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Economic performance clubs in the Americas: 1955-2003

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The aim of this paper is to study the economic dynamics of a set of countries of the Americas during the 1955-2003 period. It does this by introducing an alternative concept of economic performance based on the idea of dynamic regimes. These regimes are defined by the level and growth rate of per capita gross domestic product (GDP). By introducing a non-parametric clustering method, the study identifies two main performance clubs whose evolution is studied. One of them, identified as the club of high-performing countries, displays a relatively homogeneous structure. The second group, conversely, presents a high level of dispersion in performances, suggesting the existence of subclusters with a degree of divergence between them. The study also finds that there is mobility between the low- and high-performing groups and that the distance between clusters increases over time.

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I
Introduction

During the 1980s and 1990s, one of the most topical subjects in the economic growth literature was the convergence hypothesis. Its main claim was a corollary of the neoclassical Ramsey-Solow model indicating that poor countries are, at least potentially, able to achieve higher growth rates than rich ones because of the free movement of technology and know-how. Numerous empirical studies supported this hypothesis, either wholly or in part (Barro and Sala-i-Martin, 1995).

Nevertheless, the great disparity observed in growth rates and large increases in per capita income inequality between countries around the world called into question the existence of endogenous mechanisms inexorably reducing international differences (Lucas, 2002). Quite to the contrary, the empirical evidence revealed divergent trends in economic performance between countries. This finding and other powerful theoretical and empirical criticisms of the neoclassical growth model gave rise to a new field of research in the area of economic growth theory: endogenous growth theory (EGT) (Romer, 1994).

This new theoretical perspective provided clues as to why different economies, even if setting out from similar initial conditions and parameters, could come to diverge in their aggregate performance. Despite these advances, the first econometric studies were not wholly satisfactory, their explanatory power being not substantially different from that of earlier growth models (Amable and Guellec, 1992; Solow, 1992). For over two decades, EGT continued to make theoretical progress, focusing on endogenous sources of growth as an explanation for international divergence (Aghion and Howitt, 1999).

In parallel with the theoretical and empirical advances of EGT, D. Quah (1996 and 1997) introduced a new methodology of analysis based on identifying convergence clubs (groups of countries that present a similar long-term economic performance) and directly modelling the dynamics of countries' cross-sectional distribution. Through this work, Quah was able to show that convergence was compatible with both stable and increasing per capita incomes. The dynamics of convergence clubs and the forces giving rise to them, and the existence of inexorable poverty traps, became the bottom line of economic research (Howitt and Mayer-Foulkes, 2004, among others).

The main difference between standard works on economic convergence and the above approach is that whereas the former posit their analysis on the existence of an underlying theoretical model, the latter concentrates on the dynamic itself, irrespective of the model sustaining that dynamic.

The study conducted here follows this latter line of investigation. Its aim is to analyse the dynamic of convergence clubs from the perspective of economic performance, with a view to identifying performance clubs. It introduces the economic regime concept, whose two-dimensional character extends the interpretation of economic performance. To this end it analyses the behaviour of per capita income levels and growth rates for a group of countries in the Americas using a non-traditional (non-parametric) statistical model: the minimum spanning tree and the hierarchical tree.

This paper is organized as follows. Section II presents a brief discussion of the concept of convergence and its empirical tests, with particular reference to the countries of the Americas. Section III describes the proposed method, while section IV expounds the results. Lastly, section V sets forth the main conclusions and future directions for research.

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II
Some background on the convergence hypothesis

An initial approach to convergence analysis is provided by the idea that, given the international circulation of technology and know-how, poorer countries ought to grow faster than richer ones, causing per capita output to converge in the long run. This idea was outlined by classical economists such as Adam Smith and John Stuart Mill, who considered an equitable distribution to be the natural outcome of economic evolution and progress (De Long, 1997). From a theoretical standpoint, the concept of convergence arose with the development of the neoclassical growth model, which predicts that if all countries have the same parameters as regards production functions and utility, the countries that are least advanced will grow faster than those with higher incomes, causing per capita incomes to even out in the long run.

The key to this prediction is capital productivity: since poor countries have a smaller stock of capital than rich ones, its productivity will be greater there. Physical investment in such countries will accordingly be high, driving a high rate of growth. Thus, setting out from a single difference between countries, namely their initial per capita income level, and given decreasing marginal returns on the cumulative factor (capital), poor countries will tend to catch up with rich ones in the long run.

Convergence is not altogether straightforward to interpret. Accordingly, following Barro and Sala-i-Martin (1995), the analysis incorporates the concepts of β-convergence and σ-convergence: absolute β-convergence is said to be taking place if poor countries are tending to grow more quickly than rich ones, while σ-convergence is occurring in a group of countries if the dispersion in their real per capita GDP levels is diminishing. Clearly, the two concepts are intuitively related: if per capita GDP levels are evening out over time (σ-convergence), this is because the poorer economy is growing faster than the rich one (β-convergence). β-convergence is a necessary condition for σ-convergence and will tend to generate it, although it is considered a necessary but not sufficient condition for σ-convergence.

Criticisms of the convergence concept have been widely aired from both a theoretical and an empirical standpoint (see Barro and Sala-i-Martin, 1995; Lucas, 2002; Quah, 1997, among others). However, it is important to stress that the neoclassical model predicts convergence on the crucial assumption that the only difference between countries is their initial level of capital per person. The economic reality is that countries differ in much more than their initial endowments, and they also vary greatly in respect of other key parameters such as technology, propensity to save, population growth rates and institutional parameters, among other things. If different economies have different parameters of both behaviour and technology, they will present different steady states. Given that the theory refers to convergence to steady state (conditional β-convergence), different steady states should reveal differences in economic performance. This opens up an immense range of possibilities that confound linear predictions: it is possible to find rich countries that are below their steady state and accordingly growing faster than poor countries that are above their steady state. Retaining all the other assumptions of the neoclassical model, analysis based on the steady state concept can yield non-trivial realizations (Durlauf and Quah, 1999).

Meanwhile, numerous empirical studies have found convergence to be absent, with σ-divergence the rule: the lack of convergence between countries suggests that inequality is not only not disappearing, but is actually on the rise (Ros, 2001).

In view of this finding, in the first half of the 1990s a number of authors reformulated the relationship between the convergence hypothesis and the neoclassical model (Barro, 1991; Mankiw, Romer and Weil, 1992; Barro and Sala-i-Martin, 1995, among others). Since the neoclassical model predicts that an economy's growth rate is inversely related to its own steady state (conditional convergence), it is only valid to argue that poorer countries will grow faster than advanced economies so long as all economies have the same steady state. Thus, both a theoretical and an empirical equivalent need to be found if the approach applied in the study of convergence is to be retained.

Empirically, two ways of "conditioning the data" have been found: confining the study to sets of similar economies on the assumption that they have the same steady state (Barro and Sala-i-Martin, 1995; Barro, 1997), and running the data through multiple regressions with the introduction of additional variables as proxies for the steady state, which is kept fixed (Mankiw, Romer and Weil, 1992). Using this new empirical method, the studies mentioned have found conditional β- and σ-convergence for certain sets of countries.

In the specific case of the Americas and Latin America, the studies carried out using cross-sectional regressions have been extremely sensitive to the variables selected: Helliwell and Chung (1992) and Utrera (1999), for example, find conditional β-convergence for 20 countries of Latin America, while Dobson and Ramlogan (2002) find absolute and conditional β-divergence when, for a single group of countries, they incorporate sectoral composition and a dummy variable for oil-exporting countries. The same contradictory findings appear in studies using unit root tests in panel data (Dobson, Goddard and Ramlogan, 2003; Cáceres and Núñez Sandoval, 1999; Utrera, 1999, among others). The last of these authors conducts a convergence analysis for 20 Latin American countries between 1950 and 1990, finding conditional β-convergence in cross-sectional regressions, β-divergence in tests for unit roots and β-divergence in dynamics of distribution (Quah-style).

However, the main point when it comes to analysing the relative performance of poor and rich countries is not to validate or invalidate the neoclassical model, but to seek an economic explanation for the causes of inequality in global income distribution. Focusing the analysis on discussion of a particular model (often poorly interpreted) would not appear to be the right way of achieving this aim. The same point was made by Durlauf and Quah (1999), who present an exhaustive review of the literature on empirical techniques for analysing convergence.

