Building CERN's Future Circular Collider

An Estimation of Its Impact on Value Added and Employment

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Research assistants: Elisabeth Arnold, Maria Riegler

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Austrian Institute of Economic Research

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Commissioned by European Organization for Nuclear Research

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CERN, the European Organization for Nuclear Research, is hosting an international collaboration that develops scenarios for a new circular particle-collider based research infrastructure, the Future Circular Collider (FCC). Such a research infrastructure can also contribute to scientific and technological progress in many other areas that will be needed to construct and operate such a facility. Apart from science-changing insights and technological developments, there are direct economic benefits likely to arise from this project: the opportunities for firms to contribute to the installation and operation of this machine and the jobs that go along with these opportunities. The estimation of such effects is the purpose of this paper. The FCC is estimated to cost 12.1 billion CHF to construct and another 8.5 billion CHF to operate over its initial 15-year period. Using the economic model ADAGIO, we estimate that this will be associated with a cumulated 50 billion CHF of (world-wide) value added, in an average year securing around 26,000 jobs. Apart from the economic effects linked directly to the FCC itself, the host region will benefit from the cost-of-living expenditures of up to 11,000 FCC-related personnel as well as around 300,000 annual tourists expected to visit the largest machine ever built.

2023/4/S/WIFO project no: 22062

Medieninhaber (Verleger), Herausgeber und Hersteller: Österreichisches Institut für Wirtschaftsforschung,
1030 Wien, Arsenal, Objekt 20 • Tel. (+43 1) 798 26 01-0 • https://www.wifo.ac.at/ • Verlags- und Herstellungsort: Wien

Verkaufspreis: 40 € • Kostenloser Download: https://www.wifo.ac.at/wwa/pubid/69927 • https://doi.org/10.5281/zenodo.7382706

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Table of Content

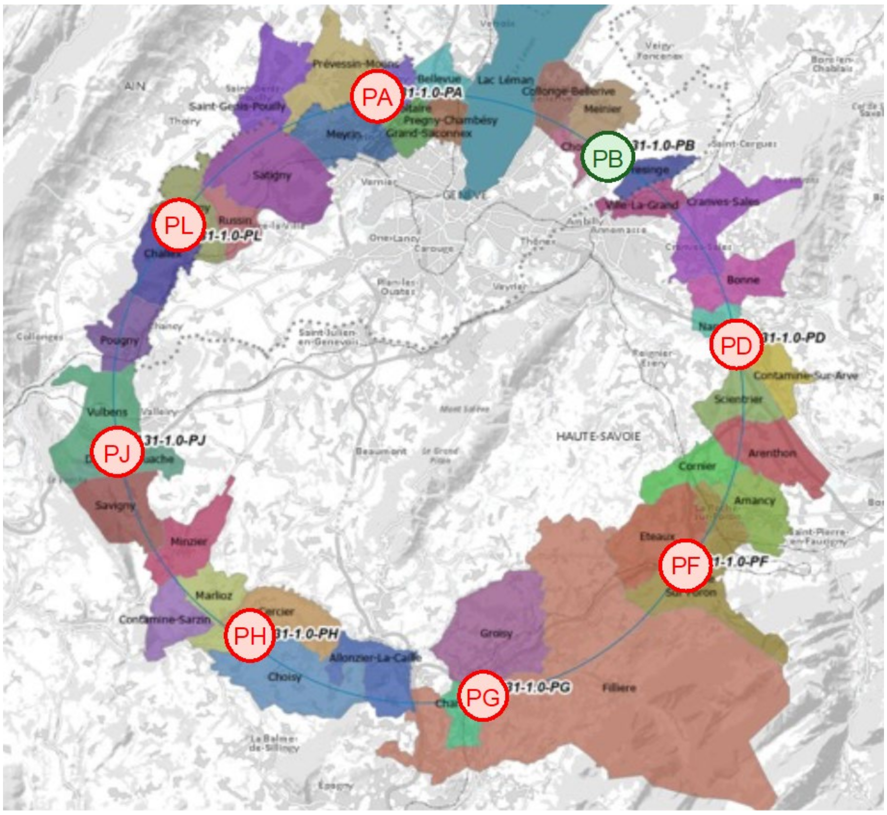
List of Figures

List of Tables

1. Introduction[1]

CERN, the European Organization for Nuclear Research, is hosting an international collaboration that develops scenarios for a new circular particle-collider based research infrastructure. The so called "Future Circular Collider" (FCC) would be located in the vicinity of CERN's main sites (Meyrin Switzerland, Prévessin France), extending significantly into the Haute-Savoie department to the "Grand Annecy" region (see Figure 1). Hosting subsequently an intensity frontier electron-positron and an energy-frontier hadron particle collider, this research infrastructure has the potentials to contribute substantially to the discipline of particle physics and the understanding of nature's workings at the sub-atomic level.

Figure 1: **Working hypothesis for a new future circular collider with a circumference of more than 90 km and eight surface sites that connects to the existing CERN particle accelerator complex.**



Source : Placement scenario PA31 developed in the frame of the FCCIS H2020 co-funded EU project.

[1] A million thanks are due to CERN's Johannes Gutleber, without whose co-operation, support, and patience this analysis would not have been possible.

Such a research infrastructure can also contribute to scientific and technological progress in many areas that will be needed to construct and operate such a facility. This boundary-pushing effect can be felt in quite unrelated areas as well: the World Wide Web was conceived at CERN around 1990, leading to the take-off of the Internet, until then known as ARPANET, a computer network used primarily by US-American academic institutions.

Apart from science-changing insights and technological developments, there are direct economic benefits likely to arise from this project: the opportunities for firms to contribute to the installation and operation of this machine and the jobs that go along with these opportunities. The estimation of such effects is the purpose of this paper[2].

[2] There will be other pay-offs from the FCC, from possible advances in fundamental research leading to practical technological progress to individual researchers' career opportunities, in and out of science. However, these aspects do not feature in the present analysis, but are dealt with in an ongoing socio-economic impact study. Interim results can for instance be looked at in Bastianin, A. (2021).

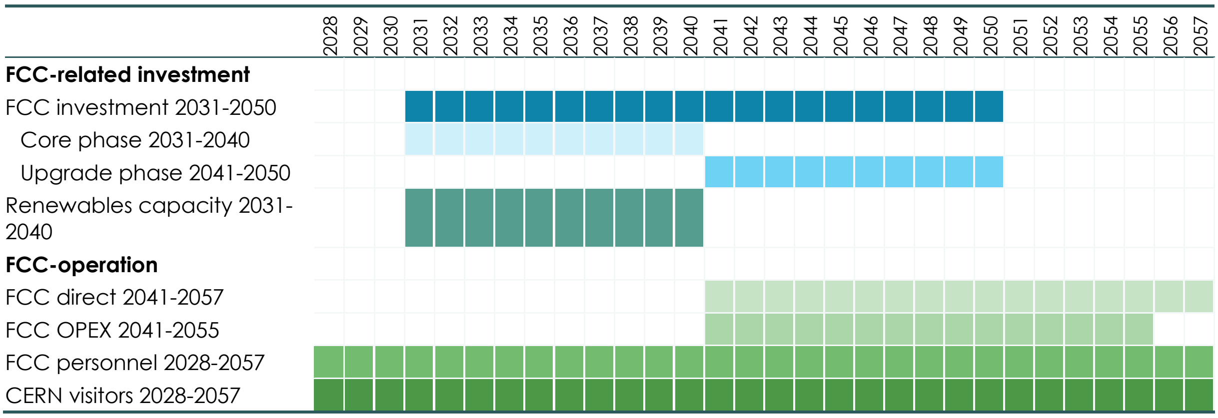
2. The Project – Summary of Project Volumes and Economic Linkages

For the purpose of the estimation of the economic impacts on the employment sector, the project can be divided into a few distinct phases (see also Table 2):

- The initial, **core investment phase**, planned to span the decade from 2031-2040, when the underground infrastructure and surface technical infrastructures are constructed and the particle collider and the experiments are installed.
- During that time, investments are considered to **build up renewable energy sources** in the frame of power purchasing agreements to supply the FCC's power demand.
- A second **upgrade investment phase**, spanning approximatively the operation period between 2041 and 2050, in which the particle collider is periodically updated to reach ever higher collision energies, as specified by the envisaged physics research programme.
- The **operation phase** during which the machine will be used for scientific research starts in 2041 and lasts until 2055. Operating in a baseline scenario with two experiments, this period will last for 15 years ("FCC OPEX" in Table 2); however, scientific research personnel will still be active for 2-3 years after the end of particle collider operation to analyse the data gathered in the course of the experiments ("FCC Personnel" in Table 2).
- During the operation phase, the FCC will generate value added directly by virtue of paying wages and through the depreciation of the original investment ("FCC direct" in Table 2).
- During those phases and including partially the "design phase" that is assumed to start around 2028 when the first project-related, relevant investments take place, between 4,000 and 11,000 persons will work for the project, not all of them on-site. The induced **consumer spending** of the resident FCC personnel will contribute to the economy of the region and beyond.
- A visitor facilities development programme that is already starting with the inauguration of the "Science Gateway" at the CERN headquarters in 2023, will permit gradually to increase the annual **visitor numbers** from the current 150,000 to around 300,000.

Figure 2 depicts the different phases used for the economic analysis of the employment sector in chronological form.

Figure 2: **Schedule of the FCC-ee project for the purpose of economic analysis of the employment sector**



Source: CERN.

In total, investment and operation costs over a 25-year lifetime (10 years of construction followed by 15 years of operation[3]) are more than 21 bn CHF[4].

Table 1: **FCC-related investment and operation costs (CAPEX and OPEX)[4]**

		Investment volume [mn CHF]	Annualised volume [mn CHF/a]
FCC-related investment			
FCC investment	2031-2050	12,097	605
Core phase	2031-2040	10,709	1,071
Upgrade phase	2041-2050	1,388	139
Renewables capacity	2031-2040	644	64
FCC-operation			
FCC OPEX	2041-2055	2,950	199
FCC personnel	2028-2057	5,400	180
Total	**2028-2057**	21,100	700

Source: FCC study preliminary cost estimates (2021).

These expenditures are linked to tangible economic spill-over effects excluding scientific effects: FCC-related CAPEX represents sales opportunities for firms, as does OPEX[5]. Employees engaged in the FCC programme earn wages, which are partially spent on consumption and

[3] 15 years of operation (plus 2 years of "scientific research and data processing with already collected data") for a setup with two "experiments".

[4] Investment volumes and operational expense are based on CERN estimates, as were all assumptions on structural details for the investment and operation phases.

[5] OPEX = Operational Expenditure; costs that a company incurs for running its day-to-day operations. CAPEX = Capital Expenditure; purchases of significant goods or services that will be used to improve a company's performance in the future.

represent therefore again potential sales for firms. The existing CERN installations are already today a major tourist attraction with up to 170,000 tourists per year before the pandemic. For the FCC operation period, visitor numbers are expected to rise to 300,000 per year inducing further effects for the regional tourism industry.

The intention of this report is to estimate such effects and linkages with a particular focus on the employment sector. These effects during the different project phases and periods described earlier have been estimated using simulations based on existing national economic data for economic sector linkages and the effects they induce. Table 2 shows the summary of the results for world-wide cumulated value added (in mn CHF) and employment (in 1000 person years).

Table 2: **Summary of economic effects and linkages related to FCC construction and operation, cumulated over FCC-related construction and operation 2028-57**[6]

				Cum. value added effects [mn CHF]					Cum. employment effects [1,000 person years]				
				Type1					Type1				
		Investment / consumption volume	Annualised invest./cons. volume	Direct	Indirect	Total Type1	Type2	Sum total	Direct	Indirect	Total Type1	Type2	Sum total
FCC-related investment													
FCC investment	2031-2050	12,097	605	5,350	6,200	11,550	2,550	14,150	80	100	180	50	230
Core phase	2031-2040	10,709	1,071	4,800	5,500	10,300	2,250	12,550	75	90	160	45	210
Upgrade phase	2041-2050	1,388	139	600	650	1,250	330	1,600	7	11	18	7	25
Renewables capacity	2031-2040	644	64	210	290	500	120	600	3	5	9	3	12
FCC-operation													
FCC direct	2041-2057	5,400	180	7,650	-	7,650	-	7,650	170	-	170	-	170
FCC OPEX	2041-2055	2,950	199	1,200	1,500	2,700	800	3,500	13	20	35	15	50
Cost-of-living – resident personnel	2028-2057	9,180	306	4,450	3,150	7,650	11,050	18,700	50	45	95	160	250
FCC visitors	2028-2057	3,900	130	1,400	2,000	3,400	1,800	5,200	20	30	50	25	75
Total	2028-2057	34,200	960	20,300	13,150	33,450	16,350	49,800	340	200	540	250	800

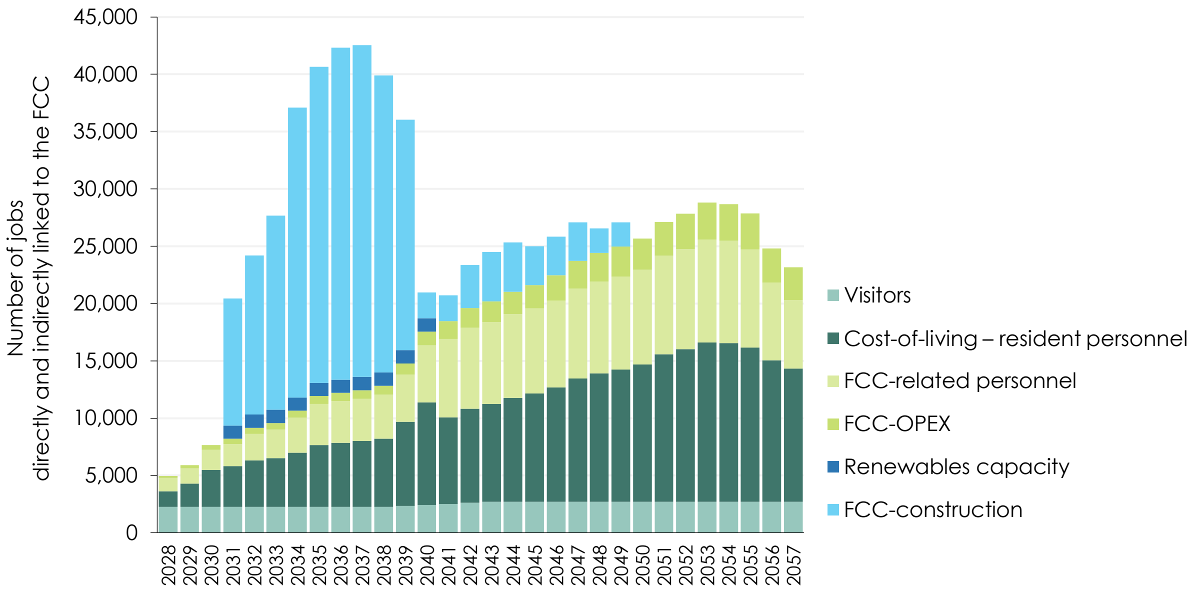
Source: Own calculations with ADAGIO based on CERN data.

Cumulated over the 30 years of FCC-related construction and operation, the economic linkages of 21 bn CHF of construction and operation costs are connected with an estimated

[6] In all tables, simulation results on value added are rounded to the nearest 50 (if value >500) or nearest 10 (if 20 < value <= 500) or 1 (if value <=20). Values on employment are rounded to one decimal. Sums are rounded independently, rounding errors are not compensated.

50 bn CHF of world-wide value added and almost 800,000 person-years of employment opportunities[7] (including the installation of renewables capacity, consumption by resident personnel and visitors). This translates into an average annual value added of almost 1.7 bn CHF and more than 26,000 jobs which are directly or indirectly related to the FCC[8], as Figure 3 shows. This means that in addition to about 6,000 directly project-related science, engineering, administration, and management jobs, more than 20,000 jobs are secured to provide the goods and services for the construction and operation of the FCC, as well as for the goods and services that are consumed by FCC staff and visitors.

Figure 3: **Summary of annual employment effects related to FCC construction and operation; World total**



Source: Own calculations with ADAGIO based on CERN data.

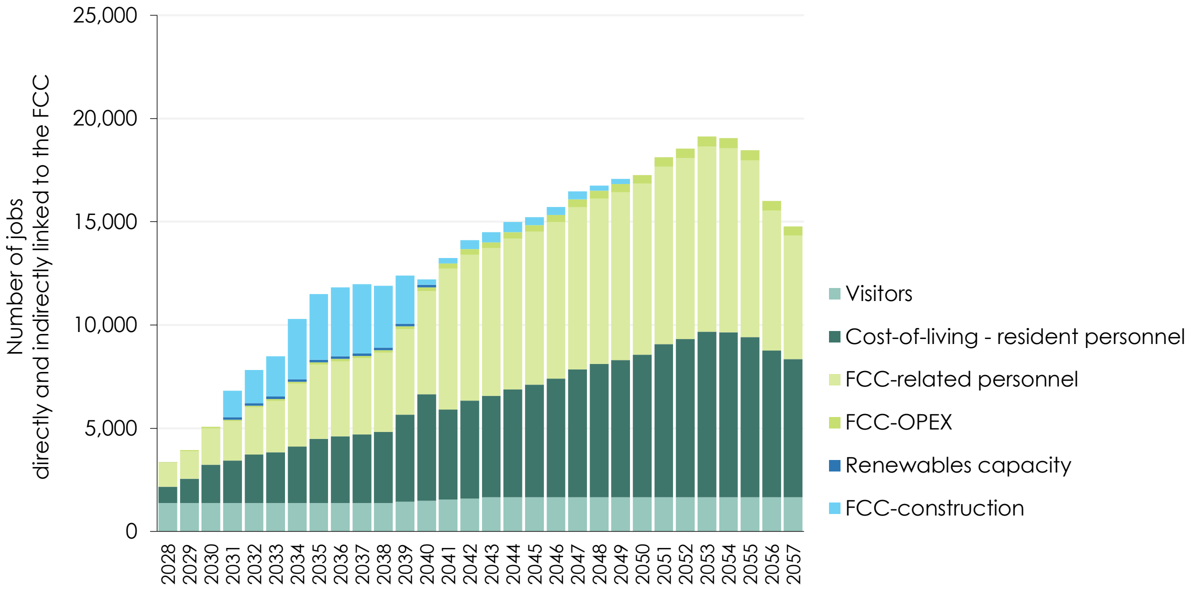
The host countries, Switzerland and France, and especially the canton of Geneva and the "départements" of Ain and Haute-Savoie will benefit most from the FCC, predominantly during operation: direct and indirect effects from the personnel and their consumption as well as the touristic visitors are concentrated in the region; Swiss and French firms will contribute goods and services during construction and operation, although they cannot be attributed to the region

[7] We use the unit "person-years", because these numbers are cumulated over the total period of 30 years; a person-year is the amount of work that fills a job for one year (typically, around 1,700 hours for a full-time job). 100 person-years in a project lasting 10 years, therefore, does not mean that 100 jobs are filled for all of the 10 years; rather, it is 10 jobs that are provided for 10 years (10 jobs for 10 years = 100 person-years).

