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PRODUCTIVITY CONVERGENCE DURING THE EUROZONE GENESIS (1992-2007): EMPIRIC EVIDENCE OF AN EXPECTED PHENOMENA

*CONVERGENCIA EN PRODUCTIVIDAD DURANTE EL GÉNESIS DE LA EUROZONA (1992-2007): EVIDENCIA EMPÍRICA DE UN FENÓMENO ESPERADO*

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ABSTRACT

This paper examines the three most common notions of convergence – beta, sigma, and times series approaches – applied to the Eurozone since its Maastricht’s design in 1992 until the start of the crisis in 2008. Due to the limitations of the income per capita approach, this paper focuses in general and sectorial productivity per hour convergence. Evidence of convergence is not found at a general level, while the sectorial picture is mixed. Some branches of services suggests convergence but industrial branches points to strong divergence. Within the neoclassical framework, convergence is an expected phenomena, but empirical evidence shows variability in its success. In fact, there is not a general process of productivity convergence among original members of the Eurozone. Hence, some key conclusions are presented in order to develop a more accurate theoretical background.

*Keywords:* Eurozone; Convergence; Productive Asymmetries; Growth Theory.

## RESUMEN

Este trabajo analiza las tres nociones más comunes de convergencia – los enfoques beta, sigma y series temporales – aplicados a la Eurozona desde su diseño en 1992 durante el Tratado de Maastricht hasta el estallido de la crisis en 2008. Debido a las limitaciones de la perspectiva basada en la renta por habitante, este trabajo analiza la convergencia en productividad tanto a nivel general como sectorial. A nivel agregado la evidencia de convergencia es inexistente, mientras que el cuadro sectorial es heterogéneo. Ciertas ramas de los servicios apuntan hacia la convergencia mientras que las ramas industriales sugieren una fuerte divergencia. Desde la perspectiva neoclásica, la convergencia es un fenómeno esperado, sin embargo, la evidencia de la Eurozona es mucho más contradictoria. De hecho, no existe un proceso generalizado de convergencia en productividad entre los miembros de la Eurozona. De este modo, ciertos elementos clave serán propuestos para lograr desarrollar un marco teórico más ajustado a la evidencia presentada en este trabajo.

*Palabras clave:* Eurozona; Convergencia; Asimetrías productivas; Teoría del crecimiento.

*Clasificación JEL:* O11.



## 1. INTRODUCTION

Is there an inherent tendency that leads less economically developed countries to grow faster than richer ones and finally catch up with them? In fact, this question, which is placed at the core of growth and development theories, should be split into two. On one hand, we have a question about the relation between growth rates and the initial level of a variable, usually, income per person. On the other, we have a question about how absolute differences -in level- between regions or countries narrow becoming eventually zero. The differentiation among alternative varieties of convergence and their mathematical formalization was developed by Robert Barro and Xabier Sala-i-Martin in a series of well-known articles (1991, 1992). Consequently, two new concepts –beta and sigma convergence- were introduced and rapidly occupied a key role within the empirical growth research and deeply influenced the theoretical debates around economic growth.

Succinctly, *beta convergence implies a negative relation between the initial level of income per capita and its growth rate*. On the other hand, *sigma convergence is related to the evolution of the dispersion of income in levels within a group of regions or countries, where a reduction of the dispersion implies sigma convergence*. Theoretically, both beta and sigma convergence are an expected outcome of the neoclassical growth model proposed by Solow (1956) as Barro and Sala-i-Martin (1992) formally proved. In an open economy framework, the neoclassical growth model predicts that technological diffusion –which is a public good- and the diminishing returns of capital strengthen convergence among regions and countries through market forces.

Consequently, economic integration processes among industrialised countries like the European Union are supposed to be accurate areas to look for absolute convergence evidence, especially the core of this process, which has configured a real monetary union: the Eurozone. Within the Euro Area, a reinforced economic convergence was explicitly expected as outcome of the European Union project since its origin in the Maastricht Treaty, as is explicitly demonstrated through the agreement. During the configuration of this monetary area, European institutions trusted in the power of an integrated market and a common currency area as driving forces of convergence. The theoretical basis underlying their policies was, hence, the Neoclassical General Equilibrium approach. Thus, the monetary union designed in Maastricht and the convergence studies which appeared a few years before shared a common theoretical background, a new –hegemonic– “Consensus” broadly known as neoliberalism.

Nevertheless, the hegemonic perspective is never the only interesting voice, although sometimes it is the only one heard. Other traditions, ranging from Keynesian to Marxian authors, but also other neoclassical studies which do not expect convergence as a natural result feed by market forces – grouped under the so-called “New Growth theory”, suggested the possibility of asymmetric growth paths. Of course, these divergent scenarios are especially interesting retrospectively, once is almost generally accepted that the Eurozone built in Maastricht was imperfect and its success under question (Priewe, 2012).

Thereby, through the next section we will analyse in deep the theoretical genesis and development of convergence studies. Especial interest is placed on its original neoclassical formulation and the more recent supply side theories known as New –or Endogenous- Growth Theory. Additionally, we will succinctly describe the post-Keynesian tradition based on Kaldor ideas as a potential interesting input on order to develop a better understanding of vicious and virtuous growth circles and their relation to convergence. Section three will focus on demonstrating the inconsistency of Maastricht’s design and its underlying theoretical assumptions. Afterwards, the remaining sections of this work are organised as follows: Section four will define our statistical methodology including a core reference on how productivity predates income per head as the optimal research variable. Section five will present our main empirical results and findings. Finally, section six concludes and discusses several policy implications.

