Productivity Convergence in Manufacturing in the European Union: The Role of Economic Structure

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Abstract

The article aims to empirically validate three questions. Have productivity differences in European manufacturing been increasing or diminishing and what has been the situation in Central and Eastern Europe countries? Are productivity differences homogenous over time and across manufacturing industries? What is the role of the internal structure of manufacturing for convergence? For this purpose, an analysis of σ- and β-convergence in 11 manufacturing industries has been conducted, making use of shift-share decomposition techniques. A complex view of catching-up is demonstrated with heterogeneity over time and across industries. Convergence occurred in Western Europe until approximately 1990, but since then disparities have been increasing and CEE countries were the only ones catching up. Convergence took place predominantly in medium-tech industries, while both low-tech and high-tech industries experienced divergence. Structural differences account for a minor share of the productivity disparities; however, changes in employment structures and productivity together led to the formation of two clubs of countries: low-tech, low productivity and high-tech, high productivity countries.

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1. Introduction

The article contributes to inquiries into the sources and nature of economic convergence by looking at the processes of productivity growth and structural change in European manufacturing. Analyses of productivity differences among the economies of the European Union seem to be of high relevance, especially from the point of view of the consequences of European integration. In the research, we concentrate on manufacturing for a couple of reasons. Firstly, results presented by several papers stand in contradiction to theoretical predictions on productivity convergence. Economic theory predicts that international trade could be an important convergence channel, facilitating technology spillovers and enhancing competition (e.g. Grossman and Helpman, 1991; Ben-David, 1996). Hence, manufacturing should be exhibiting faster convergence than other sectors, especially in the economically integrated European Union. However, Bernard and Jones (1996a, 1996b) opened the debate on productivity growth in manufacturing by demonstrating that in this particular sector no convergence had taken place among the developed countries[2]. Looking for reasons for such situation was a predominant purpose for our interest in the topic.

Secondly, despite an on-going deindustrialisation, manufacturing remains a crucial sector for long-term development, as it provides consumption and investment goods and is the source of technological change. In the context of the recent re-industrialisation debate[3], research like this seems to be of a special value (Szirmai, 2011; Naude and Szirmai, 2012). In the article, we put emphasis on the relations between productivity growth and economic structure, which is understood, following S. Kuznets (1949, s. 205), as "the relative distribution of its [economy's] resources and total output among the several industries".

We aim to answer three interrelated questions. Firstly, can we confirm Bernard and Jones' results in the sample of old European Union countries; that is, in the most economically integrated region of the world and do these results apply also to its new members from Central and Eastern Europe (CEE)? Secondly, are productivity inequalities homogenous over time and across manufacturing industries? And thirdly, what is the role of the internal structure of the manufacturing sector for productivity developments in European countries? Namely, to what extent can productivity differences and their changes be attributed to different composition of employment between manufacturing industries?

For this purpose, an analysis of σ- and β-convergence in 11 2-digit manufacturing industries will be conducted. Shift-share decomposition techniques will be used in order to distinguish growth and structure effects. The application of these techniques with a thorough discussion of the results constitutes a main part of the value of the article. The analysis will be based on data from the GGDC Productivity Level Database and the EU-KLEMS Database and will cover 14 old (for the period 1970-2006) and 8 new members (1995-2006) of the European Union. Making use of those new, precise databases is a second major originality introduced by the article to the literature.

The article is organised as follows: section 2 provides a brief description of the state of the art and a presentation of the theoretical underpinnings of the analysis. It also shows how the article contributes to the debate. Then, in section 3, methods of the research are outlined, with

[2] Hereafter, 'sector' will refer to large units e.g. Agriculture, Manufacturing, Services; and 'industry' to smaller units, within sectors, e.g. 'Food, Beverages and Tobacco'.

[3] See, for instance, recent documents of the European Commission at http://ec.europa.eu/enterprise/initiatives/mission-growth/ (access 25.05.2013).

a special emphasis on convergence decomposition techniques. Section 4 presents the results of the analysis – firstly in terms of σ-convergence and next in terms of β-convergence. Section 5 provides a discussion of the results, concludes and indicates directions for further research.

2. Literature Review and Importance of the Article

2.1. Convergence and Economic Structure and in Economic Literature

The hypothesis of convergence – of lagging economies catching-up and reducing development or productivity disparities – has its origins in the writings of Gerschenkron (1962) and Abramovitz (1986), but it was formalised mainly in neoclassical theory and its models of economic growth (Baumol, 1986; Barro, 1991). Exogenous, Solow-type models of economic growth predicted the occurrence of conditional convergence. This means that when controlling for structural parameters (like investment rates, demography) the rate of growth of the productivity of an economy in a period should be negatively related to its initial level. Mechanisms that stand behind the convergence, according to those models, are universal access to technology and knowledge and diminishing marginal returns to capital. As stated more generally by Abramovitz (1986, p. 386), "the [catch-up] hypothesis asserts that being backward in level of productivity carries a *potential* for rapid advance".

The two most popular concepts of convergence are empirical in nature. The β-convergence and σ-convergence hypotheses, proposed by Barro and Sala-i-Martin (1990), although theoretically controversial (see e.g. Temple 1999), serve as a useful benchmark for all empirical analyses of international economic inequalities. Those two concepts will be investigated in our research.

The β-convergence hypothesis (in its absolute version) states that the rate of economic growth is negatively correlated with the initial level of development of an economy. It can also be expressed that a growth rate of an economy is positively correlated with its distance from the economy that leads in terms of productivity. This can be tested in a regression of the following form:

$$\vartheta_{i,t} = \alpha + \beta(\ln y_{M,t\text{-}1} - \ln y_{i,t\text{-}1}) + \mu_t + \varepsilon_{i,t}\,, \qquad (1)$$

where: $\vartheta_{i,t}$ – rate of economic growth between period t-1 and t; ln $y_{i,t\text{-}1}$ – logarithm of lagged productivity in the economy i; ln $y_{M,t\text{-}1}$ – logarithm of lagged productivity in the leading economy in a sample; α – constant term; β – convergence parameter; and μ_t and $\varepsilon_{i,t}$ represent a period dummy and a random error term, respectively. Positive β indicates that convergence is taking place, while negative β suggests the divergence of economies.

The σ-convergence hypothesis refers to changes in inequalities between countries, measured by a chosen statistical dispersion index, typically the coefficient of variation. When its value diminishes in time, then σ-convergence is taking place in the sample.

Most of the mainstream theory and empirics in the field of economic growth and convergence, abstracting from structural issues, treat the economy as a homogenous unity represented by a production function of some sort. From this point of view, economic growth consists of a quantitative extension of the productive capabilities of the economy due to factor accumulation or the enhancement of productivity. On the other hand, there is a significant amount of research on the role of the economic structure of development, ranging from Schumpeter (1911), neo-Schumpeterian and evolutionary accounts (Nelson and Winter, 1982; Fagerberg, 2000; Verspagen, 2001) to the sectoral analysis of such authors as Kuznets (1980) and Chenery (1986). An extended review of structural change literature is provided by Silva and Teixeira (2008).

What prevails in the latter approach is the understanding that economic growth (traditionally understood in quantitative terms) and economic development (as a broader, qualitative concept) are actually indistinguishable. In a longer time horizon growth takes place thanks to a constant structural change and shifts in economic activity from traditional to modern sectors (Schumpeter, 1911). Those movements are caused by changes in demand composition and in widely defined economic potential, which consists particularly of access to qualified labour force, sufficient capital formation and the technology of production (Kuznetz, 1980).

However, even when those three elements are available, the structural change is in no way automatic and it requires a certain level of social capabilities in several areas (Abramovitz, 1986). Particular industries are heterogeneous in reference to their knowledge base, technologies in use, types of inputs or demand patterns. The concept of sectoral systems of innovations, presented by Malerba (2002), underlines the learning aspect of development and the fact that moving economic activity from one sector to another requires certain adjustments in social and organisational routines at the level of both single enterprise and whole society. The institutional surroundings, which organises the functioning of a specific sector, but also that of a horizontal importance (like education system, labour market, financial markets), needs to adapt to the requirements of the changing composition of the economy (Soete and Verspagen, 1993). Governments can significantly enhance those adaptations by influencing factor endowments. Lin (2010) argues that by providing specific types of hard and soft infrastructure, governments affect incentives for entrepreneurs and, consequently, the direction of structural change.