[8] Person-years can be converted to annual number of jobs using the schedule of annual expenditures over the programme period. For example, 230,000 person-years that are linked to the investment over a period of 20 years represents an average of about 11,500 jobs per year (= 230,000/20). This yields the estimate of jobs depicted in Figure 3.

itself[9]. Put together, around 13,000 jobs will be filled or created on average in France and Switzerland, as Figure 4 shows[10].

Figure 4: **Summary of annual employment effects related to FCC construction and operation; Switzerland and France**



Source: Own calculations with ADAGIO based on CERN data.

The subsequent sections describe the phases and the assumptions for the model simulations in greater detail. Chapter 4 presents the results of the estimation of the jobs and the value added which is linked to the construction and operation of the Future Circular Collider.

[9] ADAGIO is working at the national level and cannot isolate the effects on sub-national regions.

[10] Separate tables detailing the value added and employment effects for France and Switzerland can be found in the appendix.

3. Simulation Setup, Method, and Assumptions

Spending on projects like the FCC represents costs that have to be borne by governments, in this case mainly the CERN member states. The money thus spent represents direct opportunities for sales and employments at firms which provide the necessary goods and services for the project. Due to their locations and the involved value chains the effects will be felt globally. This report estimates such effects together with their regional and sectoral distribution – i.e. the type and intensity of effects that can be expected, by country and economic sector.

Three main groups of effects can be distinguished:

- **Direct effects** through operation of the FCC originate in the R&D sector (CERN related R&D activities are classified in the economic sector NACE[11] M72). Direct effects occur also due to investment and operating costs via purchases of intermediate products at the immediate suppliers to the FCC.
- **Indirect effects** (or "backward linkages") arise at the level of these suppliers in the production of the intermediate or investment goods needed. These firms in turn need inputs from other firms, which again gives rise to further purchases of intermediate products, creating a "global value chain". The sum of direct and indirect effects is labelled **"Type 1"** effects; they work at the level of production.
- Contrary to the production-oriented direct and indirect "Type 1" effects, **induced effects** arise from value added flows: changes in economic activity lead to changes in wages, profits, and taxes. These in turn lead to changes in final demands: higher wages lead to higher consumption; changes in profits give rise to changes in capital[12] owners' income, also feeding into consumption, as well as investment in the case of retained profits or re-investment to offset the capital "used up" in the production process as depreciation. Rising tax receipts can lead to rising public spending at constant budget deficit or reduce budget deficits at constant public spending. All these induced effects (called **"Type 2 effects"**) constitute **multiplier effects**: by working via value added, they amplify the initial direct and indirect effects.

Indirect and induced effects cannot be directly observed. Therefore, an economic model like ADAGIO needs to be used to estimate the effects via model-based simulations[13].

---

[11] NACE (Nomenclature of Economic Activities) is the European statistical classification of economic activities

[12] Notice that in this context, "capital" refers to the stock of *real* capital (mainly machinery, vehicles, buildings, but also licences and software), not "financial capital" as funds of money.

[13] This simulation-based approach can also be used to conceptually separate the different effects, direct, indirect and induced. By holding final demand constant, for example, we can simulate the direct and indirect effects alone. By letting final demand react to changes in value added, we can include induced effects.

ADAGIO – A Global Dynamic Input-Output Model

ADAGIO is an Input-Output model, distinguishing 43 countries (the EU 27 plus 16 of the major economies) and 64 sectors and commodities. At its core, it is a full representation of the flows of goods and services between these 64 sectors in the 43 countries (plus the Rest-of-the-World), tracing out the "global value chains" connected to any (idealized) commodity that is produced or consumed in the model countries. This allows ADAGIO to simulate the effects on output, value added and employment from some "demand shock", new demand that for example arises from the construction of the FCC.

A more in-depth presentation of ADAGIO can be found in the Appendix.

These three types of effects (Type 1: direct, indirect; and Type 2: induced effects) can also be given an idealized chronological interpretation, corresponding to broadening the boundaries of the economic system under investigation: the direct effects are observed at the level of the analysed firm or organization (in this case CERN). The effects are "immediate to short term". With indirect effects, more firms come into play, the time horizon extends to "short to medium term", and the sphere of influence spans the entire production system. Induced effects, then, are medium to long term. In its extreme case they completely close the economic system by making all types of consumption[14] (consumption by households, government and – in the form of depreciation and investment – also firms) endogenously dependent on primary production.

Aiming to estimate the effects on value added and employment linked to such a project exhaustively (i.e., a "complete closure") would cast a too wide net: many of these mechanisms are very long-term. Therefore, we limit ourselves to estimating the induced effects on firms and include replacement investment linked to production; we do not take into account reactions from private and public consumption, as we consider these to be "too long-term" for the duration of the FCC programme. We call these restricted Type 2 effects including depreciation of the investments (i.e., the re-investments) **"Type 2i"**.

An important question arises from assumptions about the origin of investment goods (or operational inputs), which will influence the geographic distribution of the simulated effects. This question will be discussed below; as a consequence, however, the analysis covers two scenarios: one in which the regional destination of direct expenditures is modelled according to the CERN member state contributions ("member shares") and one that follows the historically observed expenditure distribution among nations participating in CERN programmes[15] ("observed shares").

[14] which, ultimately, represent the purpose of all economic activity.

[15] Those two geographic assumptions result in similar total and also sectoral effects at the global level; they are different in the geographical attribution of those sectoral effects.

3.1 Time aspects

Assumptions about different time dependent properties are important inputs for the model. They include, but are not limited to, exchange rates, national productivity figures and interest rates. It is difficult to forecast the evolution of such parameters on the required timescales (2030 to 2060). Therefore, for this study we use average exchange rates and labour productivity figures of 2019[16], without projection into the future. The simplified assumptions can be justified by recalling that the intent of the analysis is not a reliable quantitative forecast of a 30-year project that is launched in fifteen years from now[17], but to estimate the dimensions of the effects linked to a project of such scale if it was to be built today.

[16] The most up-to-date figures available at the time of writing this report were for 2021 in the case of exchange rates and 2020 for productivity numbers. Both years, 2020 and 2021, however, are plagued by the COVID-pandemic with its ensuing economic turmoil, making especially productivity estimates unreliable. Thus, we decided to use 2019 as the base year for these exogenous variables.

[17] Also, the cost estimates are based on current prices.

4. Simulation Assumptions and Results by Project Phase

In this section, we present the input variables and assumptions used for the simulation of the economic linkages with ADAGIO and the results in terms of value added and employment. Cumulated results are not discounted, prices and other time-related economic variables are assumed to be at their pre-pandemic levels in 2019.

4.1 The investment phase 2031-2050

The FCC-related investments are estimated to be around 12 bn CHF, spent over a course of two decades from 2031 to 2050. The first decade will see the construction of the civil engineering structures, the technical infrastructures, and all particle accelerator equipment for the first operation mode. This first part is valued at 10.7 bn CHF, with 89% forming a large share of the total investment volume to be spent in the two decades from 2031. In the second decade, the machine and infrastructures are gradually upgraded following the requirements of the physics research programme, representing an investment of about 1.4 bn CHF.

The investment is broken down into a list of segments which are defined on a technical basis (magnet system, vacuum system, tunnel). Most of these segments do not follow a standard economic classification system such as NACE, the Statistical Classification of Economic Activities in the European Community, Rev. 2 (2008). It is recommended that future cost structures take this classification into account, since it permits integrating expenses with national and international best practices of accounting and economic analysis. Also, ADAGIO, the model used to estimate the economic linkages of the FCC, is based on this industry classification.

To make the two systems compatible, we devised a bridge matrix, with the FCC segments as one dimension and the NACE system as the other (the matrix is documented in the appendix). Multiplying the investment vector of segments with this matrix yields a NACE-consistent investment structure which can then be used in the economic model.

Table 3: **Asset structure of FCC investment**

System	Domain	Start year of investment	Year of completion
Main ring magnet system	Accelerator	2033	2039
Main ring vacuum system	Accelerator	2033	2039
Main ring power converters and cabling	Accelerator	2033	2038
Main ring beam transfer systems	Accelerator	2033	2039
Main ring beam diagnostics	Accelerator	2033	2039
Other main ring (controls, protection)	Accelerator	2033	2039
Injector magnet system	Accelerator	2032	2037
Injector vacuum system	Accelerator	2032	2037
Injector power converts & cabling	Accelerator	2032	2037
Injector beam transfer systems	Accelerator	2032	2037
Injector beam diagnostics	Accelerator	2032	2037
Other injector (controls, protection)	Accelerator	2032	2037
Main and top-up ring RF system (Z)	Accelerator	2035	2039
Main and top-up ring RF system (W)	Accelerator	2042	2044
Main and top-up ring RF system (H)	Accelerator	2041	2047
Main and top-up ring RF system (ttbar)	Accelerator	2041	2049
Cryogenics	Accelerator	2031	2039
Injector w. e+/e- sources	Accelerator	2032	2037
Transfer lines	Accelerator	2033	2038
Adaptation of CERN machines	Accelerator	2032	2037
Electricity infrastructure	Infrastructure	2031	2038
Cooling and Ventilation	Infrastructure	2033	2038
Transport and Installation	Infrastructure	2031	2039
Other tech. infrastructures	Infrastructure	2034	2042
Experiment 1	Experiment	2034	2041
Experiment 2	Experiment	2034	2041
Civil engineering construction	CE	2030	2039
Operation developments	Operation	2042	2053

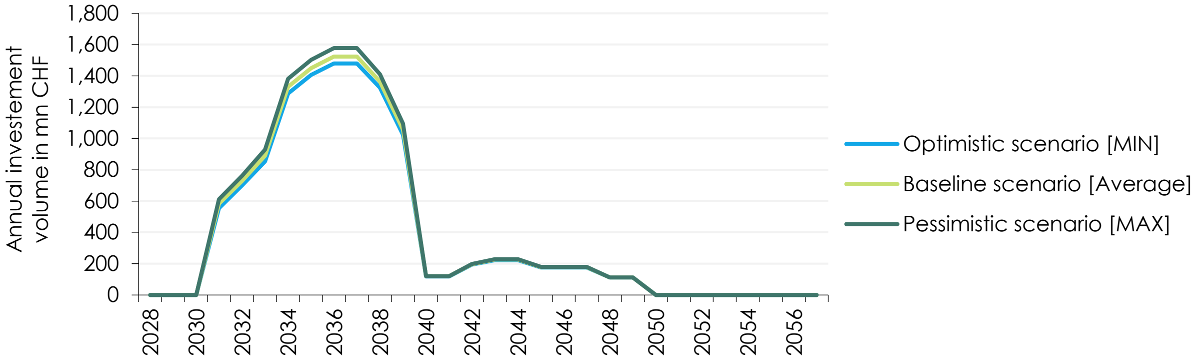
Source: CERN.

The following Figure 5 shows the investment plan. The investments are not evenly spread out over the two decades. After a gradual build-up over five years a plateau with annual outlays of around 1.5 bn CHF is reached (see Figure 5). In this period, which we call "core investment period", the civil structures, technical infrastructures and the particle accelerators are built. Subsequently, annual investment spending drops to around 110-230 mn CHF during the first operation phase that consists of different periods with upgraded machines and infrastructures (the "upgrade investment period").

In addition, three cost scenarios are distinguished: apart from the baseline scenario, an optimistic and a pessimistic cost scenario, with lower resp. higher price assumptions[18].

[18] All price estimates are base year 2019

Figure 5: **Investment chronology**
FCC-ee total capital expenditure – mn CHF



Source: CERN.

We refrained from simulating the exact investment path, as this would result only in apparent "exactness" without providing much additional insight; instead, we distinguish only between the core and the update investment periods.

4.1.1 Sourcing of investment goods

The attempt to estimate the (international) economic effects of such a (regional) investment project requires assumptions about the sourcing of the investment goods, i.e., where investment goods and services will be produced. Form today's perspective it is not possible to reliably establish such a regional sourcing pattern. Instead, we must make explicit assumptions about the origin of the goods and services.

Ideally, the contract volumes awarded to a country would reflect its contribution to the CERN budget – bigger donor countries being awarded bigger contracts. From the point of view of an international organization depending on the contributions from its members, this "fair share" arrangement makes good sense. From an economic point of view, the case is different: big donors are not necessarily home to the firms which are best suited to CERN's needs; also, global value chains can mask the true origin of goods and services. Indeed, the observed shares of CERN's historic procurement volumes have in the past only imperfectly reflected these "fair" shares. Table 4 shows the ratio between a member country's share in procurement contracts to its share in CERN's budget (values > 1 imply that the country has a disproportionately high share of procurement volumes).

Table 4: **Ratio between share in CERN procurement and share in CERN contribution by country, 2017-20**

	Supplies			Industrial services	
	Well balanced	Poorly balanced	Very poorly balanced	Well balanced	Poorly balanced
Austria	1.12				0.09
Belgium		0.54			0.05
Bulgaria	1.06				
Switzerland	4.60			8.40	
Cyprus		0.42			
Czech Republic	1.21				
Germany		0.91			0.13
Denmark		0.42		2.81	
Spain		0.93		1.33	
Finland		0.69			
France	1.14			2.81	
United Kingdom			0.40	0.42	
Greece		0.77			0.29
Croatia		0.40			0.31
Hungary	3.02				
Israel			0.23		
India			0.15		
Italy	1.18				0.39
Lithuania		0.92			
Netherlands	1.04				0.01
Norway			0.28		
Pakistan		0.84			
Poland		0.92			
Portugal		0.82			0.03
Romania	1.06				
Serbia		0.54			
Sweden		0.62			
Slovenia		0.53			
Slovakia	1.35				0.15
Turkey		0.98			
Ukraine		0.57			

Source: CERN, Report on Procurement during the period 1 January to 31 December 2020.

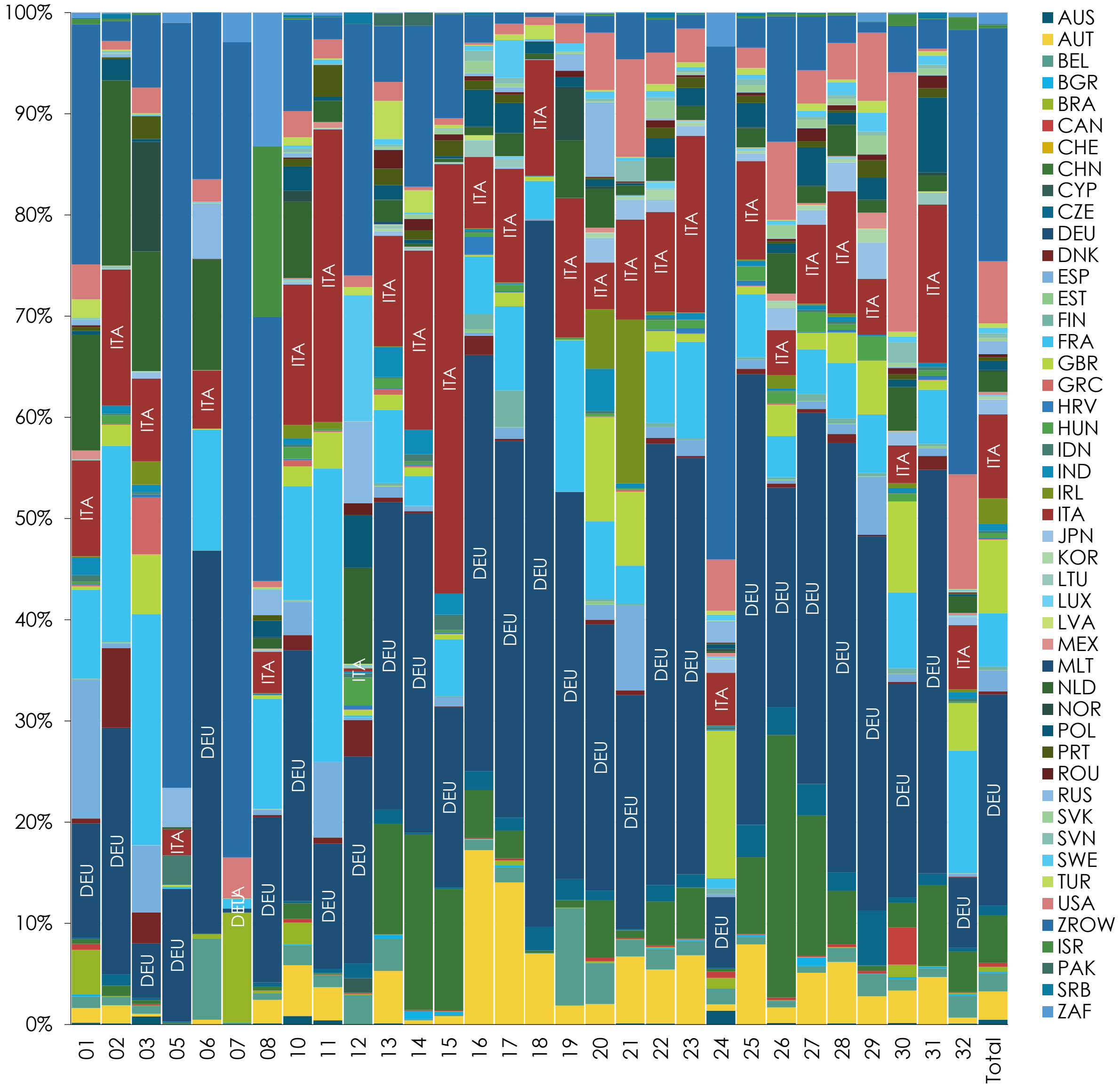
For the purpose of simulation-based estimations of the economic impacts on the employment sector, we therefore consider two scenarios regarding member states' share in total procurement volumes. One is called "fair member shares" and the other is called "observed shares". The first scenario assumes procurement for investments to be based on the member states contributions to CERN and the second scenario reflects procurement patterns as observed in the past. We will present the results of the fair share scenario in detail; the results of the observed share assumption can be found in the appendix.

