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Gianfranco Di Vaio
Research and Studies Area. Cassa Depositi e Prestiti, Rome, Italy
Center for Labor and Economic Growth, LUISS Guido Carli, Rome, Italy
Rimini Centre for Economic Analysis, Rimini, Italy

Kerstin Enflo
Department of Economic History, Lund University, Lund, Sweden

DID GLOBALIZATION DRIVE CONVERGENCE? IDENTIFYING CROSS-COUNTRY GROWTH REGIMES IN THE LONG RUN

The Rimini Centre for Economic Analysis
Legal address: Via Angherà, 22 – Head office: Via Patara, 3 - 47900 Rimini (RN) – Italy
www.rcfea.org - secretary@rcfea.org

Did Globalization Drive Convergence? Identifying Cross-Country Growth Regimes in the Long Run*

Gianfranco Di Vaio[†‡§] Kerstin Enflo[¶]

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Abstract

This paper is the first to apply a finite mixture model to a sample of 64 nations to endogenously analyze the cross-country growth behavior over the period 1870-2003. Results show that growth patterns were segmented in two worldwide regimes, the one characterized by convergence in per capita income, and the other by divergence. Interestingly, when three historical epochs are distinctly analyzed, in order to investigate the empirical link between globalization and convergence, the dynamics which dominated over the whole period seem to have emerged only during the post-1950 years. In contrast, the First Global Wave was marked by persistent heterogeneities.

Keywords: Globalization; Economic growth; Income convergence; Multiple regimes; Mixture models.

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†Research and Studies Area. Cassa Depositi e Prestiti, Via Goito 4 - 00185 Rome, Italy. Tel.: +39 0642213043. Fax: +39 0642212021. E-Mail: gianfranco.divaio@cassaddpp.it.

‡Center for Labor and Economic Growth, LUISS 'Guido Carli', Rome.

§Rimini Centre for Economic Analysis.

¶Corresponding author. Department of Economic History, Lund University. Address: Box 70 83, 220 07 Lund, Sweden. E-Mail: kerstin.enflo@ekh.lu.se.

1 Introduction

In this paper we introduce a finite mixture model to analyze the cross-country growth patterns in the long run, by using an unrestricted sample of 64 nations over the period 1870-2003. Dividing the full period into three distinct sub-periods characterized by varying degrees of globalization (i.e. 1870-1913, 1913-1950, and 1950-2003), this paper investigates the empirical link between economic integration and income convergence.

The approach followed here has two main advantages with respect to more standard econometric techniques. First, it allows an endogenous (i.e. data-determined) as well as probabilistic assignment of countries across the regimes. This feature is by far more attractive than an exogenous or *ad hoc* selection of the membership, which could be highly sensitive to arbitrariness, data mining, and sample selection bias. Then, the mixture model is appealing, since it makes use of parameter heterogeneity to circumvent the problem of lacking historical data on additional regressors (i.e. pre-1950), which are necessary to control for differences in steady-state income levels. In particular, while fixed-effects panel estimators are able to capture heterogeneities in the constant term, the mixture regression is also able to take into account variations in the marginal impact of the control variables.[1]

Starting with the pioneering studies by Abramovitz (1986) and Baumol (1986), there has been a general consensus that convergence in output per worker, or per capita, took place among the industrialized economies after 1870 (see, among others, Maddison 1987; Feinstein 1988; Broadberry 1993; Tortella 1994; and Toniolo 1998). Economic historians have generally stressed that this process was fuelled by the two globalization stages of the periods 1870-1913 and post-1950, while the inter-war years (1913-1950) were characterized by increased protectionism, slow growth and divergence. Much of the previous evidence, however, relies on the results from the presently industrialized group of countries (the so-called 'OECD-club'), which actually converged ex post. In fact, those nations that have not converged since 1870 have often been excluded from the sample, due to their present relative poverty. This introduces a sample selection problem in long-term convergence studies, as shown by De Long (1988).

Lately, the focus has gradually shifted towards the inclusion of these non-converging economies in the analysis and scholars have come to talk about club convergence. OECD countries are usually seen as a convergence club whose members have been diverging from the rest of the world. This phenomenon has not taken place gradually over time. Rather, club convergence has been associated with the forces of openness and trade related to the two 'Global Waves' of 1870-1913 and post-1950. Consequently, Williamson (1996, p.277) has argued that historical epochs provided an unambiguously positive relationship between globalization and convergence in the Atlantic economy, but not in the world economy as a whole.

Williamson (2008), for instance, adds evidence that, over the period 1870-1939, the

[1] For an interesting discussion about the growing use of latent class models – such as finite mixture models – in growth empirics, see Owen et al. (2009).

terms of trade improvements raised growth in the rich core, although failing to do the same in the poor periphery. These empirical findings confirm the predictions of some recent theoretical models that stress the role of trade for the evolution of the long-term divergence between rich and poor nations. According to Galor and Mountford (2006; 2008), the increase in world trade due to globalization might have affected the growth rate of per capita income asymmetrically according to the comparative advantages of the nations. On the one hand, the resource-abundant countries tended to specialize in the production of primary goods, reducing the incentive to invest in human capital and delaying the demographic transition. On the other hand, the resource-scarce countries specialized in manufacturing, raising the investment in human capital, spurring the demographic transition, and shifting into a sustained stage of growth. Following a similar line of reasoning, Zeira (2009) shows that globalization (i.e. the increase in international trade) can lead to a divergence of income per capita across countries, whenever technology adoption depends on factor prices. In fact, rich countries specialize in the production of skilled goods, inducing in this way a faster technical change, while poor countries produce unskilled goods and thereby experience less technological advance.

Given the recent interest in the existence of diversified growth regimes in the world economy, there is a growing need to empirically verify if club convergence was a long-run phenomenon and when it first occurred. The finite mixture model proposed here is especially useful, since it allows us to endogenously identify unknown clusters in the data, avoiding the imposition of ex ante selection criteria. This implies that we can test for the number of convergence clubs and split the time period of the sample so as to recognize the formation of clusters. The model we test is in the framework of the beta-convergence hypothesis (Barro and Sala-i-Martin 2004), for which we use data on the initial level and growth rate of GDP per capita.

We find that the period 1870-2003 is characterized by the polarization of cross-country growth behavior. Over the long run, the model identifies two regimes. The one basically consists of many of the presently advanced economies and is characterized by convergence of per capita income. The other comprises the rest of the nations and is denoted by divergence and low level of development. This finding is consistent with the long-term view of club convergence. However, when the sample is split up into three historical epochs of global and anti-global waves, we do not find evidence of an early converging club of industrializing countries between 1870 and 1913. We show instead that the converging dynamism of the advanced economies only emerged after World War II. In contrast, despite the openness of capital and labor markets, the First Global Wave exhibits a divergence pattern which is not very different from the experience identified for the interwar years, which were marked by protectionism and closure of the international markets. These results suggest that the two trade booms were not as similar in terms of convergence as has previously been argued.

Our results are partly analogous to those obtained by Epstein et al. (2003), who find that convergence was the key feature of the industrialized economies only during the post-1950 era. However, our methodology differs from their work, since they use distribution dynamics tools (Quah 1993; 1996) for a restricted sample of 17 industrialized nations, whereas we apply a finite mixture model to a larger sample of countries, which is useful for addressing the issues of sample selection bias and parameter heterogeneity, as discussed above. We also consider our approach as being more robust, due to the fact that distribution dynamics approaches can be very sensitive to small numbers of observations, especially in the estimation of the ergodic distribution. The paper is structured as follows: Section 2 focuses on the sources of long-term convergence; Section 3 explains the econometric specification; Section 4 presents the data; Section 5 describes the results; and Section 6 contains some concluding remarks.