What is more, *ex ante* assessment of structural change can differ from its ex post results. Certain movements, optimal from a static point of view, can be detrimental for growth in its dynamic aspect. Because optimal economic structure is only a relative concept, changing with development level (Haraguchi and Rezonja, 2011), the economy needs to adapt its patterns of specialisation in order to sustain its growth.

The presented heterogeneity of types of economic activity implies that structural change may function as an important convergence factor. In particular, it might accelerate growth in catching-up economies relative to the leaders (Abramovitz, 1986). Analytically, we can distinguish the following reasons for why structural transformation can be beneficial for aggregate productivity growth:

- labour might shift towards high productivity industries;
- labour might shift towards industries which are characterised by high productivity dynamics, which can partly result from their higher catching-up potential;
- the increasing economic role of some industries might generate positive spill overs to the rest of the economy.

2.2. Convergence in Manufacturing

The contemporary debate about convergence in manufacturing industries finds its milestone in the papers of Bernard and Jones (1996a, 1996b), which are probably the most important examples of the application of the economic convergence concept at the sectoral level of analysis. Their major outcome was that the occurrence and pace of convergence was diversified between economic sectors – while agriculture, mining and services experienced an equalisation of productivities between countries, no such phenomenon took place in manufacturing. This result inspired many other authors to try to verify this using different samples and employing different research techniques.

Those of them that have investigated the performance of developed countries in recent decades present results mostly in line with Bernard and Jones (e.g. Carree et al., 2000; Pascual and Westerman, 2000; Freeman and Yerger, 2001; Inklaar and Timmer, 2009). The convergence of productivity occurred only in some manufacturing industries and was faster in those less advanced technologically (Carree et al., 2000). Hultberg et al. (2004) find that conditional convergence, when controlled for investment rates and with country fixed-effects, was taking place in OECD countries through 1973–1990, which means that technological catching-up was possible. Similar results for developed countries through 1963–1982 are presented by Dollar and Wolff (1988).

Other studies, however, detect convergence – but only in large, more heterogeneous samples of countries (Rodrik, 2013) or during much longer periods (Madsen and Timol, 2010). Rodrik (2013) shows that in a global sample, manufacturing is in fact one of the sectors with significant convergence. Similar results are presented by Castellacci et al. (2008), with the reservation that processes of convergence are very heterogeneous and that there are significant nonlinearities in their pace.

Another set of studies considers the role of structural change and the sectoral composition of the economy for overall productivity growth and its convergence. A variety of shift-share decomposition techniques was developed in order to distinguish it statistically. At the level of the whole economy, the significance of the economic structure for development is well established (Chenery, 1986; Syrguin, 1986; McMillan and Rodrik, 2011). Successful catching-up in its early phase consists in industrialisation, while it becomes much more difficult close to the efficiency frontier, and then requires moving labour from low- to high-productivity industries (McMillan and Rodrik, 2011). Two hypotheses that are commonly tested in those analyses are those of "a structural bonus" and "a structural burden". The former states that with development labour concentrates in industries with higher productivity, and therefore, structural change contributes positively to growth. However, at the same time, labour might move to less dynamic industries and in this way constitute a burden for further growth (Fagerberg, 2000; Peneder, 2003). Shift-share decompositions devoted specifically to the manufacturing sector led to ambiguous implications about the role of its internal structure for development. The 'within effect', which represents average growth within industries, dominates the total productivity growth, while shifts in employment contribute to growth either positively or negatively, depending on the sample (Fagerberg, 2000; Timmer and Szirmai, 2000; Peneder, 2003).

Finally, some analyses aim to capture the role of economic structure for productivity differences between economies at a particular moment in time. They show that different employment compositions in European economies account for a small share of the development disparities (regional level: Esteban, 1999; Papalia and Bertarelli, 2009). Productivity disparities are to a large extent homogenous across industries – lagging economies have a productivity gap in most of them. Different specialisation patterns are not that important for productivity differences. However, the aforementioned studies took into consideration the whole economy.

When we focus solely on the manufacturing sector we should expect that the role of employment structure is even smaller, due to a more similar level of productivities among particular industries.

To our knowledge, little analysis of manufacturing industries, which included CEE countries, has been undertaken so far. Studies conducted for the whole economy demonstrate that CEE countries after 1995 achieved higher growth rates than old EU members. However, structural change only contributed to convergence of labour productivity (Parteka, 2009) or total factor productivity (Bah and Brada, 2009) to a limited extent.

In his comprehensive analysis of the convergence potential of six CEE countries, Stephan (2003) showed that manufacturing accounted for a large share of the total productivity gap between them and the then-European Union. He managed to identify some early specialisation patterns in manufacturing production that might have influenced future growth: Slovakia was in the best situation in the sample, whereas Poland and Estonia had employment structures that could have been detrimental to growth. Similar conclusions about evolving differences among the new member countries in the pre-accession period were drawn by Landesman (2003). Later work by Havlik et al. (2008) presents a picture of a very dynamic catching-up of transition economies. It is shown that CEE countries experience fast structural transformation and productivity growth, especially in the manufacturing sector.

2.3. Value of the Article

This article adds value for the presented literature in a number of areas. Firstly, following Inklaar and Timmer (2009) and making use of the GGDC Productivity and EU-KLEMS databases, we analyse convergence with industry-specific Purchaser Power Parities indices (given for the benchmark year 1997), which enables us to conduct a methodologically proper analysis for the European Union on the basis of yearly data up to 2007. Secondly, we employ a complex approach to the convergence problem – taking into consideration and decomposing both σ- and β-convergence. We test different versions of the productivity convergence hypothesis, allowing for time and industry heterogeneity. Thirdly, we also analyse trends in productivity differences for the new member states recognising the specificity of the transition economies of Central and Eastern Europe.

3. Research Methods

3.1. Measuring Productivity

In the analysis we make use of two traditional concepts, namely the σ- and β-convergence (Barro and Sala-i-Martin, 1990). For each of them we conduct a specific shift-share decomposition of total convergence into three elements, relating to: productivity within particular industries, structure of employment and the product of these two. Those statistical exercises can lead to important, descriptive results about sources of productivity differences and about the role of economic structure for growth and convergence.

However, it should be remembered that strict distinguishing into structural change and productivity growth makes sense only statistically, as these two processes are two, interrelated aspects of the same development. In reality, it is structural change and moves to more technologically advanced industries that sustain economic growth and *vice versa* – it is the economic growth, with its changes for both demand composition and economic potential that makes moves in structure possible (Schumpeter, 1911; Kuznets, 1970; Timmer and Szirmai, 2000).

As a measure of labour productivity we will use the value added per working hour. In order to receive reliable conclusions, industry-specific PPP should be adopted. Despite generally high tradability among all manufacturing industries, the price levels and their changes remain significantly diversified (Tyrväinen, 1998; Van Biesebroeck, 2009; Inklaar and Timmer, 2009). Therefore, we employ a deflating technique proposed by Inklaar and Timmer (2009) and make use of two (connected) databases on productivity. The GGDC Productivity Level Database (Inklaar and Timmer, 2008) provides us with data on single-deflated productivities in 2-digit industries, in relation to US levels in 1997, while from the EU-KLEMS database we obtain indices of productivity growth for the whole period of analysis. On this basis we calculate productivity levels in each year, every country and industry.

Our notation is as follows (all values refer to year *t*): - $\gamma_{i,j,t}$ single deflated value added per working hour in country *i* in industry j, in relation to US levels; - $\gamma_{i,t}$ single deflated value added per working hour in the European Union in industry *j*, in relation to US levels. In order to find productivity levels in total manufacturing in country *i* (and as well for some industries, where no aggregate productivity is provided) we need to calculate this on a weighted-average basis:

$$\gamma_{i,t} = \Sigma_j \, \omega_{i,j,t} \, \gamma_{i,j,t} \,, \tag{2}$$

where $\omega_{i,j,t} \equiv \frac{HEMPE_{i,j,t}}{HEMPE_{i,t}}$ is the share of industry *j* in total employment (HEMPE stands for number of hours worked in a year by persons engaged in an industry). Analogously, $\gamma_{i,t}$ will refer to productivity in manufacturing in the European Union.

