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Abstract

The objective of this paper is to question the conventional convergence literature, which bases its findings on the use of linear regression models. With the use of quadratic WLS regression analysis we show that a number of indicators of economic performance follow a pattern of change that is in essence non-linear. Our results indicate the formation of two clubs at the world scale: A convergence club that includes countries with a low to medium-high level of development and a divergence club including countries with a medium-high to very high levels of development. After a critical threshold the forces of divergence at the world scale dominate and the most dynamic countries eventually grow faster. Undoubtedly, the formation of a diverging leaders club and a further increase in world level development gap has serious implications for theory and policy.

1. Introduction

One of the most important questions of economic growth literature is this of economic convergence or divergence across different geographical units. The convergence argument refers to a process whereby the less advanced economies achieve higher rates of economic growth compared to the more advanced ones, and as such inequalities are reduced over time. In turn, divergence indicates that the opposite forces are in play sustaining or increasing income disparities between economies.

The debate of convergence or divergence of per capita income across countries has received considerable attention in the literature, especially during the last couple of decades, giving rise to a growing number of studies. However, empirical evidence on the issue has been mixed, affected to a great extent by the methodology chosen for investigation.

The objective of this paper is to question the findings of the convergence literature using linear-function, ordinary least squares (OLS) regression models. We claim that the aforementioned literature has failed to establish robust relationships between initial per capita income and economic growth because these relationships are fundamentally nonlinear. On these grounds, we introduce polynomial (quadratic-function) weighted least square (WLS) regression analysis to explore whether a number of indicators of economic performance follow a pattern of change that is in essence non-linear. The findings of the research are expected to shed light on a number of important questions, regarding the prospects for world level economic convergence, the decrease of regional disparities with respect to income levels and the development of a more equal world. Undoubtedly, these answers have serious implications for both theory and policy.

The paper is organized as follows. Section 2 briefly presents the theoretical arguments gave rise to the convergence/divergence debate. Section 3 outlines the methodologies developed to explore the issue and provides a short review of the most important empirical studies conducted over the last years. Section 4 discusses the main shortcomings of cross-country OLS, linear, regressions analysis and section 5 investigates econometrically non linear relationships at a global scale. Finally, Section 6 summarises the findings to provide some tentative conclusions.

2. Theoretical perspectives and the convergence debate

The starting point of conventional economic growth theorisation is the neoclassical model of Solow (1956). The basic assumptions of the model are: constant returns to scale, diminishing marginal productivity of capital, exogenously determined technical progress and substitutability between capital and labour. As a result the model highlights the savings or investment ratio as important determinant of short-run economic growth. Technological progress, though important in the long-run, is regarded as exogenous to the economic system and therefore it is not adequately explored by this model.

Following Solow (1956), proponents of the neoclassical paradigm argue that disparities are bound to diminish with growth (see Barro and Sala-i-Martin 1995, for a review). Mainly due to diminishing capital productivity imposed by constant returns to scale, the further away an economy is from its steady-state level of capital, the faster will be the growth of income levels. In other words, economies converge towards their steady states at a declining growth rate. If economies are homogeneous (identical technology, savings rate, population growth rate and depreciation rate), convergence can occur in an absolute sense since they will converge towards the same steady-state. Conversely, if economies are heterogeneous, convergence may occur only in a conditional sense since economies will grow toward different steady-state positions. In this case, diminishing returns to capital do not necessarily lead to diminishing dispersion of income.

The role of technological progress as a key driver of long–run economic growth has been put in scrutiny by more recent studies, which accept constant and increasing returns to capital. These theories, known as endogenous growth theories, propose that the introduction of new accumulation factors, such as knowledge, innovation, and the like, will induce self-sustained economic growth. Triggered by Romer's (1986) and Lucas's (1988) seminal studies[1], work within this framework highlighted three significant sources of growth: new knowledge (Romer, 1990, Grossman and Helpman, 1991), innovation (Aghion and Howitt, 1992) and public infrastructure (Barro, 1990)[2]. As a result, and in contrast to the neoclassic counterpart, policies are deemed to play a substantial role in advancing growth on a long-run basis. Turning to the convergence/divergence debate, the endogenous growth models suggest that convergence is unlikely to occur when increasing returns to scale and knowledge spillovers prevail.

