)
Ln(Capital intensity)		0.119***	0.119***	0.134***		0.154***	0.154***	0.168***
		(0.0129)	(0.0129)	(0.0129)		(0.0133)	(0.0133)	(0.0133)
Debt			0.137***	-0.114***			0.159***	-0.0923***
			(0.0181)	(0.0269)			(0.0183)	(0.0280)
Debt* $gap_{EU,i}$				0.0517***				0.0494***
				(0.00412)				(0.00418)
Constant	-0.208***	-0.258***	-0.371***	-0.278***	-0.342***	-0.710***	-0.838***	-0.734***
	(0.0149)	(0.0922)	(0.0933)	(0.0933)	(0.0186)	(0.0995)	(0.100)	(0.101)
Observations	32,499	32,164	32,164	32,164	31,838	31,510	31,510	31,510
R-squared	0.114	0.126	0.128	0.133	0.110	0.123	0.125	0.130
Number of unique firms	6,468	6,391	6,391	6,391	6,420	6,344	6,344	6,344
	0.191***	0.190***	0.188***	0.155***	0.189***	0.188***	0.186***	0.154***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note(s): FE estimation ;standard errors in parentheses. Dependent variable: annual TFP growth between; period 2003-2015. All estimates include country and two or three digit sector dummies; $\Delta \ln TFP_{EU,F}$= TFP growth of the EU frontier, $\Delta \ln TFP_{EU,F}$= TFP growth of the national frontier; $GAP_{EU,i}$= productivity gap to the European frontier; debt is measured as total assets minus shareholder funds over total assets. STATA is the econometric package used to produce the estimates shown in this Annex.

The following specific studies were used in this analysis:

- Andrews, D., C. Criscuolo and P.N. Gal (2015), "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries", OECD Productivity Working Papers 2,

OECD Publishing.

- Griffith, R., Redding, S., and Van Reenen, J. (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *Review of Economics and Statistics*, 86(4), 883-895.
- Minniti, A. and F.Venturini (2017), "R&D Policy, productivity growth and distance to frontier", *Economic Letters*, 56 (2017), 92-94.

Annex F: Customisation of the ADAGIO model

F1. Introduction

This Annex provides details on the structure of the model. Then, material is presented in order to illustrate the data work and analysis that have been done in order to customise the ADAGIO model for this particular project. For the complete disaggregation of sector C23 in the modelling framework of ADAGIO, a further step consists of calibrating the Translog specification of C23's production technology – i.e. demand for the KLEMmMd-factors as well as output prices – to the 5 new sub-groups.

F2. Theoretical considerations

ADAGIO, A Dyn**A**mic **G**lobal **I**nput **O**utput model, is part of a family of regional models with a common modelling philosophy; a philosophy which might be described as "Dynamic New Keynesian": although not "General Equilibrium" in the usual sense, this model type (which might be called "EIO" – econometric Input Output modeling – or "DYNK" – Dynamic New Keynesian) shows important aspects of equilibrium behavior. The dynamic aspect differentiates "DYNK" from the static CGE long-term equilibrium. This feature is most developed in the consumption block, where a dynamic optimization model of households is applied. But it equally applies to the equilibrium in the capital market as well as to the macroeconomic closure via a well-defined path for the public deficit.

The "New Keynesian" aspect is represented by the existence of a log-run full employment equilibrium, which will not be reached in the short run, due to institutional rigidities. These rigidities include liquidity constraints for consumers (deviation from the Permanent Income hypothesis), wage bargaining (deviation from the competitive labor market) and imperfect competition.

The DYNK model is an input-output model in the sense that it is inherently a **demand-driven model**. However, it is a much more powerful model for impact assessment than the static IO quantity and price models due to the following features:

1. The price and the quantity side of the input-output model are linked in different ways, demand reacts to prices and the price of labor reacts to demand.
1. Prices in the DYNK model are not identical for all users as in the IO price model, but user-specific due to its proper account of margins, taxes and subsidies, and import shares that are different for each user.
2. Consumption, investment and exports (i.e. the main categories of final demand) are endogenous and not exogenous as in the IO quantity model, explained by consumer behavior (demand system), regional import demand (differentiated by intermediate and final use) and producer behavior (K,L,E,M model with M split up into domestic and imported).
3. Aggregates of the column of IO coefficients (total intermediates, energy goods, value added components) are endogenous and explained in the K,L,E,M model, whereas in the IO price model they are taken as exogenous.

While the DYNK approach shows several **similarities with computable general equilibrium**

(CGE) models, it also deviates from specifications in CGE models in some important aspects. Output is demand driven and the supply side is represented with the help of a cost function that also comprises total factor productivity (TFP). The growth of TFP is the most important long-term supply side force in that sense in the DYNK model. Contrary to some CGE applications, exports are also fully demand driven via foreign demand in the DYNK approach (demand for imports in one country corresponds to demand for exports in other countries).

Members of this family of regional models are ASCANIO (a model of the 9 Austrian provinces), FIDELIO (a model of the EU27, developed for and with the IPTS, the Institute for Prospective Technology Studies in Sevilla (see Kratena et al., 2013), and ADAGIO, a model based on the WIOD data base.[335]

In ADAGIO, **prices are determined endogenously**, i.e. based on output prices (which are determined in the production block), purchaser prices are derived by taking into account commodity taxes (and subsidies) as well as trade and transport margins. For international trade, the model takes account of the cif/fob correction by explicitly incorporating international trade and transport costs.[336] Further considerations are listed below:

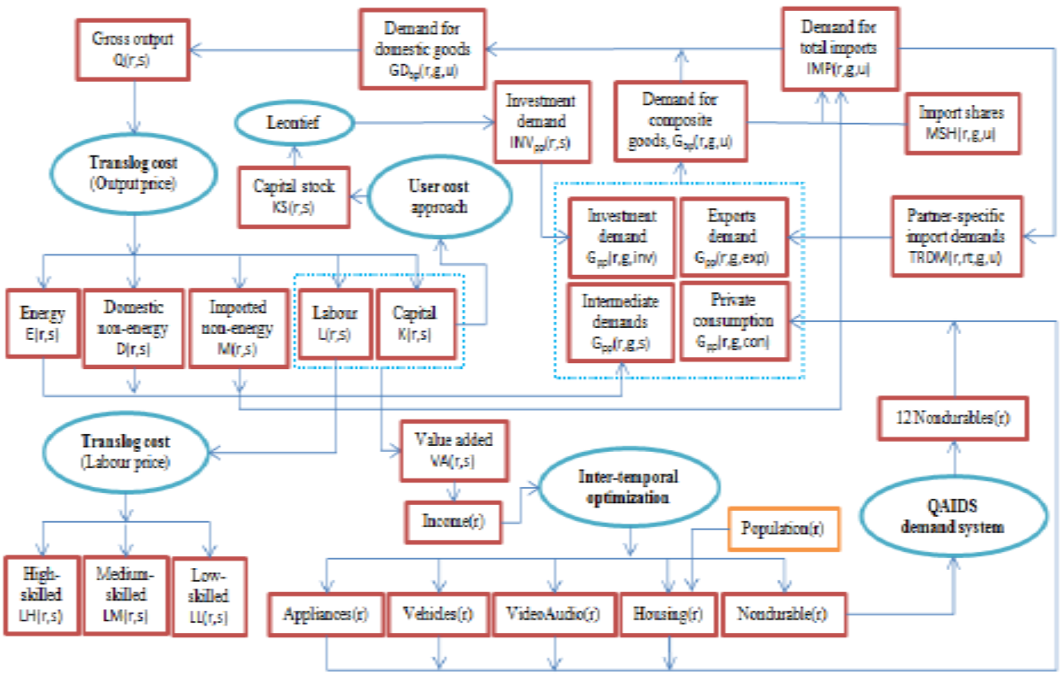
1. The **production technology** – for all sectors, we assume a $KLEM_mM_d$-technology, that is, we distinguish between 5 factors of production: Capital, labour, energy, domestically produced intermediates, and imported intermediates. Together, the capital and labour share make up value added; the aggregate of energy and intermediates (both domestically produced and imported) constitutes the use of intermediates. These factor shares, together with the Output Price, are modelled within a TRANSLOG framework.
4. **Wages** are set under a Wage bargaining assumption, taking into account sectoral productivity, the general price level, and the unemployment rate. In the wage and employment block, three skill levels – low, medium, high – are distinguished.
5. **Consumption by households –** based on the COICOP classification, we distinguish between 15 groups of consumption goods; 2 of them are treated as "durable consumption goods" (housing and vehicles), the rest as "non-durables" (food, clothing, furniture and equipment, health, communication, recreation and accommodation, financial services, electricity and heating, private transport, public transport, appliances, other consumption goods, as well as a category "durable depending", which captures the running and maintenance outlays for the durable consumption goods). Durables are modelled in a stock-flow-model, whereas the non-durables are dealt with in an AIDS-type model. The consumption block distinguishes between 5 types of households, based on their wealth (5 quintiles). Current consumption is determined by current income as well as the stock of wealth. Accumulation of wealth is modelled in an intertemporal framework.
6. Basic **energy prices** (crude oil, coal) are exogenous – other prices are **endogenous**, starting from output prices (as defined in the TRANSLOG specification of sectoral production technology; this is the price at the factory door), and adding trade and transport margins (national as well as international) and commodity taxes (which, in the case of imports, can include import duties) to finally arrive at purchaser prices (the prices relevant for the respective users; even within the same region, different users can –an typically will – face different prices for the same commodity. The main reason for this is different commodity taxes (intermediate consumption mostly faces low or no commodity taxes, because these are

[335] The WIOD project compiled Supply and Use Tables for 40 countries (the EU27 plus 13 major economies from outside Europe. WIOD was conducted within the 7th EU-framework project 'WIOD: World Input-Output Database: Construction and Applications' (www.wiod.org) under Theme 8: Socio-Economic Sciences and Humanities, Grant agreement no. 225 281.
In December 2016, an update became available, now covering 43 countries (Croatia as a new member state was added; also, Switzerland and Norway were taken in, now ensuring almost complete coverage of the European continent (excluding only the eastern states apart from Russia).
[336] For details on the estimation of consistent international trade and transport margins, see Streicher and Stehrer (2014)

typically defined as "value-added taxes": intermediate users can reclaim most input taxes that they have paid), but probably also different trade and transport margins.

ADAGIO is first and foremost a demand-driven model: demand will be satisfied immediately, excess (or inadequate) demand is not allowed. Supply-side constraints, however, enter the scene indirectly via the price model: if an economy becomes overly tight, wages will go up, taking with them output prices – and, consequently, all prices derived from them – which are all other prices. Demand for this sector's (or economy's) products will, therefore, be dampened. In fact, and unless forced (by, for example, overly devaluing the exogenous exchange rate, or an overly lax target path for the budget deficit), conditions for overheating will not arise in the first place. In other words, ADAGIO is not a business cycle model, but rather a tool for following medium- to long-term developments. For an extensive and in-depth treatment of all parts of the model, see Kratena et al (2013).

Figure F.1 ADAGIO's model structure



Source: Kratena et al (2013).

In other words, ADAGIO is an Input-Output model with econometrically estimated behavioural equations. These include Translog specifications for the production side (where, based on input prices and technology, factor and investment demand as well as output prices are determined) and a (quadratic) AIDS specification for consumption demand (based on appropriate purchaser prices). Additional econometric equations determine wages and skill shares – the model distinguishes between 3 skill levels in labour demand.

ADAGIO builds on Supply-Use tables: these tables describe the economy in term of commodity flows: which sectors of the economy produce which commodities (Supply) resp. who consumes these commodities (Use. If the consumers are sectors, then this is called intermediate use: sectors need products from other sectors in their own production processes. Final consumption, on the other hand, is what might be called the "raison d'etre" of economic activity: it consists of consumption by private households and government, investment by sectors, changes in inventory, and exports. Supply-Use tables (SUTs for short) are the basis for Input-Output tables (IOTs): whereas SUTs distinguish between producers and consumers on the one hand and commodities on the other, IOTs show directly the flow between sectors and users (with only implicit distinction between commodities: in SUTs, a sector can (and usually will) produce more than one commodity, which can be "traded" separately. In IOTs, it is only total flows between economic agents, without distinction by type of commodity. IOTs are usually calculated from SUTs; however, going from SUTs to IOTs involves a loss of information – therefore, it is not possible to reverse this process).

