DOCUMENTOS DE ECONOMÍA Y FINANZAS INTERNACIONALES

Working Papers on International Economics and Finance

DEFI 14-06

Marzo 2014

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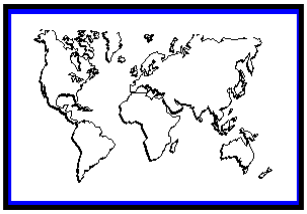

Asociación Española de Economía y Finanzas Internacionales

www.aeefi.com

ISSN: 1696-6376

A contribution to the empirics of convergence in real GDP growth: The role of financial crises and exchange-rate regimes*

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February 2014

Abstract

This paper investigates the convergence in real Gross Domestic Product (GDP) growth focusing on the impact of financial crises (i.e. banking crises, currency crises and debt crises) and nominal exchange rate regimes (i.e. fixed, intermediate and flexible) on convergence. To that end, we compute four convergence indicators (σ-convergence, γ-convergence, absolute β-convergence and conditional β-convergence), for 163 countries classified into four income groups during the 1970-2011 period. Results suggest that: (i) There is evidence in favor of σ-convergence and γ-convergence only for high income countries; (ii) absolute and conditional β-convergence are presented in each of the four income groups of countries under study; (iii) exchange-rate regimes seem to play some role in upper-middle and lower-middle income countries; and (iv) financial crises have a negative and significant impact on GDP growth independently of the level of income of countries.

Keywords: Convergence indicators, financial crises, nominal exchange-rate regimes.

JEL: O47, G15, F33

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1. Introduction

Economic growth is commonly measured as the annual rate of increase in a country´s real gross domestic product (GDP). It has been subject to extensive theoretical and empirical analysis because it is the main determinant of the material well-being of people and the source of current income differences (Acemoglu, 2009).

A key economic issue is whether poor countries or regions tend to grow faster than rich ones: are there automatic forces that lead to convergence over time in levels of per capita income and product? Indeed, real convergence has been one of the most intensively studied issues in growth literature and its assessment represents a matter of primary relevance for policy makers (Islam, 2003). However, there is a lack of sufficient studies examining if real convergence is affected by nominal exchange-rate regimes or financial crises.

Numerous theoretical and empirical writings have shown that financial development is important and causes economic growth [see, e. g., McKinnon (1973), King and Levine (1993a,b), De Gregorio and Guidotti (1995), Neusser and Kugler (1998), and Levine et al. (2000)]. Moreover, it has been widely documented that financial crises have large economic costs: large output losses are common to many crises and other macroeconomic variables (consumption, investment and industrial production) typically register significant declines [see, e.g., Claessens *et al.* (2009 and 2012), Reinhart and Rogoff (2009 and 2014) and Dwyer *et al.* (2013)].

Besides, the relationship between exchange-rate regimes and economic growth has been examined, although a theoretical consensus does not yet exist in the literature, leading a large number of empirical studies to evaluate such relationship. As pointed out by Petreski (2009), there are studies that find a positive effect on economic growth, others that obtain a negative influence and still other that either the impact remains indeterminate or simply no such effect is detected. For instance, both Mundell (1995) and Obstfeld and Rogoff (2000) find empirical evidence suggesting that those countries that adopt fixed exchange rate regime are characterized by higher economic growth. On the other hand, Bailliu *et al.* (2003) contend that the lowest growth rates are related with both an intermediate regime and a flexible regime, while Sosvilla-Rivero and Ramos-Herrera (2014) find that growth performance is best under intermediate exchange rate regimes, while the smallest growth rates are associated with flexible exchange rates.

Finally, Edwards and Levy-Yeyati (2003) claim that the optimal exchange-rate regime is the flexible one, since it is associated with a faster growth.

The main objective of this paper is to offer an exhaustive analysis of convergence in real economic growth and to explore the impact of exchange-rate regimes and financial crises. Our work contributes to previous literature in several ways. First, we use a much more study period (1970-2011) and a more comprehensive country sample (a large set of 163 developed, emerging, developing and transition countries classified into four income groups) to scrutinize real GDP convergence. Second, although some other authors use σ-convergence, γ-convergence and β-convergence, we are the only ones systematically examining all three indicators. Third, when testing β-convergence using panel data models, we assess the role played by exchange-rate regimes and financial crises.

The rest of this paper is structured as follows. Section 2 describes the data and the econometric methodology adopted in this study. Section 3 reports the empirical result, and Section 4 offers some concluding remarks.

2. Data and Methodology

2.1. Data

In this empirical analysis, we use annual data of real GDP growth, from 1970 to 2011 for 163 countries classified into four sets using the World Bank typology based on income groups: high income countries (per capita real GDP over 9,075 dollars), upper-middle income countries (per capita real GDP between 2,936 and 9,075 dollars), lower-middle income countries (per capita real GDP between 736 and 2,935 dollars) and lower income countries (per capita real GDP less than or equal to 735 dollars). Data have been obtained from World Bank´s World Development Indicators (WDI) and cover developed, emerging, developing and transition countries. We consider following countries: Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, Colombia, Comoros, Democratic Republic of the Congo, Republic of the Congo, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti,

Dominican Republic, Ecuador, Egypt, Equatorial Guinea, El Salvador, Eritrea, Estonia, Ethiopia, Fiji, Finland, Former Yugoslav Republic of Macedonia France, Gabon, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, , Guinea, Guinea-Bissau, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Korea, Kuwait, Kyrgyz Republic, Lao, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Romania, Russian Federation, Rwanda, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Tonga, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, West Bank and Gaza, Yemen, Zambia and Zimbabwe.

Given that income classifications are set each year based on their per capita income data, we recursively formed groups of countries based on the income classifications, tracking their convergence performance.

