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Structural Convergence of European Countries

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Abstract:

Building on the three-sector-hypothesis, the New Theory of Trade, and the New Economic Geography, we investigate the development of economic structures of European countries over the last three decades using employment data. We test for structural convergence which we analyze on the aggregate level as well as specifically for manufacturing and service industries. For this we implement both time series and panel data methods. Our results indicate overall structural convergence between Western European countries over time. This is mainly due to strong intersectoral convergence patterns as countries shift from industrialized to service economies. In contrast, the results regarding intrasectoral convergence are mixed: Increasing spatial concentration in production is dominant in technology-intensive manufacturing industries which are characterized by economies of scale and path-dependency, whereas convergence is found in mature, less technology-intensive industries. In most service branches country-specific differences do not change to a significant extent with the exception of transport and storage services.

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1. Introduction

The economic policy of the European Union aims to foster the integration and cohesion between its member states (art. 158 and 160 of the treaty establishing the European Community). According to economic theory, deeper integration should have initiated at least some reallocation of economic production between European countries. As trading costs diminish, the ability to exploit economies of scale as well as the access to suppliers and other complementary activities is becoming more important. These tendencies favor the concentration of industries in very few places and the specialization of countries, thereby increasing the absolute heterogeneity of countries (Krugman 1991a). Moreover, the deeper integration has enlarged the possibilities of trade, making it easier to exploit comparative advantages. Therefore, also the relative structural differences between countries are likely to have increased over time (Haaland et al. 1998).

These models, however, fail to capture European reality: labor is still a highly immobile production factor and consumers have made use of the new consumption possibilities to a lesser extent than expected. Moreover, international technology diffusion fosters catch-up processes and might lead not only to income but also structural convergence across Europe (Pigliaru 2003). In addition, the ongoing globalization affects the comparative advantages of European countries in the same way: European countries lose competitiveness in labor-intensive, low-skill and low-technology industries in favor of low-cost countries outside Europe. This forces all European countries to shift production towards high-technology, high-skill and capital-intensive industries. Altogether, the conclusion is inconclusive, suggesting extensive branch-specific differences with regard to their convergence potential.

In contrast to the vast amount of empirical literature on income convergence, studies on structural convergence are scarce. Some work has been done regarding regional convergence (e.g. Cuadrado-Roura et al. 1999, Guerrieri and Iammarino 2003, Longhi and Musolesi 2007); others investigate the interrelationship between structural convergence and income convergence (Wacziarg 2001, Imbs and Wacziarg 2003), productivity convergence (Fagerberg 2000, Gugler and Pfaffermayr 2004), and monetary integration (Brülhart 1998). Others again focus on the economic catch-up and structural assimilation of countries, e.g. Landesmann (2000) for the movement of Central and Eastern Countries towards the Western European countries and Abegaz (2002) for the convergence between industrialized, newly industrialized and least-industrial country groups.

With a focus similar to the present paper, Midelfart-Knarvik et al. (2000) investigate structural convergence between European countries. They analyze specialization tendencies of European economies and localization trends of industries from 1970 to 1997, measured by gross value of output, for both the manufacturing and service industries. In doing so, they account for the interrelationship of industry (such as capital, skill and technology intensity, returns to scale) and country characteristics (e.g. availability of R&D, high-skill workers and scientists, market potential) and the impact of these factors on structural convergence. The authors moreover introduce a measure of spatial dispersion that takes into account the relative locations of industry clusters, to evaluate the relative locations of concentrations of these individual industries. Thus, they analyze the reasons for concentration of industries and for where industries actually locate, rather than convergence of industries as a development over time.

In this paper, we examine the process of structural convergence of Western European member states at the industry-level. That is, we analyze whether countries show increased similarity with regard to their employment shares in individual industries over time. We use data for the three aggregate sectors (agriculture, manufacturing, and services) as well as for nineteen manufacturing and ten service industries, covering fourteen European countries over the period from 1970 to 2004 and 2005, respectively. The long time horizon is of great relevance for our purposes, as we want to compare the levels of structural heterogeneity between decades which are characterized by very different degrees of European and international economic integration.

Our analysis contributes to the literature in the following ways: First, we provide a comprehensive view on *both* intersectoral and intrasectoral convergence. We put the different convergence types into relation, showing that the bulk of convergence across European countries in the last decades was owed to intersectoral rather than intrasectoral convergence. For this, we define a heterogeneity index which can be decomposed into inter- and intrasectoral heterogeneity. Second, we analyze the dynamics of employment structures not only in manufacturing but also in service industries, which so far have been mostly neglected in the literature. Third, we provide evidence of industry-specific convergence (or divergence) patterns and establish a procedure to distinguish between two forms of divergence, i.e. general divergence, where some countries win employment shares in the respective industry at the expense of other countries, and concentration processes driven by one-country specialization, where employment shares of all but one country remain stable and only one country strongly increases its employment share.

The paper is structured as follows: Section 2 presents relevant theoretical concepts including the main driving forces of convergence and divergence. In Section 3 we explicate our approach to the implementation of empirical convergence tests, followed by information on the employment data used in section 4. Section 5 presents descriptive statistics as well as the results of σ- and β-convergence tests and section 6 concludes.

2. Theoretical Framework and Literature

For the discussion of structural convergence, we have to distinguish between two types of structural change, i.e. inter- and intrasectoral change. The former refers to variations of employment shares between the three aggregate sectors[3] of an economy and hence focuses on the transition from the agrarian to the industrial and finally to the service economy. The latter relates to changes of production structures within one of the aggregate sectors, for instance a change in the share of the textile industry on total manufacturing employment.

Arguments for intersectoral convergence can be derived from the three-sector-hypothesis and the convergence hypothesis of Chenery (1960), which both assume that there is a strong correlation between the production structure of a country and its per-capita income level. According to these hypotheses, intersectoral convergence is expected to occur whenever poorer countries are able to close the income gap, since consumption patterns then converge towards those of richer countries (Fisher 1939, 1952). Rising incomes therefore lead to a decline in the consumption of basic goods and a rise in the consumption of luxury goods. When the production side adapts to these changes in demand, employment in agriculture

[3] The three aggregate sectors are agriculture, manufacturing and services. In recent years the impact of industries associated with information and communication technologies (ICT) has risen dramatically and therefore it has often been argued that the three-sector-hypothesis should be complemented by a forth sector (Porat 1976 and OECD 2005). As our data are too highly aggregated to allow for a forth sector, we decided to work with three aggregate sectors and include ICT branches in the manufacturing and service sector, however. Hence, we study the impact of the diffusion of information and communication technologies in the economy only through intrasectoral convergence, as our data are too highly aggregated to allow for a forth sector.

declines, whereas employment shares rise first in manufacturing; similarly, in later stages, manufacturing declines whereas service industries increase. The three-sector hypothesis also stresses supply-side convergence potentials: Knowledge transfer enables technologically lagging countries to increase labor productivity and catch up to technologically leading countries (Clark 1940, Fourastié 1949). This process of productivity growth reduces employment in the agricultural and (in a later stage) the manufacturing sector and increases the share of the service sector. Thus, convergence of income levels and labor productivity is expected to lead to structural convergence (as stressed by Pigliaru 2003).

For our investigation of European countries we therefore expect to find that an intersectoral convergence process has taken place since the 1970s. Countries which were characterized by a disproportionately high employment share in agriculture and relatively low labor productivity at the beginning of the investigation period should have undergone a period of extensive catch-up and transition towards industrialized and service economies. Moreover, as the incomes of poorer countries have risen, demand patterns should have converged to those of richer countries. This is associated with a shift in consumption from manufacturing goods to services.

A certain degree of heterogeneity between countries will remain, however, due to differences in natural resources, country size, institutional frameworks and cultural backgrounds (Chenery 1960). Whereas the importance of the latter two factors is diminishing as a consequence of the ongoing process of European integration, the impact of differences in country size on divergence processes should not be underestimated, as is suggested by models of the New Economic Geography (Krugman 1991a, 1991b).

Regarding intrasectoral convergence and divergence, the direction of development is less clear-cut and highly dependent on the characteristics of each individual industry, but also on trading costs, trading barriers and the natural endowments of European countries. On the one hand, the ongoing process of globalization and the decline in trade costs have affected the comparative advantages of European countries similarily. The competitiveness in labor-intensive and low-skill industries has decreased compared to low-cost countries. This should have lead to a massive reallocation of labor within Europe, as low-technology and labor-intensive industries are outsourced whilst the shares of technology-, skill-, and capital-intensive industries rise. Structural change has been most dramatic in countries with a disproportionately high share of low-skill industries at the beginning of this process. Besides, the vanishing of trade barriers enhances the diffusion of knowledge so that new technologies become available to a large group of countries and enable technologically lagging countries to catch-up to technological leaders (de la Fuente 1997; Pigliaru 2003). One important precondition for this catch-up is that lagging countries have a sufficient base of "social and technological capabilities" (Nelson 2005) in order to absorb new knowledge and to use new high-class technologies (Fagerberg 1994). Within Europe, these capabilities ought to be present in all countries – whereas this is not necessarily the case for newly industrialized countries. Therefore, the diffusion of knowledge is expected to cause convergence in medium and high-technology industries. In emerging high-tech industries, however, divergence is possible, as technologically leading European countries may specialize in high-technology industries to maintain their competitive edge.

The effect of European integration, on the other hand, is ambiguous: Lower transaction costs due to European integration lower the importance for producers to be close to suppliers and customers. Therefore, according to Amiti (1998) and Rossi-Hansberg (2005) the attractiveness of locations close to large markets decreases in comparison to cost-competitive peripheral locations. This shift becomes more probable the fiercer the competition of agglomerated firms (Baldwin and Venables 1995). Thus, lowering trade costs should lead to a similar convergence across Europe for all types of industries. Yet, this implication is in contrast with the thesis of the New Economic Geography (Krugman 1980, Helpman and Krugman 1985) that both specialization and concentration increase with a decline in transport and trade costs as these enhance the opportunities of firms to exploit economies of scale and reduce production costs. Economic integration and trade liberalization therefore are expected to facilitate the international division of labor and contribute to the persistence or even the broadening of structural differences between countries.

Intrasectoral divergence may particularly be promoted by European integration in the following cases: Industries, that exhibit increasing returns to scale, are likely to concentrate production in larger countries as large domestic markets can more easily attract industrial sectors than smaller domestic markets (Midelfart et al. 2003). Similarly, a large number of up- and downstream linkages in industries leads to a high level of concentration (or clustering) of economic activities, such as in the case in the automobile industry (Fujita et al. 1999).

Further driving forces for intrasectoral divergence are the existence of pecuniary or technological externalities (Krugman and Venables 1995), because the presence of such externalities, industries are likely to be spatially concentrated in order to minimize production costs, benefit from a common pool of knowledge and infrastructure and take advantage of the path-dependency in the creation and accumulation of knowledge. In addition, the divergence of production structures is due to path-dependent developments, i.e. countries tend to specialize in those branches where they originally have comparative advantages (Ohlin 1933). This is especially true for high-skill and high-technology industries, which are likely to show strong patterns of path dependency, since the creation and accumulation of knowledge are characterized by path-dependencies.