2 Sources of long-run convergence

The long-term view of convergence has been central to the writings of economists and economic historians such as Abramowitz (1986) and Baumol (1986). Their studies build on the data set collected by Maddison (1982; 1995), which provides data on GDP per worker and per capita for most of the world's countries from 1870. Williamson (1996) focused on convergence of real wages and other factor prices over the long run. The general picture from these studies is that there have been three distinct eras in global history: 1870-1913, 1913-1950 and post-1950, and that convergence was a key feature during the two global-booms in the late 19th century and after the Second World War.[2]

According to Williamson, 'two important features of the world economy since 1970 also characterized the economy in the late 19th century. First, the earlier period was one of rapid globalization: capital and labor flowed across national frontiers in unprecedented quantities, and commodity trade boomed as transport costs dropped sharply. Second, the late 19th century underwent an impressive convergence in living standards, at least within most of what we would now call the OECD club' (1998, p. 51).

Many other studies have documented that the First Global Wave (1870-1913) was a period of globalization in capital flows, migration and trade. Concerning the capital markets, Obstfeld and Taylor (2004) provide quantitative evidence of a U-shaped evolution of international capital flows over the 20th century, in which the level of foreign-owned capital stocks, relative to the size of the world economy, was about as large in 1900-1914 as it was in 1980 (around an estimated 20 per cent of world GDP). Taylor (2002) also points out that global capital market integration seems to have returned to its pre-1913 level only fairly recently, at least when measured by the relationship between savings and investments, which was tighter in 1913-1974 than before and after.

Similarly, early globalization in world trade has been documented by Feenstra (1998), who shows that the ratio of merchandise trade to GDP in 1913 was not reached again until the late 1960s or 1970s. Estevadeordal et al. (2003) establish a similar trade

[2]The post-war period is often divided into two distinct phases: 1950-1973 and the period post-1973, with this latter being demarked by stagflation, slower growth rates, and the breakdown of the international economic framework established at Bretton-Woods.

pattern and argue that the rise of the gold standard and the fall in transport costs were the main trade-creating forces until 1913. As for labor markets, mass migration has been thoroughly documented for the First Global Wave, as about 55 million Europeans left home for the New World between 1850 and 1914 (Hatton and Williamson 1998).

These strong globalization forces in the pre-1913 period have often been connected to forces of convergence, especially among the countries of today's advanced world. Taylor and Williamson suggest that the period saw dramatic convergence, 'about as dramatic as it has been over the past century and a half', among the present industrialized countries, or an even wider sample of nations (1997, p. 27). This convergence, they assert, was to a large extent accounted for by the massive migration flows from Europe to the New World, which helped to erase productivity gaps in labor productivity and wages. They estimate such large effects of migration on convergence that it must have been offset by countervailing forces. For instance, capital accumulation could have been such a force, since capital chased after immigrants and natural resource exploitation. This implies that capital dampened any downward pressure migration otherwise would have had on real wages in the New World, and that capital inflows financed accumulation, thereby augmenting the labor demand. Thus, even though the conventional Heckscher-Ohlin prediction is that capital and labor flow in opposite directions as a result of trade, the evidence from the First Global Wave conflicts with this mechanism (Hatton and Williamson 2008).

Although factor accumulation patterns did not follow the standard predictions during the First Global Wave, earlier literature has emphasized that accumulation and globalization forces played a much larger role for convergence than the forces of human capital and technological change (Taylor 1999; O'Rourke and Williamson 1997). This may seem surprising, given that in the period 1870-1913, public education was introduced in many European countries and many important technological advancements related to the Second Industrial Revolution appeared during the same period. Taylor (1999, p. 1625), for instance, states that human capital was, if anything, an anti-convergence force between 1870 and 1913, since richer countries like the USA and Australia still had higher school enrollment rates than poorer countries like Sweden and Denmark. However, O'Rourke and Williamson (1997, p. 168) attribute some role to schooling in this period, but point out that the effects on growth and convergence were limited to a smaller number of countries and that globalization forces mattered much more.

Because of the focus on factor accumulation and factor price equalization as sources of convergence before 1913, much of the evidence has rested on data on real wages and labor productivity, only indirectly offering evidence of convergence in GDP per capita. The factor price convergence approach has clear merits when it comes to understanding the mechanisms of labor productivity convergence. Indeed, convergence of productivity, by definition, may be accounted for by either absolute convergence of relative factor endowments or factor prices (i.e. real wages), given that GDP is aggregated by weighting endowments with factor prices, as discussed by O'Rourke et al. (1996, p.500).

In fact, Taylor and Williamson (1997) analyze convergence of wages, GDP per worker and per capita simultaneously, and call upon agnosticism over the variables which provide the 'correct' convergence criterion, although they emphasize that the dynamics of wage and output measures should remain distinct and that the choice of a particular variable should depend on the question under consideration (1997, p. 32). For example, they find that convergence of GDP per capita was slower and less influenced by migration, when compared to convergence of wages and labor productivity. This result is due to offsetting forces inherent in the algebra of their model, in which labor supply losses suppressed output while increasing labor productivity and wages in the Old World (1997, p. 43). In addition, O'Rourke and Williamson (1999) acknowledge that the open-economy mechanisms behind convergence in the late 19th century only influenced GDP per capita indirectly. Still, they maintain that convergence did not only appear in labor markets, but was also extended, albeit at slower rates, to GDP per capita.

To this picture of dispersion, O'Rourke and Williamson (1997) add that there were large variations in growth experiences within the Old World before 1914. For example, although Ireland, Italy and the Scandinavian countries went through a spectacular catch-up with the industrial core, Spain and Portugal lagged behind. The authors also show that globalization was by far the dominant force accounting for these differing economic outcomes, and suggest several hypotheses covering the failure of capital flows to seek out cheap labor, diversities in schooling, and factor market isolation.

In this paper we focus on the broader question of whether convergence was a long-run phenomenon for GDP per capita, acknowledging that factor prices play a role in the explanation of those dynamics. More specifically, we focus on the debate brought about also by Epstein et al. (2003), who questioned whether the period 1870-1914 really was a phase of unconditional convergence of GDP per capita fuelled by globalization, even within the presently industrialized club of nations. Given the recent debate on convergence and globalization from a historical perspective, this paper will explicitly test whether we can endogenously identify the convergence patterns in an enlarged sample of countries during the whole period 1870-2003, as well as during the two subperiods 1870-1913 and 1950-2003, and if an early converging club can be detected for the First Global Wave as well. In doing this, the relationship between globalization and convergence is inferred from the historical periods.

3 Identifying cross-country growth regimes

In order to endogenously analyze the cross-country growth behavior, we make use of a finite mixture of models. The main feature of this approach consists in the ability to uncover heterogeneous growth patterns in the sample, without imposing *a priori* or *ad hoc* assumptions on the adherence of each country to a specific regime.[3] Mixture models or, more generically, latent class models have been employed to test the existence

[3] A brief review of the empirical methods useful for identifying heterogeneity in growth patterns is provided by Durlauf et al. 2005, pp. 616-624.

of heterogeneities in growth experiences due to poverty traps or convergence clubs, following the pioneering work by Quah (1996) which identified the so-called 'twin peaks' in the worldwide distribution of income (see Paap and Van Dijk 1998; Bloom et al. 2003; Bos et al. 2010; and Pittau et al. 2010). This kind of model has also been increasingly applied to fit the distribution of regional incomes, as in Tsionas (2000), Pittau (2005), and Pittau and Zelli (2006).

As far as we know, finite mixture models in the form of mixtures of growth regression have been previously used by Paap et al. (2005), Alfò et al. (2008), Battisti and Di Vaio (2008), and Owen et al. (2009).[4] Paap et al. (2005) apply a latent class analysis to a panel-type growth regression, so as to classify a set of developing economies according to their average growth rates over the period 1961-2000. Alfò et al. (2008) develop a multivariate mixture approach in explaining the heterogeneity of both levels and growth rates of cross-country per capita income to assess the predictive capability of savings and human capital formation rates from 1960 to 1995. Battisti and Di Vaio (2008) implement a mixture of cross-sectional growth regression with the aim of uncovering multiple regimes of per capita income convergence across EU regions for the period 1980-2002. Finally, Owen et al. (2010) estimate a finite mixture model based on the conditional distributions of growth rates, for a broad set of countries for the period 1970-2000, and find evidence of two distinct clubs, each with its own specific growth dynamics.

