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INCOME INEQUALITY CONVERGENCE IN THE DEVELOPMENT OF EUROPEAN COUNTRIES

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Abstract: *This paper examines how income inequality varied as new countries joined the European Union. We consider a convergence test of contributions to international income inequality of 32 European countries over the period 1989-2002. The results indicate a weak convergence of contributions to inequalities. The average speed of inequality convergence gets lower as the number of countries in the union increases. We also find that the effect of technological inequalities is significant and depends on the level of wealth of a country. Taking into account the heterogeneity of behavior through the convergence parameter suggests that the speed of inequality convergence varies across countries.*

JEL Classifications: *C23, O47, O57*

Keywords: *inequality, convergence, European countries*

INTRODUCTION

Europe is comprised of very different areas, and as much as it is rich in its cultural diversity, it also witnesses significant development gaps. Moreover, European integration simultaneously contributes to increasing all kinds of disparities (successive enlargements, dynamics of concentration etc.). Most studies on Europe reveal a very weak process of income convergence (see Dowrick and Nguyen, 1989; Barro and Sala-i-Martin, 1992; Mankiw et al. 1992). The objective of reducing disparities in Europe appears out of reach while a relative permanence of inequalities leads us to reconsider the efficiency of European policies. The main contribution of this work consists in analyzing how the convergence process of inequalities in income varied as new countries joined the European Union (EU), successively of 15 countries, 25 countries, and the prospect of 32 countries.

In the process of convergence of European countries and regions, we can roughly distinguish two phases. The first one, which stretches to the mid-1970s, is characterized by a high homogeneity of different EU members. During this period, the convergence of regions seemed to be clear while national factors strongly contributed to it. The process of regional convergence

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was strongly determined by national convergence. During the second phase, which started in the late 1970s and early 1980s, new factors, arising from international circumstances following two oil crises, new technological paradigms, accession of new members, etc. contributed to the transformation of the context of both regional and national convergence process. The hypothesis of long-term convergence became difficult to sustain.

Two currents of the literature on convergence at the level of countries and European regions can be juxtaposed to these two phases: the traditional approach based on *regional science* (see Molle et al. 1980) and the new growth theory approach, initiated by Barro and Sala-i-Martin (1991, 1992, 1995). Several disparity indicators were developed, mainly in terms of wealth. The results of the traditional approach indicate a tendency toward a decline of regional inequalities in terms of Gross Domestic Product (GDP) per capita, during the 1950s and the 1960s. It is recognized that national factors play an important role. Indeed, it was shown, via the Theil concentration index, that the majority of GDP per capita disparities is related to between-country disparities (see Molle et al. 1980). This acknowledgment clearly defined the objectives to be reached by any efficient European economic policy. As a priority, it should aim to reduce disparities between different EU member countries. Some later studies conclude the same (see Suarez-Villa and Cuadrado-Roua, 1993; Dunford, 1995). They recognize that the regional convergence process has been stopped in the late 1970s, thus giving birth to divergence during the 1990s.

Technological heterogeneity did not receive much attention in the empirical literature on economic convergence. A common hypothesis is that there is no systematic technological difference between economies; the convergence is attributed to the intensification of capital (see Mankiw, et al. 1992). Some authors, such as Islam (1995), take into account the technological differences but assume these differences to be stable. As a consequence, Bernard and Jones (1996) argue that we do not know enough about 'the part in the observed convergence which is attributed to technological convergence, in comparison with convergence of capital-labor ratio'. As a result, there is no consensus on the empirical methodology to be used to assess economic convergence attributed to technology, particularly in view of the absence of data on technological levels.

The main purpose of our study is to highlight the importance of income inequalities (captured by per capita GDP) across countries and the impact of inequalities in national technological activities (captured by patent applications per capita) on the convergence process. In particular, the originality of our approach resides in the fact that the tested model links the level of contributions to global inequalities of a country to its initial level and to its contributions to technological inequalities. Heterogeneity of behavior is taken into account through speed of convergence, assumed to depend on national specificities, like initial per capita GDP level and initial technological capacities.

We conduct our study with a panel of 32 countries observed over the period 1989-2002. In order to highlight the effect of UE enlargement on the convergence process, we also consider three groups of countries. The first and the second group are composed of EU-15 and EU-25, respectively. The third group includes EU-25 and 7 Balkan countries, which are part of the Stability Pact for Southeast Europe: Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Macedonia, Romania and Serbia-Montenegro.

Our results show that income inequalities in Europe are stable and persistent. The most significant disparities are found when moving from EU-15 to an enlarged Union of 32 countries. Technological inequalities are at least two times greater than income inequalities. The results also indicate a very low convergence speed of contributions to inequalities of European countries in the period 1989-2002. Technological inequalities appear as determinant factor of contributions to international income inequalities. Consideration of the heterogeneity of behavior suggests that the speed of convergence varies across countries. Overall, a convergence process essentially characterizes 12 countries of EU-15: speeds of convergence vary between 0.2% and 1.6%. A divergence process (negative speeds) is found in 20 countries comprised mainly of new countries of EU-25 and Balkan countries: speeds range from -0.2% to -1.8%.

The paper is organized as follows. In section 2, we discuss the interaction between convergence and the European integration. Section 3 presents a model of inequality convergence. Section 4 describes the data and the estimation results. The last section concludes and presents possible directions for future research.

EUROPEAN INTEGRATION, CONVERGENCE AND INEQUALITY

In the framework of European economic integration, the central objective of the EU is to equalize revenues between different member countries and regions. Since 1950, this objective, as we have seen with the traditional approach, has been achieved by reducing disparities of GDP per capita. However, the convergence process of European economies has been significantly slowed down since the end of the 1980s. The studies on convergence are largely based on the neoclassical theory of economic growth (see Dunford, 1995; Bernard and Durlauf, 1995, 1996; Durlauf and Quah, 1999; and for a review, De la Fuente, 1997, 2002). In its initial formulation, all countries and regions converge toward the same level of economic development, when the agents have identical preferences and take advantage of the same access to technology. One of the hypotheses of this approach resides in immediate dissemination of knowledge. Contrary to the neoclassical theory, the endogenous growth models consider the possibility of different growth rates across countries (see Grossman and Helpmen, 1991; Temple, 1999). This approach claims that national accumulation of knowledge and technology is endogenous.