The Supply-Use tables are based on the data base compiled in the WIOD project and encompasses 43 Countries plus a Rest-of-the-World. The base year of the model is 2011, the simulation horizon extends to 2050.

Table F.1 Regional coverage

EU member states		other Countries	
AUT	Austria	AUS	Australia
BEL	Belgium	BRA	Brazil
BGR	Bulgaria	CAN	Canada
CYP	Cyprus	CHE	Switzerland
CZE	Czech Republic	CHN	China
DEN	Denmark	IDN	Indonesia
DEU	Germany	IND	India
ESP	Spain	JPN	Japan
EST	Estionia	KOR	Korea
FIN	Finland	MEX	Mexico
FRA	France	RUS	Russia
GBR	United Kingdom	TUR	Turkey
GRC	Greece	TWN	Taiwan
HRV	Croatia	USA	United States
HUN	Hungary		
IRL	Ireland		
ITA	Italy		
LTU	Lithuania		
LUX	Luxembourg		
LVA	Latvia		
MLT	Malta		
NLD	Netherlands		
NOR	Norway		
POL	Poland		
PRT	Portugal		
ROU	Romania		
SVK	Slovak Republic		
SVN	Slovenia		
SWE	Sweden		

Source: WIFO.

As shown in Table F.2, the ADAGIO economies are disaggregated into 64 sectors; among them 4 basic sectors (Agriculture and Mining; A and B) and 19 manufacturing sectors (C).

Table F.2 Sectoral coverage

	Sector		Sector
A01	Products of agriculture, hunting and related services	I55	Accommod. services; food a.beverage serving services
A02	Products of forestry, logging and related services		
A03	Fish and fishing products	J58	Publishing activities
B05	Mining Products	J59	Audiovisual services
		J61	Telecommunications services
C10	Food products	J62	Information technology serv., communication services
C13	Textiles, Apparel and Leather products		
C16	Wood and products of wood and cork	K64	Financial services
C17	Paper and paper products	K65	Insurance, reinsurance and pension funding services
C18	Printing and recording services	K66	Services auxiliary to financial a. insurance services
C19	Coke and refined petroleum products		
C20	Chemicals and chemical products	L68	Real estate services
C21	Basic pharmaceutical products and preparations	L68imp	imputed Real estate services
C22	Rubber and plastic products		
C23	Other non-metallic mineral products	M69	Legal and accounting services
C24	Basic metals	M71	Architectural and engineering services
C25	Fabricated metal products, exc. machinery and equipment	M72	Scientific research and development services
C26	Computer, electronic and optical products	M73	Advertising and market research services
C27	Electrical equipment	M74	Other prof., scientific, technical serv.; veterinary services
C28	Machinery and equipment n.e.c.		
C29	Motor vehicles, trailers and semi-trailers	N77	Rental and leasing services
C30	Other transport equipment	N78	Employment services
C31	Furniture; other manufactured goods	N79	Travel agency, tour operator and related services
C33	Repair a.installation services of machinery a.equipment	N80	Other business support services
D35	Electricity, gas, steam and air conditioning	O84	Public administration, defence, social security services
E36	Natural water; water treatment and supply services	P85	Education services
E37	Sewerage, waste management a. remediation services		
		Q86	Human health services
F41	Buildings and building construction works	Q87	Residential care services, social work services
G45	Wholesale- a. retail trade, repair of motor vehicles	R90	Creative, arts and entertainment services
G46	Wholesale trade, exc. o.motor vehicles a. -cycles	R93	Sporting services, amusement and recreation services
G47	Retail trade, exc. o.motor vehicles a. -cycles		
		S94	Services furnished by membership organisations
H49	Land transport services a. transport services via pipelines	S95	Repair services of computers, pers. a. household goods
H50	Water transport services	S96	Other personal services
H51	Air transport services		
H52	Warehousing and support services for transportation	T97	Services of households as employers of dom. personnel
H53	Postal and courier services		

Source: WIFO.

For this project, the original SUT database has been expanded along both the sectoral and commodity dimension:

- For the EU28 countries, sector C23, ‘Other non-metallic mineral products’, has been disaggregated into the sub-sectors C23.5 ‘Cement, Lime and Plaster’ (and further into C23.51 ‘Cement’ and C23.52 ‘Lime and Plaster’), C23.6 “Concrete products” (further into C23.63 ‘ready-mix concrete’ and C23.61 ‘Other concrete products’) and a residual subsector C23.1. Together, C23.5 (~10%) and C23.6 (~30%) account for around 40% of the EU28’s C23 output.
- On the commodity side, this disaggregation has also been performed, for supply and demand structures as well as for international trade. Additionally, the sector/commodity B05, which encompasses all mining activities, be they mining for minerals or energy carriers, has been disaggregated[337] into coal; oil and gas; Uranium and Thorium ore; metal ores; other mining and quarrying products. Only in this way, the (heavy) demand of the cement and lime industries for mining products of both types – minerals as well as energy carriers – can be modelled in a consistent manner.

[337] This disaggregation was based on information from the 2014 version of WIOD. Oddly (given that WIOD is used not least as a tool for assessing environmental impacts – ‘footprints’), the new WIOD version no longer distinguishes between mining for minerals and mining for energy carriers.

An important aspect to mention is the value of the elasticities of substitution. In particular, the own-price elasticity of cement and lime products was set at -0.6 (if the price of cement and lime goes up by 1%, its nominal demand will drop by 0.6%). As attempts at estimating this elasticity from the WIOD data base yielded rather inconclusive results, this value was chosen from the moderate end of the range of estimates as found in the literature (see, for example, Meunier et al., 2014, and Röller and Steen, 2006).

In other words, the focal commodity for this analysis is sector C23 (other non-metallic mineral products). Table F.3 shows the sub-sectors that comprise sector S23.

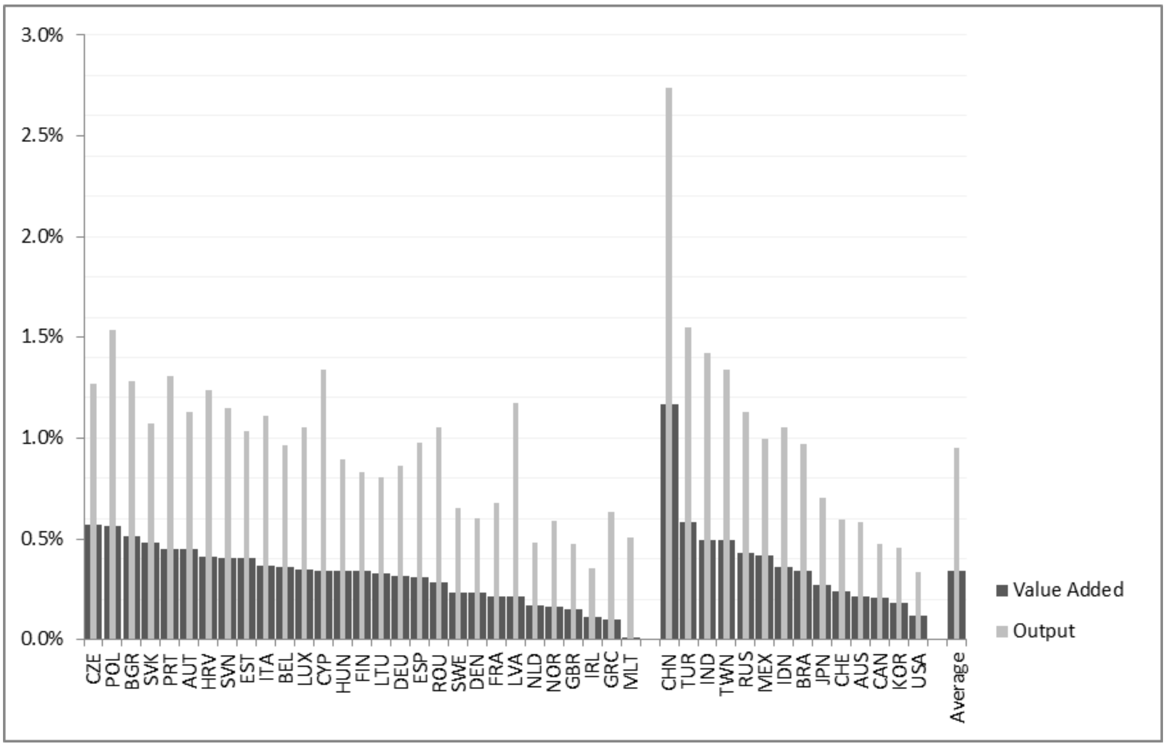
Table F.3 Cement and lime subsectors

23.1	Glass and glass products
23.2	Refractory products
23.3	Clay building materials
23.4	Other porcelain and ceramic products
23.5	Cement, lime and plaster
23.51	*Cement*
23.52	*Lime and plaster*
23.6	Articles of concrete, cement and plaster
23.7	Cut, shaped and finished stone
23.9	Other non-metallic mineral products

Source: WIFO.

Thus, the cement and lime industries are put together as sector 23.5. The most important first step was to disaggregate ADAGIO sector 23 into sectors 23.5, 23.6 and "23-other". As far as possible, 23.5 was further disaggregated into 23.51 and 23.52, 23.6 will be split into 23.63 (Ready-mix concrete) and a "23.6-other". Doing this yielded the closest approach to the isolation of the Cement and Lime industries possible on the basis of official statistics. For the combined 2-digit sector 23, the share of this sector in total output respect total value added for the 43 model countries is shown in Figure F.2.

Figure F.2 Share of Output and Value Added

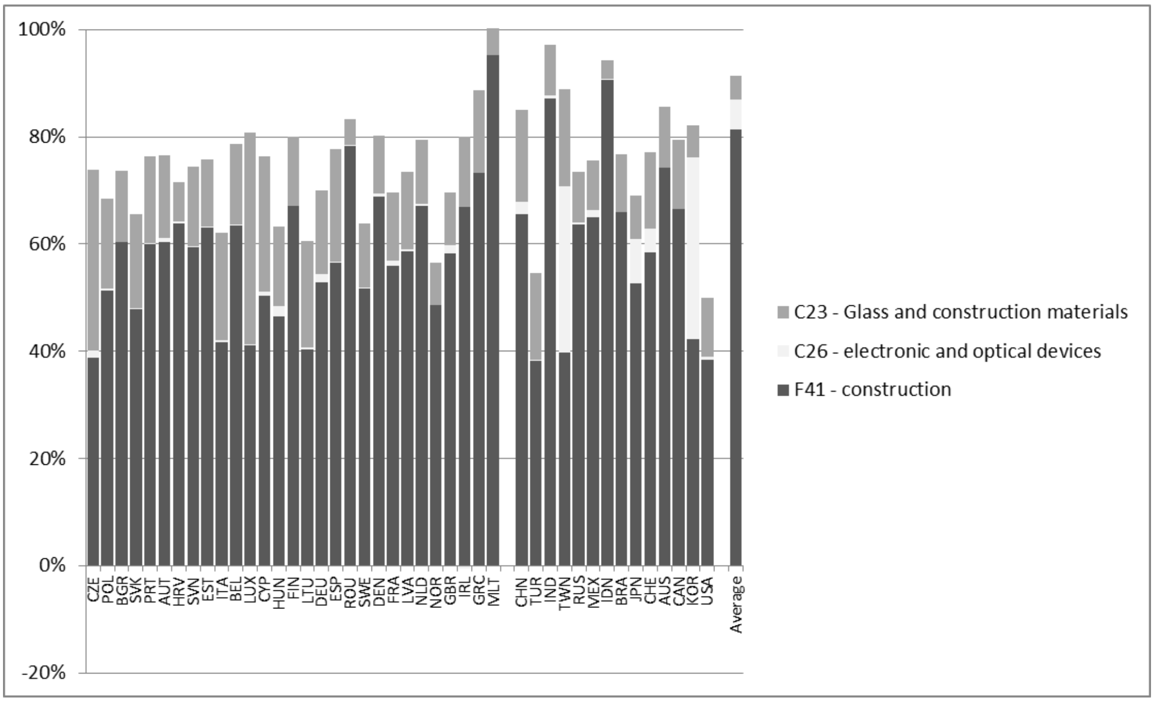


Source: WIOD; WIFO calculations.