The perspective adopted follows Battisti and Di Vaio (2008). It is worth mentioning that the model does not explicitly test the so-called 'club convergence' hypothesis. This hypothesis implies that, for each country, the probability of falling into a regime would depend on some specific variables related to the initial conditions of the country, as predicted in multiple equilibria models by Azariadis and Drazen (1990), and Galor (1996).[5] For instance, Bloom et al. (2003) argue that geographical variables, like climate and landlockedness, influence the probabilities of being assigned to a growth regime, while Owen et al. (2009) stress that institutional features of the economy, such as the quality of institutions, play a key role in predicting membership in the regimes. In contrast, we regard the probability of belonging to a growth pattern as a parameter to be optimally estimated in the model. Thus our model can be seen as a more general test of multiple regimes and aims to provide a correct assessment of which countries fall into each specific regime.

Let us assume that, for each country i, the average growth rate of per capita income, $g_i = \left[\ln(y_{i,T}) - \ln(y_{i,0})\right]/T$, between time 0 and T, is given by

$$g_i = \alpha_j + \beta_j \ln(y_{i,0}) + \varepsilon_{i,j}, \text{ with probability } \phi_j, \tag{1}$$

where $y_{i,0}$ denotes the income per capita at the beginning of the period, α_j is a constant related to the steady-state level of income, β_j is the convergence parameter, $\varepsilon_{i,j} \sim$

[4] A general reference to mixture modeling is the classic work by McLachlan and Peel (2000).

[5] One of the first empirical tests of these theories is the work by Durlauf and Johnson (1995), which is based, however, on a regression tree analysis.

$N(0,\sigma_j^2)$ is a random shock affecting the growth rate of the economy, and $j = 1, ..., k$ is the regime which the country belongs to.[6] Expression (1) is usually named 'beta-convergence' equation, after the famous study by Barro and Sala-i-Martin (1992). If β_j is estimated with a negative (positive) sign, the evidence supports the notion that poor countries tend to grow faster (slower) than rich ones and eventually converge to (diverge from) their long-run level of output per capita. As is well known, the estimated convergence parameter is usually biased if the steady-state determinants vary across the economies and are related to the explanatory variables. In this framework, we mitigate this problem by allowing for different intercepts across regimes. The lack of historical data on saving rates and human capital for a large sample of countries prevents us from explicitly controlling for these variables in the regression.

Let g_i be distributed as a finite mixture of conditional univariate normal densities:

$$g_i \sim \sum_{j=1}^{k} \phi_j f(g_i \mid \ln(y_{i,0}), \alpha_j, \beta_j, \sigma_j^2), \tag{2}$$

where

$$f(g_i \mid \ln(y_{i,0}), \alpha_j, \beta_j, \sigma_j^2) = \frac{1}{\sqrt{2\pi\sigma_j^2}} \exp\left[\frac{-\left(g_i - \alpha_j - \beta_j \ln(y_{i,0})\right)^2}{2\sigma_j^2}\right]. \tag{3}$$

The mixing proportions ϕ_j, i.e., the probabilities of belonging to a regime, are unknown and are jointly estimated with the other parameters of the model. Given a two-component model, regime memberships are more certain the further the posterior probabilities are from 0.50. This aspect makes clear that an *ad hoc* assignment of the countries to the regimes may be conducive to misleading results, due to an arbitrary imposition of the membership. Particularly, we might erroneously asses that, for instance, a country falls into a converging pattern, while, on the contrary, it follows a diverging one.

If the set of observations g_i is independently and identically distributed, the joint density or likelihood of the model, L, can be written as

$$L = \prod_{i=1}^{n}\left[\sum_{j=1}^{k} \phi_j \frac{1}{\sqrt{2\pi\sigma_j^2}} \exp\left[\frac{-\left(g_i - \alpha_j - \beta_j \ln(y_{i,0})\right)^2}{2\sigma_j^2}\right]\right], \tag{4}$$

or, in its logarithmic form,

$$\log L = \sum_{i=1}^{n} \ln\left[\sum_{j=1}^{k} \phi_j \frac{1}{\sqrt{2\pi\sigma_j^2}} \exp\left[\frac{-\left(g_i - \alpha_j - \beta_j \ln(y_{i,0})\right)^2}{2\sigma_j^2}\right]\right]. \tag{5}$$

[6] The speed at which the economy approaches the steady-state can be obtained through the following reparameterization: $\lambda_j = -\left[\ln\left(1 - \beta_j T\right)\right]/T$, where λ_j is the rate of convergence specific to regime j.

Estimation of the parameters of interest, α_j, β_j, σ_j^2, and ϕ_j, can be carried out by maximizing equation (5), subject to the constraint $\sum_{j=1}^{k} \phi_j = 1$. The condition $\sigma_j^2 > 0$ is required to avoid the unboundedness of the likelihood function. Once the parameter estimates have been obtained, i.e. $\widehat{\alpha}_j$, $\widehat{\beta}_j$, $\widehat{\sigma}_j^2$, and $\widehat{\phi}_j$, country i is assigned to regime j by looking at the posterior probabilities $\widehat{\psi}_{i,j}$, calculated by means of the empirical Bayes rule as

$$\widehat{\psi}_{i,j} = \frac{\widehat{\phi}_j f(g_i \mid \ln(y_{i,0}), \widehat{\alpha}_j, \widehat{\beta}_j, \widehat{\sigma}_j^2)}{\sum_{j=1}^{k} \widehat{\phi}_j f(g_i \mid \ln(y_{i,0}), \widehat{\alpha}_j, \widehat{\beta}_j, \widehat{\sigma}_j^2)}. \quad (6)$$

Basically,

$$\text{country } i \in \text{ regime } j \text{ if } \widehat{\psi}_{i,j} > \widehat{\psi}_{i,m} \; \forall m \neq j = 1, ..., k. \quad (7)$$

The stationary equations of the maximum log-likelihood expressed in (5) are derived by DeSarbo and Cron (1988). As for the estimation task, it can be dealt with by application of the Expectations-Maximization (EM) algorithm (Dempster et al. 1977). The EM algorithm works as follows: in the E-step, estimates of ϕ_j and $\psi_{i,j}$ are obtained maximizing the expected log-likelihood, while in the M-step α_j, β_j, σ_j^2 are estimated performing k weighted least squares regressions, the weights of which are given by the posterior probabilities. This latter step can be proved to be equivalent to a maximum likelihood estimation. After the starting values of the parameters have been assigned,[7] the algorithm iterates until a specified convergence criterion is achieved.[8] While the procedure provides a monotone increase of the objective function, convergence to a global optimum is not ensured, due to non-convexity of the log-likelihood function. Indeed, a well-known practical problem with mixture models is the multimodality in the likelihood function, which implies that the starting values are very important. To check the robustness of the results, we follow Owen et al. (2009) in running 5000 replications of the mixture regression, for each of the periods analyzed. The estimates from the model with the highest log-likelihood value are then chosen.[9]

Making inference, as well calculating confidence intervals, requires the variance-covariance matrix of the parameters, which are estimated by maximum likelihood. Louis (1982) shows how to derive the Fisher information matrix in EM environments. The inverse of this matrix provides the estimated covariance matrix (see Turner 2000, for computational aspects).

[7] In the absence of specific priors, as in the present case, they are generated randomly. A similar approach is discussed by McLachlan and Peel (2000, p. 55).

[8] We set a convergence threshold equal to 0.000001. This means that the iteration stops once the increase in the likelihood has become smaller than the threshold. Computations have been conducted by using the package 'mixreg' that works with the statistical software R.

[9] To conduct the robustness exercise, we have compiled our own code, which makes use of the R package 'mixreg'. In general, the results are very stable, except for the period 1913-1950. In this case, we find a superior but unstable equilibrium in 1 replication out of 5000. Due to negligible differences in the likelihood, the qualitative implications, and the size of the parameters, we prefer to maintain the estimates associated with the more stable equilibrium, although they are slightly inferior. Further details are available upon request.