The notion of β-convergence constitutes the link between the Barro and Sala-i-Martin's study (1991) on the convergence of economies and the neoclassical growth model. Following this approach, convergence arises because poor countries tend to grow more quickly than rich countries. More precisely, poor countries tend to catch up with the level of per capita income of rich countries. The β-convergence can be absolute or conditioned by control variables such as investment rates, technological change, human capital, industry structure, stability policies, etc. The first concept implies that all countries converge toward the same stationary state, while the second refers to country specific equilibrium. De la Fuente (1997) reviews the empirical literature on conditional convergence at the country level. He shows that countries which invest most in physical and human capital and which have a slow population growth rate tend to grow more quickly. However, estimates on country samples in the period 1950-1985 result in convergence speeds from 0.6% to 2.06% (see Dowrick and Nguyen, 1989; Mankiw *et al.* 1992; Barro and Sala-i-Martin, 1992). To the contrary of the traditional approach, this approach does not allow for the distinction of different phases of convergence and divergence which characterize the study period. Out of all the criticisms of the β-convergence notion, the most important one comes from Quah (1993, 1996) who shows that the β-convergence process of economies is compatible with an increase or decrease in inequalities (i.e., σ-convergence).

Convergence is a prerequisite for economic and monetary integration. However, convergence is late, compared with the enlargement process. Indeed, the enlargement has been followed by a significant decrease in per capita GDP and increase of disparities. The persistence in inequalities compromises the European integration process (favorable to countries endowed with growth factors) and hinders convergence. Moreover, technological inequalities make the integration process more complex, because not only inequality levels are more significant between states, but also technological activities present country specific factors. Through structural funds, European policies have to date supported the less developed countries following the logic of reducing income disparities. With the creation of the European area of knowledge and innovation, policies tend to encourage technological development (Lisbon Summit in 2000).

A MODEL FOR INEQUALITY CONVERGENCE

Indicators of Inequality

Several indicators could be used to measure inequality (see Cowell and Jenkins, 1995; Cowell, 1995, for a review). An extensively used indicator is the one of Theil (1967). This indicator has the advantage of being additive and decomposable (see Shorrocks, 1984). In an analysis of European inequalities, the decomposition property could be used to obtain the contributions of Between-group and Within-group disparities to the global inequality. Thus, if we consider n countries belonging to m groups, the Theil indicator, denoted as Th_t, could be written as the sum of the inequalities Between (Th_{tB}) and Within (Th_{tW}):

$$Th_t = Th_{tB} + Th_{tW} \tag{1}$$

The unit observation is the country. Since countries differ with respect to the size of their populations, we consider a measure of relative inequalities. In particular, if y_{it} stands for a per capita variable of country i (i = 1,..., n) at date t (t = 1, ..., T), it is possible to define the Theil index as the sum of the contributions of countries to global inequality. Let d_{it} be defined by:

$$d_{it} = y_{it} / \sum_{i=1}^{n} y_{it} = \frac{1}{n}\frac{y_{it}}{y_{\bullet t}} \text{ where } y_{\bullet t} = \frac{1}{n}\sum_{i=1}^{n} y_{it} , \tag{2}$$

the contribution of country i to global inequality is defined by:

$$TC_{it} = d_{it}\,\text{In}(d_{it}n) \tag{3}$$

Thus, the Theil index is derived as the sum of the contributions of the n countries:

$$Th_t = \sum_{i=1}^{n} TC_{it},\ Th_t \in [0; \text{In}(n)]. \tag{4}$$

In the same manner, we can define the indicator of between-group inequality as the sum of contributions of the m groups to global inequality:

$$Th_{tB} = \sum_{j=1}^{m} BC_{jt} \tag{5}$$

where $BC_{jt} = d_{jt}\,\mathrm{In}(d_{jt}\,n/n_j)$, $d_{jt} = \frac{1}{m}\frac{y_{jt}}{y_{\bullet t}}$, $y_{jt} = \sum_{\tau=1}^{n_j} y_{\tau t}$, $j = 1,...,m$ and n_j is the number of countries in group m, $n = n_1 + ... + n_m$. The second component of the global Theil index expresses within-group inequality. The within-group contribution of each country is defined by:

$$WC_{jt} = d_{jt}\left[\sum_{i=1}^{n_j} \tilde{d}_{it} \ln\left(\tilde{d}_{it} n_j\right)\right] \tag{6}$$

where $\tilde{d}_{it} = y_{it} / \sum_{i=1}^{n_j} y_{it}$. It is worth noting that the term between brackets is the global Theil index defined for the group composed of n_j countries. The index of within-group inequality is then the sum of the contributions within each group:

$$Th_{tW} = \sum_{j=1}^{m} WC_{jt} \tag{7}$$

Convergence of Inequalities

The total Theil indicator Th_t is the sum of the contributions to inequality (TC_{it}) of the different countries (see equation 4). In this way, Th_t reveals the global inequality levels at any time t. Yet, these levels can hide important processes of convergence/divergence between countries. The changes in the contributions TC_{it} could thus express these different processes. The convergence of inequalities is characterized by a decrease in rich countries' contributions and an increase in poor countries' contributions. A theoretical equilibrium situation is then characterized by a zero contribution (i.e., $Th_t \to 0$). In order to study the convergence/divergence process of contributions to inequalities of European countries, we shall consider the theoretical framework on the convergence of economies (see Barro and Sala-i-Martin, 1995) in a panel context (see Islam, 1995; Nerlove, 1999). The test of convergence of inequalities we use constitutes an important difference with respect to the classical approach of the income convergence. Ravallion (2003) discussed a similar approach, inspired by the convergence test of inequalities developed by Bénabou (1996). However, the author considers a within-country income inequalities by observing the variation of Gini index (i.e., G_{it}) over time and across country. To contrary, we consider a between-country income inequalities and we observe the evolution of contributions (i.e., TC_{it}) rather than the change in Theil index (i.e., Th_t).