3. The convergence/divergence debate: methodologies and empirical evidence

Whether economies converge or diverge over time is a topic of great importance for both theory and policy (Sala-i-Martin, 1996; de la Fuente, 2000). In particular, evidence of convergence illustrates the validity of the neoclassical growth theory contesting the

[1] Romer (1986) presented a formal model that yields positive, long-run growth rates on the basis of technological progress driven by the role of externalities, arising from learning by doing and knowledge spillover. Lucas (1988) introduced a model in which human capital plays a fundamental role in perpetuating economic growth and preventing diminishing returns to physical capital accumulation.

[2] It is important to note that these factors have already been identified in the literature before, but it is the first time that they are formalised and modelled.

importance of economic policy at all levels. In turn, indications of divergence (or even, very slow convergence) favour explanations postulated by endogenous growth theories and support the development and reinforcement of economic policies in order disparities to be reduced.

This section discusses the main concepts developed in the literature and assesses the methods used to determine whether convergence or divergence between economies is evident, to set the basis for the critique of linear modelling that takes place in the following section.

The methodological basis used to explore convergence or divergence between economies comes basically from the neoclassical paradigm. This is why convergence is set as the null hypothesis and divergence as the alternative one. Five main concepts of convergence have been developed in this literature: unconditional β-convergence, conditional β-convergence, σ-convergence, stochastic convergence and club convergence. Unconditional β-convergence assumes that all economies are structurally identical. They are characterized by the same steady state and differ only by their initial conditions of per capita incomes. This concept implies that poor economies grow faster than rich ones and therefore, over a long period of time they converge to the same level of per capita income. This kind of convergence generally is tested by regressing the growth in per capita GDP on its initial level for a given set of cross-section data. Unconditional β-convergence among countries is observed when a negative and significant relation is found between the growth rate of income per capita and the initial level of income.

When differences in economic conditions between places are accepted (like in the level of technology, savings ratio, etc.), economic units may still converge but towards different steady states of growth. This supports the case for conditional β-convergence where the correlation between growth and initial income is negative, under the assumption that the influence of these factors is held constant (partial correlation) (Barro and Sala-i-Martin, 1991, 1992). Thus, it can be said, that while the existence of absolute β-convergence implies that less advanced economies tend to catch up with more advanced ones, the existence of conditional β-convergence implies that each economy converges to its own steady state. The steady states are usually proxied by a number of additional (economic, structural or demographic) explanatory variables in the regression. It is worth noting that this kind of convergence can be assumed even when income disparities between countries are stabilising or increasing over time.

The third concept that has been used in the literature is called σ-convergence and examines the dispersal of income at a given moment in time. Thus, convergence is accepted if the dispersion (measured terms of the coefficient of variation) of real per capita income among economies falls over time (Barro and Sala-i-Martin, 1995). Quah (1993a,b) stress the importance of σ-convergence (over β-convergence) since it speaks directly as to whether the distribution of income across economies is becoming more equitable. However, β-convergence analysis has dominated the growth literature because it is considered a necessary (though not sufficient) condition for σ-convergence (Barro and Sala-i-Martin, 1995).

Another concept developed to examine the convergence/divergence hypothesis is this of stochastic convergence. This concept makes use of the econometric methods of time series and relies on the notions of unit roots and cointegration. In empirical terms, several studies have examined convergence hypothesis with these methods (see for example, Bernard and Durlauf, 1995 and Evans and Karras, 1996). Time series tests are generally more severe and usually reject unconditional convergence even among homogenous countries.

The final concept developed to assess the convergence hypothesis is termed club convergence. It is based on theoretical models that yield multiple-steady-state equilibria and classify countries into different groups with different convergence characteristics (Azariadis and Drazen, 1990; Galor, 1996). Club convergence implies convergence to a common level only for countries that are both identical in their structural characteristics and similar in their initial conditions. The empirical studies on club convergence have used various methods of analysis. Quah (1993b), for instance, employed the distributional approach to convergence based on Markov chains (a method that concentrates directly on the shape of the cross-section distribution of per capita income), whereas Durlauf and Johnson (1995) used regression tree analysis, Hansen (2000) relied on threshold regression and Liu and Stengos (1999) employed the semiparametric partially-linear method. Close to our study is this of Baumol and Wolff (1988) who used the quadratic form of Barro and Sala-i-Martin's equation to show the existence of two convergence clubs: a high income and a low income club.

