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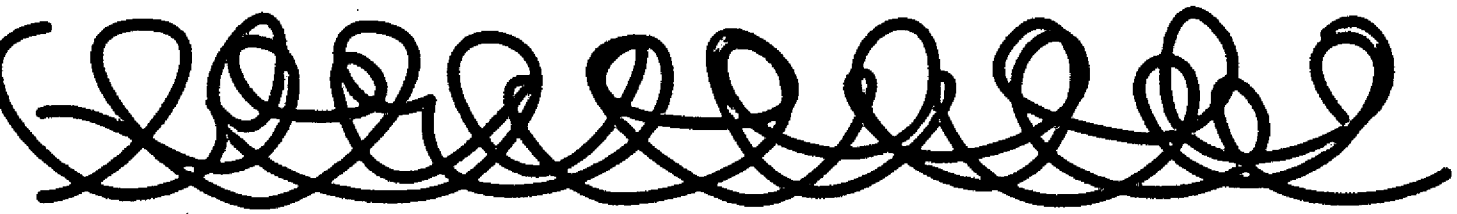
Industrial Development Report 2005
Background Paper Series

Catching up:
What are the Critical Factors for Success?



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Industrial Development Report 2005 Background Paper Series

Catching Up:
What are the Critical Factors For Success?

Jan Fagerberg and Martin Srholec

April 2005

Office of the Director-General

This series includes the background papers commissioned to cover specific aspects addressed in the Industrial Development Report 2005 "Capability building for catching-up – Historical, empirical and policy dimensions". The digital versions are available, together with the full report, on the IDR 2005's website at www.unido.org/idr.

For further information on the IDR05, please contact f.sercovich@unido.org.

Contents

	Page
Abstract	iv
Introduction	1
Catching up or falling behind? The stylized facts	2
What are the most critical factors for catch-up? Taking stock of the literature	10
Bringing the pieces together: the framework and indicators	15
Constructing composite indicators: factor analysis	19
Stylised facts on the critical factors of catching-up	24
What are the (most) critical factors for catching up? A regression analysis	37
Concluding remarks	43
References	45
Appendices	
Appendix A1 (data & sources)	52
Appendix A2 (composites of social capabilities)	63
Appendix A3: Regression results - growth (excluding countries with the most missing data and wars)	68

Abstract

This paper addresses one of the oldest and most controversial issues in economics: Why do some countries succeed in catching up, while others fall behind? In recent years the quality and availability of data on different aspects of development have improved a lot. Attempting to exploit this opportunity for more in-depth research the paper starts with an overview and assessment of the different approaches in the literature and the empirical indicators and methods that these have given rise to. This leads to the formulation of a synthetic empirical model and, with the help of factor analysis on large variable set, to the identification of set of "capabilities" which might be assumed to be of critical importance for catch up. The explanatory power of these capabilities for economic growth is tested on a sample of 135 countries in the 1990s.

JEL: E11, F43, O30.

Introduction

Is there an inbuilt tendency for productivity and income across the globe to converge? If we look at capitalist development in a long run perspective the answer is clear. The long run trend since the so-called industrial revolution has been towards divergence, not convergence in productivity and income. For instance, according to economic historian David Landes, 250 years ago the difference in income or productivity per head between the richest and poorest country in the world was approximately 5:1, while today this difference has increased to 400:1 (Landes 1998). Other sources may give different numbers but the qualitative interpretation remains the same. In section 2 of this paper we provide some evidence on these trends for a large sample of countries which confirms that the diverging winds continue to be strong.

However, in spite of this long run trend towards divergence in productivity and income, there are many examples of (initially) backward countries that – at different times – have managed to narrow the gap in productivity and income between themselves and the frontier countries, in other words, to "catch up". The current frontier country – the United States – was itself once on a catch-up path vis-à-vis the then economically and technologically leading country of the time, the United Kingdom, and so were Germany and many other European countries. Japan in the decades before and after the Second World War is another well-known example, and the so-called "Asian tigers" more recently. The question that suggests itself is how this diversity in patterns of development can be explained. Why do some countries succeed in catching up, while others fall behind? Is it related to something they do that other countries fail to undertake? In fact, this is one of the oldest and most controversial issues in economics. It can be traced back at least a few hundred years, when politicians and industrialists in countries such as the United States and Germany started to debate what was needed to be able to catch up with the then world leader, the United Kingdom (see Chang 2002).

In section 3 we start the search for what these critical factors for catch-up may be. We do this by reviewing some of the main arguments (or "views") that have been presented in the literature and discussing what empirical measures these give (or may give) rise to. Traditionally, much theorizing in this area focused on the role of capital accumulation for growth and development. Gradually this has given way to a more "institutionalist" view, focusing on how to get the institutional conditions for well-working markets (including the capital market) right. Therefore, this is sometimes called the "market friendly" approach (World Bank 1993). Its main contender has for some time been a more "knowledge based" approach, according to which catching up (or lack of such) depends not so much on capital accumulation as the abilities of a country to create and exploit knowledge (and respond to challenges arising in connection with this). This naturally leads to a focus on what influences the capacity of a country for creating and exploiting knowledge including relevant policy aspects. Concepts such as "social capability" and "absorptive capacity" have been important focusing devices within this approach. Finally we consider the most novel addition in this area, the "social capital" approach, which focuses on the role that social norms, networking and civic engagement may play in the development process.[1]

Having considered the various arguments and the empirical measures they give rise to we start in section 4 on the synthesis work. Rather than picking individual indicators we follow Adleman and Morris (1965, 1967) and Temple and Johnson (1998) in mapping the most central elements with the help of factor analysis, taking into account a variety of different indicators and sources in 135 countries over 1992-2002. Factor analysis is a useful tool in the present context because it allows us to reduce the complexity entailed by a large number of different

(but often mutually correlated) indicators into a smaller number of synthetic dimensions. The analysis illustrates the multidimensional character of "social capability", resulting in five different dimensions (or capabilities), which we label "knowledge", "openness", "finance", "governance" and "democracy", respectively. We examine the levels and changes of each of these, emphasizing the extent to which the observed change contributes to convergence or, alternatively, divergence across countries. Finally we test for the impact on economic growth, controlling for a battery of given conditions reflecting differences in geography, history etc.

Catching up or falling behind? The stylized facts

As a prelude to the main analysis we will in this section revisit some of the main facts about catching up and/or falling behind in the global economy during the last two centuries. During most of the nineteenth century the United Kingdom was the leading capitalist country in the world, with a GDP per capita that was about 50 % above the average of other leading capitalist countries (Table 1). This lead was among other things related to the process of economic, social and institutional change that had taken place in Britain for quite some time already, the so-called industrial revolution (Von Tunzelmann 1995). However, during the second half of the century, the United States started to catch up with the United Kingdom and eventually - during the early part of the twentieth century - surpassed it. In retrospect it becomes clear that US growth was based on the development of a new technological system, based not so much on new products as on a new way to organize production and distribution (taylorism, fordism etc.). The large productivity gains were secured through the development of large-scale production and distribution systems well suited for the large, fast-growing and relatively homogenous American market (Chandler 1990, Nelson and Wright 1992).

That Europe initially failed to take advantage of these innovations is perhaps not so difficult to explain. For example, one main difference between the United States and Europe in the first half of this century relates to the size of markets. The European markets were smaller, and less homogenous. Hence, it is not obvious that US methods, if applied to European conditions in this period, would have yielded superior results. This is what Abramovitz (1994a) has dubbed lack of "technological congruence". Two world wars and an intermediate period of protectionism and slow growth added to these problems (Abramovitz 1994a). Hence, the United States lead increased even further and peaked around 1950, when GDP per capita in the United States was about twice the European level.

While the period between 1820 and 1950 was one of divergence in economic performance between leading capitalist countries, as reflected in the increase in the coefficient of variation of GDP per capita (Table 1), the decades that followed were characterized by convergence, at least as far as variables such as income or GDP per capita are concerned. The productivity gap between the United States and other developed countries was significantly reduced (cut by one half). Arguably, this reduction was related to the potential for rapid productivity advance through imitation of superior US technology. For instance, European production and exports in industries such as cars, domestic electrical equipment, electronics etc. grew rapidly from the 1950s onwards. The gradual reduction of barriers to trade within Europe from the 1950s onwards has generally been regarded an important contributing factor to this process, as have the general rise in incomes and living standards (Abramovitz 1994, Maddison 1982,1991).

European countries were not alone, however, in exploiting the window of opportunity given by superior US technology. From the 1950s onwards Japan, later joined by other Asian economies, aggressively targeted the very same industries as those that had grown rapidly in Europe (Johnson 1982, Wade 1990). Initially this did not give much reason for concern among policy makers or industrialists. But during the 1970s and 1980s it became evident that Japanese suppliers outperformed their European and US competitors in many cases, and that this could not be explained solely by low wages. In became clear that the Japanese, as the Americans before them, have made important innovations in the organization of production, innovations that have led to both increased quality and higher productivity (Von Tunzelmann 1995).

While Europe, Japan and other countries started to catch up in many typical "American way of life" products, US industry leaped forward in another area; science-based industry. Before the First World War - and arguably in the interwar period as well - Europe, and Germany in particular, was at the forefront in this area. In fact, science based industry, characterized by high R&D investments, highly educated (and qualified) labour and close interaction between industry, research institutes and universities, was largely a German invention. However, in the beginning of this century the US business community started to catch up in this area (Nelson and Wright 1992, Mowery and Rosenberg 1993). Technical universities and business schools were founded, often in close interaction with industry. This drive towards a greater reliance on science and R&D was much strengthened during the Second World War and the "cold war" that followed due to massive public investments in this area. As a consequence, the leadership passed to the United States.

