

Innovation, growth and economic development: Why some countries succeed and others don't

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Paper prepared for the First GLOBELICS Conference: Innovation Systems and Development Strategies for the Third Millennium, Rio, November 2-6, 2003

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1. Introduction

Why do some countries succeed in catching up with the developed countries, while others fall behind? This is one of the classic questions in comparative growth research (Gerschenkron 1962, Abramovitz 1986, Shin 1996). Moreover, it is a question that does not seem to resolve easily. In fact, it continues to attract the attention of a large number of researchers from different theoretical strands and traditions.

What is it with this issue that makes it so central on the research agenda today? Apart from the obvious importance of the issue from a developing country point of view, this has to do with two important changes that have occurred during the last decades. The first change has to do with how the “stylised facts” of global development are perceived by researchers. Until the late 1980s, it was commonly *assumed* that the global economy was on a converging path, with poor countries catching up with the rich ones, although at different speeds, reflecting differences in efforts, capabilities and initial conditions. From the 1990s onwards, however, it became increasingly clear that this tendency towards convergence was not a global phenomenon (De Long 1988, Baumol et al. 1989). Although it seemed to hold for the developed economies, perhaps extending to some so-called “newly industrializing countries” (NICs), in the post-second-world-war period, it did not necessarily apply for longer time spans and a wider set of countries. This was, at the time, interpreted as inconsistent with the then dominating economic perspective on growth, the so-called “neoclassical growth theory” put forward by Solow (1956), for which he received the Nobel Prize in economics. A search for new ways of understanding growth followed, and out of this emerged a new perspective on economic growth, which put technology and innovation, rather than capital accumulation, at the front (Fagerberg 1987, Romer 1990, Aghion and Howitt 1992). Increasingly, the ability of a poor country to catch up with the rich was seen not only – or mainly – as a reflection of its ability to generate (or attract) sufficient investments, but also of its capacity to absorb existing and generate new technologies (e.g. innovate).

Although the link between catch-up and innovation-diffusion is well supported by contemporary theorizing in economics, historical analyses and case studies (for an overview, see Fagerberg and Godinho 2004), econometric work on the subject has been slow in catching up with the changes in the theoretical agenda. However, the econometric work that exists confirms the increasing importance of innovation for successful catch-up (Fagerberg and Verspagen 2002). It also calls into doubts catch-up strategies that are based solely on imitating the more advanced technologies of the advanced world. The prospect for drawing general conclusions from these observations, however, is hampered by the fact that econometric studies in this area have either been confined to a relatively limited sample of countries, focusing mostly on already developed economies and relatively advanced “newly industrializing countries”, or have totally ignored the role that innovation and diffusion may play (for overviews, see Fagerberg 1994, 2000 and Temple 1999).

This paper attempts to transcend these limitations of the existing literature by linking data on the growth processes in a broad sample of countries to data on factors deemed to be important for innovation and diffusion of technology and its economic and social exploitation. We start by reviewing some “stylised facts” of global economic growth from the early 1960s onwards to date. Then we proceed to a cluster analysis that allows us to distinguish between groups of countries with different performance, capabilities and characteristics. Finally we exploit these groupings to explore the factors that determine

whether a developing country belongs to those who catch up or alternatively the laggards. The final section discusses the possible lessons from this exercise.

2. Growth dynamics in the postwar global economy

For the purpose of this study we have collected data on large number countries on different level of development from the early 1960s onwards. The source of all data (also the ones used in subsequent sections of the paper, except where indicated otherwise) is the World Bank's World Development Indicators cdrom, version 2002. From this, we use the time series for GDP per capita in constant 1995 US\$, which we convert to Purchasing Power Parities (PPP, in 1995 international \$) using the 1995 observation from the series of GDP per capita in current PPP.

On average, for the sample of 96 countries that will be used throughout his section, the level of GDP per capita tripled between 1960 and 2000. In 1960, the richest country (Switzerland) was 45 times as rich as the poorest one (Malawi). Forty years later, in 2000, the richest country was Luxemburg, the poorest Sierra Leone, and the ratio of their per capital GDP levels had increased to 67.