Having outlined the methodologies used to explore convergence or divergence between economies, the discussion now turns to review the most important empirical studies conducted over the last years.

The recent interest in the convergence question was triggered off by a study conducted by Baumol. Baumol (1986) found an inverse correlation between initial productivity levels and productivity growth rates (unconditional convergence) among a subset of 16 developed countries over the long term period 1870-1979. However, when the sample was enlarged to include less developed countries, convergence could not be found. In other words, this study reached the conclusion that the advanced countries in the world appear to converge with each other, while the world as a whole does not. A subsequent research by Barro and Sala-i-Martin (1992) and Mankiw *et al* (1992) confirmed Baumol's finding across a wide sample of 98 countries in the period 1960-1985. In addition, Barro and Sala-i-Martin (1992) found evidence of conditional convergence when human capital is included into the econometric model, a result that is compatible with the traditional neoclassical model.

In the years that followed, numerous studies on convergence were published providing mixed evidence. Table 1 summarises some of the most significant. The most important conclusion that can be drawn from this review table is the lack of unconditional convergence for heterogeneous countries. Moreover, conditional convergence seems to be a very robust result independent of the method, time period and data set used.

As regards the results each method provides, they are as follows. Cross-section studies report a convergence speed of around 2% per year, as suggested by the neoclassical growth model. Panel data methods indicate a higher convergence speed, while time series tests are more severe and tend not to give support to the convergence hypothesis even in homogeneous countries. In turn, studies relying on the distribution dynamics approach usually support twin peaks.

Table 1: Convergence studies

Study	*Number of countries*	*Method*	*Time period*	*Unconditional or Conditional*	*% convergence*

Dobson and Ramlogan (2002)	20 OECD	cross-section	1970-1998	Unconditional	Divergence
				Conditional	Divergence
Mankiw *et al* (1992)	98	cross-section	1960-1985	Unconditional	Divergence
	75				Divergence
	22 OECD				1.67%
	98			Conditional	1.37 %
	75				1.82%
	22 OECD				2.03%
Jones (2002)	ECOWAS	cross-section	1960-1990	Unconditional	1,7%
Engelbrecht and Kelsen (1999)	APEC	panel data	1960-1990	Unconditional	1.00%
				Conditional	3%
Barro (1991)	98	cross-section	1960-1985	Unconditional	Divergence
				Conditional	1.00%
Salla-i-Marin (1995, 1996)	110	cross-section	1960-1990	Unconditional	Divergence
				Conditional	1.30%
	22 OECD			Unconditional	1.40%
				Conditional	2.90%
Ritchard *et a*l (2002)	22 OECD	panel data	1950-1990	Unconditional	2-4%
Di Liberto and Symons (2003)	23 OECD	ML	1950-1990	Unconditional	2.80%
Linden (2000)	16 OECD		1900-1997	Unconditional	
Molinas (1996)	24 OECD	cross-section	1960-1990	Conditional	2.30%
Caselli *et al* (1996)	98	panel data	1960-1985	Conditional	10.00%
Quah (1993)	118	Distributional dynamic	1962-1985	Unconditional	Club Convergence
Islam (1995)	98	panel data	1960-1985	Conditional	4.3-5%
	22 OECD				7-9%
Canova (1999)	21 OECD	predictive density	1951-1985	Unconditional	Divergence
De la Fuente (1995)	21 OECD	pooled data	1963-1988	Conditional	1.5-2.4%
Murthy and Ukpolob (1999)	37 African	cross-section	1960-1985	Conditional	1.7%
Cole and Neumayer (2003)	110	cross-section	1960-1996	Unconditional	Divergence
		cross-section (WLS)			Convergence
Amplatz (2003)	17 CEE	Markov chain	1996-2000	Unconditional	Club Convergence
De la Fuente (2000)	21 OECD	pooled data	1960-1985	Unconditional	NO
				Conditional	2%
Tsangarides (2002)	42 African	Panel (GMM)	1960-90	Conditional	14%
	22 OECD				13%
Bernard and Durlauf (1996)	15 OECD	times series	1900-1987	Unconditional	NO
Strazicich *et a*l (2004)	15 OECD	time series	1870-1994	Unconditional	Convergence
Le Pen (2005)	5 industrial	time series	1870-1994	Conditional	Convergence
Jen-Je Su (2003)	15 OECD	time series	1900-1987	Unconditional	NO
Evans and Karras (1996)	54	time series	1950-1990	Unconditional	NO
				Conditional	Convergence