An open issue relates to the choice of the k components, i.e. regimes, of the mixture. Whenever a mixture model is specified, it has to be shown that the selection of two components, instead of three, for instance, is a better choice. Therefore, a decision criterion needs to be adopted, even though no universal rule exists in the literature. We base our decision choice upon two main rules. First, following Turner (2000) we calculate a sequential likelihood ratio (LR) test of k versus $k+1$ components. The test is based upon parametric bootstrap, since the likelihood ratio has a non-standard distribution in this case.[10] Second, according to Hawkins et al. (2001), we look at the Bayesian information criterion (BIC),

$$BIC = -2 \ln L + n_p \ln n, \tag{8}$$

where n_p is the number of free parameters, equalling the dimension of the parameter vector minus one. The rationale of this criterion relies on assigning a penalty function to less parsimonious models, because the log-likelihood can be an increasing function of the number of components. The BIC is the recommended criterion for choosing between one and two components, in the case of a mixture of linear regression (see Hawkins et al., 2001). Finally, the model is selected according to the results of the two rules.

4 Description of the data

To estimate the model described in Section 2, we only need data on per capita GDP. These are taken for 64 countries, for the period 1870-2003, from the database *Historical Statistics for the World Economy: 1-2003 AD*, developed by Angus Maddison, which is downloadable from the Internet page http://www.ggdc.net/maddison (last update: August 2007).[11] GDP per capita is expressed in 1990 International Geary-Khamis dollars (for detailed notes, see Maddison 1995; 2001; 2003).

When dealing with long-run historical data, it is important to note that errors in estimating nineteenth century GDP per capita levels are probably unavoidable. As pointed out by De Long (1988, p. 1143), these errors may potentially bias the estimates towards convergence, even though the latter did not exist in reality. However, if the measurement errors turn out to be extreme observations in the data, the mixture model will detect them. Our finding should be therefore less sensitive to this kind of bias.

Some doubts have been also cast about the reliability of Maddison's data, since they are extrapolated from present-day PPP adjusted GDP levels on the basis of volume indices of real product. In particular, in order to obtain an internationally comparable long-run dataset, Maddison utilized a fixed PPP-converted benchmark year (1990) for the GDP levels and backcasted the GDP data by using national real product indices. This approach implies that the basket of goods and services used to construct the end-year PPP converter is supposed to be stable over time, something which may not be very realistic in the long run. Although alternative international long-run GDP estimates

[10] The test is conducted by launching 1000 replications.

[11] For the list of countries see Table 4.

have been published (Prados de la Escosura 2000), these estimates cover only about 20 countries from the present industrialized world. What is more, they rely on regression methods by assuming that a structural relationship between price levels and certain explanatory variables for the late 20th century can be projected backwards, so as to obtain inference on historical relative GDPs. Since the Maddison dataset allows us to make inference on a larger set of countries and since much of our previous knowledge on long-run convergence relies on evidence from the same data, we prefer to use Maddison's data for the present analysis.

5 Discussion of the results

As a first step, we estimate the model for the full period 1870-2003. Two distinct regimes are clearly identified, according to both the selection criteria proposed. The sequential LR test shown in Table 1 strongly rejects the null hypothesis of one versus two components of the mixture (the P-value is 1 per cent), while it is not able to reject the null of two versus three components at any conventional significance level.[12]

[TABLE 1 AROUND HERE]

[FIGURE 1 AROUND HERE]

The values of the BIC reported in Table 2 also suggest the selection of two components. This means that a single (one-component) growth regression is not the best model to fit the data and produces misleading results, due to the assignment of the same growth pattern to all the countries in the sample. The better fit provided by the mixture can be also deduced by looking at the R-squared of the two-component model shown in Table 3. This model is able to explain about one half (i.e. 48%) of the variation in long-run growth rates, compared to the extrememly modest 3% provided by the one-component model.[13]

[TABLE 2 AROUND HERE]

The results from the estimated mixture model are shown in Table 3. For the period 1870-2003, countries assigned to regime 1 have been significantly converging (with a beta coefficient of -0.007), while those assigned to regime 2 have been significantly diverging (beta is 0.003), or at least denoted a higher degree of heterogeneity in the growth behavior. This indicates that convergence of income per capita towards a common level is not a general feature of the countries of the world in the long run. In fact, the majority of the countries fall into the divergence regime, while the model identifies a convergence club consisting of only 19 countries, which experienced a convergence rate

[12] The empirical distribution of the test is shown in Figure 1.

[13] As can be seen from Table 3, the mixture regression always outperforms the one-component regression in terms of the model's fit, although the greater improvement in the values of R-squared is associated with the whole period 1870-2003 and the sub-period 1950-2003.

equal to 1.8 per cent per year.[14] Such a result implies that only a restricted group of nations behaved according to the empirical regularity of an annual 2%-convergence rate, detected in the early studies by Barro and Sala-i-Martin (1991). The rest of the world's economies faced more difersified development dynamics.

Table 4 shows the posterior probabilities of the countries belonging to each regime. Regime 1 here refers to the convergence club whereas regime 2 stands for divergence. As seen from Table 4, many of the presently industrialized countries show large probabilities of being assigned to regime 1, as would be expected.

[TABLE 3 AROUND HERE]

A few exceptions emerge: Greece, Portugal and Spain fall into the divergence regime, with probabilities ranging from 0.54 (Spain) to 0.98 (Portugal), due to relatively low average growth rates for the full period. Iberia's failure to converge is well-documented in economic history and has been explained by a relative failure to industrialize during the late 19th century. Tortella (1994) argues that the Iberian retardation can be assigned to agricultural backwardness and low levels of investment in human capital, as evidenced by low enrolment and literacy rates. It could be the case that the revision of the Maddison's GDP per worker-hour data for Italy and the Iberian countries is raising some doubt regarding the unconditional convergence hypothesis supported by early studies (see O'Rourke and Williamson 1997, p. 161, for a discussion). Germany also falls into the divergence regime. It appears harder to classify however, due to a lower certainty in regime assignment (the probability is 0.51). Germany's indecisive position is probably due to the country being particularly penalized by the slow growth of the inter-war years. The relative decline of German industrial productivity during the inter-war years has been documented by early scholars, although more recent work has emphasized that Germany's modest economic performance was rather due to a large peasant agriculture and backwardness in the service sector (Broadberry 1997).

Not surprisingly, the USA and New Zealand fall into the divergence regime with posterior probabilities of 0.9 and 0.79, respectively. Both were countries with high GDP per capita in 1870 and growing richer over time. Accordingly, these countries acted as divergence forces in the world economy.

[TABLE 4 AROUND HERE]

Although we find evidence of a long-run convegence club, we do not find any convergence regime during the First Global Wave of the period 1870-1913, as can be seen from Table 3.[15] In this case, however, the selection criteria provide discordant information, since the LR test does not reject the null of one versus two components, while the BIC chooses the two-component model.[16] We prefer the parsimonious specification given by

[14] The convergence speed is calculated through the formula in footnote 5.

[15] When analyzing the three different sub-periods, we run three separate cross-sectional mixture regressions for each period.

[16] Shifting from one to two components, however, produces only a small decrease in the value of the BIC (see Table 2).

the one-component model. Anyway, if we were willing to accept the model with two components, results would not differ in qualitative terms, since two divergence regimes would be estimated instead of one (see Table 3).[17] This clearly contradicts the previous notion of convergence of trading nations during the First Global Wave.

The scatter plots in Figure 2 show the estimated fit of the model during the different epochs. The full period is displayed in the upper left panel, where the convergence regime stands out as a range of countries positioned along a straight line with a clear negative slope and a small confidence band. The divergence regime shows up in the slightly positive slope of the fitted line, but the confidence band is much larger. As opposed to the scatter plot from the full period, the plot in the upper right panel does not indicate any convergence club during the first epoch of globalization. The slope of the fitted line, produced by the one-component specification, rather shows divergence and no distinct growth pattern is found among the countries that had the highest GDP per capita in 1870.