Gradually, however, European countries and Japan started to devote more resources to higher education, science and R&D. Following the Japanese example some of the Asian NICs started to invest massively in R&D from the seventies onwards. These changes have had a major impact on the structure of science based industry worldwide (see Fagerberg et al. 1999). Today the United States has been replaced by Japan as the country that uses the largest share of its income on R&D activities, and the club of high R&D performers has been enlarged by a number of new members, the Republic of Korea, Finland and Taiwan Province of China deserve particular mentioning (Fagerberg and Godinho 2004). However, many other countries, including the developing ones, remain low R&D performers. They also continue to lag on other aspects of great relevance for creation and exploitation of knowledge in the contemporary world, such as the spread of ICTs (Fagerberg et al. 1999, Fagerberg et al. 2004).

What is perhaps most striking about this long-run evidence is the great variability across time and country groups. The nineteenth century was essentially a period characterized by increasing differences, e.g. divergence, and the two world wars during the first half of the twentieth century did not do much alleviate this trend. But after the end of the Second World War a period of convergence sets in, and this "post-war growth and convergence boom" – to use a term suggested by Moses Abramovitz - lasted to around 1980. However, this trend was much more pronounced among the countries of the "west", e.g., Western Europe and its "offshoots" overseas (the United States, Canada, Australia and New Zealand), than in the rest of the world. In fact, the most striking in Table 1 is the great variation in performance among countries with comparable initial levels of productivity and income. We will explore this issue further in the following, focusing on the period after 1960, for which we have more comprehensive data. These data, which cover more than 90 countries at different levels of development, are drawn from The Penn World Table (Heston, Summers and Aten 2002).

Table 1
GDP per capita over 1820-2003 (in 1990 USD)

		1820	1870	1910	1950	1970	1980	1990	2003	Annual growth	
										1820-1950	1950-2003
					The first-movers:						
Western Europe	Austria	1.2	1.9	3.5	3.7	9.7	13.8	16.9	20.8	0.9	3.4
	Belgium	1.3	2.7	4.2	5.5	10.6	14.5	17.2	21.1	1.1	2.6
	Denmark	1.3	2.0	3.9	6.9	12.7	15.2	18.5	22.8	1.3	2.3
	Finland	0.8	1.1	2.1	4.3	9.6	12.9	16.9	20.5	1.3	3.1
	France	1.2	1.9	3.5	5.3	11.7	15.1	18.1	21.3	1.1	2.7
	Germany	1.1	1.9	3.5	4.3	11.9	15.4	18.6	21.0	1.1	3.1
	Greece	0.7	0.9	1.6	1.9	6.2	9.0	10.0	13.5	0.8	3.8
	Italy	1.1	1.5	2.6	3.5	9.7	13.1	16.3	19.1	0.9	3.3
	Netherlands	1.8	2.8	4.0	6.0	11.9	14.7	17.3	21.4	0.9	2.5
	Norway	1.1	1.4	2.5	5.5	10.0	15.1	18.5	25.9	1.2	3.0
	Portugal	1.0	1.0	1.2	2.1	5.5	8.0	10.8	13.9	0.6	3.7
	Spain	1.1	1.4	2.3	2.2	6.3	9.2	12.1	16.5	0.6	4.0
	Sweden	1.2	1.7	3.1	6.7	12.7	14.9	17.7	21.6	1.3	2.3
	Switzerland	1.3	2.2	4.3	9.1	16.9	18.8	21.5	22.2	1.5	1.7
	United Kingdom	1.7	3.2	4.9	6.9	10.8	12.9	16.4	21.1	1.1	2.2
Overseas	Australia	0.5	3.6	5.7	7.4	12.0	14.4	17.1	23.1	2.1	2.2
	New Zealand	0.4	2.7	5.2	8.5	11.2	12.3	13.9	17.4	2.4	1.4
	Canada	0.9	1.7	4.4	7.3	12.1	16.2	18.9	23.3	1.6	2.3
	United States	1.3	2.4	5.3	9.6	15.0	18.6	23.2	29.2	1.6	2.2
					The latecomers:						
Asia	China	0.6	0.5	0.6	0.4	0.8	1.1	1.9	4.4	-0.2	4.6
	India	0.5	0.5	0.7	0.6	0.9	0.9	1.3	2.2	0.1	2.4
	Indonesia	0.6	0.7	0.9	0.8	1.2	1.9	2.5	3.5	0.2	2.8
	Japan	0.7	0.7	1.3	1.9	9.7	13.4	18.8	21.7	0.8	4.8
	Malaysia	..	..	0.9	1.6	2.1	3.7	5.1	8.5	..	3.3
	Philippines	..	..	1.1	1.1	1.8	2.4	2.2	2.6	..	1.7
	Singapore	..	..	1.3	2.2	4.4	9.1	14.4	21.7	..	4.5
	Republic of Korea	..	..	0.9	0.8	2.0	4.1	8.7	15.8	..	6.0
	Taiwan Province of China	..	..	0.7	0.9	3.0	5.9	9.9	17.3	..	5.8

		1820	1870	1910	1950	1970	1980	1990	2003	Annual growth	
										1820-1950	1950-2003
	Thailand	..	0.7	0.8	0.8	1.7	2.6	4.6	7.1	..	4.2
	Vietnam	0.5	0.5	0.8	0.7	0.7	0.8	1.0	2.2	0.1	2.3
Latin America	Argentina	..	1.3	3.8	5.0	7.3	8.2	6.4	7.5	..	0.8
	Brazil	0.6	0.7	0.8	1.7	3.1	5.2	4.9	5.4	0.7	2.3
	Chile	..	..	2.7	3.8	5.3	5.7	6.4	10.4	..	1.9
	Colombia	..	..	1.2	2.2	3.1	4.3	4.8	5.3	..	1.7
	Mexico	0.8	0.7	1.7	2.4	4.3	6.3	6.1	7.1	0.9	2.1
	Peru	..	..	1.0	2.3	3.8	4.2	3.0	3.7	..	1.0
	Venezuela	..	0.6	1.1	7.5	10.7	10.1	8.3	7.0	..	-0.1
Africa	Egypt	..	..	0.7	0.9	1.3	2.1	2.5	3.0	..	2.3
	Ghana	..	..	0.7	1.1	1.4	1.2	1.1	1.4	..	0.5
	Morocco	..	..	0.8	1.5	1.6	2.3	2.6	2.9	..	1.3
	South Africa	..	..	1.6	2.5	4.0	4.4	4.0	4.4	..	1.1
Eastern Europe	Czechoslovakia	0.8	1.2	2.1	3.5	6.5	8.0	8.5	9.6	1.1	2.0
	Hungary	..	1.3	2.1	2.5	5.0	6.3	6.5	8.0	..	2.3
	Yugoslavia	..	..	1.0	1.6	3.8	6.1	5.8	5.2	..	2.4
	Soviet Union	0.7	0.9	1.5	2.8	5.6	6.4	6.9	5.4	1.1	1.2

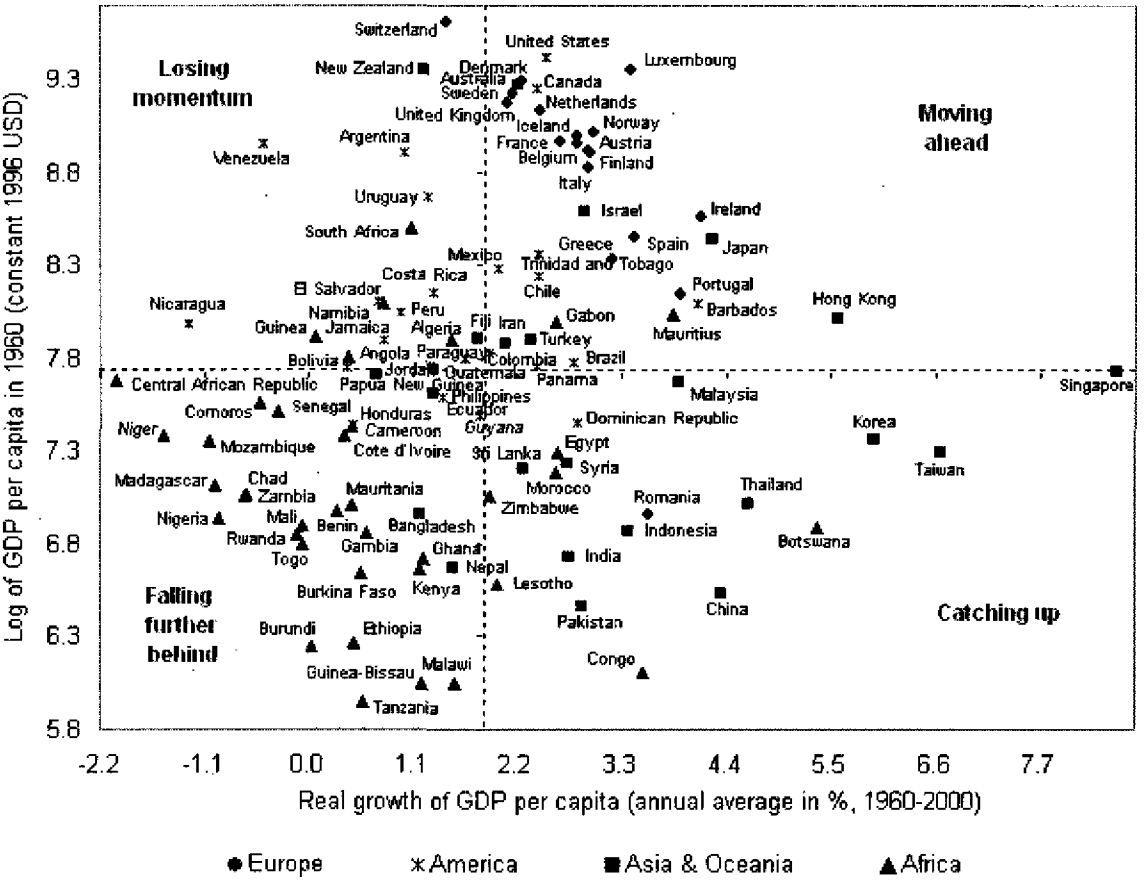
	1820	1870	1910	1950	1970	1980	1990	2003
				The first-movers:				
Mean	1.1	2.0	3.6	5.6	10.9	13.9	16.8	20.8
Coeff. of variation	0.32	0.37	0.36	0.41	0.26	0.20	0.19	0.18
				All countries (data fully available over 1820-2003):				
Mean	1.0	1.6	2.8	4.3	8.5	11.0	13.3	16.3
Coeff. of variation	0.38	0.55	0.57	0.63	0.52	0.49	0.50	0.49
				All countries (data available only over 1910-2003):				
Mean	..	..	2.2	3.5	6.7	8.7	10.4	13.1
Coeff. of variation	..	..	0.68	0.73	0.67	0.62	0.64	0.63