Due to data availability, the manufacturing sector will be decomposed into eleven 2-digit industries. Following Peneder (2007) and Eurostat's approach, the classifications of those industries according to their educational intensity and technology level are presented in Appendix 1.

Our analysis will be conducted for two samples: for EU-14 (old member states excl. Luxembourg) for 1970–2006 and for EU-22 (European Union members since 2004, excl. Cyprus, Luxembourg and Malta) for 1995–2006. Some countries were excluded due to the small size of their economies, which makes analysis at the disaggregated level difficult. For β-convergence, where data allowed, regressions were calculated until 2007[4].

3.2. σ-convergence Decomposition

Following Esteban (1999), we employ an augmented shift-share decomposition for a measure of productivity inequalities at the aggregate level. For each country and in every year, we decompose a relative difference between its productivity and the European average into three elements in the following way:

$$\frac{\gamma_{i,t}-\gamma_t}{\gamma_t} = \frac{\Sigma_j(\omega_{i,j,t}\gamma_{i,j,t}-\omega_{i,t}\gamma_{j,t})}{\gamma_t} = \frac{\Sigma_j\omega_{j,t}(\gamma_{i,j,t}-\gamma_{j,t})}{\gamma_t} + \frac{\Sigma_j\gamma_{j,t}(\omega_{i,j,t}-\omega_{j,t})}{\gamma_t} + \frac{\Sigma_j(\omega_{i,j,t}-\omega_{j,t})(\gamma_{i,j,t}-\gamma_{j,t})}{\gamma_t} = \pi_{i,t} + \mu_{i,t} + \alpha_{i,t} \,, \tag{3}$$

[4] Analyses of σ-convergence require data for full sample, while ones of β-convergence can be conducted even with some data points missing.

Therefore, the distance in productivity between each country and the European average can be decomposed into three elements:

- Productivity differential $\pi_{i,t}$ – which measures pure differences in productivity within particular industries, holding the employment structure constant. It shows what would be the difference between the economies had they had the same employment structures.
- Industry mix $\mu_{i,t}$ – which measures the role of structural differences, this time holding the productivity levels constant. It shows what would be the difference between the economies if they had the same productivities in all industries. We can expect that it will be strongly and positively correlated with π_i, since the concentration of economic activity in more productive industries should accompany general development.
- Allocation component $\alpha_{i,t}$ – which measures whether a country specializes in industries in which it is relatively efficient. Its value shows whether a country makes use of its comparative advantages and it probably is to a high extent a consequence of the institutional network and of the industrial policy of a country, not necessarily correlated with the other two.

The contribution of these three elements to productivity inequalities in Europe can be distinguished by making use of a coefficient of mean absolute deviation:

$$V_t^d \equiv \frac{d_t}{\gamma_t} = \frac{\Sigma_i^N |\gamma_{i,t} - \gamma_t|}{N\gamma_t} = \frac{\Sigma_i^N |\pi_{i,t} + \mu_{i,t} + \alpha_{i,t}|}{N} + \frac{\Sigma_i^N |\pi_{i,t}|}{N} + \frac{\Sigma_i^N |\mu_{i,t}|}{N} + \frac{\Sigma_i^N |\alpha_{i,t}|}{N} + residual_t = \pi_t + \mu_t + \alpha_t + residual_t, \quad (4)$$

where: d_t – mean absolute deviation of productivity in year t.; π_t, μ_t, α_t are average absolute values of $\pi_{i,t}$, $\mu_{i,t}$, $\alpha_{i,t}$, which were described above. Their interpretation is analogous – they represent the contribution of the productivity-differential, industry-mix and allocation components to productivity dispersion in the sample in year *t*.

The coefficient of the mean absolute deviation, though unusual for analysing convergence, for our descriptive purposes has some advantages over the coefficient of variation or logarithmic deviation (compared to e.g. Papalia and Bertarelli, 2008). Firstly, it does not lead to systematic errors at the moment of the disaggregation of total into industry-level productivity, as a measure based on logarithms would. Secondly, it gives outcomes directly in linear units, which are easier to interpret and thus preferable to quadratic ones, which would be obtained by the use of a coefficient of variation. The only problematic issue is the residual term, which will appear when the three elements: π_i, μ_i, α_i do not have the same sign, which means that differences in productivity are not perfectly correlated with structural or allocation differences.

The values of V_d and its components will be calculated for the EU-14 (old member states excl. Luxembourg) for 1970–2006 and for the EU-22 (excl. Cyprus, Luxembourg and Malta) for 1995–2006. The exclusion of some countries was undertaken due to small size of their economies, which makes analysis at the disaggregated level difficult. Trends in V_d and its components will inform us about the occurrence of σ-convergence and its characteristics – whether we can attribute it to changes in structural differences or productivity differences within industries. In addition, a more detailed investigation of the values π_i, μ_i and α_i for each country will be conducted.

3.3. Aggregate Growth Rate Decomposition and β-convergence

In order to capture the dynamic aspect of the analysed processes and to verify theoretical predictions about productivity convergence, a similar decomposition of growth rates will be conducted (e.g. Fagerberg, 2000; Krűger, 2010). This time γ_0 will stand for productivity at the beginning of a period and γ_1 at the end of the period. It can be shown that growth rate in total productivity can be decomposed into three elements:

$$\vartheta_{i,t} \equiv \frac{\gamma_{i,t}-\gamma_{i,t-1}}{\gamma_{i,t}} = \frac{\Sigma_j(\omega_{i,j,t}\gamma_{i,j,t}-\omega_{i,j,t-1}\gamma_{i,j,t-1})}{\Sigma_j\omega_{i,j,t-1}\gamma_{i,j,t-1}} = \underbrace{\Sigma_j(\tilde{\gamma}_{i,j,t-1}\vartheta_{i,j,t}\omega_{i,j,t-1})}_{\text{Within } (W)}+\underbrace{\Sigma_j(\tilde{\gamma}_{i,j,t-1}\Delta\omega_{i,j,t})}_{\text{Static-shift } (S)}+\underbrace{\Sigma_j(\tilde{\gamma}_{i,j,t-1}\vartheta_{i,j,t}\Delta\omega_{i,j,t})}_{\text{Dynamic-shift } (D)} \quad (5)$$

where: $\tilde{\gamma}_{i,j,t} \equiv \frac{\gamma_{i,j,t}}{\gamma_{i,t}}$ is productivity in industry j, relative to productivity in total manufacturing in country i; $\vartheta_{i,j,t}$ is productivity growth in industry j; and $\Delta\omega_{i,j,t} \equiv \omega_{i,j,t} - \omega_{i,j,t-1}$ measures change of employment share of industry j.

Hence, we receive a decomposition of the total productivity growth rate into three components:

- Within effect (W) – this is an average productivity growth in each of the industries, holding the employment weights constant and weighting by their relative productivities. Its value refers to the pace of productivity growth had no structural change taken place;
- Static-shift effect (S) – an effect of shifts of employment between industries, weighting by their initial productivities. It measures the results of the structural change in its static sense – if $S > 0$, then labour moved on average into industries that were initially relatively highly productive (high $\tilde{\gamma}_{i,j,t-1}$). It could be an effect of allocative efficiency (in a static sense) and it constitutes a "structural bonus" for the economy;
- Dynamic-shift effect (D) – combination of the two previous effects, which informs us about dynamic effects of structural change. If $D > 0$, then shifts of employment had the direction into industries that were the most dynamic during the period in consideration. However, a negative D would support the "structural burden hypothesis", which stands that labour in time concentrates in less dynamic industries (Fagerberg, 2000; Peneder, 2003).