Having thus estimated the total volume of contracts awarded to a member state, its composition remains to be determined, i.e. which goods and services are included in this total contract volume. As mentioned above, this should be based on a country's economic and technological strengths. To account for this economic specialization of countries, we used trade data to determine the regional pattern of imports into Switzerland[19]. If a country specializes in some commodity, then this should be reflected in an above-average share of this country in Switzerland's imports of this commodity.

The following Figure 6 shows the regional pattern Swiss imports' origin. For example, Germany ("DEU") provides 37% of Swiss imports of NACE class C29, motorcars. This is almost double Germany's share of 21% in the total import of manufactured goods. Thus, for this example, Germany has a sizable competitive advantage in the manufacture of cars.

[19] Geographical proximity is a main driver of trade and imports, but international trade data are available at the national level only (which makes "proximity" hard to asses in the case of a large country). Therefore, we used Switzerland and not France (or a combination of these two), because France is much bigger than Switzerland. Arguably, Geneva's "gravitational field of trading" is much more similar to Switzerland as a whole than France as a whole.

Figure 6: **Origin pattern of Swiss imports of manufactured goods by commodity, 2020**

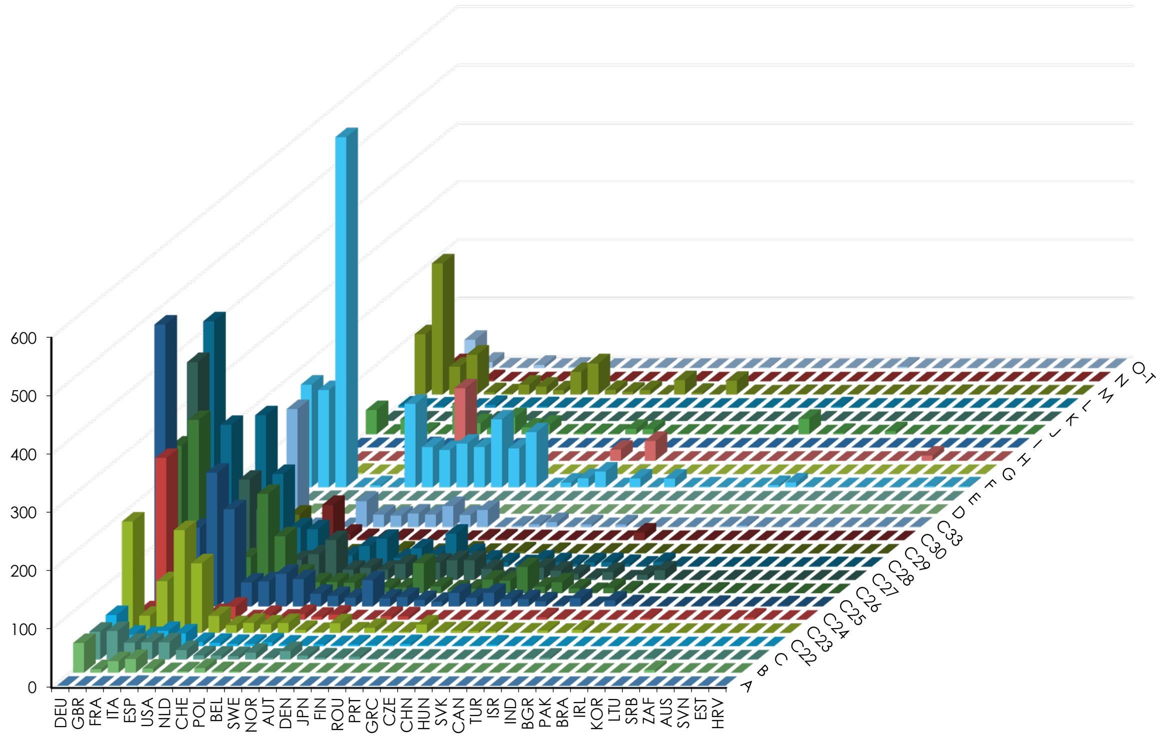


Source: Centre d'Études Prospectives et d'Informations Internationales CEPII, BACI trade data; World Input-Output Data Base WIOD.

Next, the countries' shares in total FCC investment are combined with this specialization pattern to permit modelling a "plausible" sourcing strategy which reflects both a country's economic strengths and its share of investment contracts[20]. Figure 7 shows the result of this two-dimensional alignment.

[20] This is done for both the "fair share" and the "observed share" scenario; the results presented below pertain to the fair share scenario.

Figure 7: **Scenario for FCC contract volumes by region and sector for the construction phase**



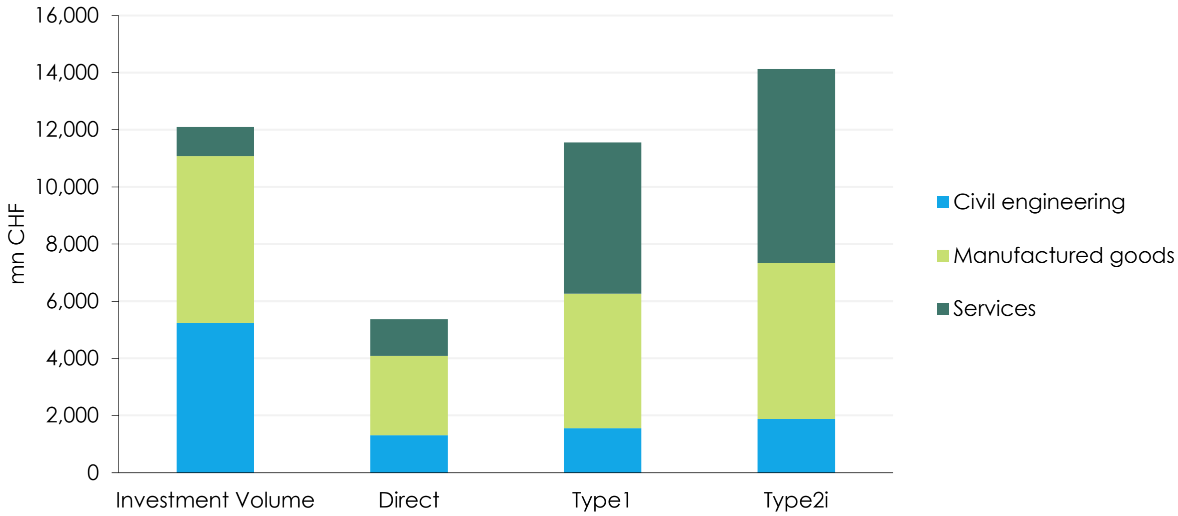
Source: Own calculations with ADAGIO based on CERN data.

Ranked by budget share, in the preliminary modelling, Germany, Great Britain, France and Italy account for more than half (56%) of investment-related contracts. Adding 12 further countries raises this cumulated share to over 90%. Of the 39 countries assumed in the model to contribute to the project, the 12 smallest contributors together account for only about 1% of the contracts.

4.1.2 Investment-related employment and value added linkages

The regional pattern of the economic effects linked to the investment-related contracts (shown in Figure 7) as estimated with ADAGIO roughly follows the contracting pattern, although during the economic cycle, effects tend to spread out both regionally and sectorally. The distribution of direct effects is similar to the contractual distribution, both in the regional and the sectoral dimensions. For indirect effects, this correlation weakens. For induced effects it is even less relevant. As Figure 8 shows, economic effects spread out more as the economic cycle increases, commodity structures are becoming more diverse and less resembling the initial procurement-related direct investment "shock".

Figure 8: **Contract value and global value added effects by type of investment good**



Source: Own calculations with ADAGIO based on CERN data.

At first sight, the results seem puzzling: the rough economic structure of the relative shares of construction, manufactured goods and services[21] changes significantly between the economic cycles. The share of services rises, while the construction industry's share plunges from more than two fifths to less than a seventh. This highlights three phenomena: first, the difference between the purchased amount of some good and the value added directly generated in the production of this good; second, the widening of the sectoral effects along the value chain; third the "exportability" of services.

1. As for the first phenomenon, when purchasing some good, the final price does not only include the costs of the good, but also the transport and trade costs incurred and, as far as applicable to the project[22], any commodity taxes that are levied on top of the net purchase price[23]. As a result, the amount paid for the good can be appreciably smaller than the "sticker price". Additionally, even the amount paid for the good, representing the "output" of the firm from which the good is purchased, is not equal to its value added; intermediate inputs have to be deducted from a firm's output in order to

[21] A detailed table of the sectoral value chain can be found in the appendix.

[22] The international organisation, funded by taxpayer contributions does not pay VAT on goods that are directly related to the construction and operation of its research infrastructures.

[23] Most prominent is "Value added tax" or VAT, a sales tax. Although VAT typically does not apply to the purchases of intermediate or investment goods, there are some instances of commodity taxes that usually cannot be avoided in the production process, like fossil fuel taxes. For some goods, transport and trade costs (so-called "trade and transport margins") can be quite large, accounting for more than half of the final price tag.

determine its valueadded content[24]. In the case of tunnel projects, the difference between output and value added is especially large: typically, the relation between output (or sales) to value added is around half. For tunnel projects around three quarters of the output value consist of intermediate inputs; only the remaining quarter constitutes value added, i.e. wages, depreciation and profits. Therefore, the construction industry commands a much higher share of the FCC-related investment volume than in the value added linked to this investment.

2. The second phenomenon can best be illustrated with the tunnel that is planned to house the colliders: as an investment commodity, it is purchased from the construction sector (NACE class F). Thus, the direct effects (both output and value added) accrue almost exclusively to this sector. To build the tunnel, however, the construction firms need to buy inputs from a wide range of firms from other sectors – for example intermediate products from construction materials producers (class C23) and steel producers (class C24), investment goods from manufacturers of construction machinery (class C28) and heavy vehicles (class C30). As is true for all other economic investment "shocks", the indirect effect of the construction works spread over significantly more sectors than the original investment bundle[25].
3. The rising share of services along the value chain illustrates the role services play in an open economy. Typically, exports are of minor importance for the service sectors, for them the "home market" is of much more importance than for manufactured goods[26]. Services, however, are important inputs for the export-oriented manufacturing industries. In this way, even purely domestic services "piggyback" on the export of manufactured goods.

The regional aspects lead to a corresponding picture: again, the shares of the contributing countries change markedly along the economic cycle; even countries with rather small or zero direct contracts can and will benefit from the knock-on effects in later stages of the value chain. China, for example, despite a hypothetical contractual volume of less than 100 mn CHF in the studied scenario (less than 1%), enjoys almost 4.5% of the Type2 "induced" effects[27].

[24] Otherwise, in adding up the different stages along the value chain, double counting would artificially inflate the grand total, as the value of intermediate purchases would be counted both as output of the provider and as part of the output of the buyer (inputs are part of his output). Therefore, economics' probably best-known indicator, Gross Domestic Product or GDP, is derived from an economy's total value added, not its total output.

[25] A similar argument can be found for the widening of the regional structure: whereas a certain commodity may be purchased from a single country, some inputs used in its production will certainly be imported from third countries. In a globalized production system, at least in the case of manufactured products, the value chain of any one commodity will contain at least a tiny element from probably every country in the world.

[26] For example in Austria, around 64% of manufactured goods end up being exported, whereas this share is only 12% even for market services. The reasons for this are manifold, from goods being much more fungible than services to issues to do with trade agreements. Also, some public and personal services cannot be exported by definition, but have to be consumed at the point of production (public administration or a haircut, say)

[27] Incidentally, this is the highest "multiple" of the countries with direct contracts, illustrating the important role China plays in the world economy.

Table 5: **Contract value and economic effects by country, 2030-50 construction phase**[28]

			Value added [mn CHF]					Employment [1,000 person years]				
			Type1					Type1				
		Investment volume	Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total		**12,097**	**5,350**	**6,200**	**11,550**	**2,550**	**14,150**	**80**	**100**	**180**	**50**	**230**
DEU	Germany	2,332	1,050	1,100	2,150	380	2,500	13	13	25	4	30
GBR	Great Britain	1,774	900	700	1,550	220	1,800	10	9	19	3	20
FRA	France	1,563	850	650	1,500	270	1,800	12	8	20	3	25
ITA	Italy	1,154	390	550	950	210	1,150	5	7	12	3	15
ESP	Spain	795	290	340	650	130	750	5	6	10	2	12
USA	USA	556	270	380	650	180	850	2	3	5	1	6
NLD	Netherlands	510	220	260	490	75	550	3	3	6	1	7
CHE	Switzerland	464	190	190	380	70	450	2	2	3	1	4
POL	Poland	312	150	170	310	50	360	4	5	9	1	10
BEL	Belgium	300	130	150	280	45	330	2	1	3	0	3
SWE	Sweden	293	150	130	280	65	350	1	1	3	1	3
NOR	Norway	259	140	140	270	35	310	1	1	2	0	3
AUT	Austria	242	100	95	200	45	240	1	1	2	0	2
DEN	Denmark	197	100	80	180	20	200	1	1	2	0	2
JPN	Japan	185	65	130	190	75	270	1	2	3	1	4
FIN	Finland	148	60	60	120	20	140	1	1	1	0	1
ROU	Romania	123	45	60	100	19	120	2	2	4	1	4
PRT	Portugal	122	50	45	95	13	110	2	1	3	0	3
GRC	Greece	118	55	40	90	7	100	2	1	3	0	3
CZE	Czech Republic	111	40	70	110	30	140	1	2	3	1	4
CHN	China	93	16	260	280	350	650	1	12	12	16	30
HUN	Hungary	72	30	30	60	12	70	1	1	2	0	2
SVK	Slovakia	55	13	25	35	9	45	0	1	1	0	1
CAN	Canada	46	19	60	80	25	100	0	1	1	0	1
TUR	Turkey	46	15	65	80	30	110	1	3	3	1	5
ISR	Israel	46	14	5	18	2	20	0	0	0	0	0
IND	India	46	0	30	30	17	50	0	4	4	3	7
BGR	Bulgaria	35	11	13	25	4	30	1	1	2	0	2
PAK	Pakistan	19	12	8	20	4	25	3	1	4	1	5
BRA	Brasil	9	0	30	30	13	40	0	1	1	1	2
IRL	Ireland	9	0	20	20	7	25	0	0	0	0	0
KOR	Korea	9	3	35	40	30	70	0	0	0	0	1
LTU	Lithuania	9	4	6	10	2	11	0	0	0	0	0
SRB	Serbia	9	3	2	6	1	7	0	0	0	0	0
ZAF	South Africa	9	4	3	7	1	8	0	0	0	0	0
AUS	Australia	9	3	19	20	13	35	0	0	0	0	0
SVN	Slovenia	9	4	9	13	3	16	0	0	0	0	0
EST	Estonia	3	1	3	4	1	5	0	0	0	0	0
HRV	Croatia	3	0	2	2	1	3	0	0	0	0	0
RoW	Rest-of-World	0	0	220	220	85	310	0	8	8	4	12

Source: Own calculations with ADAGIO.

[28] Sums are rounded independently, rounding errors are not compensated.

In total, the original investment volume of 12.1 bn CHF **directly** generates 5.4 bn CHF of global value added, securing almost 80,000 person-years of employment[29]. Including the **indirect** effects in the production process, value added linked to the FCC investment rises to 11.6 bn CHF, leading to 180,000 person-years of employment. Widening the system boundaries to include depreciation (or capital consumption, i.e. the capital stock firms need to build up or replenish in order to cope with the FCC-related production), the FCC-related value added grows to more than 14 bn CHF and leads to more than 230,000 person-years of employment opportunities.

The main economic effects are enjoyed by Germany, the UK, France, Italy and Spain (64% of value added due to direct contracts and 57% together with indirect and Type2 value added effects). Due to superior productivity, in terms of employment the effects are slightly less pronounced (57% of direct effects on the job market and 45% together with indirect and Type2 effects).

Effects expand along the sectoral dimension as well, as Table 6 shows.

The construction sector is the most beneficiary one, since almost half of the investment volume can be attributed to civil engineering. Along the cycle, however, its share steadily falls and most other sectors' shares rise. As can be seen in Table 6, this is especially true for services (sectors G to T), whose combined share rises from 22% of the direct value added to 43% of the Type 2i effects. The diagram in Figure 9 shows the expansion of effects along both the regional and sectoral dimensions.

[29] As we refrain from annually distributing the project volume over the investment period, the estimated value added can be interpreted as total value added which is generated by the project. Employment effects, however, have to be interpreted not as number of jobs but as "person-years". Thus, if the investment period were 10 years with uniform annual investment volumes, the annual direct effect would be 5.327/10 = 533 mn CHF of annual value added with 79 k/10 = 7.9 k jobs linked to this production volume.