From these arguments we derive the hypothesis that the impact of globalization has been particularly strong on mature, labor-intensive and low-technology industries. Hence, we expect convergence in these industries, as employment there should shrink in all observed countries due to outsourcing processes. Secondly, we presume convergence for low and medium technology industries due to technology diffusion across European countries. For industries which exhibit economies of scale and are technology- and knowledge-intensive, divergence ought to occur, since in these industries path-dependencies are likely to exist.

Industries in the service sector are expected to show slow development - if any - because they are characterized by a high degree of immobility. Conversely, manufacturing goods are more easily tradable. European integration as well as globalization therefore is assumed to have a greater impact on manufacturing than on the service sector. At the same time, we expect to observe differences between locally oriented branches and globalizing industries.

3. Methodological Issues

In order to detect structural convergence (or divergence, respectively) we implement the classical approaches of σ- and β-convergence that were initially introduced by Barro and Sala-i-Martin (1992, 1995) in the context of income convergence.

σ-convergence

For empirical tests on structural σ-convergence, a measure of heterogeneity is required; a number of indices developed for this purpose can be found in the literature.[4] The major drawback of all of these indices is that they are not able to distinguish between inter- and intrasectoral developments and therefore might lead to misleading conclusions about the structural economic development within Europe. We construct an index which captures the total heterogeneity of economic structures between N countries, the *Index of Structural Heterogeneity* (SHE^N). It is based on the industry-specific SHE_s^N, i.e. the N countries' heterogeneity in each industry s (similar to Krugman 1991a), calculated as the sum of the countries' deviations b_s^n from the average employment share of industry s from total employment over all countries $\bar{b}_s$:

$$SHE_s^N = \frac{1}{N}\sum_{n=1}^{N}\left|b_s^n - \bar{b}_s\right| . \tag{1}$$

Summing the index over all industries yields the aggregate index of structural heterogeneity, which indicates the overall heterogeneity of all countries' industry structures. This index is divided by the number of industries being analyzed, so for S industries and N countries this is:

$$SHE^N = \frac{1}{N}\frac{1}{S}\sum_{s=1}^{S}\sum_{n=1}^{N}|\, b_s^n - \overline{b_s}\, | \tag{2}$$

Using this index, we are able to measure absolute concentration, that is, to what degree the production structures of individual countries differ from the average production structure in Europe. We do not, however, measure relative concentration, e.g. whether country A being twice as large as country B, also produces twice as much in industry s.

In order to test for σ-convergence we calculate the SHE^N for each year in the observation period 1970-2005 (1970-2004 for manufacturing industries) and analyze the development of the index over time using the time series methods described below. A growing SHE^N is interpreted as a sign of divergence, while a decreasing SHE^N points towards convergence.

So far, differences between inter- and intrasectoral convergence have not been taken into account, i.e. the index can be used for all aggregation levels alike. Taking the shares of the three aggregate sectors, i.e. agriculture, manufacturing, and services, makes it possible to test for intersectoral change and thereby for the validity of the three-sector-hypothesis; similarly we could focus on only one of these sectors, measuring e.g. the shares of individual manufacturing industries on total manufacturing, and analyze intrasectoral convergence instead. For a comprehensive analysis, we combine the different aggregation levels and test to which extent both types of convergence contribute to overall convergence across countries. For this purpose, we have to put the respective heterogeneity index values into relation. We calculate the SHE^N for N countries and assume K aggregate sectors, each consisting of S_k industries; the employment shares b are calculated relative to total employment of the aggregate sector (marked by the subscript k) or employment of the entire economy (subscript E). It is easy to show that

[4] The best known are the Herfindahl-type indices, such as the Specialization Index of Krugman (1991a) and the Structural Deviation Index of Landesmann (2000), the Index of Inequality in Productive Structure by Cuadrado-Roura (1999), and indices based on the Theil Dissimilarity Index (1967) and the Entropy Index of Specialization and Concentration (Aiginger and Davies 2004; Brülhart and Traeger 2005).

$$\frac{1}{N}\frac{1}{S}\sum_{n=1}^{N}\sum_{s=1}^{S}\left|b_{s,E}^{n}-\bar{b}_{s,E}\right|=\frac{1}{N}\sum_{n=1}^{N}\sum_{k=1}^{K}\tfrac{1}{S_k}\left|b_{k,E}^{n}-\bar{b}_{k,E}\right|+\frac{1}{N}\sum_{n=1}^{N}\sum_{k=1}^{K}\tfrac{1}{S_k}b_{k,E}^{n}\sum_{s=1}^{S_k}\left|b_{s,k}^{n}-\bar{b}_{s,k}\right| \qquad (3)$$

Equation (3) implies that heterogeneity - and hence convergence - can be formally decomposed into an intersectoral and an intrasectoral part (given by the first and the second terms on the right-hand side, respectively), the latter being scaled by the average share of the respective sector. The smaller a sector (i.e. the smaller its employment share $\bar{b}_{k,E}$) the smaller is the impact of intrasectoral heterogeneity within this sector on the aggregate index of structural heterogeneity.

We model the development of heterogeneity as an autoregressive integrated moving average process (ARIMA(p,d,q)) with d = 1 according to the following (general) equation:

$$\Delta SHE_t = \varphi + \mu_1 \Delta SHE_{t-1} + ... + \mu_p \Delta SHE_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ... - \theta_q \varepsilon_{t-q}\,.$$

To achieve stationarity of variances and covariances we use the logarithm of the values. First differences have been taken in all time series, since the hypothesis of (trend-)stationarity was rejected for all time series.[5] The estimation result we are most interested in is the constant φ which in the case of d = 1 indicates the (deterministic) time trend of the time series. A value of φ significantly greater than zero is interpreted as a sign that heterogeneity increases over time (i.e. divergence) whereas a significant and negative φ indicates a decrease of *SHE* and thus convergence.

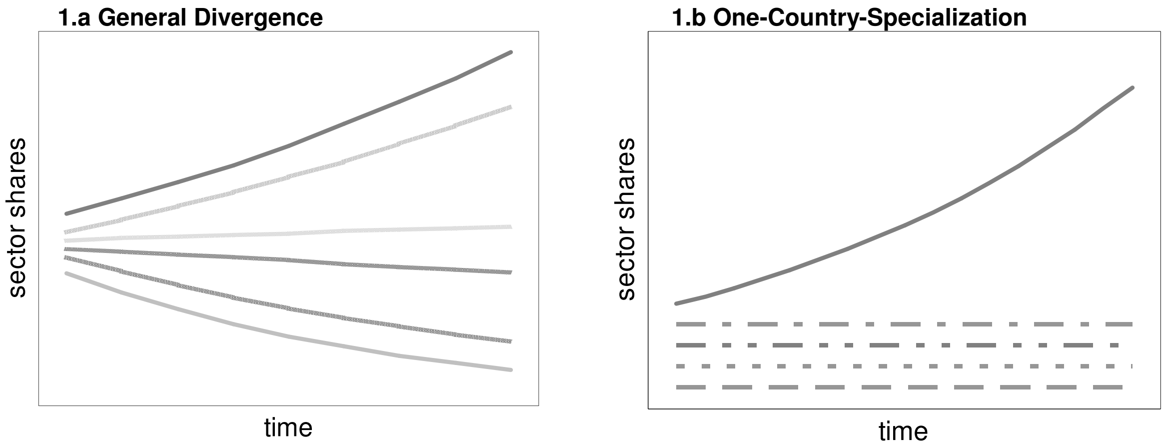
Using the *SHE* to study structural convergence and divergence still has some drawbacks: First, the *SHE* does not enable us to see which countries (de-)specialize in which industries. Second, we cannot distinguish between general divergence (convergence) in an industry and one-country specialization (catch-up). In particular in case of divergence the difference between one-country-specialization and a general dispersion trend would be notable: The latter case is (more or less) the general type of divergence, i.e. countries gradually differ regarding their factor endowment and competitiveness in the respective industry or sector. Thus, an insignificant time trend of the SHE^N here means that countries do not specialize. In the former case, in contrast, one country specializes largely in one industry or sector whereas the other countries diverge only slightly or might even converge. An insignificant time trend in this case does not imply irrelevant or slow development, but rather the combination of strong divergence evoked by the specialization of the leading country and minor divergence, stagnation or slight convergence of the N-1 countries not specialized in this industry. Both types affect the heterogeneity across countries, but they may be triggered by different reasons and in different types of industries. Figure 1 illustrates both divergence types in a simplified form.

In the literature, this distinction of divergence types is not accounted for, and in fact the differentiation is difficult, since the lines between one-country-specialization and general divergence are blurry. As an approximate solution we calculate the SHE^N, the SHE^{N-1} for the country group without the country deviating the most and the employment share of the deviating country in relation to the European average. The development of these three variables over time can be used to identify the convergence/divergence types: One-country-specialization is present instead of general divergence if the time trends of both the SHE^N and

[5] Using the Augmented Dickey-Fuller test we cannot reject the hypothesis of a unit root for all time series, but we find stationarity of the first differences for nearly all sectors/industries; for the results of the ADF see tables C1 and C2 in the appendix. Lag orders were specified for each time series separately in order to achieve a good fit of the model. However, we are not interested in the values of the AR- and MA-characteristics of the series. Therefore the complete results of the ARIMA regressions are reported only in the appendix (see tables C3-C5), while the interpretation is focused on the values of the constant.

the maximal deviation are significant and positive whilst the time trend of the SHE^{N-1} of the remaining countries is significant and negative, insignificant, or significantly smaller than the SHE^{N}. As to convergence, a similar distinction is possible for the case that the most specialized country gives up its position. We should expect a negative and significant time trend of the maximum deviation, together with an insignificant time trend of the SHE^{N-1}. To validate the result in case of one-country-specialization, we must rule out the possibility that the role of the most deviating country devolves from one country to the other from one year to the next. For general divergence a change in the most deviating country is irrelevant. In our data, we find changes regarding the role of the most deviating country only for general convergence or divergence - or to be more precise, in cases where no country is highly specialized.

Figure 1: Divergence Types



β-convergence

The second approach to measure convergence/divergence is β-convergence. We test for unconditional convergence, which implies that all countries tend to converge until all countries have the same employment shares in all respective industries. Therefore, countries whose industrial structure deviates the most from the average structure have to undergo the largest transition and adaptation process. This approach has been widely discussed in the literature (Quah 1993). Indeed, there are several difficulties, for example both catching up and leapfrogging will cause significant β-convergence, although the latter does not imply real convergence, but could even lead to divergence. Nevertheless, β-convergence is still a commonly used concept, based on the appealingly simple idea that if the initial value of the variable (in the case of structural convergence e.g. the industries' employment shares) has a significant and negative impact on the growth of the variable over the investigation period 0-T, then the countries are considered to converge:

$$\Delta e_T^{i,s} = \alpha^s + \beta^s e_0^{i,s} + \varepsilon^{i,s}, \tag{4}$$

Where $\Delta e_T^{i,s} = e_T^{i,s} - e_0^{i,s}$, and $e_t^{i,s}$ is the deviation of country i's employment share in industry s relative to the average European employment share of this industry at time t. We use the deviation from the average instead of normal employment shares to control for structural change which affects all countries similarly, thereby causing a bias on the convergence estimation.