Decomposition (5) is highly fragile in response to the length of the basic period of analysis. If $\vartheta_{i,t}$ is a one-year growth rate, the W-component accounts for almost all of the total growth and the longer the period, the larger the share of both structural components. In our analysis we chose a 10-year period, which is a standard in explaining economic growth – it smoothens growth rate amplitude, but also allows us to observe substantial structural shifts.

β-convergence analysis can, and usually does, refer only to the aggregate growth rate. However, we can also investigate whether the structural changes were more beneficial for countries with low or with high initial productivity. Our basic approach to analysing β-convergence will be as follows:

$$\vartheta_{i,t} = \alpha + \beta(\ln \gamma_{M,t-1} - \ln \gamma_{i,t-1}) + \varepsilon_{i,t} \,, \quad (6)$$

where $\vartheta_{i,t}$ is average productivity growth rate in a 10-year period t in country i.

This relates the average 10-year growth rate in the manufacturing sector to lagged distance in productivity from the leader. β-convergence in its most general version takes place if the β parameter is positive, which means that countries initially further from the productivity frontier tend to grow faster (Cameron et al., 2005; Rodrik, 2012). α will stand for average 'frontier growth', i.e. rate of growth in the leading economy. We take account of the fact that the leading economy might change in the period of analysis – each time $\gamma_{M,t\text{-}1}$ will refer to the productivity of the economy leading in period *t*-1.

Analogous regressions will be conducted for the growth rate in each industry *j*, which will potentially let us identify areas of convergence and of divergence:

$$\vartheta_{i,j,t} = \alpha + \beta(\ln \gamma_{M,j,t\text{-}1} - \ln \gamma_{i,j,t\text{-}1}) + \varepsilon_{i,j,t} \,, \tag{7}$$

Parameter β has the following interpretation: a country initially *x*-times more developed than the other, will experience on average a growth rate of productivity lower by (β ln *x*). For instance, if β=0.02, then a country more developed by 10% can expect a growth rate lower by (0.02*ln 1.1); that is, by 0.19 percentage points.

A similar analysis will be conducted for three distinguished components of the 10-year growth rates: $W_{i,t}$, $S_{i,t}$, $D_{i,t}$. Taking growth components as dependent variables will tell us whether structural shifts were relatively more beneficial for catching-up countries; that is, whether they supported or maybe counteracted productivity convergence. Those regressions will be as follows:

$$W_{i,t} = \alpha + \beta(\ln \gamma_{M,t\text{-}1} - \ln \gamma_{i,t\text{-}1}) + \varepsilon_{i,t} \,, \tag{8}$$

In order to keep correspondence between its results and the decomposition (5), $G_{i,j,t}$ will be a regular (not logarithmic) average growth rate in rolling 10-year periods. For robustness, 5-year periods will be controlled as well, which especially for the EU-22 sample can enhance the reliability of the results. We will also conduct regressions in a sample excluding Ireland, as tax and legal issues in this country might heavily influence the data on productivity. Separate parameter values for each industry indicate that we assume heterogeneity in convergence processes.

To allow for time heterogeneity of the leader's growth in an industry, we will also make use of period dummies and check for structural breaks in β parameter – running Chow test:

$$\textit{dependent variable} = \alpha_j + \beta_j(\ln \gamma_{M,j,t\text{-}1} - \ln \gamma_{i,j,t\text{-}1}) + \mu_t + \varepsilon_{i,j,t} \,, \tag{9}$$

In the sample of EU-22 countries we will also check for the heterogeneity of the β parameter between the eight Central and Eastern Europe (CEE) countries and the rest, running the following regression:

$$\textit{dependent variable} = \alpha_j + NCEE\beta_j^{NCEE}(\ln \gamma_{M,j,t\text{-}1} - \ln \gamma_{i,j,t\text{-}1}) + CEE\beta_j^{CEE}(\ln \gamma_{M,j,t\text{-}1} - \ln \gamma_{i,j,t\text{-}1}) + \varepsilon_{i,j,t} \,, \tag{10}$$

where *CEE* equals 1 for CEE countries and 0 for others (and *NCEE* oppositely).

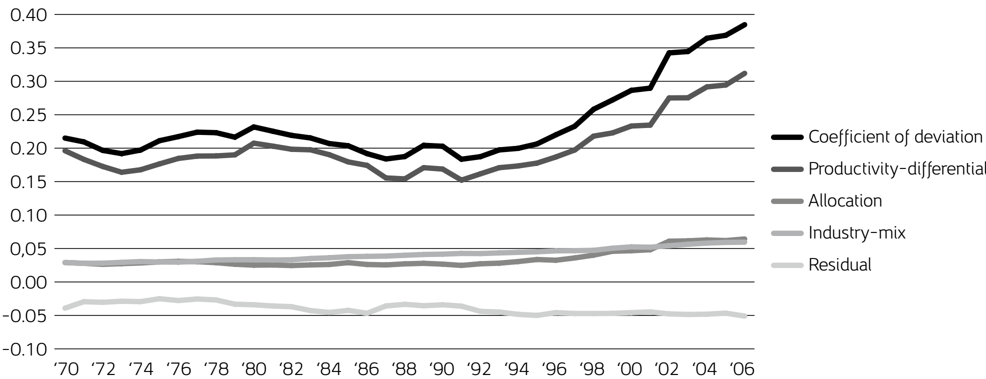
All equations will be estimated using the panel data ordinary least square method, with Arellano robust standard errors in order to control for heteroskedasticity and autocorrelation.

4. Results

4.1. σ-convergence Results

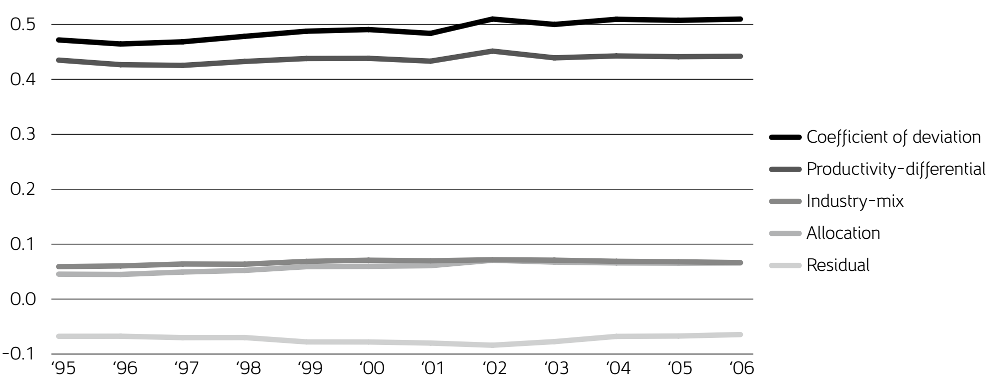
The coefficient of mean absolute deviation for EU-14 countries was quite stable until 1991 and has experienced a continuous and sharp growth since then (see Figure 1). σ-convergence took place mostly in the period 1980–1987. Most of the observed differences between countries can be attributed to different productivities within industries – the π component accounts for over 80% of the deviation coefficient and is responsible for its growth since 1991. Industry-mix and allocation components were responsible for a much smaller part of the differences and both were growing as well. The remaining residual informs us that the three elements were not perfectly correlated with each other, which means that economic structure in some cases neutralised pure productivity differences within industries.

Figure 1. Trends of the Coefficient of Mean Absolute Deviation and its Components, Labour Productivity, EU-14, 1970–2006



Source: Author's preparation, calculations based on GGDC Productivity Level Database and EU-KLEMS

Figure 2. Trends of the Coefficient of Mean Absolute Deviation and its Components, Labour Productivity, EU-22, 1995–2006



Source: Author's preparation, calculations based on GGDC Productivity Level Database and EU-KLEMS

Respective values for the EU-22 are, expectedly, much higher and also have been growing slowly, which points to σ-divergence (Figure 2). Here, the role of the productivity differential is even higher and it explains about 90% of total differences. Both figures indicate that, generally, productivity differences have a sector-wide character and that productivity disparities are only to a limited extent a result of detrimental specialisation patterns in less developed economies. This result is largely in line with other decomposition analyses (Esteban, 1999).