Typically, 1% of total economy-wide output consists of C23. In the EU, the highest share is observed in Poland, where the sector produces 1.5% of total output. This share, however, is dwarfed by China's 2.5% (by far the highest share of all model countries). For value added, the share is much lower, in all countries, at around 0.4%. This implies that Sector C23 is much more input-intensive than the "average" sector.

Further to the disaggregation of S<u>ector</u> 23, we have also disaggregated the <u>commodity</u> 23. The user structure is certainly much different for cement and lime on the one hand and, say, glass products on the other. Indeed, cement and lime have quite different usage; whereas cement is used mostly in the production of concrete (and, further on, in the building sector), lime has a broader range, from the building sector to the chemical industry.

Figure F.3 **Share of C23's main users**



Source: WIOD; WIFO calculations.

The main "consumer" of commodity C23 is the construction sector, which accounts for 40-95% of total use. Interestingly, on average (although this average is mostly driven by Taiwan and Korea), the electronic and optical sector is the second-most important user (of silicium "glass" in this case). Own-sector consumption (i.e. consumption of commodity C23 by sector C23) is the second-most important user in practically all other countries, brought about by cement (C23.51) used as input for concrete (C23.6).

Apart from (and in parallel to) disaggregating the Supply- and Use tables, the trade matrix was disaggregated as well: as expected, different sub-groups of commodity C23 exhibit much different trade patterns (with, for example, ceramic products having wider consumption areas than cement, due to much lower volume-specific value of the latter). This disaggregation is based on the UN's COMTRADE and Intra- resp. Extrastat statistics provided by EUROSTAT. COMTRADE was also used to estimate country-specific differences in producer prices (approximated by their respective export prices) and their development since 2000.

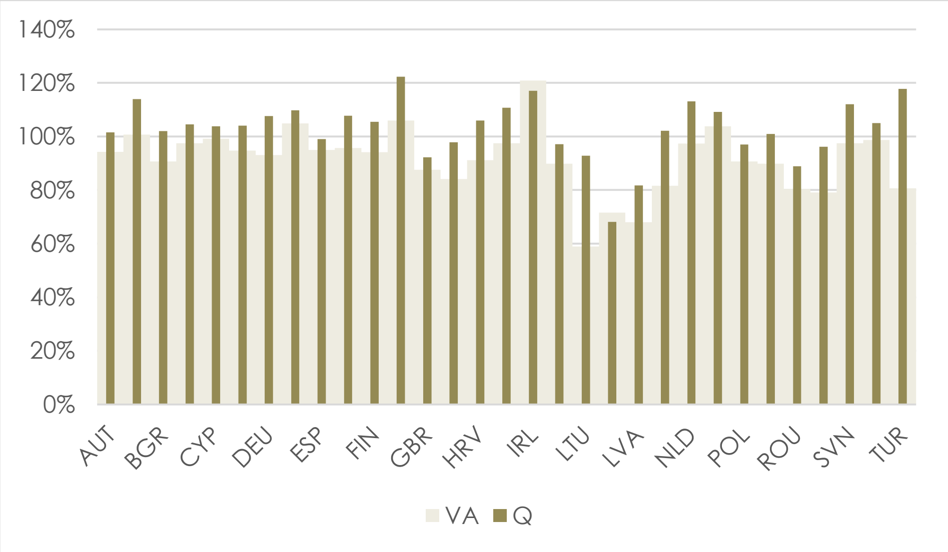
F3. Disaggregation of Sector C23 in the EU28 countries

This is based in the SBS, the Structural Business Survey available from EUROSTAT. **The level of disaggregation detail** we aim at is the following:

- C23.51 – **Cement;**
- C23.52 – **Lime;**
- C23.63 – **Ready-Mix Concrete;**
- C23.6 Rest – **Concrete Products** (= C23.61, 62, 64, 65, 69); and
- C23 Rest – **Other mineral products** (=C23.1 0, 20, 30, 40, 70, 90).

A comparison between IO-data and SBS data for C23 for the year 2011 (the base year of ADAGIO) show a very satisfactory agreement between the two data sources:

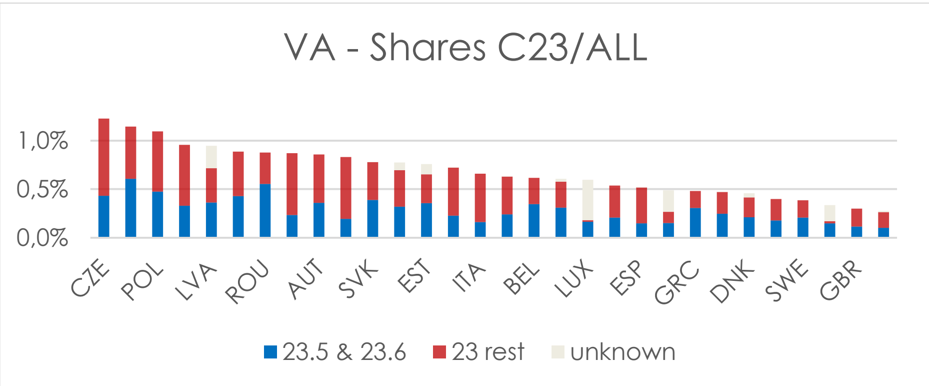
Figure F.4 Comparison between IO and SBS-data (IO data as % of SBS data)



Source: WIOD, EUROSTAT, WIFO calculations.

Given this consistency in most countries, it seems fair to conclude that a disaggregation of the IO data can be performed on the basis of SBS-data. Figure F.5 shows Sector C23's value added as percentage of economy-wide value added, as well as the share of the cement and lime subsectors (C23.5 and C23.6).

Figure F.5 Share of C&L-Subsectors and C23-Rest as % of total VA[338]

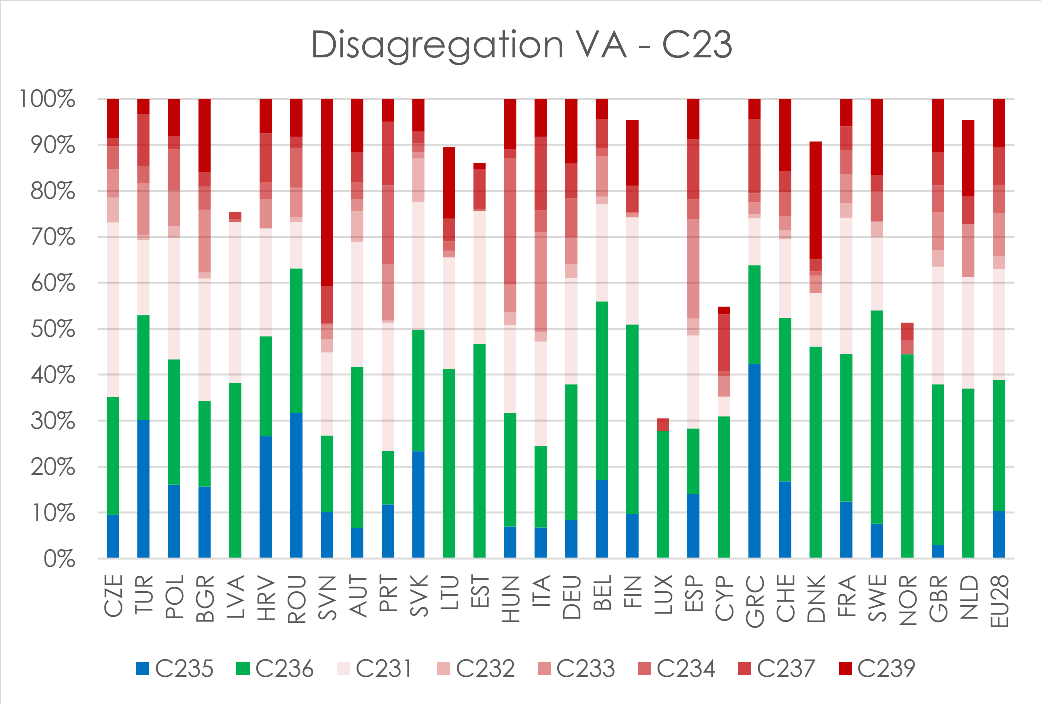


Source: EUROSTAT, WIFO calculations.

The relative size of sector C23 shows quite large variations. For instance, in the EU28, its share in the economy is between less than 0.3% in the Netherlands and more than 1.2% in the Czech Republic. The cement and lime subsectors' value added accounts for some 0.1% in the Netherlands to more than 0.5% in Romania. Of the two C&L subsectors C23.5 (Cement and Lime) and C23.6 (Concrete), C23.6 is by far the more important one, accounting for around ¾ of combined value added on average:

[338] The grey parts represent „suppressions" by EUROSTAT due to insufficient sample size (if a sub-sector consists of fewer than 5 enterprises, data are suppressed for confidentiality reasons. Note that in some cases, also subsectors with a population of more than 5 can be suppressed – in this case, this has to do with "co-suppression": if only 1 sub-sector is suppressed, it could be inferred by subtracting the known sub-sectors from the sector-total. To prevent this, at least 2 sub-sectors are suppressed.

Figure F.6 Sub-Sector composition of Sector C23[339]



Source: EUROSTAT, WIFO calculations.

The highest shares of the cement-subsector C23.5 can be found in Greece, followed by Romania (as well as Turkey). Apart from markedly different relative importance, the sub-sectors of C23 show wide differences in the characteristics of their "typical" enterprises.