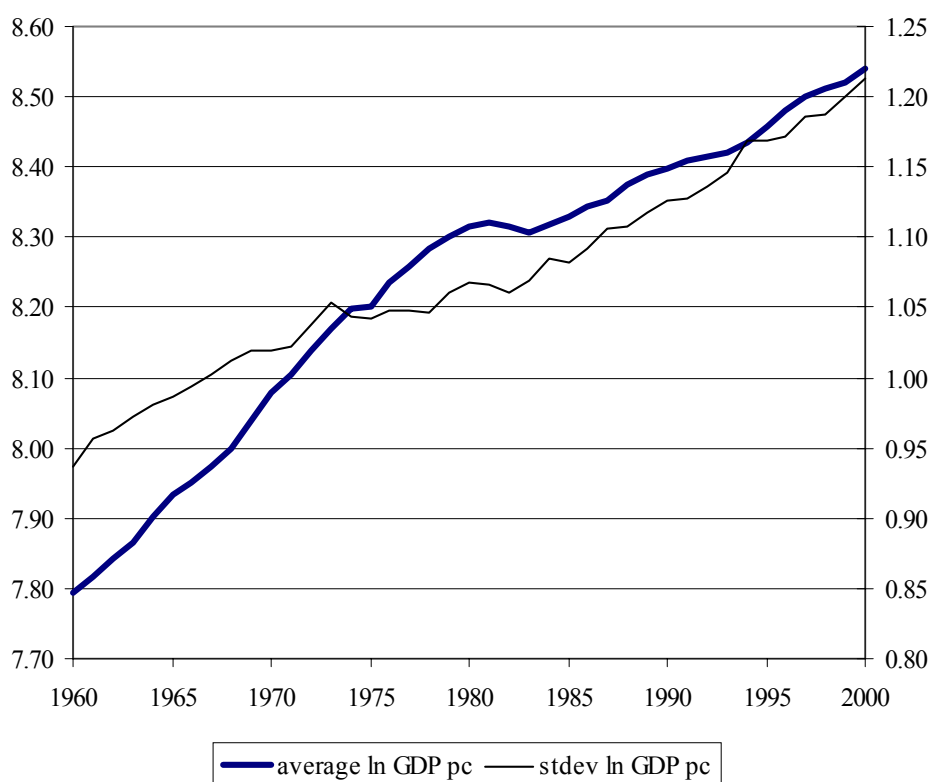


Figure 1. GDP per capita (level and dispersion) in the global postwar economy

Figure 1 shows the increase in the (unweighted) average of the natural logarithm of GDP per capita (in 1995 international \$ PPPs, as indicated before) for the 96 countries (thick line, left axis). A straight line would indicate a fixed growth rate. Over the total period, two separate regimes seem to emerge, each roughly corresponding to half of the period, i.e., 1960 – 1980

and 1980 – 2000. In the first period, growth is relatively rapid (a steep line), after 1980 the rate slows down.

The thin line in Figure 1 shows the standard deviation of the logarithm of GDP per capita in the sample (as measured before, right axis), which is an indicator for the disparity of income levels. Over the whole period, we see a steady rise in this indicator, which means that per capita income differentials are growing over time.