Source: Maddison (2001) and the Total Economy Database (GGDC 2005).

Figure 1 plots annual average growth of GDP per capita over the period 1960-2000 (horizontal axis) against the level of GDP per capita in 1960 (vertical axis). Dashed lines represent sample averages (of growth and level, respectively). In this way four quadrants emerge. The countries in the top left quadrant have a high initial GDP per capita level but grow relatively slowly; hence these countries may be said to "lose momentum". In contrast, the

countries in the top right quadrant continue to grow fast despite being relatively wealthy at the outset, these countries are "moving ahead". In the bottom right quadrant we find countries that also grow above average but from a lower initial level, hence these are the countries that succeed in "catching up". Finally we find in the bottom left quadrant countries with the least fortunate outcome, initially poor countries that grow slowly and therefore "fall behind".

Figure 1
Convergence vs. divergence in GDP per capita over 1960s-90s



Source: Penn World Table Version 6.1 (Heston, Summers and Aten 2002).

It is obvious from the figure that there is a lot of diversity in performance; all four quadrants are in fact relatively well populated. But by closer inspection it is clear that there is a higher tendency for countries to cluster in the bottom left and top right quadrant than in the two other quadrants, consistent with a long-run tendency towards divergence in the global economy. The countries that fall behind are overwhelmingly African in origin while those that move ahead are mostly from the Western hemisphere (e.g., OECD countries). Those that succeed in catching up are mostly of Asian origin, including well-known examples such as the Republic of Korea, Taiwan Province of China, China and Thailand (though some African countries also do relatively well). In contrast to the Asian experience, Latin-American economies tend to grow below average and cluster in the "losing momentum" category. However, there are several exceptions to this trend; Brazil for instance grows faster than the average, as do some other Latin-American economies.

Tables 2 and 3 present formal tests of the tendency towards convergence (divergence) in GDP per capita across countries. In Table 2 growth of GDP per capita is regressed against its initial level (in log-form). A negative relationship would imply that rich countries (those with high levels of GDP per capita) tend to grow slower than the poorer ones, so called β-convergence (Barro and Sala-i-Martin 1992). However, a positive association was found, for each decade as well as the period as a whole, indicating that high income countries on average grow faster than those with low income (divergence). The explanatory power is very low, though, consistent with the diversity in growth patterns observed in Figure 1. We also tested for the possibility that even though there is a tendency towards divergence across **countries**, there may still be convergence across **people** in different parts of the globe. This may happen if many large countries (such as China and the United States, for example) are on a converging path (in contrast to the vast majority of small countries). This hypothesis was rejected, however.

Table 2
The β-convergence hypothesis

	1960s	*1970s*	*1980s*	*1990s*	*1960-2000*	*Adjusted 1960-2000*
Testing the convergence hypothesis:						
Constant	-1.21	-1.90	-3.29**	-2.77*	-0.31	-0.01***
	(0.64)	(1.97)	(2.19)	(1.89)	(0.26)	(3.04)
Log of the initial level	0.53**	0.50**	0.53***	0.48***	0.28*	0.55***
	(2.31)	(2.14)	(3.10)	(2.91)	(1.91)	(6.54)
R2	0.04	0.04	0.06	0.05	0.02	0.92
F-stat	5.36	4.56	9.59	8.47	3.66	42.82
Number of countries	107	112	115	116	105	105
Estimate without outliers:						
Constant	-2.20	-2.87*	-5.96***	-2.03**	-2.04**	-0.01***
	(1.55)	(1.97)	(5.67)	(2.13)	(2.09)	(2.92)
Log of the initial level	0.64***	0.62***	0.81***	0.40***	0.48***	0.40***
	(3.68)	(3.59)	(0.12)	(3.75)	(2.96)	(9.27)
R2	0.09	0.09	0.19	0.07	0.11	0.85
F-stat	13.55	12.90	44.98	14.08	15.68	85.99
Number of countries	94	96	103	102	95	101

Note: The last column gives results based on variables weighted by shares in world population in 1960. The dependent variable is the average annual growth rate of GDP per capita (constant 1996 USD) in % over the period; log of the initial year is natural logarithm of GDP per capita in the first year of the period; absolute value of robust t-statistics in brackets; DFITS statistics used to exclude outliers with a cut-off point at abs(DFITS)>2*sqrt(k/n); *, **, *** denote significance at the 10, 5 and 1 percent levels.

Source: Penn World Table Version 6.1 (Heston, Summers and Aten 2002).

While Table 2 tests for the tendency of poorer countries to grow faster than the richer ones ("catching up"), Table 3 investigates whether the distribution narrows or widens through time, so-called σ-convergence.[2] The results confirm, again, that for the sample as a whole the long-run tendency is towards divergence, and this tendency gains force after 1980. But when the sample is divided into subgroups on the basis of the initial level of GDP per capita a more complex pattern emerges. For those in the richest quartile, there actually was a tendency towards convergence before 1980, after which a divergence trend sets in, consistent with the results for the smaller data-set included in Table 1. However, a similar tendency cannot be detected among the countries in the poorest quartile. For these countries the tendency points consistently towards divergence (though less so before the 1980s than later).

Table 3
The σ-convergence hypothesis

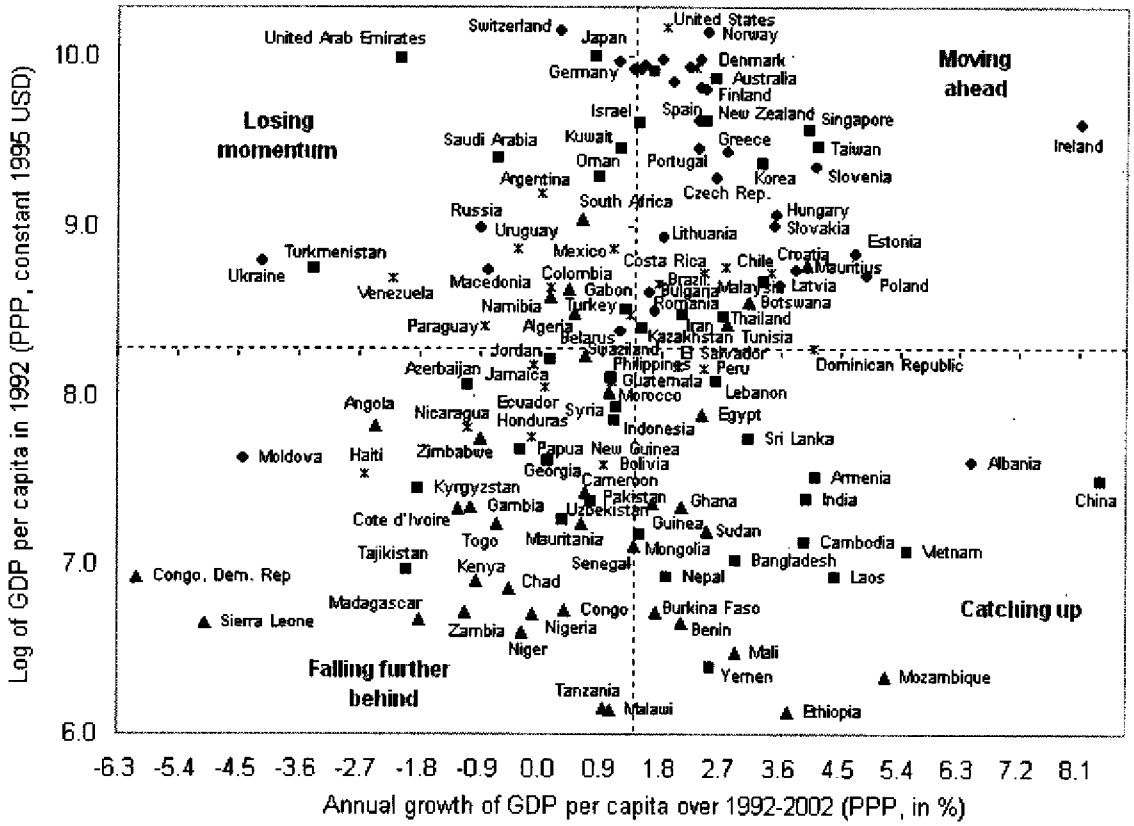
	1960	*1970*	*1980*	*1990*	*2000*
Number of countries	96	96	96	96	96
Coefficient of variation (standard deviation / mean)					
All countries	0.948	0.959	0.952	1.017	1.057
The richest quartile in 1960	0.304	0.279	0.271	0.329	0.367
The poorest quartile in 1960	0.298	0.374	0.381	0.679	0.694
Max / min country	39	61	50	54	91
The richest to the poorest quartile in each period	11.3	13.8	16.0	20.0	24.1

Note: GDP per capita (constant 1996 USD).