[FIGURE 2 AROUND HERE]

From convergence theory we would expect the richest countries to face modest growth rates due to diminishing returns to capital. Instead, looking at the period 1870-1913, these countries are positioned in two clusters on each side of the fitted line. Countries like Australia, Belgium, the Netherlands, the United Kingdom and Uruguay follow the predicted pattern since they are all below the fitted line and thus exhibit some tendency for slower growth than many countries in the sample. However, there is a set of initially rich countries that show relatively high growth rates and diverging tendencies for the period. These countries cluster above the fitted line and are Austria, Canada, Germany, Denmark, France and Switzerland. Many of these nations were earlier assigned to a convergence regime of wages and labor productivity. Taylor (1999), for example, specifically states that the labor productivity growth patterns of Germany, France, Denmark, Sweden, the UK, the USA and Australia provided evidence that the period 1870-1914 was an era of convergence, with a speed of about 1 per cent per annum (Taylor 1999, p. 1623).

The late 19th century growth of the Scandinavian countries has often been described as a catch-up phenomenon and taken as evidence of the strong forces of convergence during the First Global Wave. O'Rourke and Williamson document a spectacular catch-up in factor prices, but smaller for GDP per worker-hour and even less so for GDP per capita (1997, pp. 158-59). The lion's share of the estimated factor price convergence is assigned to mass migration from Scandinavia to the New World. However, the scatter plot in Figure 2 does not suggest that the growth pattern of the Scandinavian countries contributed to a general picture of convergence among the 64 countries during the First Global Wave. On the contrary, Sweden, Norway and Denmark cluster on a position right in line with the confidence interval of the fitted line's positive slope. This is because these three countries were initially quite rich compared with the rest of the sample, and showed relatively high GDP per capita growth rates of 1.4-1.6 per cent annually.

[17] The convergence parameters of regime 1 and 2 are almost identical (0.002 and 0.004, respectively).

Thus, although the Scandinavian countries have been singled out as backward and fast-growing in accordance with the convergence hypothesis, they cannot be considered poor in 1870 when compared with the rest of our sample.

So what about capital movements? According to economic theory, capital should flow from the rich industrial core to the poor periphery and contribute to convergence. This pattern is confirmed for example by the Scandinavian case. The Scandinavian countries were net importers of capital during these years, and the combination of capital inflow and outward migration has been suggested as a main source of growth. However, it is also interesting to note that the exporters of capital, such as the initially rich countries Germany and France, also showed high growth rates during the same period and we cannot find any clear pattern of fast-growing capital importers and slow-growing capital exporters. In addition, enormous amounts of capital were placed in the New World, although countries like the USA, New Zealand and Australia belonged to the richest countries of the sample in 1870. The tendency for capital accumulation to have a diverging effect on the income distribution during this period has earlier been documented by Taylor and Williamson (1997), among others. Still, one country that did adhere to the expected convergence pattern was Britain, which was one of the wealthiest countries in 1870, exported large amounts of capital to the New World, and experienced modest growth rates of only 1 per cent annually until 1913.[18]

Even though the open market forces of migration and capital created growth in several parts of the world during the First Global Wave, the data do not unambiguously support the claim of an early convergence club. This becomes especially clear in the larger sample of countries that we analyze. It also appears that capital was flowing to countries that were already wealthy in 1870 and therefore acted as a countervailing force to convergence.

Turning to the inter-war period 1913-1950, we identify only one regime. Also in this case, the selection criteria do not provide a clear indication. The LR test selects the two-component specification, while the BIC chooses the model with one component. Anyway, the rejection of the null of one versus two components, produced by the LR test, is not particularly strong, since the P-value is at the significance threshold of 5 per cent (see Table 1). Results do not substantially differ between the two specifications, since both of them support divergence–or at least non-convergence–of per capita income, as can be seen from Table 3. This finding underlines the pre-existing historical notion that the inter-war period was characterized by a closing of markets that suppressed the alleged convergence forces from the First Global Wave. The scatter plot in the lower left panel in Figure 2 also shows that the period was characterized by diverging tendencies and modest growth rates. The only exception is Venezuela, an initially poor country, showing remarkable growth rates of 5 per cent annually due to the discovery of oil in the region.

The post-war period stands out as one in which a group of 20 countries, mainly

[18] However, given Britain's large involvement in the world capital market, it is possible that GNP grew more rapidly than GDP during this period. Unfortunately, there is no comparable data on international GNPs to test this hypothesis.

industrialized nations, show strong and significant convergence, while the rest of the countries in the sample exhibit no clear patterns and more heterogenous growth experiences. The existence of multiple cross-country growth regimes in the post-1950 period has been investigated in the literature since the pioneering study by Durlauf and Johnson (1995). This result is also in line with recent studies, which adopt methodologies more similar to our paper (Owen et al. 2009). Looking at the selection criteria, the choice of the two-component mixture is clearly supported by the LR test, while the BIC seems to suggest a three-component specification. The identification of the convergence regime, however, is robust to the choice of the number of components, since the estimation of a three-component mixture produces the division of the large persistent regime into two smaller ones.[19]

Table 3 shows that the point estimate of the beta-coefficient of regime 1 (-0.016) is roughly twice as large, in absolute terms, as the estimate for the full period. The implied convergence speed is equal to 3.8 per cent per year. From the posterior probabilities in Table 4 we note that all but three of the converging countries assigned to regime 1 (Taiwan, Hong Kong and Singapore) belong to the OECD. On the other hand, 44 countries in our sample are members of regime 2, which exhibits no significant pattern. This suggests that, excluding the Asian tigers, large parts of the poor world have not experienced the predicted convergence. Yet, we also assign a few presently industrialized countries, like Norway (with a probability of 0.51), the United States (with a probability of 0.8), Greece and Portugal (with probabilities of 0.99 each) to regime 2. The first two nations are examples of rich countries getting richer, whereas the last two exhibit rather disappointing growth rates given their initial GDP.

Finally, Table 4 indicates that the countries belonging to the long-run convergence club are as good as identical to those singled out for the post-war period.[20] The long-run convergence pattern which we estimated by means of the mixture of growth regression thus appears to be mainly determined by the dynamics of the post-war period.

6 Concluding remarks

This article shows that growth patterns have been diverse since 1870 and, in the long-run, the world economy has been segmented into two regimes, the one characterized by higher growth rates as well as convergence of per capita income, and the other by divergence and more diversified development patterns. The identification of the two growth regimes is plausibly consistent with the predictions of some recent economic theories (Galor and Mountford 2006; 2008; Zeira 2009) and with recent empirical findings about club convergence. However, we find that the so-called 'Great Divergence' started later

[19] We do not show the results to save space. They are available upon request.

[20] Norway was originally assigned to the convergence regime for the full period, but its remarkable growth after the discovery of oil in the 1970s puts it in the divergence regime when the post-war period is analyzed separately. Spain, on the contrary, was assigned to the divergence regime for the full period, but due to rapid catch-up during the last decades it is assigned to the convergence regime after 1950.

than has previously been suggested. When three historical epochs of global (1870-1913, 1950-2003) and anti-global (1913-1950) waves are analyzed separately, results show that the dynamics which dominated the whole period emerged only after World War II. In the post-war period, in fact, globalization seems to have been accompanied by convergence for only a subset of nations belonging mainly to the today's industrialized world.

According to our results, the two global-booms were not as similar in terms of convergence as previously suggested. The First Global Wave exhibited a complex inter-play of migration, capital and trade that made it less similar to the post-war period in terms of convergence. During this period capital did not flow to capital-scarce economies, since much of it went to the resource-rich New World and, although migration acted as a convergence force, the net result appears to have been divergence in per capita GDP, even among the industrialized nations. When looking at the data, the so-called convergence pattern of the First Global Wave does not look very different from the pattern of divergence and heterogeneity that emerged during the inter-war years.

Finally, our findings are in line with Epstein et al. (2003), who reached similar conclusions for a sample of industrialized countries, although using a completely different methodology. A question for future research is why globalization has brought about convergence in some countries but not in others. Especially the trade flows and their composition need to be further analyzed, but new models need to acknowledge that globalization only seems to have produced club convergence during the last few decades.