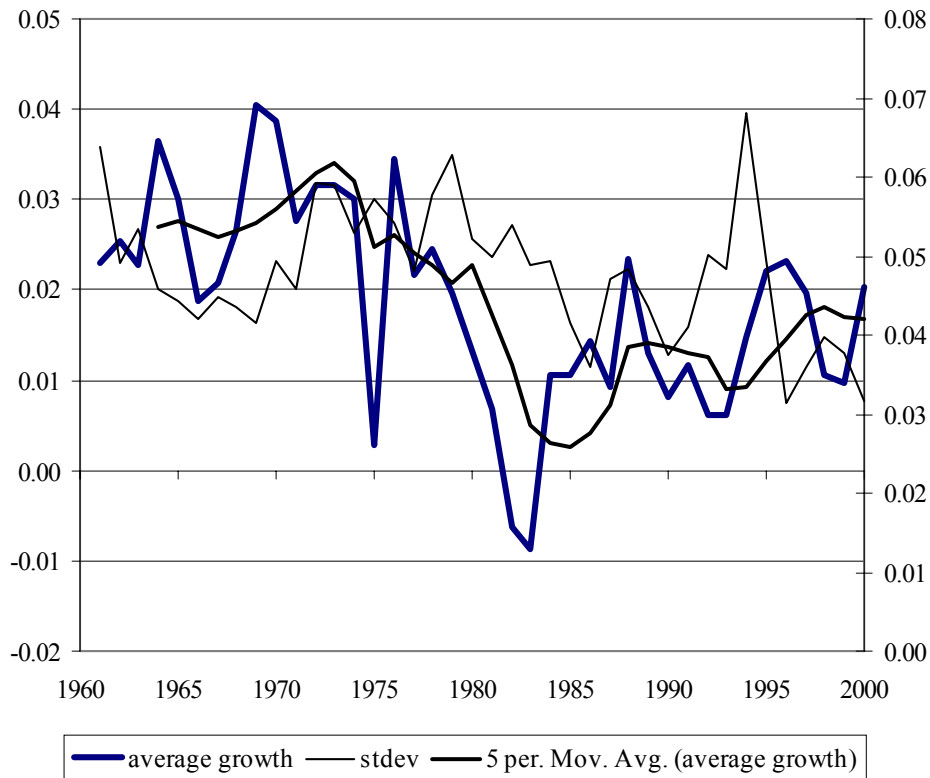


Figure 2. Growth rates in the postwar global economy

This slowdown in economic growth, which is also well documented elsewhere (Maddison 1995), is apparent from Figure 2 as well. The figure shows, for the same sample of countries, the average yearly growth rates of GDP per capita (the thick line). Until the early/mid 1970s, the average growth rate fluctuates around a constant level. During the decade that follows the growth rate slows down markedly, and eventually settles at a level that is roughly half of what it was in the 1960s. The dispersion of the growth rates (the thin line in Figure 2) also slows down (but less than the growth rate itself).

In Figure 3, we plot the dispersion of 10-year growth rates of GDP per capita for four different decades, against the level of GDP per capita. For each decade we start out with the dispersion of GDP per capita for the entire sample (observations to the far left in the graph). As we move from left (low levels of GDP per capita) to right (high levels of GDP per capita) along the dispersion curve, observations for the poorest countries are eliminated one by one, thus calculating the dispersion indicator for an ever smaller and comparatively richer subset of countries. However, we (arbitrarily) stop to calculate the level of dispersion when it is only 10 countries left. Hence, for each decade the point to the far right of the dispersion curve gives the level of dispersion for the 10 richest countries of the sample.