Source: Penn World Table Version 6.1 (Heston, Summers and Aten 2002).

In the remaining of this paper we are going to focus on the most recent decade (1992-2002), for which we have better and more extensive data (including not only GDP per capita but also a range of factors that influence it). As is evident from the above, however, this period is by no means exceptional, but conforms to the long run pattern discussed above. Figure 2 plots the annual average growth of GDP per capita for 135 countries over the period 1992-2002 (horizontal axis) against the level of GDP per capita in 1992 (vertical axis). As for the entire period there is a lot of diversity in growth performance, with all four quadrants populated to some extent. But, as above, there is a concentration of countries in the bottom left and top right quadrants, consistent with an overall tendency towards divergence in GDP per capita.

Figure 2
Convergence vs. divergence in GDP per capita over 1992-2002



Source: World Bank (World Development Indicators).

There are, as before, many African countries in the group that fall behind (bottom left), but these countries are now joined by a number of countries that formerly belonged to the USSR (so called "transition" countries). Most OECD member countries continue to be among those that move ahead (top right quadrant), but these countries are now joined by a number of former catch-up economies that due to their good performance in previous decades have moved closer to the frontier (Singapore, the Republic of Korea and Taiwan Province of China are the most obvious examples but Botswana may also be mentioned). In addition this group also includes many of the former socialist economies that recently joined the European Union. The countries that catch up continue to be mainly of Asian origin joined by some African countries (and one single European country, namely Albania). Those that "lose momentum" (top left) are more of a mixed bag, including some former USSR members, some Arab countries, some Latin-American countries and – closer to the average growth performance – some of the technologically leading countries in the world, such as Switzerland and Japan.

To summarize, convergence appears to be a relatively "local" affair, constrained in time and space. The larger the sample, the weaker the converging trends appears to be. However, at any time some countries "make it". In the following we are going to explore what distinguish those that succeed in catching up from those that fail. In so doing we will in particular focus on what the most relevant capabilities for catch-up are, following the literature on the subject, how

these can be measured and what the empirical backing is for placing more emphasis on one type of capability as compared to another one.

What are the most critical factors for catch-up? Taking stock of the literature

Intuitively, most people easily accept the idea that knowledge and economic development is intimately related, and hence that access to knowledge should be regarded as a vital factor. However, this is not the way different levels of development used to be explained by economists. From the birth of the so-called "classical political economy" – a term invented by Karl Marx - two centuries ago, what economists have focused on when trying to explain differences in income or productivity is accumulated capital per worker. Similarly, differences in economic growth have been seen as reflecting different rates of capital accumulation. This perspective arguably reflects the important role played by "mechanization" as a mean for productivity advance during the so-called (first) industrial revolution, the period during which the frame of reference for much economic reasoning was formed. Closer to our own age Robert Solow adopted this perspective in his so-called "neoclassical growth theory" (Solow 1956). The theory predicted that, under otherwise similar circumstances, investments in poor countries (e.g. those with little capital) would be more profitable than in the richer ones, so that the former would be characterized by higher investment and faster economic growth than the latter. As a consequence of this logic, a narrowing of the development gap (so-called "convergence") should be expected.

It soon became clear, however, that this could not be the whole story. When students of economic growth started apply this perspective to long run growth processes in the USA and elsewhere, they found that capital accumulation, or factor accumulation more generally, could only explain a relatively small share of actual growth (Abramovitz 1956, see Fagerberg 1994 for an extended account). This finding has since been repeated many times for different data sets.[3] Moreover, as pointed out above, the prediction that global capitalist dynamics would be accompanied by a convergence in income and productivity between initially poor and rich countries was not borne out of the facts either. In fact, it is rare to see a prediction that is so completely rejected by the evidence as this one is.

From capital accumulation to institutions and geography

It should be emphasized, however, that Solow's theory was based on standard neoclassical assumptions on how markets and agents perform, which might not fit very well in developing countries. Hence, one possible explanation for the failure of many countries to catch up could be that markets did not work properly, agents did not receive the right incentives, government interfered too much in the economy etc., in short; that "the rules of the game" were not adhered to. Following the terminology used by Douglas North (1981) such rules are customary called institutions. However, in common parlance as well as in some scholarly work, the concept institutions is also used in a broader sense, to include not only rules and norms, but also organizations and other types of collaborative activities. In the sizeable empirical literature that has emerged on the subject, both definitions are in fact used, and this arguably contributes to confusion.

Taking issue with the role of institutions for growth and development Glaeser et al. (2004) argue that institutions in the narrow sense of the term (rules, norms) should be assumed to be relatively stable over time. However, the authors point out that many indicators of "institutions" suggested in the recent scholarly literature are far from stable (rather volatile in

fact). Hence, the authors argue that such indicators in most cases do not reflect "institutions" in the above sense, but political choices, policies pursued by governments etc. They also show that if the analysis is restricted to indicators of institutions in the narrow sense (reflecting constitution, judicial checks, etc.) and their relationship with levels and growth of GDP, the correlations are in fact rather weak, in contrast to what can be shown to hold for the more broadly defined "institutional variables" (which Glaeser et al. see as reflecting political choices). Thus, institutions in the more narrow sense are not good predictors of successful catch-up. What seem to be of greater importance are the policies actually pursued. Hence, the available econometric evidence seems to confirm what follows from casual observation, namely that the political and legal systems of successful countries (and unsuccessful ones as well) can differ a lot. There is no "one best way". Catch-up friendly policies, it seems, may originate in very different political and legal systems (from communist China to democratic Ireland, to take just one example).[4]

In recent years, a sizeable empirical literature has also emerged trying to expand on the type of analysis just presented by pushing the search for explanatory factors far back in time, such as what kind of systems (countries) the colonial settlers came from (Acemoglu, Johnson and Robinson 2001,2002), or by taking into account other types of exogenous variables that might have an impact on development (and policies), such as climate, exposure to diseases, geography (access to sea for instance), ethnic diversity etc. (Sachs et al. 2004, Masters and MacMillan 2001, Bloom et al. 2003, Alesina et al. 2003). Arguably, it is difficult to deny that factors of a historical or geographical nature may have an impact on long-run growth. Hence, it appears pertinent to control for this when testing for the impact of other factors (such as different types of policy, for instance), and we will follow this practice here. However, it might be noted that in most cases there is conflicting evidence and interpretation about the impact of history, geography and nature on growth.[5] One reason for this may be that variables reflecting different causes sometimes are so strongly correlated that little can be said with certainty (apart from, perhaps, that there is a joint impact). Alesina et al. (2003), for instance, conclude on this basis that "In the end one has to use theory and priors to interpret our correlations" (p. 183). Another possibility, pointed out already by Moses Abramovitz (1994a), could be that the problems that such conditions give rise to, may also spur the creation of new knowledge and new social arrangements, which eventually may totally eliminate the problems (and even making society better off over a long-run). This leads us to the role of knowledge in growth, to which we now turn.

Knowledge, capabilities and development

"Knowledge", or "knowing things", may take many forms. It may be theoretical, based on an elaborate understanding of the phenomena under scrutiny. But it may also be practical, based on, say, cause-effect relationships that have been shown to hold in practice, although a total understanding of the underlying causes may be lacking. It may be created through search or learning but it may also be acquired through education or training or simply by observing what others do and trying to imitate it. The creation (or acquisition) of knowledge does not require an economic motive (or effect), although this is quite common. The subset of knowledge that deals with how to produce and distribute goods and services, which is what interest economists most, is usually labelled "Technology".[6] As a subject "technology" it is taught in engineering schools and technical universities.

Traditionally, economic theorists have faced great problems in incorporating knowledge (technology) into their analysis of development. This had to do with a particular view on knowledge that had come to dominate economics; knowledge as a body of information, freely available to all interested, that can be used over and over again (without being depleted).

Arguably, if this is what knowledge is about, it should be expected to benefit everybody all over the globe to the same extent, and cannot be invoked to explain differences in growth and development.