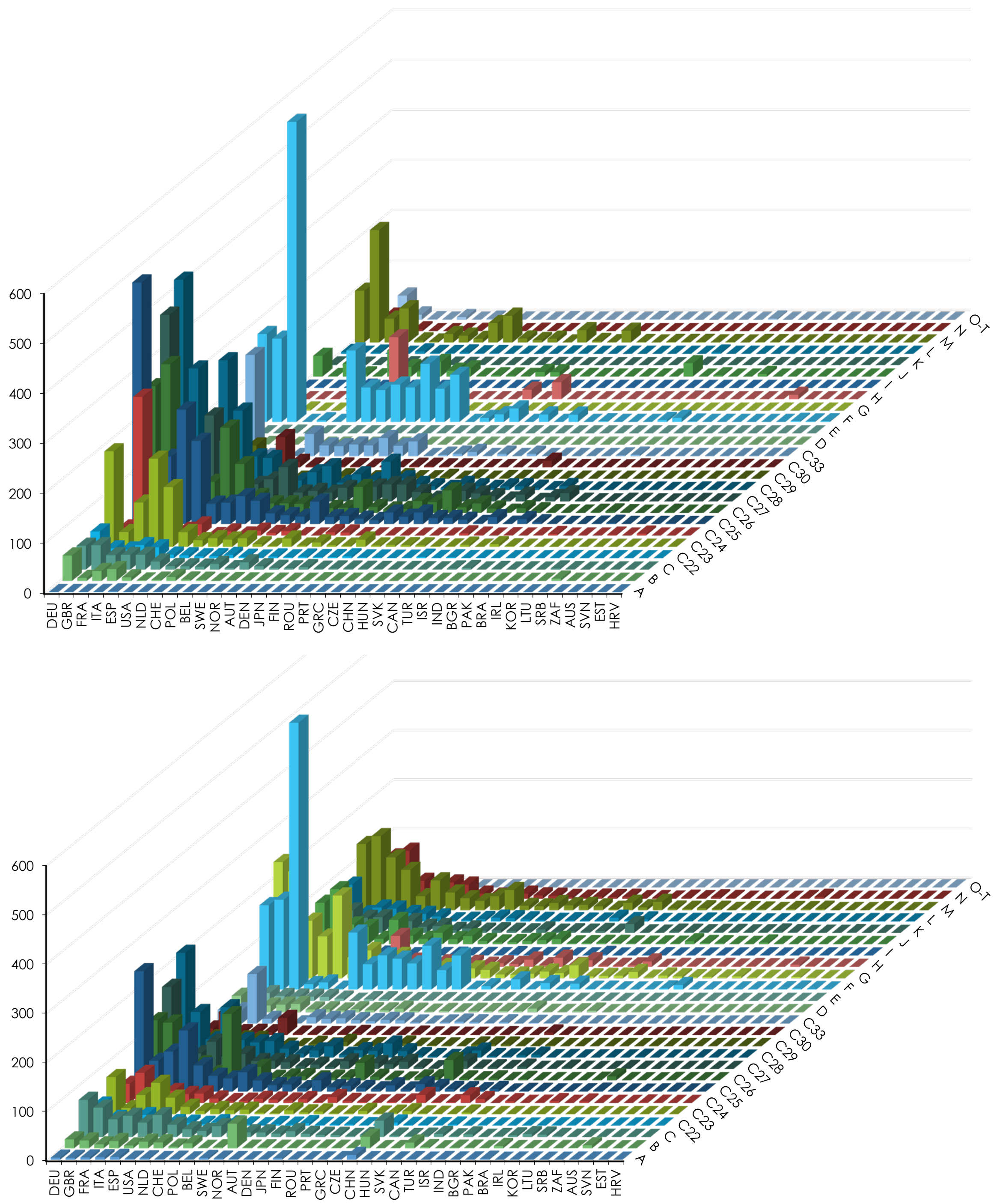
Table 6: **Contract value and economic effects by sector, 2030-50 construction phase**[30]

			Value added [mn CHF]					Employment [1,000 person years]				
			Type1					Type1				
Economic sector		Investment volume	Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total		**12,097**	**5,350**	**6,200**	**11,550**	**2,550**	**14,150**	**80**	**100**	**180**	**50**	**230**
A	AGRICULTURE, FORESTRY AND FISHING	6	5	55	60	25	85	0	5	5	3	8
B	MINING AND QUARRYING	136	55	220	270	70	350	0	2	2	1	3
C	MANUFACTURING	287	120	410	550	130	650	2	7	9	3	13
C22	Manufacture of rubber and plastic products	199	65	110	180	25	210	1	2	3	1	4
C23	Manufacture of other non-metallic mineral products	781	220	110	330	35	360	3	2	5	1	6
C24	Manufacture of basic metals	424	85	240	330	50	380	1	4	5	1	6
C25	Manufacture of fabricated metal products	1,554	500	340	850	70	900	8	6	14	2	16
C26	Manufacture of computer, electronic, optical prod.	1,443	500	180	700	80	750	4	2	6	1	7
C27	Manufacture of electrical equipment	1,437	390	140	500	40	550	5	2	8	1	9
C28	Manufacture of machinery and equipment n.e.c.	1,698	550	200	750	160	900	6	3	9	3	12
C29	Manufacture of motor vehicles, trailers	184	75	85	160	80	240	1	1	2	1	3
C30	Manufacture of other transport equipment	284	100	45	140	30	170	1	0	1	0	2
C33	Repair and installation of machinery and equipment	555	180	70	250	35	280	2	1	3	1	4
D	ELECTRICITY, GAS, STEAM SUPPLY	2	14	160	170	35	210	0	1	1	0	1
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT	4	8	95	100	12	120	0	1	1	0	1
F	CONSTRUCTION	1,798	1,300	240	1,550	330	1,900	25	4	30	10	40
G	WHOLESALE AND RETAIL TRADE	9	490	800	1,300	290	1,600	8	16	25	7	30
H	TRANSPORTATION AND STORAGE	196	100	450	550	100	650	2	8	10	2	12
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	4	3	55	55	16	70	0	2	2	1	2
J	INFORMATION AND COMMUNICATION	277	200	280	480	230	700	2	3	5	2	7
K	FINANCIAL AND INSURANCE ACTIVITIES	10	10	290	300	85	390	0	2	2	1	3
L	REAL ESTATE ACTIVITIES	26	20	240	260	80	340	0	1	1	0	1
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	660	210	650	850	340	1,200	3	9	11	4	16
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	41	30	490	500	100	650	0	10	11	2	13
O-T	PUBLIC & OTHER SERVICES	80	130	230	360	120	480	3	5	8	3	11

Source: Own calculations with ADAGIO based on CERN data.

[30] Sums are rounded independently, rounding errors are not compensated.

Figure 9: **FCC contracts and type2-effects by region and sector, construction phase**

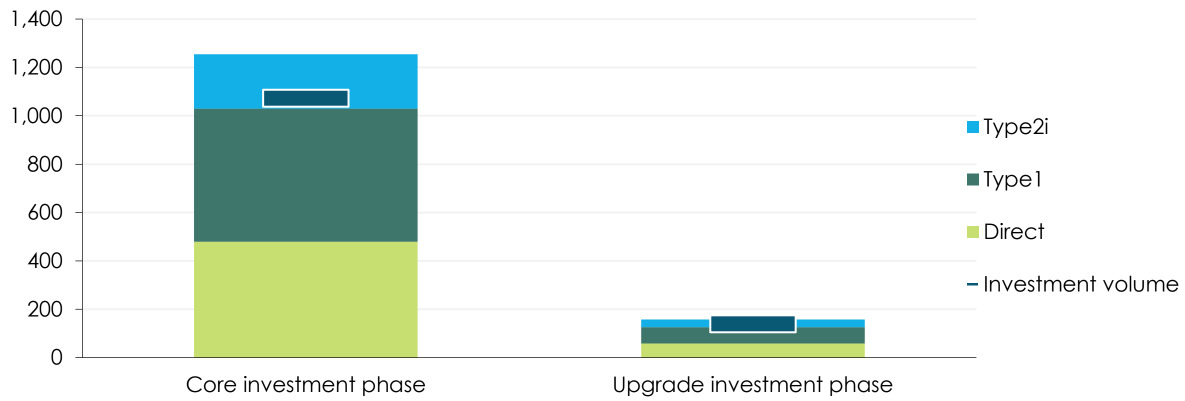


Source: CERN; WIFO calculations with ADAGIO.

These sectoral results cannot be interpreted as particularly "high-tech" when using the OECD's classification of sectors according to their technological content (which lists only sectors C21, pharmaceuticals, and C26, computers and electronics, as high-tech sectors): only 4.5% of the investments flow directly into these sectors. However, this does not do justice to the true nature of the FCC endeavour. Rather than relying on high-tech components according to the common definitions, the FCC pushes the technology of many sectors to their limits (and beyond), for instance in the metal sector (usually considered medium-low-tech) or electrical and mechanical sector for ultra-high vacuum systems. Even the "down-to-earth" construction sector will face technologically intense developments connected to a project on the FCC scale[31].

The total investment period of around two decades is split into two very distinct phases (see Chapter 4.1 above). Here we will briefly present the implications for the economic linkages of these two phases.

Figure 10: **Annualized value added effects of the investment phases**



Source: Own calculations with ADAGIO based on CERN data.

Figure 10 shows the levels of the average annual investment volume and the total direct, indirect and induced effects on value added for the core investment period and for the upgrade period. The effects are reported in terms of million CHF. The effects are significantly larger during the core investment phase than during the upgrade investment phase, with more than 1 bn CHF in the first vs. around 140 mn CHF in the second phase.

4.2 The operation phase 2041-2055

The operation phase requires a very different mix of labour and intermediate inputs compared to the investment phase. Total costs, however, are still considerable: assuming an average annual FCC-related wage bill of 180 mn CHF for personnel involved in the project plus annual

[31] To put the size of the FCC into perspective: currently, only two water tunnels in the US and Finland, at 137 km and 120 km, are longer than the tunnel housing the FCC. The 57 km Gotthard Base railway tunnel is among the longest non-water tunnels ever built (see https://en.wikipedia.org/wiki/List_of_longest_tunnels).

intermediate inputs of 199 mn CHF, over a 15-year long research programme (undiscounted) cumulated costs will be 5.7 bn CHF, half the investment volume. The overall mix between labour and intermediate inputs, as well as the commodity structure of the intermediates, will be different.

During the operation phase, economic linkages arise from on-site and off-site aspects:

1. As a major host of employment[32] in the region, CERN produces direct value added and employment.
2. OPEX occur due to the operation of the particle collider encompassing a wide range of different spending types such as maintenance, repair, electricity, water, gases, administration, security, site maintenance and much more.
3. The wages paid to personnel involved in the FCC research programme will to a large part be spent on consumption.
4. The FCC is considered to be a major tourist attraction with corresponding benefits for the regional tourism industry in France and Switzerland.

As these aspects work through different routes, the economic linkages will be dealt with separately.

4.2.1 Direct effects from FCC operation

The operation of the FCC generates value added by paying wages and social security contributions and through the depreciation of the FCC investment[33]. No (net) operating surplus is considered since CERN, as a purely scientific research organization, is not profit-oriented. The outputs of this activity, e.g. the generation of scientific products, are considered in a general societal impact study that is carried out in the FCC feasibility study by the Centre for Industrial Studies (CSIL, Milano, Italy) in the framework of a H2020 co-funded EU project. A "correct" depreciation rate for an infrastructure like the FCC is hard to estimate[34]. However, the FCCIS H2020

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[32] The economic effects on the employment sector do not distinguish between personnel that is directly employed by CERN or by personnel that is employed by organizations which dispatch their personnel to CERN. The analysis only distinguishes direct effects (persons working on the project), indirect effects (persons required to fulfill the upstream requirements of the project) and induced effects (persons that are employed to satisfy the consumption of employees or the investment of firms linked to the FCC project).

[33] In national accounting, a firm's value added is the difference between its sales (output, turnover) and its purchases of intermediate products (goods and services which are used in the production of its own products). Value added, then, is the value that is added by a firm's workers and its owner(s) to the cost of these intermediate inputs; it consists of two main components – the part going to workers (as wages and social security contributions), and the part remaining for the owner(s) of the firm, as gross operating surplus. To earn this operating surplus, the owner(s) have to provide capital. This "capital stock" (machines, buildings, etc.), however, loses value, through wear and tear, but also simply by getting older. Deducting this "depreciation of capital" from gross operating surplus yields net operating surplus, or what is commonly called "profits" – the owners' income.

[34] Not least because the usual definition of "depreciation" used in National Accounting is usually market based; as it is put in Wikipedia, "In economics, **depreciation** is the gradual decrease in the economic value of the capital stock of a firm, nation or other entity, either through physical depreciation, obsolescence or changes in the demand for the services of the capital in question", a concept which cannot easily be applied to a purely scientific endeavor like the

EU project[35], assumes a "Social Discount Rate" for the project that has been established at 2.27% per year. This rate is used to determine the residual asset value of those assets that are considered to be of value for the subsequent hadron collider (FCC-hh) phase according to the EU ESFRI guidelines for research infrastructures[36]. The cumulative residual asset value at the end of the physics research operation phase accounts to about 3.7 bn CHF.

For the purpose of estimating the direct value added generated by the operating of the FCC, we apply above rate, which estimates annual depreciation at 12,097 x 0.0227 = 274 mn CHF[37]. Adding personnel costs of 180 mn CHF per year[38], the direct value added is estimated at around 450 mn CHF per year.

The sectoral classification of this value added is in NACE class M72 ("Scientific Research and Development"). The regional attribution of this value added is more contentious: as an international organization, CERN does not fall under the remit of the national statistical offices of either Switzerland or France, thus does not directly count towards either of these two countries' Gross Domestic Product (GDP). For the purposes of this analysis, we will split its value added evenly between France and Switzerland.

4.2.2 Indirect effects of the operation phase

For the operation of the FCC, a mix of inputs (intermediate goods and services) is needed, whose procurement will provide suitable firms with the opportunity for sales and employment. In estimating these effects, the necessary assumptions about the commodity structure of these inputs are based on the current inputs for the LHC, as presented in Table 7.

At 80 mn CHF, around About 40% of the total average annual budget of almost 200 mn CHF relate to electricity procurement. This is a simplified assumption for the employment estimates since the annual electricity needs vary significantly between the different operation modes throughout the 15 years long research programme. Compared with the investment vector, the intermediate inputs are much more related to services.

The economic linkages of the operational inputs can be estimated as well. Again, the "member share" assumption is applied for the regional distribution of the inputs' origin – each member country is assumed to be awarded contracts to supply the FCC operation in proportion to its

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FCC. Assuming a depreciation rate of 2.27% period of 50 years for the engineering part (i.e. the tunnel), and 20 years for the accelerator itself, annual depreciation of the 12 bn CHF investment is around 380 mn CHF per year.

[35] FCCIS deliverable "Plan for research infrastructure socio-economic impact analysis", downloadable at https://cordis.europa.eu/project/id/951754/results

[36] https://www.esfri.eu/latest-esfri-news/new-study-guidelines-cost-estimation-research-infrastructures-str-esfri

[37] Which is appreciably lower than CERN's current depreciation according to its financial statements (which is around 500 mn CHF). The exact value of the FCC's depreciation, however, is of secondary importance to the analysis presented here, because the economic effects of the FCC's investment are explicitly estimated (and, therefore, depreciation has no further importance beyond the estimate of CERN's direct value added).

[38] These are the wages of up to 2,000 CERN staff dedicated to the FCC. In addition. Up to 9,000 temporary scientists and other staff are estimated to work at the FCC, but being paid by their (mostly academic) home institutions.

budget contribution[39]. The content of the contracts is again co-determined by the economic specialization of the supplying countries. Table 8 summarises the simulation results on regional value added and employment for the operation phase.

Table 7: **Estimation of the annual material expenses related to the FCC operation phase**

	Average 2019/20	FCC-ee assumption	Comments
	In unit		
Goods, Consumables etc	**78,963**	**80,325**	
Civil engineering and buildings	6,720	5,000	Repair and maintenance of tunnels and buildings
Electronics and electrical engineering	16,083	12,800	Current CERN expenditures used as approximation
Gases and chemicals	3,599	110	Lhe and lN cryogens. Other gases may be required.
Health, safety and environment	3,398	2,800	Current CERN expenditures used as approximation
Information technology	15,138	12,000	Current CERN expenditure as approximation
Low temperature	2,970	3,000	Maintenance and repair of cryogenic systems
Magnets	4,418	3,500	Maintenance and repair of magnet systems
Measuring instruments	1,813	3,300	All types of beam diagnostics systems
Mechanical engineering and raw materials	17,998	16,000	Includes cooling and ventilation systems
Office supply and equipment	1,630	1,200	Current CERN expenditures used as approximation
Optics and photonics	1,030	900	Current CERN expenditures used as approximation
Other supplies	83	200	Current CERN expenditures used as approximation
Particle and photon detectors	644	10,000	Maintenance, repair of two experiments
Radiation equipment	46	15	Current CERN expenditures used as approximation
Radiofrequency systems		2,500	
Transport, handling and vehicles	1,584	3,000	
Vacuum and particle detection equipment / supplies	1,896	4,000	
Stock variation	–86		
Electricity (average annual cost)	**23,493**	**80,000**	From renewable energy sources
Water (average annual cost)		**5,000**	Mainly for refrigeration purposes (made explicit for FCC-ee)
Industrial Services	**72,521**	**25,000**	
Of which:			
Service contracts	44,463	25,000	Includes about 5.38 mn CHF of water supply
Other Overheads total	**46,154**	**8,410**	
Of which:			
Communication	1,065	1,000	
Insurance	3,476	3,000	
Training	2,801	1,000	
Transport	1,613	500	
Visits and conferences	1,523	2,910	Workshop and conference organisation in FCC-ee collaboration
Total	**221,130**	**198,735**	

Source: Assumptions based on CERN Financial Statements for 2019 and 2020[40].

[39] This is more contentious than in the case of investments, because operation expenditure is heavier on services; therefore, they are less tradeable and more localised. Therefore, the estimates include the two scenarios, "fair share" and "observed share" (the results for "observed share" can be found in the appendix).

[40] See https://cds.cern.ch/

Table 8: **Regional economic linkages of FCC's operating phase – intermediate inputs**[41]

			Value added [mn CHF]					Employment [1,000 person years]				
			Type1					Type1				
		Investment volume	Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total		**199**	**80**	**100**	**180**	**55**	**230**	**0.9**	**1.5**	**2.3**	**1.0**	**3.4**
DEU	Germany	38	15	18	35	8	40	0.1	0.2	0.3	0.1	0.4
GBR	Great Britain	29	16	10	25	4	30	0.2	0.1	0.4	0.1	0.4
FRA	France	26	8	11	19	8	25	0.0	0.1	0.1	0.1	0.2
ITA	Italy	19	7	9	16	4	20	0.1	0.1	0.2	0.1	0.2
ESP	Spain	13	5	5	10	2	12	0.1	0.1	0.2	0.0	0.2
USA	USA	10	5	6	11	3	14	0.0	0.0	0.1	0.0	0.1
NLD	Netherlands	8	3	4	8	2	9	0.0	0.0	0.1	0.0	0.1
CHE	Switzerland	8	2	4	6	2	8	0.0	0.0	0.0	0.0	0.1
POL	Poland	5	2	2	5	1	5	0.1	0.1	0.1	0.0	0.1
BEL	Belgium	5	2	2	4	1	5	0.0	0.0	0.0	0.0	0.0
SWE	Sweden	5	2	2	4	1	5	0.0	0.0	0.0	0.0	0.0
NOR	Norway	4	2	3	5	1	6	0.0	0.0	0.0	0.0	0.0
AUT	Austria	4	1	2	3	1	4	0.0	0.0	0.0	0.0	0.0
DEN	Denmark	3	1	1	3	1	3	0.0	0.0	0.0	0.0	0.0
JPN	Japan	3	1	2	3	1	4	0.0	0.0	0.0	0.0	0.1
FIN	Finland	2	1	1	2	0	2	0.0	0.0	0.0	0.0	0.0
ROU	Romania	2	1	1	2	0	2	0.0	0.0	0.0	0.0	0.1
PRT	Portugal	2	1	1	2	0	2	0.0	0.0	0.0	0.0	0.0
GRC	Greece	2	1	1	2	0	2	0.0	0.0	0.0	0.0	0.0
CZE	Czech Republic	2	1	1	2	1	2	0.0	0.0	0.0	0.0	0.0
CHN	China	2	0	3	4	6	10	0.0	0.2	0.2	0.3	0.4
HUN	Hungary	1	0	0	1	0	1	0.0	0.0	0.0	0.0	0.0
SVK	Slovakia	1	0	0	1	0	1	0.0	0.0	0.0	0.0	0.0
CAN	Canada	1	0	1	1	0	2	0.0	0.0	0.0	0.0	0.0
TUR	Turkey	1	0	1	1	1	1	0.0	0.0	0.0	0.0	0.1
ISR	Israel	-	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
IND	India	1	0	0	0	0	1	-	0.1	0.1	0.1	0.1
BGR	Bulgaria	1	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
PAK	Pakistan	-	0	0	0	0	0	0.0	0.0	0.0	0.0	0.1
BRA	Brasil	0	0	0	0	0	1	-	0.0	0.0	0.0	0.0
IRL	Ireland	0	0	0	0	0	1	-	0.0	0.0	0.0	0.0
KOR	Korea	0	0	0	1	1	1	0.0	0.0	0.0	0.0	0.0
LTU	Lithuania	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
SRB	Serbia	-	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
ZAF	South Africa	-	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
AUS	Australia	0	0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
SVN	Slovenia	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
EST	Estonia	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
HRV	Croatia	0	0	0	0	0	0	-	0.0	0.0	0.0	0.0
RoW	Rest-of-World	0	0	5	5	2	7	0.0	0.2	0.2	0.1	0.2

Source: Own calculations with ADAGIO based on CERN data.