## 2. CONVERGENCE: ORIGIN, DEFINITION AND CONTROVERSY

Convergence is a well-known notion in Economics, at least in its broadest sense: *a reduction of differences between units –generally countries or regions- for a certain variable –generally income or productivity- along a defined period of time*. However, during the period covering from the forties until the mid-eighties, convergence was a topic almost forgotten by mainstream economic research agenda. At least as a natural result of market forces rather than rational public policies. The modern approach to convergence was empirically inaugurated by Baumol (1986) and only a few years later was formalised by Barro and Sala-i-Martin (1991, 1992). Through this movement, convergence acquired an explicit link to the neoclassical growth model developed, among others, by Robert Solow (1956). Along it, convergence was formally defined as a statistically measurable phenomena. Two core notions emerged from the works of Barro and Sala-i-Martin, *beta* and *sigma* convergence. Both perspectives share three key features: They imply a specific definition of convergence, an associated test methodology and are directly predicted by the neoclassical growth model (Barro, Sala-i-Martin, 1992). Beyond this similarities, Beta and Sigma convergence imply completely different definitions and properties. Beta convergence, relates initial income levels to actual growth rates. Regressing the mean growth rate for a defined period onto the initial level, a negative relation



between this initial level and the growth rate is expected. This phenomena is called beta convergence, and could be formalised as follows:

$$\Delta \ln \bar{y}_i = \alpha + \beta \ln y_{i0} + \sum_{p=1}^p \delta_p X_i + \varepsilon_i \quad (1)$$

Where:

$$\Delta \ln \bar{y}_i = (1/T) \ln \left( \frac{y_{iT}}{y_{i0}} \right) \quad (2)$$

For a group of  $n$  countries, the first component represents a logarithmic approximation of the average growth rate of income per capita between  $t=0$  and  $t=T$  for a country  $i$ . Then, we regress this value on the logarithm of the level of income per capita in the initial period for each  $i$  country. If  $\beta < 0$  there is statistical convergence. Furthermore, represents a vector row of variables controlling structural differences between countries beyond  $\ln y_{i0}$ , a condition expected for heterogeneous samples. Then, if we define  $\sum_{p=1}^p x_i \delta_p = 0$  and  $\beta < 0$  holds, the convergence can be defined as absolute convergence. On the other hand, if  $\beta < 0$  only holds once we have introduced some control variables, we consider this process as conditional convergence. On the other hand, sigma convergence implies the reduction of the dispersion in level of income within a group of countries along time. In other words, the differences in levels are becoming narrower, usually measured through the standard deviation. Following the standard formulation, we can define sigma convergence as follows:

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^n (\ln y_i - \ln \bar{y})^2}{n}} \quad (3)$$

At last, the growth of a time series perspective on convergence is related to a growing emphasis in overcoming the limitations associated to a cross-sectional beta convergence perspective (Quah, 1993). Taking advantage of the properties of unit root analysis, this definition was born in Quah's (1990) and Bernard & Durlauf's (1991). From this dynamic perspective, there is convergence if the differences between a country and a reference –country or defined mean- are only transitory. Following the easiest way of specification:

$$\Delta z_{it} = \alpha_i + \delta z_{i,t-1} + \varepsilon_i \quad (4)$$

Where:

$$z_{it} = (\ln \bar{y}_t - \ln y_{it}) \quad (5)$$

$$\delta = (\beta - 1) \quad (6)$$

Therefore, if  $\beta < 1$ , we can reject the null hypothesis of a unitary-root, and support the convergence hypothesis. If we consider the process as stationary with zero mean –i.e.  $\alpha_i = 0$ – the process will be absolute, otherwise, if a drift is included, convergence will be only conditional. This approach seems really attractive but, like the formers, is not free of shortcomings due to its sensibility. Moreover, beyond the differences in definition and application, these three main approaches to convergence share a core element: all of them are implied by the neoclassical Solow’s model. However, other important theoretical traditions do not predict convergence as the natural result of market forces. Within the family of supply side neoclassical models and parallel to the first developments of convergence theory, an important challenge to Solow’s growth model appeared. The so-called New Growth theory, originally proposed by Romer (1986) and Lucas (1988), suggested a family of models characterized by an endogenization of technological change. Its simplest version, the so-called AK model (Romer, 1986) proposed a broader concept of capital including human labour. As a result, constant and not diminishing returns to scale are expected for this new conception of capital. One core implication of this change is that convergence is not necessarily the only possible outcome and differences between countries and regions might be persistent.

However, the dissimilarities between “New” and “Classical” growth theories could be constrained to how they do consider capital and technology (Fine, 2000). Their common structure, that is, a supply side closed-economy perspective grounded in Walrasian micro-foundations is basically preserved. On the contrary, a completely different perspective on convergence was developed by post-Keynesian authors, inheritors of a tradition that considers growth process circular and cumulative. Following Kaldor’s considerations on growth and development (Kaldor, 1970) a family of models were developed considering growth both export-led and determined by Verdoorn’s law (Thirlwall, 2014). The latter constitutes a stylized fact which establishes a positive causal relation between output growth in manufactures and productivity growth, implying the existence of dynamic increasing returns. Thus, the so-called Kaldorian Endogenous Growth perspective predates its neoclassical counterpart (Setterfield, 2013). These models present, additionally, two main advantages in front of hegemonic supply side proposals: (1) they take into account differences between sectors, (2) they adopt an explicit open-economy framework. Among these different theories, our analytical position is going to be neutral, neither expecting convergence nor divergence. However, as we will discover through the next section, the same cannot be said about the European institutions, which, although no explicitly, deeply embraced the neoclassical growth model predictions and assumptions.