Levels of productivity inequalities, but also their tendencies, varied across industries (Table 1). In the EU-14 until the most recent period, the majority of industries had exhibited much higher inequalities than total manufacturing. This means that different countries are good at different types of economic activity, which diminishes disparities at the level of the whole sector. We can observe quite similar trends for EU-14 and EU-22 with convergence industries being: Non-Metallic Minerals, Metals, Machinery, Transport Equipment and Recycling. Divergence took place continuously in Textiles and in Chemicals, while Food, Wood, Paper and Electrical and Optical Equipment had U-shaped paths of inequalities, with dynamic growth in them since the late 90s.

Very simple explanations, like those relating linear convergence to the technology level of an industry, do not hold here. It looks like divergence took place either in high-tech industries or in traditional, labour-intensive low-tech industries. At this moment we can pose a hypothesis for further research that more efficient economies were able to introduce capital-intensive methods and reduce employment in low-tech industries, while at the same time they adopted new, frontier technologies in modern industries. In less-developed countries traditional industries remain organised with labour-intensive methods (European Commission, 2012). Convergence occurred mainly in medium-technology, heavy industries, with high levels of internationalisation; however, this should also be the subject of further analysis.

Table 1. The Coefficient of Mean Absolute Deviation by Industry

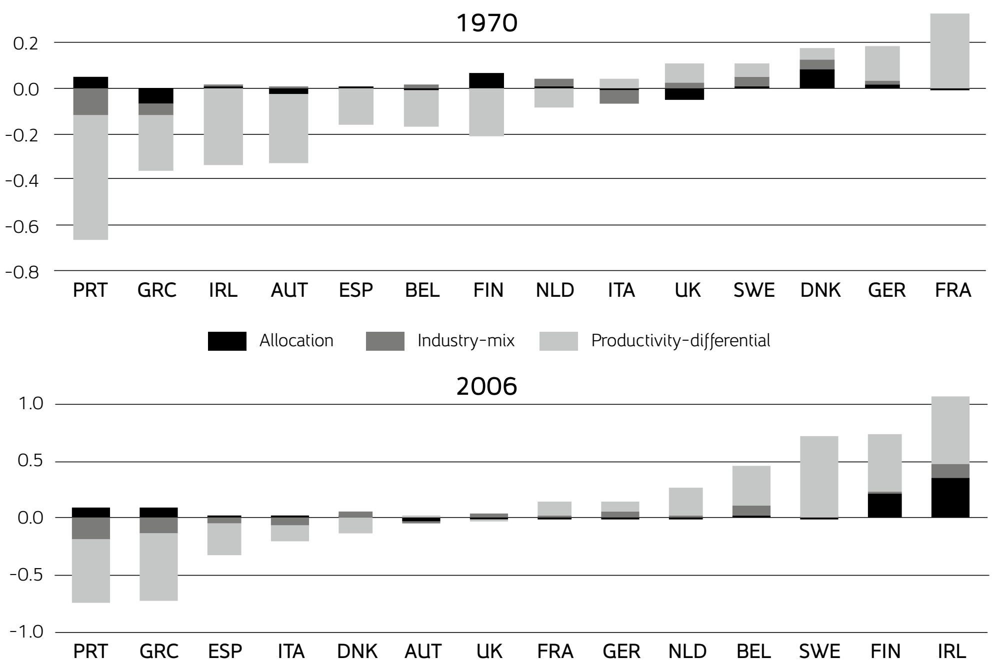
Industry	EU-14				EU-22		
	1970	1982	1994	2006	1995	2000	2006
Total Manufacturing	0.215	0.219	0.200	0.385	0.472	0.491	0.510
Food, Beverages and Tobacco	0.297	0.285	0.243	0.395	0.481	0.470	0.499
Textiles, Textile, Leather and Footwear	0.205	0.244	0.256	0.421	0.533	0.553	0.610
Wood and of Wood and Cork	0.437	0.341	0.377	0.434	0.568	0.551	0.556
Pulp, Paper, Printing and Publishing	0.288	0.185	0.226	0.402	0.437	0.499	0.490
Chemical, Rubber, Plastics and Fuel	0.287	0.311	0.311	0.479	0.491	0.553	0.563
Other Non-Metallic Mineral	0.239	0.209	0.199	0.183	0.406	0.341	0.297
Basic Metals and Fabricated Metal	0.499	0.265	0.227	0.232	0.444	0.408	0.344
Machinery, N.e.c.	0.352	0.266	0.235	0.267	0.463	0.424	0.395
Electrical and Optical Equipment	0.337	0.286	0.241	0.669	0.428	0.506	0.739
Transport Equipment	0.384	0.333	0.327	0.314	0.497	0.453	0.413
Manufacturing N.e.c.; Recycling	0.455	0.402	0.392	0.330	0.529	0.498	0.451

Note: N.e.c. stands for "nowhere else classified"
Source: Author's calculations.

A more detailed analysis leads us to further insights about the nature of convergence. High productivity was strongly and positively correlated with beneficent economic structure – the correlation coefficient between π and μ components reached on average 0.75. It is an expected result, indicating that economic activity shifts to more productive industries alongside the development path. The allocation component at different periods either strengthened or countervailed the productivity differences. In 1980–1994, allocation efficiency was relatively improving in less-developed countries, but from 1994 an opposite trend was observable. This means that highly-developed countries exhibited positive structural changes and became more specialised in industries that gave them a comparative advantage. Analogous implications can be made for the enlarged European Union.

The hierarchy of countries based on the criterion of aggregate productivity changed seriously during the period of analysis. France, Germany, Denmark and the United Kingdom, which were the initial leaders, now take places in the middle of the scale, whereas Ireland, Finland, Sweden and Belgium have become the new leaders. Portugal and Greece are still lagging seriously behind the rest of the European Union. The distribution of productivity differences has become much more fat-tailed – both lagging and leading countries are now much further away from the average than they were in 1970 (Figure 3). Additionally, the allocation component benefits two groups of countries the most – productivity leaders and laggards. Altogether, a sharp division into two clubs of countries has taken shape: low-productivity, low-tech-specialised on the one hand, and high-productivity, high-tech-specialised on the other. It is also apparent that both groups consist of small economies, with big European countries situated in the middle of the scale.

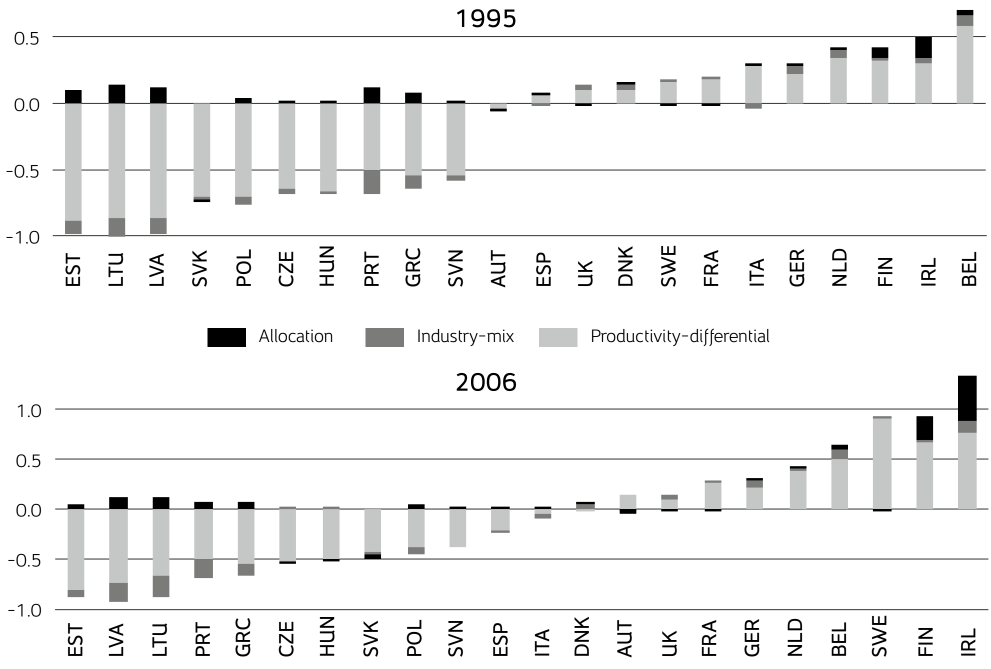
Figure 3. Decomposition of Differences in Productivity from the EU Average, EU-14, 1970 and 2006



Source: Author's preparation

Now, let us turn to a comparison of productivities in the EU-22 sample. Firstly, in 1995 a very strict division into two groups was apparent. The transition economies, together with Portugal and Greece, formed a club that lagged behind the rest of the EU and specialised in low-productivity industries. Until 2006, Central and Eastern Europe countries had reduced much of its distance to the EU average, overtaking Greece and Portugal and getting close to Spain. Most of this catching-up can be attributed to the reduction of the productivity-differential component, while structural differences remained significant. Only some countries (Czech Republic, Hungary and Slovenia) experienced positive structural change, which possibly can be beneficial for them in the future. On the other hand, the structure of manufacturing in Baltic countries is a detrimental factor for their productivity and in this sense makes them similar to Greece and Portugal.