339 See footnote above, for an explanation of the "missing" parts of the bars.

Figure F.7 Summary statistics of Subsectors C23.51/2 and C23.6

		AUT	BEL	BGR	BIH	CHE	CYP	CZE	DEU	DNK	ESP	EST	FIN	FRA	GBR	GRC	HRV	HUN	IRL	ITA	LTU	LUX	LVA	MLT	NLD	NOR	POL	PRT	ROM	SVK	SVN	SWE	EU28	Ø EU28
Number of Enterprises	23	1332	1715	1379	354	674	330	6865	###	546	9898	194	802	8613	3801	4355	1357	2166	342	###	1099	40	375	155	1912	716	9261	4491	2359	3156	580	2133	101708	3,336
	238	971	1137	786	144	489	205	5528	7733	362	7082	126	556	7077	2882	2688	956	1525	176	###	893	29	246	0	1468	457	5714	3791	1314	1594	432	1801	75,797	2,471
	2351	7	20	5	7		1		32	3	90	1	2	15		12	7	7		67	1	1	1	0	5	3	31	10	9	12	2	13	-	13
	2352	5	5	66	7		1		42	3	102	1	2	42		170	6	51		132	1	0	0	0	2	5	30	21	39	6	4	6	752	28
	2363	125	126	236	60		68		601	25	780	7	42	568		294	61	136	45	1300	11	6	24		57	99	293	59	217	315	16	56	5,795	208
	2368	224	337	286	129		55		1799	153	1844	59	200	913	700	1191	327	447	76	2286	193	4	104	0	380	152	3193	610	780	1174	126	257	19,026	621
Turnover Q	23	6583.5	8862	1084	279	6104	473	5322	###	2864	###	381	3367	###	###	1931	1015	2047	1316	###	427		367	102	6801	3805	11929	4338	2580	1692	919	5039	220,000	7,703
	238	3517.4	3995	633	78.2	2469	147	3144	###	1383	12418	129	986	###	8386	666	467	1245	567	###	189	8.4	109	0	3112	1864	6090	2648	889	849	606	2133	123,117	4,083
	2351	353.6	776	128	67.8		86.7		2798		1974			2747		454	219	171		2440				0			1533	669	609	247			17,464	898
	2352	9.2	390	33.2	20.6		13		1103		351			438		38.3	20.5	34.2		465		0	0	0			339	49	39.3	114			4,095	181
	2363	1060.1	955	148	39.7		194		3519	194	2236		365	5226		558	96.7	154	204	4361	42.5		25.4			539	873	387	330	105	36.3	797	25,905	935
	2368	1643.2	2496	128	69.8		44.4		11870	923	2928	131	969	5172	4722	215	171	443	173	5795	113	0	83.7	0	2285	1057	2897	586	712	377	168	1208	50,413	1,634
Specialisation - VA	23	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	238	59%	43%	56%	20%		30%	60%	62%	47%	62%	39%	33%	59%	57%	35%	50%	68%	34%	71%	47%		29%	0%	50%	50%	51%	69%	33%	49%	72%	45%	59%	48%
	2351	6%	11%	25%	40%		27%		6%		15%			11%		36%	23%	6%		6%				0%			19%	13%		13%			10%	16%
	2352	0.1%	4.6%	2.9%	5.9%		0.3%		2.6%		2.0%			10%		2.0%	2.0%	13%		12%			0.0%	0.0%			2.7%	13%		8.2%			1.8%	2.2%
	2363	12%	7%	7%	11%		31%		4%	5%	7%		7%	8%		15%	5%	3%	10%	8%	8%		4%			12%	3%	5%	7%	5%	3%	11%	7%	8%
	2368	23%	31%	8%	22%		11%		25%	34%	13%	36%	30%	17%	29%	12%	16%	22%	17%	14%	30%		18%	0%	33%	28%	23%	12%	14%	25%	15%	24%	22%	21%
Q/Enterprise	23	5	5	1	1	9	1	1	5	5	2	2	4	4	4	0	1	1	4	2	0		1	1	4	5	1	1	1	1	2	2	2.2	2.5
	238	4	4	1	1	5	1	1	4	4	2	1	2	2	3	0	0	1	3	1	0	0	0		2	4	1	1	1	1	1	1	16	17
	2351	51	39	26	10		87		87		22			183		38	31	24		36							49	67	68	21				52.4
	2352	2	78	1	3		1		26		3			10		0	3	1		4							11	2	1	19			5.4	10.4
	2363	8	8	1	1		3		6	8	3		9	9		2	2	1	5	3	4		1			5	3	7	2	0	2	14	4.5	4.4
	2368	7	7	0	1		1		7	6	2	2	5	6	7	0	1	1	2	3	1		1		6	7	1	1	1	0	1	5	2.6	3.0
Value Added VA/Employee	23	0.07	0.1	0.0	0.0		0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0		0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4%
	238	0.07	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4%
	2351	0.12	0.2	0.1	0.1		0.2		0.1		0.1			0.2		0.1	0.1	0.0		0.1							0.1	0.1		0.0			0.1	11%
	2352	0.08	0.2	0.0	0.0		0.0		0.1		0.1			0.1		0.0	0.0	0.0		0.1							0.1	0.1		0.1			0.1	6%
	2363	0.08	0.1	0.0	0.0		0.0		0.0	0.1	0.0		0.1	0.1		0.0	0.0	0.0	0.0	0.1	0.0		0.0			0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4%
	2368	0.07	0.1	0.0	0.0		0.0		0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4%
Wages/Q	23	19%	13%	9%	11%		15%	12%	17%	23%	17%	12%	18%	14%	17%	22%	13%	12%	18%	13%	12%		10%	16%	16%	17%	10%	14%	9%	11%	16%	15%	15%	14%
	238	21%	15%	9%	14%	25%	16%	13%	18%	22%	17%	13%	23%	17%	19%	23%	16%	12%	15%	14%	12%	27%	11%		17%	18%	11%	17%	12%	12%	18%	16%	14%	16%
	2351	15%	12%	7%	11%		13%		15%		18%			9%		25%	11%	15%		12%							6%	7%		12%			12%	13%
	2352	15%	8%	11%	11%		31%		15%		15%			6%		22%	13%	8%		11%							6%	8%		10%			11%	13%
	2363	14%	8%	7%	8%		13%		13%	19%	15%		9%	7%		16%	8%	7%	23%	10%	6%		8%			12%	5%	9%	6%	10%	7%	9%	11%	10%
	2368	19%	14%	10%	10%		18%		17%	26%	20%	15%	19%	15%	16%	26%	12%	13%	25%	12%	15%		11%		16%	20%	11%	14%	6%	11%	15%	18%	15%	16%
VA/Q	23	35%	27%	30%	30%		31%	32%	30%	36%	31%	30%	33%	28%	29%	43%	29%	28%	29%	27%	25%		29%	27%	28%	29%	31%	30%	32%	30%	26%	32%	30%	30%
	238	39%	26%	28%	21%	40%	30%	32%	32%	35%	31%	34%	37%	31%	32%	43%	32%	31%	23%	30%	27%	55%	28%		31%	29%	31%	34%	31%	29%	28%	34%	32%	32%
	2351	40%	33%	64%	50%		46%		31%		49%			36%		66%	31%	19%		24%							45%	26%		26%			37%	39%
	2352	35%	28%	28%	24%		38%		33%		35%			19%		43%	28%	22%		26%							29%	34%		36%			30%	31%
	2363	25%	16%	15%	23%		24%		18%	28%	19%		20%	14%		22%	15%	10%	19%	19%	19%		17%			24%	14%	15%	18%	23%	19%	23%	18%	19%
	2368	32%	30%	21%	27%		36%		30%	37%	28%	32%	34%	29%	29%	46%	27%	29%	38%	24%	29%		22%		28%	29%	29%	27%	17%	33%	21%	33%	29%	29%
Energy E/Q	23	6%	7%	13%	9%		14%	8%	7%	5%	9%	8%	5%	5%	7%	14%	13%	9%	7%	4%	12%		15%		5%	4%		14%	12%	13%		4%		9%
	238	6%	7%	13%	7%		9%	10%	7%	5%	9%	9%	5%	6%	7%	13%	13%	8%	4%	2%	8%	2%	11%		8%	4%		16%	13%	13%		5%		8%
	2351	18%	21%	25%	17%		37%		17%		18%			11%		22%	24%	18%		18%								20%		27%				21%
	2352	7%	13%	27%	23%		38%		25%		17%			12%		16%	13%	19%		24%								38%		31%				22%
	2363	6%	3%	7%	5%		9%		4%	1%	6%		2%	1%		8%	8%	7%	8%	6%	5%		8%			3%		3%	6%	3%		0%		5%
	2368	4%	2%	3%	4%		7%		4%	1%	4%	4%	2%	3%	5%	10%	5%	6%	5%	1%	7%		6%		2%	2%		4%	4%	3%		3%		4%
Exports X/Total Q	23	30%	37%	27%	70%	36%	30%	29%	19%	36%	11%	49%	20%	22%	27%	26%	32%	40%	34%	10%	64%		48%	72%	46%	27%	17%	17%	31%	46%	41%	29%	22%	34%
	238	47%	71%	39%	184%	71%	80%	43%	30%	58%	17%	123%	52%	36%	49%	68%	56%	59%	68%	14%	119%		144%		70%	41%	30%	23%	77%	74%	52%	56%	34%	64%
	2351	25%	17%	20%	51%		4%		5%		3%			12%		4%	11%	28%		6%							5%	3%	4%	16%			10%	13%
	2352	129%	14%	13%	8%		93%		8%		1%			19%		3%	11%	21%		3%							4%	48%	19%	10%			15%	25%
	2363	2%	2%	1%	3%		1%		0%	4%	0%		1%	0%		0%	2%	1%	1%	0%	2%		2%			1%	1%	1%	2%	11%	7%	1%	1%	2%
	2368	12%	9%	13%	19%		38%		4%	22%	4%	15%	6%	11%	5%	13%	18%	8%	27%	3%	20%		15%		22%	20%	3%	11%	9%	25%	18%	17%	7%	14%
Exports M/Total Q	23	29%	47%	41%	17%	15%	1%	45%	27%	31%	25%	67%	18%	15%	15%	16%	34%	55%	18%	24%	53%		52%	7%	34%	6%	23%	37%	11%	47%	47%	19%	26%	29%
	238	48%	82%	62%	16%	36%	1%	65%	39%	46%	35%	109%	53%	27%	28%	30%	48%	83%	23%	34%	81%		78%		62%	9%	41%	51%	26%	71%	57%	36%	39%	47%
	2351	10%	24%	11%	11%		2%		19%		12%			3%		18%	45%	10%		5%							3%	15%	3%	49%			13%	15%
	2352	132%	45%	4%	42%		0%		15%		8%			31%		6%	26%	10%		5%							5%	11%	5%	12%			17%	22%
	2363	1%	2%	1%	1%		0%		3%	10%	0%		0%	0%		1%	1%	2%	0%	1%	1%		2%			1%	1%	1%	0%	1%	3%	0%	1%	1%
	2368	10%	19%	27%	26%		0%		11%	16%	14%	68%	10%	3%	3%	13%	12%	15%	19%	8%	40%		59%		14%	2%	7%	21%	6%	14%	41%	11%	10%	18%

Source: COMTRADE, WIOD, WIFO calculations.

Typically, the number of enterprises in C23.5 is quite low (only Spain, Greece and Italy have more than 100 enterprises), while turnover (Q) per enterprise is high (at around 20 Mio. € in C23.5, it is 10 times the turnover of C23 on average; also, enterprises in the Cement Sector C23.51 are much larger than Lime enterprises, C23.52). Compared with the Concrete Sector 23.6, they are about 10 times larger on average. Productivity, defined as value added per employee, is twice the overall average in C23.5, but only 50% higher in C23.6.

Value added as a percentage of output (Q) is above-average in C23.5, and below-average in C23.6. Production of Cement and Lime is hugely energy-intensive: energy costs in C23.5 are more than a fifth of turnover, against some 10% for the 2-digit C23 (Concrete, C23.6, on the other hand, spends only around 5% of Turnover on energy). Cement and lime export and import shares are markedly lower(not surprisingly, given the rather low specific value of cement, which implies that transport margins are high with respect to transported value); at around 13%, they are only half of C23's trade shares. Even lower are trade shares for the Concrete sector C23.6: only around 5% of production is exported resp. imported. So, trade shares are low, and so are trading distances, as the next chapter will show.

F4. Disaggregation of Commodity C23 in the EU28 countries

Generic information about the detailed use of the C23-subgroups at the level of the EU28 and EUROSTAT is sparse, and would most probably involve custom evaluations by individual statistical offices. To circumvent this problem, an indirect approach was taken: the first step involves using detailed information from more disaggregated IO tables to estimate use structures at the sub–2-digit level. In the second step, these detailed commodity structures are scaled to the 2-digit "boundary values" given by the ADAGIO data base.

As sources of more disaggregated IO tables, three countries could be identified: USA, Japan and Australia. The Japanese table is for base year 2011 and distinguishes between 220 sectors; the Australian one, for 2013-14, between 114 sectors. Both are quite recent compilations, which would make them quite suited for the task at hand. However, with a base year of 2007, the USA table was chosen as the template used for the disaggregation: at 390, the number of sectors was superior to both Japan and Australia. Also, and more importantly, they featured the best approximation to the cement and lime sub-groups; a bonus which is assumed to outweigh the drawback of the somewhat outdated base year:

Table F.4 Relevant sectors of the USA IO-tables

Code	Sector
327100	Clay product and refractory manufacturing
327200	Glass and glass product manufacturing
327310	Cement manufacturing
327320	Ready-mix concrete manufacturing
327330	Concrete pipe, brick, and block manufacturing
327390	Other concrete product manufacturing
327400	Lime and gypsum product manufacturing
327910	Abrasive product manufacturing
327991	Cut stone and stone product manufacturing
327992	Ground or treated mineral and earth manufacturing
327993	Mineral wool manufacturing
327999	Miscellaneous nonmetallic mineral products

Source: Bureau of Economic Analysis BEA.

The correspondence is a quite direct one: C23.51 (Cement) corresponds to 327310; C23.52 (Lime and Plaster) to 327400; C23.63 (Ready-Mix) to 327320; and C23.6-Rest to 327330+327390.
in contrast, the Australian table only distinguishes between 4 sub-groups, without a similar direct correspondence:

Table F.5 Relevant sectors of the Australian IO-tables

Code	Sector
2002	Ceramic Product Manufacturing
2003	Cement, Lime and Ready-Mixed Concrete Manufacturing
2004	Plaster and Concrete Product Manufacturing

2005	Other Non-Metallic Mineral Product Manufacturing

Source: Australian Bureau of Statistics.