In addition, we also use gross saving (public and private) as a share of GDP and the (total) dependency ratio from World Bank Indicators database; population growth, openness to trade and CPI inflation from PWT 7.1 (Heston et al., 2012); and the number of years spent in secondary education from UNESCO´s Institute for Statistics.

As for the exchange rate regimes, we use the "natural fine classification" of Reinhart and Rogoff (2004), updated to December 2010 by Ilzetzki, Reinhart and Rogoff (2011), to distinguish between a wide range of *de facto* regimes: 1) no separate legal tender; 2) pre announced peg or currency board arrangement; 3) pre announced horizontal band that is narrower than or equal to ±2%; 4) *de facto* peg; 5) pre announced crawling peg; 6) pre announced crawling band that is narrower than or equal to ±2%; 7) *de factor* crawling peg; 8) *de facto* crawling band that is narrower than or equal to ±2%; 9) pre announced crawling band that is wider than or equal to ±2%; 10) *de facto* crawling band that is narrower than or equal to ±5%; 11) moving band that is narrower than or equal to

±2% (i.e., allows for both appreciation and depreciation over time); 12) managed floating; 13) freely floating; 14) freely falling; 15) dual market in which parallel market data is missing. As the tables in Ilzetzki, Reinhart and Rogoff (2011) provide data 2010, we can identify the exact date of the change of regime. For 2011, we assume that there is not modification in the exchange rate regime. According to previous studies, we consider three broad categories of exchange rate regimes: fixed (regimes 1 to 4 in the "natural fine classification"), intermediate (regimes 5 to 11) and flexible (regimes 12 to 15).

Regarding the financial crisis dates, we make use of the information provided by Laeven and Valencia (2008) and Reinhart (2010). The former covers all systemically important banking, currency and debt crises for the period 1970 to 2007 for 261 countries, while the later offers the individual timeline of public and private debts, banking, sovereign domestic and external debt crises, and hyperinflation, for 70 countries, from their independence to 2010.

2.2. Methodology

Convergence can be studied from two different perspectives: cross section analysis and time series analysis. In the cross section approach, countries are considered as a group and traditionally, three convergence indicators are used: σ-convergence, γ-convergence and β-convergence indicators. However, the time series approach analyses convergence in pairs of countries. As we are interested in analyzing convergence for country groups based on income groups we focus on the cross section approach.

2.2.1. σ-convergence

The use of σ-convergence analysis to measure convergence became popular with the work of Quah (1993). σ-convergence occurs when the dispersion of real GDP growth rates declines over time. We measure the dispersion using the coefficient of variation (*CV*):

$$CV_t = \frac{\sigma_t}{\bar{y}_t} \quad (1)$$

where $\bar{y}_t - \frac{1}{n}\sum_{i=1}^{n} y_{it}$ is the mean value of n countries

and $\sigma_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{it} - \bar{y}_t)^2}$ is the standard deviation.

In other words, σ-convergence appears when the standard deviation of the logarithm of the real GDP tends to decrease over time.

2.2.2. γ-convergence

Boyle and McCarthy (1997, 1999) develop an index of rank concordance, called γ-convergence. This index takes into account the change in the ranking of income levels and it is based in Kendall´s index of rank concordance (Siegel, 1956). Formally, the binary version of the index, that computes the concordance between the ranks in year t and year 0, is

$$\gamma = \frac{var[R(y_{it}) + R(y_{i0})]}{var[2R(y_{i0})]} \qquad (2)$$

where *var* [*R(y)*] is the corresponding variance of the ranks of real GDP growth, *it* refers to country *i* from 1971 to 2011 and i_0 refers country *i* in the reference year 1970. The value of the rank of equation (2) ranges from zero to unity. The proximity of the index to 0 shows a greater mobility within the distribution and so a greater evidence of γ-convergence.[1]

2.2.3. Absolute β-convergence

While both σ-convergence and γ-convergence are not justified by any economic theory, the β-convergence approach has been considered the more convincing under the theoretical viewpoint, as well as the more appealing, since it leads to a quantification of the speed of convergence. The concept of β-convergence is directly related to the neoclassical Solow-Swan exogenous growth theory (Solow, 1956; Swan, 1956), assuming exogenous saving rates and a production function based on decreasing productivity of capital and constant returns.

The analysis of absolute β-convergence is a widely instrument to measure convergence. Initiated from studies made by Baumol (1986), the concept of absolute β-convergence

[1] We compute the significance of γ-convergence using $2(n-1)R \approx x^2_{n-1}$.

became popular with the contributions of Barro and Sala-i-Martin (1991,1992). Absolute β-convergence occurs when there is a negative relationship between the initial level of real GDP and its average growth rate, without taking into account the initial conditions and assuming that all the economies converge to the same stationary state. We analyze absolute β-convergence through the estimation of the following econometric model:

$$ln\left(\frac{y_{i,t,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \lambda D^{r}_{i,t,t+k} + \delta D^{fc}_{i,t,t+k} + \varepsilon_{i,t,t+k} \quad (3)$$

where $y_{i,t,t+k}$ is the k-year forward average of annual growth rates of real GDP between t and $t+k$ of country i, with $k = 5$[2] and t = 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005; $y_{i,t}$ is the annual growth rate of real GDP in t; $D^{r}_{i,t,t+k}$ is the k-year forward average of the dummy variable between t and $t+k$ indicating the nominal exchange rate regime (fixed, intermediate or flexible) of country i; $D^{fc}_{i,t,t+k}$ is the k-year forward average of the dummy variable between t and $t+k$ capturing financial crises (banking crises, currency crises and/or debt crises) of country i; and $\varepsilon_{i,t,t+k}$ is a random error term.