Figure 4. Decomposition of Differences in Productivity from the EU Average, EU-22, 1995 and 2006



Source: Author's preparation

4.2. β-convergence Results

The basic results of growth rate decomposition for the EU-14 are demonstrated in Table 2, which presents for every country: an average 10-year productivity growth (in rolling periods) and its three components reflecting the productivity growth within industries, and static and dynamic aspects of structural change. It is visible that productivity growth accounted for the majority of the total values and that shifts in structure did not play a large role. This is in line with Fagerberg's (2000) insight that contemporary technical change is rather employment saving than employment expanding. All countries benefited from a structural bonus ($S>0$), while structural burden ($D<0$) was negligible. However, it is also apparent that the three most dynamic countries in the whole period benefited the most from shifting employment to dynamic industries – this was in some sense a necessary condition to become a leading economy. On the other hand, the static-shift element was not that strongly correlated with the aggregate growth rate. Countries like Germany, France or the United Kingdom were in the second half of the scale regarding the average growth rate, even though they experienced significant shifts to highly-productive industries.

Table 2. Decomposition of 10-year Labour Productivity Growth Rates, Average Values, EU-14 Countries 1970–2007

Country	Average 10-year growth rate	Average values of components		
		Within (*W*)	Static-shift (*S*)	Dynamic-shift (*D*)
Ireland	103.9%	91.5%	3.1%	9.3%
Finland	69.1%	62.1%	2.1%	4.9%
Belgium	59.1%	54.9%	1.8%	2.3%
Austria	51.9%	49.6%	1.7%	0.5%
Sweden	49.8%	49.1%	0.2%	0.4%
Netherlands	43.1%	42.5%	0.9%	-0.4%
Portugal	35.4%	35.2%	0.0%	0.2%
United Kingdom	35.3%	32.2%	3.7%	-0.5%
Italy	34.9%	33.7%	1.7%	-0.4%
Germany	32.1%	29.7%	2.1%	0.3%
Spain	29.7%	28.9%	0.9%	-0.1%
France	28.7%	26.5%	2.0%	0.2%
Denmark	22.6%	20.9%	1.1%	0.5%
Greece	22.0%	20.1%	1.2%	0.7%

Note: Countries are ordered by decreasing average growth rate.
Source: Author's calculations

Now, we move on to discuss the results of the estimation of β-convergence equations (Table 3). In total manufacturing, as expected, we observed β-divergence (negative β value). This process was not stable over time, which is reflected by the significance of time-dummies and by the structural break indicated by Chow's test. The latter occurred around 1989 – before this year β was positive (but very small), but since 1989 more developed countries have been improving their productivity faster than the lagging ones. The descriptive power of the simple convergence model is very low, which means that factors other than sector-wide catching-up mechanisms determined the actual growth rates.

Table 3. Results of the Estimation of β-convergence for Manufacturing Industries, EU-14, 1970–2007
Dependent Variable: Average Productivity Growth Rate in 10-year Rolling Periods

	No time-dummies		Time-dummies		Structural breaks
Industry	β (*t* distribution)	R^2	β (*t* distribution)	R^2	β
1. Total manufacturing	-0.0237* (1.932)	0.022	-0.0225** (-2.017)	0.074	Before 1989: 0.0032 After 1989: -0.0629*
2. Industries					
Food, Beverages and Tobacco	0.0075 (1.377)	0.036	0.0066 (1.255)	0.102	Before 1989: 0.0079 After 1989: 0.0047
Textiles, Textile, Leather and Footwear	-0.0014 (-0.186)	0.001	0.0001 (0.010)	0.076	Before 1989: 0.0074 After 1989: -0.0178**
Wood and of Wood and Cork	0.0101* (1.935)	0.037	0.0106* (1.935)	0.068	Before 1989: 0.0182** After 1989: -0.0088*
Pulp, Paper, Printing and Publishing	0.0051 (0.622)	0.006	0.0049 (0.563)	0.050	Before 1985: 0.0231** After 1985: -0.0182**
Chemical, Rubber, Plastics and Fuel	0.0026 (0.212)	0.001	0.0029 (0.231)	0.044	Before 1985: 0.0215 After 1985: -0.0163
Other Non-Metallic Mineral	0.0282*** (5.795)	0.204	0.0292*** (5.364)	0.286	No breaks
Basic Metals and Fabricated Metal	0.0173** (2.527)	0.225	0.0307** (2.190)	0.328	Before 1985: 0.0297** After 1985: 0.0138
Machinery, N.e.c.	0.0232* (1.849)	0.141	0.0232* (1.956)	0.205	Before 1985: 0.0337** After 1985: 0.0059
Electrical and Optical Equipment	0.0327** (2.190)	0.129	0.0526*** (4.141)	0.293	Before 1994: 0.0402*** After 1994: -0.0194*
Transport Equipment	0.0205*** (9.165)	0.178	0.0209*** (8.995)	0.238	Before 1989: 0.0097** After 1989: 0.0356
Manufacturing N.e.c; Recycling	0.0189*** (4.051)	0.208	0.0200*** (3.646)	0.244	Before 1991: 0.0210*** After 1991: 0.104

Note: *** - significance at 0.01 level; ** - sign. at 0.05 level; * - sign. at 0.1 level
Source: Author's calculations

Analysis at the level of individual industries shows great heterogeneity of β values and of their significance. However, almost all of them are positive, which implies that convergence at industry level was on average more typical, contrary to the aggregate level. This is a very important result, for which we can propose some hypothetical explanations. Firstly, in some industries β-convergence coincided with σ-divergence, which indicates that an effect of regression towards the mean took place (Quah, 1993). Secondly, we can suspect that, analogously to σ-convergence, the distribution of the performance of countries differed across industries. If one of the leading countries, for instance France, reduced its productivity gap in an industry in which it lagged behind the leader, it actually contributed to divergence in the whole manufacturing sector. Thirdly, different specialisation patterns in European economies might have played a significant role for divergence in total manufacturing. This last hypothesis will be evaluated in a subsequent part of the article.

Analogously to the interpretation of σ-convergence (see Table 1), the industries with diminishing inequalities were: the manufacturing of Wood, Non-Metallic Minerals, Metals, Machinery, Transport Equipment and Others, but also Electronics and Optical Equipment. On the other hand, industries that exhibited divergence in a σ sense, here have positive, yet very small and insignificant β values. When we check for structural breaks, we receive a more complex view and an explanation of those contradictory results. In many industries, the most prominent example being Electronics and Optical Equipment, the β parameter changes its value from positive in 1970s and 1980s to negative in the most recent period[5]. This confirms one of the conclusions from the σ-convergence analysis, namely the divergent trends of productivity growth in the EU-14 from roughly 1990 on.

The β-convergence analysis conducted for three components of growth rates seems to confirm our hypothesis (Table 4). For the within the component, we receive a negative and insignificant β, with a structural break in 1989, which is in accordance with the results in Table 3. What is important is that the static-shift component worked in favour of the more developed countries, which means that they managed to improve their labour allocation better than lagging economies. This might explain β-divergence in manufacturing with β-convergence in its industries. The close to zero estimation of β for the dynamic-shift component suggests that on average there was no significant relation between its value and the productivity level.