Source: Own elaboration

4. A critique of growth and convergence econometric models

Even since 20 years ago where the seminal studies of Kormendi and Meguire (1985), Grier and Tullock (1989) and Barro (1991) had been published, researches were confident that econometric analysis can provide a rigorous and robust way to explore the determinants of economic growth. The development of more advanced econometric and statistical techniques and the provision of larger databases over the following years have boosted their confidence resulting in an increased number of studies. However, both growth and convergence linear regression analyses suffer from a number of weaknesses which are concisely addressed in this section.

An important weakness of cross-country regressions is the uncertainty of the developed models resulting from the high volume of independent variables (and factors) examined. The problem is caused, to a great extent, by the absence of unifying, generally-accepted, formal theory of economic growth. As a result, determinants have mutli-theoretical bases, drawn, in many cases, from other than economics disciplines such as political science and sociology. In other words, econometric analysis rather than theory indicates which determinants of economic performance are important, something which is heavily affected by the combination of variables put into the regression analysis. Up to now, the number of determinants that have been used in the empirical literature is over 150 and the majority of them have been found to be statistically significant (Duraluf *et al*, 2005). However, Levine and Renelt (1992), using a version of Leamer's (1985) extreme bounds analysis and a cross-section of 119 countries during the period 1960-1989, conclude that very few of these determinants are robust and capable of explaining the long run growth rate,. On the contrary, Sala-i-Martin (1997) expresses the view that the criterion employed by Levine and Renelt is too restrictive for any variable to pass the test. When a less restrictive criterion is used, the number of variables that are strongly related to growth increases substantially.

Some other significant weaknesses of the econometric analysis both for growth and convergence models include parameter heterogeneity, outliers, endogeneity, measurement errors and error correlation (see Durlauf and Quah, 1999 and Temple, 1999 for reviews). Heterogeneity is closely related with the basic hypothesis of cross-country regression analysis that growth qualities are the same for any country. However, this is the exception rather than the rule. Panel data models with stochastic parameters could give a reliable solution but they demand long time series data, which are unavailable for many countries.

Outliers may also be a problem requiring caution in the interpretation of results or in the selection of regression samples. A solution here is robust estimation procedures. Measurement errors are another issue, which is related to imprecise measurement of the factors examined. Although proxies are generally used, the danger of erroneous interpretations is apparent. Sensitivity analysis can be applied to reduce such effects. Endogeneity, closely related with model uncertainty, is a serious problem because several variables are bi-directional leading to causation links. The use of instrumental variable may alleviate, but not completely eliminate, this problem. Finally, error correlation exists since the disturbances in regressions may not be interpedently distributed. A reliable solution here includes the use of spatial econometric methods (Anselin, 1998).

Concerns have also been raised in the literature with specific reference to the β-convergence models. Petrakos *et al* (2005) argue that these models are unable to capture potential short-run effects of business cycles on growth. However, capturing business cycles is necessary because their timing varies across countries and therefore, convergence or divergence trends heavily depend on the choice of time intervals. In addition, they point out that the use of β-conditional models to study the convergence process is also problematic by their nature, and, thus, misleading. This is because the economic, structural or demographic variables included in the analysis remove the influence of structural characteristics and find tendencies of convergence among economies that do not exist in reality. That is why in many cases, conditional β-convergence findings coincide with unconditional β-divergence.