In this discussion, the pivotal role of the steady state concept imposes a limitation on the analysis. By contrast with the previous case, however, it is possible to develop a method of empirical analysis that dispenses with any specific underlying model.

As mentioned in the introduction, the first contribution of this kind was made by D. Quah (1993). That author's work focuses on the instrumental aspect of empirical convergence analysis, and his principal criticism is that convergence tests are affected by Galton's Fallacy of regression to the mean.[1]

In these tests it is said that regression to the mean, interpreted together with the idea of convergence, could describe the (theoretically posited) fact that countries with higher levels of output tend to present lower growth rates. As part of his critique of conventional convergence analysis, however, Quah shows that a negative coefficient in a cross-sectional regression on initial output levels is perfectly consistent with a lack of convergence. Consequently, he proposes an alternative way of evaluating the presence of convergence, which consists in directly examining the evolution over time of the cross-sectional distributions of per worker output (Quah, 1996). On the basis of his research, Quah concludes that while the gap between poor and rich countries widened in the period considered, the intermediate class tended to become poorer (twin peaks hypothesis).

Quah also considers it highly likely that there are stochastic tendencies in incomes within economies which ensure that the process of estimating the convergence coefficient is uniform and thus not derived from genuine convergence. Another even more general point is that convergence estimates do not consider aspects of the dynamics of economies as they move towards equilibrium states. The absence of these dynamic aspects may lead to faulty conclusions about the presence of a phenomenon in which economies tend to a steady state (Moncayo, 2004).

The dynamic is crucial in this type of analysis. Accordingly, and in the light of what has been said here, the following section will present a statistical method for describing performance and performance clubs that is based on the behaviour dynamics of the different countries, making it possible to establish convergence or divergence between groups and subgroups of economies without the need for prior conditioning of the data.[2]

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[1] The fallacy is known by this name because of the research by Francis Galton in 1885 entitled "Regression toward Mediocrity in Hereditary Stature", where Galton noted that the sons of tall fathers regressed to the mean height, since on average these people were shorter than their parents.

[2] Standard econometric or multivariate models of convergence analyse this phenomenon on the assumption that a particular steady state exists and incorporate a group of variables that describe the economy with a view to validating or invalidating the underlying model. The data are thus "conditioned" to an existing idea of a steady state. With our model, although two types of variables are worked with (per capita GDP and its growth rate), no model is presupposed, the data being grouped by a purely statistical process.

III

Convergence in regime dynamics

This section proposes a new way of defining convergence, considering dynamics in terms of regimes that provide a qualitative description of the evolution of economies (Brida, 2008). In this case, the space of states is defined using per capita GDP and GDP growth rates, which are classic variables in economic growth theory. A distinctive feature of the method presented here that sets it apart from most of the studies described in the previous section is that a "multidimensional analysis" is conducted.

The present study defines four regimes on the basis of the observed dynamics. In particular, the regimes are represented by the division of the space on the basis of two threshold values, which are taken to be the means of per capita GDP and the growth rate of this value for all the countries and the whole sampling period.[3] If these values are m_y and m_g, then our regimes are represented by the following subsets of the space of states:

$R_1 = \{(y, g_y): y < m_y, g_y < m_g\}$, $R_2 = \{(y, g_y): y < m_y, g_y > m_g\}$, $R_3 = \{(y, g_y): y > m_y, g_y < m_g\}$, $R_4 = \{(y, g_y): y > m_y, g_y > m_g\}$

where, for example, R_1 is the regime of low GDP and low growth, so that a country occupying that period would be deemed poor and slow-growing. The other regimes can be interpreted similarly. Figure 1 shows the grid characterizing the four regimes.

At this point we can ignore the precise values for GDP levels and growth rates and describe an economy's evolution on the basis of the regime changes that have occurred over its history. This gives us a rough description of the dynamic, telling us only what regime an economy was in at a given point in time.

This dynamic can be described in terms of symbolic time series as follows: a time series is constructed from the values of the regime in each country and year, yielding a matrix of N x T data (N countries and T periods), in which each value of the regime $R_{n,t}$ is located. The regime dynamics in each country can be analysed with techniques like those used in Brida, Puchet and Punzo (2003), Brida and Garrido (2006) and Accinelli and Brida (2007). The following characteristics can be observed in table 1:

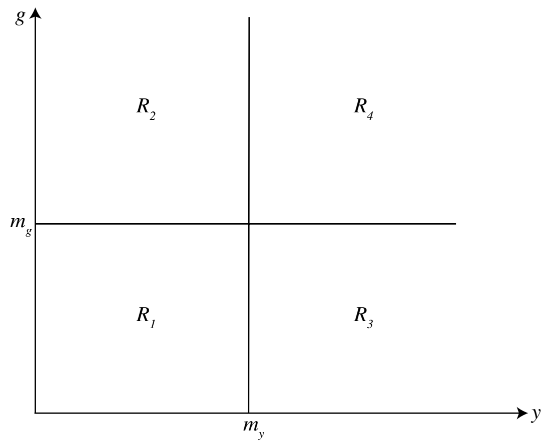
(i) Canada and the United States are the countries that spend the most time in regime 4, approximately 66%, only temporarily passing through regime 3 in the other periods.

(ii) The opposite situation is found in countries such as Haiti and Honduras, which spend most time in regime 1 (more than 60%), passing over to regime 2 in the remaining periods. The question arises here as to how a country like Haiti, which is in a low-GDP and low-growth regime for 66% of the time, could converge with a country like the United States, which spends 66% of its time in a high-GDP and high-growth regime.

(iii) Other countries, on the other hand, seem to have made the transition from low-performance to high-performance regimes. Argentina, for example, passed through regimes 1 and 2 in the early years before moving into 3 and 4. The same is true of Mexico, which was in regimes 1 and 2 in the first 24 years before moving into 3 and 4.

FIGURE 1

Performance regimes



Source: prepared by the authors.

[3] This paper has used a division into regimes based on threshold values for both variables, calculated from observations. This is an example of endogenous partition, i.e., partition based on a property of the data (and thus varying with the set of observations). An exogenous partition is predetermined; it does not depend on the dataset and in many cases it is induced by an economic theory describing the process being analysed (Brida and Punzo, 2003).

TABLE 1

The Americas (25 countries): percentage of visits to each regime

Country	R_1	R_2	R_3	R_4
CAN	0.00	0.00	33.96	66.04
USA	0.00	0.00	33.96	66.04
TTO	5.66	5.66	26.42	62.26
PRI	1.89	28.30	16.98	52.83
ARG	1.89	5.66	45.28	47.17
VEN	0.00	0.00	54.72	45.28
CHL	22.64	28.30	7.55	41.51
URY	18.87	9.43	35.85	35.85
MEX	11.32	33.96	24.53	30.19
PAN	18.87	47.17	20.75	13.21
BRA	20.75	50.94	16.98	11.32
CRI	26.42	52.83	9.43	11.32
COL	39.62	49.06	5.66	5.66
DOM	30.19	69.81	0.00	0.00
PER	41.51	58.49	0.00	0.00
ECU	47.17	52.83	0.00	0.00
BOL	49.06	50.94	0.00	0.00
CUB	49.06	50.94	0.00	0.00
JAM	52.83	47.17	0.00	0.00
SLV	54.72	45.28	0.00	0.00
GTM	54.72	45.28	0.00	0.00
NIC	54.72	45.28	0.00	0.00
PRY	54.72	45.28	0.00	0.00
HND	62.26	37.74	0.00	0.00
HTI	66.04	33.96	0.00	0.00

Source: prepared by the authors on the basis of data from the appendix.

CAN: Canada. USA: United States. TTO: Trinidad and Tobago. PRI: Puerto Rico. ARG: Argentina. VEN: Bolivarian Republic of Venezuela. CHL: Chile. URY: Uruguay. MEX: Mexico. PAN: Panama. BRA: Brazil. CRI: Costa Rica. COL: Colombia. DOM: Dominican Republic. PER: Peru. ECU: Ecuador. BOL: Plurinational State of Bolivia. CUB: Cuba. SLV: El Salvador. GTM: Guatemala. JAM: Jamaica. NIC: Nicaragua. PRY: Paraguay. HND: Honduras. HTI: Haiti.

To compare the evolution over time of the different dynamics followed by the countries of the Americas, it is necessary to have some notion of the neighbourhoods of these evolutions. Different notions of distance can be defined in the space of the symbolic successions (see Brida and Punzo, 2003, and Brida, 2006).