Table 4. Results of the Estimation of β-convergence for Growth Rate Components, EU-14, 1970–2006

	No time-dummies		Time-dummies		Structural breaks
Growth rate component	β (*t* distribution)	R^2	β (*t* distribution)	R^2	β
Within	-0.0138 (-0.178)	0.000	-0.0202 (-0.262)	0.035	Before 1989: 0.0981 After 1989: -0.1923**
Static-shift	-0.0099** (-1.993)	0.056	-0.0108** (-2.302)	0.124	No breaks
Dynamic-shift	-0.0080 (-1.042)	0.009	-0.0091 (-1.209)	0.070	No breaks

Source: Author's calculations

A similar analysis will be presented for the EU-22 countries, with the special qualification of eight transition economies (Table 5). Here, the data are based only on 2–3 10-year periods, so they have to be interpreted with much caution. Nevertheless, what is outstanding here is a very diffuse distribution of growth rates. Productivity in manufacturing in some of the transition economies grew in the 10-year period on average by 170–180%, while Italy and Spain experienced almost no growth at all. Virtually all growth in the most dynamic economies can be assigned to productivity changes within industries, with little role of structural shifts. This suggests that the space for catching-up on the part of Central and Eastern Europe was large and distributed among industries. On the other hand, countries in this region, which were initially more developed (i.e. Hungary, Czech Republic and Slovenia), benefited a lot from employment shifts to more dynamic industries. Those three countries are described by the

[5] We run the Chow test for different years. Presented results refer to a year with the highest significance of the test.

European Commission (2012) as relatively innovative economies, with technology and capital-driven growth – in comparison to, for instance, Poland or Latvia which specialise in labour-intensive, low-tech activities. Only some of the Western countries managed to reach growth rates similar to those of transition economies, while most of them grew at a much lower pace. Sweden seems to be an interesting case for further research, as it experienced very large improvements in productivity, despite detrimental structural changes.

Table 5. Decomposition of 10-year Labour Productivity Growth Rates, Average Values, EU-22 Countries 1995–2007

Country	Average 10-year growth rate	Average values of components		
		Within (*W*)	Static-shift (*S*)	Dynamic-shift (*D*)
Poland	183.7%	179.4%	3.9%	0.4%
Lithuania	169.3%	165.6%	1.6%	2.2%
Slovakia	169.1%	181.6%	-4.0%	-8.5%
Sweden	120.2%	127.8%	1.0%	-8.6%
Ireland	113.3%	99.6%	7.1%	6.5%
Hungary	98.2%	83.4%	0.7%	14.0%
Latvia	96.1%	85.6%	4.4%	6.0%
Finland	92.8%	85.2%	0.2%	7.3%
Slovenia	89.3%	78.8%	5.1%	5.3%
Czech Republic	88.0%	77.7%	2.9%	7.4%
Estonia	78.0%	83.7%	1.4%	-7.1%
Austria	61.8%	59.6%	1.7%	0.5%
France	50.6%	47.0%	3.0%	0.5%
United Kingdom	44.9%	44.0%	2.8%	-1.8%
Netherlands	43.3%	43.1%	0.3%	-0.1%
Germany	36.5%	35.8%	0.9%	-0.1%
Portugal	33.4%	30.3%	2.7%	0.5%
Belgium	33.4%	30.8%	2.3%	0.2%
Greece	32.4%	26.7%	2.5%	3.2%
Denmark	26.8%	23.1%	1.6%	2.1%
Spain	11.6%	9.4%	2.2%	0.1%
Italy	7.1%	4.8%	2.3%	0.0%

Note: Countries are ordered by decreasing average growth rate
Source: Author's calculations

β-convergence took place in total manufacturing and in all of its industries, with parameters significant in 8 out of 11 cases (Table 6). It was the fastest in medium-low technology, heavy industries and the slowest in either high-tech (Chemicals, Electronics) or in low-tech industries (Food, Textiles). Now we will present the results for 5-year rolling periods, which allows us to check for structural breaks (and does not change general conclusions). In those industries where structural breaks took place, the Chow test was of the highest significance in 1999. Results of this test indicate that the first half of the period of analysis was in general characterised by higher β values. This means that divergence was the most pronounced in 1995–1999. In this case, time-dummies were insignificant (probably due to the much shorter period), so their results were omitted.

Table 6. Results of Estimation of β-convergence for Manufacturing Industries, EU-22, 1995–2007
Dependent Variable: Average Productivity Growth Rate in 5-year Rolling Periods

	Homogeneous parameters			With CEE-dummies		
Industry code	β (*t* distribution)	R^2	Structural break in 1999 – β values	$β^{NCEE}$ (*t* distribution)	$β^{CEE}$ (*t* distribution)	R^2
1. Total	0.0169** (2.462)	0.167	No break	-0.0204** (-2.449)	0.0132** (2.147)	0.358
2. Industries						
Food, Beverages and Tobacco	0.0045 (1.3283)	0.029	Before: 0.0079** After: 0.0007	-0.0046 (-1.4261)	0.0038 (1.1271)	0.072
Textiles, Textile, Leather and Footwear	0.0067* (1.6652)	0.098	No breaks	-0.0056 (-0.949)	0.0046 (1.22)	0.158
Wood and of Wood and Cork	0.0135*** (2.8288)	0.221	Before: 0.0160*** After: 0.0107	-0.0046 (-1.3361)	0.0131*** (3.386)	0.417
Pulp, Paper, Printing and Publishing	0.0094** (2.4271)	0.160	Before: 0.0143*** After : 0.043***	-0.0053 (-0.9327)	0.0074** (2.145)	0.254
Chemical, Rubber, Plastics and Fuel	0.0102 (1.2634)	0.125	No breaks	-0.0038 (-0.67)	0.0077 (1.069)	0.210
Other Non-Metallic Mineral	0.0338*** (4.7225)	0.449	No breaks	0.0148* (1.7573)	0.0309*** (4.64)	0.494
Basic Metals and Fabricated Metal	0.0239*** (3.7531)	0.326	Before: 0.0164*** After : 0.0320	0.0102** (2.0509)	0.0228*** (3.948)	0.346
Machinery, N.e.c.	0.0226*** (5.9098)	0.545	Before: 0.0219 After: 0.0236	0.0034 (0.8062)	0.0213*** (6.127)	0.611
Electrical and Optical Equipment	0.0077 (1.0912)	0.045	Before : 0.0146 After : 0.0030	-0.0134 (-1.3578)	0.0052 (0.78)	0.115
Transport Equipment	0.0267*** (3.9028)	0.470	No breaks	0.0093*** (2.4875)	0.0261*** (4.196)	0.535
Manufacturing N.e.c; Recycling	0.0168** (2.1993)	0.188	Before : 0.0126*** After: 0.0146	0.0029 (0.4456)	0.0158** (2.279)	0.233

Source: Author's calculations

Allowing for parameter heterogeneity for the CEE countries leads us to more reliable results, with R^2 significantly higher in all cases. At the level of whole manufacturing, catching-up took place only in Central and Eastern Europe, while in the group of old EU members strong divergent tendencies occurred. Similarly to previous analyses (Tables 3 and 4), in Western Europe there was convergence in only three industries (Non-Metallic Minerals, Metals, Transport Equipment). However, divergent trends in the remaining industries were slow and insignificant, which means that economic structure must have benefited more developed countries, so that β in total manufacturing exceeds -0.0200.

The positive β indicates that convergence took place in the region of Central and Eastern Europe. This process was common for all manufacturing industries, though its speed was diversified. In Non-Metallic Minerals, Machinery and Transport Equipment industries it was the fastest, while in Food, Textiles, Chemicals and Electronics – the slowest.