[41] Sums are rounded independently, rounding errors are not compensated.

As with the investment effects, the main beneficiaries are again Germany, the UK, France, Italy, and Spain with a combined 63% of contracts, and 56% of total effects (Type 1 plus 2i) in value added (125 mn CHF out of a global total of 230 mn CHF). Their share of employment effects, at 42% of total effects of 3,400 person years, is appreciably smaller, due to their superior productivity.

Table 9: **Sectoral economic linkages of FCC's operating phase – intermediate inputs**[42]

			Value added [mn CHF]					Employment [1,000 person years]				
			Type1					Type1				
	Economic sector	Investment volume	Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total		**199**	**80**	**100**	**180**	**55**	**230**	**0.9**	**1.5**	**2.3**	**1.0**	**3.4**
A	AGRICULTURE, FORESTRY AND FISHING	0	0	1	1	0	1	0.0	0.1	0.1	0.1	0.1
B	MINING AND QUARRYING	0	0	6	6	1	7	0.0	0.0	0.0	0.0	0.1
C	MANUFACTURING	63	19	20	40	17	55	0.3	0.3	0.6	0.3	0.9
D	ELECTRICITY, GAS, STEAM SUPPLY	70	25	12	35	1	35	0.1	0.1	0.1	0.0	0.1
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT	16	8	2	10	0	10	0.1	0.0	0.1	0.0	0.1
F	CONSTRUCTION	5	2	3	5	8	13	0.0	0.1	0.1	0.2	0.3
G	WHOLESALE AND RETAIL TRADE	0	4	10	14	6	20	0.1	0.2	0.3	0.1	0.4
H	TRANSPORTATION AND STORAGE	2	1	6	7	2	9	0.0	0.1	0.1	0.0	0.2
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	1	1	1	1	0	2	0.0	0.0	0.0	0.0	0.1
J	INFORMATION AND COMMUNICATION	20	10	6	16	5	20	0.1	0.1	0.2	0.0	0.2
K	FINANCIAL AND INSURANCE ACTIVITIES	3	2	5	7	2	9	0.0	0.0	0.1	0.0	0.1
L	REAL ESTATE ACTIVITIES	0	0	4	4	2	6	0.0	0.0	0.0	0.0	0.0
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	5	3	10	13	6	19	0.1	0.1	0.2	0.1	0.3
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	9	4	8	12	2	15	0.1	0.2	0.3	0.0	0.3
O-T	PUBLIC & OTHER SERVICES	4	4	5	9	2	11	0.1	0.1	0.2	0.1	0.2

Source: Own calculations with ADAGIO based on CERN data.

By sector, the highest direct effects are expected in electricity, manufacturing, and information/communication; via induced effects (investments at the suppliers), construction, (professional) services and trade benefit from FCC operation.

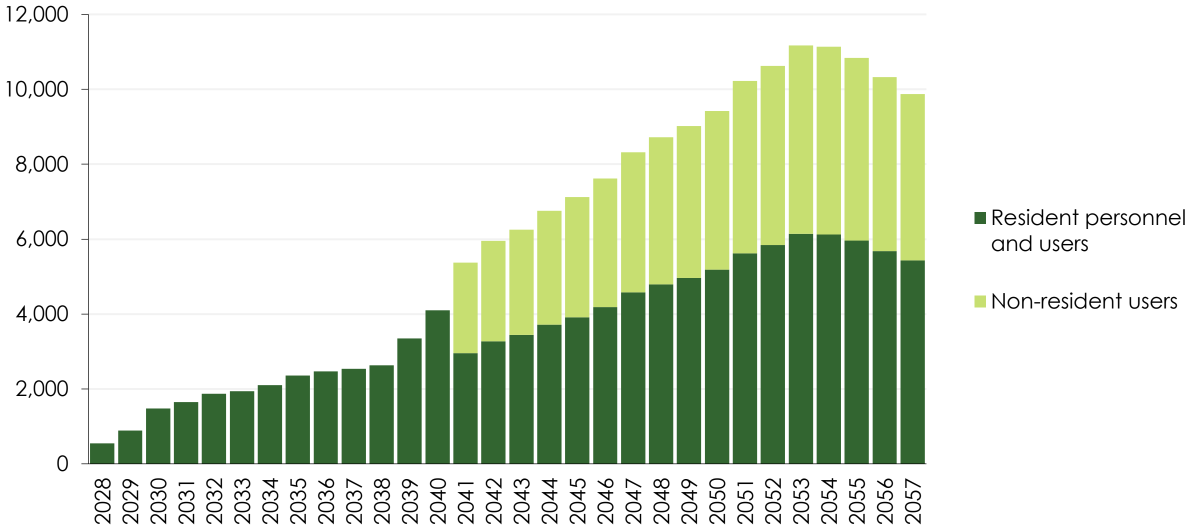
4.2.3 Economic effects linked to the wages and consumption of FCC-related personnel

Even if the regional attribution of the FCC operation related direct value added is contentious, the resident scientific, engineering, technical, administration and management employees associated to the programme live in the French-Swiss border region. Their consumption expenditures positively impact the region, leading to pronounced local economic effects. The tentative figure of direct project associated personnel evolves over time as shown in Figure 11 below.

[42] Sums are rounded independently, rounding errors are not compensated.

Part of these people are considered residents in France and in Switzerland ("Resident personnel and users" in Figure 11), while another part is considered to live in the region for limited periods of time ("Non-resident users").

Figure 11: **Potential employment path during FCC construction and operation**



Source: Assumption of personnel active in the FCC-ee project, socio-economic impact studies for FCC carried out in the frame of the FCCIS H2020 co-funded EU project.

During the design and construction phases, the number of FCC-related personnel (both from CERN and external persons) assumed to be present at CERN reaches about 4,100, numbering 2,150 on average. During the operation phase, this number is envisaged to grow to about 11,000 due to the increased presence of experiment collaboration members, also known as "users", carrying out the scientific research[43]. Only a fraction of these people is assumed to be directly employed by CERN or local programme-related organisations. On average, 7,100 external persons will be working at the experiments. Typically, they will be employed by their home institutes or companies. For the model simulations, we assume that 100% of the people associated with the project will be residents during the design and construction phase and 55% of the people associated with the project will be treated as residents during the operation phase. This implies that on average, 4,800 people will be residents during the operation phase from 2041 to 2057 (the maximum is 6,150), or 3,700 over the whole 30-year period including the investment phase.

[43] Not all of them will be present at CERN for longer time periods. They are referred to as "Non-resident Users".

Two types of residents are distinguished to estimate the impacts on the local economy: employees of CERN and local project-related organisations and persons who are dispatched by their home institutes and companies ("users"). They differ mainly in household composition and available annual household income. Total wages of residents (personnel plus users) are assumed to be around 450 mn CHF, of which around 310 mn CHF will be consumed (for the resident users, we assume lower regional consumption expenditures than for CERN employees, due to their limited period of residency[44]).

The economic linkages of this consumption volume are estimated by ADAGIO (see Table 10).

As expected, the main effects are estimated for France and Switzerland, with over 90% of direct effects and still 75% of total (Type 1 plus Type2) effects[45]. The total value added of more than 620 mn CHF per year supports 8,400 jobs, the majority again in France and Switzerland.

By economic sector, the structure of the consumption effects is markedly different from the effects of the FCC investment and operating expenditures: real estate activities, (retail) trade, personal services and the hospitality sector are the main beneficiaries of the consumption of CERN's employees (see Table 11).

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[44] Typically, workers temporarily living abroad have ongoing spending obligations in their home countries, which reduces consumption possibilities in their work countries.

[45] Contrary to the simulation setup for the investment and the OPEX, where only re-investment was considered, we extend the Type 2 effects to include effects on income and spending by households as well. The reason is the duration of the impact: CERN has been established a long time ago, so the regional economy has certainly had time to react to the (continuing) presence of its resident personnel. This justifies a longer time horizon in the estimation of the induced effects.

Table 10: **Regional economic linkages of consumption expenditures by FCC-related personnel**[46]

			Value added [mn CHF]					Employment [1,000 jobs]				
			Type1					Type1				
		Investment volume	Direct	Indirect	Total Type1	Type2	Sum total	Direct	Indirect	Total Type1	Type2	Sum total
Total		310	150	110	250	370	620	1.6	1.6	3.2	5.2	8.4
FRA	France	230	100	50	150	200	350	1.1	0.5	1.6	2.2	3.8
CHE	Switzerland	80	40	16	55	65	120	0.3	0.2	0.5	0.5	1.0
DEU	Germany		2	8	10	20	30	0.0	0.1	0.1	0.3	0.4
CHN	China		1	3	4	13	17	0.0	0.2	0.2	0.6	0.9
USA	USA		1	4	4	9	13	0.0	0.0	0.0	0.1	0.1
GBR	Great Britain		1	4	5	8	13	0.0	0.1	0.1	0.1	0.2
ITA	Italy		1	3	4	8	12	0.0	0.0	0.1	0.1	0.2
ESP	Spain		1	2	4	6	10	0.0	0.0	0.1	0.1	0.2
NLD	Netherlands		1	2	3	5	8	0.0	0.0	0.0	0.1	0.1
BEL	Belgium		1	2	2	4	7	0.0	0.0	0.0	0.0	0.1
IRL	Ireland		0	2	2	3	5	0.0	0.0	0.0	0.0	0.1
TUR	Turkey		0	1	1	2	3	0.0	0.0	0.1	0.1	0.2
POL	Poland		0	1	1	2	3	0.0	0.0	0.0	0.1	0.1
JPN	Japan		0	1	1	2	3	0.0	0.0	0.0	0.0	0.0
NOR	Norway		0	1	1	2	3	0.0	0.0	0.0	0.0	0.0
AUT	Austria		0	1	1	2	3	0.0	0.0	0.0	0.0	0.0
BRA	Brasil		0	1	1	2	2	0.0	0.0	0.0	0.1	0.2
SWE	Sweden		0	1	1	2	2	0.0	0.0	0.0	0.0	0.0
IND	India		0	1	1	2	2	0.0	0.1	0.2	0.3	0.5
CAN	Canada		0	1	1	1	2	0.0	0.0	0.0	0.0	0.0
CZE	Czech Republic		0	0	0	1	2	0.0	0.0	0.0	0.0	0.0
KOR	Korea		0	0	0	1	2	0.0	0.0	0.0	0.0	0.0
ROU	Romania		0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
DEN	Denmark		0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
PRT	Portugal		0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
AUS	Australia		0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
HUN	Hungary		0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
SVK	Slovakia		0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
FIN	Finland		0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
SVN	Slovenia		0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
GRC	Greece		0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
BGR	Bulgaria		0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
LTU	Lithuania		0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
HRV	Croatia		0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
EST	Estonia		0	0	0	0	0	-	0.0	0.0	0.0	0.0
RoW	Rest-of-World		0	3	3	6	9	0.0	0.1	0.1	0.2	0.3

Source: Own calculations with ADAGIO based on CERN data.

[46] Sums are rounded independently, rounding errors are not compensated.

Table 11: **Sectoral economic linkages of consumption expenditures by FCC-related CERN employees**[47]

			Value added					Employment				
			Type1					Type1				
Economic sector		Consumption volume	Direct	Indirect	Total Type1	Type2	Sum total	Direct	Indirect	Total Type1	Type2	Sum total
Total		306	150	110	250	370	620	1.6	1.6	3.2	5.2	8.4
A	AGRICULTURE, FORESTRY AND FISHING		2	6	8	8	16	0.1	0.2	0.3	0.4	0.7
B	MINING AND QUARRYING		0	3	3	5	8	0.0	0.0	0.0	0.1	0.1
C	MANUFACTURING		13	19	30	60	95	0.2	0.3	0.5	1.0	1.6
D	ELECTRICITY, GAS, STEAM SUPPLY		2	4	6	7	12	0.0	0.0	0.0	0.0	0.1
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT		1	1	2	2	4	0.0	0.0	0.0	0.0	0.0
F	CONSTRUCTION		2	2	4	35	40	0.0	0.0	0.1	0.6	0.7
G	WHOLESALE AND RETAIL TRADE		25	11	40	45	85	0.4	0.2	0.6	0.8	1.5
H	TRANSPORTATION AND STORAGE		5	8	13	17	30	0.1	0.1	0.2	0.3	0.5
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES		10	1	11	11	20	0.2	0.0	0.2	0.2	0.4
J	INFORMATION AND COMMUNICATION		4	6	10	20	30	0.0	0.0	0.1	0.2	0.2
K	FINANCIAL AND INSURANCE ACTIVITIES		6	10	16	18	35	0.0	0.1	0.1	0.1	0.2
L	REAL ESTATE ACTIVITIES		50	5	55	50	110	0.1	0.0	0.1	0.1	0.1
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES		1	12	13	30	45	0.0	0.1	0.1	0.3	0.5
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES		1	10	11	17	30	0.0	0.2	0.2	0.3	0.5
O-T	PUBLIC & OTHER SERVICES		25	6	35	35	65	0.5	0.1	0.6	0.7	1.3

Source: Own calculations with ADAGIO based on CERN data.

4.3 Accompanying investment - electricity procurement

The electricity needs of large-scale particle collider-based physics research create opportunities for building up renewable energy resources in Europe and to act as a lever to evolve the regulatory frameworks that govern and restrict today's energy transition process in Europe.

Depending on the operation mode, the FCC-ee particle collider research infrastructure has an average annual electricity need that varies between 400 GWh and 2 TWh[48] (see Table 12).

[47] Sums are rounded independently, rounding errors are not compensated.

[48] All estimates and assumptions about the FCC's energy demand are based on CERN calculations.

Table 12: **FCC-ee electricity consumption estimates**

Year	Type	Beam energy	Min power	Max power	Annual consumption
		GeV	MW	MW	TWh
2036	Construction		20	50	0.4
2037	Construction		20	50	0.4
2038	Construction		20	50	0.4
2039	Construction		20	50	0.4
2040	Construction		20	50	0.4
2041	Z operation	45.6	65	237	1.30
2042	Z operation	45.6	65	237	1.30
2043	Z operation	45.6	65	237	1.30
2044	Z operation	45.6	65	237	1.30
2045	W operation	80	68	263	1.43
2046	W operation	80	68	263	1.43
2047	H operation	120	69	292	1.58
2048	H operation	120	69	292	1.58
2049	H operation	120	69	292	1.58
2050	Long shutdown		65	65	0.57
2051	TT operation	182.5	78	385	2.07
2052	TT operation	182.5	78	385	2.07
2053	TT operation	182.5	78	385	2.07
2054	TT operation	182.5	78	385	2.07
2055	TT operation	182.5	78	385	2.07
2056	Upgrade		50	50	0.44
2057	Upgrade		50	50	0.44
2058	Upgrade		50	50	0.44
2059	Upgrade		50	50	0.44
2060	Upgrade		50	50	0.44
2061	HH operation				

Source: CERN.

During an initial 20-year period, the total energy consumption is estimated to be in the order of 26 TWh, on average about 1.3 TWh per year. The maximum instantaneous power demand of 385 MW during the highest performance operation mode can be compared to the capacity of recently installed solar power plants in Europe[49] or two thirds of recent off-shore wind farms[50]. The maximum annual electricity consumption corresponds to 1.5 % of all de-carbonised electricity produced in the Auvergne-Rhône-Alpes region (France) in 2021.

With the goal of providing the FCC with renewable energy and creating value added by supplying it at competitive cost during the time that the FCC does not need that energy, a long

[49] Cestas (France): 300 MW, Mula (Spain): 494 MW, Lepizig Witznitz (Germany): 650 MW

[50] Kriegers Flak (Denmark), 600 MW

term brokered engagement with energy suppliers, storage, transmission and supply partners is envisaged. Assuming an available capacity of 500 MW of renewable energy sources to cover the peak demand creates an opportunity to supply an additional 20 TWh to other societal consumers.

4.3.1 Assumptions about the renewable energy technology

For the purpose of a high-level, preliminary economic effect analysis with a focus on the employment sector, we assume a mix of PV and wind energy sources with different construction costs[51]: for PV we assume a cost of 650 €/kW, and for wind we assume 1,500 €/kW. The two types of installation also differ in terms of cost structures: a large part of wind turbines' costs is attributed to mechanical and electrical engineering (drivetrain, generator). PV is much heavier on electronic components. Table 13 shows our estimate of the respective cost structures:

Table 13: **Assumptions about costs for photovoltaic (PV) and wind power (Wind) capacities**

		PV	Wind	Remark
	Total costs €/kw	**650**	**1,500**	
	Investment structure (NACE):			
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials		7%	Rotor
C22	Manufacture of rubber and plastic products		6%	Rotor
C23	Manufacture of other non-metallic mineral products	4%	7%	Rotor, PV module
C25	Manufacture of fabricated metal products, except machinery and equipment	8%	15%	Tower
C26	Manufacture of computer, electronic and optical products	30%		PV module, inverter
C27	Manufacture of electrical equipment	38%	22%	Inverter, generator, cables
C28	Manufacture of machinery and equipment n.e.c.		20%	Drive train
C33	Repair and installation of machinery and equipment	4%	4%	Installation work
F41	Civil engineering	6%	9%	Foundation, site access, specialised construction
M71	Architectural and engineering activities; technical testing and analysis	10%	10%	Planning, engineering

Source: Own estimates based on Aufleger et al. (2020); Bründlinger et al. (2020); Kaltschmitt et al. (2020); Stehly et al. (2019); online sources: Matmatch; IEA; Errard et al. (2021).