In this exercise we shall take a distance d, which considers the regime overlaps of two different countries, with weightings. In other words, if two countries are in the same regime at time t, this will add a 0 in place t to the total sum, whereas if they are in different regimes, this will add a positive value p in place t of the addition. The number p may be 1, 2 or 3, depending on how far apart the regimes of the two countries are. This metric is defined by equation (1).

$$d(i,j)=\sqrt{\frac{\sum_{t=1}^{t=T}(S_{it}-S_{jt})^2}{T}} \qquad (1)$$

where S_{it} and S_{jt} are the regimes that countries i and j are in at time t, respectively, while T is the period studied.

On the basis of this metric, the countries can be regrouped using a clustering technique. Given the distance determined, the minimum spanning tree (MST) connecting the countries in the sample is constructed using Kruskal's algorithm.[4] The basic idea is to successively choose the edges of minimum weight. If the sample has n time series, the algorithm derives from the following steps:

(i) Initiate the MST with n nodes and no MST arcs[5] = ({*1,2, ...,n*), *ø*).

(ii) Create a list L of arcs in ascending order of weight (in this case, the distances between the time series). Arcs with the same weight are ordered randomly.

(iii) Select the arc (*i, j*) which is at the beginning of L. It is transferred to T and deleted from L.

(iv) If L is non-empty, go back to step 3; otherwise the process ends.

Table 2 gives the list T of the relevant distances after applying the algorithm for this problem.[6]

The procedure for constructing the minimum spanning tree graphically is as follows. Table 2 shows that the shortest distance is *d(CAN, USA)*=0.3885, so that Canada (CAN) is connected to the United States (USA) in one group. This is followed by the second-shortest distance, which is *d(GTM, PRY)*=0.5140, connecting Guatemala (GTM) to Paraguay (PRY) in another group, after which the third-shortest distance *d(HTI, GTM)*=0.5494 is taken, connecting Haiti (HTI) to the group of Guatemala and Paraguay. The process goes on until all the countries are connected in a tree, as shown in figure 2. In this way, the arcs of the minimum spanning tree represent the connections

[4] Kruskal's algorithm is an algorithm in graph theory for finding a minimum spanning tree for a connected weighted graph. This means it finds a subset of the edges that forms a tree that includes every vertex, where the total weight of all the edges in the tree is minimized. The algorithm was first published in 1956 and was written by Joseph Kruskal (Kruskal, 1956).

[5] The arcs are graphically represented by the lines joining the nodes or vertices in the MST.

[6] The total number of distances obtained is 46, including a country's distances from itself; the relevant distances for the eight countries are seven in number, however.

TABLE 2

The Americas: main connections between countries

Connection	Country i	Country j	Distance	Connection	Country i	Country j	Distance
1	CAN	USA	0.3885	13	VEN	CAN	0.7137
2	GTM	PRY	0.514	14	ARG	TTO	0.7524
3	HTI	GTM	0.5494	15	BRA	CRI	0.8578
4	SLV	GTM	0.5828	16	COL	BOL	0.8687
5	NIC	SLV	0.5828	17	ARG	VEN	0.8687
6	HND	SLV	0.5828	18	CRI	COL	0.9007
7	ECU	PRY	0.528	19	MEX	URY	0.9316
8	DOM	NIC	0.5987	20	PAN	CRI	0.9517
9	CUB	SLV	0.5987	21	PRI	MEX	0.981
10	BOL	SLV	0.5987	22	PRI	ARG	1.0187
11	PER	DOM	0.6143	23	CHL	PRI	1.1159
12	JAM	HND	0.6295	24	CHL	BRA	1.1655

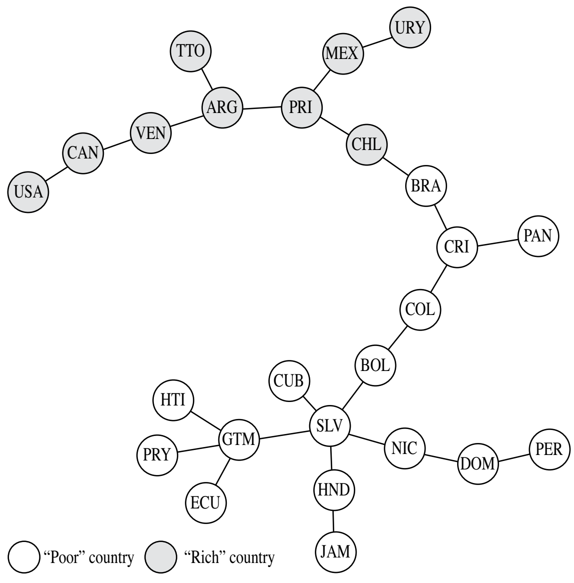
Source: prepared by the authors.

URY: Uruguay. TTO: Trinidad and Tobago. MEX: Mexico. USA: United States. CAN: Canada. VEN: Bolivarian Republic of Venezuela. ARG: Argentina. PRI: Puerto Rico. CHL: Chile. BRA: Brazil. CRI: Costa Rica. PAN: Panama. COL: Colombia. BOL: Plurinational State of Bolivia. HTI: Haiti. CUB: Cuba. PRY: Paraguay. GTM: Guatemala. SLV: El Salvador. NIC: Nicaragua. DOM: Dominican Republic. PER: Peru. ECU: Ecuador. HND: Honduras. JAM: Jamaica.

FIGURE 2

Minimum spanning tree for the countries of the Americas

(Unweighted)



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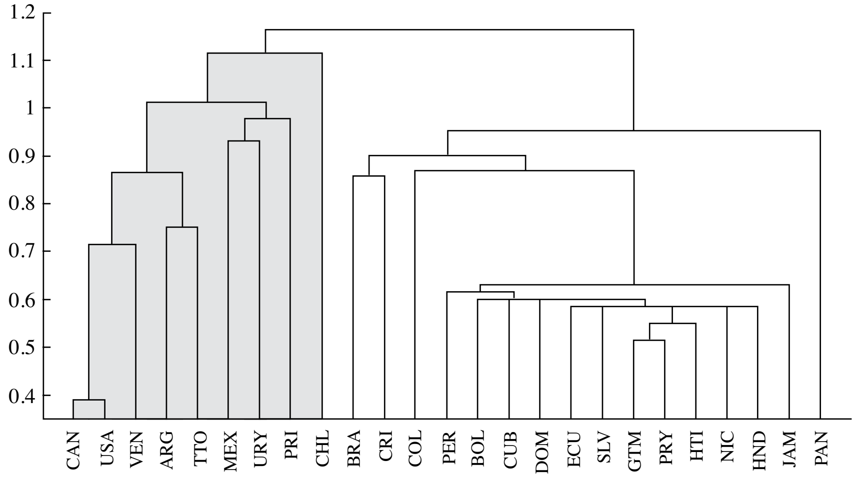
between the countries and their length is the distance between the countries connected. To create a chart that is easier to view, the lines in figure 2 are not weighted by distances, but these can be observed in the hierarchical tree of figure 3.

The minimum spanning tree (MST) is thus progressively constructed by relating all the countries of the sample in a graph characterized by the minimum distance between the time series, starting with the shortest distance. The main appeal of this tree is that it provides an arrangement of the countries in which the most important connections are selected for each element in the sample. Any two vertices of the MST can be connected either directly or through one or more vertices. In any event, the connections represent the shortest routes between these. The MST thus reveals any clusters that form and shows which countries are most connected with the rest and which are most isolated in their dynamic, establishing a topology between their growth dynamics. This same procedure allows the ultrametric distance (see Mantegna, 1999) to be constructed from the MST, and this can be used to study the degree of hierarchical organization of the vertices of the graph—of the countries in the sample, for instance. The ultrametric distance $d<(i,j)$ between i and j is the maximum of the distances $d(k,l)$ (i.e., the distances that are represented by the arcs or lines in the MST) from node (or vertex) i to node j by the

FIGURE 3

Hierarchical tree for the 25 countries of the Americas

(Grey = "rich" countries, white = "poor" countries)



Source: prepared by the authors.