In particular, our study on the convergence of inequalities in production activities is based on the following specification:

$$TC_{it} = \alpha_0 + \alpha_1 TC_{i0} + u_{it}, \tag{8}$$

where TC_{i0} and TC_{it} stand for the levels of contributions of country i at the initial date and at date t, respectively. u_{it} is a zero-mean random term with variance σ_u^2. The constant α_0 may be interpreted as an equilibrium level, $\alpha_0 \equiv (1 - \alpha_1)TC^*$ where TC^* is the equilibrium level of contribution. The hypothesis $\alpha_1 > 1$ implies a tendency to increase the inequalities (*divergence*). On the contrary, if $0 < \alpha_1 < 1$, the contributions to global inequalities change over time because of the *convergence* process. On average, the contributions to inequalities of countries characterized by a low initial level TC_{i0} increase over time. Conversely, they decrease for countries with very high initial contributions. The speed of convergence, denoted as λ, is derived from the relation $\alpha_1 = \exp(-\lambda T)$.

The two previous situations express the hypothesis of a transformation in the structure of national contributions to global inequalities: the cases of divergence ($\alpha_1 > 1 \Rightarrow \lambda < 0$) or convergence ($0 < \alpha_1 < 1 \Rightarrow \lambda > 0$) correspond to significant changes in national contributions. The tendency of inequalities to persist is a situation where $\alpha_1 \to 1$. This persistence could be the result of either the stability of contributions, or compensation between the convergence processes of a subset of countries and the divergence process of other subsets.[1]

The specification (8) assumes that countries are approaching the same equilibrium level, and this situation will be referred to as *absolute convergence*. The hypothesis of a *conditional* convergence assumes the control of the factors differentiating countries. Thus, we can rewrite equation (8) under a general specification with the following error component model:

$$TC_{it} = \alpha_0 + \alpha_1 TC_{i0} + X'_{it}\gamma + \mu_i + \varepsilon_{it} \tag{9}$$

Where X_{it} is a vector of exogenous variables which determines the individual equilibrium level of countries contributions and ε_{it} is an error term. μ_i captures the national specificities and can be fixed or random. In this form, the national heterogeneity is taken into account by adding μ_i. Equation (9) implicitly assumes that countries reach possibly different steady states but at the same speed of convergence. The latter assumption looks rather strong and the specification could be enriched by allowing for heterogeneous α_1 coefficients:

$$\alpha_{i1} = \beta_0 + Z'_{i0}\beta_1 \tag{10}$$

where Z_{i0} is a vector of initial variables (may be different from the X_{it}) and expresses initial specificities. The latter can represent a number of factors of variation in the speed of convergence.

Within the framework of a modelization at the international level, the choice of explanatory variables and periods of estimation is strictly limited by the availability of data across countries and through time. Additionally, a crucial question resides in the determinants of inequality (see Barro, 2000). Most studies on these determinants consider the variants of the Kuznets curve. Nevertheless, Li *et al.*, (1998) conclude that the Kuznets curve remains satisfactory in a cross section approach. Among the relevant factors, it is wise to consider the variables already used in the studies on the conditional convergence (see Dowrick and Nguyen, 1989; Mankiw *et al.* 1992; Barro and Sala-i-Martin, 1992; Sala-i-Martin, 1994, 1996; De la Fuente, 1997). Levine and Renelt (1992) list no less than 15 variables used in the literature on economic growth. However, the authors conclude that convergence continues to be robust with the investment and the initial value of income, while other variables lose their significance (i.e., population growth, monetary and tax-related variables, etc.).

In this paper, our objective is limited to the study of the impact of technological inequalities in production activities. In particular, we analyze the effect of the contributions of technological inequalities, expressed by the patent applications per capita and denoted as TCp_{it}, on those of income inequality. The country specific variables incorporated in the vector Z_{i0} are the initial level of GDP per capita (GDP_{i0}) and the corresponding level of technological capacities expressed by the density of patents (Pat_{i0}).

To estimate the model, we have to take into account the possible endogeneity of some variables in order to get unbiased and convergent estimators. If all the explanatory variables are correlated with the national effects μ_i, the Within estimator is obtained by applying OLS (Ordinary Least Squares) to the specification in terms of deviations from means of variables. In this case, the effects are treated as fixed. However, as the transformation Within eliminates μ_i, but also the time-invariant variables, i.e., TC_{i0}, the parameters of the latter cannot be identified. To the contrary, if the effects μ_i are supposed to be random and not correlated with the regressors, the GLS estimator (Generalized Least Squares) provides efficient estimators and allows to identification of all structural parameters (see Baltagi, 2001). The Hausman statistics, based on the difference between the two estimators, allows for a statistical test of independence between the effects and the explanatory variables of the model (see Hausman, 1978).[2]

EMPIRICAL ANALYSIS

Statistical Framework

Our empirical investigations examine the evolution of two indicators of production activities (GDP per capita) and innovation (patent per capita). The availability of data over a long period and for all the countries under consideration leads us to consider several statistical sources. The data extracted from the Eurostat Regio database (referred to as ES data) concerns the GDP per capita expressed in PPS (Purchasing Power Standards) related to prices in 1995. The data on European patents *EPAT* (*European Patent*) come from the EPO (European Patent Office) database. The two sets of data cover the period 1989-2002 and concern the EU-15 group of countries.

The GDP data we use come from the United Nations (referred to as UN data) and are available for all the 32 countries of this study and on almost the whole period 1989-2002. The GDP is expressed in 1990 U.S dollars. Finally, the patent applications related to residents are extracted from the database of the WIPO (World Intellectual Property Organization).

Table 1 presents the inequality indicators of production activities (GDP/capita) and technology (Patents/capita) for the three groups of countries. The first group represents EU-15 countries. As we can see, the inequalities in income remained stable during the whole period (see Figure 1). Considering the Eurostat data, the Theil index fell from 0.070 to 0.065 between 1989 and 2002.[3] The same remark remains valid on UN data. A more significant decrease is observed for technological activities. Indeed, the Theil index fell from 0.324 to 0.256 between 1989 and 2002.[4] The WIPO data, however, do not corroborate this result. This could be explained by the fact that part of WIPO patents extend to EPO and we can suppose that all the countries do not have the same extension rate. We must notice that in 2002, for example, the Theil indices calculated from the applications to EPO and WIPO are very close.