In order to fully exploit our cross-sectional time series data, we depart from the aforementioned basic model and estimate the following equation:

$$\Delta e_t^{i,s} = \alpha^s + \beta^s e_{t-1}^{i,s} + \varepsilon_t^{i,s} \qquad (5)$$

Here, $\Delta e_t^{i,s}$ is the annual change of country *i*'s deviation of the employment share in industry *s* at time *t* from the European average, i.e. we test the hypothesis that there is a negative (or in the case of divergence, positive) link between the deviation from the European average in the previous year and the growth of the employment share in relation to the European average. For the analysis of β-convergence, we use a linear[6] random effects estimator, as we don't want to attribute the changes in employment shares to specific (fixed) country effects.[7] Each industry has been analyzed separately in order to distinguish between diverging and converging branches, instead of making generalizations across industries.

4. Data

Our empirical analysis is based on macro data of 14 EU member states (EU 15 without Luxembourg), covering the observation period of 1970-2004/2005. The data is drawn from the KLEMS data base (see Timmer et al. 2007), which provides data collected from the EU countries' national accounts, and additionally from the public Eurostat data base.

Above we presented a method of detecting convergence and divergence, respectively. For the implementation of these concepts, we use a classification of three aggregate sectors (agriculture, manufacturing, and services), 19 manufacturing industries and 10 service branches, according to the NACE classification. The agricultural sector is not further differentiated, since we don't expect substantial intrasectoral structural change within this sector, which contains only three industries. Manufacturing industries are classified according to their technology intensity, which is used for the analysis of technology diffusion processes. The definition of technology classes is based on the OECD industry ranking on sector-average R&D expenditures between 1991 and 1999 (see OECD 2003), which we adapted to our aggregation level of manufacturing branches. Similarly, we build two groups of service industries according to their knowledge intensity (see Laafia 1999), although classification is only rough due to the high aggregation level of the branches. The knowledge and technology classification, as well as a listing of the manufacturing and service industries, can be found in table A1 in the appendix.

We exclude a number of industries due to various reasons: For public administration and community services, like refuse disposal or cultural activities, data is partly missing or available only on a high aggregation level. Besides, these branches are likely to be dominantly influenced by the national political and administrative system. We also exclude the construction sector due to its high sensitivity to the business cycle and public spending as well as power and utilities (electricity, gas and water supply) for which we assume systemic differences according to national regulatory conditions.

The main variable used is employment, captured in total yearly hours worked by employed persons, which is the most comprehensive and (for our purpose) robust measure of sector (industry) shares available. Total hours worked per year are preferable to the number of employees, which can be biased by national and intertemporal differences in working hours and the share of part-time workers. But a drawback of employment data is a productivity bias:

[6] On our empirical method one could argue that a linear model does not take into account that our dependent variable, the deviations from employment shares, is limited between -1 and 1 by definition. But as we don't expect any observations near the boundaries the OLS model is a reasonable choice, mainly due to its robustness to heteroscedasticity and non-normality.
[7] The adequacy of the random effects model has been confirmed by Hausman tests.

The production share of an industry in total production of the economy could be overestimated if productivity in this industry is lower than average productivity, so that comparing two countries, the one being less productive in the respective industry will appear (wrongly) more specialized than it is in reality. Alternatively, output-oriented indicators such as value added or exports could be used, but these bear the risk of being biased by inflation, exchange rates, world market influences (e.g. the prices of intermediate inputs), variation due to the business cycle and outsourcing. Besides, the calculation methods used for the national accounts have been standardized only in 1995, so that measurement errors may occur in particular at the beginning of the observation period.

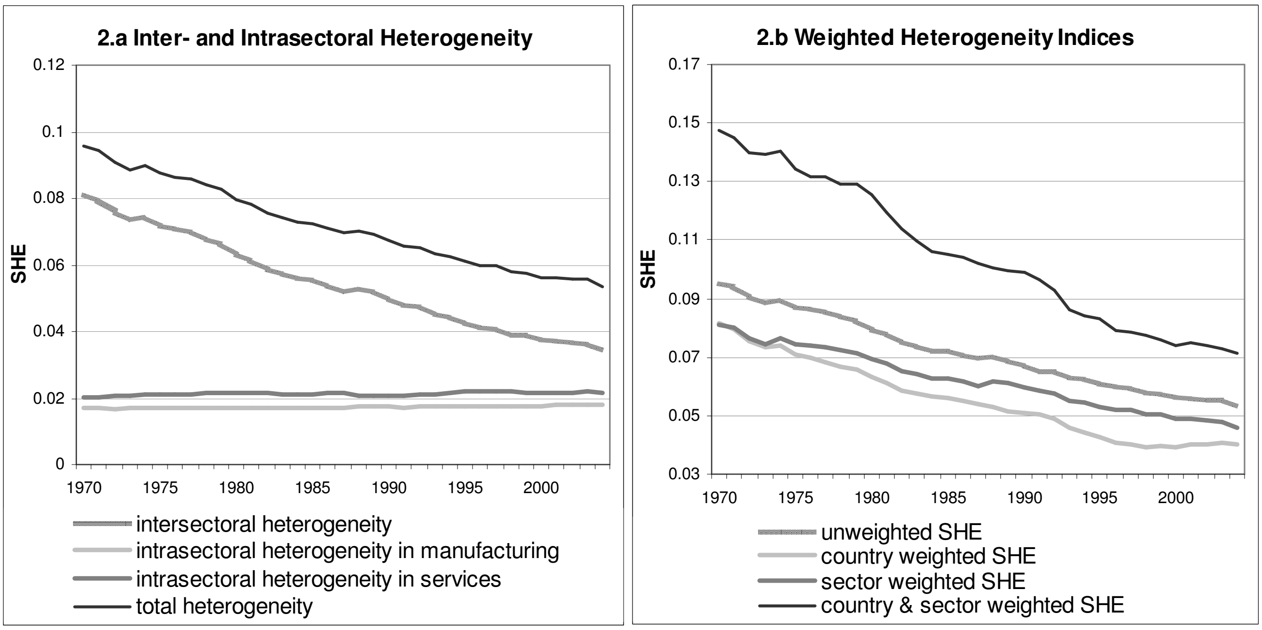
Although employment data is less problematic than value added, some drawbacks of the long observation period remain: At the beginning of our observation period only the six founding member states comprised the European Community. Since then the European Union has been continuously enlarged up to 15 member countries in 1995. We analyze member and (still) non-member states together, without accounting for potential differences due to membership. To put it differently, to just examine the impact of European integration on structural convergence, one would have to adjust the sample according to membership. But as our focus is not only on (politically induced) European integration, we investigate countries' development irrespective of their accession to the European Union. Furthermore, countries are likely to benefit from the expected accession to the European Union before the official accession date, so that the membership bias can be neglected for our purposes. A second question is how to treat Germany before and after reunification in 1990: On the one hand comparability is affected if we switch between West and Unified Germany; on the other hand, excluding East Germany after Unification and thus including only West Germany in the analysis for the whole period will result in a biased picture of the German industry structure. Therefore, we use the extrapolated values for Germany at its present size for 1970-1990 which are included in the KLEMS database.

5. Empirical results

In the overall picture, which comprises both intersectoral and intrasectoral aspects, we clearly find convergence between the European countries: Total structural heterogeneity (expressed by the structural heterogeneity index) decreases steadily from 1970 to 2004 (from 0.096 to 0.054). As can be seen from figure 2.a, the driver of convergence is intersectoral change, as the shares of the three aggregate sectors are getting more and more similar over time due to industrialization and tertiarization processes occurring in all countries, especially in countries which were characterized by a relatively large agricultural sector in the 1970s. So far the 3-sector-hypothesis is corroborated.[8] Intrasectoral convergence, in contrast, cannot be found: Both within manufacturing and service industries, European countries do not seem to converge, but rather diverge slightly. This is not unexpected, since the industries aggregated in these two sectors may not develop in identical directions. Some industries may diverge due to path-dependencies and economies of scale, whereas in other industries congestion costs and high labor costs at production centers may lead to convergence. As these (simultaneous) opposing trends may cancel each other out in the aggregate view, an analysis on the industry level is necessary to detect intrasectoral convergence and divergence tendencies.

[8] We do not go into detail on aggregate basic sectors, which have been investigated in some detail in previous work (see e.g. Chenery and Syrquin 1989).

Figure 2: Structural convergence over time



Source: EU KLEMS Database, March 2007

Note: The lines depicting inter- and intrasectoral heterogeneity in figure 2.a do not add up to total heterogeneity, because the total SHE contains intrasectoral heterogeneity weighted by the respective sector share (see equation (3)). Figure 2.a depicts the intrasectoral SHE in its unweighted form to abstract from changes in the size of the sector, which would bias the SHE in manufacturing towards convergence and in services towards divergence.

Figure 2.b makes evident the sensitivity of the results to the weighting scheme of the heterogeneity index. Conditional on the weight we assign to the relative size of countries or sectors, the conclusions vary considerably. In figure 2.b, we compare the unweighted index of structural heterogeneity (which we will use throughout the paper) with country- and sector-weighted versions.[9] We find that giving more weight to large sectors strengthens the divergence trend, whereas favoring large countries over smaller ones leads to more convergence. This shows that it is mainly large countries and small sectors which drive convergence, while small countries and large sectors apparently tend to diverge. Analyzing inter- and intrasectoral shifts separately, yields similar findings, as can be seen from figure B1 in the appendix. However, this comparison confirms our argument that results produced by a composite index might be somewhat misleading and ought to be complemented by an in-depth analysis of the development of the individual industries. In order to provide this analysis, we take a closer look at intrasectoral convergence and divergence in the next paragraphs.

A first overview of the data is given in tables 1 and 2, which list the values of the intrasectoral heterogeneity indices SHE^N of manufacturing and service industries at the beginning and the end of the observation period.

[9] For the calculation methods of the weighted indices see appendix B.