The Japanese tables live in multiple versions, from a more condensed 108 sector version, to one with almost 600 sectors. The latter distinguishes the sub-groups shown in Table F.6.

Table F.6 Relevant sectors of the Japanese IO-tables

Code		Sector
		Sheet glass and safety glass
2511	-011	Sheet glass
2511	-012	Safety glass and multilayered glass
2511	-021	Glass fiber and glass fiber products, n.e.c.
		Miscellaneous glass products
2511	-091	Glass processing materials
2511	-099	Glass products, n.e.c.
2521	-011	Cement
2521	-021	Ready mixed concrete
2521	-031	Cement products
		Pottery, china and earthenware
2531	-011	Pottery, china and earthenware for construction
2531	-012	Pottery, china and earthenware for industry
2531	-013	Pottery, china and earthenware for home use
2591	-011	Clay refractories
2591	-099	Miscellaneous structural clay products
2599	-011	Carbon and graphite products
2599	-021	Abrasive
2599	-099	Miscellaneous ceramic, stone and clay products

Source: Statistics Japan.

In principle, the Japanese table seems the most promising. However, some idiosyncrasies in the setup of the IO tables resulted in the choice of the US tables as the primary source of information.
The aggregate result at the level of the EU28, after scaling to the respective boundary values, is depicted in the following figure.

Figure F.8 Use shares of C&L subgroups

Good	C23.Rest	C2351	C2352	3.6 Rest	C2363	total C23
A01	0%	0%	1%	3%	0%	0%
A02	0%	0%	0%	0%	0%	0%
A03	0%	0%	0%	0%	0%	0%
B05	0%	3%	2%	0%	0%	0%
C10	3%	0%	0%	0%	0%	2%
C13	0%	0%	1%	0%	0%	0%
C16	1%	0%	2%	0%	0%	1%
C17	0%	0%	1%	0%	0%	0%
C18	0%	0%	0%	0%	0%	0%
C19	0%	0%	0%	0%	0%	0%
C20	1%	0%	0%	0%	0%	0%
C21	0%	0%	5%	0%	0%	0%
C22	0%	0%	1%	2%	0%	1%
C2310	9%	7%	5%	0%	0%	6%
C2350	0%	1%	0%	0%	0%	0%
C2351	1%	6%	1%	0%	0%	1%
C2352	0%	0%	0%	0%	0%	0%
C2360	0%	18%	0%	0%	0%	1%
C2361	0%	21%	0%	1%	1%	2%
C2363	0%	12%	0%	0%	0%	1%
C24	1%	0%	6%	0%	0%	1%
C25	1%	0%	0%	0%	0%	1%
C26	1%	1%	1%	2%	0%	1%
C27	1%	1%	2%	1%	0%	1%
C28	2%	0%	1%	1%	0%	2%
C29	5%	0%	0%	0%	0%	3%
C30	0%	0%	0%	0%	0%	0%
C31	1%	0%	1%	0%	0%	0%
C33	0%	0%	0%	0%	0%	0%
D35	0%	0%	0%	2%	0%	0%
E36	0%	0%	0%	0%	0%	0%
E37	0%	0%	0%	2%	0%	0%
F41	19%	15%	53%	54%	79%	32%
G45	0%	0%	0%	0%	0%	0%
G46	2%	0%	0%	2%	1%	2%
G47	0%	0%	0%	1%	0%	0%
H49	0%	0%	0%	0%	0%	0%
H50	0%	0%	0%	0%	0%	0%
H51	0%	0%	0%	0%	0%	0%
H52	0%	0%	0%	0%	0%	0%
H53	0%	0%	0%	0%	0%	0%
I55	0%	0%	2%	1%	0%	0%
J58	0%	0%	0%	0%	0%	0%
J59	0%	0%	0%	0%	0%	0%
J61	0%	0%	0%	0%	0%	0%
J62	0%	0%	0%	0%	0%	0%
K64	0%	0%	0%	0%	0%	0%
K65	0%	0%	0%	0%	0%	0%
K66	0%	0%	0%	0%	0%	0%
L68	0%	0%	0%	3%	12%	2%
L68impute(	0%	0%	0%	1%	3%	1%
M69	0%	0%	0%	0%	0%	0%
M71	0%	1%	2%	1%	1%	0%
M72	0%	0%	0%	0%	0%	0%
M73	0%	0%	0%	0%	0%	0%
M74	0%	0%	0%	0%	0%	0%
N77	0%	0%	0%	0%	0%	0%
N78	0%	0%	0%	0%	0%	0%
N79	0%	0%	0%	0%	0%	0%
N80	0%	0%	3%	0%	0%	0%
O84	0%	0%	0%	0%	0%	0%
P85	0%	0%	0%	0%	0%	0%
Q86	0%	0%	0%	0%	0%	0%
Q87	0%	0%	0%	0%	0%	0%
R90	0%	0%	0%	0%	0%	0%
R93	0%	0%	0%	0%	0%	0%
S94	0%	0%	0%	0%	0%	0%
S95	0%	0%	0%	0%	0%	0%
S96	0%	0%	0%	1%	0%	0%
CP	8%	0%	0%	0%	0%	5%
I	1%	0%	0%	0%	0%	0%
X	39%	14%	5%	20%	1%	30%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: WIFO calculations.

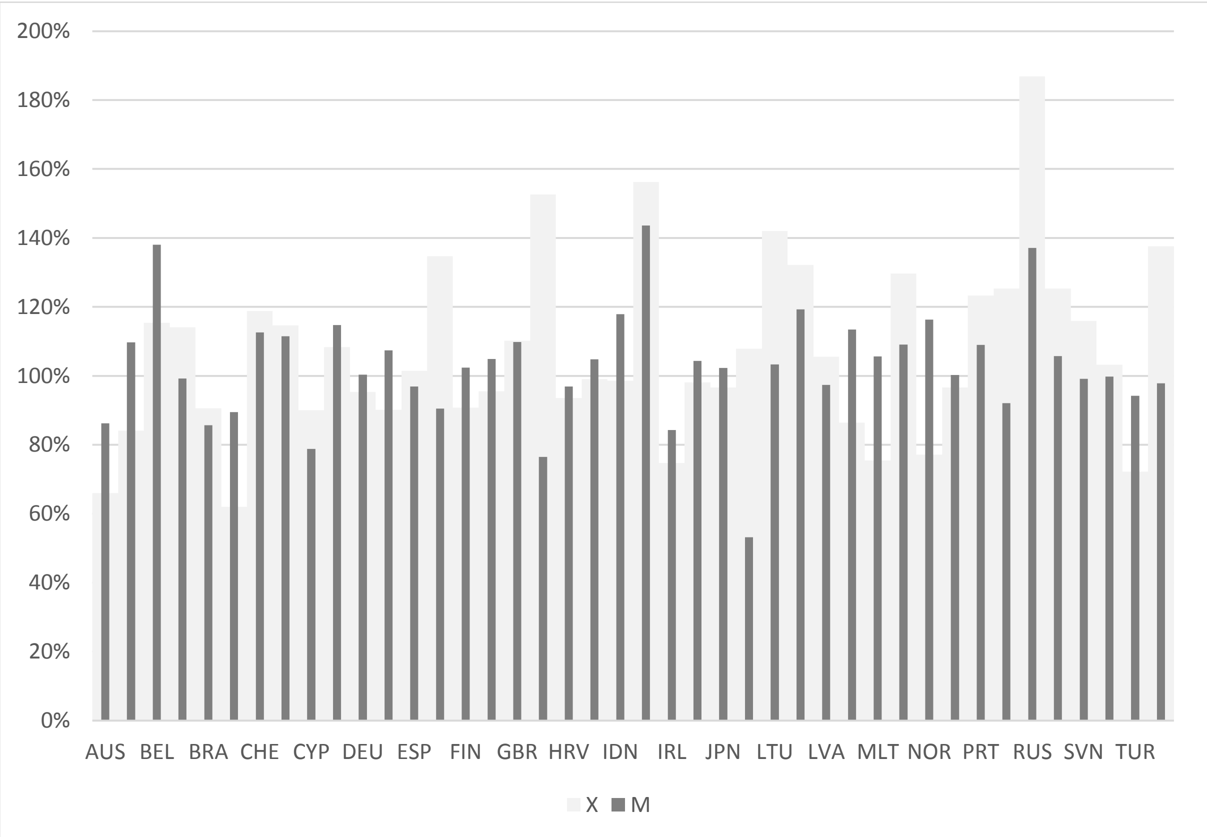
The most important user for 3 of the 5 subgroups is the construction sector F41, which accounts for more than half of the demand for Lime (C23.52), Concrete products (C23.6-Rest) and Ready-mix (C23.63). Cement (C23.51) ends up in F41 eventually, but only via C23.6, Concrete products and Ready mix. Other, non-construction (or non-housing L68) related sectors, are only minor users of C23 products: C21 (Pharmaceuticals) consumes 5% of Lime, and Basic Metals (C24) a further 6%. Producers of vehicles (C29) account for 5% of demand for other, non-C&L subgroups (C23-Rest).

Thus, the disaggregation of C23 in the IO data base is complete. The disaggregation of international trade flows is reported in the next chapter. As mentioned above, for the complete disaggregation of sector C23 in the modelling framework of ADAGIO, an additional step consists of calibrating the Translog specification of C23's production technology – i.e. demand for the KLEM^{m}M^d-factors as well as output prices – to the 5 new sub-groups. At the time of this interim report, this task has not yet been completed.

F5. Trade of cement and lime

Figure F.9 shows a comparison between COMTRADE and WIOD trade data.

Figure F.9 A comparison between IO and COMTRADE-data (COMTRADE data as % of IO data)



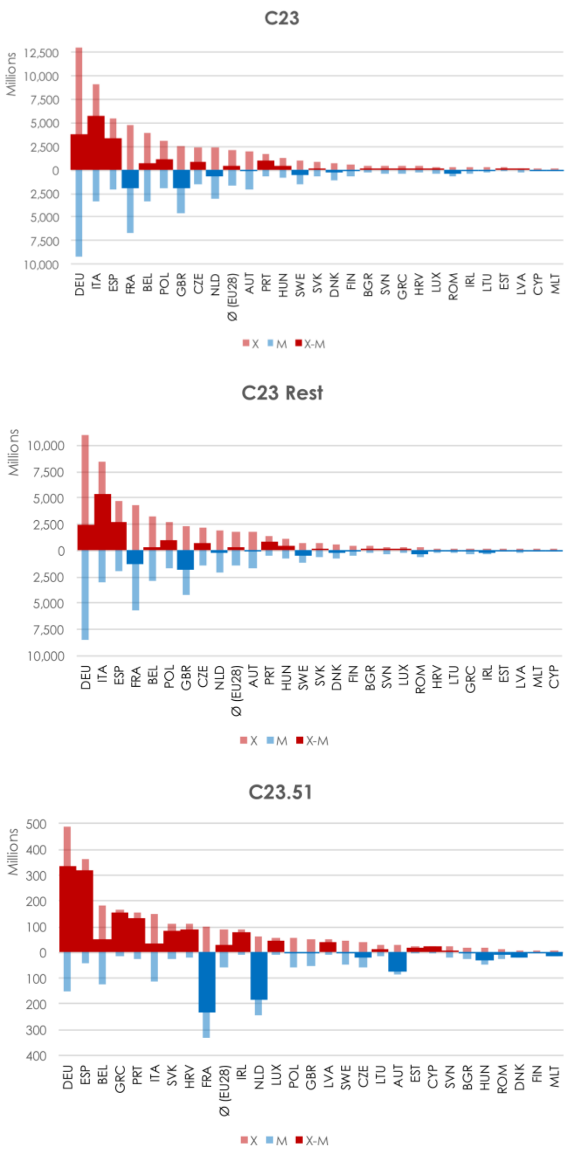
Source: COMTRADE, WIFO calculations.

