Convergence in Structure and Productivity in European Manufacturing?

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Abstract: We find very fast convergence in productivity for the 99 3-digit European industries over the 1985-1998 period. According to our estimates half of any productivity gap is closed on average in 10 years. The speed of convergence is much higher than obtained previously in the literature. Convergence in industrial structure is, however, much slower than productivity catch up. Skill intensity fastens structural adjustment but seems to have no effect on convergence in productivity. The Heckscher-Ohlin model but also agglomeration effects and path-dependency may explain the puzzling result of rapid productivity convergence but slow or even non-existent convergence in structure.

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1. Introduction[1]

The literature on "technological gaps" (Nelson, Wright, 1992, Abramovitz, 1986) and on catching up (see e.g. Fagerberg, 1994, 1995) usually restricts itself to the macro level. Recently, there has been increasing interest in the question whether the experiences of individual industries confirm the observed pattern of catching up at the macro level. Many studies focus on convergence in productivity, but systematic evidence on the determinants of industry growth rates and, thus on the direction and speed of structural adjustment, is not yet available. This is particularly worrying since most of the EU policies are designed to increase output and employment growth by speeding up structural change. The present paper wants to contribute to what is known about convergence at the industry level and especially provide new evidence on the relationship between convergence in relative productivity and in industry structure of European Countries.

We analyse the relationship between convergence in productivity and structure by estimating convergence equations for value added, employment and productivity, all measured relative to the corresponding EU-aggregates. Our estimates are based on a comprehensive panel of 99 3-digit industries for 14 EU countries, covering the period 1985-1998. We investigate whether growth performance differs between European countries and industries, and whether and how fast convergence has taken place. To sum up, our estimation results indicate that convergence was quite rapid for productivity, while there was almost no convergence in structure (value added and employment). Productivity catch up takes place in nearly all countries, and in most of the industries across the board.

Our results are consistent with the equilibrium predictions of the Heckscher-Ohlin-model. In the Heckscher-Ohlin model, we observe equal factor prices in the cone of diversification and thus equal productivities at the industry level. However, different production structures exist

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in equilibrium as a consequence of different factor endowments.[2] Additional arguments explaining a high degree of persistence in structure come from the models of the new theories of geography and trade as well as from evolutionary approaches. Forces of agglomeration, for example induced by forward and backward linkages, may preserve industry structure for some time despite possible convergence in productivity and/or labour costs (Fujita, Krugman, Venables, 1999). Evolutionary models emphasise the cumulative and path dependent character of technological change and the importance of knowledge (Fagerberg, 1994), which may likewise induce persistent differences in relative industry size and deepen existing patterns of specialisation despite successful catching up in productivity (Dalum, Villumsen, 1996).

The studies most closely related to the present are those by Pugel (1992), Bernard and Jones (1996a, b), Carree et al. (1997, 1998), and Dollar and Wolff (1988, 1994). Pugel (1992) finds that the growth rates of manufacturing industries within Europe (EU-12), the US, and Japan vary widely, indicating substantial structural change. Concerning productivity catch-up at the industry level, Bernard and Jones (1996a, b) claim that while aggregate productivity was converging for a group of 14 industrialised countries over the 1970 to 1987 period, individual sectors show quite disparate behaviour. In particular, convergence in the manufacturing sector was only marginally significant, while convergence in the service sector was significant at standard level. Similar results are presented by Carree et al. (1997). In contrast, Dollar and Wolff (1988, 1994) find convergence in nearly every individual industry and conclude that convergence in productivity within industries is the main cause of convergence in aggregate labour productivity.

The paper is structured as follows: the next section briefly describes our database; Section 3 presents the main results, and the last section provides tentative conclusions.

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[2] In contrast, Ricardian trade theory predicts that if there is exogenous convergence in productivity, induced either by the diffusion of technology or by convergence in immobile sector specific factor endowments (Ricardo-Viner model), there is also convergence in structure.

2 The data

Eurostat provides data on nominal value added and employment for manufacturing industries at the 3-digit level for 14 member countries of the European Union (EU) over the period 1985-1998.[3] Values are not provided for all industries in some countries (mostly for reasons of confidence and problems which have evolved from the reclassification of NACE codes). The Austrian Institute of Economic Research (WIFO) interpolated or estimated missing data, constructing a full and comprehensive database (for detailed variable definitions see Appendix I).

In order to eliminate short run fluctuations, all variables are averages over the period 1985-1998. Value added deflators at the three-digit level are of poor quality, and methods of measurement differ across the EU-member countries. Reliable price deflators are not available, so we must use nominal value added. Several arguments defend our approach. First, we control for fixed country effects in all our regressions which capture a bundle of influences, such as country size, country specific differences in inflation and exchange rate movements, and macroeconomic performance. While the precise cause of country effects remains unidentified, these effects at least partially wipe out purely nominal phenomena. Secondly, quality-adjusted prices are relevant. Since quality adjustment, especially in the computer industry, is a very difficult task and beyond the scope of this contribution, we found it preferable to confine our investigation to the use of nominal, rather than real figures. However, we do test for the robustness of our estimation results by matching data from the OECD-STAN database, which provides information on real and nominal value added, mainly at the two-digit level. We calculate the implicit deflators and impute them at the three-digit level. The correlation between growth in nominal and real value added across countries and industries is 0.83. Furthermore, our estimation results do not vary substantially (see Appendix II). This confirms our view that the inclusion of nominal growth rates does not significantly distort our conclusions. The smaller number of valid observations for the real values in the unbalanced panel provides an additional argument for concentrating on the nominal figures.