Table 1: Heterogeneity in manufacturing industries

Industry	SHE^N		SHE^N/branch size	
	1970	**2004**	**1970**	**2004**
Food, Beverages & Tobacco	0.5681	0.3976	0.0523	0.0301
Textile	0.6410	0.8927	0.0401	0.1066
Leather & Footwear	0.1298	0.2021	0.0539	0.1295
Wood	0.2686	0.1934	0.0856	0.0565
Paper	0.1828	0.1473	0.0704	0.0609
Printing & Publishing	0.1861	0.2134	0.0442	0.0364
Non-metal Mineral Products	0.1586	0.1691	0.0308	0.0353
Basic Metals	0.3402	0.1710	0.0689	0.0545
Fabricated Metals	0.2518	0.1848	0.0267	0.0166
Coke & Fuel	0.0464	0.0431	0.0685	0.0847
Rubber & Plastic	0.0758	0.1447	0.0260	0.0305
Machinery	0.4260	0.4591	0.0420	0.0442
Transport Equipment	0.3232	0.4571	0.0405	0.0527
Others; Recycling	0.1902	0.2507	0.0407	0.0409
Chemicals	0.1803	0.2679	0.0344	0.0502
Accounting & Computing Machines	0.0462	0.0893	0.0914	0.1641
Electrical Engineering	0.1853	0.1603	0.0457	0.0365
Communications Equipment	0.1458	0.1687	0.0606	0.0709
Medical, Precision & Optical Instruments	0.1734	0.1920	0.0652	0.0646

Source: EU KLEMS Database, March 2007

Table 1 shows that the degree of heterogeneity varies widely between industries. Note that the heterogeneity index relative to industry size is relevant for this comparison in addition to the *SHE,* as the *SHE* measures the absolute deviations from the European average. For example, when considering the *SHE,* e.g. in 2004, the most heterogeneous branch seems to be Textiles with a *SHE* of 0.8927, but if taking into account the size of the branches the (smaller) Accounting and Computing Machines industry is obviously more heterogeneous than the (larger) textile branch, with 0.1641 versus 0.1066, respectively. It is noticeable that the impression of larger heterogeneity in low-technology industries, which is given by the absolute *SHE* (in the left two rows of table 1), is not confirmed by the *SHE* relative to industry size (in the right two rows of table 1). Evidently, the higher values of the absolute *SHE* are a result of the larger employment shares of low-technology industries especially in the 1970's. Industries differ not only regarding the degree of heterogeneity, but also exhibit differences in the rate and direction of the development of heterogeneity: Some industries, e.g. wood and paper, are more homogeneous in 2004 as compared to 1970, while others increase their heterogeneity, such as the textile, leather and footwear industries.

The same differences in the degree and development of heterogeneity can be found in service industries (see table 2). The most heterogeneous branch is domestic services, both in 1970 and in 2005, when taking into account heterogeneity in relation to branch size. Absolute heterogeneity (listed in the second and third columns of table 2) even increases in this industry, while the value of *SHE*/branch size is lower in 2005 than in 1970. This implies that the increase in heterogeneity is due to employment growth of the industry, which expands heterogeneity, rather than due to specialization tendencies. In other words: The *SHE* shows that heterogeneity between countries has increased due to the development in the domestic service industry, whereas the *SHE* in relation to branch size shows a reason for the shift in heterogeneity.

Table 2: Heterogeneity in service industries

Industry	SHE^N		SHE^N/branch size	
	1970	2005	1970	2005
Domestic Services	0.2828	0.3035	0.1130	0.0943
Hotels & Restaurants	0.4250	0.4721	0.0504	0.0533
Wholesale & Retail Trade	0.3853	0.4511	0.0104	0.0173
Transport & Storage	0.2609	0.1326	0.0214	0.0159
Real Estate	0.0773	0.0884	0.0651	0.0513
Post & Telecommunication	0.1080	0.0795	0.0277	0.0336
Financial Intermediation	0.1467	0.1551	0.0288	0.0317
Business Services	0.4407	0.5788	0.0476	0.0283
Health & Social Work	0.4778	0.6133	0.0414	0.0414
Education	0.1966	0.1813	0.0223	0.0197

Source: EU KLEMS Database, March 2007

Tables 1 and 2 reveal that an overall convergence trend exists neither in manufacturing nor in the service sector. Both sectors harbor both converging and diverging industries. This result is not unexpected, since the various forces for and against convergence may influence individual industries to a different degree.

Table 3: National differences in manufacturing industry shares

Country	High-technology industries		Medium high-technology industries		Medium low-technology industries		Low-technology industries	
	1970	2004	1970	2004	1970	2004	1970	2004
Austria	0.116	0.147	0.221	0.315	0.222	0.212	0.441	0.326
Belgium	0.158	0.199	0.204	0.264	0.254	0.221	0.384	0.315
Denmark	0.119	0.191	0.273	0.312	0.155	0.161	0.454	0.336
Finland	0.073	0.193	0.248	0.274	0.119	0.177	0.560	0.355
France	0.124	0.150	0.289	0.307	0.193	0.201	0.394	0.343
Germany	0.183	0.196	0.284	0.358	0.186	0.178	0.348	0.268
Greece	0.057	0.066	0.209	0.208	0.138	0.157	0.596	0.569
Ireland	0.135	0.320	0.194	0.194	0.151	0.133	0.519	0.352
Italy	0.130	0.135	0.221	0.265	0.202	0.214	0.444	0.385
Netherlands	0.187	0.171	0.259	0.351	0.155	0.166	0.399	0.313
Portugal	0.073	0.068	0.158	0.191	0.150	0.162	0.619	0.579
Spain	0.107	0.116	0.215	0.283	0.212	0.218	0.465	0.383
Sweden	0.127	0.173	0.291	0.373	0.196	0.181	0.386	0.273
UK	0.167	0.168	0.297	0.328	0.216	0.171	0.320	0.334
EU-Average	0.149	0.156	0.264	0.305	0.195	0.191	0.392	0.349

Source: EU KLEMS Database, March 2007

We argued that to a certain extent, structural convergence across Europe is due to the shift to more technology- and knowledge-intensive industries. An impression of this shift as well as one of national differences regarding the starting level and the speed of this development are given by tables 3 and 4. Table 3 displays the countries' employment shares in the four technology classes of manufacturing industries in 1970 and 2004. The considerable differences between the countries are evident on a first glance. In 1970 for example, the

Netherlands have had three times as much high-technology industry employment as Greece (18.7% vs. 5.7%). The general shift from low to high-technology industries over time is also remarkable. The transition of Finland and Ireland is particularly notable in this respect, whereas the share of high-technology industries in Portugal has not only remained low, but has even fallen from 1970 to 2004. Regarding the three countries with the highest shares of high-tech industries in 1970 only Germany could substantially increase employment whereas the Netherlands and the UK shifted towards more medium-high-technology industries. It would be dangerous, however, to draw conclusions from these rough summary statistics.

A similar picture arises regarding the services sector (see table 4): There are large differences between more developed and lagging countries (e.g. 48.1% knowledge intensive industry employment in Sweden vs. 23.2% in Portugal in 1970), as well as a pronounced shift towards high-value service branches for all countries.

Table 4: National differences in service industry shares

Country	**High knowledge intensity**		**Low knowledge intensity**	
	1970	**2005**	**1970**	**2005**
Austria	0.356	0.506	0.644	0.494
Belgium	0.407	0.609	0.593	0.391
Denmark	0.422	0.592	0.578	0.408
Finland	0.383	0.561	0.617	0.439
France	0.451	0.584	0.549	0.416
Germany	0.388	0.549	0.612	0.451
Greece	0.335	0.401	0.665	0.599
Ireland	0.386	0.545	0.614	0.455
Italy	0.305	0.421	0.695	0.579
Netherlands	0.413	0.569	0.587	0.431
Portugal	0.232	0.337	0.768	0.663
Spain	0.247	0.399	0.753	0.601
Sweden	0.481	0.633	0.519	0.367
United Kingdom	0.447	0.575	0.553	0.425
EU-Average	0.386	0.518	0.614	0.482

Source: EU KLEMS Database, March 2007

Estimation results – manufacturing sector

Building on these descriptive statistics, we analyze intrasectoral convergence and divergence using time-series and panel data methods (for σ- and β-convergence tests, respectively), starting with the manufacturing sector.

As table 5 shows, we find both σ-convergence and σ-divergence in the manufacturing sector. In low-technology industries, we find highly significance for both convergence and divergence. There is a remarkably strong convergence trend in industries which are intensive in natural resources such as the food, beverages and tobacco industry and the wood industry. The development in both cases appears to be driven by de-specialization of formerly lagging countries. In contrast, the labor-intensive textile production clearly diverges. The production of leather and footwear also shows significant divergence; in both cases the most deviating country, Portugal, significantly extends its lead in the leather and footwear industry over the observation period. It seems therefore that while the North European countries developed towards high-technology branches, Portugal remains specialized in low-technology industries.

Table 5: σ-convergence in manufacturing industries

	time trend $\ln SHE_s^N$		time trend $\ln SHE_s^{N-1}$		time trend *max deviation*	
Food, Beverages & Tobacco	-0.0110 **	(0.0052)	-0.0087	(0.0071)	-.0193 **	(0.0091)
Textile	0.0097 ***	(0.0030)	0.0105 **	(0.0041)	0.0075	(0.0050)
Leather & Footwear	0.0135 **	(0.0059)	0.0122 **	(0.0061)	0.0187 *	(0.0106)
Wood	-0.0097 **	(0.0047)	-0.0072 *	(0.0044)	-0.0195 *	(0.0112)
Paper	-0.0065	(0.0062)	-0.0047	(0.0069)	-0.0083	(0.0105)
Printing & Publishing[1]	0.0160 *** -0.0215 ***	(0.0051) (0.0081)	0.0203 *** -0.0194 *	(0.0067) (0.0114)	-0.0057	(0.0106)
Non-metal Mineral Products[2]	-0.0221 * 0.0188 **	(0.0122) (0.0086)	-0.198 0.0213 **	(0.0215) (0.0089)	-0.0080	(0.0138)
Basic Metals[5]	-0.0044	(0.0027)	-0.0036	(0.0023)	-0.0235 ***	(0.0088)
Fabricated Metals	-0.0091 *	(0.0052)	-0.0106 *	(0.0057)	0.0052	(0.0244)
Coke & Fuel	0.0001	(0.0119)	-0.0025	(0.0158)	0.0062	(0.0193)
Rubber & Plastic	0.0192 ***	(0.0056)	0.0212 ***	(0.0058)	0.0056	(0.0101)
Machinery	0.0022	(0.0031)	0.0016	(0.0035)	0.0109	(0.0073)
Transport Equipment	0.0110 *	(0.0061)	0.0109 *	(0.0064)	0.0103	(0.0113)
Others; Recycling	0.0081 *	(0.0046)	0.0019	(0.0043)	0.0188 **	(0.0089)
Chemicals	0.0116 **	(0.0059)	0.0067 *	(0.0037)	0.0373 ***	(0.0115)
Accounting & Computing Machines	0.0194	(0.0163)	0.0029	(0.0132)	0.0387 *	(0.0198)
Electrical Engineering	-0.0050	(0.0035)	-0.0065 *	(0.0037)	0.0078	(0.0068)
Communications Equipment[3]	0.0050	(0.0141)	-0.0028	(0.0158)	-0.0099 0.1145 *	(0.0103) (0.0614)
Medical, Precision & Optical instruments[4]	0.0033	(0.0047)	-0.0035	(0.0031)	-0.0057 0.0830 **	(0.0107) (0.0344)

***/**/* significant at 1/5/10 percent; standard errors in parenthesis.

[1] structural break in 1993/1994; [2] structural break in 1984/1985; [3] structural break in 1994/1995; [4] structural break in 1991/1992. In all cases, the first sub-period is in the upper line. [5] no logarithm.