It is understandable, therefore, that the first systematic attempts to conceptualise the relationship between knowledge and development did not come from the economics mainstream but from economic historians (who looked at knowledge or technology in a rather different way). Rather than something that exists in the public domain and can be exploited by anybody everywhere free of charge, technological knowledge, whether created through learning or organized R&D, is in this tradition seen as deeply rooted in the specific capabilities of private firms and their networks/environments, and hence not easily transferable. Compared with the traditional neoclassical growth theory discussed earlier these writers painted a much bleaker picture of the prospects for catch-up. According to this latter view catch-up is not something that can be expected to occur only by market forces left alone, but requires a lot of effort and institution-building on the part of the backward country.

The economic historian Alexander Gerschenkron set the stage for much of the subsequent literature (Gerschenkron 1962).[7] Some countries are at the technological frontier, he pointed out, while others lag behind. Although the technological gap between a frontier country and a laggard represents "a great promise" for the latter (a potential for high growth through imitating frontier technologies), there are also various problems that may prevent backward countries from reaping the potential benefits to the full extent. His favourite example was the German attempt to catch up with Britain more than a century ago. When Britain industrialized, technology was relatively labour intensive and small scale. But in the course of time technology became much more capital and scale intensive, so when Germany entered the scene, the conditions for entry had changed considerably. Because this, Gerschenkron argued, Germany had to develop new institutional instruments for overcoming these obstacles, above all in the financial sector, "instruments for which there was little or no counterpart in an established industrial country". He held these experiences to be valid also for other technologically lagging countries.

Moses Abramovitz, arguing along similar lines, also placed emphasis on the potential for catch-up by late-comers. He defined it as follows: "This is a potential that reflects these countries' greater opportunity to advance by borrowing and adapting the best practice technology and organization of more productive economies" (Abramovitz 1994b, p. 87). He suggested that differences in countries' abilities to exploit this potential might to some extent be explained with the help of two concepts, technological congruence and social capability.[8] The first concept refers to the degree to which leader and follower country characteristics are congruent in areas such as market size, factor supply etc. As mentioned above, the technological system that emerged in the USA towards the end of the nineteenth century was highly depended on access to a large, homogenous market, something that hardly existed in Europe at the time, which may help to explain its slow diffusion there. The second concept points to the capabilities that developing countries have to develop in order to catch up, especially improving education (particularly technical) and the business infrastructure (including the financial system). Abramovitz explained the successful catch up of Western Europe in relation to the US in the first half of the post-WWII period as the result of both increasing technological congruence and improved social capabilities. As an example of the former he mentioned how European economic integration led to the creation of larger and more homogenous markets in Europe, facilitating the transfer of scale-intensive technologies initially developed for US conditions. Regarding the latter, he pointed among other things to such factors as the general increases in educational levels and how effective the financial system had become in mobilizing resources for change.

The concept "social capability" soon became very popular. Arguably, it is hard to find an applied paper on cross-country growth that does not reference it. But it is, as Abramovitz himself admitted, quite "vaguely" and "poorly" defined (Abramovitz 1994a, p. 24 and 36) and this has left a wide scope for different interpretations. However, although Abramovitz found it hard to measure, it is not true that he lacked clear ideas about what the concept was intended to cover. In fact he developed a long list of aspects that he considered to be particularly relevant:[9]

- technical competence (level of education)
- experience in the organization and management of large scale enterprises
- financial institutions and markets capable of mobilizing capital on a large scale
- honesty and trust
- the stability of government and its effectiveness in defining (enforcing) rules and supporting economic growth

Another popular concept in the applied literature on growth and development that touches on some of the same issues is "absorptive capacity". Wesley Cohen and Daniel Levinthal who suggested the term defined it as "the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128). They saw it as largely dependent on the firm's prior related knowledge, which in turn was assumed to reflect its cumulative R&D. However, they also noted that the path dependent nature of cumulative learning might make it difficult for a firm to acquire new knowledge created outside its own specialized field, and that it therefore was important for firms to retain a certain degree of diversity in its knowledge base through, among other things, nurturing linkages with holders of knowledge outside its own organization. As with social capability it is not obvious how to measure it but the following dimensions seem to follow logically from Cohen and Levinthal's discussion:

- (cumulative) research and development (R&D)
- diversity of knowledge base
- degree of openness/interaction across organizational boundaries

Although their focus was on firms, many of the same considerations seem to apply at more aggregate levels, such as regions or countries, and the concept has won quite general acceptance. It should be noted, however, that the concept by definition collapses three different processes into one, namely (1) search, (2) assimilation (or absorption) of what is found and (3) its commercial application. Hence, it refers not only to "absorption" in the received meaning of the term, but also on the ability to exploit and create knowledge more generally. The authors, being well aware of this, defend their position by arguing - with reference to relevant psychological literature - that the ability to assimilate existing and the ability to create new knowledge are so similar so there is no point in distinguishing between them (ibid, p. 130). However, Zahra and George (2002), in a review of the literature, argue out that the skills required for creating and managing knowledge differ from those related to its exploitation and that the two therefore deserve to be treated and measured separately. They term the latter "transformative capacity". Kim (1997) equates absorptive capacity with "technological capability" and identifies three different aspects of it; innovation capability, investment capability and production capability. In a similar vein Fagerberg (1988) and Fagerberg, Knell and Srholec (2004) distinguish between a country's ability to compete on technology (what they term technology competitiveness) and its ability to exploit technology commercially independently of where it was first created (so-called capacity competitiveness).

Social capital and development

Four decades ago Irma Adleman and Cynthia Morris (1965) concluded, on the basis of an in-depth study of a number of indicators on development for a large number of countries, that "the purely economic performance of a community is strongly conditioned by the social and political setting in which economic activity takes place" (p. 578). Although, this important insight largely got lost in the years that followed, during the nineties interests in the social (societal) prerequisites for economic development and catching-up rebounded. In an important contribution, aimed at explaining to the marked gap in economic development between two Italian regions, Robert Putnam (1993) put forward the argument that this gap had to do with different capacities for responding to social and economic challenges through appropriate forms of collective action. Such differences (in the capacity for collective action) did according to Putnam reflect historically given differences in social norms, networking and civic engagements, or "social capital" as he puts it, using an already established sociological term (Coleman 1990).

Although this interpretation of history was received by little enthusiasm by the policy makers of the lagging region, who saw it as advocacy for historical determinism and hence not very helpful in practice (Putnam 1993), it contributed to a rapidly increasing body of research on the role of social capital in development. Michael Woolcock and Deepa Narayan of the World Bank, in a recent survey (Woolcock and Narayan 2000), defines social capital as "norms and networks that enable people to act collectively". However, as they and other contributors to this literature point out, dense local networks are in themselves no guarantee for development. To take just one example, the participants in a local Mafia may be well connected, but their activities can hardly be said to be socially beneficial. More generally, groups of strongly connected people may be very dynamic, outward oriented and conducive for the creation of new and more efficient economic arrangements to the mutual benefit of all concerned. But they may also be conservative, inward looking, conflict oriented and act as a constraint for engagement in socially constructive collaborative activities. Therefore, it is pointed out, strong ties, keeping the participants of a group together (so-called "bonding"), need to be complemented by a web of weaker ties to a more diverse set of external actors (so-called "bridging") to ensure balanced, socially efficient outcomes. A central theme in the policy relevant literature on the subject has thus become what governments can do to support the creation of trust and strengthen constructive collaboration across different (social, political, religious, ethnic etc.) groups (see Woolcock and Narayan 2000).

The fact that the type of factors taken up by the literature on social capital may matter for economic development is widely accepted. For instance, Kenneth Arrow pointed out more than three decades ago that "It can plausibly be argued that much of the economic backwardness in the world can be explained by lack of mutual confidence" (Arrow 1972, p. 357). The importance of honesty and trust was, as mentioned previously, also emphasized by Abramovitz (1994b). The problem is rather how to measure and influence such factors. The inherent measurement problems probably explain why there is not yet a large empirical literature focusing on the impact of social capital on economic growth and development. One possible source of information that has been exploited to throw some light on the issue is the "World Value Survey". Stephen Knack and Philip Keefer used such data to analyse the relationship between trust, norms of civic behaviour and membership in groups on the one hand and economic growth on the other for a sample of 29 (mostly developed) countries (Knack and Keefer 1997). They found trust and civic behaviour to be positively related to investment and economic growth.[10] However, in contrast to some of the assertions in the literature this did not extend to membership in groups or organizations (which is perhaps not so surprising given that not all types organizations should necessarily be expected to have beneficial economic effects, cf. the Mafia-example above).

There are, however, continuing problems with this way of measuring of social capital. One important deficiency is the very restrictive coverage in terms of countries and time span. An alternative way to approach social capital and its role in economic development has been suggested by Jonathan Temple and Paul Johnson (Temple 1998, Temple and Johnson 1998). Their approach is a continuation of the pioneering work by Adleman and Morris during the 1960s (mentioned above), aimed at exploring the interrelationship between economic, social and political forces in development. Adleman and Morris saw economic development as contingent on broader social and political changes accompanying the transition from a traditional (rural) ways of life, based on high degree of self-sufficiency, to a modern industrialized society characterized by market-relationships and new forms of institutions and governance. They therefore set out to identify (and measure) a wide set of indicators (twenty-two in total) of economic, social and political modernization, drawing on a number of different sources, for a large group of developing countries. The relationships between these various indicators were then explored through so-called factor analysis. It was shown that the variation in the data could be reduced to four common factors, one of which was deemed especially significant. This factor, an amalgam of structural factors (share of agriculture, urbanization etc.), socio-economic characteristics (role of middle class, social mobility, literacy etc.) and the development of mass communication (measured through the spread of newspapers and radios in the population), is what Temple and Johnson suggest using as a measure for what they chose to call "social capability" which, they argue, embraces "social capital". Note that Temple (1998) tends to use the terms "social capability", "social capital" and "social arrangements" interchangeably.