The second group of countries is the EU-25. We can see that the inequalities are now more important, but they remain stable over the period. The third group is EU-32. This group is composed of EU-25 countries and seven Balkan countries. The Theil indices are even more higher, but they do not cast doubt on the persistence of inequalities, despite a slight tendency to decrease (see Figure 1). Moreover, income inequality is more of a Between-group phenomenon than it is a Within-group. The parts of the component Between (Th_{tB}) vary from 67% to 84% in the total Theil index (Th_t). These proportions are, however, not as high for technological activities (they vary from 34% to 63%).

Table 1
Indicators of Inequalities of European Countries

		GDP/capita			*Patents/capita*		
	Theil index	*1989*	*1995*	*2002*	*1989*	*1995*	*2002*
ES-EPOdata (a)							
EU-15	Total	0.070	0.064	0.065	0.324	0.274	0.256
EU-25	Total	-	0.257	0.247	-	0.623	0.602
	part Between	-	67%	68%	-	55%	57%
EU-32	Total	-	0.322	0.309	-	0.694	0.670
	part Between	-	84%	84%	-	61%	63%
UN-WIPO data (b)							
EU-15	Total	0.063	0.059	0.062	0.281	0.317	0.288
EU-25	Total	0.241	0.237	0.224	0.310	0.463	0.555
	part Between	71%	71%	68%	-	34%	48%
EU-32	Total	0.363	0.367	0.347	0.278	0.499	0.620
	part Between	78%	81%	77%	-	42%	54%

Notes: (a) GDP is expressed in terms of PPS (Purchasing Power Standards) at the prices of 1995. The Theil indices are calculated without Malta for the period 1995-98. EU-32: EU-25 and Bulgaria, Croatia and Romania. Patents are European applications. The Theil indices are calculated without Malta for the year 1995. EU-32: EU-25 and Bulgaria and Romania. (b) GDP is expressed in 1990 U.S dollars. For EU-25 and EU-32 the data in the column 1989 are related to year 1990. For the patents, these are residents' applications. For year 1995: without Cyprus (EU-25) and without Cyprus and Bosnia-Herzegovina (EU-32). For the year 1990 (column 1989): EU-25: EU-15 and Czech Republic, Hungary, Malta and Poland. EU-32: EU-15 and Czech Republic, Hungary, Malta, Poland, Bulgaria, Romania and Serbia -Montenegro. *Source: Calculation by the authors using the data ES (Eurostat) and UN (United Nations) for the GDP/capita and the data of EPO and WIPO for patents/capita.*

The statistics reported in Table 1 and Figure 1 suggest that income inequalities remained stable during the period 1989-2002. This stability, however, hides important changes in national contributions to international inequalities. Table 2 presents the observed levels of contributions to global inequalities of the 32 European countries at the beginning and at the end of the period under study. These results deserve several remarks. The majority of positive contributions come from the EU-15 countries. Luxembourg distinguishes itself clearly with a higher contribution and a strong increase over the period 1989-2002. Ireland, which initially presented a negative (within the framework of EU-15) or weak contribution (within the framework of EU-25 or EU-32) is characterized by the strongest progression of its contribution. On the other hand, an important decreases can be observed for Finland, Sweden, Germany and Denmark. Finally, the respective contributions of Greece, Portugal, the new countries in EU-25 and the seven Balkan countries are negative and almost unchanged during the whole period under study.

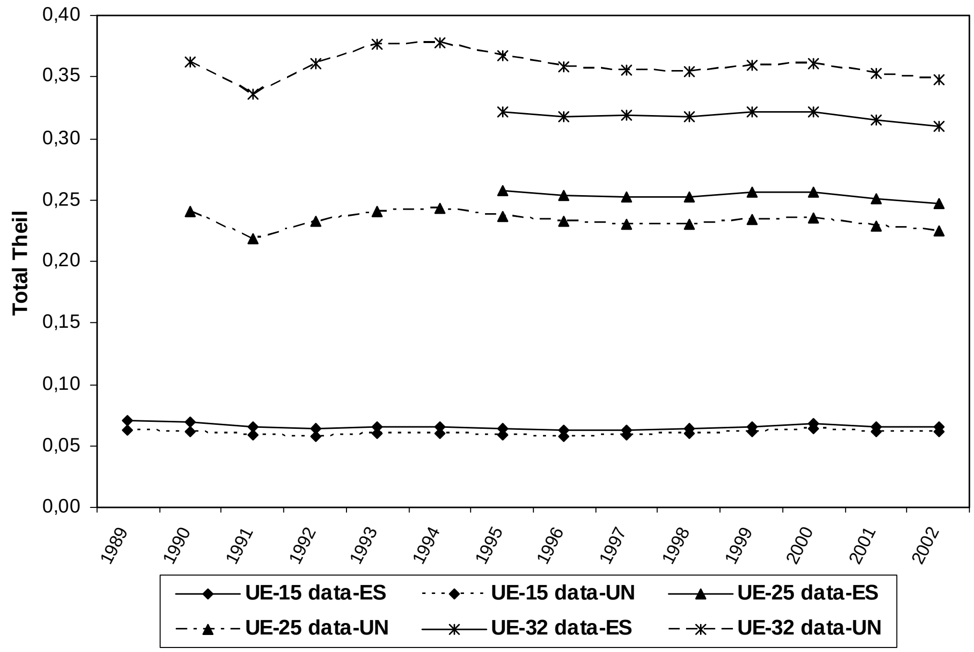

Figure 1: Income Inequality in Europe

Estimation Results

The estimation results[5] of the model under the hypothesis of absolute convergence are presented in Table 3. The estimations were conducted over the period 1989-2002 for EU-15. As some data were missing for the year 1989 for some countries, the estimations were conducted over the period 1990-2002 for EU-25 and EU-32. As we can see, the speed of convergence $\hat{\lambda}$, derived from the relation $\hat{\alpha}_1 = \exp(-\hat{\lambda}T)$, is very low and indicates persistence of national contributions to the global inequalities in per capita GDP.[6] However, the hypothesis that all the countries approach the same steady state level is very restrictive. The test of existence of national effects ($(H_0 : \sigma^2_\mu = 0)$ leads to a very significant Fisher statistic. It shows that national variability $(\sigma^2_\mu / \sigma^2_\mu + \sigma^2_\varepsilon)$ takes an important position of the total variability (between 66% and 72%). These results lead us to reject the hypothesis of the inexistence of country specific effects and, consequently, the hypothesis of absolute convergence.