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shortest route connecting vertex *i* with *j* in the MST.[7] In other words, using the MST the distance *d<(i,j)* between *i* and *j* is given by

$$d^{<}(i,j) = Max\left\{d_0(w_i;w_{i+1});1 \le i \le n-1\right\}$$

where $\{(w_1;w_2), (w_2;w_3), ..., (w_{n-1},w_n)\}$ denotes the unique minimum path in the MST that connects *i* and *j*, where $w_1=i$ and $w_n=j$ (see Ramal, Toulouse and Virasoro, 1986). This formula can be used to calculate the value of *d<(i,j)* for each pair of countries. The MST makes it possible to construct the hierarchical tree (HT) from the ultrametric distances. To find out the ultrametric distance between the United States and Panama, for example, it will be necessary to observe all the distances that are on the path from the United States to Panama. Figure 2 reveals that the path is composed by the set shown in the following expression:

$$\left\{\begin{matrix}(USA,CAN); (CAN,VEN); (VEN,ARG); (ARG,PR);\\ (PR,CHL); (CHL,BRA); (BRA,CRI); (CRI,PAN)\end{matrix}\right\}$$

This shows that the maximum distance is *d(CHL,BRA)*=1.1655, and this will be d<(USA,PAN)=1.1655. Figure 3 shows the hierarchical tree for the full period.

[7] If we have two points *i* and *j* that are joined by *l (i-j-l)*, the ultrametric distance meets the following condition, which is more restrictive than triangular inequality: *d<(i,j)=max{d<(i,l),d<(l,j)}*, i.e., it will be the maximum between the two distances joining *i* and *l* via *j*.

IV

Analysis of the findings

Two clearly differentiated clusters can be observed in the hierarchical tree, and these are distinguished in figures 2 and 3 by the colours grey and white, respectively.[8] The "grey" cluster comprises Canada, the United States, the Bolivarian Republic of Venezuela, Argentina, Trinidad and Tobago, Mexico, Uruguay, Puerto Rico and Chile. An initial interpretation of the countries in this group is that they are those which historically have performed best so that, stretching a point, we shall call them "rich" countries. Note that we can distinguish two subclusters within this cluster, one of which is formed by Canada and the United States, the countries closest together in the sample. These are without a doubt the best-performing countries, as they are the only ones to have been in regime 4 (high per capita GDP and high growth) on more than 60% of occasions, and they have never been in the low-GDP regimes (regimes 1 and 2).

The "white" cluster ("poor" countries) comprises Brazil, Costa Rica, Panama, Colombia, the Plurinational State of Bolivia, El Salvador, Honduras, Jamaica, Cuba, Haiti, Guatemala, Paraguay, Ecuador, Nicaragua, the Dominican Republic and Peru. Within this cluster it is likewise possible to distinguish some differences between the constituent countries. A compact subgroup of countries that are very close together can be observed, formed by Panama, the Plurinational State of Bolivia, El Salvador, Honduras, Jamaica, Cuba, Haiti, Guatemala, Paraguay, Ecuador, Nicaragua, the Dominican Republic and Peru. These are the countries that historically have performed worst within the group of "poor" countries. Meanwhile, Brazil, Costa Rica and Colombia stand some way apart from this subgroup, but not far enough away to enter the "grey" cluster or form another cluster; they might be considered a "white" subcluster. The economic record of Brazil, Colombia and Costa Rica shows these countries to be in an intermediate situation between those defined here as "poor" and "rich" countries, so that they clearly stand further apart (in terms of distances) from the other members of their own group.

Consequently, while the findings bring out two well-differentiated groups, something that can be visualized in a superficial initial analysis simply by observing table 2, the dynamics within the groups are not homogeneous, so that a finer examination of the evolution of the groups or clusters constructed will be needed to obtain a more detailed analysis.

Evolution of the groups

In view of the above, and on the basis of the clusters constructed, what needs to be studied is how these have evolved —whether there have been countries that have changed cluster or if the clusters have remained stable over time. Again, if there are countries that have remained in the same groups, the idea is to investigate whether they have moved closer together or further apart. This analysis can be carried out by taking a moving time window in the time period we are considering, i.e., by taking a window $v<T$ in length and considering all subperiods of duration v encompassed within the time arc being analysed, and then repeating this technique to construct the respective trees and identify groups within them. This will show how the clusters have evolved.[9] When the exercise was carried out, trees were obtained for windows 5, 10, 20 and 30 years long.

To study whether the countries in a group are moving together or apart over time, an overall measurement of distance is needed. Following the methodology proposed by Onnela (2002), this measurement can be obtained by adding together all the distances in the tree. This represents the diameter of the group. Figure 4 represents the evolution of the distance between all the American countries for windows of 5, 10, 20 and 30 years.

In figure 5, the window technique is applied to the "grey" group. Note that the distance between the nine countries defined as "rich" decreases over time, which could be interpreted as their converging upon a common dynamic.

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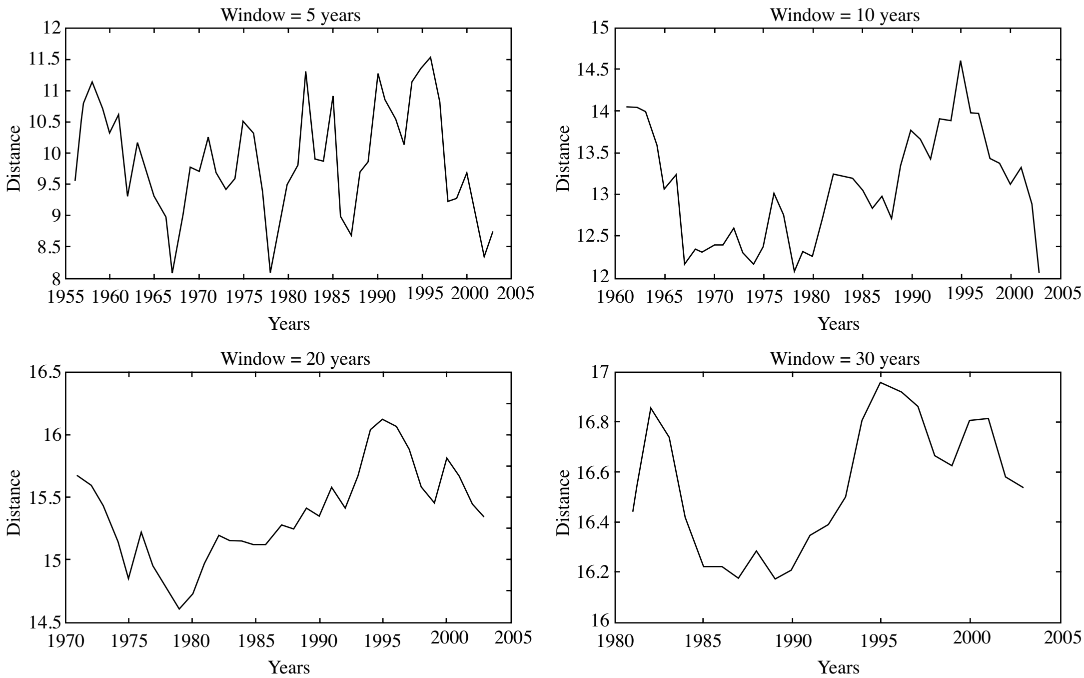
[8] It should be noted that, once the clusters are formed, the condition of the distance between countries within a given cluster being shorter than the distance between clusters is met.

[9] For reasons of space, this paper does not include the tables and trees obtained.