From equation (3), first, we estimate the parameter β. The existence of β-convergence would imply the estimated value of the parameter β would be negative and statistically significant. Moreover, we compute the annual rate of convergence, r_β, that can be calculated as follows:

$$r_\beta = \frac{\ln(\beta+1)}{(-T)} \quad (4)$$

where T is the length of the period under study.

Second, from equation (3) we obtain evidence about the role of financial crises and changes in the nominal exchange rate regime in the process towards convergence in real GDP growth rates.

[2] Note that several tradeoffs are involved in the choice of the length of the growth episode (k). While k=1 maximises the number of observations, this strategy may lead to estimates that are fully driven by business cycle fluctuations and suffer from serious endogeneity. To mitigate these problems, k is usually set equal to 5, although this strategy greatly reduces the number of observations and introduces some arbitrariness about the selection of the first and last unusable observations, that we try to minimise using several starting and final points and using regressors in the right-hand side of (3) and (5) that are predetermined with respect to the five-year forward average growth rate.

2.2.4. Conditional β-convergence

The idea that economic growth is a composite function of a great number of interrelated factors has led some economists to develop the idea of conditional economic convergence. The conditional approach is coherent with the neoclassical framework, but it concerns the tendency of a cross-section of countries to converge to their own steady states as a function of a number of conditioning variables: in this case, economies are considered different in their structural features.

Indeed, Barro and Sala-i-Martin (1992) argue that it is more informative to look at conditional β-convergence, allowing that the equilibrium varies in each economy, with each tending towards its own equilibrium. To that end we estimate of the following model:

$$ln\left(\frac{y_{i,t,t+k}}{y_{i,t}}\right) = \alpha + \beta \ln(y_{i,t}) + \varphi X_{i,t,t+k} + \lambda D^{r}_{i,t,t+k} + \delta D^{fc}_{i,t,t+k} + \varepsilon_{i,t,t+k} \qquad (5)$$

where $y_{i,t,t+k}$ is the k-year forward average of annual growth rates of real GDP between t and $t+k$ of country i, with k = 5 and t = 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005; $y_{i,t}$ is the annual growth rate of real GDP in t; $X_{i,t,t+k}$ is the k-year forward average of the a set of other regressors to that are potential determinant of growth; $D^{r}_{i,t,t+k}$ is the k-year forward average of the dummy variable between t and $t+k$ indicating the nominal exchange rate regime (fixed, intermediate or flexible) of country i; $D^{fc}_{i,t,t+k}$ is the k-year forward average of the dummy variable between t and $t+k$ capturing financial crises (banking crises, currency crises and/or debt crises) of country i; and $\varepsilon_{i,t,t+k}$ is a random error term.

A satisfactory conditional β-convergence model strongly depends on the choice of an appropriate list of conditioning variables X_t. In this paper, we use both state variables (affecting the structure of an economic system: total gross saving -public and private- as a share of GDP and the number of years spent in secondary education as an indicators of the stock of physical and human capital) and environmental variables (population growth, the dependency ratio, openness to trade and CPI inflation). We expect a positive effect of gross savings, schooling and openness on real GDP growth, while the

impact of the population growth and dependency ratio is expected to be negative. Regarding inflation, the associated coefficient could be positive or negative, since there has been considerable debate on the nature of the inflation and growth relationship (Temple, 2000).

For the estimated $\hat{\beta}$ from equation (5), we also compute the corresponding annual rate of convergence, r_{β}.

Finally, it is worth noticing that, although the concepts of σ- and β-convergence are not identical, it is possible to demonstrate that the two formulation of convergence are linked each other. In particular, we can say that β-convergence is a necessary condition for obtaining σ-convergence, in other words if there is no β-convergence there cannot be σ-convergence (Sala-i-Martin, 1996).

3. Empirical results

3.1. σ-convergence

Figure 1 panel (a) illustrates the empirical results obtained for high income countries when analyzing σ-convergence. As we can be observed, we could distinguish three sub-periods: from 1970 to 1974 with evidence in favor of σ-convergence indicating that dispersion in real GDP growth decreases during these years; from 1975 to 1982 where the dispersion increases strongly (CV>0.5); and from 1983 to the end of the sample, where we detect evidence of a clear tendency towards σ-convergence.

[Insert Figure 1 here]

Something similar occurs for the set of upper-middle income countries, as we can see graphically in Figure 1 panel (b): after an initial period (from 1970 to 1982) of evidence in favor of dispersion, we observe from 1983 to the end of the sample evidence in favor of σ-convergence.

For lower-middle income countries results suggest evidence of substantial dispersion along the full sample (CV≥0.5). In this line, strong evidence of dispersion is presented in the lower income countries for the studied period (CV>1).

In sum, for high and upper-middle income countries results suggest evidence in favor of σ-convergence from around 1983 up until the end of the sample.

3.2. γ-convergence

Figure 2 panel (a) plots the γ-convergence empirical results for high income countries. As we can be seen, it looks that the γ-convergence index is trended downwards until around 1998 but thereafter the trend stabilizes (between 0.6 and 0.8).

[Insert Figure 2 here]

For upper-middle and lower income countries (Figure 2, panels (b) and (d)) the behavior of γ-convergence index is very similar: the trend is stabilized along the sample (the values oscillates around 0.8).

Finally, for lower-middle income countries, except for the first part of the sample (from 1979 to 1981) where γ-convergence is not significant, the γ-convergence index is trended upwards, oscillating the values between 0.9 and 1.

In sum, results suggest some weak evidence in favor of γ-convergence only for high income countries.

3.3. Absolute β-convergence

Our data set consists of a large number of variables that are observed on a sequence of successive moments in time forming a panel data. To estimate such panel, we consider three basic panel regression methods:

- The fixed-effects (FE) method, that accounts for differences between countries and allows the constant terms to vary among them to capture the country heterogeneity.
- The random effects (RE) method, that assumes that the constant terms consist of independent drawings from an underlying population and that the disturbances are more complex, as (within countries) they are correlated over time.
- The pooled-OLS method, were the data for different countries are pooled together, and the model is estimated ordinary least squares (OLS).