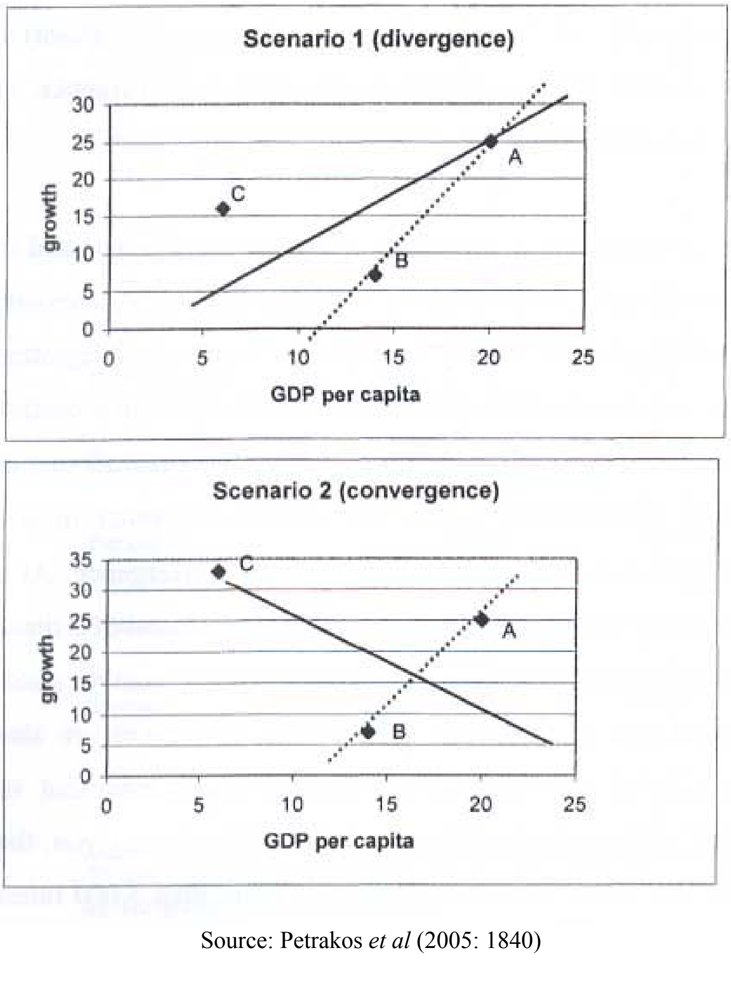
Furthermore, Petrakos *et al* (2005) and Artelaris and Petrakos (2006) consider another major drawback of conventional OLS econometric models. They argue that growth and β-convergence models by overlooking the relative population size of each region and treating all observations as equal may come to erroneous conclusions. Their point can be illustrated with the following example. Table 2 provides the relevant data for three hypothetical regions, one of which is very small in size, while Figure 1 depicts their scatter plot of unconditional β-convergence. The two growth scenarios make clear that the performance of the tiny region (region C) can highly affect the overall conclusion of the model regarding whether convergence or divergence is occurring. Although region A is more advanced and grows faster than region B, signalling a clear case of regional divergence (see dotted line in Figure 1), the model may not produce a positive slope coefficient if the performance of region C is also accounted for. Thus, under scenario 2 (Figure 1), the model fails to see a clear case of divergence, where the metropolitan region A grows faster than region B, because region C blurs the picture. To overcome the problem, Petrakos *et al* (2005) suggest the use of weighted coefficients of variation (CVw) as a measure of inequality, which, taking into proper account the relative importance of regional size, indicates that divergence is the prevailing tendency.

Table 2: Ill-detected convergence due to heterogeneous samples in terms of size

Regions	Population (Million)	GDP per capita in period t (Million$)	GDP per capita growth in period [t, t+k] (%) (Scenario 1)	GDP per capita growth in period [t, t+k] (%) (Scenario 2)
A	4	20	25	25
B	1.5	14	7	7
C	0.1	6	16	33
CVw		0.44	0.52	0.49

Source: Petrakos *et al* (2005: 1840)

Figure 1: Ill-detected convergence due to heterogeneous samples in terms of size



Source: Petrakos *et al* (2005: 1840)