As is common in the applied growth literature Temple and Johnson (1998) include their measure of "social capability" or "social capital", which they term "SOCDEV", as one of the independent variables in a regression on subsequent economic growth (together with initial GDP per capita and other variables that were deemed relevant). They demonstrate that the SOCDEV index has considerable explanatory power for the observed differences in growth performance. This result was found to be robust to the inclusion of a number of other factors. But when so-called "policy-variables" - shorthand for accumulation of physical and human capital among other things - were introduced, the significance and explanatory power of the SOCDEV variable decreased somewhat, arguably indicating that a lot of its impact may be through its influence on how policies are shaped. These findings are suggestive. However, it also has to be acknowledged that the SOCDEV index is a mixed bag of different types of variables, of which some arguably have little to do with "social" factors. Arguably, we still lack a satisfactory measure of "social capital" that covers a broad range of countries.

Bringing the pieces together: the framework and indicators

The literature in this area has identified a number of different mechanisms that developing countries may exploit to catch up. Some of these are easily measurable, while others are much harder to quantify. Is it possible to embed the variety of mechanism and indicators suggested in the literature in a common framework? To start with it is worth noting that many contributions in this area, despite theoretical differences, share a common empirical framework. This framework, so-called Barro-regressions, consists of regressing economic growth against initial GDP per capita and a number of other factors that may be deemed relevant (for a cross-country sample). In this framework the GDP per capita variable measures the scope for catch-up (or convergence). The other variables represent factors that are assumed to be of importance for (e.g. "condition") the ability to exploit the scope for catch-up (or convergence). Hence in the literature these factors are often dubbed "conditional factors", and the growth-regressions with these factors included are interpreted as tests of so-called "conditional convergence". In contrast to the (absolute) convergence (or divergence) discussed in section 2 of this paper, which refer to

observable empirical patterns, "conditional convergence" is not directly observable. The reason is that the potential for catch-up that it refers to may be masked by unfavourable "conditional factors" (which hence need to be controlled for in order to assess the true potential).

Although named after Robert Barro (1991), he did not invent this framework. Arguably, the first to introduce this technique was John Cornwall (1976), who was inspired by Schumpeter's emphasis on creation and diffusion of technology as the source of economic development. In contrast to many recent exercises in this area, Cornwall had a clear argument for the inclusion of GDP per capita as an explanatory variable; it represented the gap in technology between frontier and the late-comer countries. As such it represented a potential for high growth in the latter through successful imitation of superior technology developed elsewhere. This argument was subsequently refined by the so-called "technology gap approach" to economic growth (Fagerberg 1987, 1988 ,Verspagen 1991). This approach, distinctly Schumpeterian in flavour, emphasized the dynamic character of technology gaps. Such gaps, it was argued, are not only exploited (through imitation) but also created (through innovation). Following this view, any analysis of the evolving global income distribution has to be based a thorough understanding of innovation-diffusion at a global scale and the factors underpinning this dynamics.

The above arguments are of course firmly based on what we have called the knowledge-based approach. This approach, in our view, provides a general framework that is consistent with the existing empirical work in this area and flexible enough to accommodate the other – to some extent more partial - arguments that have been raised in the literature. We restate it as follows:

1. Development is about increasing knowledge and capabilities along several complementary dimensions.
2. Countries facing a knowledge gap may get an extra bonus from the possibility to imitate more advanced knowledge already in place elsewhere.
3. The exploitation of this potential is, however, contingent on increasing the countries own level knowledge and (social) capabilities.
4. As the distance to the frontier declines, the importance of the ability to create new knowledge, e.g., to innovate, increases relative to other factors.

Based on the preceding discussion Figure 3 presents an overview of the factors that we expect to be of particular relevance for catch-up, along with possible indicators of these factors. Starting from the bottom we first have factors related to differences in geography and nature. Such factors are important for development, especially at an early stage, and are therefore important to take into account, although there is not much one can do about it.[11] This also holds, to a large extent, for social characteristics that are the result of historical processes in the distant past, such as the roles of language(s), religion(s), ethnic groupings etc. As a consequence we do not include these in what we call the "policy space", shorthand for factors that within a reasonable time frame can be shaped through policy interventions. It is also debatable whether what is termed institutions belong to this policy space. For instance, the differences across regions in attitudes towards social collaboration studied by Putnam (and labelled "social capital"), were shown to have their roots way back in history (and to be remarkably persistent). Depending on the time frame, however, there is a lot of scope for improvements in the organization of society, the formulation/ implementation of rules/regulations, policies etc., and we therefore include such aspects in our definition of the policy space. In this we also include what Moses Abramovitz termed social capabilities, e.g., organizational competence, adequate financial infrastructure, education etc., and factors associated with technological capability (absorptive capacity) such as R&D infrastructure.

Figure 3
An integrated framework for analysis

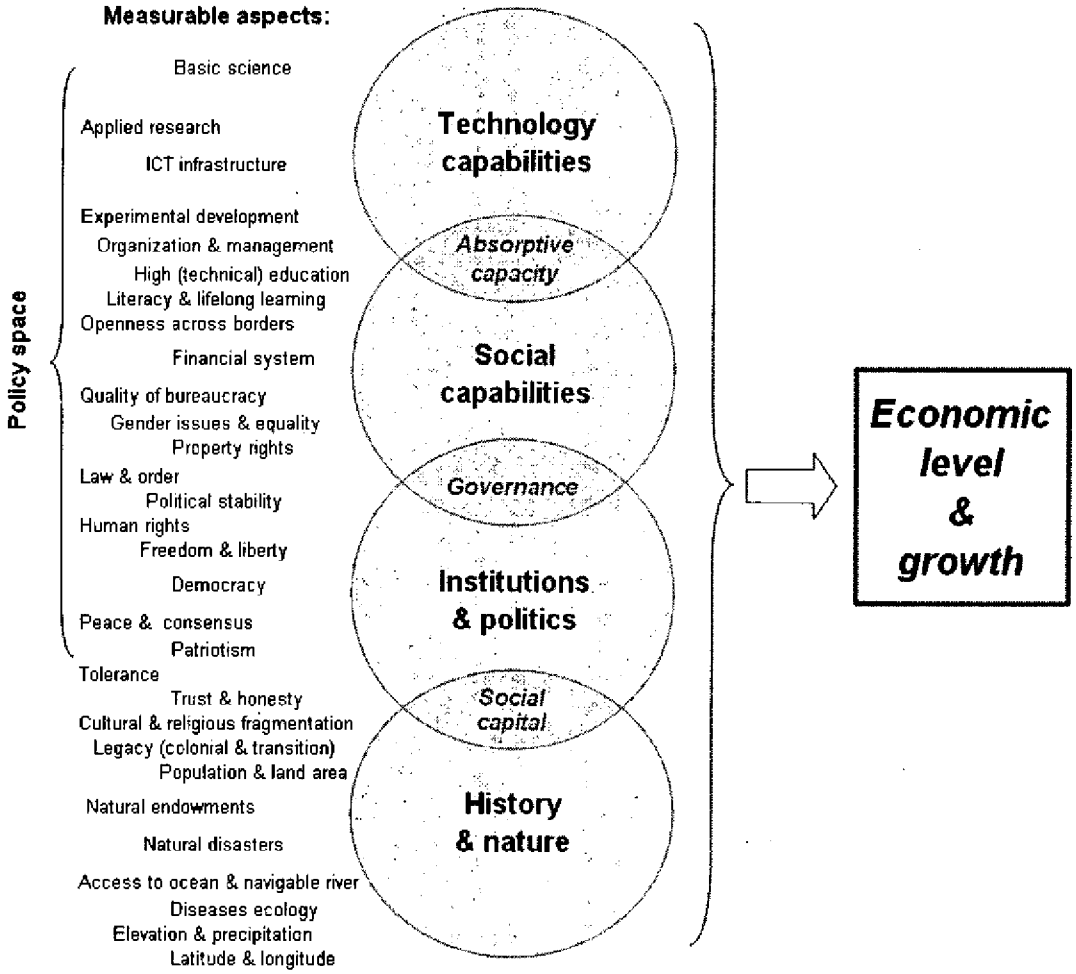


Figure 3 also gives some hints on measurable aspects of the dimensions in question. **Technological capability** refers to the ability to develop new goods and services and new production methods. It is closely related to the innovation system of a country (Lundvall 1992, Nelson 1993). We have three sources of data, which capture different aspects of this dimension. On the input side, research and development (R&D) expenditures, measure some (but not all) resources that are used for developing new products or processes. On the output side, number of patents[12] count (patentable) inventions while articles published in scientific and technical journals reflect the quality of a country's science base (on which innovation and invention activities to some extent depend).[13] In addition, a well-developed ICT infrastructure is widely acknowledged as a critical factor for the ability to benefit from new technology. We use three indicators of ICT diffusion in the economy: personal computers, Internet users and fixed/mobile phone subscribers. Another important aspect of the growing global technological competition is the increasing role played by quality standards for which the ISO 9000 certification seems to be most relevant and broadly available indicator.