The rejection of the hypothesis according to which the countries converge toward the same level of equilibrium contributions leads us to take into consideration the variables which determine the individual levels. Table 4 reports the estimates of the conditional model. Compared to previous results, we can notice that the part of national variability decreases from 72% to around 41% for EU-15 countries. This reduction remains modest compared to EU-25 and EU-32.

Table 2
Contributions to Total Per capita GDP Inequalities

	EU-15		*EU-25*		*EU-32*	
Country	*1989*	*2002*	*1990*	*2002*	*1990*	*2002*
Belgium	0.007	0.005	0.022	0.017	0.032	0.027
Denmark	0.025	0.024	0.050	0.043	0.062	0.055
Germany	0.029	0.010	0.029	0.019	0.040	0.029
Greece	-0.024	-0.024	-0.012	-0.012	-0.007	-0.007
Spain	-0.020	-0.019	-0.001	-0.002	0.007	0.006
France	0.011	0.001	0.028	0.020	0.038	0.030
Ireland	-0.022	0.001	0.000	0.026	0.007	0.037
Italy	-0.012	-0.016	0.021	0.013	0.031	0.022
Luxembourg	0.054	0.090	0.067	0.091	0.080	0.107
Netherlands	0.004	0.003	0.022	0.019	0.032	0.029
Austria	0.015	0.012	0.029	0.022	0.039	0.032
Portugal	-0.024	-0.024	-0.013	-0.013	-0.009	-0.009
Finland	0.013	0.006	0.057	0.047	0.070	0.060
Sweden	0.023	0.009	0.060	0.053	0.073	0.065
United Kingdom	-0.009	-0.013	0.013	0.011	0.022	0.020
Cyprus			-0.012	-0.012	-0.006	-0.006
Czech Republic			-0.014	-0.013	-0.011	-0.011
Estonia			-0.014	-0.014	-0.011	-0.009
Hungary			-0.014	-0.014	-0.011	-0.011
Lithuania			-0.013	-0.014	-0.011	-0.011
Latvia			-0.014	-0.015	-0.011	-0.011
Malta			-0.014	-0.013	-0.009	-0.008
Poland			-0.010	-0.010	-0.009	-0.009
Slovenia			-0.011	-0.012	-0.005	-0.006
Slovakia			-0.013	-0.013	-0.011	-0.011
Albania					-0.005	-0.005
Bosnia and Herzegovina					-0.004	-0.011
Bulgaria					-0.010	-0.009
Croatia					-0.011	-0.011
Macedonia					-0.010	-0.008
Romania					-0.009	-0.008
Serbia and Montenegro					-0.011	-0.007
Theil index	0.070	0.065	0.241	0.224	0.363	0.347

Notes: The Theil index is derived as the sum of the contribution to per capita GDP inequalities of the countries in the union (sum of each column). The contributions are calculated on the basis of Eurostat data for EU-15 and on the basis of UN data for EU-25 and EU-32.

Source: Calculation by the authors according to the ES-data (Eurostat) and UN-data (United Nations).

Table 3
Estimation Results of the Absolute Convergence Model

Dependent variable	*EU-15 (a)*	*EU-25 (b)*	*EU-32 (b)*
Intercept $(\hat{\alpha}_0)$	-0.000	-0.000	0.000
	(0.001)	(0.000)	(0.000)
$TC_{i0}(\hat{\alpha}_1)$	1.029**	0.980**	0.981**
	(0.027)	(0.012)	(0.009)
Speed of convergence $\hat{\lambda}$	-0.2%	+0.2%	+0.1%
σ^2_μ	5.78E-05	2.25E-05	2.06E-05
σ^2_ε	2.26E-05	1.12E-05	1.08E-05
National Effect	72%	67%	66%
SSE	0.016	0.011	0.013
Fisher-*test*	36.9**	27.1**	25.9**
Observations	210	325	416

Notes: Estimation method: OLS (Ordinary Least Squares). The terms between parentheses are standard errors. SSE: Sum of Squared Errors. (*) and (**): significant at 5% and 1%, respectively.
(a) Estimation results on the basis of Eurostat data, $t = 0$ in 1989.
(b) Estimation results on the basis of United Nations data, $t = 0$ in 1990.

Concerning the results themselves, the introduction of explanatory variables expressing national contributions to technological inequalities (TCp_{it}) does not cast doubt on the persistence of contributions to income inequalities: the estimated speed is almost zero. However, the results suggest that the effect of TCp_{it} is indirect as its statistical significance is ensured only in regression implying the EU-15 group of countries. The independence test[7] (Hausman-test) indicate that we cannot reject the hypothesis of a correlation between the national effects (μ_i) and the explanatory variables of the model. If we suppose that the impact of contributions to technological inequalities is indirect and depends on the levels of GDP per capita, this hypothesis is not rejected. Columns 2, 4 and 6 present the results of estimates for the countries of EU-15, EU-25 and EU-32 respectively, incorporating an interactive term $TCp_{it} \times (GDP_{i\bullet} / GDP_{e\bullet})$ in the specification. The variables $GDP_{i\bullet}$ and $GDP_{e\bullet}$ represent the average level of GDP per capita of country *i* and the average European level, respectively. We can see that the direct effect of TCp_{it} is negative while the sign of the interactive term is positive and significant. This suggests that the rich countries contribute positively to global inequalities during their technological development. Thus, the regression shows that the countries with income per capita 1.04 times (0.283/0.271 ≅ 1.04), 1.96 times (0.139/0.071 ≅ 1.96) and 2.46 times (0.128/0.052 ≅ 2.46) the European level, respectively within the framework of EU-15, EU-25 and in a Union of 32 countries, create more inequalities. To the contrary, the effect of technological contributions of poor countries (low level of income per capita) to global inequalities remains negative.