A changing behavior is found in the case of printing and publishing: Until 1993, the estimation reveals divergence, followed by significant convergence in the period 1994-2004.

These developments are not related to any particular specialization or de-specialization tendencies of individual countries. A mixed picture arises also for the medium-low-technology industries: The production and fabrication of metal products tends to converge, while the non-metal mineral products branch has been diverging from the mid 1980s. Hence, it seems that in the two metal industries the globalization factor prevails, i.e. the energy-intensive fabrication of metal products is being outsourced, while in the non-metal industry factors like economies of scale are more important.

Interestingly, none of the high and medium-high-technology industries shows significant convergence, but a number of them clearly diverge. Above, we argued that two types of divergence must be distinguished, though the distinction is to some extent blurry. Our data point towards one-country-divergence in the chemical and recycling industries, whereas we find general divergence for the transport equipment and the rubber and plastics industries. It seems difficult to explain the differing development of these industries, which have many characteristics in common: the existence of economies of scale, relatively high skill intensity and path dependencies. The reason for the differential development may lie in a particular starting position of the most deviating country in the case of one-country-specialization, which is unobservable on the basis of our data.

No significant development is found for the high-technology industries “Accounting and Computing Machines”, “Communications Equipment” and “Medical, Precision and Optical Instruments” - at least as regards the overall picture. But in these industries, the significant and positive trend of the maximum deviation is remarkable. It can be interpreted as a form of one-country-specialization. The specialization in the last two industries above only starts in the 1990s, with the emerging technological development and the growing importance of these industries. We believe the reason for this pattern to lie in economies of scale and path dependencies. Interestingly, the specializing countries are Finland (in Communications Equipment) and Ireland (the other two branches), so this development can be seen as the counterpart to the above-mentioned de-specialization of Finland and Ireland in low-technology industries.

The estimations of β-convergence in general confirm these results, but in addition stress two further aspects: The development of industry concentration (and thus divergence and convergence) over the industry lifecycle, as well as the impact of European integration and globalization become evident from the analysis of the three sub-periods shown in table 6. We divided the observation period in order to capture the main changes of economic and technological conditions. The first break in 1985/1986 corresponds to the Single European Act (SEA), which we took as a milestone in European integration; the second break in 1994/1995 relates to the foundation of the WTO and the associated globalization tendencies.

The results show dynamic developments in particular in the first and the last period. Significant convergence, visible by the significant and negative coefficient of the initial value (β), is found in mature low and medium-low-technology industries, such as food and wood. At a first glance, the divergence of the textile and leather production which are clearly labor intensive, mature industries does not fit the pattern. But as both industries are to a large extent path dependent and economic structures of the Mediterranean countries traditionally strongly relied on them, structural change in Southern Europe took more than one decade to abandon the textile industry, so that convergence started only in the 1990s. In the last sub-period both branches show clear convergence, given the significant and negative β-values. These patterns can be explained by a number of factors: First, lagging countries (in particular the south of Europe) are catching up, which becomes manifest in both an increase in productivity and a structural reorientation away from low-technology branches and towards more technology and capital intensive industries.

Table 6: β-convergence in manufacturing industries

	1970-1985		1986-1994		1995-2004	
	β	Wald Chi²	β	Wald Chi²	β	Wald Chi²
Food, Beverages & Tobacco	-0.0050 (0.0036)	0.84	-0.0284 *** (0.0067)	17.95 ***	-0.0196 (0.0130)	2.26
Textile	0.0139 *** (0.0029)	29.89 ***	0.0076 (0.0057)	1.79	-0.0108 ** (0.0050)	4.74 **
Leather & Footwear	0.0264 *** (0.0055)	23.26 ***	0.0155 * (0.0081)	3.69 *	-0.0159 *** (0.0056)	8.03 ***
Wood	-0.0233 *** (0.0052)	17.87 ***	-0.0109 (0.0094)	1.34	-0.0084 (0.0089)	0.89
Paper	-0.0122 *** (0.0033)	11.50 ***	0.0084 (0.0054)	2.41	-0.0220 *** (0.0043)	25.60 ***
Printing & Publishing	0.0017 (0.0071)	0.30	0.0011 (0.0114)	0.01	-0.0302 ** (0.0129)	5.46 **
Non-metal Mineral Products	-0.0186 ** (0.0076)	5.08 **	-0.0104 (0.0161)	0.41	0.0122 (0.0113)	1.17
Basic Metals	-0.0185 *** (0.0044)	13.78 ***	-0.0463 *** (0.0078)	35.51 ***	-0.0112 (0.0129)	0.76
Fabricated Metals	-0.0091 (0.0070)	1.50	-0.0095 (0.0126)	0.57	-0.0097 (0.0117)	0.69
Coke & Fuel	-0.0064 (0.0062)	0.66	-0.0193 (0.0132)	2.13	0.0000 (0.0104)	0.00
Rubber & Plastic	-0.0041 (0.0127)	0.13	0.0181 (0.0111)	2.66	0.0074 (0.0108)	0.47
Machinery	0.0009 (0.0056)	0.00	0.0026 (0.0057)	0.21	-0.0003 (0.0078)	0.00
Transport Equipment	0.0074 (0.0102)	0.58	-0.0128 (0.0105)	1.49	0.0173 * (0.0094)	3.38 *
Others; Recycling	0.0030 (0.0084)	0.39	0.0038 (0.0128)	0.09	0.0107 (0.0122)	0.77
Chemicals	0.0141 ** (0.0069)	4.83 **	0.0168 (0.0117)	2.06	0.0138 * (0.0080)	2.97 *
Accounting & Computing Machines	0.0270 *** (0.0074)	16.20 ***	0.0601 *** (0.0074)	65.85 ***	0.0027 (0.0133)	0.04
Electrical Engineering	0.0022 (0.0077)	0.10	-0.0054 (0.0127)	0.18	-0.0156 (0.0158)	0.97
Communications Equipment	0.0043 (0.0041)	0.88	-0.0087 (0.0203)	0.18	0.0008 (0.0175)	0.00
Medical, Precision & Optical Instruments	-0.0010 (0.0058)	0.07	-0.0033 (0.0104)	0.10	0.0336 ** (0.0145)	5.40 **
Observations per industry	224		126		140	

***/**/* significant at 1/5/10 percent; standard errors in parenthesis.

In contrast to the low-technology industries, high-technology branches like the chemical industry and computing machine production tend to diverge. In these industries economies of scale, technological capabilities (as defined by Nelson 2005), and local knowledge spillovers may act as preconditions that industries concentrate in few locations, in particular during early stages of the industry lifecycle, which causes divergence. As industries become more mature, technology diffusion will enable the follower countries to catch up, so that in later stages the industry might converge if economies of scale do not outweigh the technology diffusion effect - as might be the case in medium low-technology industries like basic metal production. Interestingly, for two industries (Transport Equipment and Medical, Precision and Optical Instruments) significant divergence is found only from 1995 onwards. Reasons for this development could be the increasing importance of economies of scale, in particular in transport equipment, or technological dynamics which strengthen the competitive advantages of specialized countries.

In the medium low-technology industries we find β-convergence at the beginning of the observation period, which we attribute mainly to technology transfer effects. Remarkable are the differences to the results of the σ-convergence test: The production of non-metal mineral goods was characterized by σ-divergence from the mid-1980s onwards, whereas we do not find any significant β in the last two sub-periods. On the other hand, the production of basic metals significantly converges only with regard to β, while convergence of the fabricated metals industry is significant only in σ. This shows the limitations of convergence tests in case of developments at a low magnitude.

Estimation results – service sector

In the service sector our expectations that convergence or divergence should be low (as pointed out in chapter 2), is largely confirmed. The time trends of the heterogeneity index are not significant in most industries, as shown in table 7.[10] Significant trends of the *SHE* are found only in Transport and Storage, Post and Telecommunications Services, and Financial Intermediation. The logistics branch significantly converges over the observation period, while the latter two industries show a divergence trend in the second sub-period, which appears to be caused by the specialization of one country: Ireland.

The remaining service branches do not show significant changes in heterogeneity over time. In the first three branches, i.e. Domestic Services, Hotels and Restaurants and Trade, the reason may be the immobility of these services, which restrains both (path dependent) specialization within Europe and outsourcing to low-cost countries outside Europe. The results for Education as well as for Health and Social work mirror the differences in the social systems of the European countries. Interestingly, no significant divergence is found for business services, which we expected to be characterized by economies of scale and a strong dependence on the (diverging) manufacturing industries.

[10] This impression is confirmed by figure B2 in the appendix, which reveals that there are in fact no pronounced shifts in the values of the SHE^N.

Table 7: σ-convergence in service industries

	time trend $\ln SHE_s^N$		time trend $\ln SHE_s^{N-1}$		time trend *max deviation*	
Domestic Services[1]	-0.0168	(0.0138)	0.0072	(0.0052)	-0.0423 **	(0.0170)
	0.0096	(0.0068)			0.0279	(0.0253)
Hotels & Restaurants	0.0025	(0.0022)	0.0044	(0.0068)	-0.0061	(0.0173)
Wholesale & Retail Trade	0.0042	(0.0074)	0.0004	(0.0078)	0.0162	(0.0120)
Transport & Storage	-0.0191 **	(0.0089)	-0.0116 *	(0.0060)	-0.0331	(0.0225)
Real Estate	0.0038	(0.0074)	0.0052	(0.0114)	0.0007	(0.0156)
Post & Telecommunication[2]	-0.0236 ***	(0.0052)	-0.0260 **	(0.0098)	-0.0132	(0.0227)
	0.0105 *	(0.0060)	0.0056	(0.0074)	0.0233 *	(0.0123)
Financial Intermediation[3]	-0.0058	(0.0163)	0.0012	(0.0209)	-0.0112	(0.0183)
	0.0160 **	(0.0072)	0.0023	(0.0108)	0.0839 ***	(0.0321)
Business Services	0.0086	(0.0087)	0.0090	(0.0093)	0.0042	(0.0168)
Health & Social Work	0.0073	(0.0058)	0.0082	(0.0065)	0.0030	(0.0063)
Education	-0.0023	(0.0097)	-0.0068	(0.0173)	0.0091	(0.0063)

***/**/* significant at 1/5/10 percent; standard errors in parenthesis.

[1] structural break in 1981/1982 for SHE^N, in 1990/1991 for the most deviating country; [2] structural break in 1988/1989; [3] structural break in 1993/1994. In all cases, the first sub-period is in the upper line.

As to β-convergence, presented in table 8, convergence trends are visible for several branches: Significant convergence is found for Logistics, Post and Telecommunication, Financial Intermediation and real estate, while in the other industries the initial value does not significantly influence the development of the sector share.

The convergence in the logistics industry (Transport and Storage) confirms the results of the ARIMA regressions. It might be caused by a general increase of transport volumes on the one hand and productivity increases due to rationalization and automation in lagging countries on the other hand. Regarding Post and Telecommunication Services, we find convergence only until 1994, but no significant change afterwards. This is in contrast to the ARIMA-results which point towards divergence in the second half of the observation period. However, in the periods before 1994, the results of both methods correspond to each other and show a clear convergence trend, which we attribute to the technological and organizational developments. Interestingly, the divergence in financial intermediation cannot be reproduced, but in the sub-period 1986-1994 we find convergence in this branch.