In order to determine the empirical relevance of each of the potential methods for our panel data, we make use of several statistic tests. In particular, we test FE *versus* RE using Hausman test statistic to test for non-correlation between the unobserved effect

and the regressors (see Baltagi, 2008, chapter 4). Additionally, to choose between to test pooled-OLS and RE, we use the Breusch and Pagan (1980)'s Lagrange multiplier test for testing for the presence of an unobserved effect. Finally, we use the *F* test for fixed effects to test whether all unobservable individual effects are zero, in order to discriminate between pooled-OLS and RE.

We start with a simplified version of equation (3) and consecutively include the dummy variable for the nominal exchange-rate regime ($D^{r}_{i,t,t+k}$) and the dummy capturing the effects of financial crises ($D^{fc}_{i,t,t+k}$) as a further explanatory variables to test for the robustness of the results. The coefficients of interests in the analysis are β (the coefficient associated with the annual growth rate of real GDP), λ (the effect of nominal exchange rate regimes) and δ (the effect of financial crises). Tables 1 shows the results for our four groups of countries. To save space, we only report the results obtained using the FE method corrected for heteroskedasticity and autocorrelation[3], since the specification tests indicate that the FE model is the relevant one in all cases[4].

[Insert Table 1 here]

As can be seen in column (1) of Panel A in Table 1, for the high income countries we find a significant (at the 1% level) and negative value for β implying the presence of absolute β-convergence. The inclusion of dummy variables to control for exchange rate regimes reduces the estimated parameter of β without affecting its significance [see columns (2) to (4)] but these dummies appear not significant. When adding also the dummy capturing the effect of financial crises [columns (5) to (7)], the results suggest a reduction in the estimated β and a significant (at the 1% level) and negative impact of this extra dummy on real growth rates. It is interesting to note that all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.0860,-0.0505).

Regarding the upper-middle income countries, estimation results in column (1) of Panel B in Table 1 also suggest the presence of absolute β-convergence among them during the 1970-2011 period. The inclusion of dummy variables to control for fixed and

[3] The estimation results using RE and pooled OLS and the specification tests are available from the authors upon request.

[4] The Hausman test rejects the RE model in favour of the FE estimation. The joint significance of the fixed error component model is strongly confirmed, suggesting that FE is needed. The Breusch and Pagan LM test fails to reject the null that variances across entities are zero, concluding that RE is not appropriate.

intermediate exchange rate regimes increases the estimated parameter of β while the dummy capturing the effect of flexible exchange rate regimes reduces it [see columns (2) to (4)]. However, only in the latter case the dummy variable us significant at the 5% level. The incorporation of the dummy controlling for the impact of financial crises [columns (5) to (7)] lead to an increase in the estimated β for the fixed regime case and reduction for the other two cases, being again only significant and negative the dummy for flexible exchange rate regimes. Once again all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1615,-0.0565).

In relation to the lower-middle income countries, we find a significant (at the 1% level) and negative value for the parameter β in column (1) of Panel C in Table 1. The inclusion of dummy variables to control for exchange rate regimes increases the estimated parameter of β, although none of them are statistically significant at the usual levels [see columns (2) to (4)]. The further addition of the dummy controlling for the impact of financial crises [columns (5) to (7)] produces also an increase in the estimated β and indicates a significant (at the 10% level) and positive impact of intermediate exchange rate regimes and a significant (at the 1% level) and negative effect of financial crises on real GDP growth in this group of countries. Once more, all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1786,-0.0842).

As for the lower income countries, our estimations results also suggest the presence of absolute β-convergence, with estimated parameters of β increasing in relation to the value of -0.0951 obtained in model (1) of Panel D in Table 1 when successively including the dummy variable for the nominal exchange-rate regimes and the dummy capturing the effects of financial crises. Nevertheless, all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1314,-0.0589). None of the dummies controlling for the exchange rate regimes are found to be statistically significant. In contrast, the coefficient associated with the dummy variable for financial crisis is found to be significant (at the 1% level) and negative.

Finally, we observe that the highest annual rate of convergence is associated to upper-middle income countries and the lowest rate of convergence to lower income countries.

3.4. Conditional β-convergence

To test for conditional β-convergence we adopt a general-to specific modelling strategy. Our empirical analysis starts with a general unrestricted statistical model including all explanatory variables in equation (5) except the dummies to capture the essential characteristics of the underlying dataset, using standard testing procedures to reduce its complexity by eliminating statistically-insignificant variables, and checking the validity of the reductions at every stage in order to ensure congruence of the finally selected model. We consecutively include the dummy variable for the nominal exchange-rate regime and the dummy capturing the effects of financial crises as a further explanatory variable to test for the robustness of the results. The coefficients of interests in the analysis are now β (the coefficient associated with the annual growth rate of real GDP), φ (the effects of potential determinant of growth), λ (the effect of nominal exchange rate regimes) and δ (the effect of financial crises).

As for absolute convergence, the specification tests indicate that the FE model is the relevant one in all cases[5] and we only report in Table 2 the final results obtained from the general-to-specific modelling strategy using the FE method corrected for heteroskedasticity and autocorrelation[6].