References

[1] Abramovitz, M. (1986) Catching up, forging ahead, and falling behind. *Journal of Economic History*, *46(2)*, 385-406.

[2] Alfò, M., Trovato, G., Waldmann, R.J. (2008) Testing for country heterogeneity in growth models using a finite mixture approach. *Journal of Applied Econometrics, 23(4)*, 487-514.

[3] Azariadis, C., Drazen, A. (1990) Threshold externalities in economic development. *Quarterly Journal of Economics*, *105(2)*, 501-526.

[4] Barro, R.J., Sala-i-Martin, X. (1991) Convergence across states and regions. *Brookings Papers on Economic Activity*, *22(1)*, 107-182.

[5] Barro, R.J., Sala-i-Martin, X. (1992) Convergence. *Journal of Political Economy, 100(2)*, 223-251.

[6] Barro R.J., Sala-i-Martin, X. (2004) *Economic growth.* Cambridge, MA: MIT Press.

[7] Battisti, M., Di Vaio, G. (2008) A spatially filtered mixture of β-convergence regressions for EU regions, 1980-2002. *Empirical Economics*, *34(1)*, 105-121.

[8] Baumol, W.J. (1986) Productivity growth, convergence, and welfare: What the long-run data show. *American Economic Review*, *76(5)*, 1072-1085.

[9] Bloom, D.E., Canning, D., Sevilla, J. (2003) Geography and poverty traps. *Journal of Economic Growth*, *8(4)*, 355-378.

[10] Bos, J.W.B., Economidou, C., Koetter, M., Kolari, J.W. (2010) Do all countries grow alike? *Journal of Development Economics*, *91(1)*, 113-127.

[11] Broadberry, S.N. (1993) Manufacturing and the convergence hypothesis: What the long-run data show. *Journal of Economic History*, *53(4)*, 772-795.

[12] Broadberry, S.N. (1997) *The productivity race: British manufacturing in international perspective 1850-1990*. Cambridge: Cambridge University Press.

[13] De Long, J.B. (1988) Productivity growth, convergence, and welfare: Comment. *American Economic Review*, *78(5)*, 1138-1154.

[14] Dempster, A.P., Laird, N.M., Rubin, D.B. (1977) Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society B*, *39(1)*, 1-38.

[15] De Sarbo, W.S., Cron, W.L. (1988) A maximum likelihood methodology for clusterwise linear regression. *Journal of Classification*, *5(2)*, 249-282.

[16] Durlauf, S.N., Johnson, P.A. (1995) Multiple regimes and cross-country growth behaviour. *Journal of Applied Econometrics, 10(4)*, 365-84.

[17] Durlauf, S.N., Johnson, P.A., Temple J.R.W. (2005) *Growth econometrics*. In Aghion, P., Durlauf, S.N. (Ed. by) *Handbook of economic growth*, Vol. 1A. Amsterdam: Elsevier, 555-677.

[18] Epstein, P., Howlett, P., Schulze, M.-S. (2003) Distribution dynamics: Stratification, polarization, and convergence among OECD economies, 1870-1992. *Explorations in Economic History*, *40(1)*, 78-97.

[19] Estevadeordal, A., Frantz, B., Taylor, A.M. (2003) The rise and fall of world trade, 1870-1939. *Quarterly Journal of Economics*, *118(2)*, 359-407.

[20] Feenstra, R.C. (1998) Integration of trade and disintegration of production in the global economy, *Journal of Economic Perspectives, 12(4)*, 31-50.

[21] Feinstein, C. (1988) Economic growth since 1870: Britain's performance in international perspective. *Oxford Review of Economic Policy*, *4(1)*, 1-13.

[22] Galor, O. (1996) Convergence? Inferences from theoretical models. *Economic Journal*, *106(437)*, 1056-1069.

[23] Galor, O., Mountford, A. (2006) Trade and the great divergence: The family connection. *American Economic Review*, *96(2)*, 299-303.

[24] Galor, O., Mountford, A. (2008) Trading population for productivity: Theory and evidence. *Review of Economic Studies*, *75(4)*, 1143-1179.

[25] Hatton, T., Williamson J.G. (1998) *The Age of Mass Migration: Causes and Economic Impact.* New York and Oxford: Oxford University Press.

[26] Hatton, T., Williamson J.G. (2008) The impact of immigration: Comparing two global eras. *World Development*, *36(3)*, 345-361.

[27] Hawkins, D.S., Allen, D.M., Stromberg, A.J. (2001) Determining the number of components in mixture of linear models. *Computational Statistics and Data Analysis*, *38(1)*, 15-48.

[28] Louis, T.A. (1982) Finding the observed information matrix when using the EM algorithm. *Journal of the Royal Statistical Society B*, *44(2)*, 226-233.

[29] McLachlan, G., Peel, D. (2000) *Finite Mixture Models*. New York: John Wiley & Sons.

[30] Maddison, A. (1982) *Phases of capitalist development.* Oxford and New York: Oxford University Press.

[31] Maddison, A. (1987) Growth and slowdown in advanced capitalist economies: Techniques of quantitative assessment. *Journal of Economic Literature*, *25(2)*, 649-698.

[32] Maddison, A. (1995) *Monitoring the World Economy 1820-1992*. Paris: OECD.

[33] Maddison, A. (2001) *The World Economy: A Millennial Perspective.* Paris: OECD Development Centre.

[34] Maddison, A. (2003) *The World Economy: Historical Statistics*. Paris: OECD Development Centre.

[35] Obstfeld, M., Taylor, A.M. (2004) *Global capital markets: Integration, crisis, and growth.* Cambridge: Cambridge University Press.

[36] O'Rourke, K.H., Taylor, A.M., Williamson, J.G (1996) Factor price convergence in the late nineteenth century, *International Economic Review, 37(3)*, 499-530.

[37] O'Rourke, K.H., Williamson, J.G. (1997) Around the European periphery 1870-1913: Globalization, schooling and growth. *European Review of Economic History, 1(2)*, 153-190.

[38] O'Rourke, K.H., Williamson, J.G. (1999) *Globalization and history: The evolution of a nineteenth century Atlantic economy.* Cambridge MA: MIT Press.

[39] Owen, A.L., Videras, J., Davis, L. (2009) Do all countries follow the same growth process?. *Journal of Economic Growth*, *14(4)*, 265-286.

[40] Paap, R., van Dijk, H.K. (1998) Distribution and mobility of wealth of nations. *European Economic Review*, *42(7)*, 1269-1293.

[41] Paap, R., Franses, P.H., van Dijk, D. (2005) Does Africa grow slower than Asia, Latin America and the Middle East? Evidence from a new data-based classification method. *Journal of Development Economics, 77(2)*, 553-570.

[42] Pittau, M.G. (2005) Fitting regional income distributions in the European Union. *Oxford Bulletin of Economics and Statistics*, *67(2)*, 135-161.

[43] Pittau, M.G., Zelli, R. (2006) Empirical evidence of income dynamics across EU regions. *Journal of Applied Econometrics*, *21(5)*, 605-628.

[44] Pittau, M.G., Zelli, R., Johnson, P.A. (2010) Mixture models, convergence clubs, and polarization. *Review of Income and Wealth*, *56(1)*, 102-122.

[45] Prados de la Escosura, L. (2000) International comparisons of real product, 1820-1990: An alternative data set. *Explorations in Economic History*, *37(1)*, 1-41.

[46] Quah, D.T. (1993) Empirical cross-section dynamics in economic growth. *European Economic Review*, *37(2/3)*, 426-434.

[47] Quah, D.T. (1996) Twin peaks: Growth and convergence in models of distribution dynamics. *Economic Journal*, *106(437)*, 1045-1055.

[48] Taylor, A.M. (1999) Source of convergence in the late nineteenth century. *European Economic Review*, *43(9)*, 1621-1645.