From the above discussion it becomes clear that the inability of conventional β-convergence models to take the relative size of observations into consideration may lead to erroneous results. This issue has been almost completely ignored in the literature with the exception of Sala-i-Martin (2003) and Firebaugh (2003). They support the view that if the goal of a study is to test for different growth models, then each national economy should be weighted equally and treated as a single unit of observation (i.e. unweighted measures of inequality are more suitable). But if the goal is to explore issues related to people's income and to make inferences about inequality, then the use of weighted measures is more appropriate. Unweighted measures can capture the effect of changing income ratios but miss the effect of changing population shares, while weighted ones capture both. Empirical analysis, at the international level, reveals that these measures can lead to extremely different conclusions about inequalities: when unweighted GDP per capita is used, both standard deviation (σ-convergence) and inequality increase while when countries are weighted by population size, both standard deviation and inequality decline (Sala-i-Martin, 2002; Firebaugh, 2003; Wade, 2004). The same pattern is found when β-convergence model is used: unweighted β-convergence model (OLS) shows divergence whereas population weighted β-convergence model (WLS) attests convergence (Cole and Neumayer, 2003).

4. Exploring non-linearity in convergence models

This section examines whether various indicators of economic performance follow a non-linear pattern of change. For this purpose, WLS regression analysis is conducted exploring both linear and quadratic functions for a cross-section of countries. The period examined is from 1990 to 2004, were data are available.

The indicators of economic performance that we have examined are first, the real *GDP per capita* and, second, a number of composite variables measuring economic dynamism, called Economic Dynamism Indicators (EDIs), which have been developed by Arvanitidis and Petrakos (2007).

Arvanitidis and Petrakos (2007) have defined economic dynamism as the potential an area has for generating and maintaining high levels of economic performance mainly due to its knowledge capacity. Informed by the relevant literature (such as Chen and Dahlman, 2005), we identified four key dimensions of the concept: economic performance, human capital, innovation ability and access to information. The variables that were selected (on the basis of availability and reliability of the source[3]) to reflect these dimensions are: *real GDP per capita* (Y), *real GDP per capita annual growth* (g), *Gross enrolment ratio in tertiary education* (EDU), *R&D expenditure as a percentage of GDP* (RD) and *Internet users per thousand inhabitants* (W). However, these variables were not treated equally. In particular, the weighting applied in constructing the EDIs reflects the idea that economic dynamism is primarily the result of current economic performance which, however, has to be adjusted for the 'knowledge' characteristics of the economy and its past 'momentum' (i.e. the economic growth achieved). The knowledge and growth components were given equal weight.

Overall, we calculated the EDIs according to the following formula: $\mathrm{EDI} = \mathrm{Y} * \left(1 + SV\sum_{i=1}^{n} SVx_{\mathrm{i}}\right)$, where Y reflects the current economic performance (measured by real GDP per capita) and x_i refers to the adjusting component i (i.e. the knowledge elements and growth) which is standardised[4] with the 'minimum-maximum' method according to the formula $SV = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}}$ (where x_{min} is the lowest and x_{max} the highest values of the sample).

The choice of the specific EDIs to be used in the current study was made on the basis of data availability and sample-size adequacy. Three different EDIs were selected, each one reflecting a different component mix. Thus, the first EDI accounts only for past economic growth, the second adds the element of human capital and the last takes into account all economic dynamism dimensions.

To explore our hypothesis we develop two econometric models for each variable under examination: one with a linear regression function (which is a typical unconditional β-convergence model) and another with a quadratic polynomial regression function.

[3] Again, the data used are from from the World Bank database and cover the period 1990–2002.

[4] This is necessary since the variables are measured in different units.

All regressions were estimated using weighted least squares (WLS). As discussed above, the majority of econometric studies tend to overlook the relative population size of each country treating all observations as equal (for exceptions see Edwards, 1998; Folster and Henrekson, 1999; and Grier and Tullock, 1989). Yet, countries vary widely in terms of population at international level. WLS allow countries to have an influence on regression results which is analogous to their size, via the weight matrix W. The population of each country can be used as the diagonal element in the weighting non-singular positive definite matrix, which has zero off-diagonal elements.