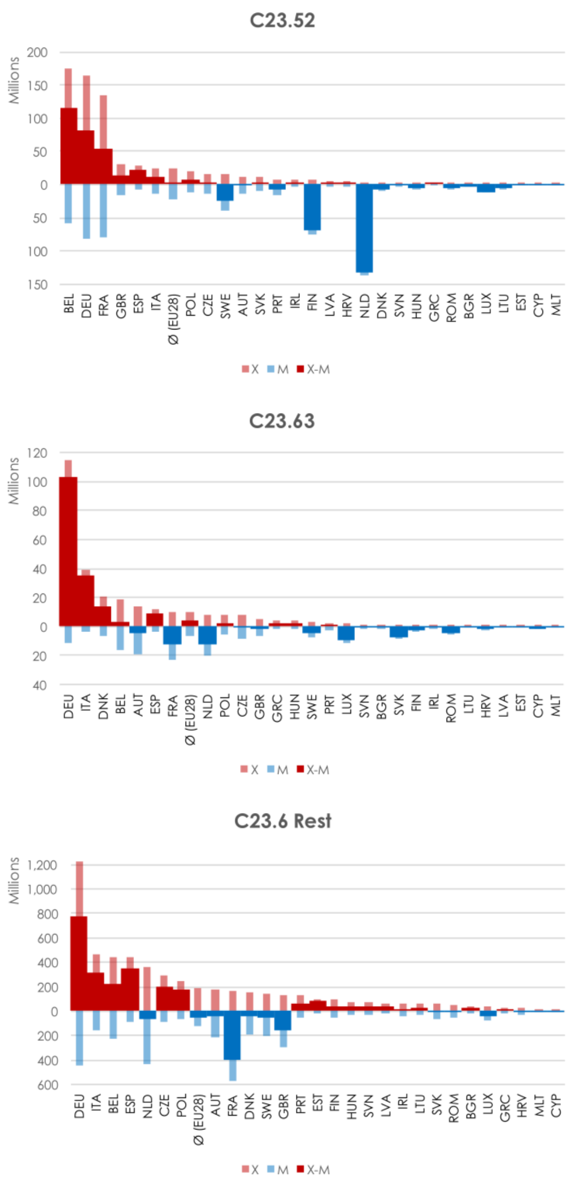
Again, we have a very satisfactory agreement between the data bases at the level of the 2-digit C23 commodity, which implies that 3- and 4-digit shares from COMTRADE can quite safely be used to infer trade flows for the extended ADAGIO model.

F6. Imports, Exports and Net Exports

Trade is strongly correlated with the size of the economy. In particular, Germany, Spain, France and Italy are typically the most important sources and destinations of trade flows (with Germany, Spain and Italy showing positive net exports and France negative net exports), with two major exceptions: Belgium is an important exporter of all cement and lime commodities, Denmark in the case of Ready-mix C23.63.

Figure F.10 Imports, exports, and net exports for the C&L commodities

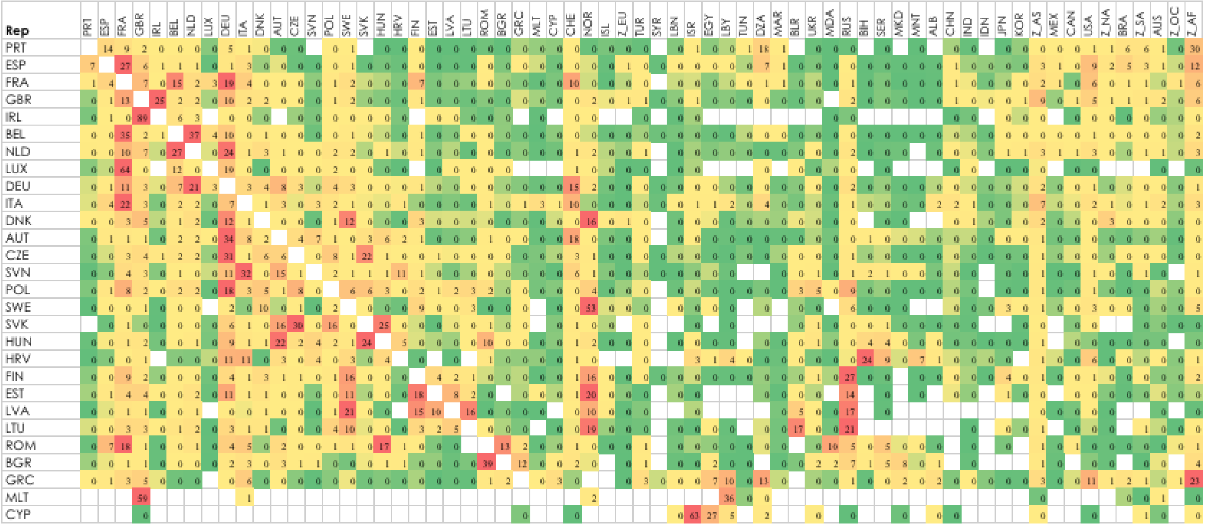




Source: COMTRADE; WIFO calculations.

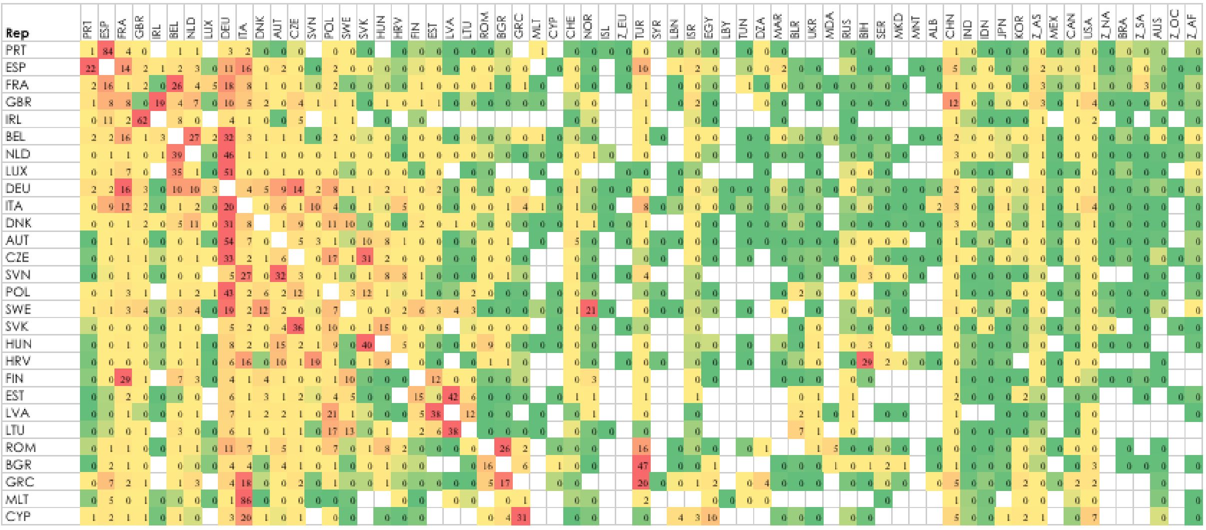
As shown in Figure F.11, trading distances are not very long. Here, countries are roughly ordered by distance; as a tendency, countries which are neighbours geographically are also neighbours in the matrix of the figure. It is obvious that higher shares of trading are clustered around the diagonal, hinting at trade being concentrated between neighbouring countries – for exports as well as for imports.

Figure F.11 Destination of Exports by Reporter and Partner Country – C23.5&6; % share of total Reporter exports, 2011-2014



Source: COMTRADE, WIFO calculations.

Figure F.12 Sources of Imports by Reporter and Partner Country – C23.5&6; % share of total Reporter imports, 2011-2014



Source: COMTRADE, WIFO calculations.

The concentrations are even higher for concrete products C23.6 than for cement and lime C23.5: based on the – very crude - measure of "distance between capitals", the average import trade takes place within a 700-1000 km radius (less than half of the average distance of around 2.500 km in the case of the total C23 commodity); Ready-mix's (C23.63) average import distance is even shorter, at 600 km. Most trade takes place between neighbours: in the case of cement and lime commodities, almost ¾ of imports (though a bit less of exports) come from direct neighbours (against only 2/5 in the case of non-cement and lime sub-groups). Intra-EU trade is dominant: around 90% of cement and lime imports come from the common market, more than 2/3 of exports are headed for common market.

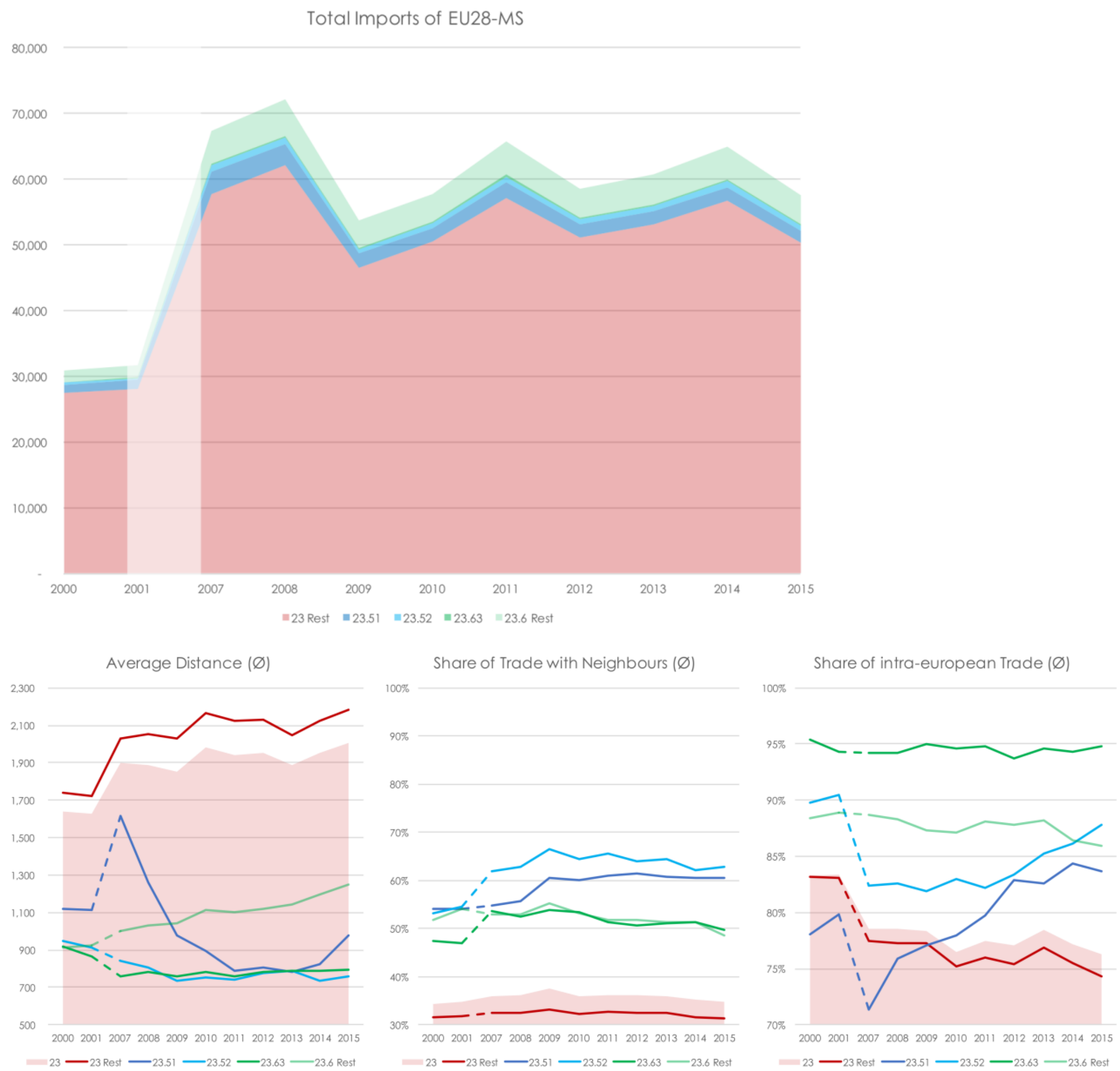
Figure F.13 Summary statistics on trade patterns