### 3. CONVERGENCE AS THE EUROZONE'S TARGET: DESIGN, GOALS AND EVIDENCE

For our purpose, convergence goes far beyond its formal economic definition. In fact, convergence among its members was the explicit goal of the European Union established in late 1992 by the Maastricht Treaty. The agreement established sustainable economic growth and convergence as the final goals of the Union. These goals were considered to be achieved through a process of economic integration which includes (1) a common market and (2) a monetary union coordinated through (3) a set of common policies. Thus, the 2<sup>nd</sup> article of the Treaty of Rome was redefined in the following way:

“The Community shall have as its task, by establishing a common market and an economic and monetary union (...) to promote throughout the Community a harmonious and balanced development (...) sustainable and non-inflationary growth respecting the environment, a high degree of convergence (...) and social cohesion and solidarity among Member States.” (*Maastricht Treaty, 1992: 11-12, emphasis added*)

Maastricht was the nuclear point of the European integration process. It both inaugurated the common market and established the basis for a monetary union which culminated in the adoption of the euro in 2002. Together, they constitute the core of the so-called *Economic Union*. However, what constitutes an economic union and how it could promote growth and convergence is a debated question rooted on the theory that we choose to base our economic assumptions. In this sense, the Maastricht Treaty is certainly problematic, because it does not make any explicit theoretical linkage for its proposals. Nevertheless, theoretical voids do not exist. If we want to identify Maastricht theoretical background we have to highlight how the designed instruments -a common market and a monetary union- relate through certain tools –economic and monetary policies – to the explicit goal of growth and convergence. These links can be clearly identified, for instance, in the 3<sup>rd</sup> article of the Treaty:

“1. For the purposes set out in Article 2, the activities of the Member States and the Community shall include (...) the adoption of an economic policy which is based (...) and conducted in accordance with the principle of an open market economy with free competition (...) and the Community shall entail compliance with the following guiding principles: stable prices, sound public finances and monetary conditions and a sustainable balance of payments.” (*Maastricht Treaty, 1992: 6-7*)

These guidelines have an obvious pro-market bias that also determined the final configuration of the European Central Bank and the conceptualization of a common monetary policy. On the other hand, the monetarist profile of the Monetary Union built over the institutions designed through Maastricht can be explicitly found in the 5<sup>th</sup> section of the Treaty:

“The primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability. (...)The ESCB shall act in accordance with the principle of an open market economy with free competition, favouring an efficient allocation of resources, and in compliance with the principles set out in Article 3a.” (*Maastricht Treaty, 1992: 29-30*)

The consideration of both economic and monetary policy in “Washington Consensus” fashion implied radical consequences over two other remaining policy dimensions: fiscal integration and industrial policies. The first one because is completely absent; the second, because is explicitly forbidden through a specific article -144- which constrains the role of industrial policies:

“(...) in accordance with a system of open and competitive markets, their action shall be aimed at: speeding up the adjustment of industry to structural changes; (...) This Title shall not provide a basis for the introduction by the Community of any measure which could lead to a distortion of competition.” (*Maastricht Treaty, 1992: 52-53*)

It is straightforward to highlight how Maastricht Treaty considers that an Economic Union which leads to convergence is the sum of a common market and a monetary union sustained by generalized pro-market policies along forbidden industrial policies or a non-independent central bank. In sum, the Treaty follows a theory where (1) an open market with (2) free competition along (3) sound finances and (4) stable prices guaranteed by a central bank will lead, if markets are not distorted, to an efficient allocation of resources, where (5) industrial policy is inefficient and fiscal integration is omitted. The resultant (6) structural adjustment and its potential costs will be absorbed by (7) structural and cohesion funds focusing on mean income per head deviations.

The logical chain that relates the seven highlighted elements to boosted growth and convergence as outcome can only be rooted in a neoclassical framework, where convergence is a natural outcome. A non-surprising event during a period characterised by a neoliberal unanimity in almost every country or international institution. However, stable prices and open markets do not directly imply perfect competence and an efficient allocation of resources by markets. Within the real world and outside herculean assumptions the problem is not to avoid market distortion but that markets are already distorted. Transport costs, internal and external economies to scale or monopoly rents can lead to a scenario characterised by increasing returns, imperfect markets and absence of economic convergence. These cautions were predicted by a wide range of perspectives before Maastricht Agreement was signed, but were usually ignored by European institutions. Nonetheless, if we do not suppose the perfect and efficient functioning of markets and free capital flows, then, fiscal integration and industrial intervention are not avoidable –as in Maastricht- but mandatory –as in the US. An Economic





Union among asymmetric States that does not consider fiscal integration will be unstable and risky. This point was highlighted even by mainstream non suspicious economists as Milton Freeman (1992). On the other hand industrial policy is not exactly absent as is explicitly forbidden and its role is replaced by the so-called Structural and Cohesion Funds. These funds were conceived to absorb the costs associated to the weakest areas economic opening process. However, as long as industrial policy is forbidden and they usually do not look beyond income per head as target, their optimality is in question outside an environment characterised by efficient markets and perfect competence.

Focusing on previously reported evidence of economic convergence among the members of the Eurozone, the results are mixed as they deeply vary depending on where we place our analytical focus. Recent Studies considering the whole UE usually include in their samples eastern enlargement countries, which introduces an important bias towards convergence. Consequently, they tend to find evidence of convergence especially using the dominant cross section perspective either focusing on income (Le Gallo and Dall'Erba, 2006; Alexiadis 2013) or productivity per worker (Gugler and Pfaffmayer, 2004; Villaverde and Maza, 2008). On the other hand, the limited evidence following a time series perspective is more contradictory and does not draw a convergent picture (Tsionas, 2000; Sondermann, 2012). Finally, those analysis looking for productivity per hour convergence in the Eurozone –our own perspective- are really scarce. For a similar period of analysis and variable no study has explicitly focused on a sigma-beta perspective whereas, as previewed above, time series evidence consistently suggests a divergent scenario (Sondermann, 2012). As far as we know, the work of Sondermann (2012) and a special issue developed by the European Commission (Balta, 2013) are the only analysis focusing on productivity per hour convergence among the members of the Eurozone.