Table 8: β-convergence of service industries

	1970-1985		1986-1994		1995-2005	
	β	Wald Chi²	β	Wald Chi²	β	Wald Chi²
Domestic Services	0.0014 (0.0143)	0.01	-0.0224 .0292	0.58	-0.0084 (0.0088)	0.90
Hotels & Restaurants	0.0015 (0.0043)	0.12	-0.0230 .0164	1.96	-0.0031 (0.0082)	0.14
Wholesale & Retail Trade	-0.0086 (0.0128)	0.45	-0.0229 .0191	1.44	-0.0030 (0.0091)	0.10
Transport & Storage	-0.0128 ** (0.0064)	3.95 **	-0.0473 *** .0136	12.14 ***	-0.0503 *** (0.0126)	15.87 ***
Real Estate	0.0085 (0.0066)	1.70	-.0196 .0187	1.09	-0.0426 *** (0.0157)	7.40 ***
Post & Telecommunication	-0.0204 *** (0.0073)	7.91 ***	-0.0401 ** .0190	4.46 **	-0.0266 (0.0173)	2.34
Financial Intermediation	-0.0079 (0.0100)	0.62	-0.0334 ** .0160	4.39 **	0.0012 (0.0160)	0.01
Business Services	-0.0033 (0.0086)	0.15	-0.0018 .0122	0.02	0.0017 (0.0108)	0.03
Health & Social Work	0.0036 (0.0090)	0.16	-0.0064 .0067	0.92	-0.0044 (0.0051)	0.76
Education	-0.0077 (0.0092)	0.71	-0.0248 .0197	1.59	-0.0123 (0.0125)	0.97
Observations per industry	210		126		154	

***/**/* significant at 1/5/10 percent; t-statistics in parenthesis.

Two aspects of our β-convergence tests are remarkable: First, we don't find any evidence of divergence in service industries, and second, changes regarding the European and global conditions do not seem to influence the localization of services in European countries to a large extent. Partly, this corresponds to our expectations on the immobility of many services, which prevents a pronounced specialization of countries. But as we analyze service branches on a rather aggregate level, some concentration tendencies within our aggregate industries might be hidden, like the divergence in investment banking, which is included in the financial intermediation branch in our data.

There is a final point to note regarding both the manufacturing and service industries: By the choice of the three sub-periods in the β-convergence tests, our analysis relies implicitly on the assumption that EU integration and the liberalization of the world market influence the development of industry concentration. Yet we do not find such a clear impact. In many cases, significance of the β increases or decreases from one sub-period to the next, but a general pattern does not become evident from our findings. Only in the textile and leather industries can effects of globalization be detected when the development shifts from divergence to convergence. A number of reasons could be behind these results: On the one hand, mobility within Europe may be rather low; on the other hand, intra-industrial developments cannot be caught by our rough industry classification. Finally, European integration and trade liberalization are continuous processes which cannot be associated with only key dates such as the Single European Act or the establishment of the WTO.

6. Conclusion

Structural convergence between industrialized countries is a topic which has not been paid a great deal of attention in the literature. We fill this gap by providing a comprehensive investigation of convergence of 14 European countries over the period 1970-2004/2005. Our analysis is based on employment data drawn from national accounts, which is provided by the EU KLEMS database. We take into account both intersectoral and intrasectoral convergence, focusing first on shifts between agriculture, manufacturing and services and second on 19 manufacturing and 10 service industries, respectively. Relying on the two common convergence tests, σ- and β-convergence, we consider also industry specific differences i.e. that some branches might converge and others diverge (instead of drawing generalizing conclusions for all manufacturing or service industries).

We find significant and rapid intersectoral convergence, accompanied by a mixed picture with regard to intrasectoral convergence. In total, European countries do not become more similar regarding the sector composition within the industry and service sectors, respectively; rather some industries are found to converge over time, whereas others diverge or do not change at all. In particular, mature, labor intensive industries show convergence tendencies, while emerging technology- and knowledge-intensive branches tend to diverge. We explain this by the changes in the preponderance of the existing antagonistic forces over the industry life cycle: In emerging industries (with high-technology or knowledge intensity) convergence-favoring influences prevail, such as knowledge spillovers and the existence of a specialized labor force. With increasing maturity, these effects diminish, and industries disperse over the other countries, as long as economies of scale do not outweigh the technology diffusion effect. In mature branches, finally, general outsourcing and shrinking trends lead to convergence. Our results on manufacturing industries confirm these hypotheses, showing a distinct divergence-convergence pattern over time. Service branches, in contrast, converge or diverge less dynamically, due to the low mobility of services and the importance of local markets. We find significant convergence only in Post and Telecommunication Services and Logistics, which might be caused by technological and organizational developments. A more disaggregated branch classification would be required in order to detect country specialization effects, like that of the UK in investment banking.

Overall, the results presented in this paper draw a comprehensive picture of the complex interplay between the European countries, varying from industry to industry. For future research, we see two promising possibilities: First, research could combine the overall view on European countries with a finer focus on regional convergence in order to distinguish between international and intra-national convergence and shed light on the role of regional industry concentration. In this respect it will be interesting to test to what degree the higher factor mobility between regions has an effect on overall concentration and specialization patterns and whether the ongoing European integration has favored the concentration of economic activity in metropolitan areas at the expense of peripheral regions. Second, it would be interesting to investigate the adjustment process of the Central and Eastern European countries towards the economies of Western Europe; catch-up in terms of income and nominal convergence has been substantial, and one might expect the same to hold for structural convergence as well.

7. References

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8. Appendix

Appendix A: Data

Table A 1: Classification of industries and technology/knowledge classes

Sectors	Technology/ Knowledge	Classification of Industries	NACE
Agriculture	-	Agriculture, Hunting, Forestry and Fishing	01, 02
Manufacturing	Low-technology	Food, beverages and tobacco	15, 16
		Textiles and textile products	17-18
		Leather and footwear	19
		Wood, wood products and furniture	20
		Pulp, paper and paper products	21
		Printing and Publishing	22
	Medium low-technology	Non-metallic mineral products	26
		Basic metals products	27
		Fabricated metal products	28
	Medium high-technology	Coke, refined petroleum, and nuclear fuel	23
		Rubber and plastics products	25
		Machinery and equipment, n.e.c.	29
		Transport equipment: Motor vehicles, aircraft and spacecraft	34,35
		Manufacturing n.e.c.; recycling	36, 37
	High-technology	Chemical industry	24
		Office, accounting and computing machines	30
		Electrical machinery and apparatus, n.e.c.	31
		Radio, TV, communication equipment	32
		Medical, precision and optical instruments	33
Services	Low knowledge intensity	Domestic services	95
		Hotels and Restaurants	55
		Wholesale and retail trade	50-52
		Transport and Storage	60-63
		Real Estate	70
	High Knowledge intensity	Post and Telecommunication	64
		Financial Intermediation	65-67
		Business Services	71-74
		Health and Social Work	85
		Education	80

Appendix B: Heterogeneity Indices

1. Country-weighted heterogeneity index

$$cwSHE^N = \frac{1}{S}\sum_{n=1}^{N} w^n \sum_{s=1}^{S} \left| b_s^n - \bar{b}_s \right|; \quad w^n = \frac{total\ employment\ country\ n}{total\ employment\ EU};$$

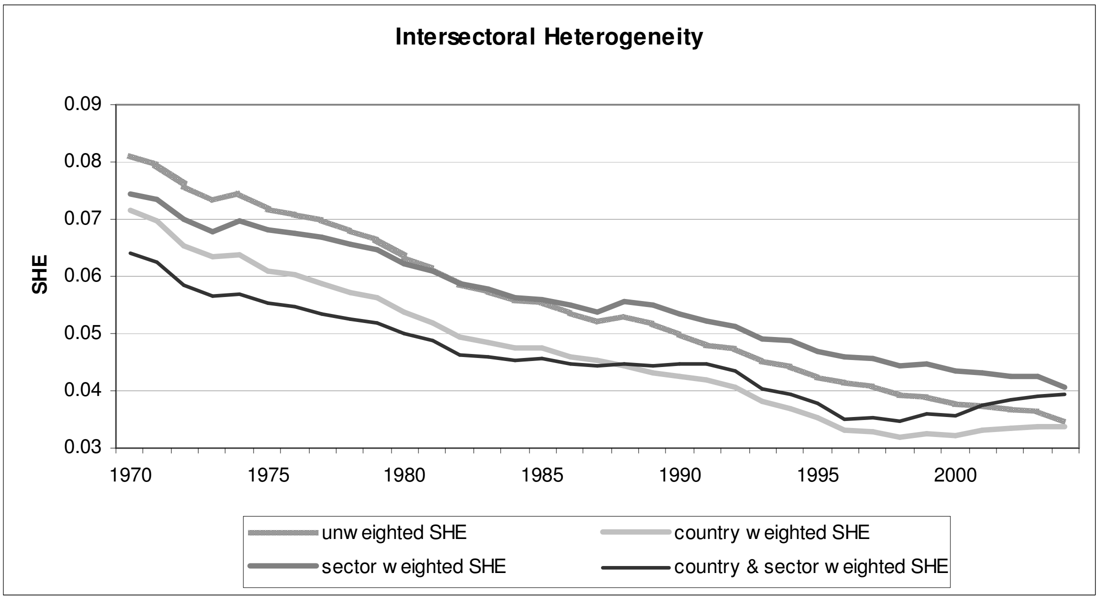
2. Sector-weighted heterogeneity index

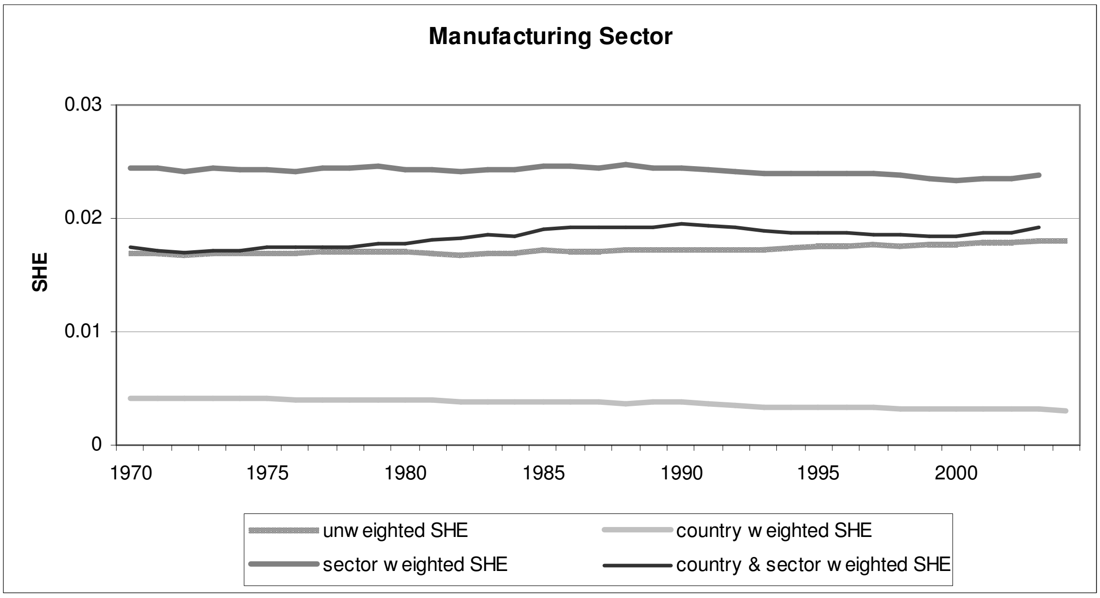
$$swSHE^N = \frac{1}{N}\sum_{n=1}^{N}\sum_{s=1}^{S} w^s \left| b_s^n - \bar{b}_s \right|; \quad w^s = \bar{b}_s;$$