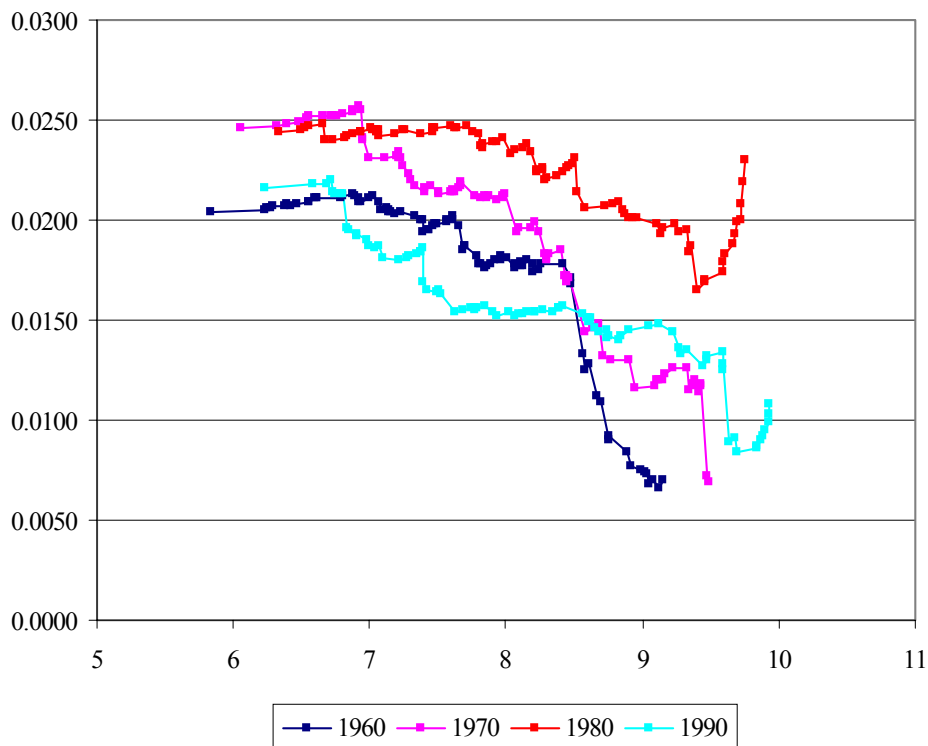


Figure 3. Changes in dispersion in the postwar global economy

The dispersion curves tend to be relatively flat to the left, indicating that the level of dispersion of GDP per capita growth is not much affected by the elimination a few poor countries. However, as more and more poor countries are eliminated, and the sample becomes increasingly homogenous, the dispersion of GDP per capita growth tends to decline (differences in growth becomes smaller). This tendency towards convergence in GDP per capita growth rates as countries become richer, weakens over time, though, as shown fact that the curves become flatter for later periods. For the most recent decades, there are clear signs of increasing differences in growth among the richest countries, with some countries forging ahead of others (this is reflected in the upward bending part of the curve to the far right in the graph).

Summarizing, there are clear signs of changes in the way global capitalism works. A high growth regime (before 1980) has been replaced by a low growth regime. Among the poorer economies, however, there continue to be marked differences in growth performance. Growth also tends to be less similar among the high-income countries, with some countries forging ahead of others. The latter finding is consistent with the results in Fagerberg and Verspagen (2002), who found that some countries, notably the USA and the UK, seemed to experience a change in trend growth in the positive direction.

3. Why growth differs

Why do some low-income countries succeed in catching up, while others fall behind? This is the question that we will try to explore in the following. Economic analyses of differences in growth across countries have mostly been based on one of two perspectives. The first, based on the traditional neo-classical theory of economic growth (Solow 1956), is based on the

assumption that technology is a public good, available to anyone free of charge. This perspective puts the emphasis on capital accumulation as the main vehicle for reducing differences in productivity across countries or regions. Moreover, this is assumed to happen more or less automatically, as long as markets are allowed to work freely. The other, competing, perspective puts the main emphasis on innovation and diffusion of technology as the driving force behind differences in growth (Nelson and Phelps 1966, Fagerberg 1987, Barro and Sala-i-Martin 1995, ch. 8). The latter perspective is based on a totally different view on technology than the former, emphasizing its public as well as private character, and the complementarities with other factors that take part in the growth process. This leads to the hypothesis that without the ability to develop such complementary factors, countries or regions are likely to fall behind rather than catch up.

We have in previous work analyzed differences in growth performance with the help of a so-called “technology-gap approach”, based on the second of the two perspectives outlined above (Fagerberg 1987, 1988, Verspagen 1991). In this approach economic growth is analysed as the outcome of three sets of factors:

- The potential for exploiting knowledge developed elsewhere (diffusion),
- Creation of new knowledge in the country (innovation), and
- Complementary factors affecting the ability to exploit the potential entailed by knowledge independently of where it is created.

The approach, based essentially on Schumpeterian thinking, is consistent with much existing knowledge on innovation and diffusion processes. Many of the assumptions and derived predictions can also be made consistent with “new growth theories” that focus on innovation-diffusion as the driving force of capitalist development (Romer 1990, Grossman and Helpman 1991). Empirical work on cross-country samples based on this perspective has confirmed the importance of national technological capabilities (and other supporting factors) for successful catch up (for overviews, see Fagerberg 1994, 2002a).

To illustrate how the technology gap framework can usefully be applied to interpret the high variability in growth performance that was illustrated in the previous section, with particular emphasis on the poorer economies, we apply a cluster analysis on the data for growth over the 1960 – 2000 period, with two of the three factors mentioned above as variables.¹ As a first variable in the cluster analysis we used the (initial) log of GDP per capita. This variable is commonly used as an indicator of the potential for catch-up based growth (the lower the initial income, the higher the catch-up potential is). As an indicator of the role of innovation in growth, we take the number of patents granted in the US to applicants from a specific country, divided by the country’s population. Because patents in the US market are subject to a (worldwide) novelty requirement, it seems reasonable to take this as an indicator of the country’s contribution to the world technological frontier. The patenting data are taken from the US Patent and Trademark Office (population again from the World Bank). Finally, we include GDP per capita growth over a 10-year period, as a measure of economic performance.