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[3] Belgium and Luxembourg are treated as a single country.

The three variables of primary interest are value added, employment, and labour productivity (value added per worker). The average rate of nominal growth in a typical 3-digit industry amounted to 3.3% p.a. during the thirteen-year period 1985-1998 (see Table 1)[4]. The

Table 1: Average industry growth p.a. by EU-countries: 1985 to 1998

	Value added		Employment	Productivity	
	Nominal	Real		Nominal	Real
Portugal	8.0	3.2	0.0	8.0	2.5
Ireland	6.4	-	2.0	4.4	-
Austria	4.7	1.0	-1.7	6.4	2.7
The Netherlands	4.4	-	0.4	4.0	-
Denmark	4.2	-0.1	-0.3	4.5	1.6
Belgium	3.9	1.1	-2.6	6.5	1.2
Spain	3.8	2.4	0.4	4.2	3.4
Italy	3.5	2.2	-1.0	4.4	3.4
Germany	3.1	0.2	-2.2	5.3	2.3
United Kingdom	2.5	-0.1	-2.2	4.7	2.1
Greece	2.5	1.4	-2.0	4.5	3.9
France	2.4	0.0	-1.3	3.7	1.6
Finland	0.0	0.8	-2.5	2.6	3.2
Sweden	-2.4	-5.0	-3.9	1.4	-1.2
Average Total EU	3.3	0.6	-1.2	4.6	2.2

Note: Belgium and Luxembourg are treated as one country. Due to the unavailability of appropriate price deflators, Ireland and the Netherlands are not included at all in the real variables. Productivity is defined as value added per worker. The growth rates refer to a typical industry and are therefore not weighted to account for size and composition effects. Therefore, they do not represent growth in aggregate manufacturing. All variables are expressed in logarithmic differences.

standard deviation of 5.8 percentage points in the growth rates (not shown in Table 1) reveals high variation across EU member countries and across sectors.[5] The Portuguese manufacturing industries performed best, growing on average by 8.0% per annum in nominal terms, this high average growth rate is also confirmed by the real figures. At the bottom end of the scale, Sweden and Finland experienced a period of deep recession during the nineties. Note that on average, Ireland, the Netherlands and Spain have been the only countries in which industrial

[4] Note the real growth rates differ quite substantially from the nominal figures, because a lot of industries (mostly fast growing ones) have missing values in the deflator series. So the figures are not representative.

[5] In the sequel, two digit industries are referred to as 'sectors'; three digit industries as 'industries'.

employment has been on the rise.

The analysis of variance in Table 2 reveals high turbulence in industry growth rates of nominal value added, employment, and (nominal) productivity, with systematic differences across countries and industries. With respect to value added growth, forty-seven percent of the variation can be explained by country, sector, and combined sector and country effects.

Table 2: Analysis of variance

Source	Nominal value added		Growth in Employment		Nominal productivity	
	Partial sum of squares	Degrees of freedom	Partial sum of squares	Degrees of freedom	Partial sum of squares	Degrees of freedom
Model	20,656	305	12,249	305	10,655	305
Intercept	8,352	1	1,613	1	17,305	1
Country effect	4,671	13	1,746	13	2,515	13
Sector effect	2,610	21	2,587	21	563	21
Combined country-sector effect	9,978	271	6,790	271	6,653	271
Residual	24,570	1,040	17,013	1,040	17,312	1040
Total	45,226	1,345	29,262	1,345	27,966	1345
N	1,346		1,346		1,346	
R^2	0.47		0.42		0.38	

Note: Sectors are defined at the 2-digit level. The dependent variables are in logarithmic difference.

The variation across countries is more pronounced than the sector effects, indicating that the country specific environment has a significant impact on industry growth. This picture is consistent with the view that European manufacturing is not yet fully integrated. The sources of variation of employment growth are different, sector variation is more pronounced. For (nominal) productivity growth, the constant term accounts for most of the variation, indicating a marked general upward trend in labour productivity in all industries and all countries across the board. The variation across countries is higher than across industries. For all three variables, a significant amount of the variation in average growth rates can be attributed to combined country-sector effects. So the country specific environments combined with industry specific determinants common throughout the entire EU – such as demand growth – seem to be the important ingredients of long run performance.