These results show that countries approach different levels of equilibrium, but with the restrictive hypothesis of a constant speed of convergence. This constraint can also partly explain the low estimates of $\hat{\lambda}$ in the previous regressions. It is interesting to suppose that in a process

Table 4
Estimation Results of the Conditional Convergence Model

Dependent variable	*EU-15* *(1)*	*EU-15* *(2)*	*EU-25* *(3)*	*EU-25* *(4)*	*EU-32* *(5)*	*EU-32* *(6)*
Intercept $(\hat{\alpha}_0)$	-0.001	-0.002	0.000	-0.000	0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
$TC_{i0}(\hat{\alpha}_1)$	0.984**	1.005*	1.001**	1.001**	1.004**	1.006**
	(0.111)	(0.104)	(0.038)	(0.039)	(0.030)	(0.030)
TCp_{it}	0.041*	-0.283*	-0.015	-0.139**	-0.018	-0.128**
	(0.020)	(0.144)	(0.010)	(0.036)	(0.009)	(0.034)
$TCp_{it} \times (GDP_{i\bullet} / GDP_{e\bullet})$		0.271*		0.071**		0.052**
		(0.120)		(0.020)		(0.015)
Speed of convergence $\hat{\lambda}$	+0.1%	-0.0%	-0.0%	-0.0%	-0.0%	-0.0%
σ^2_μ	2.24E-05	2.06E-05	1.86E-05	1.87E-05	1.73E-05	1.74E-05
σ^2_ε	3.17E-05	2.89E-05	1.17E-05	1.16E-05	1.11E-05	1.10E-05
National Effect	41%	42%	61%	62%	61%	61%
SSE	0.004	0.004	0.003	0.003	0.004	0.004
Fisher-*test*	10.9**	11.0**	21.8**	22.1**	21.2**	21.4**
Hausman-*test*	$\chi^2_1 = 7.76$*	$\chi^2_2 = 0.90$	$\chi^2_1 = 2.42$	$\chi^2_2 = 0.30$	$\chi^2_1 = 2.76$	$\chi^2_2 = 0.37$
Observations	210	210	325	325	416	416

Notes: Estimation method: Random effects-GLS (Generalized Least Squares). The terms between parentheses are standard errors. SSE: Sum of Squared Errors. (*) and (**): significant at 5% and 1%, respectively.
Columns (1) and (2): Estimation results on the basis of Eurostat data, *t*=0 in 1989.
Columns (3) to (6): Estimation results on the basis of United Nations data, *t*=0 in 1990.

of convergence, the heterogeneity of behavior causes the speed to vary across countries, due to different initial conditions. Country specific factors may induce an acceleration or deceleration of the convergence process. Table 5 presents the estimations of the model under the variable speed variation hypothesis. In particular, this specification assumes that $\alpha_{i1} = \beta_0 + Z'_{i0}\beta_1$. The vector Z_{i0} contains the initial GDP per capita (GDP_{i0}) and the initial technological capacities measured by the patent per capita (Pat_{i0}). In order to assess the influence of these variables compared to an average level, they are related to the European average levels of GDP per capita (GDP_{e0}) and of patent per capita (Pat_{e0}) respectively. For some EU-25 countries (essentially the new comers) and for the majority of Balkan countries, the data on patents are not available at the beginning of the period (the early 1990s). We then retained the average levels of technological capacities $Pat_{i\bullet}$ and $Pat_{e\bullet}$ for EU-25 and EU-32 estimations.

The results suggest that the speed of convergence in the contributions to global income inequalities varies across countries. It decreases with the initial level of GDP per capita: the sign of the interactive term $TC_{i0} \times (GDP_{i0} / GDP_{e0})$ is positive and very significant in all specifications. Consequently, the coefficient α_{i1} has a tendency to increase with the ratio (GDP_{i0} / GDP_{e0}), and correlatively the speed of convergence is much lower. The technological capacities seem to accelerate convergence. In particular, since the sign of the interactive term $TC_{i0} \times (Pat_{i0} / Pat_{e0})$ (for EU-15) or TCi0 × $(Pat_{i\bullet} / Pat_{e\bullet})$ (for EU-25 and EU-32) is negative, countries with weak technological capacities (i.e., less than the average capacity) converge less rapidly than

Table 5
Estimation Results of the Conditional Convergence and the Variable Speed Models

Dependent variable	*EU-15* *(1)*	*EU-15* *(2)*	*EU-25* *(3)*	*EU-25* *(4)*	*EU-32* *(5)*	*EU-32* *(6)*
Intercept $(\hat{\alpha}_0)$	-0.003	-0.003	0.000	0.001	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
$TC_{i0}(\hat{\beta}_0)$	0.293	0.457*	0.672**	0.792**	0.691**	0.793**
	(0.205)	(0.196)	(0.177)	(0.196)	(0.171)	(0.186)
$TC_{i0} \times UE25$			0.293	0.272	0.374	0.345
			(0.215)	(0.235)	(0.288)	(0.308)
$TC_{i0} \times UE32$					0.312	0.291
					(0.305)	(0.327)
$TC_{i0} \times (GDP_{i0} / GDP_{e0})$	0.950**	0.838**	0.306**	0.231*	0.215**	0.166*
	(0.193)	(0.180)	(0.100)	(0.111)	(0.074)	(0.081)
$TC_{i0} \times (Pat_{i0} / Pat_{e0})$	-0.379**	-0.396**				
	(0.107)	(0.098)				
$TC_{i0} \times (Pat_{i\bullet} / Pat_{e\bullet})$			-0.134**	-0.130**	-0.086**	-0.083**
			(0.039)	(0.042)	(0.027)	(0.028)
TCp_{it}	0.040*	-0.304*	-0.004	-0.120**	-0.007	-0.108**
	(0.019)	(0.138)	(0.010)	(0.037)	(0.010)	(0.035)
$TCp_{it} \times (GDP_{i\bullet} / GDP_{e\bullet})$		0.289 *		0.065 **		0.047 **
		(0.116)		(0.020)		(0.016)
Speed of Convergence: $\bar{\hat{\lambda}}$,	+1.3%	+0.9%	+0.3%	-0.0%	-0.0%	-0.3%
	[-2.3%;	[-2.1%;	[-1.1%;	[-1.5%;	[-1.6%;	[-1.8%;
$[\hat{\lambda}_{i,MIN}; \hat{\lambda}_{i,MAX}]$	+5.0%]	+5.6%]	+2.3%]	+2.1%]	+1.8%]	+1.6%]
σ_μ^2	1.09E-05	1.07E-05	1.04E-05	1.04E-05	1.11E-05	1.10E-05
σ_ε^2	2.52E-05	2.31E-05	1.21E-05	1.21E-05	1.15E-05	1.16E-05
National Effect	30%	32%	46%	46%	49%	49%
SSE	0.004	0.004	0.003	0.003	0.004	0.004
Fisher-*test*	7.1**	7.5**	12.1**	12.1**	13.5**	13.3**
Hausman-*test*	$\chi_1^2 = 4.05$*	$\chi_2^2 = 0.95$	$\chi_1^2 = 4.12$*	$\chi_2^2 = 0.60$	$\chi_1^2 = 4.67$*	$\chi_2^2 = 0.58$
Observations	210	210	325	325	416	416