FIGURE 4

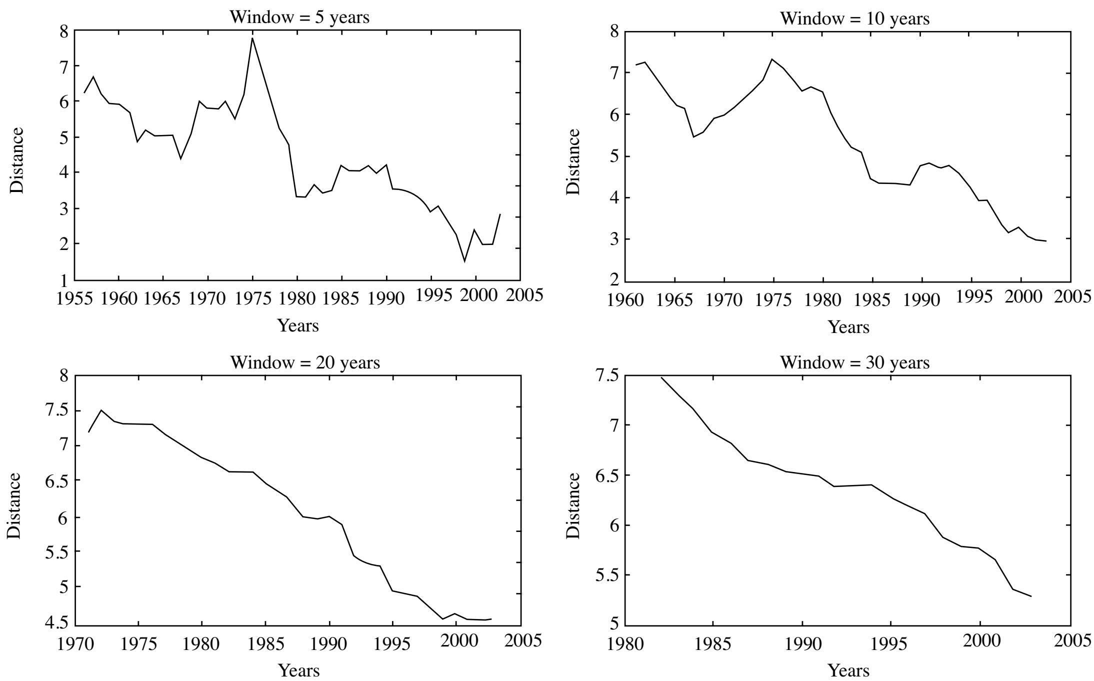
Evolution of the overall distance between the countries of the Americas



Source: prepared by the authors.

FIGURE 5

Evolution of the distance between the nine richest countries of the Americas



Source: prepared by the authors.

Figure 6, meanwhile, presents the evolution of the overall distance for the 16 "poor" countries; as can be seen, these countries present a distance that has increased over time. This can be interpreted as an increase in the heterogeneity of the group, with some countries set apart by a performance that has improved in relative terms in recent periods.

Figure 7, lastly, seeks to show what has happened between an average country in the "rich" group and one in the "poor" group. An initial observation seems to suggest that, on average, the "poor" countries have been moving away from the "rich" ones.

The results obtained would seem to bear out the studies by Quah (1993 and 1997), who concludes from his "mobility matrices" analysis that there is a degree of convergence between "poor" countries and between "rich" countries, while the likelihood of convergence towards one or other of the states is more equitable for middle-income groups. These studies gave rise to the well known "twin peaks hypothesis", according to which there is a long-run tendency for convergence clubs to form.

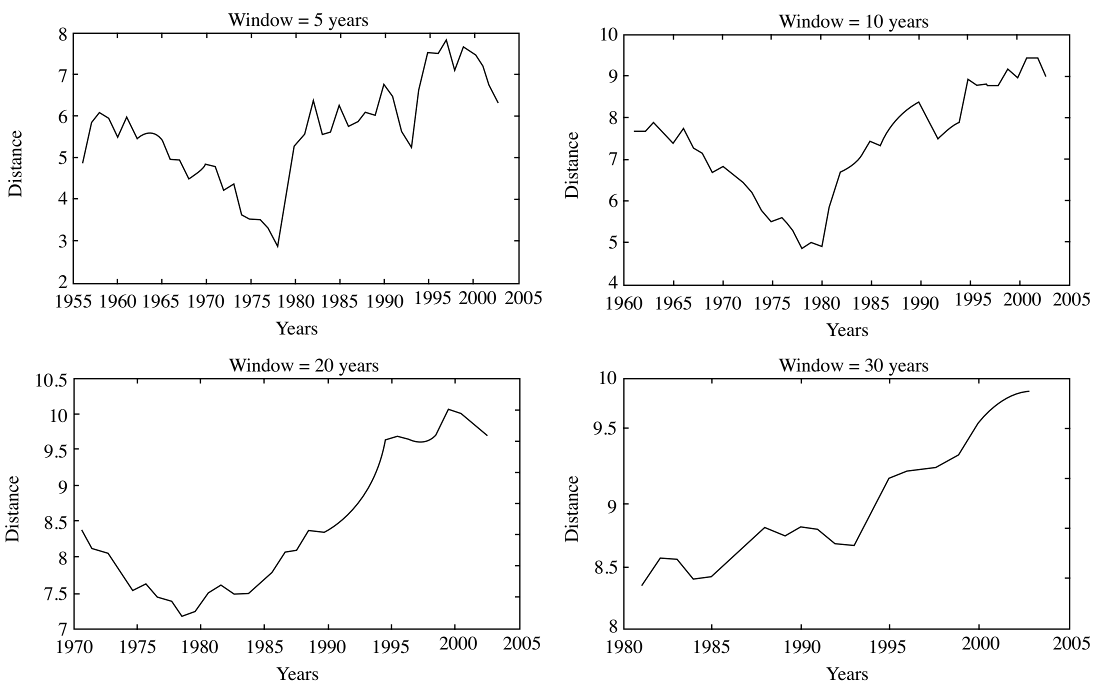
There is, however, a crucial difference in the analysis proposed here, which uses a broader concept of convergence: the convergence encountered is related not only to the level of GDP attained, but to the general performance of the countries throughout the period of analysis, which is why we speak of performance clubs.

To make the result of the analysis conducted here more robust and to bring out the differences from a traditional convergence study, 20,000 Monte Carlo simulations were generated for "poor" and "rich" countries over 51 years. The function obtained from these simulations is a probability distribution simulated for constant distances between two countries. In particular, a 5% and 95% confidence interval can be selected; thus, if two countries are moving apart (together), but remain within the confidence interval, it can be said that this increase (decrease) in distance was not significant and their distances can therefore be considered to have remained constant.

The simulated probability distribution function for average distances between the "rich" and "poor" country, which is obtained from the simulation, therefore makes it possible to analyse whether these are moving together or apart. Figure 7 shows the 5% and 95% confidence intervals as dotted lines. In the 1990s, the distances fall outside the confidence intervals, marking a significant movement apart.

FIGURE 6

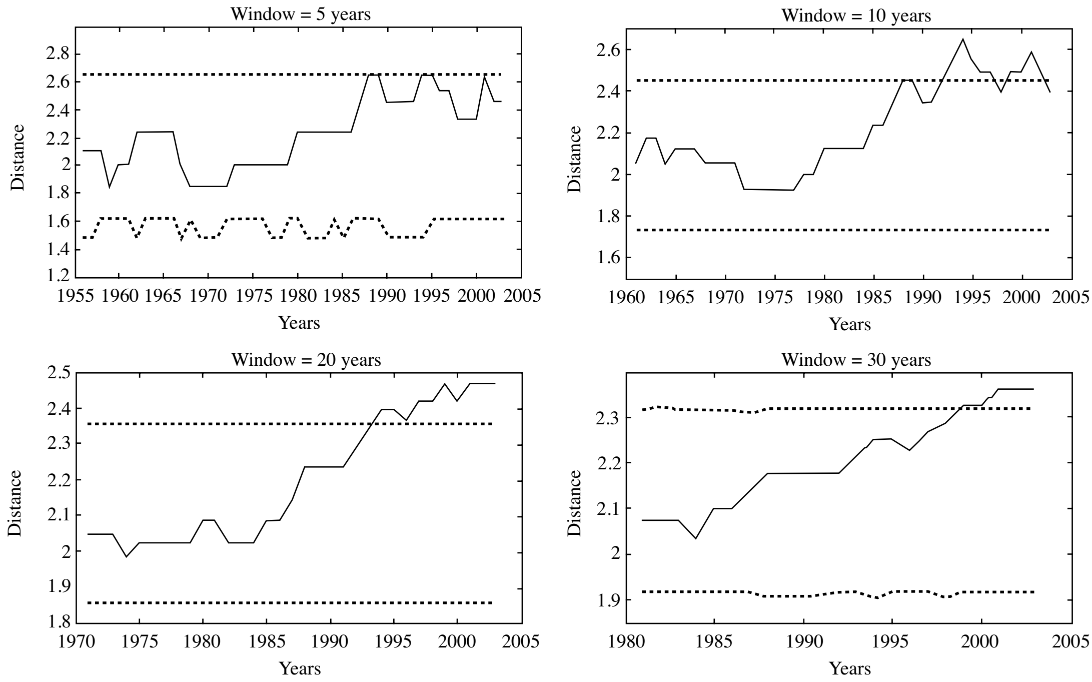
Evolution of the distance between the 16 poorest countries of the Americas



Source: prepared by the authors.