There are two main factors which explains this contradictory evidence. First, completely different methodologies are applied to analyse the presence of economic convergence. As we have seen in the previous section, traditional and time series approaches could lead to almost opposite results, where the former tends to exaggerate a convergent picture. However, the second and most important factor explaining this heterogeneity is the selected variable of analysis. A majority of the literature focuses on income per head while the other main choice has been productivity per worker/hour. Within the neoclassical framework this selection is superfluous as a direct and constant relation between employment and population is expected (Barro, Sala-i-Martin, 1991). However, this assumption is especially problematic and unrealistic for the Eurozone. The next section will cover this topic in deep while afterwards our own proposed methodology will be presented.

#### 4. METHODOLOGY: VARIABLE, SAMPLE AND TEST

##### 4.1 THE VARIABLE

The question about which analytical variable do we choose is not a minor one as the neoclassical theory seems to suggest. On the contrary, if we abandon the clearing-markets assumption,<sup>1</sup> a direct proportionality between productivity and IPH is no longer expected. Furthermore, the relation among productivity and IPH although straightforward is nuclear to growth theory. Considering output as  $Y$ , let us define IPH as the ratio  $Y/N$ , where  $N$  denotes total population. Additionally, let define productivity as  $Y/L$ , where  $L$  denotes the number of workers –or worked hours-. Then, we can directly relate both notions as follows:

$$IPH = \frac{Y}{L} \cdot \frac{L}{N} \quad (7)$$

Taking logarithms and differencing respect time (7) becomes:

$$\Delta \ln IPH = \Delta \ln \left( \frac{Y}{L} \right) + \Delta \ln \left( \frac{L}{N} \right) \quad (8)$$

Hence, there is a direct and positive relation between IPH changes and productivity improvements. But also, there is a positive relation among IPH and the percentage of active population-  $L/N$ . The only –realistic- assumption is to consider the economy outside full employment equilibrium. Then, extensive growth of output per capita based on increasing employment on low productivity sectors is compatible with stagnant or decreasing productivity. The only requisite is that  $|\Delta \ln(\frac{Y}{L})| < \Delta \ln(\frac{L}{N})$  if productivity growth is negative. In fact, this relation, as we will demonstrate, can explain the late evolution of IPH observed in graph 1 and fits perfectly with the situation observed in European southern countries. This reasoning must be also applied to analysis which focus in productivity per worker instead of productivity per hour as optimal choice. Productivity per worker can be explained either by real productivity improvements or increasing the intensity of work. As the second is not a real improvement, then the election must be productivity per hour. Furthermore, as Alexiadis (2013) shows, there is a strong negative relation between the mean number of worked hours by employee, and the country productivity level.

##### 4.2 THE TEST

In order to explore evidence on convergence we are going use three different types of test –beta, sigma and time series, applied over a sample, the original 12-Eurozone, which is expected to be a convergent area. As we know,

<sup>1</sup> Namely, allow for unemployment or capacity underutilisation.



absolute convergence tests are suggested for more homogenous samples like the OECD; that is, a framework where the Eurozone fits perfectly. Our first approach will be sigma convergence, defined as the evolution of the standard deviation of productivity for the members of the Eurozone:

$$\sigma_{j,t} = \sqrt{\frac{\sum_{i=1}^n (\ln y_i - \ln \bar{y})^2}{n}} \quad (9) \text{ From } t=1992 \text{ until}$$

2007, for each j sector. Thus, if  $\sigma_{j,t}$  decreases, it implies sigma convergence for this sector. In other words, if  $\sigma_{j,1992} > \sigma_{j,2007}$ , the process can be characterized as sectorial or general sigma convergent. Hence, the differences in productivity levels are decreasing along time. Our second test will follow beta convergence definition. Simplifying (1) for an absolute convergence test we have:

$$\Delta \ln \bar{y}_{j,i} = \alpha + \beta_j \ln y_{j,i,0} + \varepsilon_i \quad (10) \text{ For each } j \text{ sector.}$$

Consequently,  $\beta_j < 0$  implies absolute convergence for sector j. This coefficient describes a negative relation between initial levels and growth rates. Relatively poorer countries will grow faster than richer ones. Finally, we compute a final test derived from a time series approach. There are not clear precedents of our test. Our proposal is to integrate the notion of sigma convergence in a time series framework. Therefore, integrating (2) into (5) the resultant equation is:

$$\Delta \sigma_{jt} = \alpha_j + \delta_j \sigma_{j,t-1} + \varepsilon_i \quad (11) \text{ From } t=1992 \text{ until}$$

2007, for each j sector. If  $\delta < 0$ , then, we can reject the null hypothesis of a unit root in sector j and hence, describe the process as convergent from a time series viewpoint. Allowing to  $\alpha_j \neq 0$ , if we reject the existence of a unit root, makes the process compatible with conditional convergence. This approach has three main advantages. First, it allows us to combine the gains of a joint analysis without the problems associated to panelling individual time series. Second, derived from the neoclassical assumptions, a null value of  $\sigma$  is expected if we make the period arbitrarily long, suiting perfectly to time series properties. Lastly, the economic implications of this specification are much clearer than using other Dickey-Fuller expansions, where the link to a theoretical definition of economic convergence is not clear.