	Ø Distance in km						Share of Trade with Neighbours						Share of Trade with EU28-MS					
	23	23 R	23.51	23.52	23.63	23.6 R	23	23 R	23.51	23.52	23.63	23.6 R	23	23 R	23.51	23.52	23.63	23.6 R
Imports																		
AUT	1,561	1,725	522	762	713	769	74%	71%	93%	97%	98%	89%	83%	81%	86%	98%	98%	96%
BEL	2,221	2,441	696	397	500	915	49%	45%	71%	93%	68%	76%	75%	72%	96%	98%	100%	92%
BGR	1,553	1,662	582	611	813	1,524	41%	35%	93%	75%	35%	48%	62%	65%	14%	26%	95%	76%
CYP	2,745	2,800	1,512	914	1,465	2,837	0%	0%	0%	0%	0%	0%	77%	79%	26%	11%	96%	74%
CZE	1,501	1,612	442	503	514	763	56%	52%	96%	95%	87%	80%	84%	83%	100%	99%	100%	96%
DEU	2,829	2,980	633	583	640	1,133	41%	38%	84%	93%	89%	71%	63%	61%	98%	95%	93%	91%
DNK	1,800	2,021	762	766	642	1,069	27%	26%	41%	52%	52%	28%	81%	78%	79%	96%	98%	93%
ESP	3,068	3,142	2,148	1,802	1,415	1,938	29%	29%	28%	32%	17%	42%	71%	71%	63%	87%	99%	82%
EST	1,564	1,693	406	469	993	900	15%	9%	86%	73%	22%	33%	80%	79%	94%	95%	82%	90%
FIN	2,200	2,446	981	1,705	1,157	848	16%	16%	14%	9%	34%	24%	77%	72%	97%	99%	74%	90%
FRA	2,057	2,180	2,237	650	591	974	60%	58%	71%	88%	94%	74%	78%	77%	77%	97%	99%	94%
GBR	3,286	3,370	1,038	975	1,026	2,643	3%	2%	28%	51%	4%	15%	61%	60%	91%	88%	96%	71%
GRC	2,285	2,326	1,322	1,071	1,304	2,331	23%	21%	46%	46%	4%	34%	71%	72%	51%	87%	96%	68%
HRV	1,136	1,307	377	464	481	444	25%	16%	70%	58%	27%	54%	81%	84%	65%	49%	83%	69%
HUN	1,739	1,894	282	384	577	613	21%	15%	96%	69%	39%	38%	82%	80%	99%	87%	99%	92%
IRL	2,270	2,485	926	619	566	1,040	51%	49%	57%	80%	85%	61%	75%	72%	98%	100%	99%	94%
ITA	2,898	3,004	1,334	1,713	1,263	2,100	20%	19%	38%	35%	29%	22%	68%	67%	74%	84%	95%	81%
LTU	1,344	1,517	471	513	709	605	42%	38%	49%	82%	43%	66%	81%	79%	84%	92%	99%	92%
LUX	840	1,149	231	207	223	259	78%	68%	99%	99%	98%	95%	92%	88%	100%	100%	100%	100%
LVA	1,218	1,329	354	576	896	685	35%	31%	88%	59%	23%	40%	83%	81%	99%	89%	83%	91%
MLT	1,952	2,373	753	1,060	786	1,724	0%	0%	0%	0%	0%	0%	81%	75%	99%	94%	100%	83%
NLD	1,907	2,412	311	240	294	888	56%	44%	90%	91%	93%	81%	78%	72%	98%	93%	99%	92%
POL	2,352	2,466	718	989	956	1,159	42%	40%	80%	78%	77%	64%	73%	72%	95%	99%	100%	95%
PRT	1,625	1,769	623	727	804	923	60%	56%	90%	81%	75%	83%	90%	89%	99%	100%	100%	97%
ROM	1,629	1,740	699	650	919	954	27%	25%	21%	62%	33%	47%	76%	76%	40%	44%	99%	94%
SVK	1,429	1,614	299	371	372	439	48%	42%	96%	80%	84%	83%	86%	83%	100%	100%	100%	99%
SVN	1,299	1,442	507	538	471	492	54%	50%	83%	75%	85%	70%	85%	84%	90%	88%	100%	90%
SWE	1,855	2,064	1,221	1,005	735	992	14%	10%	0%	37%	39%	30%	76%	76%	97%	65%	62%	74%
EU28	2,341	2,529	1,017	710	633	1,150	40%	36%	70%	73%	72%	60%	73%	71%	86%	92%	96%	89%
Exports																		
AUT	2,342	2,547	535	526	679	884	54%	50%	97%	92%	77%	78%	59%	57%	93%	94%	87%	72%
BEL	1,070	1,191	562	466	714	669	67%	62%	93%	90%	76%	82%	87%	86%	94%	97%	91%	93%
BGR	1,195	1,245	1,193	344	335	665	45%	42%	60%	96%	94%	67%	70%	71%	42%	53%	77%	78%
CYP	888	2,127	689	529	822	3,421	0%	0%	0%	0%	0%	0%	10%	75%	0%	33%	0%	1%
CZE	1,509	1,632	419	480	472	838	48%	45%	99%	87%	89%	61%	76%	74%	100%	98%	96%	90%
DEU	2,323	2,568	772	862	1,056	1,046	48%	43%	78%	78%	77%	74%	62%	60%	83%	81%	66%	69%
DNK	2,119	2,351	1,735	593	1,846	1,252	17%	17%	11%	3%	19%	17%	61%	61%	74%	15%	68%	61%
ESP	2,985	2,959	2,566	2,258	1,935	3,668	27%	26%	33%	59%	44%	33%	53%	54%	48%	67%	61%	51%
EST	861	852	655	902	348	930	24%	25%	87%	78%	37%	6%	69%	74%	38%	30%	80%	70%
FIN	2,151	2,282	1,579	1,227	883	1,578	33%	27%	85%	95%	92%	55%	60%	63%	4%	11%	9%	49%
FRA	2,510	2,565	2,234	1,510	2,391	2,084	44%	43%	53%	50%	67%	60%	64%	63%	65%	86%	59%	54%
GBR	3,039	3,061	2,327	3,984	3,334	2,687	11%	10%	16%	12%	42%	31%	63%	63%	68%	54%	59%	65%
GRC	3,360	3,559	3,504	738	1,004	1,641	13%	18%	5%	96%	34%	28%	27%	33%	16%	32%	53%	46%
HRV	856	607	1,425	548	284	807	44%	42%	49%	62%	91%	40%	57%	67%	35%	22%	35%	62%
HUN	1,593	1,685	255	252	474	569	20%	16%	87%	96%	72%	67%	83%	82%	86%	78%	84%	87%
IRL	1,056	1,609	523	460	494	551	76%	62%	83%	100%	99%	97%	92%	84%	100%	100%	99%	99%
ITA	3,038	3,084	1,078	2,818	2,126	2,926	24%	23%	52%	24%	36%	33%	55%	55%	61%	55%	59%	57%
LTU	868	829	566	691	652	1,158	62%	68%	79%	90%	92%	30%	40%	40%	32%	20%	27%	45%
LUX	476	539	267	226	261	369	81%	76%	100%	99%	98%	86%	96%	95%	100%	100%	100%	96%
LVA	1,005	1,553	524	370	308	604	43%	35%	62%	100%	97%	34%	67%	68%	57%	65%	93%	75%
MLT	3,556	3,732	2,724	5,090	172	1,888	0%	0%	0%	0%	0%	0%	66%	67%	0%	27%	100%	68%
NLD	1,411	1,415	1,221	1,402	1,034	1,392	47%	46%	75%	57%	60%	48%	81%	81%	85%	68%	81%	80%
POL	1,604	1,672	996	793	1,051	1,083	46%	46%	72%	72%	60%	44%	75%	74%	79%	49%	74%	78%
PRT	2,578	2,443	3,802	4,300	3,412	2,548	26%	28%	2%	14%	18%	31%	66%	72%	3%	32%	48%	71%
ROM	1,573	1,655	944	493	737	1,329	28%	24%	79%	95%	77%	35%	75%	75%	74%	63%	69%	77%
SVK	907	1,063	259	433	311	527	55%	46%	95%	89%	86%	71%	90%	88%	99%	85%	92%	94%
SVN	1,398	1,537	404	572	530	1,035	37%	31%	99%	91%	39%	46%	73%	70%	99%	93%	48%	79%
SWE	1,873	2,021	2,775	447	542	1,032	40%	34%	13%	72%	45%	77%	48%	54%	30%	81%	63%	21%
EU28	2,252	2,383	1,529	1,150	1,320	1,519	40%	37%	57%	70%	63%	56%	65%	64%	63%	81%	69%	70%

Source: COMTRADE; WIFO calculations.

Over time, C23 imports have increased substantially, more than doubling in the 2000-2008 period. After a crisis-induced fall in 2009, imports have remained quite stable since. The increase has extended to all cement and lime commodities. However, border-crossing Ready-mix C23.63 remains a niche product.

Figure F.14 Development of trade patterns over time, 2000-2014



Source: COMTRADE; WIFO calculations.

The average[340] import distance has increased since 2007, except in the case of Cement C23.51: prior to the housing bust of 2008, Spain imported huge quantities of cement from China (up from virtually nothing in 2000). This development was due to the combination of the housing boom in Spain and huge overcapacity in the Chinese cement industry. As a result, in 2007 China accounted for almost half of all Spanish cement imports (In the EU as a whole, China supplied 14% of cement imports in 2007). In 2008, Spanish imports fell by half and did not recover since.

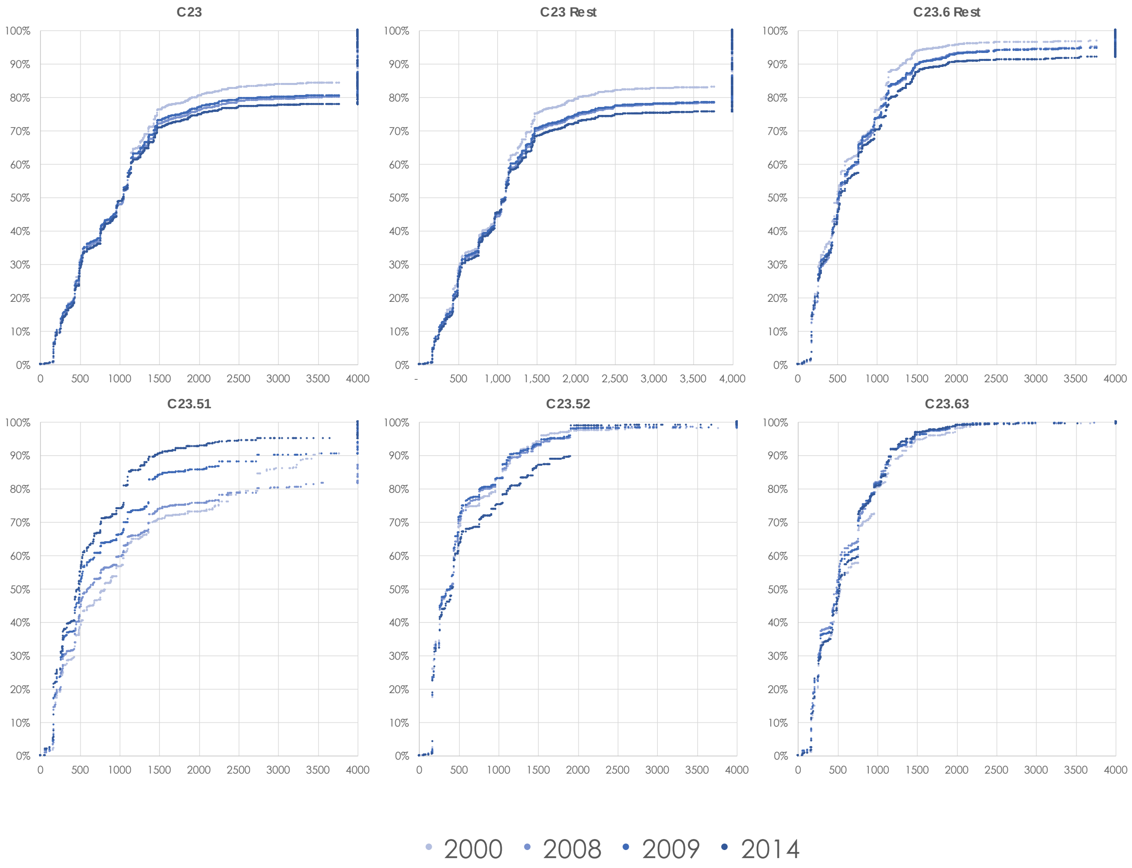
For the cement and lime commodities, intra-EU trade has mostly deepened for the cement and lime commodities, except for concrete products 23.6-Rest (and the non-cement and lime 23-Rest).