3. Country- & sector-weighted heterogeneity index

$$cswSHE^N = \sum_{n=1}^{N} w^n \sum_{s=1}^{S} w^s \left| b_s^n - \bar{b}_s \right|;$$

Figure B 1: Inter-/intrasectoral heterogeneity indices





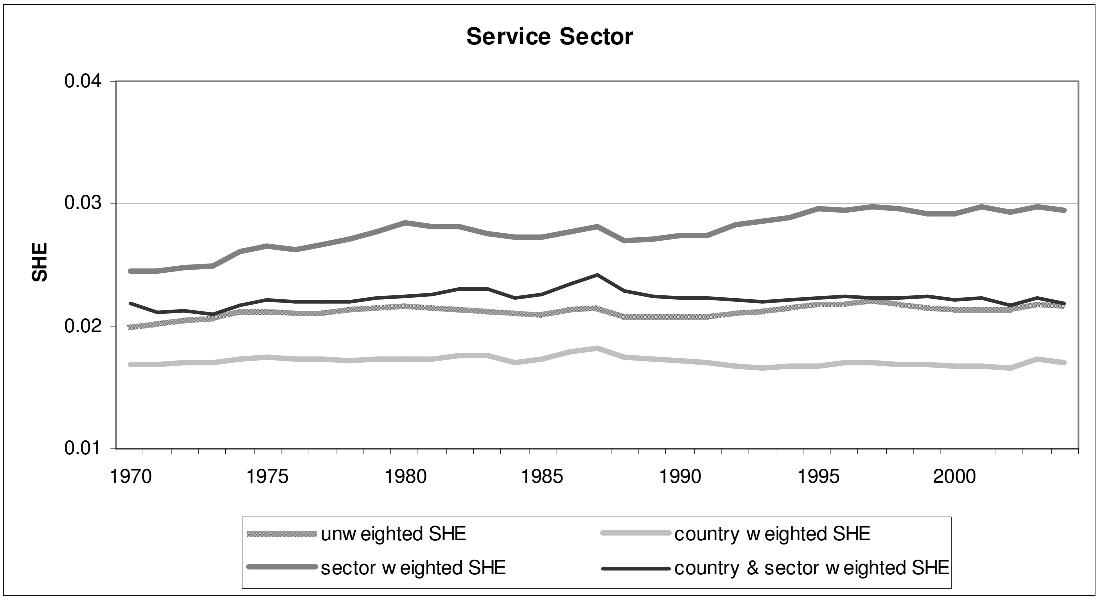
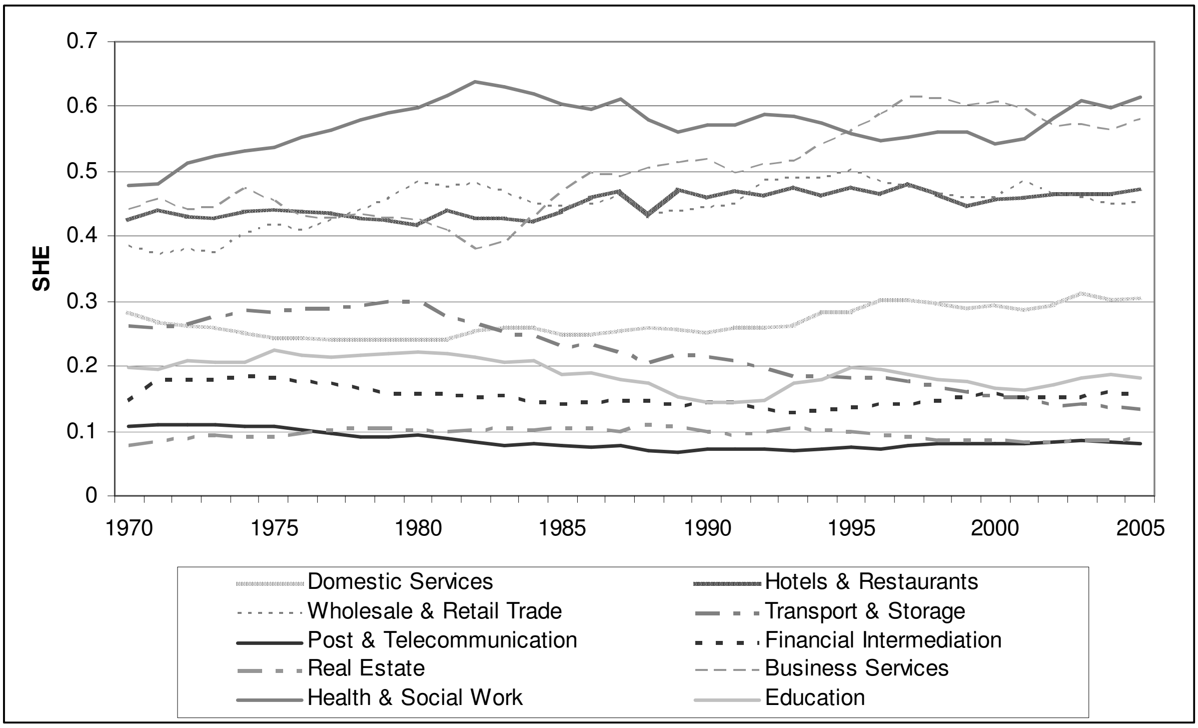


Figure B 2: σ-convergence in service industries



Appendix C: Empirical results

Table C 1: Augmented Dickey-Fuller test for manufacturing industries

	$\ln SHE_t^N$		$\ln SHE_t^{N-1}$		ln *max deviation*	
	d = 0	d = 1	d = 0	d = 1	d = 0	d = 1
Food, Beverages & Tobacco	-0.852	-4.742	-1.835	-4.891	0.461	-3.874
Textile	-2.922	-4.417	-2.398	-5.114	-2.023	-5.273
Leather & Footwear	-2.759	-3.737	-3.036	-3.822	-1.189	-4.311
Wood	-1.608	-4.089	-1.427	-5.148	-1.655	-5.000
Paper	-1.037	-3.995	-1.779	-5.359	-0.645	-5.443
Printing & Publishing	-1.632	-4.102	-1.741	-3.988	-0.597	-6.090
Non-metal Mineral Products	-1.446	-3.703	-1.469	-4.049	-2.661	-4.587
Basic Metals	-0.468	-5.101	-1.245	-5.067	-1.644	-3.884
Fabricated Metals	0.179	-6.200	0.279	-6.321	-1.376	-5.110
Coke & Fuel	-0.512	-3.569	-0.241	-4.042	-1.543	-5.394
Rubber & Plastic	-1.330	-3.826	-1.641	-3.599	0.58	-6.157
Machinery	-1.078	-5.279	-1.548	-5.951	-2.07	-3.725
Transport Equipment	-0.394	-4.791	-0.879	-4.728	-1.414	-5.388
Others; Recycling	-0.636	-5.024	-1.046	-4.753	-0.557	-5.515
Chemicals	-1.371	-7.161	-1.231	-7.235	-2.022	-5.239
Accounting & Computing Machines	-1.194	-2.187	-1.203	-2.638	0.498	-4.009
Electrical Engineering	-0.250	-4.309	-2.055	-5.396	2.606	-2.523
Communications Equipment	-0.468	-4.127	-0.980	-4.354	-0.194	-5.227
Medical, Precision & Optical instruments	0.111	-4.599	-1.512	-4.688	-0.073	-3.518

1%/5%/10% critical values: -3.689/-2.975/-2.619 (d=0); -3.696/-2.978/-2.620 (d=1).

Table C 2: Augmented Dickey-Fuller test for service industries

	$\ln SHE_t^N$		$\ln SHE_t^{N-1}$		ln *max deviation*	
	d = 0	d = 1	d = 0	d = 1	d = 0	d = 1
Domestic Services	-0.596	-5.630	0.006	-5.767	-2.270	-6.041
Hotels & Restaurants	-2.383	-9.826	-1.249	-8.087	-1.597	-4.606
Wholesale & Retail Trade	-2.034	-5.449	-1.359	-4.634	-2.539	-8.004
Transport & Storage	1.348	-5.279	0.302	-6.338	0.852	-5.894
Real Estate	-2.380	-4.946	-2.684	-5.253	-1.207	-3.365
Post & Telecommunication	-1.711	-5.457	-1.899	-6.065	-1.174	-5.468
Financial Intermediation	-1.461	-7.091	-1.027	-8.038	-0.056	-4.895
Business Services	-0.636	-4.032	-0.548	-4.187	-1.577	-2.769
Health & Social Work	-2.629	-4.347	-2.529	-4.391	-1.926	-4.83
Education	-1.323	-4.517	-1.242	-4.330	-1.844	-4.99
Observations	35	34	35	34	35	34
1% critical value	-3.682	-3.689	-3.682	-3.689	-3.682	-3.689

1%/5%/10% critical values: -3.682/-2.972/-2.618 (d=0); -3.689/-2.975/-2.619 (d=1).