Conventional (linear-function) convergence econometric models have the following form:

$$g_i = \alpha + \beta y_i + \varepsilon_i \qquad i = 1, 2, \ldots, n$$

where g_i is the average growth rates of the explanatory variable in the [0, T] period for the n countries; y_i is the explanatory variable at date 0; ε_i is the error term ($\boldsymbol{\varepsilon} \sim N(0, \sigma^2)$); and α and β are parameters to be estimated. The former (α) is a constant term and the latter (β) is the coefficient of the explanatory variable. As discussed, a negative and significant β coefficient indicates unconditional β-convergence across countries, in a given time period, while a positive sign indicates unconditional β-divergence.

In turn, econometric models with a 2nd-order polynomial (quadratic) regression function take the form:

$$g_i = \alpha + \beta y_i + \gamma y_i^2 + \varepsilon_i \qquad i = 1, 2, \ldots, n$$

where g_i is the average growth rates of the explanatory variable in the [0, T] period for the n countries; y_i is the explanatory variable at the beginning of the period examined; ε_i is the error term ($\boldsymbol{\varepsilon} \sim N(0, \sigma^2)$); and α, β and γ are parameters to be estimated. The curve of a quadratic function is a parabola. If parameter β is negative and γ is positive the parabola opens upward; if β is positive and γ is negative the parabola opens downward. In terms of convergence-divergence this implies the development of two clubs of countries at the world scale. In the former case (negative β and positive γ), countries converge up to a threshold, while divergence trends dominate afterwards. In turn, a positive β and a negative γ indicate divergence of counties for values of the explanatory variable that are below a threshold point, followed by convergence of the most dynamic economies. The first derivative of the quadratic function indicates this threshold, which is the turning point of the parabola (vertex) and equals $-\frac{\beta}{2\gamma}$.

The results of the models produced are provided in Table 3 below, which omits the presentation of constant term's estimators for simplicity. For each model we report the estimated coefficients, their t-statistics, the number of observations, the turning points of the quadratic functions, the adjusted R^2 value of the regressions, and three measures of the goodness of fit of the estimated models. These are the log-likelihood value (logL), the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). Given any two estimated models, the model to be preferred is the one with the highest logL value, or the lower AIC or SIC values.

Table 3: Exploring non-linearity in convergence models

Indicators of economic performance examined	*Models*	*β*	*t-stat(β)*	*γ*	*t-stat(γ)*	*Turning point*	*N*	*Adj R^2*	*Log likelihood*	*Akaike Information Criterion*	*Schwarz Information Criterion*
Real GDP per capita (Y)	Linear	-4.53E-06	-4.493763				152	0.897137	13.89893	-0.15656	-0.11677
	Quadratic	-2.40E-05	-4.049818	6.95E-10	3.331926	17266.19		0.903627	19.36053	-0.21527	-0.15558
Y[1+*SV*(g)]	Linear	-2.85E-06	-4.02391				143	0.911694	25.16246	-0.32395	-0.28251
	Quadratic	-1.20E-05	-2.29346	2.42E-10	1.7642	24793.39		0.913614	26.73460	-0.33195	-0.26970
Y[1+*SV*Σ*SV*(g, EDU)]	Linear	-1.06E-06	-3.16895				146	0.978164	71.96965	-0.95840	-0.91753
	Quadratic	-5.49E-06	-2.79621	8.14E-11	2.286468	33722.36		0.978000	74.99595	-0.97438	-0.91307
Y[1+*SV*Σ*SV*(g, EDU, RD, W)]	Linear	-3.94E-06	-8.184496				43	0.983042	32.60648	-1.42355	-1.34164
	Quadratic	-1.57E-05	-5.535189	2.12E-10	4.186470	37028.30		0.987914	40.41234	-1.74041	-1.61753

Source: Own elaboration (data acquired from World Bank and Barro-Lee databases)

The examination of the economic performance indicators, in Table 3, reveals a number of interesting points. In particular, all linear-function models produce a negative and significant (at or below the 10% level) β coefficient, indicating that a catching up process is in motion. This means that the less advanced economies achieve higher rates of growth compared to the more advanced ones; so, over the years, the former see their income levels to converge to the income levels of the latter (i.e. unconditional β-convergence across countries is confirmed).