Notes: Estimation method: Random effects-GLS (Generalized Least Squares). The terms between parentheses are standard errors. SSE: Sum of Squared Errors. (*) and (**): significant at 5% and 1%, respectively.
Columns (1) and (2): Estimation results on the basis of Eurostat data, t=0 en 1989.
Columns (3) to (6): Estimation results on the basis of United Nations data, t=0 in 1990.

countries with a strong technological density. Finally, taking into account the indications related respectively to new countries of EU-25 (variable *UE*25 =1 for the new countries in EU-25) and to countries of the Stability Pact (variable *UE*32 =1 for the Balkan countries) leads to positive but not significant effect.

The estimates of the speed of convergence reported in Table 6 deserve a number of remarks. The average speed gets lower as the number of countries in the union increases: 0.9% in EU-15 and -0.3% in EU-32. Then, the speed of convergence of contributions to inequalities remains high only in Germany (+1.6%), the United Kingdom (+1.2%), Sweden (+1%), Ireland and Portugal (+0.9%) and Greece (+0.8%). Luxembourg, the new countries of the EU-25 and the

Table 6
Convergence Speed (in %) of Contributions to GDP/capita Inequalities

Country	*EU-15* (1)	*EU-25* (2)	*EU-32* (3)
Belgium	-0.5	-0.3	-0.2
Denmark	-0.9	0.3	0.2
Germany	5.6	2.1	1.6
Greece	1.6	0.6	0.8
Spain	0.4	0.1	0.3
France	0.4	0.1	0.2
Ireland	1.2	1.0	0.9
Italy	0.6	-0.5	-0.3
Luxembourg	-2.1	-0.7	-0.6
Netherlands	2.3	0.5	0.4
Austria	0.4	0.3	0.3
Portugal	1.7	0.7	0.9
Finland	-0.0	0.4	0.3
Sweden	1.2	1.3	1.0
United Kingdom	2.1	1.5	1.2
Cyprus		-1.5	-1.8
Czech Republic		-0.4	-1.0
Estonia		-0.9	-1.3
Hungary		-0.4	-1.0
Lithuania		-0.7	-1.2
Latvia		-0.6	-1.1
Malta		-1.2	-1.6
Poland		-0.4	-1.0
Slovenia		-1.0	-1.5
Slovakia		-0.7	-1.2
Albania			-0.7
Bosnia and Herzegovina			-0.9
Bulgaria			-0.7
Croatia			-1.0
Macedonia			-0.8
Romania			-0.6
Serbia and Montenegro			-0.7
Mean Speed	+0.9	-0.0	-0.3

Note: The speed of convergence of the EU-15, EU-25 and EU-32 countries is derived from the estimates in columns 2, 4 and 6 of Table 5, respectively.

countries of the Stability Pact are characterized by a divergence of contributions (negative speed). This result can be explained by the high level of GDP per capita, rather superior to the European level for Luxembourg, or by a low level of technological activities (in the new countries of EU-25 and in the countries of the Stability Pact). To sum up, a process of convergence essentially characterizes 12 countries of EU-15: the speed of convergence varies between 0.2% and 1.6% (see Figure 2.a). A process of divergence (negative speed) is observed in 20 countries, essentially the new countries in EU-25 and the Balkan countries: the speed ranges from -0.2% to -1.8% (see Figure 2.b). These two processes compensate each other to generate a situation of