3 Econometric specification and estimation results

Below, we analyse growth of nominal value added, employment, and (nominal) labour productivity in European manufacturing using the standard specification for ß-convergence (Barro, Sala-i-Martin, 1995). For a typical industry and country, convergence would require that the deviation of the growth rate from its long run value is negative proportional to the deviation of the level from the long run value. Skipping the industry and country index, the log linearisation around the long run values gives:

$$\frac{d\left(ln\,y - ln\,y^{*} \right)}{dt} \approx -b\left(ln\,y - ln\,y^{*} \right) \qquad (1)$$

where y denotes the level of the variable, y^{*} the corresponding steady state value, and b the factor of proportionality. Solving this differential equation assuming $y_t^{*} = Be^{gt}$, where g is the long run growth rate and B the steady state industry size at time 0, results in the equation for the growth rate over a period of length T:

$$ln\left(y_T\right) = ln\left(y_T^{*}\right) + e^{-bT}\, ln\left(y_0^{*}\right) - e^{-bT}\, ln\left(y_0\right) \qquad (2a)$$

Subtracting $\ln\left(y_0\right)$ on both sides, inserting $y_t^{*} = Be^{gt}$ and dividing by T gives the average growth rate over a period of length T:

$$\frac{1}{T} ln\left(\frac{y_T}{y_o}\right) = g + \frac{1}{T} ln\, B\left(1 - e^{-bT}\right) - \frac{1}{T}\left(1 - e^{-bT}\right) ln\, y_0 \qquad (2b)$$

Since we are interested in convergence in both productivity and in industry size (conditional upon country size), and thus in the question whether specialisation and/or concentration of production decreased over the course of the integration process, we postulate the same equation (2) for the European manufacturing industries (derived as the aggregate of each industry over countries). In order to eliminate the common but unobserved industry characteristics, we subtract this figure (denoted by a bar) from (2b):

$$\frac{1}{T}\left[ln\left(\frac{y_T}{y_0}\right) - ln\left(\frac{\bar{y}_T}{\bar{y}_0}\right)\right] = g - \bar{g} + \frac{1}{T}\left(ln\,B - ln\,\overline{B}\right)\left(1 - e^{-bT}\right) - \frac{1}{T}\left(1 - e^{-bT}\right)\left[ln\,y_0 - ln\,\bar{y}_0\right] \quad (3)$$

For each industry/country observation, equation (3) decomposes the average industry growth rate relative to that of the corresponding aggregate EU-industry into three components: (i) differences in the long run steady state growth rates ($g - \bar{g}$), (ii) differences in relative initial steady state industry size ($ln B - ln\overline{B}$) at time 0, and (iii) the catch-up term. Note that (ii) and (iii) vanish when T grows large and have no effect on steady state relative growth. Introducing fixed country effects as proxies for remaining unobserved country differences translates (3) into our econometric specification. As mentioned above, the continuous variables on the right and left hand sides are defined as deviations from the corresponding EU-industry:

$$\begin{aligned} &\Delta \ln\left(\frac{y_{ic}}{\bar{y}_i}\right) = ß \ln\left(\frac{y_{ic,0}}{\bar{y}_{i,0}}\right) + \boldsymbol{l}_c + \boldsymbol{e}_{ic} \\ &\boldsymbol{e}_{ic} \sim N\left(0, \boldsymbol{s}^2\right); \quad i = 1,...,99; \quad c = 1,...,14 \end{aligned} \qquad (4)$$

Index i denotes industries, c countries, and $\boldsymbol{l}_c$ are country specific dummy variables. Since in (4) industry specific determinants are constant across countries, we can use simple OLS instead of fixed effects to estimate the convergence equations. The interpretation of specification (4) is a subtle issue, since both value added and employment as measures of industry size are not independent of country size such as productivity. The country dummies control for country size relative to the EU, so that this specification provides a measure of convergence in structure. This can easily be seen if one applies the sweeping operation induced by the country dummies (see Baltagi, 1995):

$$\Delta\, ln\left(\frac{y_{ic}}{\bar{y}_i}\right) - \frac{1}{N}\sum_{i=1}^{N}\Delta\, ln\left(\frac{y_{ic}}{\bar{y}_i}\right) = ß\left[ln\left(\frac{y_{ic,0}}{\bar{y}_{i,0}}\right) - \frac{1}{N}\sum_{i=1}^{N} ln\left(\frac{y_{ic,0}}{\bar{y}_{i,0}}\right)\right] + \boldsymbol{e}_{ic} - \boldsymbol{e}_{.c} \qquad (5)$$

If a country's share of an industry in the corresponding EU industry aggregate is initially below (above) the geometric average country share, as compared to the geometric average industry share in EU manufacturing, the right hand side of (5) is negative (positive) and, given convergence (*ß<0*), this industry is expected to grow faster (slower) relative to the corresponding aggregate EU-industry.[6] Thus, convergence towards the common mean should occur from above and below and reduce the specialisation of countries and/or concentration of industries.[7]

ß-convergence is a necessary but not sufficient condition for convergence (Barro, Sala-i-Martin, 1995). We test for the robustness of the findings of the growth regressions by comparing the standard deviations of the three variables taken relative to the EU and corrected for country size as in (4). We denote s_0^2 as the standard deviation for a particular industry in 1985, and s_T^2 as that for 1998. Following Carree, Klomp (1997a and b) we test for the hypothesis $s_0^2 = s_T^2$, which means that the regression $y_t = r y_{t-1} + v_t$ represents a random walk. If the starting value is $y_o \sim N\left(0, s_0^2\right)$ and $v_t \sim iid, N\left(0, s_v^2\right)$, this is the case if $r = 1 - \frac{s_v^2}{s_0^2}$. In contrast, there is σ-convergence if $r < 1 - \frac{s_v^2}{s_0^2}$. Carree, Klomp (1997a) provide a likelihood-ratio test which performs well even in small samples.