[Insert Table 2 here]

As can be seen in column (1) of Panel A in Table 2, for the high income countries we find a significant (at the 1% level) and negative value for the parameter β implying the presence of conditional β-convergence, meaning that the real growth gap between countries that are similar in observable categories appears to narrow over time. We obtain a significant (at the 1% level) and positive effect of human capital and CPI inflation and marginal significant (at the 10% level) and negative of population growth on real GDP growth. The addition of dummy variables to control for exchange rate regimes increases the estimated parameter of β without affecting its significance [see columns (2) to (4)] but these dummies are not statistically significant at the usual levels. When adding also the dummy capturing the effect of financial crises [columns (5) to (7)], the results suggest a reduction in the estimated β and a significant (at the 5% level)

[5] The Hausman test rejects the RE model in favour of the FE estimation. The joint significance of the fixed error component model is strongly confirmed, suggesting that FE is needed. The Breusch and Pagan LM test fails to reject the null that variances across entities are zero, concluding that RE is not appropriate.

[6] The estimation results using RE and pooled OLS and the specification tests are available from the authors upon request.

and negative impact of this extra dummy on real growth rates. All estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1219,-0.0674).

With regard to the upper-middle income countries, estimation results in column (1) of Panel B in Table 2 also suggest the presence of conditional β-convergence among them during the 1970-2011 period. Interestingly, we do not obtain a significant effect for any of the potential growth determinants under study (i.e. gross saving -public and private- as a share of GDP, population growth, the number of years spent in secondary education, the dependency ratio, openness to trade and CPI inflation). We report the results for the most significant determinant (human capital), although it shows a negative insignificant effect on real GDP growth. The inclusion of dummy variables to control for exchange rate regimes reduces the estimated parameter of β [see columns (2) to (4)], being only marginally significant (at the 10% level) and negative the dummy variable associated with flexible exchange rate regimes. The inclusion of the dummy controlling for the impact of financial crises [columns (5) to (7)] lead to an further decrement in the estimated β, being significant (at the 10%) and negative both the dummy for flexible exchange rate regimes and the dummy for financial crises. In all cases the estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1703,-0.0445).

Concerning the lower-middle income countries, we find a significant (at the 1% level) and negative for the parameter β in column (1) of Panel C in Table 2. We obtain a significant (at the 1% level) and positive effect of gross saving as a share of GDP, human capital and openness on real GDP growth. The inclusion of dummy variables to control for exchange rate regimes increases the estimated parameter of β, although only the dummy associated with the intermediate regimes is found to be significant (at the 1%) and negative [see columns (2) to (4)]. The further addition of the dummy controlling for the impact of financial crises [columns (5) to (7)] produces also an increase in the estimated β and indicates a significant (at the 1% level) and negative impact of intermediate exchange rate regimes and a significant (at the 5% level) and negative effect of financial crises on real GDP growth in this group of countries. Once more, all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1936,-0.0503).

In relation to the lower income countries, our estimations results also suggest the presence of absolute β-convergence, with estimated parameters of β increasing in relation to the value of -0.0826 obtained in model (1) of Panel D in Table 2 when successively including the dummy variable for the nominal exchange-rate regimes and the dummy capturing the effects of financial crises. Nevertheless, all estimated parameters of β in columns (2) to (7) are within the 95% confidence interval for the estimated β in column (1) (-0.1364,-0.0328). As can be seen, for this group of countries we obtain a significant (at the 1% level) and positive effect of gross saving as a share of GDP, human capital and CPI inflation on real GDP growth. None of the dummies controlling for the exchange rate regimes are found to be statistically significant. In contrast, the coefficient associated with the dummy variable for financial crisis is found to be significant (at the 1% level) and negative.

Finally, we observe the highest annual rate of convergence is associated once again to upper-middle income countries and the lowest rate to lower income countries.

4. Concluding remarks

This paper has attempted to contribute to the empirical literature by offering an exhaustive analysis of convergence in real economic growth during the 1970-2011 period for 163 countries classified into four income groups, as well as exploring the possibility that convergence could be related to changes in exchange-rate regimes or financial crises To that end, we have offered a systematic examination of the usual indicators of convergence: σ-convergence, γ-convergence, absolute β-convergence and conditional β-convergence.

Our results can be summarized as follows: when evaluating σ-convergence, for high and upper-middle income countries we find evidence in favor of a decline in the dispersion of real GDP growth rates from around 1983 up until the end of the sample.

When evaluating γ-convergence, results suggest some weak evidence in favor of γ-convergence only for high income countries.

Regarding absolute β-convergence, our results indicate that it is presented in each of the four income groups of countries under study, with the highest annual rate of convergence being associated to upper-middle income countries and the lowest rate to lower income countries. We find a significant (at the 5% level) and negative impact of

flexible exchange rates and a marginally significant (at the 10% level) and positive effect of intermediate exchange rate regimes on real GDP growth for upper-middle income countries and for lower-middle income countries, respectively. With regard to financial crises, in all cases we detect a significant (at the 1% level) and negative impact on real GDP growth.

As for the conditional convergence, our results seem to indicate its presence of conditional β-convergence in each of the four income groups of countries under study, with the highest annual rate of convergence being associated once again to upper-middle income countries and the lowest rate to lower income countries. We find a marginally significant (at the 10% level) and positive impact of intermediate exchange rate regimes on real GDP growth for upper-middle income countries and a significant (at the 5% level) and negative effect of intermediate exchange rate regimes on real GDP growth for lower-middle income countries, while we detect a marginally significant (at the 10% level) and negative impact of flexible exchange rate regimes on real GDP growth for upper-middle income countries, respectively. With regard to financial crises, in all cases we document a significant (at the 1% level) and negative impact on real GDP growth.

In relation to the role of exchange-rate regimes on real GDP growth, our results are in line with Frankel (1999)'s conclusion that no single currency regime is right for all countries or at all times and can help to shed light on the consequences of national choices of exchange rate regimes.

The detected negative association between financial crisis and growth creates a scope for welfare-increasing government interventions and poses important challenges for the point of view of the economic policy. The challenges are both functional and institutional. They involve a more proactive and intensive micro-and macro prudential considerations to preserve financial stability and reduce systemic risk by the appropriate supervision and the necessary coordination between international organizations and the national competent authorities.