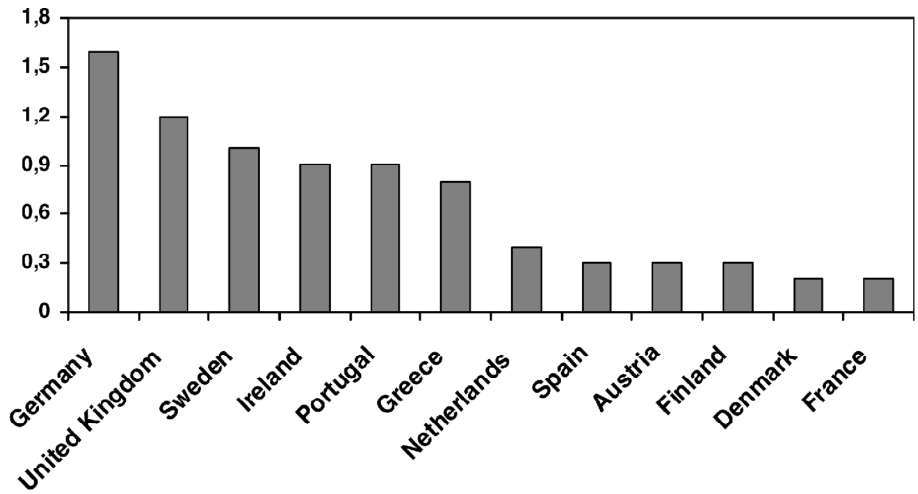

Figure 2a: Speed of Convergence $(\hat{\lambda} > 0)$

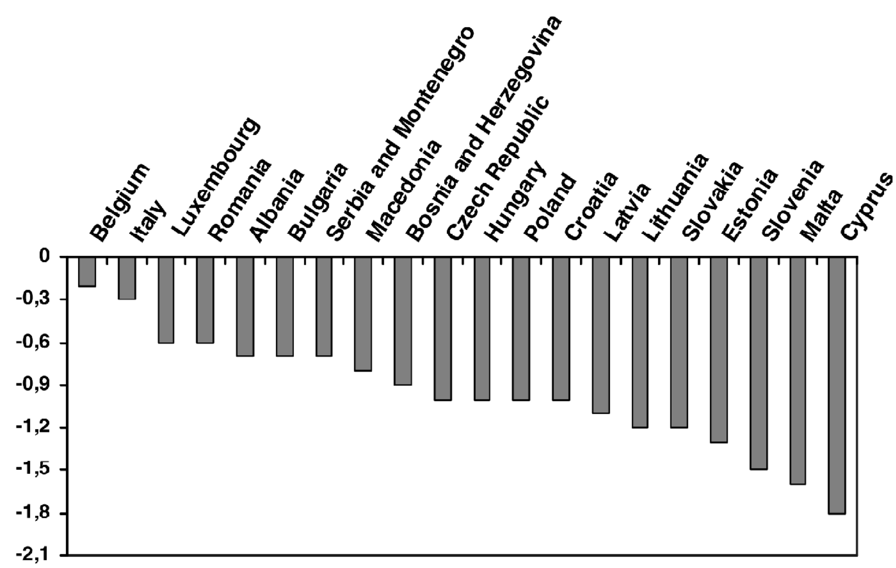

Figure 2b: Speed of Divergence $(\hat{\lambda} < 0)$

persistence of inequalities between the European countries. Furthermore, the overall results do not change by controlling for certain number of variables usually identified as determinants of economic growth. More particularly, the new variables (i.e., the rate of investment, the population growth rate and the rate of employment) do not weaken the estimates of the speed of inequality convergence, and do not improve substantially the fit of the regressions.[8]

CONCLUSION

In this study, we presented a first attempt to model the convergence of inequalities in per capita GDP. The originality of our approach is to consider the convergence of contributions to global inequalities of nations, compared to the classical approach of convergence of income (see Barro and Sala-i-Martin, 1991, 1992, 1995). Our empirical investigations were conducted on a panel of 32 countries (EU-25 plus seven Balkan countries) that covers the period 1989-2002.

The results show the emergence of a tendency toward the persistence of contributions to global inequalities of European countries. However, this persistence hides important processes of convergence/divergence, which give rise to stationary situations of inequality. As a matter of fact, the hypothesis according to which the process of convergence proceeds at different speeds in different countries is confirmed by our results. The speed thus varies from 5.6% (for Germany) to –2.1% (for Luxembourg) within EU-15 framework. By observing the convergence of contributions in EU-25 and in EU-32 countries, we find that the speed decreases: it is of 2.1% and 1.6% for Germany and of -1.5% and -1.8% for Cyprus. The initial level of GDP per capita is a deceleration factor of convergence speed, while initial technological capacities appear as an acceleration factor. In other respects, the conditional model confirms the hypothesis according to which countries approach different levels of equilibrium. Thus, it appears that the effect of contributions to technological inequalities is indirect. This suggests that rich countries contribute positively to global inequalities during their technological development.

The results obtained in this paper constitute a contribution to the studies on the convergence of countries. Our approach deals with the evolution of inequalities between countries, and on the efficiency of European policies. The weakness of the process of convergence and the persistence of disparities suggest that other structural changes should be considered to ensure convergence (reduction in the innovation costs, technological creativity, etc.). A reorientation of policies aiming at the reduction of inequalities needs to be considered. Finally, based on our approach, numerous directions of research emerge. It would be interesting, for example, to study in more depth the interactions between income inequalities and technological inequalities. The patent applications used to calculate the latter remain partial indicators (see Basberg, 1987; Griliches, 1990). It would be interesting, then, to extend the analysis by considering other indicators such as the R&D activities, the scientific publications, etc.

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Notes

1. The hypothesis according to which $\alpha_1 < 0$ corresponds to a profound transformation contributions in such a way that countries which present initially a negative contribution, will in the end present a positive contribution and vice-versa. This situation does not seem to be very plausible in the short term.
2. To estimate the model under the hypothesis that some regressors are exogenous, it is necessary to use the methods of instrumental variables (see Baltagi, 2001, pp. 118-125). The difficulty of this method consists in finding enough instruments independent of the national effects to identify all the structural parameters.
3. In particular, in 1989 the Theil index was 0.070 with a variance $s_{1989}^2 = 0.119$ and $n_{1989} = 15$ countries, while in 2002 the Theil index was 0.065 with a variance $s_{2002}^2 = 0.171$ and $n_{2002} = 15$ countries. Hence, the absolute value of the test statistic is $|\hat{t}| = |d| / s_d \cong 0.035$, d = 0.065-0.070=-0.005, $n = n_{1989} = n_{2002} = 15$, $s_d \cong 0.144$ where $s_d = \sqrt{s_{1989}^2 + s_{2002}^2 / n - 1}$. So, as $|\hat{t}|$ is lower than the critical value of the *t*-distribution, one cannot reject the null hypothesis that the difference *d* is statistically significant. Note that we cannot reject also the null hypothesis of the equal variances as the ratio $\hat{F} = s_{1989}^2 / s_{2002}^2$ is not significantly different from 1.
4. However, there is insufficient evidence to say that the difference is statistically significant.
5. Our empirical applications were made using Software Rats Version 5.
6. In particular, the hypothesis '$\alpha_1 = 1$' is not rejected at 5% significant level for EU-15 and EU-25 (the *t*-Student are respectively 1.04 and 1.66), and it is close to the rejection for EU-32 (the *t*-Student is in the order of 1.96).
7. The test is based on the difference between the within estimator of the fixed effects specification (not reproduced here in order to lighten the presentation) and the GLS estimator of the random effects specification.
8. In order to lighten the presentation, these results are not reported here, but are available from authors on request.

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