As for **social capability** the importance of education (or human capital) for assimilation and creation of knowledge goes almost without saying. We include five indicators that reflect different aspects. On the one hand the focus is on broad measures of human capital; the number of years in school, the teacher-pupil ratio in primary education and life expectancy. The teacher-pupil ratio is included to reflect the qualitative dimension of education, while life expectancy at birth is included as a measure of the time horizon for individual investments in education. On the other hand emphasis is placed on higher education as reflected in the share of population with completed higher education and the rate of enrolment in tertiary education. Note that we do not use indicators of enrolment in primary and secondary education, since these are measures of flows, that may not have any impact on the labour force within the time span considered here, and have upper boundaries ("saturation" levels) that imply that most developed countries will have values close to 100%. Indicators with the latter property are not well suited in factor analysis, because they tend to cluster into a single dimension due to this property alone, regardless of the economic content. However, this problem is less severe for enrolment in tertiary education than for other enrolment indicators, which is why we include it here.

As pointed out in the literature on absorptive capacity, openness (or interaction) across country borders may serve as an important channel of technology transfer (or spillovers) from abroad. This issue is also very much emphasized in work inspired by the so-called "new growth theories" (see, for instance, Grossman and Helpman 1991 and Coe and Helpman 1995). Four channels of technology transfer across country borders have been examined in the literature: migration, licensing, trade and foreign direct investment (FDI) (for an overview see Cincera and van Pottelsberghe de la Potterie 2001). However, due to lack of data we only take into account the two latter, e.g.; diffusion of technology embodied in (merchandise) imports and (stock) of inward FDI.

The crucial role of country's financial system for mobilizing resources for catching-up has been emphasized repeatedly. We capture this aspect by the amount of credit (to the private sector) and by capitalization of companies listed in domestic capital markets. These quantitative measures are complemented by the interest rate spread (lending rate minus deposit rate), which is included as a measure of the efficiency of the financial system.[14]

The importance of **institutions, governance and policies**, furnishing economic agents with incentives for creation and diffusion of knowledge, is generally acknowledged in the literature. Although such factors often defy "hard" measurement, especially in a cross-country comparison, there exist some survey-based measures that may be considered here.[15] We include the following aspects (taken from such surveys):

- Adherence to human rights (freedom from extra judicial killing, torture, imprisonment, etc.)
- impartial courts,
- law and order,
- protection of property rights,
- how difficult it is to start/operate a business,
- size of informal market (extent of corruption),
- democratic versus autocratic government,
- checks an balances in the political system,

- degree of competition for posts in the executive and legislature and
- the extent of political rights and civil liberties.

These indicators clearly refer to institutions both in the broad sense ("quality of governance") and in the narrow sense ("rules of the game"). One of the challenges in the following will be to find ways to distinguish between these two aspects.[16]

Note that we do not use the composite "governance matters" indicators developed by the World Bank, which provide composite measures of "voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, control of corruption" for a large sample of countries between 1996 and 2002. However, the sources for the World Bank indicators are by and large the same as those utilized here, so most of the information included in the World Bank indicators is taken into account. The reason is, as explained by Kaufmann et al (2003, pp. 31), that these indicators by construction eliminate the time trend in the data, such as for instance a general trend towards more (less) democratic government (which clearly would be of interest here). However, as pointed by Glaeser et al. (2004), time-trends may be problematic, since it cannot be excluded that the perceptions of the respondents may also be influenced by factors other than the issue in question. Hence the resulting indicators have to be interpreted with care.

Measurability is a key issue, of course, but data availability proved to be an even more serious concern for the large sample of countries considered here (135 countries). The relatively short time frame (1992-2002) allowed us to include a swarm of newly independent - former centrally planned - countries emerging from the break up of the USSR, Yugoslavia and Czechoslovakia. However, in spite of this short time frame, there were some missing observations for certain indicators/countries, especially for the initial period. In general, a fully complete data set was available for one third of the countries only, another third was in the 90-99% range, while the remaining had between 70-90% of the data needed.[17] Typically, most developed market economies figure prominently among those with full coverage, while many developing countries and former socialist economies lacked data on some indicators/years. Since the purpose of the analysis was to explore trends for a broad sample of countries, including many developing ones, we chose to estimate the missing observations with the help of information on other, similar, variables/ countries (rather than reducing the sample).[18] Hence the main focus of the analysis is on the overall dynamics, and on groups of countries with similar characteristics, rather than on the development of specific countries/indicators. To ensure comparability over time and across countries, all indicators were measured in real units (quantity), deflated (if applicable) with population or GDP and on an increasing scale (from low score (weak) to high score (strong)).[19] To limit the influence of shocks occurring in specific years, we express all indicators as three-year averages for the initial period over 1992-1994 and for the final period over 2000-2002.

Constructing composite indicators: factor analysis

The total number of indicators taken into account here equals twenty-nine (excluding indicators related to geography, nature and history). Hence there is potentially a lot of information to exploit in the analysis. But it goes without saying that it would not be meaningful to take all these variables on board in, say, a regression analysis on economic growth, since many of them reflect slightly different aspects of the same reality and tend to be highly correlated (hence multicollinearity may be expected). How to combine this information into a smaller number of dimensions with a clear-cut economic interpretation? This is one of the key the challenge confronting us in this study.

The most widely used approach to construct composite indicators is to use judgment to select the relevant variables and then weigh these together (normally using equal weights). This requires that we know in forehand which indicators to combine into a single dimension. However, if we lack this knowledge, this way of doing things runs into problems, as appears to be case here. Fortunately there is a well-developed branch of multivariate analysis, so-called "factor analysis" (or principal components analysis), that is designed to advice on questions like this.[20] It is based on the very simple idea that variables referring to the same dimension are likely to be correlated, and that we may use this insight to reduce the complexity of a data set (consisting of many variables) into a small number of uncorrelated composite variables, each reflecting a specific dimension of the total variance of the data set. This method has been widely used in the social sciences for a long time (Spearman 1904, Hotelling 1933) and was applied to the study of development in the pioneering study by Adleman and Morris (1965, 1967).

The aim of factor analysis is to reduce a complex set of variables into a small number of (principal) factors that account for a high proportion of variance. First a matrix of correlations is computed. We then identify a vector explaining as much as variance in the matrix as possible and extract it from the data. This procedure is repeated as long as the last factor identified explains more of the total variance than an original variable (more than the inverse value of the number of variables).[21] The result of this iterative process is a set of new (latent) variables that are linear combinations of the underlying indicators.

The problem, of course, is how to interpret the retained factors. In doing so it is helpful to look at the correlations with the original set of variables (the so-called "factor loadings"). These "factor loadings" show the proportion of the total variance of an original variable that is accounted for by the new composite factor, e.g., a loading 0.60 of a variable indicates that 36% of its variance is explained by the composite factor. The first factor identified typically explains by far the largest proportion of the variance, with most of the variables highly loaded in it. However, such a general factor - with many high loadings - is difficult to interpret. Furthermore, it is an artefact of the method that the general factor is followed by a series of bipolar factors with mixed positive and negative loadings, the interpretation of which are even more difficult. Therefore, in a second step of the factor-analysis we rotate the solution to maximize differences in loadings of the original variables across the extracted factors.[22] After the rotation, only a limited number of variables will load high on each factor, which simplifies the interpretation.[23] This second step also provides us with the weights used to calculate the composite indicators (the "factor score coefficients").

The composite indicators that follow from weighing together the original variables with the "factor score coefficients" (so-called "factor scores") are uncorrelated with each other, which is of course a highly desirable property in regression analysis. However, since each factor score is a linear combination of **all** the original variables (although only a few of them may have high weights), doubts may be expressed about the interpretation. To reduce such interpretation problems one possibility might be to only take into account those original variables that load highly when constructing a particular indicator (and disregard the other, less important variables). For instance, one might chose to include only those original variables for which the factor loadings are shown to be significantly different from zero at, say, a 1 % level of significance.[24] Alternatively one might allow each original variable to be included in only one of the composite indicators, which would of course be preferable for an interpretation point of view. Note, however, that one less desirable consequence in this way may be that the property of uncorrelatedness may no longer apply.

Before we move to the results from the factor analysis there are some issues that deserve mentioning. First, the indicators have to be standardized (deducting mean and dividing by standard deviation) before aggregating them into a composite. We have standardized the indicators with the mean and standard deviation of the pooled data (from the initial and final

period). This means that the change of a composite indicator over time will reflect both changes in each country's relative position (across countries) and changes in the absolute level of the underlying variables (over time). Second, variables should be relatively evenly distributed, e.g., variables with a "two sample split" (for example very high values for the developed countries and close to zero for the poorer ones) should be avoided. For the very same reason outliers need to be dealt with. Simply excluding outliers from the sample may not be the best solution, as we then may lose the important evidence (countries). A log-transformation of the data set was used to significantly reduce these problems.[25]

In Table 4 we present the results from a factor analysis on pooled data for the initial and final period for the 135 countries covered by the analysis (270 observations). The table presents the factor loadings after rotation and the corresponding factor score coefficients. Entries in bold represent significant correlation coefficients (absolute value above 0.15). The shaded areas show the variables associated with the various factors (composite indicators) when only one link is allowed between a variable and a factor (composite indicator).