This rise and fall in European imports from China also shows up in the development of cumulative trade distances. All cement and lime commodities show a gradual and homogenous increase towards longer trading distances. In the case of cement, however, 2008 exhibits a tilt in the cumulative distance function, with long distances becoming much more important (mostly

[340] The averages in this figure are unweighted averages of the 28 member states.

at the expense of medium distances of around 2500 km). After 2008, the cumulated share of shorter distances rises markedly.

Figure F.14 Cumulative EU import shares by distance, 2000-2014



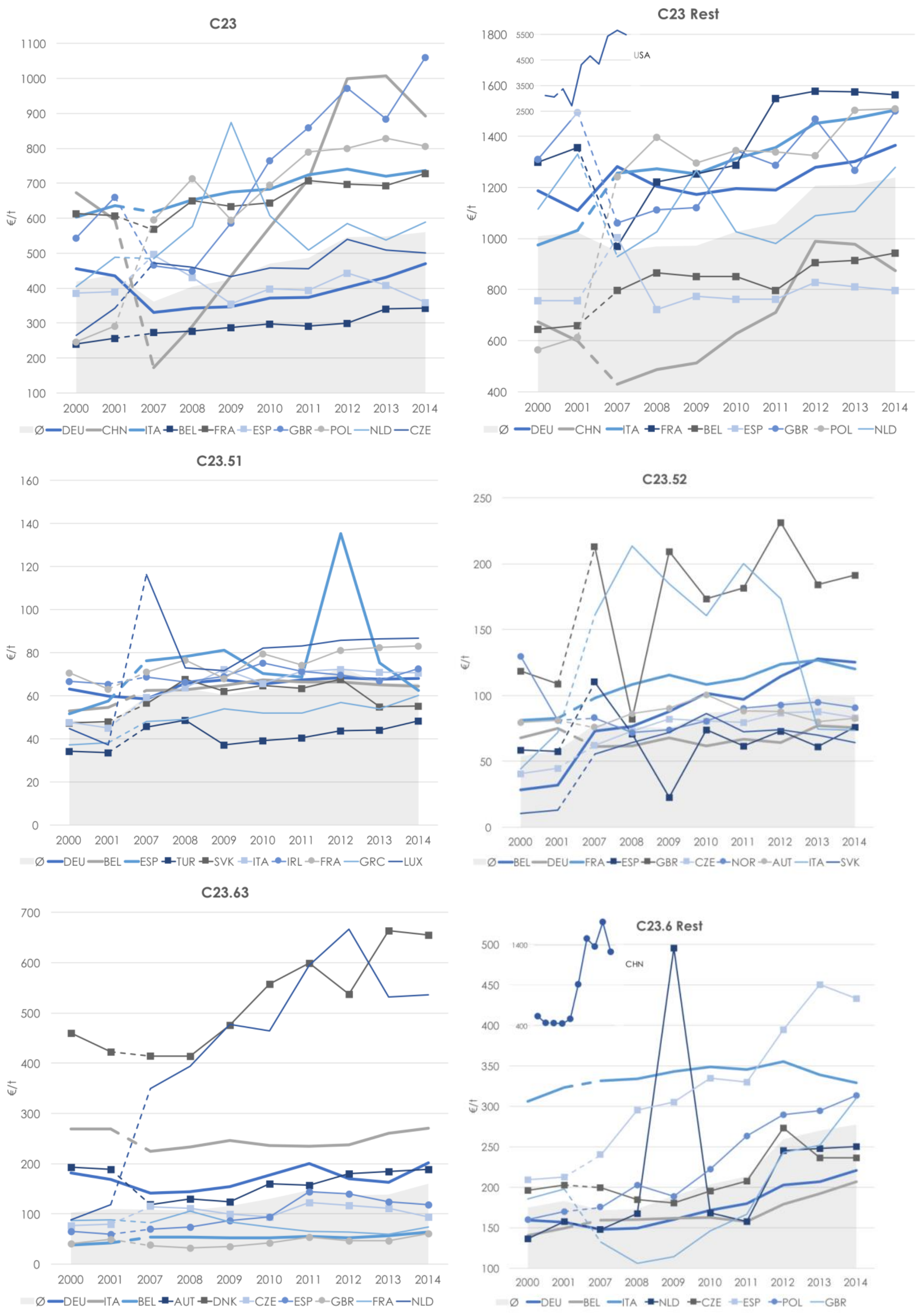
Source: COMTRADE; WIFO calculations.

In the context of ADAGIO, initial trade structures will be derived from these trade patterns.

F7. Export Prices

The following figure shows the unit export prices (in fob, calculated as the ratio of value and quantity) for the 10 most important exporters to the common market.

Figure F.15 Development of export prices (fob), 2000-2014



Source: COMTRADE; WIFO calculations.

Average Cement and Lime prices increased between 2000 and 2007, with only modest increases since. The other commodities exhibit a more homogenous development. A comparison across countries has revealed that price differences are visible, but mostly not all too dramatic: in the case of cement, for example, prices in 2014 are in the 50-80 € range - with some notable exceptions, however: the Chines price of concrete products C23.6-Rest more than trebled after 2009. This hints at a structural shift in Chinese exports. The pronounced rise in the US price of C23-Rest, however, is probably due to the depreciation of the € vis-a-vis the US$. In the context of the calibration of ADAGIO, export prices – together with results from the questionnaire - will serve as a proxy for output prices.

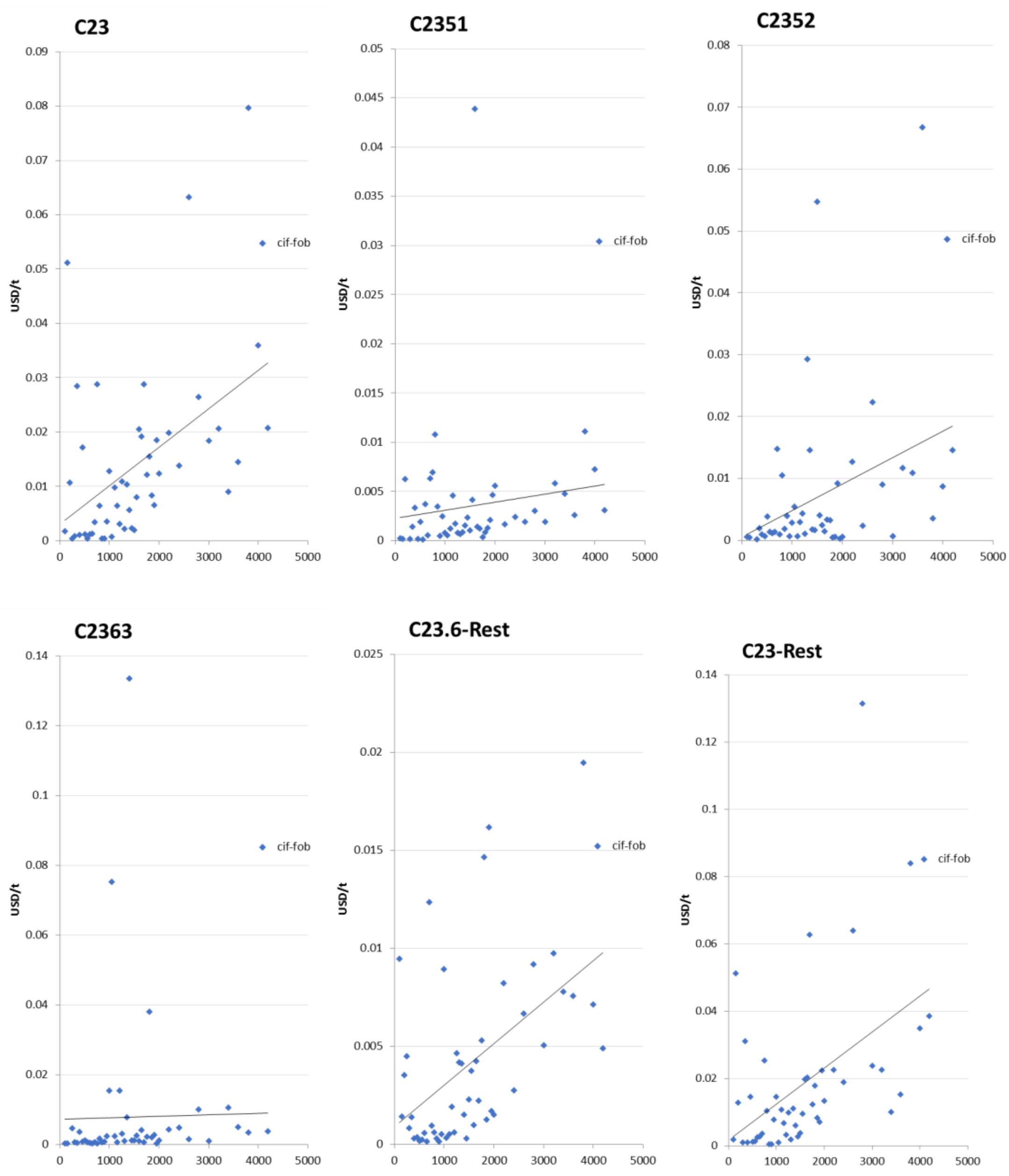
F8. Cif-fob Difference and international Trade and Transport Prices

In principle, the Cif-fob difference should be an indicator of international transport costs: exports are valued at fob (i.e. the value at the border of the exporting country), while imports, evaluated at the border of the importing country, are cif prices; the difference cif-fob, therefore, should be equal to the trade costs (transport, but probably also other trading costs) between the exporting and the importing country[341]. In particular, it should be true that for all country pairs, $P_M^{ij}>P_X^{ji}$.

Thus, by looking at pairs of flows and mirror flows from the COMTRADE data base, it should be possible to deduce such international transport costs as the difference between the (specific) price an importer (the destination D) pays and the price an exporter (the origin O) receives. However, a look at corresponding mirror flows in COMTRADE reveals that a significant share of OD-relations shows the "wrong direction" – the import value is lower than the export value, cif < fob. This share is sizable, and can be a third of all observations. To circumvent this problem (which is common when working with trade data bases like COMTRADE[342]), OD-relations with the "wrong" direction are usually disregarded. This exercise has led to the identification of the following relationships for commodity C23 (and its 5 sub-groups): the diagrams show cif-fob differences (in USD/t) as a function of distance.[343] For each distance class (between 100 and2000 km in 50 km steps, over 2000 in 100km steps), data for all EU28 are averaged.

[341] from this definition it is clear that for countries sharing a common border, the cif-fob difference should be zero.
[342] one of the reasons for this is that, due to the collection of tariffs, import numbers are most certainly of better quality than export numbers.
[343] the „distance" refers to the geographical distance between capitals.

Figure F.16 Cif-fob differences in [USD/t], pooled EU28 data, 2011-2014



Source: COMTRADE, WIFO calculations.

Disregarding problematic OD-relationships, the correlation patterns between distance and specific costs look quite plausible, with the regression line showing some kind of "fixed costs" plus "variable" costs which are positively correlated with distance. Transport costs, at around 80 cent/tkm, are cheapest for C23.51, Cement (most probably due to modal split, which in the case of cement is probably mostly ship and rail). Lime (C23.52) exhibits specific transport costs of around 4USD/tkm, Concrete products (C23.6-Rest) of around 2 USD/tkm. Ready-mix C23.63 is peculiar in that it shows almost no distance-related increase in costs. Most probably, this is due to the fact that Ready-Mix, requiring special transport equipment, is not transported in larger quantities over longer distances (by mass, trade in ready-mix is only around 6% of trade in cement, and around 11% by value).

In policy simulations, the results of this chapter will form the basis of the modelling of (international) trade and transport margins, and will thus allow the consistent investigation of the impact of, for example, transport cost increases, e.g. brought about by road pricing.

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ET-05-16-110-EN-N

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doi:10.2873/300170