Future research on the dynamics of convergence should further consider with more detailed the separate effects of hyperinflations, systemic banking, currency and debt crises in order to disentangle their individual impact on real GDP growth and on its convergence for different groups of countries. In view of the encouraging results of the

present study, some optimism about the benefits from implementing this analysis seems justified.

Acknowledgements

The authors are very grateful for the financial support from the Spanish Ministry of Science and Innovation (ECO2011-23189).

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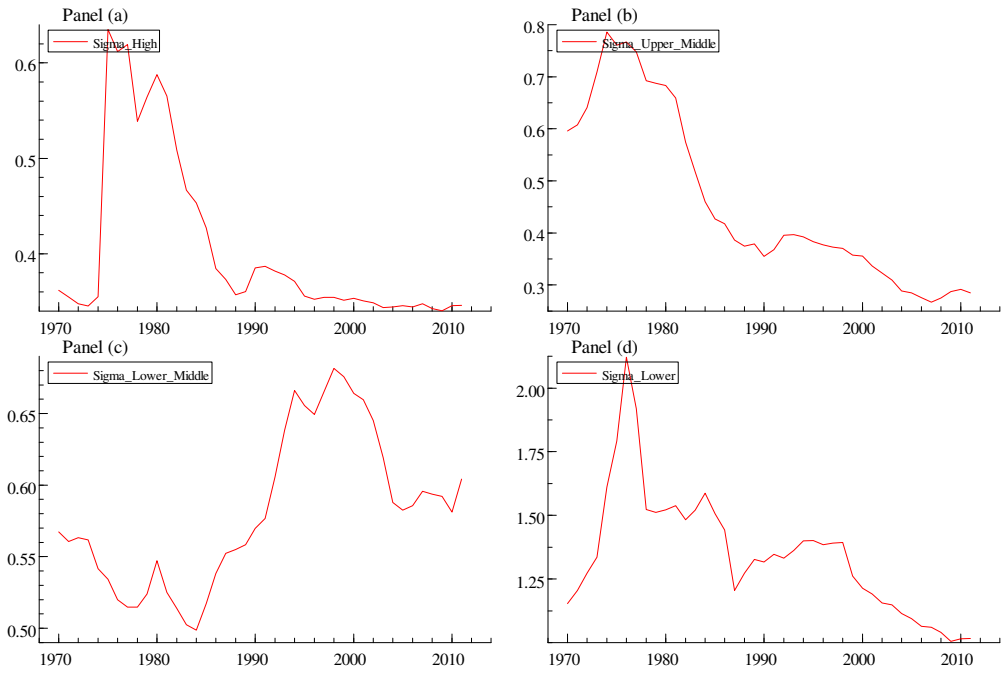

Figure 1. σ-convergence in high income countries, upper-middle income countries, lower-middle income countries and low income countries, 1970-2011.

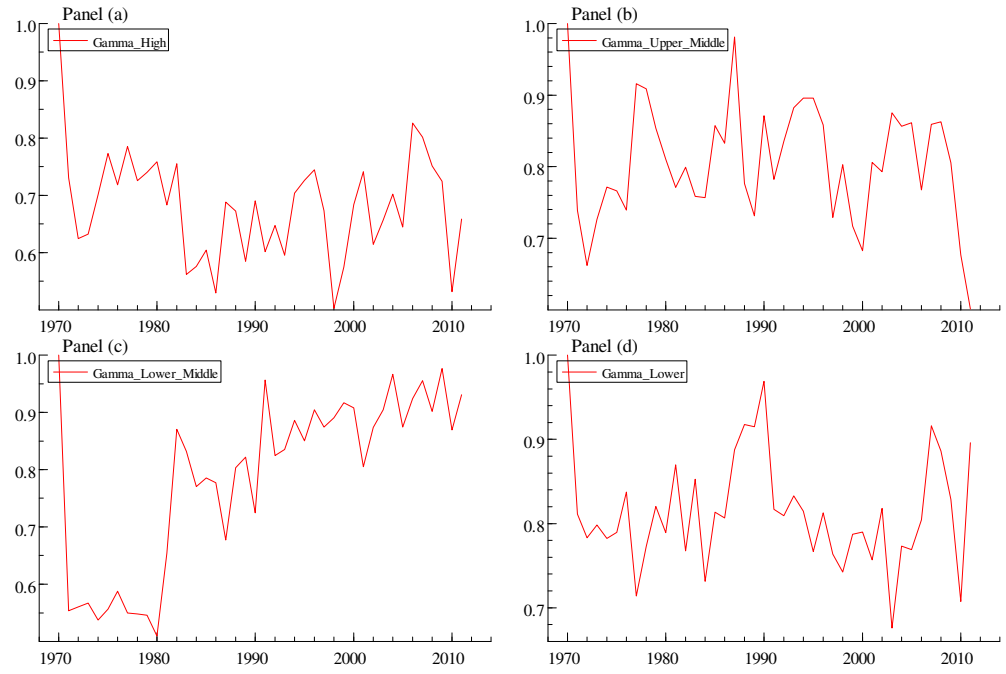

Figure 2. γ-convergence in high income countries, upper-middle income countries, lower-middle income countries and low income countries, 1970-2011.