As for the mix of wind and PV, we chose the respective shares to reflect the 2020 mix of installed capacity in the EU 27, which according to EUROSTAT amounts to 175 GW of wind and 110 GW of PV, or roughly 60:40. For the installation of a 500 MW capacity, therefore, total cost is estimated at 580 mn € (650 mn CHF at 2019 exchange rates).

[51] See e.g. Aufleger et al. (2020); Bründlinger et al. (2020); IEA (2021); Kaltschmitt et al. (2020); Resch et al. (2017); Stehly et al. (2019); Wallasch et al. (2019; online sources: Matmatch; Errard et al. (2021)

4.3.2 Employment and value added linkages related to energy supply

The locations of the electricity supply plants cannot be determined 20 years before operation starts and they may also dynamically change depending on the 24/7 renewable energy supply concept. For the purpose of estimating the economic effect linked to the necessary renewables capacity, we therefore chose the currently known installed capacities per EU member country as its fictitious share in the new installations and we added a 10% share for Switzerland[52]. Accordingly, Table 14 presents regional results in a rough "EU & Switzerland vs. Rest-of-World" disaggregation.

Table 14: **Regional economic linkages of renewables capacity**[53]

		Value added [mn CHF]					Employment [1,000 person years]				
		Type1					Type1				
	Investment volume	Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total	**644**	**210**	**290**	**500**	**120**	**620**	**3.5**	**5.2**	**8.7**	**2.9**	**11.6**
EU28&CHE	644	200	230	430	80	510	3.1	3.2	6.3	1.1	7.4
Rest-of-World	-	10	60	70	40	110	0.4	2.0	2.4	1.8	4.2

Source: Own calculations with ADAGIO.

Europe's share of the economic linkages is very high. This relates to the assumption about the location of the "investment shock", i.e. that the new installations are set up in Europe. Also, Europe's market share especially in wind turbines is quite substantial[54]. The direct value added relating to the construction activities is about 200 mn CHF, linked to 3,500 person years of employment. Including intermediate inputs and investments needed to produce and install the equipment, the contribution to Europe's value added rises to 510 mn CHF, securing 7,400 person years of employment in Europe. World-wide added value effects amount to 620 mn CHF and 11,600 person years of employment.

[52] One could argue that the regional pattern is of secondary importance, as both PV parts and wind turbines are dominated by international producers, with prices set by a "world market". Prices for groundwork, like foundations or installation work, will depend much more on local economic conditions; these, however, represent only a minor share of total costs.

[53] Sums are rounded independently, rounding errors are not compensated.

[54] Denmark being the pioneer in wind energy, the world's largest manufacturer of turbines is Danish. Although its share of the world market is only some 12%, other European firms are among the top producers as well. The situation is a bit different in PV, where China has a leading position in PV modules. Europe, however, is trying to re-capture some of the market share it has lost in the past decade. All told, some gearing towards the "home market" (in the spirit of CERN's attempt to source its supplies primarily from member countries) is to be expected, contributing to a rather high European share of the investment effects.

Table 15: **Sectoral economic linkages of renewables capacity**[55]

Economic sector		Investment volume	Value added [mn CHF]					Employment [1,000 person years]				
			Type1					Type1				
			Direct	Indirect	Total Type1	Type2i	Sum total	Direct	Indirect	Total Type1	Type2i	Sum total
Total		**644**	210	290	500	120	620	**3.5**	**5.2**	**8.7**	**2.8**	**11.6**
A	AGRICULTURE, FORESTRY AND FISHING	-	0	5	6	2	7	0.0	0.3	0.3	0.2	0.5
B	MINING AND QUARRYING	-	0	9	9	3	12	0.0	0.1	0.1	0.1	0.2
C	MANUFACTURING	526	110	90	200	35	240	1.8	1.7	3.4	0.8	4.2
D	ELECTRICITY, GAS, STEAM SUPPLY	-	1	7	8	2	10	0.0	0.0	0.0	0.0	0.1
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT	-	0	4	4	1	5	0.0	0.0	0.1	0.0	0.1
F	CONSTRUCTION	54	20	8	30	15	45	0.4	0.2	0.5	0.6	1.1
G	WHOLESALE AND RETAIL TRADE	-	50	40	85	14	100	0.8	0.9	1.7	0.4	2.1
H	TRANSPORTATION AND STORAGE	-	2	20	25	5	30	0.0	0.4	0.4	0.1	0.6
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	-	0	3	3	1	4	0.0	0.1	0.1	0.0	0.1
J	INFORMATION AND COMMUNICATION	-	1	11	12	10	20	0.0	0.1	0.1	0.1	0.2
K	FINANCIAL AND INSURANCE ACTIVITIES	-	0	14	14	4	18	0.0	0.1	0.1	0.1	0.2
L	REAL ESTATE ACTIVITIES	-	0	13	14	4	18	0.0	0.0	0.0	0.0	0.1
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	64	25	30	60	15	75	0.5	0.5	0.9	0.2	1.1
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	-	0	20	20	5	25	0.0	0.5	0.5	0.1	0.6
O-T	PUBLIC & OTHER SERVICES	-	1	11	12	6	18	-	0.3	0.3	0.2	0.5

Source: CERN; own calculations with ADAGIO.

Table 15 shows that the highest benefits accrue to the manufacturing sector, although its share of the effects drops markedly along the value chain (value added content of construction turnover is markedly below average), with the sectoral Type1-pattern strongly reflecting the input structure of the manufacturing sector. The trade sector is much stronger than in the case of the FCC research infrastructure because we assume that investments are made within the electricity sector rather than directly by CERN[56].

4.4 CERN as a tourist destination

4.4.1 Existing data and assumptions

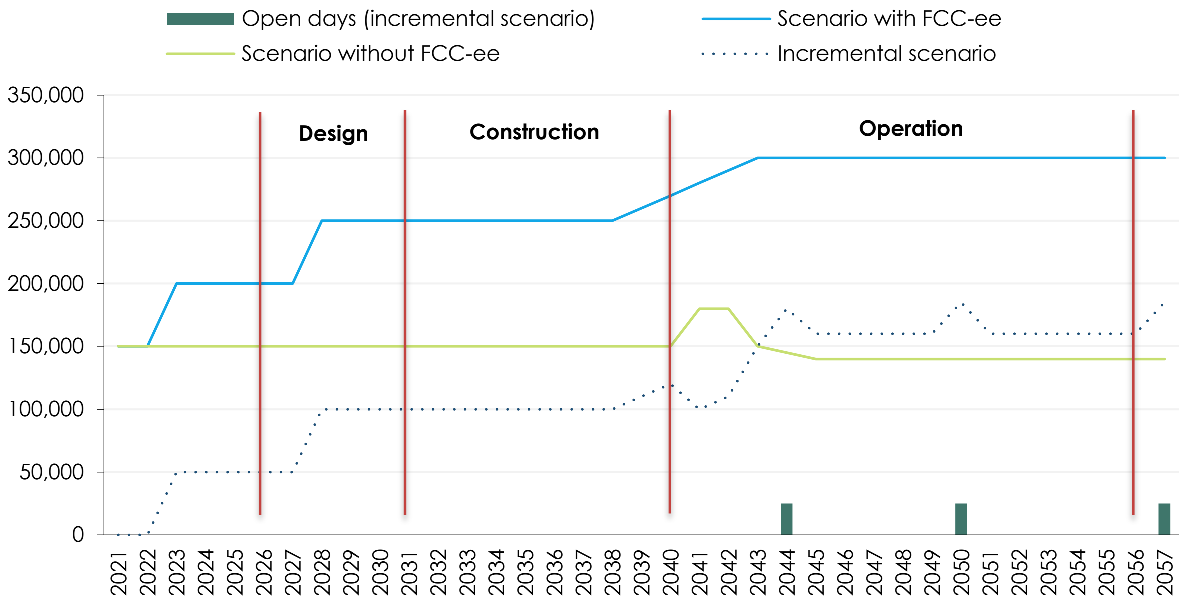
In the recent past, CERN attracted around 150,000 visitors per year. Although visits and guided tours are free of charge, they generate appreciable economic effects for the regional tourist infrastructure: especially since the start of the LHC and discovery of the Higgs boson (in 2008 and 2012, respectively), the number of visitors has increased substantially, reaching a peak of

[55] Sums are rounded independently, rounding errors are not compensated.

[56] For the CERN investment, we assumed direct purchases by CERN from the respective suppliers, largely bypassing intermediaries like wholesale or retail traders.

around 170,000 at the end of the 2010's[57]. For the FCC, a further increase in visitor numbers is envisaged. The combined opportunity to visit CERN's installations, the no longer used LHC and its experiments, the FCC construction sites and eventually the new particle collider experiments can lead to a sustained annual visitor number of about 300,000. This is a substantial figure, even when compared to Geneva's overall tourist statistics (according to Switzerland's *Bundesamt für Statistik*[58], before the pandemic in 2019 Geneva recorded around 3.2 mn overnight stays from 1.6 mn arrivals)[59]. This implies that CERN visitors make up 10 to 20% of the tourists coming to the Canton of Geneva. Today, the share is lower for France's Rhone-Alpes region, which is much larger, reporting around 18 mn arrivals in 2018. However, with an FCC project that expands significantly further south into the Haute-Savoie region, an increase of tourists for France is expected.

Figure 12: **Projected visitor numbers for the FCC site**



Source: Forecast of CERN tourists with and without an FCC project (FCCIS H2020 EU co-funded project).

Today, around 55% of visitors are part of groups whose main reason is to visit CERN (Crespo-Garrido, 2022). Groups stay on average 4.5 days in the region and carry out additional excursions in the vicinity (Geneva, Lausanne, Montreux, Orbe and Avenches' Roman heritage sites, Vevey, Yvoire, Evian, Annecy, Mont Blanc, Lyon, and other locations as well as hiking and skiing

57 This is about the maximum number of visitors that CERN can handle at the moment (demand would be even greater). For the FCC, a substantial extension to its visitor facilities is planned, leading to the aforementioned 300 k visitors per year.

58 Relevant data retrieved from: https://www.pxweb.bfs.admin.ch/pxweb/de/px-x-1003020000_103/px-x-1003020000_103/px-x-1003020000_103.px

59 In 2020, these numbers fell by two thirds. Even in 2021, arrival and stays reached only half of the level in 2019.

excursions in the nearby Jura and Pre-Alps). The average spending per person during this period is about 800 CHF. The other 45% are predominantly day-tourists whose primary purpose was originally not to visit CERN. The economic effects of those tourists are not considered since they cannot be causally attributed to CERN. Around 85% of surveyed visitors come from locations farther than 500 km, making air travel the most common type of arrival in the region (60%). Geneva is well connected through its international airport that is in the vicinity of CERN.

Combining these figures and shares, the lower limit for annual tourism spending in the (wider) Geneva region is around 130 mn CHF. These data also permit the approximation of the commodity structure of these expenditures, shown in Table 16.

Table 16: **Commodity structure of expenses by CERN visitors**

	Share
Travel cost	35%
Accommodation	24%
Food and drinks	26%
Souvenirs	5%
Visits to other sites (museums, exhibitions, …), excl. CERN	5%
Transport in the region of visit	4%

Source Crespo-Garrido, I. (2020). *Socio-economic impact at CERN: Social networks and onsite CERN visitors*. Master thesis, Rey Juan Carlos University, Madrid, Spain. https://cds.cern.ch/record/2711506/.

The place of consumption for all commodities is the Geneva region – except for travel costs. For these we assume a share of 60% for air travel and 40% for land transport. A rough-and-ready assumption about the "place of production" of these totals by transport mode is[60]:

- Air travel:
    - 45% IRL (EasyJet),14% CHE (Swiss), 5% BEL & GBR, 4% FRA, 2% DEU, PRT & ESP
- Surface travel:
    - distributed to CHE and FRA as well as the neighbouring countries AUT, ITA and DEU

4.4.2 Value added and employment linked to tourism

Based on this available information and assumptions, as well as the forecast of the tourism development associated with a FCC research programme, ADAGIO estimates the economic effects of CERN tourists as shown in Table 17 below.

[60] Especially air travel is dominated by a handful of multinationals (like Ireland's RyanAir and EasyJet in low-cost travel) with a global network of routes. This makes the origin or destination of travellers a poor predictor of their carriers' nationality. Instead, we take different carriers' share in arrivals at Geneva airport as a proxy. see https://www.gva.ch/en/Downloads/Aeroport/2019_Statistiques-Geneve-Aeroport.pdf?ext=.

Table 17: **Economic linkages of CERN visitors by country**[61]

		Consumption volume	Value added [mn CHF] Type1 Direct	Indirect	Total Type1	Type2	Sum total	Employment [1,000 person years] Type1 Direct	Indirect	Total Type1	Type2	Sum total
Total		**131**	50	72	119	65	185	0.8	1.0	1.9	0.9	2.8
CHE	Switzerland	57	20	25	45	15	60	0.3	0.2	0.6	0.1	0.7
FRA	France	57	30	18	45	30	75	0.5	0.2	0.7	0.3	1.0
Rest of Europe		10	0	20	20	14	35	0.0	0.3	0.3	0.2	0.5
Rest of World		7	0	9	9	6	15	0.0	0.3	0.3	0.3	0.6

Source: Own calculations with ADAGIO.

Switzerland and France share the bigger part of the total effects, with around 1,700 jobs linked to visitors. Another 500 jobs are European, the rest – around 600 – are filled outside Europe. Globally, tourism effects would generate 2,700 jobs over several decades.

Table 18: **Economic linkages of CERN visitors by sector**[62]

	Economic sector	Consumption volume	Value added [mn CHF] Type1 Direct	Indirect	Total Type1	Type2i	Sum total	Employment [1,000 person years] Type1 Direct	Indirect	Total Type1	Type2i	Sum total
Total		**130**	**50**	**70**	**120**	**65**	**190**	**0.8**	**1.0**	**1.8**	**0.9**	**2.7**
A	AGRICULTURE, FORESTRY AND FISHING		0	4	4	1	5	0.0	0.1	0.1	0.0	0.2
B	MINING AND QUARRYING		0	2	2	0	2	0.0	0.0	0.0	0.0	0.0
C	MANUFACTURING		0	12	13	10	25	0.0	0.2	0.2	0.2	0.3
D	ELECTRICITY, GAS, STEAM SUPPLY		0	2	2	1	2	0.0	0.0	0.0	0.0	0.0
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT		0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
F	CONSTRUCTION		0	1	1	7	9	0.0	0.0	0.0	0.1	0.1
G	WHOLESALE AND RETAIL TRADE		2	10	12	7	19	0.0	0.1	0.2	0.1	0.3
H	TRANSPORTATION AND STORAGE		15	12	25	4	30	0.2	0.2	0.4	0.1	0.4
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES		25	2	30	5	35	0.5	0.1	0.6	0.1	0.7
J	INFORMATION AND COMMUNICATION		1	3	3	4	7	0.0	0.0	0.0	0.0	0.1
K	FINANCIAL AND INSURANCE ACTIVITIES		0	4	4	3	7	0.0	0.0	0.0	0.0	0.0
L	REAL ESTATE ACTIVITIES		0	2	2	11	13	0.0	0.0	0.0	0.0	0.0
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES		0	7	7	4	11	0.0	0.1	0.1	0.0	0.1
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES		0	6	6	1	7	0.0	0.1	0.1	0.0	0.1
O-T	PUBLIC & OTHER SERVICES		4	5	9	7	15	0.1	0.1	0.2	0.2	0.3

Source: Own calculations with ADAGIO.

[61] Sums are rounded independently, rounding errors are not compensated.

[62] Sums are rounded independently, rounding errors are not compensated.

Apart from the tourist sector (row I in Table 18), which comprises a diverse set of economic activities such as accommodation and restaurants, the transport sector (row H in Table 18*)* profits most from FCC visitors. The trade sector and other services are also noteworthy beneficiaries. Manufacturing profits from tourist-related shopping, but also – like the construction sector – from investment in touristic infrastructure.

5. Discussion of Results

This report estimates the economic and employment effects that are connected to the construction and operation of a new particle collider-based research infrastructure that extends the current scientific research activities at CERN. These effects arise mainly from the construction of the particle collider in a more than 90 km long circular underground structure, its operating expenses, and the consumption related to its employees. Additional economic effects exist but can only be estimated today as far as they are known and depending on their development status. An example is the supply of the research infrastructure with renewable electricity capacities and the effects of a sizable number of touristic visitors. Additional opportunities that are not yet fully developed today, such as heat supply near surface sites, the reinforcement of the regional electrical infrastructure, the strengthening of regional water supply and treatment facilities, sustained education, training, and innovation activities are not captured in this report.

According to our estimations using an economic input-output model, the cumulated FCC-related expenditure of about 21 bn CHF could be connected to around 26,000 jobs per year via global value added chains.

These figures must be interpreted with some caution. Most importantly, the "indirect jobs" are derived under a steady-state assumption – the estimates do not project major economic variables into the future (exchange rates, price levels and productivity being the most important ones). Therefore, the effects are estimated as if the FCC was constructed and operated **right now**. This need not be considered a shortcoming, as it also helps decision makers to easier grasp the effects of the estimates when referring to a familiar frame of reference – the economy as we know it today. The resulting figures on value added are less compromised by this simplification, which is due to the fact that the evolution of economic key performance parameters cannot be forecast on the time scale of an FCC project with construction starting in the mid-2030s and a coming into operation after 2040. The employment figures linked to the expenditures represent reliable upper bounds since labour productivity is expected to rise. Even under changing economic conditions, the FCC would remain what it is today – a major undertaking for the scientific community and society at large, with likely significant scientific, technological, engineering and economic impacts.

In this report, we tried to cover some aspects that go beyond the narrowly defined purpose of the FCC; these include for instance the installation of renewable capacity and the touristic aspects, but also the induced effects from the cost-of-living expenditures of FCC personnel. However, this is certainly not exhaustive, and a multitude of additional effects and developments with links to the FCC might be identified, whose economic potential however could not be explored here[63]:

[63] Some of them were dealt with in other reports on the FCC, such as the impact on science as well as individual careers within and outside science or the impact of technological challenges on suppliers to the FCC.