Table 3 presents the estimation results for equation (4), constraining the β-coefficient to be equal across countries and industries. The dependent variables are the average, annual, compound 3-digit industry level growth rates in (respectively) nominal value added, employment, and productivity; all relative to the respective EU-average 3-digit industry growth rates over the 13 year period 1985 to 1998. β–ABOVE is the coefficient of an

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[6] An example might help. If 2 percent of Germany's total manufacturing employment were in e.g. "electronics components", but the "electronics components" industry EU-wide had a share of only 1 percent of the entire EU manufacturing employment, this industry is predicted to grow slower in Germany relative to the EU.

[7] Note that specialisation and concentration are treated symmetrically, since we just analyse shares at the country/industry level and do not aggregate across countries or industries. The former would give measures of concentration for each industry, whereas the latter provides indicators of specialisation for each country. When calculating measures of specialisation and concentration, differences between the two concepts arise if, for example, small and heavily specialised countries grow on average faster than the larger ones (see Aiginger et al., 1999).

interaction term for the initial level variables with ABOVE, a dummy variable equal to 1 if, for an industry in a particular country, the ratios of value added, employment, and productivity to the country's total manufacturing sector are larger than the ratio of the industry's EU-wide variable to total EU-manufacturing, and otherwise is zero. As such, this coefficient measures whether relative industrial convergence differs depending on whether the industry started out with a relatively larger share of the variables as defined above. We also provide estimates for the speed of adjustment coefficients and half-lives of adjustment (for definitions, please see the notes to Table 3) as well as the country fixed effects (the basis of comparison is Germany).

On average, there was significant relative ß-convergence at the 3-digit industry level in nominal value added, employment, and productivity during the period 1985 to 1998 in the member countries of the European Union. However, with an estimated speed of adjustment coefficient of 0.009 and an expected half-life of adjustment of around eighty years, relative convergence for nominal value added and employment at the industry level was very slow or even non-existent.

ß-convergence in output and employment can be interpreted as convergence in industrial structure among the EU member countries. What we see in the period analysed is slowly *decreasing* concentration[8]: we predict that those industries which have a smaller initial output or employment share relative to the corresponding EU share will grow faster (in terms of output and employment) relative to the corresponding EU industry aggregate. However, this convergence in shares will be rather slow and, as we shall see, country dependent.

In contrast, relative convergence of labour productivity is quite rapid and highly significant, with an estimated β-coefficient of -0.045 and a t-value of around twenty. This implies that industries which, in 1985, lagged behind in labour productivity relative to the EU average would be predicted to close half of a given gap in ten years. In other words, we predict that

[8] At least at the 3-digit industry level. With the data at hand, we cannot analyse whether there was e.g. increased concentration at the four or five (i.e. product group) digit level across countries. Nor can we analyse whether there was regional concentration within countries.

the lower the initial level of productivity relative to the EU-average, the higher the subsequent growth rate in productivity for this 3-digit industry relative to the EU growth rate.[9]

Relative convergence is a bit slower if our dummy variable ABOVE is one, particularly for output and employment structure. However, convergence also remains significant "from above". Since this interaction term does not alter the basic conclusions about relative convergence, we omit it from the analysis which follows.

Fixed country effects are highly significant and differ from Germany (our basis of comparison; the F-statistic is around thirty for labour productivity). As already mentioned, these fixed country effects control for differences in average manufacturing growth across countries not attributable to either catching up or to size (see equation (4)), but also for cross country variation in exchange rate movements, and for inflation rates.

[9] One may wonder why the β–coefficients for value added and employment do not add to the productivity estimates. This is because nominal value added and employment are functionally related and empirically highly correlated (with a correlation coefficient of 0.93) and, therefore, the data generating processes are not additive.