Table 1: Absolute β-convergence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: High income countries							
α	0.3080 [a] (8.1906)	0.2937 [a] (8.2474)	0.3003 [a] (8.4499)	0.2969 [a] (8.2869)	0.2939 [a] (8.6114)	0.2991 [a] (8.7926)	0.2981 [a] (8.6952)
β	-0.0683 [a] (-7.7002)	-0.0650 [a] (-7.7515)	-0.0659 [a] (-7.8731)	-0.0654 [a] (-7.6951)	-0.0646 [a] (-8.0416)	-0.0653 [a] (-8.1522)	-0.0655 [a] (-8.0621)
Fixed regimes		0.0036 (1.1866)			0.0025 (0.8501)		
Intermediate regimes			-0.0016 (-1.2728)			-0.0014 (-1.1963)	
Flexible regimes				-0.0001 (-0.1089)			0.0005 (0.4360)
Financial crises					-0.0421 [a] (-4.1301)	-0.0425 [a] (-4.1954)	-0.0435 [a] (-4.2418)
r_β (%)	0.030	0.031	0.032	0.032	0.031	0.032	0.032
Panel B: Upper-middle income countries							
α	0.4180 [a] (4.3660)	0.4474 [a] (3.5210)	0.4667 [a] (3.9442)	0.3951 [a] (3.3247)	0.4420 [a] (3.6774)	0.4905 [a] (4.1390)	0.4098 [a] (3.4413)
β	-0.1090 [a] (-4.1521)	-0.1170 [a] (-3.4261)	-0.1247 [a] (-3.8221)	-0.1015 [a] (-3.1027)	-0.1225 [a] (-3.5653)	-0.1306 [a] (-4.0044)	-0.1047 [a] (-3.2008)
Fixed regimes		-0.0013 (-0.0856)			-0.0043 (-0.2883)		
Intermediate regimes			0.0081 (1.6176)			0.0096 [c] (1.9006)	
Flexible regimes				-0.0102 [b] (-2.0748)			-0.0103 [b] (-2.1034)
Financial crises					-0.0254 (-1.2207)	-0.0320 (-1.5565)	-0.0252 (-1.2532)
r_β (%)	0.070	0.095	0.100	0.082	0.100	0.110	0.080
Panel C: Lower-middle income countries							
α	0.4267 [a] (5.7622)	0.5074 [a] (5.5678)	0.4929 [a] (5.6569)	0.4633 [a] (5.3713)	0.5237 [a] (6.0317)	0.5074 [a] (6.1200)	0.4727 [a] (5.7448)
β	-0.1314 [a] (-5.5681)	-0.1556 [a] (-5.4216)	-0.1540 [a] (-5.4986)	-0.1427 [a] (-5.1685)	-0.1578 [a] (-5.7757)	-0.1562 [a] (-5.8635)	-0.1430 [a] (-5.4322)
Fixed regimes		-0.0110 (-1.2886)			-0.0129 (-1.5797)		
Intermediate regimes			0.0046 (1.5448)			0.0055 [c] (1.9315)	
Flexible regimes				-0.0016 (-0.5790)			-0.0016 (0.5435)
Financial crises					-0.0569 [a] (-4.9327)	-0.0575 [a] (-4.988)	-0.0561 [a] (-4.8423)
r_β (%)	0.042	0.061	0.060	0.055	0.062	0.061	0.055

Table 1: Absolute β-convergence (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel D: Lower income countries							
α	0.2507[a] (5.4247)	0.3033[a] (5.8070)	0.3046[a] (5.9039)	0.3151[a] (5.8660)	0.2955[a] (5.9506)	0.2971[a] (6.0569)	0.3052[a] (5.9739)
β	-0.0951[a] (-5.2450)	-0.1142[a] (-5.4903)	-0.1166[a] (-5.7975)	-0.1198[a] (-5.7475)	-0.1088[a] (-5.4967)	-0.1113[a] (-5.8112)	-0.1137[a] (-5.7249)
Fixed regimes		-0.0048 (-0.6488)			-0.0047 (-0.6715)		
Intermediate regimes			0.0029 (1.0579)			0.0027 (1.0138)	
Flexible regimes				-0.0009 (-0.4006)			-0.0006 (-0.2817)
Financial crises					-0.0523[a] (-5.1565)	-0.0521[a] (-5.1437)	-0.0523[a] (-5.1444)
r_β (%)	0.028	0.041	0.042	0.043	0.040	0.040	0.041

Notes: In the brackets below the parameter estimates are the corresponding *z*-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors. a, b and cindicate significance at 1%, 5%, and 10%, respectively.

Table 2: Conditional β-convergence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: High income countries							
α	0.4047 [a] (7.6055)	0.4131 [a] (8.4929)	0.4104 [a] (8.3784)	0.4109 [a] (8.4304)	0.4052 [a] (8.4385)	0.4037 [a] (8.3496)	0.4044 [a] (8.4034)
β	-0.0947 [a] (-6.9413)	-0.0958 [a] (-7.6857)	-0.0953 [a] (-7.6263)	-0.0950 [a] (-7.5929)	-0.0930 [a] (-7.5455)	-0.0928 [a] (-7.5055)	-0.0927 [a] (-7.4937)
Fixed regimes		-0.0002 (-0.0534)			-0.0001 (-0.0248)		
Intermediate regimes			0.0005 (0.4300)			0.0003 (0.2626)	
Flexible regimes				-0.0006 (-0.5441)			-0.0002 (-0.2337)
Financial crises					-0.0228 [b] (-2.3960)	-0.0226 [b] (-2.3716)	-0.0225 [b] (-2.3442)
Human capital	0.0026 [a] (2.8193)	0.0025 [a] (3.1072)	0.0026 [a] (3.2051)	0.0025 [a] (3.1402)	0.0022 [a] (2.6472)	0.0022 [a] (2.7197)	0.0021 [a] (2.6998)
CPI inflation	0.4480 [a] (3.6973)	0.4985 [a] (4.9422)	0.5035 [a] (4.9645)	0.5033 [a] (4.9798)	0.4508 [a] (4.4499)	0.4543 [a] (4.4510)	0.4535 [a] (4.4523)
Population growth	-8.0268 [c] (-1.8381)	-14.5632 [a] (-3.6560)	-14.8739 [a] (-3.6805)	-14.6950 [a] (-3.6951)	-14.7056 [a] (-3.7461)	-14.8945 [a] (-3.7409)	-14.7595 [a] (-3.7653)
r_β (%)	0.050	0.053	0.053	0.053	0.052	0.052	0.052
Panel B: Upper-middle income countries							
α	0.4210 [a] (3.9291)	0.3946 [a] (2.7860)	0.4233 [a] (3.1428)	0.3697 [a] (2.7997)	0.4158 [a] (2.9525)	0.4374 [a] (3.2870)	0.3767 [a] (2.8714)
β	-0.1074 [b] (-3.4151)	-0.0939 [b] (-3.2676)	-0.1057 [b] (-2.5950)	-0.0899 [b] (-2.2783)	-0.0943 [b] (-2.2993)	-0.1052 [b] (-2.6175)	-0.0875 [b] (-2.2332)
Fixed regimes		-0.0019 (-0.1239)			-0.0067 (-0.6649)		
Intermediate regimes			0.0075 (1.4238)			0.0090 [c] (1.7125)	
Flexible regimes				-0.0101 [c] (-1.8338)			-0.0094 [c] (-1.7250)
Financial crises					-0.0389 [c] (-1.7077)	-0.0427 [c] (-1.9161)	-0.0342 [c] (-1.8452)
Human capital	-0.0012 (-0.5080)	-0.0040 (-1.1664)	-0.0033 (-0.9534)	-0.0023 (-0.6476)	-0.0057 (-1.5953)	-0.0049 (-1.4015)	-0.0036 (-1.0477)
r_β (%)	0.070	0.080	0.090	0.075	0.080	0.090	0.073