#### 4.3 SAMPLE AND DATA ORIGIN

Finally, our sample is constituted by the twelve original members of the Eurozone – Austria, France, Germany, Luxembourg, Netherlands, Belgium, Italy, Spain, Portugal, Ireland, Finland and Greece- who adopted the euro on 1<sup>st</sup> January 2002. The period to analyse covers from 1992 to 2007, both inclusive. Then, since the start of the monetary integration process until the start of the 2008 recession. Our analysis will cover the whole economy plus its nine

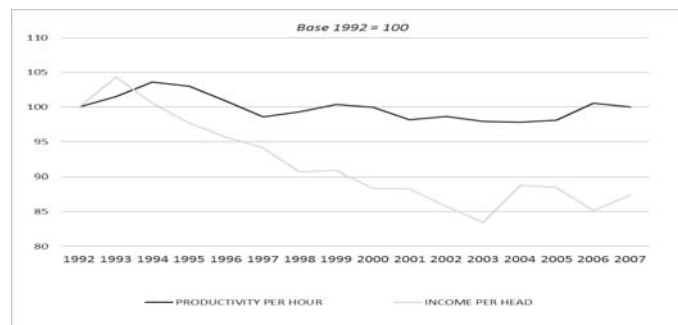
most important economic branches using data obtained exclusively from the EUKLEMS Project database. As stated at the beginning of this section, real productivity per hour will be our main analytical variable and is defined as the ratio between net output and total worked hours deflated by a price index.

## 5. EVIDENCE

### 5.1 SIGMA

Starting from an aggregated picture, if we expect a reinforced convergent process derived from the monetary integration, the results are quite disappointing. Graph 1 shows this situation comparing income and productivity paths valued in index numbers base 1992. A first look shows that productivity differences have not narrowed during the analysed period. On the contrary, the value in 2007 is slightly higher than in 1992, almost flat. Correspondingly, the picture shows how income convergence was not based on productivity improvements, rather on the contrary –as this work has previously suggested– income and productivity have evolved independently, pointing to a structural deadlock. However, this general view is, for sure, superficial. In order to overcome that problem, we are going to discompose total economy in its nine main branches: two from primary sector, three from the industrial sector and the six main branches of services.<sup>2</sup>

GRAPH 1 PRODUCTIVITY VS INCOME SIGMA CONVERGENCE -INDEX NUMBERS-



Source: euklems.

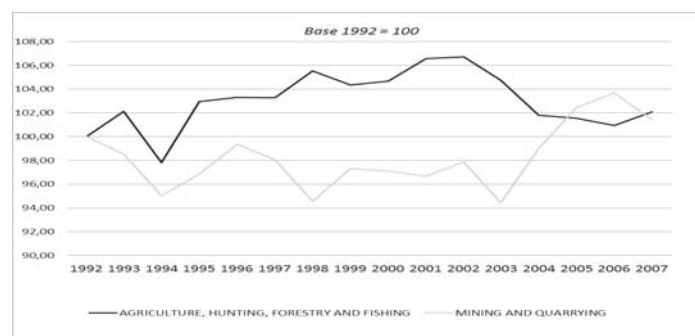
Graph 2 displays the behaviour of primary activities. In general, although suggesting certain differences during their evolution, both branches support a

<sup>2</sup> These branches are primary activities, manufactures, energy, construction, wholesale and retail trade, financial activities, transport, real estate, telecommunications and social services and other non-market activities. All of them adopted from an ISIC4 two-digit classification.



divergent path. Agriculture's standard deviation showed an increase during the first years followed by a reduction after 2004. Nevertheless, the resultant sigma value is bigger than the original, and thus, leads this sector to divergence. Mining activities, on the contrary, narrowed their productivity differences during the first years, but before 2003, the differences grew leading another time, to a divergent result for the whole period. However, the importance of primary activities within the Eurozone is, at least, limited.

GRAPH 2: PRIMARY ACTIVITIES SIGMA CONVERGENCE -INDEX NUMBERS-



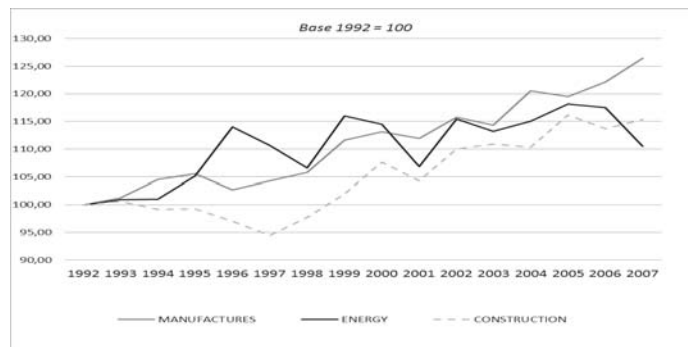
Source: euklems.

In contrast, the importance of industrial branches is central although their relative weight has diminished during the last thirty years. Not only due to their relative size, but also because industrial activities, especially manufactures, are the core of productivity improvements. Once we have decomposed the industrial sector into its branches, the general picture of manufactures is displayed in graph 3, which is incredibly consistent with a divergent scenario. Differences grew in a sustained way during the whole period. This behaviour is compatible to theories focusing on increasing returns and path dependant development, or also, to New Economic Geography analysis. Focusing on the other two main industrial branches, the performance is similar, but less exaggerated. Both energy and construction manifested a sustained divergent path while in energy sector, a minor decrease happened during the last three years; however, without compensating the tendency of the whole period.