Table 3: Main results: European convergence of nominal value added, employment and productivity at the 3-digit industry level

Dependent variable: Average annual compound growth rate relative to EU growth rate of:

	Nominal value added	Employment	Productivity
β-Coefficient	-0.008	-0.008	-0.045
t-Value	-4.41**	-4.11**	-19.83**
β-ABOVE	0.001	0.001	0.002
t-Value	1.58	1.26	0.62
Speed of adjustment	0.009	0.009	0.069
Half-life (Number of years)	79.5	80.6	10.0
Fixed country effects:		Coefficient, (t-value)	
Austria	-0.002, (0.03)	-0.013, (-2.08)**	0.006, (2.56)**
Belgium	-0.008, (-1.39)	-0.021, (-3.09)**	0.017, (5.53)**
Denmark	-0.007, (-0.97)	0.003, (-0.38)	-0.002, (- 0.90)
Spain	0.000, (-0.06)	0.012, (3.07)**	-0.024, (- 9.61)**
Finland	-0.044, (-5.83)**	-0.020, (-2.98)**	-0.013, (- 4.69)**
France	-0.008, (-2.75)**	0.006, (1.94)*	-0.011, (- 5.60)**
Greece	-0.031, (-2.72)**	-0.025, (-2.81)**	-0.041, (-11.36)**
Ireland	0.005, (0.58)	0.017, (1.79)**	-0.012, (- 4.27)**
Italy	0.001, (0.25)	0.008, (2.28)**	-0.003, (- 1.29)
Netherlands	-0.004, (-0.74)	0.006, (1.01)	-0.005, (- 1.45)
Portugal	0.023, (2.70)**	0.086, (1.46)	-0.035, (- 7.08)**
Sweden	-0.055, (-9.06)**	-0.025, (-3.62)**	-0.017, (- 6.78)**
United Kingdom	-0.008, (-2.39)**	-0.002, (-0.81)	-0.006, (- 2.75)**
Constant	-0.014, (-4.02)**	-0.020, (-5.60)**	0.006, (4.70)**
R^2	0.31	0.23	0.51
Number of observations	1,299	1,298	1,300
Number of industries	99	99	99
F-test for differential fixed country effects	F (13, 1283)= 22.9**	F (13, 1282)= 18.6**	F (13, 1284)= 29.5**

Note: The regression estimated is $\Delta \ln \tilde{y}_{ic} = ß \ln \tilde{y}_{ic,0} + m + l_c + e_{it}$, where $\Delta \ln \tilde{y}_{ic}$ is the average annual compound 3-digit industry level growth rate in nominal value added, employment and productivity, respectively, relative to the EU-average growth rate over the 13 year period 1985 to 1998, and $\ln \tilde{y}_{ic,0}$ is the respective initial level. The estimation method is OLS corrected for heteroscedasticity (White, 1980). β–ABOVE is the coefficient of an interaction term of the lagged level variable with ABOVE, a dummy variable equal to 1, if the ratio of nominal value added (employment, productivity) of the respective industry in a given country to the total manufacturing sector of this country is larger than the ratio of the industry EU-wide variable to total EU-manufacturing, and is otherwise zero. The speed of adjustment coefficient b is derived from $ß = (1 - e^{-bT}) / T$, where T is the length of the time interval. The half-life measures the years for which the adjustment is half of a given discrepancy to the steady state value (Barro and Sala-i-Martin, 1995). The fixed country effects measure differences in growth rates not attributable to relative convergence growth and relative to Germany. The number of observations differs from 14*99 = 1386 because (1) there are some zero values (40), and (2) because we view those observations with corresponding standardised residuals greater than three as outliers and drop them (therefore the number of observations might also slightly differ across columns).
** significant at 5%; * significant at 10%.

Our estimates for labour productivity convergence are much higher than those previously obtained in the literature. For example, Bernard and Jones, 1996a, 1996b, obtain an only marginally significant β-coefficient of -0.026 (t-value = 1.78) for total manufacturing labour productivity (real value added per worker) for 14 OECD countries over the 1970-1987 period.[10] This implies that either (1) convergence accelerated during the last decade, and/or (2) convergence was much faster intra-EU than when countries outside of the EU are included (e.g. Bernard and Jones, 1996a, b include Australia, the US, Canada, and Japan), and/or (3) the level of disaggregation (i.e. the unit of analysis) should really be at or beyond the 3-digit level in order to accurately assess convergence within industries.[11]

Fortunately, our database permits the analysis of differential country convergence. The results are reported in Table 4a. On average, relative convergence is fairly uniform for nominal value added, but is less uniform for employment (the F-test is significant at the 10 percent level), and is significantly asymmetric for labour productivity (F = 2.7).

For the structure of nominal value added, there is only an insignificant or even a positive β-coefficient for Sweden, Finland, France, and Germany. Perhaps as expected, the largest negative β-coefficient is obtained by Portugal (-0.017, t = 5.02).

Regarding employment structure, differences across countries are more pronounced, and there is only insignificant or no convergence for Sweden, Germany, Denmark, Greece, Italy, and Austria. The highest speed of convergence was achieved by Belgium. Thus, while there are signs of increased integration via structural convergence in most EU countries, the tendency to converge to the EU average in some countries is either slow or non-existent. Idiosyncratic country characteristics and/or policies remain important.

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[10] The countries are Australia, Belgium, Canada, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, the United States, and West Germany. The data source is the OECD Intersectoral Database (ISDB).