However, the picture changes when we allow for non-linearity in the growth patterns of the economic performance indicators that we examine. The positive γ coefficient indicates that convergence occurs up to a threshold level (the turning point in Table 2), beyond which divergence trends appear. This means that countries with higher-to-the-threshold initial performance grow faster compared to the others, increasing the world gap between the less and the more advanced economies.

Overall, we verify the existence of two clubs of countries concerning economic development prospects: a convergence club that includes countries with lower-to-the-threshold development levels and a divergence club including countries with levels of development above the threshold point.

Countries of the first club (i.e. those with low-to-medium levels of development) are more likely to be characterized by a productive system where resource-intensive activities dominate, markets are relatively sallow or fragmented, inefficient institutional structures, while quality, diversity and factor augmenting technology are limited. These characteristics possibly describe a constant-returns-of-scale environment, where capital productivity is declining. As a result, in low-to-medium stages of development convergence forces dominate and the least advanced economies grow faster.

In turn, the productive system of the countries of the second cub is more likely to be characterized by economies of scale, positive externalities and agglomeration, higher levels of R&D, higher quality of human resources, more advanced market structure, better mix of activities, larger size and more committed-to-development institutional structures. The combination of these characteristics may generate a favorable environment where increasing returns and home-market-effects yield over time increasing growth rates. Consequently, in medium-to-advanced stages of development divergence forces dominate, as the leading economies grow faster.

As regards the critical threshold values for each indicator they appear to be around: 17,000 in *real GDP per capita (in PPP)*, 25,000 in the EDI that accounts only for the past economic growth, 34,000 in the EDI that accounts both for the past economic growth and for the human capital element, and 37,000 in the EDI that takes into account all economic dynamism dimensions.

Turning to the goodness of fit indicators, we observe that quadratic functions consistently produce higher logL value and lower AIC and SIC values, as compared to those of the linear function, indicating the supremacy of the former models over the latter.

5. Conclusions

The paper has questioned the empirical findings of the conventional convergence literature using OLS linear-function models. To this purpose it introduced polynomial (quadratic) WLS regression analysis to show that a number of indicators of economic performance follow a pattern of change that is in essence non-linear. As Baldwin and Sbergami (2000) and Marino (2004) argue, allowing for non-linearity does have substantial empirical, theoretical and policy implications. Three particular points drawn by this paper need to be emphasized.

First, the higher explanatory power of the non-linear models indicates the formation of two clubs at the world scale. On the one hand there is a convergence club that includes countries with a low to medium-high level of income, and on the other, there appears to be another group of countries, of medium-high to very high levels of income, with diverging dynamics. This implies that there is a threshold level of development above which countries eventually grow faster and as a result divergence trends appear. This casts doubt on the prospects for world level convergence and the emergence of a more equal world.

Second, both the neoclassical argument and the endogenous growth theories receive empirical support, although their explanatory power seems to be stronger in different stages of development. The results tend to indicate that the neoclassical setting has a greater potential to explain growth performance in low-to-medium levels of development, while the endogenous growth type of theoretical setting in medium-to-high levels. In particular, the neoclassical type of forces, such as constant returns to scale and diminishing productivity or low factor cost dominate up to a critical development threshold, leading to convergence. After that, home-market effects, scale effects, heterogeneity and externalities gradually dominate and allow advanced areas to grow faster than areas in intermediate levels of development. On these grounds we assert both processes of convergence and divergence may co-exist at all levels of development, but in different proportions and with different strength. This mix of convergence/divergence forces changes, as the development levels of countries change.

Finally, an increase in the world-level development gap has serious implications in terms of policy. Although there might be positive spillovers spreading growth from the more to the less advanced economies, they are incapable of bringing the system into a state of balance, if market forces alone are left at work. In other words, economic policy has to come into play to correct those imbalances. If not, there is a danger that increases in income disparities will trigger new waves of South-North and East-West migration at the global scale, putting pressure on western societies and requiring costly policies of safeguarding or sealing borders. It will also trigger radicalism, militarism and political instability in sensitive areas in Asia and Africa and contribute to a vicious circle of income disparities, radicalism and migration.

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