- A global co-operation on a technologically intensive project like the FCC creates a special environment in which personal and institutional networks can thrive, laying the foundation for future collaborations on scientific or commercial endeavors.
- FCC contracts with their exacting specifications on size and quality push the limits for many suppliers, even for those that would not be counted as "high tech"[64].
- Given the dimensions of the tunnel housing the FCC, the excavated material should not be simply transferred to deposits; instead, processes should be developed for innovative use of this "waste" material.
- Similarly, the FCC can trigger the development of more efficient electrical distribution systems, heat exchangers and cooling systems, which will benefit many future users of such equipment.
- As in the past (e.g. with the World Wide Web), FCC-related work is likely to advance the state-of-the-art in software applications, from business information systems to general software libraries.
- With up to 11,000 people working at the FCC, it is an important economic player in the region, even beyond the consumption spending of those people (whose impact has been dealt with explicitly). Including family, these employees fill the equivalent of a small town – public infrastructure will accordingly react to their presence in the region, from schooling to administrative facilities.

At a general level, the results derived and presented in this report show that the "costs" that a project like the FCC entails are also connected with "economic impacts", in terms of sales opportunities for firms and employment opportunities for scientists and non-scientists alike. By concentrating on a core set of transmission mechanisms only, these results constitute a lower bound for the expected economic effects. Therefore, even though the narrow economic linkages of the construction and operation of the FCC are not larger than would be expected for a project of this size, the potential for spillovers into probably quite unrelated areas of technology and business are certainly much more pronounced – for example, only few projects would have the FCC's touristic attractiveness, not to mention its technological and scientific potential.

Also, by estimating the regional structure of the effects linked to the construction and operation of the FCC, the analysis has shown that the connection between contribution to CERN, direct contracts and indirect benefits is not always clear-cut. For example, China, which is not a member of CERN, is estimated to have sizable economic benefits due to its prominent role in global value chains. Probably this information could form the basis for negotiations between CERN and countries such as China on intensifying (and formalizing) closer collaborations in the future, which would be beneficial for both parties.

[64] For many suppliers, this also pays off commercially by improving their (future) profit potential: Gutleber et al (2021) conclude in Chapter 4.3. that "1 Euro spent for LHC procurement generates on average 15.3 Euro of additional revenues and 2 euro of additional profits for the supplier" (or even 20 resp 3.11 Euro in the case of a high-tech procurement contract).

6. Annex

6.1 Annex A: ADAGIO - A DynAmic Global Input Output model

ADAGIO, A DynAmic Global Input Output 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.
2. 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.
3. 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).
4. 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 EU 27, developed for and with the IPTS, the Institute for Prospective

Technology Studies in Sevilla (see Kratena et al., 2013, 2017), and ADAGIO, a model based on the WIOD data base[65].

Prices are determined endogenously: 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[66].

a. 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.
b. 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.
c. 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 accomodation, 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.

[65] The WIOD project compiled Supply and Use Tables for 40 countries (the EU 27 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. See Timmer et al (2015).

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).

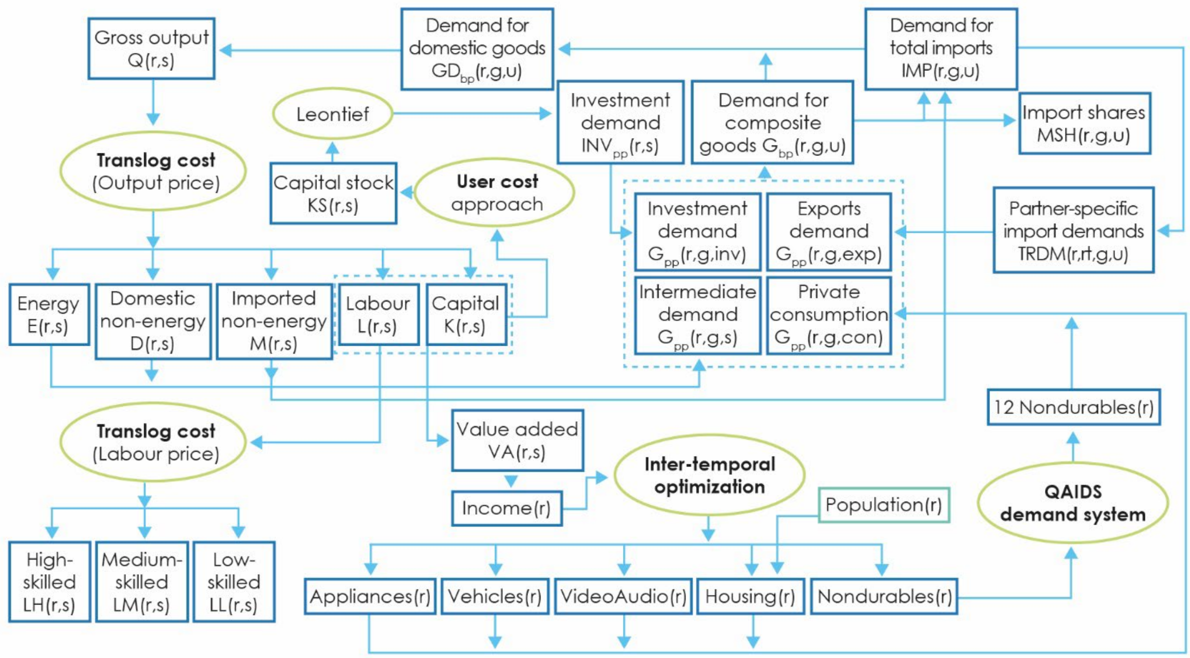
[66] For details on the estimation of consistent international trade and transport margins, see Streicher and Stehrer (2015).

Basic energy prices (crude oil, coal) are exogenous. All 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 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.

For an extensive and in-depth treatment of all parts of the model, see Kratena et al. (2013, 2017). For key applications of ADAGIO, see Christen et al. (2021); De Swart et al. (2016); European Commission (2018); Kratena and Streicher (2017); Schmid et al. (2016); Streicher and Kettner (2022).

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.

Figure A 1: **ADAGIO's model structure**



Source: Kratena et al. (2013).

To sum up: 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 set of regions included in the WIOD project and encompasses 43 Countries plus a Rest-of-the-World. In the current version of ADAGIO, however, the data base itself is no longer taken from WIOD, as the update of this data base was discontinued in 2017 (the most recent year in WIOD is 2014). Instead, ADAGIO is based on Supply-Use-Tables adapted from EUROSTAT (for the EU 27/8) and OECD (for the remaining countries). The current base year of the model is 2017/18.

Table A 1: **ADAGIO country List**

EU member states		Non-EU countries	
AUT	Austria	AUS	Australia
BEL	Belgium	BRA	Brasil
BGR	Bulgaria	CAN	Canada
CYP	Cyprus	CHE	Switzerland
CZE	Czech Republic	CHN	China People's Republic
DEN	Denmark	IDN	Indonesia
DEU	Germany	IND	India
ESP	Spain	JPN	Japan
EST	Estonia	KOR	South Korea
FIN	Finland	MEX	Mexico
FRA	France	NOR	Norway
GBR	Great Britain	RUS	Russia
GRC	Greece	TUR	Turkey
HRV	Croatia	TWN	Taiwan
HUN	Hungary	USA	USA
IRL	Ireland		
ITA	Italy		
LTU	Lithuania		
LUX	Luxembourg		
LVA	Latvia		
MLT	Malta		
NLD	Netherlands		

Source: Eurostat, WIFO.

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 A 2: **ADAGIO sectors**

NACE code	Industry	NACE code	Industry
A01	Crop and animal production, hunting	H50	Water transport
A02	Forestry and logging	H51	Air transport
A03	Fishing and aquaculture	H52	Warehousing and support activities for transportation
B05-07	Mining of coal and lignite	H53	Postal and courier activities
B08-09	Other mining and quarrying	I55-56	Accommodation
C10	Manufacture of food products	J58	Publishing activities
C11-12	Manufacture of beverages	J59	Audio and video production
C13	Manufacture of textiles	J60	Programming and broadcasting activities
C14	Manufacture of wearing apparel	J61	Telecommunications
C15	Manufacture of leather and related products	J62-63	Computer programming and consultancy
C16	Manufacture of wood and of products of wood	K64	Financial service activities, except insurance
C17	Manufacture of paper and paper products	K65	Insurance, reinsurance and pension funding
C18	Printing and reproduction of recorded media	K66	Activities auxiliary to financial and insurance services
C19	Manufacture of coke a. refined petroleum products	L68	Real estate activities
C20	Manufacture of chemicals and chemical products	M69	Legal and accounting activities
C21	Manufacture of pharmaceutical products	M70	Activities of head offices; management consultancy
C22	Manufacture of rubber and plastic products	M71	Architectural, technical and engineering activities
C23	Manufacture of other non-metallic mineral products	M72	Scientific research and development
C24	Manufacture of basic metals	M73	Advertising and market research
C25	Manufacture of fabricated metal products	M74-75	Other professional, scientific and technical activivities
C26	Manufacture of computer, electronic a. optical prod.	N77	Rental and leasing activities
C27	Manufacture of electrical equipment	N78	Employment activities
C28	Manufacture of machinery and equipment n.e.c.	N79	Travel agency, tour operator and other reservation
C29	Manufacture of motor vehicles, trailers	N80-82	Security and investigation activities
C30	Manufacture of other transport equipment	O84	Public administration and defence; social insurance
C31	Manufacture of furniture	P85	Education
C32	Other manufacturing	Q86	Human health activities
C33	Repair and installation of machinery and equipment	Q87-88	Residential care activities
D35	Electricity, gas, steam and air conditioning supply	R90	Creative, arts and entertainment activities
E36	Water collection, treatment and supply	R91	Libraries, archives, museums a. other cultural activities
E37-39	Sewerage	R92	Gambling and betting activities
F41	Construction of buildings	R93	Sports, amusement and recreation activities
F42	Civil engineering	S94	Activities of membership organisations
F43	Specialised construction activities	S95	Repair of computers a. personal a. household goods
G45	Wholesale and retail trade a. repair of motor vehicles	S96	Other personal service activities
G46	Wholesale trade, except of motor vehicles	T97	Activities of households as employers
G47	Retail trade, except of motor vehicles		

Source: Eurostat.

6.2 Annex B: Detailed simulation results

Table A 3: **Summary of economic effects and linkages related to FCC construction and operation in France, cumulated over FCC-related construction and operation 2028-57**[1]

		Cum. value added effects [mn CHF]					Cum. employment effects [1,000 person years]				
		Type1			Induced		Type1			Induced	
Origin of effect	Period	Direct	Indirect	Total Type1	Type2	Sum total	Direct	Indirect	Total Type1	Type2	Sum total
Construction-phase											
FCC investment	2031-50	850	650	1,500	270	1,800	12.1	7.9	20.0	2.9	22.9
Renewable capacity	2031-40	35	35	70	14	85	0.4	0.4	0.8	0.2	1.0
Operation-phase											
FCC direct	2041-2057	3,850	-	3,850	-	3,850	85.0	-	85.0	-	85.0
FCC OPEX	2041-2055	120	170	290	120	400	0.5	1.3	1.8	1.3	3.2
Cost-of-living – resident personnel	2028-2057	3,050	1,550	4,500	5,950	10,500	32.5	16.0	48.5	65.6	115.0
Visitors	2028-2057	850	550	1,400	900	2,300	13.7	6.5	20.2	9.6	29.8
Total	2028-2057	8,700	2,900	11,550	7,300	18,850	144.2	32.1	176.4	79.7	256

Source: Own calculations with ADAGIO based on CERN data.

Table A 4: **Summary of economic effects and linkages related to FCC construction and operation in Switzerland, cumulated over FCC-related construction and operation 2028-57**

		Cum. value added effects [mn CHF]					Cum. employment effects [1,000 person years]				
		Type1			Induced		Type1			Induced	
Origin of effect	Period	Direct	Indirect	Total Type1	Type2	Sum total	Direct	Indirect	Total Type1	Type2	Sum total
Construction-phase											
FCC investment	2031-50	190	190	380	70	450	1.6	1.5	3.1	0.5	3.6
Renewable capacity	2031-40	16	15	30	5	35	0.1	0.1	0.2	0.0	0.2
Operation-phase											
FCC direct	2041-2057	3,850	-	3,850	-	3,850	85.0	-	85.0	-	85.0
FCC OPEX	2041-2055	30	60	85	30	120	0.1	0.4	0.6	0.2	0.8
Cost-of-living – resident personnel	2028-2057	1,150	480	1,600	1,900	3,500	9.9	4.6	14.5	17.5	31.0
Visitors	2028-2057	650	700	1,350	450	1,800	10.3	7.1	17.5	2.5	20.0
Total	**2028-2057**	5,850	1,450	7,300	2,450	9,750	107.1	13.8	120.9	19.8	140.6

Source: Own calculations with ADAGIO based on CERN data.

[1] In this table as well as all the following, sum totals are rounded independently, rounding errors are not compensated.

Table A 5: **Simulation results – FCC investment, minimum resp. mean cost estimate combined with "fair share" assumption for the nationality of suppliers**

	FCC-investment – member share – minimum							FCC-investment – member share – mean						
		Value added [mn CHF]			Employment [1,000 persons]				Value added [mn CHF]			Employment [1,000 persons]		
	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)
AUS	9	3	20	35	0	0	0	9	3	20	35	0	0	0
AUT	234	100	190	230	1	2	2	242	100	200	240	1	2	2
BEL	291	130	270	320	2	3	3	300	130	280	330	2	3	3
BGR	34	11	25	25	1	2	2	35	11	25	30	1	2	2
BRA	9	0	25	40	0	1	2	9	0	30	40	0	1	2
CAN	46	19	80	100	0	1	1	46	19	80	100	0	1	1
CHE	449	190	370	440	2	3	4	464	190	380	450	2	3	4
CHN	92	16	270	600	1	12	28	93	16	280	650	1	12	29
CYP	0	0	0	1	0	0	0	0	0	0	1	0	0	0
CZE	107	40	100	140	1	3	4	111	40	110	140	1	3	4
DEN	191	100	170	200	1	2	2	197	100	180	200	1	2	2
DEU	2,257	1,000	2,050	2,450	13	26	30	2,332	1,050	2,150	2,500	13	26	31
ESP	769	280	600	750	5	10	12	795	290	650	750	5	10	12
EST	3	1	4	5	0	0	0	3	1	4	5	0	0	0
FIN	143	60	110	130	1	1	1	148	60	120	140	1	1	1
FRA	1,513	800	1,450	1,750	12	19	22	1,563	850	1,500	1,800	12	20	23
GBR	1,717	850	1,500	1,750	10	19	21	1,774	900	1,550	1,800	10	19	22
GRC	114	50	90	95	2	2	3	118	55	90	100	2	3	3
HRV	3	0	2	3	0	0	0	3	0	2	3	0	0	0
HUN	69	25	55	65	1	2	2	72	30	60	70	1	2	2
IDN	0	0	13	25	0	1	3	0	0	13	25	0	2	3
IND	46	0	30	45	0	4	7	46	0	30	50	0	4	7
IRL	9	0	19	25	0	0	0	9	0	20	25	0	0	0
ITA	1,117	380	900	1,100	5	12	15	1,154	390	950	1,150	5	12	15
JPN	185	65	190	270	1	3	4	185	65	190	270	1	3	4
KOR	9	3	40	70	0	0	1	9	3	40	70	0	0	1
LTU	9	4	10	11	0	0	0	9	4	10	11	0	0	0
LUX	0	0	11	14	0	0	0	0	0	11	15	0	0	0
LVA	0	0	2	3	0	0	0	0	0	2	3	0	0	0
MEX	0	0	25	40	0	1	1	0	0	25	40	0	1	1
NLD	494	210	470	550	3	5	6	510	220	490	550	3	6	7
NOR	251	130	260	300	1	2	2	259	140	270	310	1	2	3
POL	302	140	300	350	4	9	10	312	150	310	360	4	9	10
PRT	118	50	90	100	2	3	3	122	50	95	110	2	3	3
ROU	119	45	100	120	2	4	4	123	45	100	120	2	4	4
RUS	0	0	140	190	0	5	7	0	0	150	190	0	5	7
SVK	53	13	35	45	0	1	1	55	13	35	45	0	1	1
SVN	9	4	13	15	0	0	0	9	4	13	16	0	0	0
SWE	283	140	270	330	1	3	3	293	150	280	350	1	3	3
TUR	46	15	80	110	1	3	4	46	15	80	110	1	3	5
TWN	0	0	20	30	0	1	1	0	0	20	35	0	1	1
USA	555	270	650	800	2	4	6	556	270	650	850	2	5	6
PAK	18	12	19	25	3	4	5	19	12	20	25	3	4	5
ISR	46	13	18	20	0	0	0	46	14	18	20	0	0	0
SRB	9	3	6	7	0	0	0	9	3	6	7	0	0	0
ZAF	9	4	7	8	0	0	0	9	4	7	8	0	0	0
Total	**11,742**	5,200	11,200	13,700	77	175	225	**12,097**	5,350	11,550	14,150	79	180	230

Source: CERN; WIFO calculations with ADAGIO.