[11] Fagerberg and Verspagen, 1996, obtain a β–coefficient of -0.029 (t = 5.84) for regional GDP per capita for 68 European regions over the period 1970-1990. This coefficient is also lower than our estimated -0.045, suggesting that *regional* convergence differs in speed as compared to *industrial* convergence, i.e. convergence speeds differ across industries within regions!

Table 4a: Differential convergence by countries

Dependent variable: Average annual compound growth rate relative to the EU growth rate of:			
	Nominal value added	Employment	Productivity
		β-Coefficients, (t-value)	
Austria	-0.009 (-1.75)*	-0.008 (-1.64)	-0.034 (- 5.91)**
Germany	-0.008 (-1.53)	0.001 (0.07)	-0.044 (- 6.02)**
Belgium	-0.014 (-3.99)**	-0.021 (-4.17)**	-0.054 (-12.92)**
Denmark	-0.013 (-2.94)**	-0.003 (-0.80)	-0.021 (- 1.58)
Spain	-0.012 (-2.48)**	-0.012 (-3.46)**	-0.036 (- 4.50)**
Finland	-0.002 (-0.37)	-0.012 (-2.13)**	-0.072 (- 5.72)**
France	-0.006 (-1.12)	-0.011 (-1.83)*	-0.031 (- 2.78)**
Greece	-0.009 (-2.08)**	-0.005 (-1.46)	-0.056 (-11.46)**
Ireland	-0.010 (-2.19)**	-0.014 (-2.93)**	-0.042 (- 6.72)**
Italy	-0.013 (-1.88)*	-0.008 (-1.18)	-0.044 (- 3.02)**
Netherlands	-0.009 (-1.99)**	-0.009 (-3.39)**	-0.024 (- 2.05)**
Portugal	-0.017 (-5.02)**	-0.013 (-3.76)**	-0.036 (-7.79)**
Sweden	0.003 (0.54)	0.004 (0.75)	-0.061 (- 7.45)**
United Kingdom	-0.016 (-2.47)**	-0.010 (-1.77)*	-0.050 (- 6.48)**
Fixed country effects:		Coefficient, (t-value)	
Austria	-0.006, (-0.29)	-0.026, (-1.28)	0.007, (2.89)**
Belgium	-0.030, (-2.03)**	-0.083, (-3.75)**	0.019, (6.13)**
Denmark	-0.030, (-1.45)	0.005, (0.23)	-0.005, (- 1.59)
Spain	-0.011, (-0.80)	-0.011, (-0.82)	-0.021, (- 6.75)**
Finland	-0.020, (-0.86)	-0.052, (-1.96)*	-0.008, (- 2.02)**
France	-0.005, (-0.38)	-0.012, (-0.75)	-0.012, (- 5.72)**
Greece	-0.040, (-1.50)	-0.026, (-1.35)	-0.050, (-11.20)**
Ireland	-0.005, (-0.19)	-0.030, (-1.09)	-0.011, (- 4.15)**
Italy	-0.009, (-0.59)	-0.004, (-0.22)	-0.003, (- 1.04)
Netherlands	-0.008, (-0.46)	-0.009, (-0.66)	-0.007, (- 1.88)*
Portugal	-0.023, (-1.26)	-0.023, (-1.44)	-0.021, (- 2.98)**
Sweden	-0.019, (-0.90)	0.008, (0.35)	-0.010, (- 2.40)**
United Kingdom	-0.023, (-1.68)*	-0.018, (-1.24)	-0.006, (- 2.77)**
Constant	-0.014, (-1.90)*	-0.008, (-0.79)	0.006, (4.87)**
R^2	0.33	0.25	0.53
Number of observations	1,397	1,299	1,297
Number of industries	99	99	99
F-tests:			
Differential country convergence	F(13, 1269) = 1.2	F(13, 1271) = 1.5*	F(13, 1273) = 2.7**
Differential fixed country effects	F(13, 1269) = 0.7	F(13, 1274) = 1.7*	F(13, 1274)= 22.9**

Note: ** significant at 5%; * significant at 10%.

In contrast, all β-coefficients are negative for nominal labour productivity, and productivity convergence is only insignificant for Denmark. For productivity, half-lives of adjustment range from the highest value of 28.5 years for Denmark to the lowest value of 3.2 years for Finland. We interpret this result as evidence that convergence in productivity takes place in all countries and in most industries across the board, although there are significant differences in the speed of adjustment across countries. Convergence in productivity does not seem to be conditional upon convergence in industrial structure.

High human capital stocks potentially alleviate technology transfer by for example increasing the mobility of the work force. Thus, industries using skilled labour more intensively should converge faster. In Table 4b, we include an interaction term between the initial level variables and skill intensity, defined as the share of white-collar high-skilled workers in the industry (for more details see the notes to Table 4b and Appendix I).