[49] Taylor, A.M. (2002) A century of current account dynamics. *Journal of International Money and Finance, 21(6)*, 725-748.

[50] Taylor, A.M., Williamson, J.G. (1997) Convergence in the age of mass migration. *European Review of Economic History*, *1(1)*, 27-63.

[51] Toniolo, G. (1998) Europe's golden age, 1950-1973: Speculations from a long-run perspective. *Economic History Review*, *51(2)*, 252-267.

[52] Tortella, G. (1994) Patterns of economic retardation and recovery in south-western Europe in the nineteenth and twentieth centuries. *Economic History Review*, *47(1)*, 1-21.

[53] Tsionas, E.G. (2000) Regional growth and convergence: Evidence from the United States. *Regional Studies*, *34(3)*, 231-238.

[54] Turner, R.T. (2000) Estimating the propagation rate of a viral infection of potato plants via mixtures of regressions. *Applied Statistics*, *49(3)*, 371-384.

[55] Williamson, J.G. (1996) Globalization, convergence, and history. *Journal of Economic History*, *56(2)*, 277-306.

[56] Williamson, J.G. (1998) Globalization, labor markets and policy backlash in the past. *Journal of Economic Perspectives, 12(4)*, 51-72.

[57] Williamson, J.G. (2008) Globalization and the great divergence: Terms of trade booms, volatility and the poor periphery, 1782-1913. *European Review of Economic History, 12(3)*, 355-391.

[58] Zeira, J. (2009) *Globalization and Divergence*. Unpublished manuscript.

Table 1. Sequential LR test of k versus $k+1$ components*

Period	1 vs 2	2 vs 3
1870–2003	26.6 (.01)	3.97 (.81)
1870–1913	3.85 (.76)	-
1913–1950	17.2 (.05)	5.99 (.71)
1950–2003	26.3 (.00)	23.3 (.17)

* P-values between parentheses. Maximum number of components: $k = 3$.

Table 2. Bayesian information criterion (BIC)

	1 Comp.	2 Comp.	3 Comp.	Selected
Period 1870-2003	-491.4	-497.2	-486.6	2 Comp.
Period 1870-1913	-510.2	-512.5	-510.9	2 Comp.
Period 1913-1950	-407.2	-407.1	-400.0	1 Comp.
Period 1950-2003	-378.8	-385.1	-391.8	3 Comp.

Table 3. Cross-country growth regimes: estimation results

	1 Component (OLS)	2 Components (ML)	
		Regime 1	Regime 2
Period 1870-2003			
Constant	.005	.070***	-.003
Log of p.c. GDP 1870	.002	-.007***	.003**
Weight (%)	-	23	77
R-squared	.03	.48	
Log-likelihood	249.9	263.1	
Period 1870-1913			
Constant	-.010	-.004***	-.013
Log of p.c. GDP 1870	.003***	.002***	.004***
Weight (%)	-	18	82
R-squared	.15	.28	
Log-likelihood	259.2	270.8	
Period 1913-1950			
Constant	-.015	-.038***	-.010***
Log of p.c. GDP 1870	.003*	.006***	.003***
Weight (%)	-	19	81
R-squared	.05	.39	
Log-likelihood	207.7	216.4	
Period 1950-2003			
Constant	.045***	.168***	.044***
Log of p.c. GDP 1870	-.003	-.016***	-.003
Weight (%)	-	25	75
R-squared	.03	.42	
Log-likelihood	193.6	207.1	

***, **, * denote statistical significance at 1%, 5%, and 10%, respectively. In grey: mixture results. Dependent variable: average growth rate of per capita GDP (various periods). Observations: 64.

Table 4. Posterior probabilities*

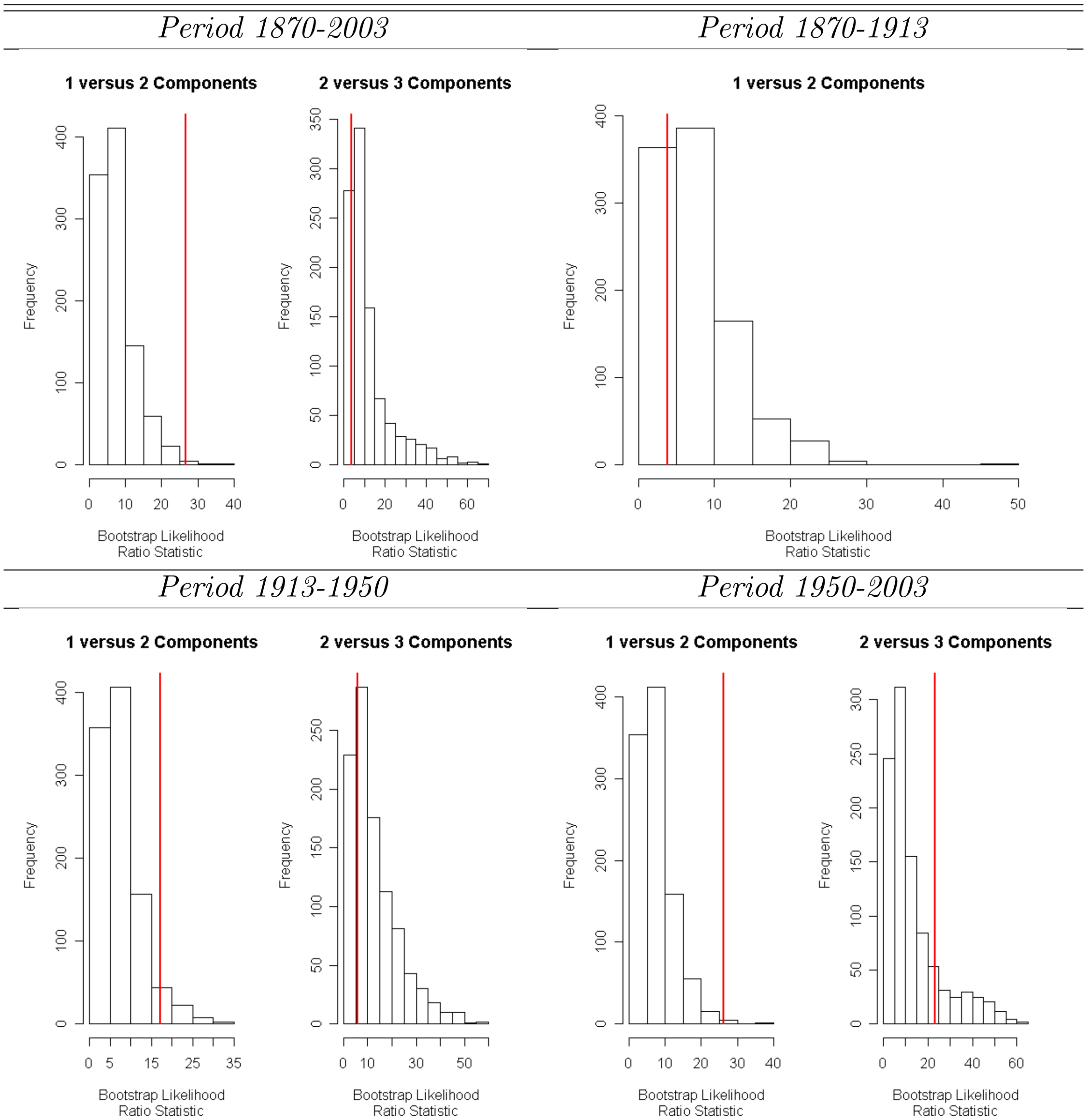
Period 1870-2003			*Period 1950-2003*		
Country	Regime1	Regime 2	Country	Regime 1	Regime 2
Taiwan	1.00	0.00	Taiwan	1.00	0.00
Hong Kong	0.99	0.01	South Korea	0.99	0.01
Japan	0.99	0.01	Japan	0.96	0.04
Singapore	0.99	0.01	Singapore	0.95	0.05
South Korea	0.95	0.05	Austria	0.84	0.16
Finland	0.86	0.14	Hong Kong	0.83	0.17
Sweden	0.66	0.34	Finland	0.77	0.23
Australia	0.62	0.38	Spain	0.77	0.23
Canada	0.62	0.38	Italy	0.75	0.25
United Kingdom	0.61	0.39	France	0.74	0.26
Austria	0.60	0.40	Belgium	0.70	0.30
France	0.60	0.40	Denmark	0.69	0.31
Italy	0.58	0.42	Ireland	0.69	0.31
Netherlands	0.57	0.43	Australia	0.68	0.32
Switzerland	0.57	0.43	Canada	0.68	0.32
Belgium	0.56	0.44	Germany	0.68	0.32
Denmark	0.56	0.44	Netherlands	0.68	0.32
Norway	0.56	0.44	Sweden	0.64	0.36
Ireland	0.51	0.49	United Kingdom	0.61	0.39
Germany	0.46	0.54	Switzerland	0.60	0.40
Spain	0.42	0.58	Norway	0.49	0.51
New Zealand	0.21	0.79	United States	0.20	0.80
United States	0.10	0.90	New Zealand	0.02	0.98
Greece	0.03	0.97	Greece	0.01	0.99
Portugal	0.02	0.98	Portugal	0.01	0.99
Albania	0.00	1.00	Albania	0.00	1.00
Algeria	0.00	1.00	Algeria	0.00	1.00
Argentina	0.00	1.00	Argentina	0.00	1.00
Brazil	0.00	1.00	Brazil	0.00	1.00
Bulgaria	0.00	1.00	Bulgaria	0.00	1.00
Burma	0.00	1.00	Burma	0.00	1.00
Chile	0.00	1.00	Chile	0.00	1.00
China	0.00	1.00	China	0.00	1.00
Czechoslovakia	0.00	1.00	Czechoslovakia	0.00	1.00
Egypt	0.00	1.00	Egypt	0.00	1.00
Ghana	0.00	1.00	Ghana	0.00	1.00
Hungary	0.00	1.00	Hungary	0.00	1.00