Table 2: Conditional β-convergence (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel C: Lower-middle income countries							
α	0.2656 [a] (2.6342)	0.3409 [a] (2.8792)	0.3343 [a] (2.9527)	0.3560 [a] (3.0627)	0.3358 [a] (2.8914)	0.3362 [a] (2.9384)	0.3454 [a] (3.0317)
β	-0.1220 [a] (-3.4048)	-0.1519 [a] (-3.6173)	-0.1515 [a] (-3.6303)	-0.1560 [a] (-3.7489)	-0.1414 [a] (-3.4185)	-0.1406 [a] (-3.4256)	-0.1440 [a] (-3.5117)
Fixed regimes		0.0054 (0.6384)			0.0035 (0.4194)		
Intermediate regimes			-0.0025 [a] (-0.9034)			-0.0020 [a] (-0.7426)	
Flexible regimes				0.0003 (0.1401)			0.0005 (0.2330)
Financial crises					-0.0285 [b] (-2.5687)	-0.0284 [b] (-2.5627)	-0.0290 [b] (-2.6219)
Gross saving	0.0014 [a] (2.7379)	0.0018 [a] (2.9365)	0.0019 [a] (3.0540)	0.0019 [a] (2.9388)	0.0016 [b] (2.6042)	0.0016 [a] (2.6918)	0.0016 [a] (2.6172)
Human capital	0.0078 [a] (3.2864)	0.0090 [a] (3.3568)	0.0088 [a] (3.3606)	0.0086 [a] (3.2464)	0.0070 [b] (2.5866)	0.0070 [a] (2.6167)	0.0067 [b] (2.5011)
Openness	0.0008 [a] (3.5033)	0.0008 [a] (3.3199)	0.0008 [a] (3.3189)	0.0008 [a] (3.4246)	0.0007 [a] (3.0944)	0.0007 [a] (3.0827)	0.0008 [a] (3.1590)
$r_\beta(\%)$	0.063	0.090	0.090	0.090	0.081	0.080	0.082
Panel D: Lower income countries							
α	0.2792 [a] (3.6262)	0.1881 [b] (2.2750)	0.2050 [b] (2.5130)	0.2025 [b] (2.4269)	0.1845 [b] (2.3896)	0.1957 [b] (2.5748)	0.1968 [b] (2.5309)
β	-0.0846 [a] (-3.2673)	-0.0890 [b] (-2.6216)	-0.1005 [a] (-3.0931)	-0.1007 [a] (-3.0458)	-0.0835 [a] (-2.6317)	-0.0991 [a] (-3.0045)	-0.0926 [a] (-2.9997)
Fixed regimes		-0.0104 (-1.3699)			-0.0075 (-1.0542)		
Intermediate regimes			0.0023 (0.9043)			0.0020 (0.8266)	
Flexible regimes				0.0010 (0.4960)			0.0005 (0.2623)
Financial crises					-0.0365 [a] (-4.3103)	-0.0371 [a] (-4.3920)	-0.0372 [a] (-4.3867)
Gross saving	0.0014 [a] (5.4840)	0.0013 [a] (3.9635)	0.0014 [a] (4.3337)	0.0014 [a] (4.1776)	0.0012 [a] (4.0626)	0.0013 [a] (4.3670)	0.0013 [a] (4.25511)
Human capital	0.0058 [b] (2.6712)	0.0056 [b] (2.1903)	0.0061 [b] (2.4077)	0.0067 [b] (2.7833)	0.0046 [c] (1.9306)	0.0049 [b] (2.0535)	0.0054 [b] (2.3901)
CPI inflation	0.3092 [a] (2.6461)	0.3618 [a] (2.7865)	0.3399 [b] (2.6039)	0.3633 [b] (2.7554)	0.2602 [b] (2.1133)	0.2411 [c] (1.9492)	0.2571 [b] (2.0508)
$r_\beta(\%)$	0.040	0.055	0.063	0.063	0.052	0.062	0.058

Notes: In the brackets below the parameter estimates are the corresponding *z*-statistics, computed using White (1980)'s heteroskedasticity-robust standard errors. [a], [b] and [c] indicate significance at 1%, 5%, and 10%, respectively.