In order to complete sigma convergence analysis, we are going to focus on the main branches of services covered by graph 4. Due to the general divergence perceived in primary and secondary sectors, some evidence of convergence is expected in order to justify the almost flat behaviour of sigma reported at a general level. However, the picture of services is only mixed. Some branches like transport, financial activities and real estate exhibit a strong convergent path. This result is not surprising. As a consequence of the free movement of factors and abolished trade barriers, a reduction in transport

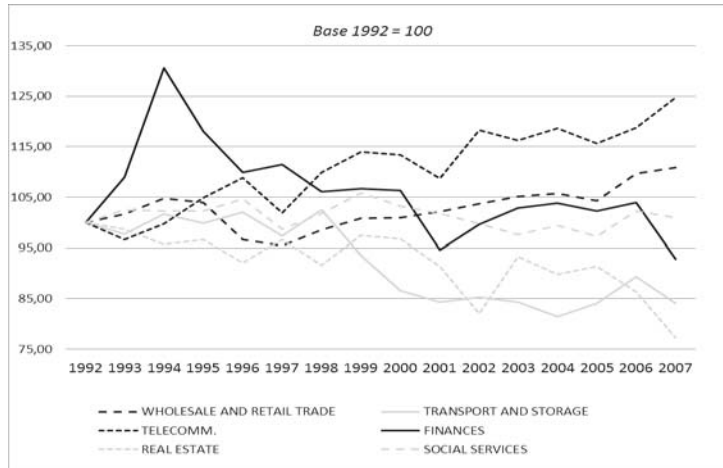
costs is expected. Additionally, the monetary integration process strengthened financial convergence. The explanation for real estate activities is much more difficult. Actually, this process is related to the incredible housing assets bubbles observed in some southern countries, like Spain and Greece. The explanation of this phenomena requires a much more detailed analysis focusing on capital misallocation (Balta, 2013).

GRAPH 3: INDUSTRIAL BRANCHES SIGMA CONVERGENCE -INDEX NUMBERS-



Source: euklems.

GRAPH 4: SERVICES BRANCHES SIGMA CONVERGENCE -INDEX NUMBERS-



Source: euklems.



The remaining 3 sectors show less clear evidence of convergence. Non-market services show weak convergence within an almost plain behaviour. Wholesale and retail trade points to weak divergence. Finally, telecommunications suggest a strong evidence of sigma divergence. Due to the centrality of this sector in the so-called “new economy”, these results, in addition to the observed industrial behaviour, are quite disappointing. The most productive sectors as telecommunications and manufactures display a strong divergent path. The observed process is highly compatible to Bernard and Jones' (1996), Le Gallo and Dall'erba' (2005) and Sondermann's (2012) previous findings: while some branches within services show evidence of convergence; the general picture for the industry is divergent. From a theoretical perspective, this kind of evolution looks quite harmonious to the Kaldorian approximation which focuses on the centrality of manufactures through Verdoorn's law. Nevertheless, in order to have a complete analysis, we need to focus on the two remaining perspectives.

## 5.2 BETA

First of all, we have to bear in mind certain particularities of a beta convergence approach. Due to the less restrictive conditions of beta convergence,<sup>3</sup> we can expect stronger evidence of this kind of convergence compared to sigma evidence. However, this approach has a clear advantage. Because of the properties of cross-sectional linear regression, we are able to graph the individual situation of each country within a scatter-plot. If we also transform the data to index numbers,<sup>4</sup> we can divide the graph in 4 quadrants,<sup>5</sup> defining each individual situation. We consider this extension more intuitive than only offering the results of the regression and has been reported for some core branches. Also, Table 1 shows the main parameters and statistics resulted from our estimations for each considered economic sector.

Starting from descriptive scatter-plots, we can observe weak – statistically non-significant– absolute beta convergence evidence for total economy, a phenomena also shown in graph 5. The two main advantages of graphing the data clearly appear. First, we can identify groups of countries, for example, the circled group of southern countries. Second, showing that this result, although compatible to sigma evidence of weak divergence, advises us about the risk of regression fallacy mentioned above. The extreme improvement of relatively low-productivity countries like Ireland could lead to a negative beta coefficient biasing resultant estimations. Also, if we compare these results to

<sup>3</sup> Sigma convergence implies beta convergence but not on the contrary as the former looks for convergence in levels and the latter in growth rates.

<sup>4</sup> When is possible. We cannot develop index numbers from series containing both positive and negative numbers.

<sup>5</sup> Each quadrant implies one of four possible situations: q1 and q3 supports convergence. Poor countries grow faster and rich slower, respectively. On the contrary, q2 and q4 reflects richer countries growing faster, and poorer growing slower. Therefore, q2, and q4 points to divergence.

data plotted in graph 6 focusing on income, beta convergence is, as expected, comparatively stronger. This last graph points to an impressive improvement of all southern countries but Italy in terms of income per head. More formally, looking to reported equations, the picture is heterogeneous. Starting from total economy, we find almost null values in the equation associated to graph 5 along a non-significant parameter which p-value is above 0,6, rejecting the presence of statistically significant aggregate convergence.