In the analysis we divide the period 1960-2000 into four decades, beginning in 1960, 1970, 1980 and 1990, respectively. Growth is always measured over a 10-year period (1960-70, 1970-80, 1980-90, 1990-2000), the other two variables at the beginning of the period (except patenting in 1960, which is not available, and we substitute this with the value for 1963). The clustering method used is the so-called K-means clustering in SPSS (also known as ‘quick clustering’). The number of clusters was initially (and arbitrarily) fixed to three, but

¹ The “complementary factors” are a much too complex group of variables to introduce at this stage. We come back to this later.

with this fix we obtained always one or two very small clusters (1 or two countries), something that, on inspection of the data, was obviously due to large outliers (e.g., a country facing extremely low growth rates due to some catastrophic event). Thus, we increased the number of clusters to accommodate these outliers, until we arrived at a result where there are three clusters that each contain a ‘substantial’ number of countries, plus one or two ‘clusters’ containing only a single country. We exclude these single-country clusters from the documentation and interpretation of the results. In the last period (1990 – 2000 growth rates), this method yielded four clusters of more than one country. One of these four clusters was small compared to the other three (5 members), and is documented separately. We standardize (i.e., subtract the mean and divide by the standard deviation) all variables before entering them into the clustering exercise, in order to make the clustering results invariant to differences in scales between the variables.

Table 1 sums up the results of the cluster analysis. We obtained three relatively large clusters, with between 19 and 49 countries each, and, for the final period, an additional small cluster with 5 countries. Focusing on the three large ones, these consist of two low-income clusters, both characterized by little (or almost zero) patenting but with marked differences in growth performance, and one high-income cluster, for which patenting is considerably higher. In the two low-income clusters, we always have one that displays high growth rates (in fact, higher than the high-income cluster), and one cluster that displays low growth rates (lower than the high-income cluster).

Table 1: Global growth-clubs

Variable		Low income, low growth		Low income, high growth		High income, inter-mediate growth		Total sample		Front-Not runners cla (only ss. 1990s)		
		Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	
1960s	Growth rate	0.013	43	0.059	19	0.031	32	0.028	96	2		
	Initial GDP	7.072		7.716		8.701		7.795				
	Patenting	0.068		0.570		8.011		6.082				
1970s	Growth rate	-0.001	30	0.047	33	0.023	40	0.023	105	2		
	Initial GDP	7.297		7.580		9.183		8.153				
	Patenting	0.195		0.178		12.110		8.601				
1980s	Growth rate	-0.011	49	0.032	22	0.023	32	0.009	105	2		
	Initial GDP	8.016		7.380		9.541		8.385				
	Patenting	0.196		0.037		22.242		10.352				
1990s	Growth rate	-0.011	31	0.028	33	0.020	35	0.012	105	1	0.012	5
	Initial GDP	7.652		7.776		9.605		8.473			10.067	
	Patenting	0.069		0.069		19.269		13.369			144.985	

Applying our technology gap framework, the clustering results clearly bring out the role of the catch-up potential and innovation in economic growth. The low-income, high-growth cluster consists of countries that have been able to benefit from catching-up. For them, low initial income indeed points to a high catch-up potential. For the low-income, low-growth

cluster, catch-up potential has not materialized, something that, in this interpretation, should be associated with a low capability to assimilate knowledge from the richer countries. Finally, the high-income, intermediate growth cluster is the group where pure innovation-based growth is a realistic proposition, and the results show that this indeed leads to sustained growth, although at a lower rate than the countries that are catching-up. Naturally, the crucial question coming out of this is what determines to which of the two low-income groups a less-developed country belongs, and how this can be influenced by policy.

In order to try to find at least a preliminary answer to this question, we examined the composition of the three clusters over time. From this, we note that the high-income, intermediate-growth cluster is the most stable one, with 23 countries staying in this group in all four periods (and a number of others belonging to this group in three out of the four decades studied).² However, some Latin American and Arab countries that initially were in this cluster, did not manage to hold on, and slipped down into the low-growth clusters. On the other hand, the countries of the high-income cluster were joined by a number of other countries that at different points in time moved up from the low-income clusters. These were the countries that were most successful in catching up. The group includes, among others, European countries such as Greece, Portugal and Spain, and Asian countries such as Hong Kong, Japan, Korea and Singapore.