Table 7. Results of Estimation of β-convergence for Growth Rate Components, EU-22, 1995–2007

	Homogeneous model		With CEE-dummies		
Growth rate component	β (*t* distribution)	R^2	β^{NCEE} (*t* distribution)	β^{CEE} (*t* distribution)	R^2
Within	0.3247*** (3.010)	0.280	-0.2639** (2.216)	0.2743*** (2.737)	0.428
Static-shift	-0.0024 (0.433)	0.008	-0.0005 (0.052)	-0.0023 (-0.406)	0.008
Dynamic-shift	0.0015 (0.101)	0.000	-0.0013 (-0.619)	0.0002 (0.017)	0.008

Source: Author's calculations

Table 7 presents the relation between the initial productivity gap and growth components in 10-year rolling periods and confirms the conclusions from Tables 5 and 6. In the homogenous sample, β-convergence of the within component is confirmed. Introduction of CEE-dummies changes the picture: productivities were diverging in Western Europe and converging in the new EU members. In all cases, the two structural components of growth rate were in a very weak relation to initial productivity.

4.3. The Case of Ireland

To check for the robustness of our basic results, we rerun all the calculations on smaller samples, with Ireland excluded. Ireland was one of the best performing countries in the European Union: it managed not only to catch up to the European average, but also to jump ahead and become the leader in overall productivity. As was presented, in the period of analysis it benefited heavily from structural changes and from improved allocation of resources. However, those results might be to some extent a consequence of its tax and legal regulations, which allow the multinational corporations to register income without placing real production in this country[6]. As stated in the 2012 Industrial Performance Scoreboard (European Commission, 2012, p. 8): "Ireland's productivity level is to a significant extent inflated by the operations of foreign multinationals, in particular in the chemicals and pharmaceuticals sectors. The very high values are likely to be affected by R&D and marketing activities undertaken mainly outside Ireland, and by transfer pricing activities."

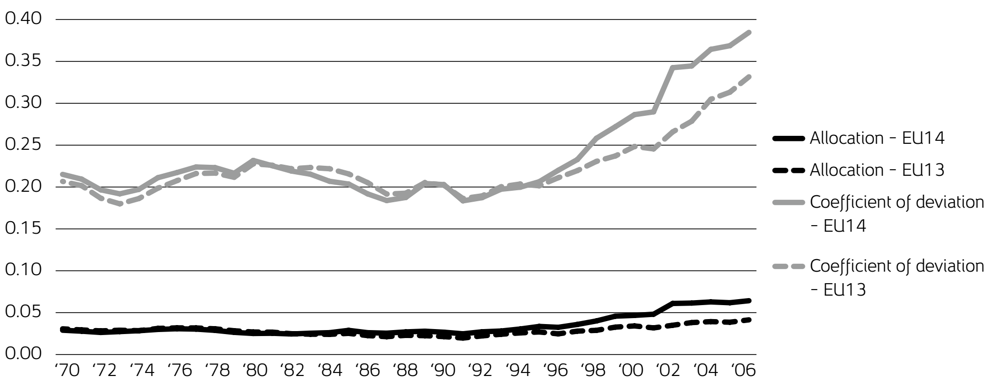
Our calculations support this view: since early 90s Ireland started to increase its productivity highly over the European average – in total manufacturing and in a few specific industries. Apart from the Chemical Industry in which Irish productivity, at least officially,

[6] In early 2000's Ireland used to be place by IMF on its Offshore Financial Centers list.

even exceeded 500% of the European average, its leadership was the most pronounced in Food, Beverages and Tobacco and in Pulp, Paper, Printing and Publishing industries. By the beginning of the 21st century, productivity in Irish manufacturing reached over 200% of the EU-14 average. To what extent this was a result of real industrial development is a question for another study – here we will simply present those results that differ significantly when Ireland is excluded from the sample.

Recalculations of both σ- and β-convergence decompositions show that the results differ most significantly for total manufacturing and for the three aforementioned industries. About a third of the growth of total inequalities since 1990 can be attributed to Ireland; the same situation exists in regard to its productivity-differential and allocative components. Nonetheless, the most important outcome of the research, namely the productivity divergence, is sustained. The comparison of the coefficient of mean absolute deviation and its allocation component for two samples is presented in Figure 5.

Figure 5. Comparison of Inequalities in EU-14 and EU-13 (without Ireland) – Coefficient of Mean Absolute Deviation and its Allocation Component



Source: Author's calculations

At the sectoral level, analyses of both σ- and β-convergence show that the exclusion of Ireland from the sample makes the productivity divergence after 1990 much less pronounced in three industries: Food, Beverages and Tobacco; Pulp, Paper, Printing and Publishing and the Chemical Industry. Nonetheless, most of the results and implications about productivity differences and their tendencies remain unchanged.

5. Conclusions

The article's most important result is that the conclusion by Bernard and Jones (1996a, 1996b) of no convergence in manufacturing also holds for the European Union. However, the view of productivity convergence we present is much more complex, with important heterogeneities in reference to time, industry and country and with many diversified patterns of growth. Therefore, we can conclude that catching-up is not automatic, but rather a highly conditional process with many country and industry-based characteristics at play.

Most of the productivity differences between the manufacturing sectors of EU countries are the result of dispersed development level within particular industries, and not the different internal compositions of the sector. This suggests that industry productivity is to a great extent determined by more general horizontal factors. Economic structure reinforces those differences, as catching up is usually accompanied by shifts from low-tech, traditional industries to modern ones. Such changes took place in those countries that became new productivity leaders – in Belgium, Finland and Ireland. Their high dynamics, accompanied by the stagnant growth in southern European countries, led to the formation of two clubs of countries, each of them achieving their comparative advantage. Greece and Portugal, but also Spain and Italy, did not manage to adopt beneficial structural change and traditional industries remain very strong there. This poses a large barrier for the development of the whole manufacturing sector, as low-tech industries are more vulnerable to international competition. CEE countries dynamically reduced their productivity gap; however, with little employment shifts across industries. It seems that clustering is taking place in this region as well, as differences between Czech Republic, Hungary, Slovenia ('high-tech' club) and Poland and the Baltics ('low-tech' club) are increasing.

Medium-tech industries were those in which convergence was significant and constant over time. Since the late 80s and early 90s, productivities in most low-tech and high-tech industries were diverging, except for in Central and Eastern Europe, and strongly influenced divergence at the aggregate level. Diverse mechanisms probably stand behind those observations, possibly related to the spread of a new technological paradigm (Perez, 1983) and faster adoption of ICT technologies in more developed countries.

Two important research directions emerge from the described picture. Firstly, what are the crucial differences between industries that allow for or block convergence? Possibly, referring to micro-level data and the processes of firm development will help us find answers for this question. Secondly, what mechanisms allowed Ireland and Finland to develop dynamically, with substantial and positive structural shifts, while Greece and Portugal lagged behind? Did entrepreneurs respond to given factor endowments and institutions or did perhaps some patterns of behaviour allow them to induce a structural shift and further socioeconomic adjustments? What was the role of public policies in the catching-up processes? Providing answers in this area seems crucial from the point of view of the long-term development of Central and Eastern European countries, because structural differences are starting to take shape within this group and this indicates possible differences in long-term growth paths across the region.

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Appendix

Table 1. Classification of Manufacturing Industries under Analysis

Industry	ISIC-code	Educational intensity (Peneder, 2007)	Technology level (Eurostat)
Food, Beverages and Tobacco	15-16	Low	Low
Textiles, Textile, Leather and Footwear	17-19	Very low	Low
Wood and of Wood and Cork	20	Very low	Low
Pulp, Paper, Printing and Publishing	21-22	Intermediate	Low
Chemical, Rubber, Plastics and Fuel	23-25	Med-low/Med-high	Mixed
Other Non-Metallic Mineral	26	Low	Medium-low
Basic Metals and Fabricated Metal	27-28	Low	Medium-low
Machinery, Nec	29	Intermediate	Medium-high
Electrical and Optical Equipment	30-33	Intermediate/high	Medium high/High
Transport Equipment	34-35	Intermediate/med-high	Mixed
Manufacturing Nec; Recycling	36-37	Med-low	Low

Note: N.e.c. stands for “Nowhere else classified”.
Source: Author’s preparation, on the basis of Peneder (2007) and Eurostat information.