Table A 6: **Simulation results – FCC investment, maximum cost estimate combined with "fair share" assumption; mean cost estimate with "observed share" assumption**

	FCC-investment – member share – maximum							FCC-investment – observed share – mean						
		Value added [mn CHF]			Employment [1,000 persons]				Value added [mn CHF]			Employment [1,000 persons]		
	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)
AUS	9	3	20	35	0.0	0.1	0.2	0	0	12	20	0.0	0.1	0.1
AUT	251	110	210	250	1.2	2.1	2.6	267	110	230	280	1.2	2.3	2.8
BEL	312	140	290	340	1.7	3.1	3.6	160	70	190	230	0.8	1.9	2.3
BGR	36	12	25	30	1.0	1.8	2.0	36	12	25	30	1.0	1.7	1.9
BRA	9	0	30	40	0.0	1.4	2.1	0	0	25	35	0.0	1.2	1.8
CAN	46	19	80	100	0.2	0.8	1.0	0	0	30	45	0.0	0.3	0.4
CHE	481	200	400	470	1.7	3.3	3.8	2103	900	1,550	1,750	7.1	12.1	13.6
CHN	93	17	290	650	0.7	12.7	29.4	0	0	210	480	0.0	9.4	22.1
CYP	0	0	0	1	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
CZE	115	40	110	140	1.3	3.2	4.0	132	45	120	160	1.4	3.5	4.4
DEN	205	110	190	210	1.5	2.2	2.4	82	40	85	100	0.5	0.9	1.0
DEU	2419	1,100	2,200	2,600	13.5	27.5	32.1	2091	900	2,050	2,450	11.3	25.1	29.9
ESP	824	300	650	800	5.0	10.7	13.0	728	270	600	700	4.4	9.6	11.7
EST	3	1	4	6	0.0	0.1	0.1	0	0	2	2	0.0	0.0	0.1
FIN	153	60	120	140	0.6	1.3	1.5	101	40	85	100	0.4	0.9	1.0
FRA	1621	900	1,600	1,850	12.6	20.8	23.8	1755	900	1,650	1,950	13.0	21.5	24.9
GBR	1839	900	1,650	1,850	10.9	20.1	23.0	699	330	700	850	4.0	8.8	10.6
GRC	122	55	95	100	1.7	2.6	2.9	89	40	70	75	1.2	2.0	2.1
HRV	3	0	2	3	0.0	0.1	0.1	1	0	3	4	0.0	0.1	0.1
HUN	74	30	60	70	1.1	2.1	2.4	213	80	130	150	2.9	4.5	5.0
IDN	0	0	13	25	0.0	1.6	2.7	0	0	11	19	0.0	1.2	2.2
IND	46	0	35	50	0.0	4.6	7.6	7	0	30	45	0.0	4.2	7.1
IRL	9	0	20	30	0.0	0.1	0.1	0	0	45	60	0.0	0.4	0.5
ITA	1196	410	950	1,200	5.2	12.7	15.5	1341	460	1,100	1,350	5.8	14.2	17.4
JPN	186	65	200	270	0.8	2.6	3.7	0	0	55	100	0.0	0.7	1.3
KOR	9	3	40	75	0.0	0.5	0.9	0	0	35	65	0.0	0.4	0.8
LTU	9	4	10	12	0.1	0.3	0.3	9	4	9	11	0.1	0.2	0.3
LUX	0	0	12	15	0.0	0.1	0.1	0	0	13	16	0.0	0.1	0.1
LVA	0	0	2	3	0.0	0.1	0.1	0	0	2	2	0.0	0.0	0.1
MEX	0	0	25	40	0.0	0.6	1.1	0	0	16	25	0.0	0.4	0.7
NLD	529	230	500	600	3.0	5.9	6.8	503	200	460	550	2.5	5.2	6.0
NOR	269	140	280	320	1.6	2.4	2.6	76	40	110	130	0.4	0.7	0.8
POL	323	150	330	380	4.5	9.2	10.7	462	210	420	480	6.2	11.9	13.7
PRT	127	50	100	110	1.7	2.8	3.2	209	80	150	170	2.6	4.3	4.7
ROU	128	50	110	130	2.1	3.9	4.6	325	130	250	290	5.2	8.7	10.0
RUS	0	0	150	200	0.0	5.2	7.4	69	30	220	280	1.3	8.0	10.7
SVK	57	13	40	45	0.4	1.1	1.4	164	35	80	95	1.1	2.4	2.8
SVN	9	4	13	16	0.1	0.3	0.4	5	2	11	14	0.1	0.2	0.3
SWE	303	150	290	360	1.5	2.7	3.3	34	16	70	110	0.2	0.6	0.9
TUR	46	15	85	110	0.7	3.4	4.7	47	15	90	120	0.7	3.7	5.0
TWN	0	0	20	35	0.0	0.6	1.0	0	0	19	30	0.0	0.5	0.8
USA	558	270	650	850	2.0	4.6	6.0	0	0	190	300	0.0	1.3	2.1
PAK	19	12	20	25	3.1	4.5	5.3	16	9	16	19	2.3	3.5	4.2
ISR	46	14	18	20	0.1	0.1	0.1	11	3	4	5	0.0	0.0	0.0
SRB	9	3	6	7	0.1	0.2	0.2	5	2	3	4	0.1	0.1	0.1
ZAF	9	4	7	8	0.3	0.4	0.5	0	0	0	0	0.0	0.0	0.0
Total	12,507	5,550	11,950	14,600	82	186	240	11,742	5,050	11,200	13,750	78	179	229

Source: CERN; WIFO calculations with ADAGIO.

Table A 7: **Simulation results – FCC investment, mean cost estimate combined with "fair share" assumption. Separate simulations for 2031-40 and 2041-50**

	FCC-Investment - Member Share - Mean 2040-50							FCC-Investment - Member Share - Mean 2030-40						
		Value Added [mn CHF]			Employment [1000 persons]				Value Added [mn CHF]			Employment [1000 persons]		
	FCC investment	direct effect	indirect effect	Type 2i (including depreciation)	direct effect	indirect effect	Type 2i (including depreciation)	FCC investment	direct effect	indirect effect	Type 2i (including depreciation)	direct effect	indirect effect	Type 2i (including depreciation)
AUS	2	1	3	5	0.0	0.0	0.0	8	3	19	30	0.0	0.1	0.2
AUT	20	8	17	20	0.1	0.2	0.2	223	95	180	220	1.0	1.9	2.3
BEL	28	11	25	30	0.1	0.2	0.3	272	120	260	300	1.5	2.8	3.2
BGR	3	1	2	2	0.1	0.1	0.1	32	10	20	25	0.9	1.6	1.8
BRA	1	0	3	5	0.0	0.1	0.2	8	0	25	35	0.0	1.2	1.8
CAN	6	3	10	13	0.0	0.1	0.1	41	17	70	90	0.2	0.6	0.9
CHE	44	17	35	45	0.1	0.2	0.3	420	180	350	410	1.5	2.9	3.3
CHN	26	4	55	110	0.2	2.4	4.9	67	12	230	500	0.6	10.0	23.8
CYP	-	0	0	0	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
CZE	17	5	12	16	0.1	0.3	0.4	94	35	95	120	1.2	2.8	3.5
DEN	15	7	13	15	0.1	0.1	0.1	182	95	170	190	1.3	2.0	2.2
DEU	263	120	230	280	1.3	2.8	3.3	2,069	900	1,900	2,250	11.7	23.7	27.6
ESP	70	30	60	70	0.5	1.0	1.2	725	260	550	700	4.4	9.4	11.3
EST	0	0	0	0	0.0	0.0	0.0	2	1	4	5	0.0	0.1	0.1
FIN	17	7	13	15	0.1	0.1	0.2	131	55	100	120	0.5	1.1	1.3
FRA	127	55	110	140	0.5	1.1	1.5	1,436	800	1,400	1,650	11.6	18.9	21.4
GBR	264	130	220	250	1.3	2.5	2.9	1,510	750	1,350	1,550	9.1	16.9	19.3
GRC	18	8	13	14	0.2	0.3	0.4	100	45	80	85	1.5	2.2	2.4
HRV	0	0	0	0	0.0	0.0	0.0	3	0	2	3	0.0	0.1	0.1
HUN	10	3	6	7	0.1	0.2	0.2	62	25	50	65	1.0	1.8	2.1
IDN	-	0	2	3	0.0	0.2	0.3	0	0	12	20	0.0	1.3	2.4
IND	5	0	3	5	0.0	0.5	0.8	41	0	30	45	0.0	4.0	6.6
IRL	1	0	3	4	0.0	0.0	0.0	8	0	16	25	0.0	0.0	0.1
ITA	124	45	100	130	0.6	1.3	1.6	1,029	350	850	1,000	4.4	10.9	13.4
JPN	32	11	30	45	0.1	0.4	0.6	154	55	160	230	0.7	2.2	3.1
KOR	2	1	7	12	0.0	0.1	0.2	7	2	30	60	0.0	0.4	0.8
LTU	1	1	1	1	0.0	0.0	0.0	8	4	9	10	0.1	0.2	0.3
LUX	-	0	2	2	0.0	0.0	0.0	0	0	10	13	0.0	0.1	0.1
LVA	-	0	0	0	0.0	0.0	0.0	0	0	2	3	0.0	0.1	0.1
MEX	-	0	3	5	0.0	0.1	0.2	0	0	20	35	0.0	0.5	0.9
NLD	70	17	40	50	0.2	0.4	0.5	440	210	440	500	2.7	5.3	6.0
NOR	21	9	19	25	0.1	0.1	0.1	238	130	250	290	1.4	2.2	2.4
POL	28	9	25	30	0.3	0.7	0.8	284	140	290	330	4.1	8.2	9.5
PRT	11	3	7	8	0.1	0.2	0.2	111	45	85	100	1.6	2.5	2.8
ROU	10	4	9	11	0.1	0.3	0.4	113	40	95	110	1.9	3.5	4.1
RUS	-	0	14	19	0.0	0.5	0.7	0	0	130	170	0.0	4.5	6.4
SVK	12	2	5	6	0.1	0.2	0.2	43	11	30	40	0.3	0.9	1.1
SVN	1	0	1	1	0.0	0.0	0.0	9	4	12	14	0.1	0.3	0.3
SWE	29	14	25	35	0.1	0.2	0.3	263	130	250	310	1.3	2.4	2.9
TUR	4	1	8	11	0.1	0.3	0.4	42	13	75	100	0.7	3.0	4.1
TWN	-	0	4	6	0.0	0.1	0.2	0	0	17	25	0.0	0.4	0.8
USA	99	60	110	130	0.2	0.5	0.7	458	210	550	700	1.8	4.1	5.2
PAK	1	0	1	1	0.1	0.2	0.3	17	11	18	20	2.9	4.3	5.0
ISR	5	2	2	2	0.0	0.0	0.0	41	12	16	18	0.0	0.1	0.1
SRB	1	0	0	0	0.0	0.0	0.0	9	3	5	6	0.1	0.2	0.2
ZAF	1	0	0	1	0.0	0.0	0.0	9	4	6	8	0.2	0.4	0.4
Total	1,388	600	1,250	1,600	7	18	25	10,709	4,800	10,300	12,550	73	162	207

Source: CERN; WIFO calculations with ADAGIO.

Table A 8: **Simulation results – FCC operation, combined with "fair share" resp. "observed share" assumptions**

	FCC OPEX – member share							FCC OPEX – observed share						
		Value added [mn CHF]			Employment [1,000 persons]				Value added [mn CHF]			Employment [1,000 persons]		
	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)	FCC investment	Direct effect	Indirect effect	Type 2i (including depreciation)	Direct effect	Indirect effect	Type 2i (including depreciation)
AUS	0	0	0	1	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
AUT	4	1	3	4	0.0	0.0	0.0	0	0	1	1	0.0	0.0	0.0
BEL	5	2	4	5	0.0	0.0	0.0	0	0	1	2	0.0	0.0	0.0
BGR	1	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
BRA	0	0	0	1	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
CAN	1	0	1	2	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
CHE	8	2	6	8	0.0	0.0	0.1	67	25	50	60	0.1	0.3	0.4
CHN	2	0	4	10	0.0	0.2	0.4	0	0	2	7	0.0	0.1	0.3
CYP	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
CZE	2	1	2	2	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
DEN	3	1	3	3	0.0	0.0	0.0	10	4	7	9	0.0	0.1	0.1
DEU	38	15	35	40	0.1	0.3	0.4	5	2	10	18	0.0	0.1	0.2
ESP	13	5	10	12	0.1	0.2	0.2	18	7	14	17	0.1	0.2	0.3
EST	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
FIN	2	1	2	2	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
FRA	26	8	19	25	0.0	0.1	0.2	76	25	55	75	0.2	0.4	0.6
GBR	29	16	25	30	0.2	0.4	0.4	13	7	13	17	0.1	0.2	0.2
GRC	2	1	2	2	0.0	0.0	0.0	1	0	0	1	0.0	0.0	0.0
HRV	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
HUN	1	0	1	1	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
IDN	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
IND	1	0	0	1	0.0	0.1	0.1	0	0	0	1	0.0	0.0	0.1
IRL	0	0	0	1	0.0	0.0	0.0	0	0	1	1	0.0	0.0	0.0
ITA	19	7	16	20	0.1	0.2	0.2	8	3	8	11	0.0	0.1	0.1
JPN	3	1	3	4	0.0	0.0	0.1	0	0	0	1	0.0	0.0	0.0
KOR	0	0	1	1	0.0	0.0	0.0	0	0	0	1	0.0	0.0	0.0
LTU	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
LUX	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
LVA	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
MEX	0	0	0	1	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
NLD	8	3	8	9	0.0	0.1	0.1	0	0	2	3	0.0	0.0	0.0
NOR	4	2	5	6	0.0	0.0	0.0	0	0	2	2	0.0	0.0	0.0
POL	5	2	5	5	0.1	0.1	0.1	0	0	1	1	0.0	0.0	0.0
PRT	2	1	2	2	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
ROU	2	1	2	2	0.0	0.0	0.1	0	0	0	0	0.0	0.0	0.0
RUS	0	0	4	6	0.0	0.1	0.2	0	0	5	6	0.0	0.1	0.2
SVK	1	0	1	1	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
SVN	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
SWE	5	2	4	5	0.0	0.0	0.0	0	0	1	1	0.0	0.0	0.0
TUR	1	0	1	1	0.0	0.0	0.1	0	0	0	1	0.0	0.0	0.0
TWN	0	0	0	0	0.0	0.0	0.0	0	0	0	0	0.0	0.0	0.0
USA	10	5	11	14	0.0	0.1	0.1	0	0	2	5	0.0	0.0	0.0
PAK	-	0	0	0	0.0	0.0	0.1	-	0	0	-	0.0	0.0	0.0
ISR	-	0	0	0	0.0	0.0	0.0	-	0	0	0	0.0	0.0	0.0
SRB	-	0	0	0	0.0	0.0	0.0	-	0	0	0	0.0	0.0	0.0
ZAF	-	0	0	0	0.0	0.0	0.0	-	0	0	-	0.0	0.0	0.0
Total	197	80	180	230	0.9	2.3	3.4	199	75	180	240	0.6	1.9	3.0

Source: CERN; WIFO calculations with ADAGIO.

6.3 Annex C: Structures and bridges

Table A 9: **Commodity bridge from CERN investment segments to ADAGIO commodities in NACE classification**

NACE	Industry	Magnet	Diagnostics	Controls, protection	RF-System	Cryogenics	Transfer lines	El-Infra	other tech	Experiment	Tunnel	Vacuum	Converter	Transfer	Injector	Adaptation	Cooling	Transport	Develop-ment
A01	Crop and animal production, hunting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A02	Forestry and logging	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A03	Fishing and aquaculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B05-07	Mining of coal and lignite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B08-09	Other mining and quarrying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C10	Manufacture of food products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C11-12	Manufacture of beverages	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C13	Manufacture of textiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14	Manufacture of wearing apparel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15	Manufacture of leather and related products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16	Manufacture of wood and of products of wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17	Manufacture of paper and paper products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C18	Printing and reproduction of recorded media	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C19	Manufacture of coke and refined petroleum products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C20	Manufacture of chemicals and chemical products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C21	Manufacture of pharmaceutical products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C22	Manufacture of rubber and plastic products	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
C23	Manufacture of other non-metallic mineral products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C24	Manufacture of basic metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C25	Manufacture of fabricated metal products	0.5	0.0	0.0	0.2	0.0	0.6	0.0	0.1	0.0	0.1	0.4	0.0	0.6	0.4	0.2	0.3	0.0	0.0
C26	Manufacture of computer, electronic and optical products	0.0	0.4	0.5	0.5	0.0	0.1	0.0	0.1	0.3	0.0	0.1	0.1	0.1	0.1	0.2	0.0	0.0	0.0
C27	Manufacture of electrical equipment	0.0	0.0	0.2	0.1	0.3	0.1	0.8	0.4	0.1	0.0	0.0	0.8	0.1	0.2	0.3	0.1	0.0	0.0
C28	Manufacture of machinery and equipment n.e.c.	0.1	0.0	0.0	0.0	0.5	0.1	0.0	0.1	0.1	0.1	0.4	0.0	0.1	0.2	0.1	0.4	0.0	0.0
C29	Manufacture of motor vehicles, trailers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C30	Manufacture of other transport equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
C31	Manufacture of furniture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C32	Other manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C33	Repair and installation of machinery and equipment	0.1	0.2	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
D35	Electricity, gas, steam and air conditioning supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E36	Water collection, treatment and supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E37-39	Sewerage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F41	Construction of buildings	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F42	Civil engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F43	Specialised construction activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

G45	Wholesale and retail trade and repair of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G46	Wholesale trade, except of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G47	Retail trade, except of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H49	Land transport and transport via pipelines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H50	Water transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H51	Air transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H52	Warehousing and support activities for transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H53	Postal and courier activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I55-56	Accommodation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J58	Publishing activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J59	Audio and video production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J60	Programming and broadcasting activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J61	Telecommunications	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J62-63	Computer programming and consultancy	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
K64	Financial service activities, except insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K65	Insurance, reinsurance and pension funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K66	Activities auxiliary to financial and insurance services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L68	Real estate activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M69	Legal and accounting activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M70	Activities of head offices; management consultancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M71	Architectural, technical and engineering activities	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
M72	Scientific research and development	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
M73	Advertising and market research	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M74-75	Other professional, scientific and technical activivities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N77	Rental and leasing activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N78	Employment activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N79	Travel agency, tour operator and other reservation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N80-82	Security and investigation activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O84	Public administration and defence; social insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P85	Education	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q86	Human health activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q87-88	Residential care activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R90	Creative, arts and entertainment activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R91	Libraries, archives, museums and other cultural activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R92	Gambling and betting activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R93	Sports, amusement and recreation activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S94	Activities of membership organisations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S95	Repair of computers and personal and household goods	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S96	Other personal service activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T97	Activities of households as employers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: CERN, WIFO.

Table A 10: **Country codes**

Code	Country	Code	Country	Code	Country
AUS	Australia	GBR	Great Britain	NOR	Norway
AUT	Austria	GRC	Greece	POL	Poland
BEL	Belgium	HRV	Croatia	PRT	Portugal
BGR	Bulgaria	HUN	Hungary	ROU	Romania
BRA	Brasil	IDN	Indonesia	RUS	Russia
CAN	Canada	IND	India	SVK	Slovak Republic
CHE	Switzerland	IRL	Ireland	SVN	Slovenia
CHN	China People's Republic	ITA	Italy	SWE	Sweden
CYP	Cyprus	JPN	Japan	TUR	Turkey
CZE	Czech Republic	KOR	South Korea	TWN	Taiwan
DEN	Denmark	LTU	Lithuania	USA	USA
DEU	Germany	LUX	Luxembourg	ZROW	Rest-of-World
ESP	Spain	LVA	Latvia	ISR	Israel
EST	Estonia	MEX	Mexico	PAK	Pakistan
FIN	Finland	MLT	Malta	SRB	Serbia
FRA	France	NLD	Netherlands	ZAF	South Africa

Source: Eurostat.

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