There was considerably less stability among the poorer economies, with many shifting between the low and high growth clusters at least once. However, it was possible to identify a group of 12 persistent slow-growers, consisting mainly of African economies. These, evidently, are examples of countries falling behind.

What we will do in the following is to analyze the differences in growth performance between the countries in our sample with the help regression analysis inspired by our technology gap perspective. For the potential to exploit knowledge developed elsewhere (diffusion) we use, as before in the cluster analysis, the initial level of GDP per capita in the region (log-form). The higher this level, the smaller the scope for imitating more advanced technologies developed elsewhere. Hence, the expected impact of this variable is negative. To this we add a number of other variables that reflect technological, economic and institutional factors deemed to be of relevance for the ability of a country to exploit existing and develop and implement new, economically valuable knowledge. Since many of the available indicators reflect aspects of a larger inter-related complex, and hence were likely to be correlated, we carried out a factor-analysis with the aim to reduce our many variables into a smaller number of dimensions that capture the main correlations in the sample. The method used for extracting is the principal components method. The number of factors (components) is determined endogenously on the basis of eigenvalues.

The following variables were, for the 1970s, 1980s and 1990s, included in the factor analysis:

- The birth rate (number of births per 1000 people)
- CO₂ emissions (kg per 1995 US\$ of GDP)
- Openness (exports and imports as a % of GDP)
- Population density (people per square km)
- Enrollment in primary education (gross, % of age group enrolled)
- Enrollment in secondary education (gross, % of age group enrolled)
- Share of agriculture in GDP (%)

² In terms of this 'mobility analysis' for the last period, we considered the frontrunners group as a part of the high-income, intermediate growth cluster.

- Share of industry in GDP (%)
- Share of services in GDP (%)
- Agriculture yield (kg cereal per hectare)
- Patenting per head of population (as measured before)

All variables are measured at the beginning of the decade, but sometimes we use different years when data are unavailable for the preferred year. In this way, we identify always three factors:

- The first factor, which we label “development”, has high (negative) loading on the birth rate, high (negative) loading on the share of agriculture in GDP, high (positive) loading on agricultural yield, high (positive) loading on primary and secondary education enrollment and high (positive) loading on patenting.
- A second factor, “industrialisation”, load high (positive) on the share of industry in GDP and also on its consequence, CO₂ – emissions.
- The third factor, which is a mixture of various effects, loads high (positive) on population density and openness

We enter these three factors, together with initial GDP per capita, in a regression on GDP per capita growth. Separate regressions were undertaken for different time periods and samples of countries.

The results are reported in Table 2. For the entire sample, all four variables receive some support, but the support is clearly weaker for the “Industrialization” factor than for the other three. Between the various periods, there are signs of a weakened impact of the scope for diffusion (initial GDP) in the 1990s: the absolute value of the coefficient on this variable declines and becomes less significant.

Table 2: Why growth rates differ

	Initial GDP	Factor “Development”	1: Factor “Industrialization”	2: Factor 3: “Openness/ Urbanization”	$\overline{R^2}$	N
<u>1970s</u>	-0.017	0.020	0.005	0.009	0.21	78
Total	(3.72) *	(4.40) *	(1.73) ***	(3.28) *		
Low Income	-0.018 (2.57) **	0.039 (4.60) *	0.002 (0.50)	0.008 (2.37) **	0.35	51
<u>1980s</u>	-0.021	0.027	0.001	0.006	0.29	83
Total	(4.66) *	(5.87) *	(0.22)	(2.65) *		
Low Income	-0.024 (4.73) *	0.030 (4.54) *	0.001 (0.24)	-0.004 (0.70)	0.30	62
<u>1990s</u>	-0.009	0.017	0.005	0.006	0.23	90
Total	(1.62) ****	(2.98) *	(2.25) **	(2.93) *		
Low Income		0.017 (3.15) *	0.001 (0.14)	0.004 (1.49) ***	0.23	59

Note:

Absolute t-statistics in brackets.

One, two, three and four stars indicate significance at the 1, 5, 10 and 15 % level respectively. Estimated by OLS.