TABLE 1: BETA CONVERGENCE ANALYSIS RESULTS

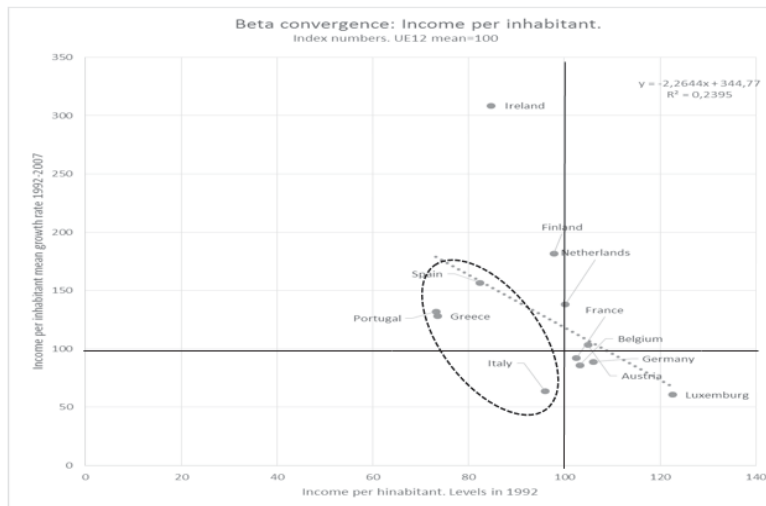
Sector/Period	Estimated equation	T-stat	Prob	R-squared
Total Economy	$y = -0.567x + 166.05$	-0.437	0.671	0.01
Primary activities	$y = -0.00002x + 0.039$	-0.777	0.454	0.05
Manufactures	$y = 1.108x + 12.957$	0.974	0.352	0.09
Energy	$y = -0.157x + 115.43$	-0.134	0.895	0.00
Construction	$y = 0.0002x + 0.0152$	0.848	0.416	0.06
Telecommunications	$y = 0.034x + 103.641$	0.039	0.969	0.00
Wholesale and Retail Trade	$y = 0.631x + 60.289$	0.444	0.666	0.02
Transport	$y = -1.766x + 275.810$	-2.062**	0.060	0.30
Real Estate	$y = -0.001x + 0.111$	-2.705**	0.022	0.42
Financies	$y = 3.669x + 490.013$	1.714	0.117	0.23
Social Services	$y = -0.00 + 0.002$	-0.039	0.969	0.00

Notes:

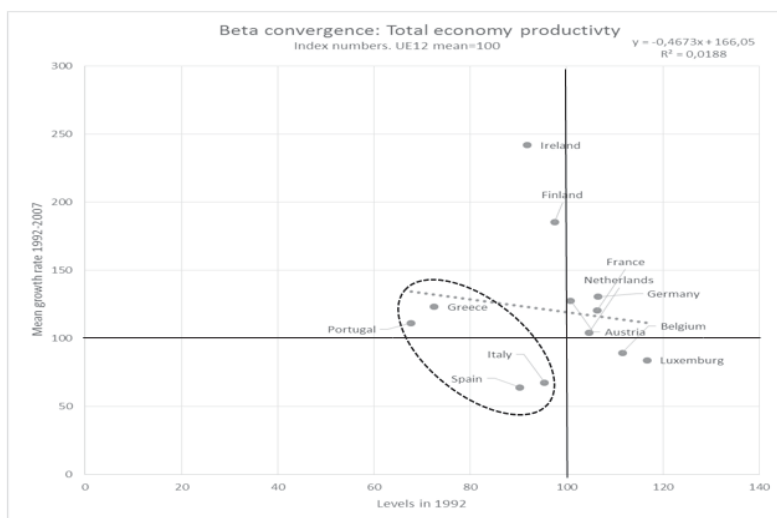
\*, \*\*, \*\*\*, imply a rejecting the null hypothesis at the 10%, 5% and 1% levels of statistical signification

Source: EUKLEMS

GRAPH 5, 6: PRODUCTIVITY AND INCOME BETA CONVERGENCE







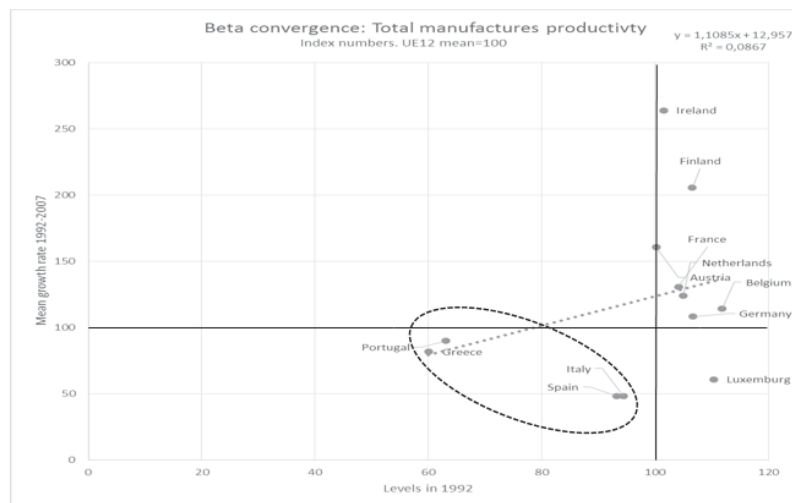
Source: euklems, ameco and own elaboration.

Turning to sectorial analysis, the situation, as in sigma convergence analysis, presents numerous sharps. Within industry, there is weak beta convergence in the energy sector. On the contrary, construction and manufactures point to divergence. The manufacturer sector, shows really strong evidence of absolute beta divergence as it associated scatter-plot draws in graph 8. If we focus on the individual situation of each country within manufactures, paradoxically, all southern countries are placed in the worst quadrant (q4), which implies that starting from a worse position implies lower future productivity improvements. Again, this evidence is highly compatible to cumulative causation, increasing returns and path dependant development. On the other hand, primary activities show a picture characterised by weak statistically non-significant convergence.

Focusing on services, all sectors except telecommunications and wholesale & retail trade exhibit absolute beta convergence. The process is weaker in non-market services where the regression line is almost plain. Once again, transport, real estate and finances show strong evidence of convergence with high R-squared values and significant coefficients for transport and real estate. Focusing on the financial sector, we have the expected outcome for a neoclassical perspective. Strong financial convergence as the expected result of a monetary integration process based on free capital mobility. The same argument can be extended to the transport sector based on productive factors mobility. However, in hand to the divergent evidence suggested by other sectors, it could be responsible of important imbalances, namely: capital misallocation to highly

profitable sectors but characterised by low productivity improvements. Generally, non-tradable sectors like real estate are highly sensitive to financial bubbles. In sum, reported results are consistent and complementary to previous sigma convergence evidence, finding significant convergence only in transport, finances and real estate.