* In grey: Countries assigned to regime 1.

Table 4. (Continued)

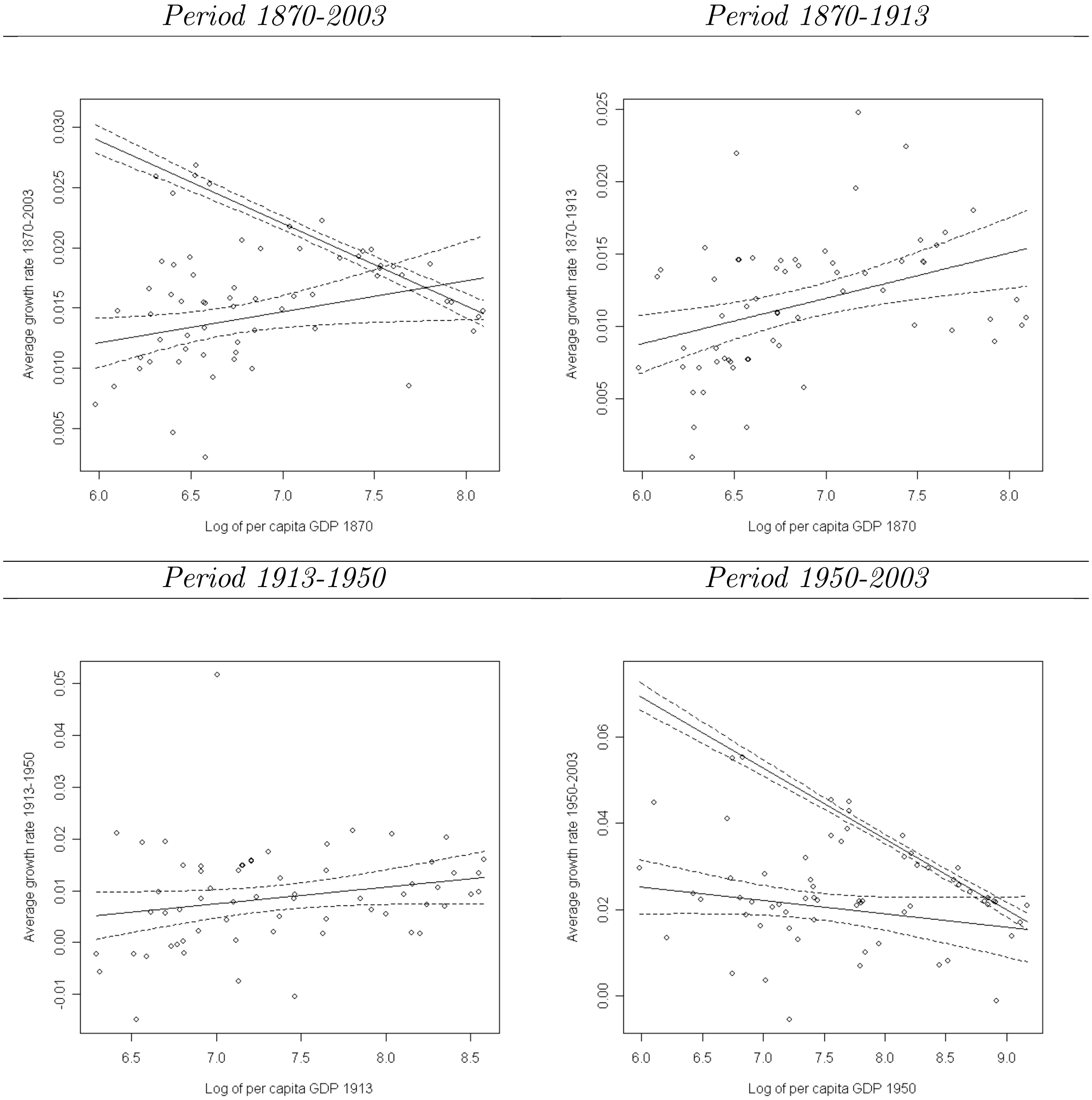
Period 1870-2003			*Period 1950-2003*		
Country	Regime 1	Regime 2	Country	Regime 1	Regime 2
India	0.00	1.00	India	0.00	1.00
Indonesia	0.00	1.00	Indonesia	0.00	1.00
Iran	0.00	1.00	Iran	0.00	1.00
Iraq	0.00	1.00	Iraq	0.00	1.00
Jamaica	0.00	1.00	Jamaica	0.00	1.00
Jordan	0.00	1.00	Jordan	0.00	1.00
Lebanon	0.00	1.00	Lebanon	0.00	1.00
Malaysia	0.00	1.00	Malaysia	0.00	1.00
Mexico	0.00	1.00	Mexico	0.00	1.00
Morocco	0.00	1.00	Morocco	0.00	1.00
Nepal	0.00	1.00	Nepal	0.00	1.00
North Korea	0.00	1.00	North Korea	0.00	1.00
Philippines	0.00	1.00	Philippines	0.00	1.00
Poland	0.00	1.00	Poland	0.00	1.00
Romania	0.00	1.00	Romania	0.00	1.00
Russia (USSR)	0.00	1.00	Russia (USSR)	0.00	0.00
South Africa	0.00	1.00	South Africa	0.00	1.00
Sri Lanka	0.00	1.00	Sri Lanka	0.00	1.00
Syria	0.00	1.00	Syria	0.00	1.00
Thailand	0.00	1.00	Thailand	0.00	1.00
Tunisia	0.00	1.00	Tunisia	0.00	1.00
Turkey	0.00	1.00	Turkey	0.00	1.00
Uruguay	0.00	1.00	Uruguay	0.00	1.00
Venezuela	0.00	1.00	Venezuela	0.00	1.00
Vietnam	0.00	1.00	Vietnam	0.00	1.00
Yugoslavia	0.00	1.00	Yugoslavia	0.00	1.00
W. B. and Gaza	0.00	1.00	W. B. and Gaza	0.00	1.00

Figure 1. Empirical distribution of the LR test*



*1000 bootstrap replications.

Figure 2. Cross-country growth regimes: model's fit*



*Solid line: regression fit; dotted line: confidence band at 95% level.