The skill intensity of an industry has a major and significantly positive impact on the speed of convergence of industrial structure (output and employment). For example, the half-life of adjustment in the structure of value added, evaluating the skill intensity term at its mean value, from the range up to the 25^{th} percentile, is 82.7 years. This half-life figure drops to 62.1 years when we increase skill intensity to its mean value, from the range above the 75^{th} percentile. However, skill intensity has no effect on productivity convergence. While our estimates are consistent with the speed of convergence in structure being positively influenced by human capital stocks and educational efforts, we are left with a puzzle, as far as catching up in productivity is concerned.

Table 4b: Differential convergence with respect to skill-intensity

Dependent variable: Average annual compound growth rate relative to EU growth rate of:	Nominal Value Added	Employment	Productivity
		β-Coefficients, (t-value)	
Initial level	-0.007, (-5,19) **	-0.008, (-5.50) **	-0.050, (-15.58) **
Skill intensity*initial level	-0.008, (-4.31) **	-0.004, (-2.18) **	0.005, (0.38)
Half-lives of convergence for skill intensity at its mean in the range:			
< 25th percentile (i.e. 0.11)	82.7	73.9	8.7
25th – 75th percentile (i.e. 0.15)	79.4	72.3	8.7
>75th percentile (i.e. 0.40)	62.1	63.1	9.2
R^2	0.25	0.31	0.57
Number of observations	1,302	1,303	1,296
Number of industries	99	99	99
F-tests:			
Diff. Fixed country effects	F(13,1287)=19.2**	F(13,1287)=23.3**	F(13, 1277)= 37.0**

Note: All regressions include country fixed effects. *Skill* intensity is defined as the share of white-collar high-skilled workers in the industry, whereby these include legislators, senior officials, managers, professionals, technicians and associate professionals (see OECD, 1998). ** significant at 5%; * significant at 10%.

If there is relative (and *unconditional*) catching up, we also get the prediction that the growth rates of the dependent variables should monotonically decline with the initial gap. Table 5 illustrates that these predictions are exactly matched. In Table 5, initial (1985) GAP is defined as the percentage deviation of the initial level variables relative to the EU average, and ABOVE is the same dummy variable as defined in Table 3. It is equal to zero if the industry is "lagging" in the variable relative to the EU average, and it is equal to one if the industry is "leading" (relative to the EU average). Additionally dividing the sample into those industries "lagging more" than the median, "lagging less" than the median, "leading less" than the median, and "leading more" than the median, we obtain four subsamples ranked according to the initial gap. *All* our predictions are fulfilled. Those industries initially "lagging" most exhibit the highest subsequent relative growth rates in all three variables. Those industries initially "leading" most exhibit the lowest subsequent relative growth rates. In accordance with our results on β-convergence, the effects are most pronounced for productivity.

Table 5: Is there really convergence?: Some summary statistics

		Average annual compound growth rate relative to the EU growth rate of:		
		Nominal value added	Employment	Productivity
	& 1985 GAP:			
ABOVE = 0	> Median	2.1	1.4	2.2
ABOVE = 0	< Median	0.3	0.2	0.4
ABOVE = 1	< Median	-0.4	-0.1	-0.5
ABOVE = 1	> Median	-0.6	-0.5	-1.9

Note: Initial (1985) GAP is defined as the percentage deviation of the initial level variables relative to the EU average. ABOVE is the same dummy variable as defined in Table 3, namely, equal to 1 if the ratio of nominal value added (employment, productivity) of the respective industry in a given country to the total manufacturing sector of this country is larger than the ratio of the industry EU-wide variable to total EU-manufacturing, and is otherwise zero, i.e. ABOVE is equal to zero if the industry is "lagging" in the variable relative to the EU, and is equal to one if the industry is "leading" (relative to the EU average). Then we divide the sample into those industries "lagging more" than the median (ABOVE = 0 AND GAP > Median), those "lagging somewhat less" (ABOVE = 0 AND GAP < Median), those "leading slightly" (ABOVE = 1 AND GAP < Median), and, finally, those industries "leading considerably" relative to the EU average (ABOVE = 1 AND GAP > Median). (Thus, the allocation of industries to the classes may vary with the analysed variable.) Therefore, if there is really (relative and *unconditional*) catching up, we get the prediction that the relative growth rates of the variables should monotonically decline across sub-samples.

The interpretation of a negative β-coefficient as evidence for convergence has been criticised (see Quah, 1993; Friedman, 1992). In essence, the criticism centers around the argument that a negative sign on the initial-condition coefficient does not indicate a

Table 6: Is there really convergence?: σ-Convergence

	Median standard deviation		Number of industries with	
	1985	1998	σ-convergence	T_2-statistic[a)] sig. at 10%
Nominal value added	0.74	0.78	41	6
Employment	0.70	0.73	40	5
Nominal productivity	0.34	0.28	59	24

Note: For each industry, standard-deviations are calculated across countries. All variables are defined as in the regressions (Table 4) and are additionally corrected by country averages, see (4).

a) $T_2 = (N - 2.5) ln\left[1 + \frac{1}{4}\frac{(\hat{s}_0^2 - \hat{s}_T^2)^2}{\hat{s}_0^2 \hat{s}_T^2 - \hat{s}_{0T}^2}\right]$ from Carree, Klomp (1997a) which is distributed as $\chi^2(1)$ in the limit under the H_o of no σ-convergence (i.e. equal variances).

collapsing cross-sectional distribution, but simply the Galtonian fallacy of a regression towards the mean. We respond to this criticism by additionally analysing σ-convergence. If there is a collapsing cross-sectional distribution, the standard deviation of the relevant variable for each industry across countries should decline over time. Table 6 shows that there is σ-convergence only for productivity: in 59 of the 99 industries, the cross country standard deviation declines; in 24 industries this decline is significant at the 10% level, as evidenced by the T_2 statistic of Carree, Klomp, 1997a. We do not find significant σ-convergence for industrial structure.