GRAPH 7: MANUFACTURES BETA CONVERGENCE



Source: euklems and own elaboration.

### 5.3 TIME SERIES

Finally, we are going to focus on the data from a dynamic perspective. Recalling our proposed definition and methodology for a time series analysis, table 2 shows the resulting estimations after applying a Dickey-Fuller scheme. We have chosen 2 different periods, one of them starting in 1970 in order to improve the power of the test, originally conceived for long series. The other one covers our standard period 1992 -2007. Furthermore, we have included a conditional convergence test due to the really restrictive implications of absolute convergence through this perspective. Beginning with a long-term perspective 1970-2007, we found some evidence of absolute convergence on non-market services and finances, more significant in the former. If we allow for conditional convergence, we found also evidence on transport and real estate sectors. These results are consistent to both previous literature (Sondermann, 2012) and our findings through beta and sigma convergence approaches. No evidence is found at a general level or in primary or secondary sectors. Hence, convergence seems to be concentrated in some branches of services.



TABLE 2: TIME SERIES ANALYSIS RESULTS

Sector/Period	1971-2007				1992-2007			
	Absolute		Conditional		Absolute		Conditional	
	t stat	prob	t stat	prob	t-stat	prob	t-stat	prob
Total Economy	-1.95	0.305	-0.227	0.597	-0.145	0.617	-1.668	0.427
Agriculture	-2.27	0.185	-0.16	0.621	0.544	0.822	-2.894*	0.068
Minery and quarrying	-1.61	0.46	0.11	0.714	-0.143	0.618	-2.206	0.211
Manufactures	0.992	0.995	2.14	0.991	2844	0.997	-0.5481	0.856
Energy	-1.9	0.325	-0.75	0.381	0.134	0.771	-1.915	0.317
Construction	-1.4	0.568	-0.007	0.673	0.7655	0.889	-0.329	0.901
Telecommunications	-2.15	0.224	-0.602	0.449	1205	0.933	-0.686	0.823
Wholesale and retail trade	-1.75	0.398	0.83	0.888	11126	0.924	-0.727	0.812
Transport	-1.53	0.507	-2.000**	0.044	-1167	0.211	-1.45	0.682
Real estate	0.205	0.96	-1.64*	0.094	-1109	0.23	-1.187	0.652
Financies	-3.11**	0.033	-2.103**	0.035	-9262	0.575	-1.909	0.32
Social services	-5.699***	0.001	-1.901*	0.055	-0.062	0.646	-2.846*	0.07

Notes

Dickey-Fuller test

Null hypothesis: The serie has a unit root.

\*, \*\*, \*\*\*, imply rejecting the null hypothesis at the 10%, 5% and 1% of significance respectively.

Source: EUIKLEMS

Focusing in our core period 1992-2007, obtained evidence is less clear. Only primary activities point to weak evidence of conditional convergence. The remaining sectors cannot reject the null hypothesis of a unit root both from a conditional or an absolute perspective. These results do not deny our findings looking at beta or sigma analysis. On the contrary, they are related to the strong definition of convergence derived from a time series perspective. Moreover, due to the limitations of small samples in time series analysis, these results may be biased. Then, a longer perspective is preferable. Using longer series, as we have seen, the evidence is strongly consistent to the observed sigma and beta results. Briefly, some branches of services suggest evidence of convergence while industrial branches and telecommunications point to strong divergence. As a consequence, Eurozone's general picture aims to soft general divergence, an unexpected result of the integration process following the conventional neoclassical approach.

## 6. CONCLUSIONS AND POLICY IMPLICATIONS

A common conclusion can be traced from the three approaches implemented in this work. There is not a general process of productivity convergence among Eurozone original members during the period 1992-2007. Only following a beta convergence definition, the weakest, we found some evidence of general convergence but statistically non-significant. Time-series and sigma perspectives point undoubtedly to absence of convergence at a general level. Decomposing into branches, another clear fact appears. While some branches of services aim to convergence, industry suggest strong divergence

following any perspective. Transport, financial activities and real estate point to the strongest evidence of convergence. On the contrary, manufactures within industrial branches, and telecommunications in services, lead the strongest divergence. These findings are in line to previous studies and highlight an important issue: convergence occurs within branches involved in low productivity improvements. On the other hand, divergence imposes its path on highly productive sectors where increasing returns tend to appear, namely, manufactures and “New Economy” sectors like telecommunications. Consequently, this work does not provide support for the neoclassical growth model from an empirical perspective.

The Eurozone was supposed to be more homogeneous than OECD samples, but paradoxically, we do not find general evidence of economic convergence. These results, although contradictory, are still compatible to different alternative theoretical frameworks, especially if considered in relation to trade imbalances and specialization patterns. However, further research is necessary in order to explicitly link our results to any theory, analysing sectorial shares evolution and output structure, income elasticities of demand or the presence of increasing returns. Furthermore, once we have discovered the deadlocks characterising the scheme built in Maastricht and that more openness per se does not lead to economic convergence, other kind of proposals should be considered by European policy-makers. New policies which take into account that convergence is the product of policies rather than automatic forces. Hence, different instruments as a coordinated industrial policy, a deeper integration in terms of labour market or fiscal and wage policies should be consider in order to strengthen productive cohesion. Otherwise, monetary integration would lead to asymmetric outcomes; boosting unsustainable processes of income convergence without underlying productivity convergence as the one experienced by Eurozone’s members. These situations, unstable in nature, cannot perpetuate ad infinitum as the crisis exploded in 2008 demonstrated. Thus, considering the centrality of the topic, this study only opens a window for further research on Eurozone’s productive dynamic and its relation to the recent crisis.

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