Table C 3: ARIMA results: SHE^N in manufacturing industries

	constant	AR(1)	AR(2)	AR(3)	MA(1)	MA(2)
Food, Beverages & Tobacco	-0.0110 ** (0.0052)	-0.8182 *** (0.2410)	-	-	1.1116 *** (0.2637)	0.4358 ** (0.2050)
Textile	0.0097 *** (0.0030)	-	-	-	-	-
Leather & Footwear	0.0135 ** (0.0059)	-0.0095 (0.3936)	-	-	0.4636 (0.3502)	-
Wood	-0.0097 ** (0.0047)	-	-	-	-	-
Paper	-0.0065 (0.0062)	0.3044 (0.1353)	-	-	-	-
Printing & Publishing (structural break 1993/1994)	0.0160 *** (0.0051)	-	-	-	-0.0876 (0.2328)	-
	-0.0215 *** (0.0081)	0.4501 (0.3335)	-0.5169 (0.4687)	-	-	-
Non-metal Mineral Products (structural break 1984/1985)	-0.0221 * (0.0122)					
	0.0188 ** (0.0086)	-0.8893 *** (0.2022)	-	-	0.9905 *** (0.2780)	0.2930 (0.2785)
Basic Metals	-0.0044 (0.0027)	0.3004 * (0.1700)	0.2937 (0.2602)	-	-	-
Fabricated Metals	-0.0091 * (0.0052)	-	-	-	-	-
Coke & Fuel	0.0001 (0.0119)	0.3259 (0.2650)	-	-	-	-
Rubber & Plastic	0.0192 *** (0.0056)	-0.9524 (0.6912)	-0.4422 (0.7513)	-0.2954 (0.2134)	0.8789 (0.6797)	0.2001 (0.6706)
Machinery	0.0022 (0.0031)	-	-	-	-	-
Transport Equipment	0.0110 * (0.0061)	0.3072 (0.1942)	-	-	-	-
Others; Recycling	0.0081 * (0.0046)	0.9357 * (0.4903)	-0.3041 (0.2303)	-	-0.7709 * (0.4308)	-
Chemicals	0.0116 ** (0.0059)	-	-	-	-	-
Accounting & Computing Machines	0.0194 (0.0163)	-	-	-	0.1121 (0.2353)	-
Electrical Engineering	-0.0050 (0.0035)	-	-	-	-0.4579 *** (0.1535)	-
Communications Equipment	0.0050 (0.0141)	-	-	-	0.6350 *** (0.1182)	-
Medical, Precision & Optical instruments	0.0033 (0.0047)	-	-	-	0.3229 * (0.1805)	-0.2331 (0.1842)

Table C 4: ARIMA results: SHE^{N-1} in manufacturing industries

	constant	AR(1)	AR(2)	AR(3)	MA(1)	MA(2)
Food, Beverages & Tobacco	-0.0087 (0.0071)	-0.8331 *** (0.1297)	-	-	1.4896 *** (0.1895)	0.9194 *** (0.2205)
Textile	0.0105 ** (0.0041)	-	-	-	-	-
Leather & Footwear	0.0122 ** (0.0061)	-0.0332 (0.3298)	-	-	0.5102 * (0.3030)	-
Wood	-0.0072 * (0.0044)	-0.0875 (0.2778)	-0.0080 (0.2899)	-	-	-
Paper	-0.0047 (0.0069)	0.0180 (0.1698)	-	-	-	-
Printing & Publishing (structural break 1993/1994)	0.0203 *** (0.0067)	-	-	-	-	-
	-0.0194 * (0.0114)	0.7412 (0.4637)	-0.6332 *** (0.1964)	-	-	-
Non-metal Mineral Products (structural break 1984/1985)	-0.198 (0.0215)	0.4498 * (0.2586)	-	-	-	-
	0.0213 ** (0.0089)	-0.9459 ** (0.3776)	-	-	0.9244 (0.5650)	0.1017 (0.3010)
Basic Metals	-0.0036 (0.0023)	0.3003 ** (0.1374)	0.1411 (0.1498)	-	-	-
Fabricated Metals	-0.0106 * (0.0057)	-	-	-	-	-
Coke & Fuel	-0.0025 (0.0158)	-0.2329 (0.7247)	-	-	0.5736 (0.6588)	0.3112 (0.2927)
Rubber & Plastic	0.0212 *** (0.0058)	-0.0544 (0.8166)	-0.2461 (0.2472)	-	-0.0892 (0.7846)	-
Machinery	0.0016 (0.0035)	-	-	-	-	-
Transport Equipment	0.0109 * (0.0064)	0.2703 (0.2067)	-	-	-	-
Others; Recycling	0.0019 (0.0043)	1.4622 *** (0.1409)	-0.8896 *** (0.1570)	-	-1.5698 *** (0.2733)	0.8202 *** (0.2549)
Chemicals	-0.0067 * (0.0037)	-	-	-	-0.3843 ** (0.1701)	-0.1182 (0.2140)
Accounting & Computing Machines	0.0029 (0.0132)	-0.6367 * (0.3442)	-	-	0.8203 *** (0.3116)	-
Electrical Engineering	-0.0065 * (0.0037)	-	-	-	-0.4693 *** (0.1497)	-
Communications Equipment	-0.0028 (0.0158)	-	-	-	0.9047 *** (0.0824)	-
Medical, Precision & Optical instruments	-0.0035 (0.0031)	-	-	-	0.1267 (0.1662)	-0.4917 *** (0.1702)

Table C 5: ARIMA results: max. deviation in manufacturing industries

	constant	AR(1)	AR(2)	MA(1)	MA(2)	MA(3)
Food, Beverages & Tobacco	-0.0193 ** (0.0091)	-	-	0.3448 *** (0.1055)	-	-
Textile	0.0075 (0.0050)	-	-	-	-	-
Leather & Footwear	0.0187 * (0.0106)	-	-	0.1941 (0.1504)	-	-
Wood	-0.0195 * (0.0112)	0.1217 (0.1721)	-0.3774 * (0.2226)	-	-	-
Paper	-0.0083 (0.0105)	-	-	0.2091 (0.1643)	-0.0570 (0.1972)	0.4099 ** (0.2004)
Printing & Publishing	-0.0057 (0.0106)	-0.0687 (0.1755)	0.1400 (0.2090)	-	-	-
Non-metal Mineral Products	-0.0080 (0.0138)	-	-	-	-	-
Basic Metals	-0.0235 *** (0.0088)	-	-	-	-	-
Fabricated Metals	0.0052 (0.0244)	-	-	0.5850 *** (0.2206)	0.4892 *** (0.1645)	-
Coke & Fuel	0.0062 (0.0193)	-0.5194 * (0.2741)	-	0.8919 *** (0.1433)	-	-
Rubber & Plastic	0.0056 (0.0101)	-	-	-	-	-
Machinery	0.0109 (0.0073)	-0.7674 *** (0.1822)	-0.7130 *** (0.1770)	1.2787 *** (0.2243)	0.5794 ** (0.2509)	-
Transport Equipment	0.0103 (0.0113)	-0.6154 * (0.3182)	-	0.8133 *** (0.2562)	-	-
Others; Recycling	0.0188 ** (0.0089)	0.4145 *** (0.1518)	-	-	-	-
Chemicals	0.0373 *** (0.0115)	-	-	0.4547 *** (0.1651)	-	-
Accounting & Computing Machines	0.0387 * (0.0198)	-	-	-	-	-
Electrical Engineering	0.0078 (0.0068)	0.0835 (0.1704)	-0.2185 (0.1275)	-	-	-
Communications Equipment	-0.0099 (0.0103)	-	-	0.0946 (0.2067)	-	-
	0.1145 * (0.0614)	-	-	-	-	-
Medical, Precision & Optical instruments	-0.0057 (0.0107)	-	-	0.0562 (0.2829)	-	-
	0.0830 ** (0.0344)	-	-	-	-	-

Table C 6: ARIMA results: SHE^N in service industries

	constant	AR(1)	AR(2)	AR(3)	MA(1)
Domestic Services (structural break in 1981/1982)	-0.0168 (0.0138)	0.5568 * (0.2983)	-	-	-
	0.0096 (0.0068)	-	-	-	-
Hotels & Restaurants	0.0025 (0.0022)	-0.1322 (0.2436)	-	-	-0.4863 ** (0.2158)
Wholesale & Retail Trade	0.0042 (0.0074)	-0.6853 (0.4620)	0.0820 (0.2907)	0.1968 (0.2445)	0.7845 * (0.4383)
Transport & Storage	-0.0191 ** (0.0089)	0.0529 (0.1975)	0.2380 (0.2155)	-	-
Real Estate	0.0038 (0.0074)	-	-	-	-
Post & Telecommunication (structural break in 19888/1989)	-0.0236 *** (0.0052)	-	-	-	-0.4013 * (0.2251)
	0.0105 * (0.0060)	-0.5492 (0.3920)	-0.4022 (0.4116)	-	-
Financial Intermediation (structural break in 1993/1994)	-0.0058 (0.0163)	-	-	-	-
	0.0160 ** (0.0072)	-	-	-	-0.1536 (0.3831)
Business Services	0.0086 (0.0087)	-	-	-	0.4059 *** (0.1538)
Health & Social Work	0.0073 (0.0058)	0.2431 (0.1822)	-	-	-
Education	-0.0023 (0.0097)	-	-	-	-

Table C 7: ARIMA results: SHE^{N-1} in service industries

	constant	AR(1)	AR(2)	MA(1)
Domestic Services	0.0072 (0.0052)	-	-	-
Hotels & Restaurants	0.0044 (0.0068)	-0.9343 *** (0.1487)	-	0.7923 ** (0.3482)
Wholesale & Retail Trade	0.0004 (0.0078)	0.2420 (0.1945)	-	-
Transport & Storage	-0.0116 * (0.0060)	-0.1660 (0.7663)	-0.2183 (0.2317)	0.0531 (0.8739)
Real Estate	0.0052 (0.0114)	-	-	0.2596 * (0.1495)
Post & Telecommunication (structural break in 1988/1989)	-0.0260 ** (0.0098)	-	-	-
	0.0056 (0.0074)	-0.4213 (0.2708)	-	-
Financial Intermediation (structural break in 1993/1994)	0.0012 (0.0209)	-	-	0.6706 ** (0.3112)
	0.0023 (0.0108)	0.2854 (0.4288)	-	-
Business Services	0.0090 (0.0093)	-	-	0.4015 *** (0.1465)
Health & Social Work	0.0082 (0.0065)	-	-	0.2338 (0.1614)
Education	-0.0068 (0.0173)	0.2492 (0.3009)	-	-

Table C 8: ARIMA results: *max deviation* in service industries

	constant	AR(1)	AR(2)	MA(1)	MA(2)
Domestic Services (structural break in 1990/1991)	-0.0423 ** (0.0170)	-	-	-	-
	0.0279 (0.0253)	-0.0192 (0.4432)	-	-	-
Hotels & Restaurants	-0.0061 (0.0173)	-	-	0.1506 (0.1725)	-0.3205 (0.2143)
Wholesale & Retail Trade	0.0162 (0.0120)	-0.3245 ** (0.1342)	-	-	-
Transport & Storage	-0.0331 (0.0225)	0.0083 (0.2103)	0.3359 (0.2614)	-	-
Real Estate	0.0007 (0.0156)	0.1674 (0.4171)	-	0.2643 (0.3625)	0.4720 *** (0.1574)
Post & Telecommunication (structural break in 1988/1989)	-0.0132 (0.0227)	0.3067 (0.3823)	-	-	-
	0.0233 * (0.0123)	-0.3459 * (0.1879)	-	-	-
Financial Intermediation (structural break in 1993/1994)	-0.0112 (0.0183)	-	-	0.6312 ** (0.2569)	-
	0.0839 *** (0.0321)	-0.2533 (0.5193)	-0.7490 ** (0.3383)	-	-
Business Services	0.0042 (0.0168)	-	-	0.6331 *** (0.1943)	-
Health & Social Work	0.0030 (0.0063)	-	-	-	-
Education	0.0091 (0.0063)	-	-	-	-

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