FIGURE 7

Evolution of the distance between the average "poor" country and the average "rich" country



Source: prepared by the authors.

This last analysis clearly shows that the countries made differential adjustments to their macroeconomic policies after the 1980s debt crisis, resulting in a kind of temporary divergence in performance. In the dynamic analysis, these differences could mark the emergence (or disappearance) of new clusters. The simulation thus bears out the findings of the initial analysis for the average countries.

To progress with the study of "cluster dynamics", the minimum spanning tree has been calculated by taking time intervals (windows) of 20 years. It transpires that the only link to survive intact over the 33 years of analysis is the one between Canada and the United States, indicating a very close relationship between the two countries and a dynamic different to that of the rest of the sample. The Latin American countries do not present such strong links, the longest-lasting being those between Colombia and Brazil and between Cuba and El Salvador.[10] As shown by a subsequent analysis, however, the country groups are relatively stable and tend to perpetuate themselves, although some countries display a tendency to change group.

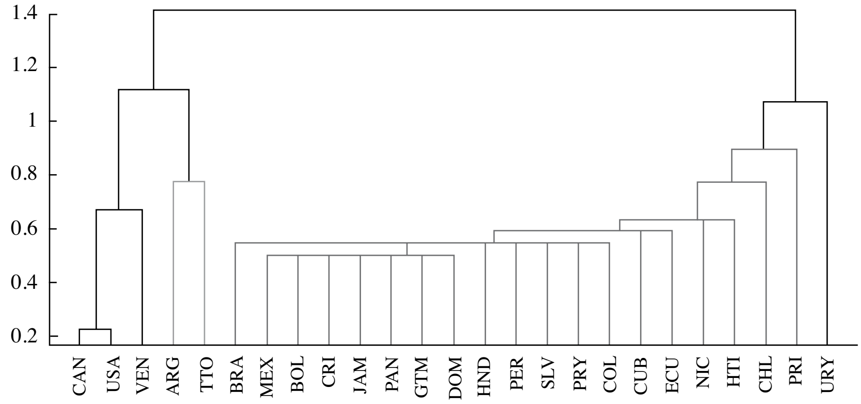
When the hierarchical trees are analysed, certain developments can be appreciated. The first tree is for 1971 and deals with the previous 20 years. Two major groups are observed. First there are the "rich" countries, comprising two subgroups, the first of which contains Canada and the United States and the second Argentina, the Bolivarian Republic of Venezuela and Trinidad and Tobago. Then there is the group of "poor" countries, with Uruguay in a relatively favourable position, as to a certain degree are Chile and Puerto Rico. The situation remains stable until 1976, when Puerto Rico shows a tendency to join the group of "rich" countries and Mexico starts to pull away slightly from the "poor" countries. By 1982 we find that Puerto Rico belongs to the "rich" group along with Canada, the United States, Trinidad and Tobago, Argentina and the Bolivarian Republic of Venezuela. Meanwhile, Mexico and Uruguay have formed a new cluster separating them from the "poor" countries and Chile continues to perform in a way that sets it apart from the "poor" countries, just as Panama does the following year.

[10] As noted earlier, the persistence of the proximity between Colombia and Brazil and between El Salvador and Cuba is due to macroeconomic similarities in industrial and structural conditions between the two pairs of countries.

FIGURE 8

Hierarchical tree for the Americas, 1971

(Taking a 20-year window)



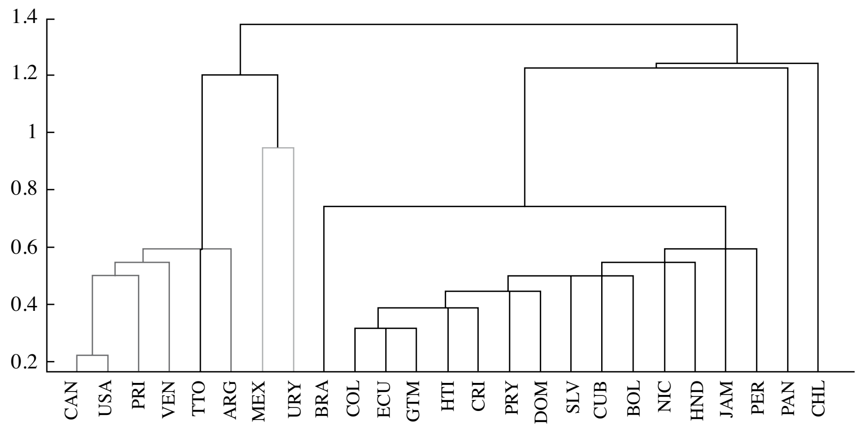
Source: prepared by the authors.

CAN: Canada. USA: United States. VEN: Bolivarian Republic of Venezuela. ARG: Argentina. TTO: Trinidad and Tobago. MEX: Mexico. URY: Uruguay. PRI: Puerto Rico. CHL: Chile. BRA: Brazil. CRI: Costa Rica. COL: Colombia. PER: Peru. BOL: Plurinational State of Bolivia. CUB: Cuba. DOM: Dominican Republic. ECU: Ecuador. SLV: El Salvador. GTM: Guatemala. PRY: Paraguay. HTI: Haiti. NIC: Nicaragua. HND: Honduras. JAM: Jamaica. PAN: Panama.

FIGURE 9

Hierarchical tree for the Americas, 1987

(Taking a 20-year window)



Source: prepared by the authors.

CAN: Canada. USA: United States. VEN: Bolivarian Republic of Venezuela. ARG: Argentina. TTO: Trinidad and Tobago. MEX: Mexico. URY: Uruguay. PRI: Puerto Rico CHL: Chile. BRA: Brazil. CRI: Costa Rica. COL: Colombia. PER: Peru. BOL: Plurinational State of Bolivia. CUB: Cuba. DOM: Dominican Republic. ECU: Ecuador. SLV: El Salvador. GTM: Guatemala. PRY: Paraguay. HTI: Haiti. NIC: Nicaragua. HND: Honduras. JAM: Jamaica. PAN: Panama.

In 1987, the group formed by Mexico and Uruguay joined the "rich" country club, while Panama and Chile pulled away considerably from the "poor" countries and Brazil showed a performance that began to distance it from that group. In 1992, although still some way behind, Chile entered the group of "rich" countries, and in 1997 Panama presented a similar performance. In 2001, Brazil and Costa Rica formed a group whose performance differed from that of the "poor" countries, and Colombia moved in a similar direction.

In 2003, at the end of the period, we find three groups: that of the "rich" countries comprising the United States, Canada, Argentina, Uruguay, Mexico, Trinidad and Tobago, Puerto Rico, the Bolivarian Republic of Venezuela and Chile; a group of intermediate countries (which join the club of "rich" countries) comprising Brazil, Costa Rica and Panama; and lastly, the club of "poor" countries, from which Colombia is evidently diverging.

The analysis reveals that there have always been basically two clubs of countries, and that countries originally belonging to the "poor" club have gone over to the "rich" club. This happened with Puerto Rico first, followed by Mexico and Uruguay and, lastly, Chile. Panama, Costa Rica and Brazil form a group that has still not fully caught up with the "rich" countries by the end of the period. Interestingly, there is no movement in the other direction, i.e., no country belonging to the "rich" countries' club has gone over to the club of "poor" countries.

The findings are reinforced when the evolution of the groups is studied on the basis of 30-year windows. The first thing that is observed is that besides the link between Canada and the United States, which remains intact in the 23 years following 1981, the other connection that remains unchanged is the one between Mexico and Uruguay.