These results reassert themselves when the model is estimated for the low-income countries separately, which we define, in every decade, as the members of the two low-income clusters that emerged in the cluster analysis above. The potential for diffusion, while very important in the 1970s and 1980s, totally fails to appear as a significant factor in the 1990s in this sub-sample. The degree of industrialization also fails to explain why some low-income countries do better than others. The “openness/urbanization” variable also became less influential than in the total sample.

For the 1990s, more variables are available, and we repeated the factor analysis for this period including these variables. The additional variables (all variables entered in the previous factor analysis are again included here) were:

- Foreign Direct Investment (inward, % of GDP)
- Investment (gross fixed capital formation, % of GDP)
- Number of papers in scientific and technical journals
- Enrollment in tertiary education (gross, % of age group enrolled)

The factor analysis on this larger data-set (1990s) generated five factors. The first factor (“development”) had, as before, a high (negative) loading on the birth rate, a high (negative) loading on the share of agriculture in GDP, a high (positive) loading on agricultural yield and a high (positive) loading on primary and secondary educational enrollment. A high (positive) loading on patenting, however, was now included in a second factor (“science & technology”), together with a high (positive) loading on scientific and technical publications. As before, a separate factor (“industrialization”) emerged reflecting a high share of industry in GDP and high CO₂ – emissions. However, the third factor of the previous analysis was now split in two, one focusing exclusively on openness (now including also FDI), the other reflecting a high population density (“urbanization”).

Table 3: A closer look at the 1990s

	Initial GDP	Factor 1: Development	Factor 2: Technology	Factor 3: Industrialization	Factor 4: Openness	Factor 5: Urbanization	$\overline{R^2}$	N
Total	-0.008 (1.57) ****	0.017 (3.10) *	0.004 (1.23)	0.006 (3.08) *	0.002 (0.75)	0.008 (3.79) *	0.30	83
Low Income		0.021 (4.08) *	0.027 (2.55) **	0.004 (1.72) ***	0.002 (0.64)	0.011 (3.12) *	0.37	55

Note:

Absolute t-statistics in brackets.

One, two, three and four stars indicate significance at the 1, 5, 10 and 15 % level respectively. Estimated by OLS.

Interestingly, when the regression analysis is repeated with initial GDP per capita and these five factors included, the “openness” factor becomes totally insignificant (Table 3). Moreover, for the low-income countries, the “technology” factor - reflecting innovation (as revealed by patents) and research quality (as measured through publications) - also turns up as a positive and significant factor. Thus, the evidence indicates that variables related to the development of the broader “innovation” system, such as educational efforts, the research infrastructure and innovative activity, are indeed important for whether a low-income country manages to exploit the potential for catch up or – alternatively – falls behind.

4. Concluding remarks

This paper has shown that there have been important changes in how the global economic system works. Starting a quarter of a century ago, a high growth regime was gradually substituted by a regime characterized by relatively low growth (about one half of what was normal previously). As shown in this paper, and also corroborated by previous research (Fagerberg and Verspagen 2002), this new growth regime gradually became characterized by much more stringent conditions for catch up. While, until the end of the 1980s, the scope for technological imitation was, conditional on other complementary factors, a significant factor in generating growth in countries below the technology frontier, this does not appear to be the case to the same extent in the 1990s. Moreover, there are signs of divergence occurring among the developed economies, with some experiencing much higher growth than others.

Such tendencies towards divergence, however, are - if anything - even more characteristic for the low-income countries. In the 1990s in particular, the scope for imitation does not appear to have any explanatory power whatsoever for how well a low-income country performs. Instead, the factors that seem to matter are, as pointed out above, a high “absorptive capacity”, as reflected by variables such as educational efforts, R&D, and innovative activity. This is, of course, the kind of factors that are highlighted in the literature on “national systems of innovation”. The apparent importance of such factors, and the total lack of evidence for particularly positive effects of variables such as “openness” and FDI, is noteworthy.

This being said, this paper should only be regarded as a first step towards increasing our knowledge of why some poor economies manage to catch up, while others fall behind. In fact, some of the factors taken into account here are poorly understood, such as for instance the impact of “urbanization”, and this clearly points to need for further research. It would also be advisable to expand the above analysis to take account institutional and political factors that, at least in some cases, may be as relevant than those taken into account here.

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