4. Conclusions

We find very fast convergence in productivity for the 99 3-digit European industries over the 1985-1998 period. The speed of convergence is much higher than obtained previously in the literature. In contrast, convergence in industrial structure (measured by relative nominal value added and employment) is much slower or even non-existent. The skill intensity of industries is a major determinant of structural convergence, but it is irrelevant for productivity convergence.

While the speed of productivity convergence differs across countries, it does take place in most industries without significantly changing the structure of comparative advantages. An explanation for the puzzling result of fast productivity convergence with stickiness in structure could be the Heckscher-Ohlin theory. In the long run, when countries employ equal technologies, we observe factor price equalisation within integrated countries and thus equal productivities, while industrial structure is determined by factor endowments. However, agglomeration effects as well as the cumulative and path dependent character of technological change may likewise preserve the existing structure, while productivity possibly converges. It remains an open question for future research which theory best explains slow or absent structural convergence, while productivity gaps are being closed so rapidly.

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Appendix I: The Database

Our database comprises information at the 3-digt level for manufacturing from NACE 15 to 36 for the period 1985-1998 and 14 European Countries (Belgium and Luxembourg are treated as one country). EU = EU 12 up to 1994; EU 15 since then. WIFO added A, SF, S for the period 1988 – 1994.

Variable definitions: Nominal value added and employment are from the SBS-database (Structural Business Statistics), provided by EUROSTAT. Data are complete for total manufacturing (up to publication in 1998). There are some missing values at the 2- digit level. Up to 30% are missing at the 3-digit level, specifically early and late years. The WIFO estimation strategy is conservative, trying to avoid biases from assuming too much turbulence (see Aiginger et al., 1999 for details).

Real value added and nominal value added from the STAN-database from the OECD are used to calculate implicit deflators (1990=100), which are imputed at the 3-digit NACE level. The data are converted from ISIC Rev.2 to NACE Rev.1. The real values are calculated in 1990 ECUs. For Ireland and the Netherlands and also for some industries, these data are missing.

Skill intensity: defined as the share of white-collar high-skilled workers in the industry in 1990, whereby these include legislators, senior officials, managers, professionals, technicians and associate professionals (see OECD, 1998). The occupational data are based on the International Standard Classification of Occupations of the International Labour Office, ISCO 88. Note that the variable does not vary across countries.

Appendix II: Estimation results for real value added and real productivity

Table A1 shows that the results for the real variables do not change our conclusions; on the contrary, speed of real productivity convergence estimates are even higher than for the nominal variables.

Table A1: European convergence of real value added and real productivity at the 3-digit industry level

Dependent variable: Average annual compound growth rate relative to EU growth rate of:	Real value added	Real productivity
β-Coefficient	-0.009	-0.057
t-Value	-3.46**	-19.87**
β-ABOVE	0.004	0.002
t-Value	3.21**	0.45
Speed of adjustment (BELOW)	0.010	0.104
Half-life (Number of years)	71.16	6.63
Fixed country effects:	(Coefficient, t-value)	
Austria	-0.003, (-0.37)	0.004, (1.39)
Belgium	-0.003, (-1.70)*	0.007, (2.07)**
Denmark	-0.025, (-2.40)**	-0.011, (- 3.75)**
Spain	0.017, (2.89)**	-0.009, (- 3.79)**
Finland	-0.012, (-1.36)	0.015, (5.41)**
France	-0.004, (-1.03)	-0.003, (- 1.25)
Greece	-0.022, (-1.36)	-0.044, (- 9.50)**
Ireland	-	-
Italy	0.013, (2.98)**	0.013, (4.74)**
Netherlands	-	-
Portugal	0.006, (0.47)	-0.078, (-14.00)**
Sweden	-0.048, (-5.28)**	-0.001, (- 0.21)
United Kingdom	-0.004, (-0.84)	-0.010, (- 4.15)**
Constant	-0.015, (-3.05)**	0.005, (3.97)**
R^2	0.22	0.54
Number of Observations	819	817
F-test for fixed country effects	F (11, 805)= 12.7 **	F (13, 1)= 30.1 **

Note: Due to the unavailability of appropriate price deflators, Ireland and the Netherlands are completely excluded. The number of observations also falls further due to the removal of some industries from our study.
** significant at 5%; * significant at 10%.