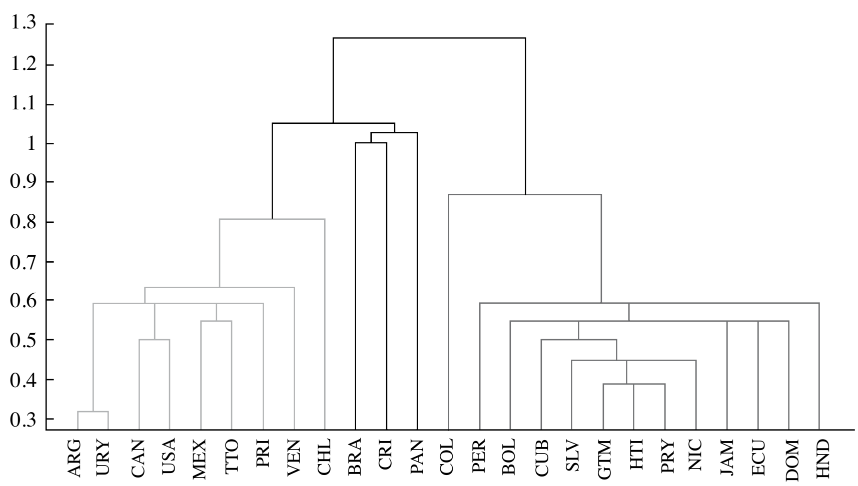
Certain facts stand out when the hierarchical trees are studied. The first appears in 1981, when we find the "rich" group of countries being formed by Canada, the United States, the Bolivarian Republic of Venezuela, Argentina and Trinidad and Tobago. Meanwhile, Puerto Rico, Uruguay, Mexico and Chile are pulling away from the "poor" countries but without leaving the cluster. In 1984, Puerto Rico makes the jump into the cluster of "rich" countries and Mexico and Uruguay form a group whose performance sets it apart from that of the "poor" countries. In 1990, the group containing Mexico and Uruguay is observed to join the "rich" country club, while Chile and also Panama are trying to distance themselves from the "poor" countries. In 1993, Chile succeeds in entering the "rich" country cluster, while Panama and to some extent Brazil perform in a way that sets them apart from the "poor" countries.

In 2003, the cluster of "rich" countries is found to be composed of Canada, the United States, Puerto Rico, the Bolivarian Republic of Venezuela, Trinidad and Tobago, Mexico, Uruguay, Argentina and, albeit some way behind, Chile. In the "poor"

FIGURE 10

Hierarchical tree for the Americas, 2003

(Taking a 20-year window)



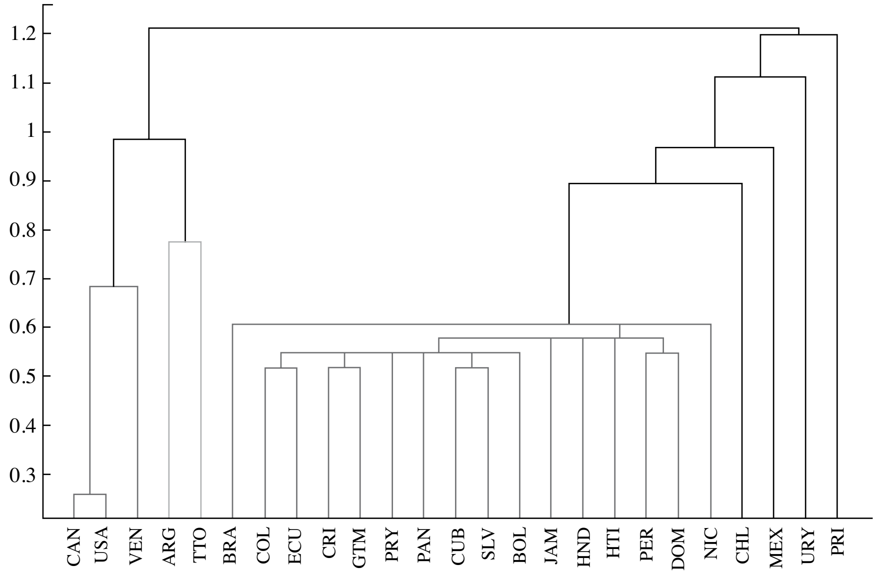
Source: prepared by the authors.

ARG: Argentina. URY: Uruguay. CAN: Canada. USA: United States. MEX: Mexico. TTO: Trinidad and Tobago. PRI: Puerto Rico. VEN: Bolivarian Republic of Venezuela. CHL: Chile. BRA: Brazil. CRI: Costa Rica. PAN: Panama. COL: Colombia. PER: Peru. BOL: Plurinational State of Bolivia. CUB: Cuba. SLV: El Salvador. GTM: Guatemala. HTI: Haiti. PRY: Paraguay. NIC: Nicaragua. JAM: Jamaica. ECU: Ecuador. DOM: Dominican Republic. HND: Honduras.

FIGURE 11

Hierarchical tree for the Americas, 1981

(Taking a 30-year window)



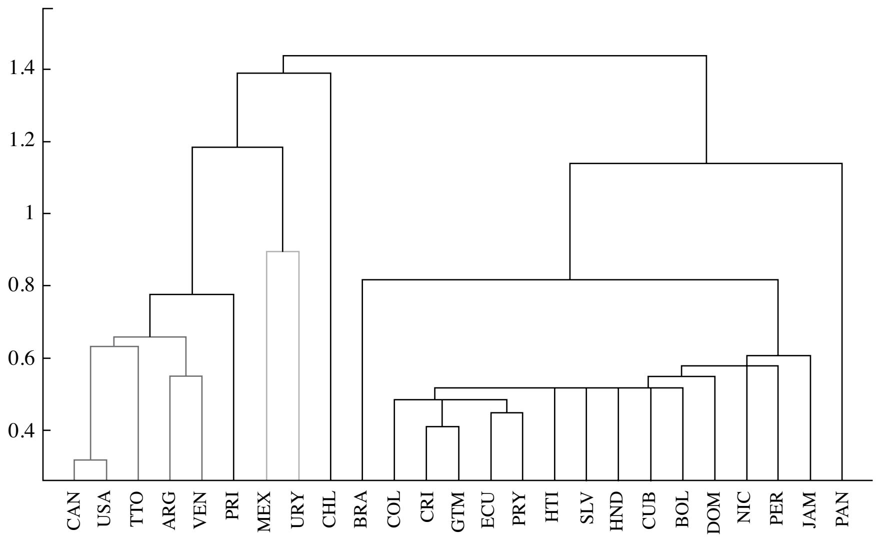
Source: prepared by the authors.

CAN: Canada. USA: United States. VEN: Bolivarian Republic of Venezuela. ARG: Argentina. TTO: Trinidad and Tobago. BRA: Brazil. COL: Colombia. ECU: Ecuador. CRI: Costa Rica. GTM: Guatemala. PRY: Paraguay. PAN: Panama. CUB: Cuba. SLV: El Salvador. BOL: Plurinational State of Bolivia. JAM: Jamaica. HND: Honduras. HTI: Haiti. PER: Peru. DOM: Dominican Republic. NIC: Nicaragua. CHL: Chile. MEX: Mexico. URY: Uruguay. PRI: Puerto Rico.

FIGURE 12

Hierarchical tree for the Americas, 1993

(Taking a 30-year window)



Source: prepared by the authors.

CAN: Canada. USA: United States. TTO: Trinidad and Tobago. ARG: Argentina. VEN: Bolivarian Republic of Venezuela. PR: Puerto Rico. MEX: Mexico. URY: Uruguay. CHL: Chile. BRA: Brazil. COL: Colombia. CRI: Costa Rica. GTM: Guatemala. ECU: Ecuador. PRY: Paraguay. HTI: Haiti. SLV: El Salvador. HND: Honduras. CUB: Cuba. BOL: Plurinational State of Bolivia. DOM: Dominican Republic. NIC: Nicaragua. PER: Peru. JAM: Jamaica. PAN: Panama.

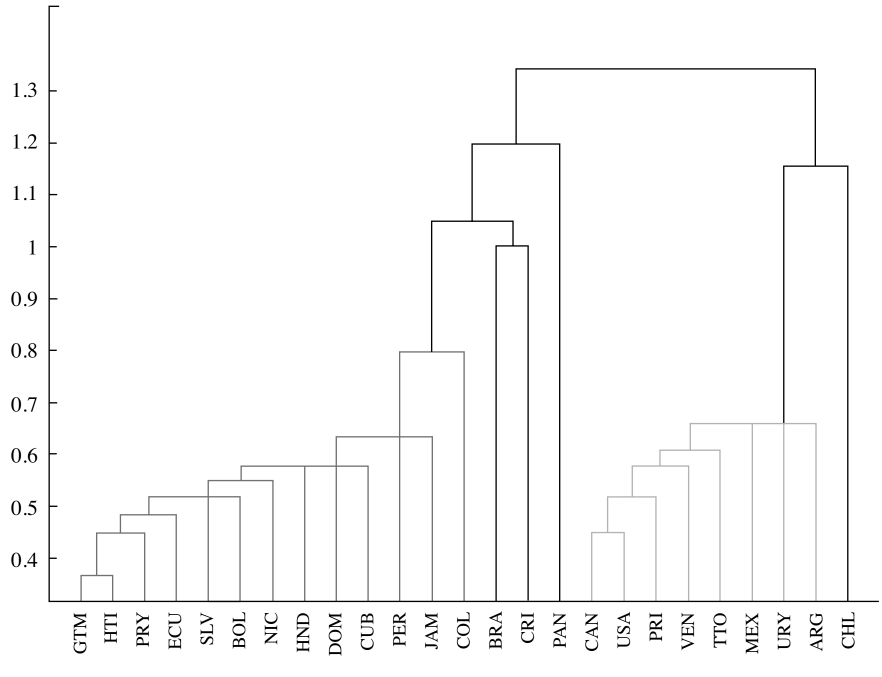
countries group, meanwhile, we find Brazil and Costa Rica forming a subgroup of countries which, with Panama, still display a performance that sets them apart from that group.

Here again, the leaps are only from "poor" to "rich" and not back the other way. Puerto Rico, Mexico, Uruguay and Chile are the countries that move from one club to another over the entirety of the period. This analysis is once again found to coincide with that conducted by Quah (1993), although it represents an advance in explanatory power and the breakdown of the dynamic. As that author notes, the likelihood of "rich" countries becoming "poor" countries is extremely low, while the likelihood of "poor" countries converging on the "rich" category is higher. Middle-income countries behave more erratically, however, so that the transition from "poor" to "rich" country is not assured in terms of traditional convergence. This last finding is reinforced by the time window analysis, which shows that Quah-style mobility is conditioned by the relative performance of each country.

FIGURE 13

Hierarchical tree for the Americas, 2003

(Taking a 30-year window)



Source: prepared by the authors.

GTM: Guatemala. HTI: Haiti. PRY: Paraguay. ECU: Ecuador. SLV: El Salvador. BOL: Plurinational State of Bolivia. NIC: Nicaragua. HND: Honduras. DOM: Dominican Republic. CUB: Cuba. PER: Peru. JAM: Jamaica. COL: Colombia. BRA: Brazil. CRI: Costa Rica. PAN: Panama. CAN: Canada. USA: United States. PRI: Puerto Rico. VEN: Bolivarian Republic of Venezuela. TTO: Trinidad and Tobago. MEX: Mexico. URY: Uruguay. ARG: Argentina. CHL: Chile.

V

Conclusions

This study has presented a non-parametric method of clustering based on the dynamic regime concept. The technique was applied with a view to contributing to the economic convergence debate. In particular, a new idea of convergence is used that differs from the traditional one, based on convergence towards a steady state. With this new concept of convergence, two countries "converge" if their regime dynamics become more similar, without their variables necessarily tending towards a steady state.

In the exercise, the technique is applied to a group of countries in the Americas, including countries deemed to be both developed and undeveloped, and what come out are a number of results that a traditional convergence analysis would not bring to light. First, while two well-differentiated groups have been marked out (what we call "poor" and "rich" countries), heterogeneous performances have been found within them. Two subgroups can be found inside each of these two groups: among the "rich" countries we have a subgroup comprising the United States and Canada (the closest together in the sample), which present a dynamic different from that of the rest of the "rich" country group. Among the "poor" countries, meanwhile, there is a compact group which we might consider the poorest, and then there are Brazil, Costa Rica and Colombia which, without graduating to the "rich" group, stand considerably apart from the "poorest".

A second interesting behaviour pattern that can be found in this analysis is the presence of larger disparities in the "poor" country group than in the "rich" one. While the "richest" countries have converged among themselves, the "poorest" countries have shown something of a tendency to diverge over time.

By studying the evolution of the distance between the average "poor" and "rich" country and carrying out 20,000 Monte Carlo simulations for "poor" and "rich" countries, we obtained the result that the distance between the average "poor" country and the average "rich" one fell outside the confidence interval (of a constant distance) in the 1990s. This suggests that much of the separation between "rich" and "poor" countries in the Americas took place in that decade.

The wealth of findings, which enable the economic performance of the countries of the Americas to be described in accordance with their economic history, would seem to account for the failure to find a unique result in the traditional convergence analyses mentioned in previous sections. In any event, the findings partially match those presented by Mayer-Foulkes (2001) and Howitt and Mayer-Foulkes (2004), who identify convergence clubs on the basis of a specific model.

In summary, this new methodological proposal has made it possible to establish patterns and trends in the economic performance of the countries of the Americas. What has been analysed in particular is the convergence or divergence in the economic performance of these countries, allowing performance clubs to be identified without the need to "condition the data" in advance in order to adapt the convergence analysis to the traditional tools, or specify a concrete model. From a methodological standpoint, the main difference is that all the results encountered (groups of countries, divergence/convergence between and within groups, etc.) are ex post, which eliminates any selection bias.

Lastly, the proposed method allows other variables (economic, institutional, social and others) to be incorporated into the analysis so as to compare the influence of these variables on the formation of clubs in the light of changes in performance. In particular, it is possible to carry out a comparative analysis of the dynamics of growth clubs and development clubs by taking qualitative variables such as the Human Development Index or detailed analysis of human capital accumulation, among others. An initial hypothesis is that a number of countries in Latin America and the Caribbean present a profound duality in their quantitative and qualitative historical performance: per capita income figures alone give no clue to the possibility that income distribution may be becoming increasingly unequal even as a country develops or that its economy may be tending towards dualism in its economic and social structure, with qualitative development variables thus potentially returning increasingly negative values. This is an area for further research.

(Original: Spanish)

APPENDIX

Data used

This study uses per capita GDP (GDP divided by population) in constant 1990 dollars and per capita GDP growth, both for the 1951-2003 period, in 25 countries of the Americas. These data were obtained from "Historical statistics for the world economy: 1-2003 AD", prepared by Angus Maddison (2001a).

According to Maddison, the data are contained in three books: *Monitoring the World Economy, 1820-1992* (Maddison, 1995), *The World Economy: A Millennial Perspective* (Maddison, 2001b) and *The World Economy: Historical Statistics* (Maddison, 2003). All these books have detailed notes.

The GDP of Latin America in 2000-2003 was revised and updated by ECLAC in the *Statistical Yearbook for Latin America and the Caribbean, 2004* and a preliminary version of the *Statistical Yearbook for Latin America and the Caribbean, 2005*, supplied by Andre Hofman (ECLAC, 2005 and 2006). For Chile, 1820-2003 GDP was provided by Rolf Lüders in *The Comparative Economic Performance of Chile 1810-1995* (Lüders, 1998), with population estimates by J. Díaz, R. Lüders and G. Wagner in "La República en cifras: Chile 1810-2000" (Díaz, Lüders and Wagner, 2005). For Peru, the figures are from "PIB 1896-1990 y población 1896-1949", by Bruno Seminario and Arlette Beltrán, in *Crecimiento económico en el Perú 1896-1995* (Seminario and Beltrán, 1998).

The Americas (25 countries): per capita GDP and annual growth averages, 1951-2003

Country	Per capita GDP	Average annual growth
United States	18 133.77	2.14%
Canada	14 634.00	2.24%
Venezuela (Bol. Rep. of)	9 310.72	-0.02%
Trinidad and Tobago	9 071.34	3.04%
Puerto Rico	7 680.12	3.71%
Argentina	7 002.68	0.94%
Chile	5 961.25	2.22%
Uruguay	5 930.91	0.81%
Mexico	5 000.49	2.16%
Costa Rica	4 124.87	2.36%
Panama	4 090.70	2.19%
Brazil	3 903.59	2.35%
Colombia	3 773.94	1.71%
Peru	3 548.00	1.17%
Guatemala	3 297.49	1.30%
Ecuador	3 242.75	1.24%
Jamaica	3 202.38	2.04%
Paraguay	2 451.82	1.24%
Cuba	2 349.87	0.61%
El Salvador	2 192.45	1.19%
Bolivia (Plur. St. of)	2 182.55	0.65%
Dominican Republic	2 107.32	2.57%
Nicaragua	2 106.95	0.12%
Honduras	1 710.50	0.78%
Haiti	992.29	-0.54%

Source: authors' calculations.

GDP: Gross domestic product.

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