Five principal factors were retained, which jointly explain 76.7% of the total variance. The first factor correlates highly with various aspects associated with creation, use and transmission of knowledge, e.g.; R&D and innovation, scientific publication, ICT infrastructure, ISO 9000 certifications and education. Hence we label it *knowledge*. The second factor may be labelled "*openness*" (as it shows high correlation with imports and inward FDI) and the third factor may be similarly labelled "*financial system*". A brief look at the remaining two factors reveals that the above mentioned difference between "governance" and "policy outcomes" on the one hand and "rules of the game" on the other are clearly mirrored in the results. In fact, the fourth factor loads highly with variables reflecting the "*governance*" dimension, while the fifth factor reflects aspects of the political system, and we shall call it "*democracy*" in the following.

In the following we will concentrate mainly on the cases with one original variable per composite factor, since this makes the interpretation of the factors easier. Comparing the case with one variable per factor with that of significant loadings reveals that the meanings of the factors change quite a bit, although the broad characteristics given above may still hold. This change is especially significant for the openness factor, which in addition to FDI and imports would also include aspects related to internet use, adherence to international quality standards (ISO 9000) and human rights. Of course, these additional variables may still merit as aspects of "openness" albeit in a broader sense than previously. The same goes to some extent for the "financial system" which would also take on board aspects related to science and technology, spread of computers, adherence to international quality standards and the working of the legal system (impartial courts and extent of corruption). Similar considerations apply for the governance factor. Hence, using significant loadings creates partly overlapping but not necessarily less meaningful factor definitions. We may chose to use these estimates test for the sensitivity of changing the factor definitions by including a broader range of potentially relevant variables.

Table 4
Results of factors analysis

Number of observations = 270 (factor analysis of 135 countries on pooled data for the initial and final period)	*Factor loadings*					*Factor score coefficients*				
	Knowledge	*Openness*	*Financial system*	*Governance*	*Democracy*	*Knowledge*	*Openness*	*Financial system*	*Governance*	*Democracy*
Research and development expenditure (% of GDP)	**0.77**	**-0.19**	**0.30**	**0.25**	0.14	**0.13**	**-0.16**	**0.00**	**-0.01**	-0.03
USPTO patents (per capita)	**0.65**	-0.01	**0.46**	**0.36**	**0.28**	**0.05**	-0.07	**0.08**	**0.01**	**0.00**
Science & engineering articles (per capita)	**0.69**	-0.06	**0.42**	**0.35**	0.15	**0.08**	-0.09	**0.06**	**0.02**	-0.04
Personal computers (per capita)	**0.62**	**0.23**	**0.46**	**0.21**	**0.39**	**0.04**	**0.07**	**0.10**	**-0.07**	**0.03**
Internet users (per capita)	**0.50**	**0.43**	**0.35**	-0.01	**0.47**	**0.04**	**0.20**	**0.09**	-0.16	**0.06**
Fixed line and mobile phone subscribers (per capita)	**0.81**	**0.24**	**0.28**	**0.21**	**0.30**	**0.13**	**0.09**	**-0.03**	**-0.05**	**-0.01**
ISO 9000 certifications (per capita)	**0.55**	**0.33**	**0.52**	0.14	**0.37**	**0.02**	**0.14**	**0.16**	-0.11	**0.02**
Tertiary school enrolment (% gross)	**0.89**	0.01	0.14	0.15	**0.26**	**0.19**	-0.04	-0.10	-0.05	**-0.01**
Teacher-pupil ratio in primary education	**0.83**	0.06	0.12	**0.24**	0.01	**0.19**	0.00	-0.11	**0.01**	-0.08
Life expectancy at birth	**0.82**	0.03	**0.21**	**0.17**	0.15	**0.16**	-0.02	**-0.05**	**-0.04**	-0.04
Average schooling years in population	**0.87**	0.11	0.09	**0.20**	**0.20**	**0.19**	0.03	-0.13	**-0.01**	**-0.03**
Share of higher school complete in population	**0.86**	0.00	0.05	0.12	**0.24**	**0.20**	-0.04	-0.14	-0.04	**-0.01**
Merchandise imports (% of GDP)	0.04	**0.78**	-0.06	**0.22**	-0.11	0.00	**0.46**	-0.11	**0.09**	-0.09
FDI inward stock (% of GDP)	-0.02	**0.77**	0.15	-0.02	0.25	-0.06	**0.43**	0.06	-0.08	0.02
Interest rate spread (lending rate minus deposit rate)	-0.09	0.05	**-0.72**	**-0.16**	-0.06	0.11	0.07	**-0.37**	**0.08**	0.02
Market capitalization of listed companies (% of GDP)	**0.33**	0.13	**0.74**	0.14	0.10	**-0.05**	0.03	**0.33**	-0.12	-0.04
Domestic credit to private sector (% of GDP)	**0.39**	0.06	**0.68**	**0.30**	**0.25**	**-0.05**	-0.02	**0.25**	**-0.04**	**0.00**
Physical integrity human rights	**0.25**	**0.38**	-0.07	**0.69**	0.12	**0.00**	**0.19**	-0.24	**0.31**	-0.04
Impartial courts	0.14	-0.01	**0.53**	**0.61**	0.03	-0.10	-0.05	**0.16**	**0.18**	-0.04

Number of observations = 270 (factor analysis of 135 countries on pooled data for the initial and final period)	*Factor loadings*					*Factor score coefficients*				
	Knowledge	*Openness*	*Financial system*	*Governance*	*Democracy*	*Knowledge*	*Openness*	*Financial system*	*Governance*	*Democracy*
Law and order	**0.38**	0.06	**0.27**	**0.52**	0.00	**0.01**	0.00	**-0.01**	**0.16**	-0.06
Property rights	**0.30**	0.01	**0.41**	**0.71**	**0.22**	**-0.06**	-0.06	**0.03**	**0.23**	**0.00**
Regulation	**0.35**	0.01	**0.32**	**0.65**	0.11	**-0.02**	-0.05	**-0.01**	**0.22**	-0.03
Informal Market (corruption)	**0.32**	**0.20**	**0.51**	**0.58**	0.10	**-0.06**	**0.07**	**0.11**	**0.14**	-0.05
Index of democracy and autocracy	0.15	0.04	0.08	0.10	**0.90**	-0.05	-0.04	-0.03	-0.02	**0.24**
Political constraint	**0.17**	-0.06	0.10	**0.25**	**0.76**	**-0.05**	-0.10	-0.04	**0.06**	**0.20**
Legislative index of political competitiveness	**0.25**	0.08	0.12	-0.15	**0.79**	**0.00**	-0.01	0.03	-0.16	**0.21**
Executive index of political competitiveness	**0.21**	0.15	0.13	-0.07	**0.85**	**-0.03**	0.03	0.02	-0.12	**0.22**
Political rights	**0.18**	-0.01	0.06	**0.51**	**0.78**	**-0.07**	-0.08	-0.12	**0.19**	**0.19**
Civil liberties	**0.18**	0.06	0.08	**0.57**	**0.72**	**-0.08**	-0.04	-0.12	**0.22**	**0.17**
Explained % of total variance	26.8	6.6	12.9	13.2	17.2	..	..	..	..	..

Note: Extraction method: principal components; rotation : varimax normalized; the highest loading for each variable marked by grey shading; significant loadings (at 1% level) in bold.

Source: See Appendix A1.

The results suggest that the factors identified in the literature can be summarized along five dimensions:

- knowledge
- openness to technology/knowledge from abroad
- the development of the financial system
- quality of governance
- degree of democracy

The first and second terms together arguably comes close to what is normally meant with "absorptive capacity". In contrast, the third and fourth dimension (finance and quality of governance) clearly belong to "social capability" in Abramovitz' sense. But so does much of what is included in the "knowledge" term, especially when account is taken of the very high weights for the educational variables. The fifth term, degree of democracy, does not belong to any of the above sets but figures prominently in what we dubbed the "institutional" approach. However, "Social capital", in the tradition from Putnam, is not reflected here due to lack of adequate data sources, which might be seen as a weakness (but one that is difficult to remedy with the available data).

Stylised facts on the critical factors of catching-up

In this section we explore, mainly with the help of graphs, the "stylised facts" that emerge from an analysis of the levels and changes over time of the five composite variables/capabilities. The first thing to note is the very high correlation between the level of income of a country and its level of knowledge (Figure 4). In fact, the latter explain 77 % of the former, a very high number indeed. The main source of deviation comes from a group of small natural-resource rich countries (such as United Arab Emirates, Oman and Botswana) , which all have higher levels of income that follow form their levels of knowledge, and from a group of former Soviet countries for which it is the other way around. Second, it is worth pointing out that knowledge is a highly dynamic variable, with positive mean growth, and relatively large differences across different country groups (Figure 5). Many countries, particularly in Asia, experience rapid knowledge growth, and much more so than the developed countries (despite the high initial level of knowledge of the latter. Hence, the distribution of knowledge across different parts of the globe is clearly changing, with a lot of catch-up going on. This tendency is not limited to the countries of South-East Asia and the Asian Tigers, although their performance is striking, but extends to countries in West Asia, North Africa and the new EU members as well. The least favourable performance is recorded by the former members of the Soviet block and the countries of Sub-Saharan Africa, which both fell behind in knowledge, indicating that these countries face severe problems in adapting to the requirements of the global knowledge based economy.

Figure 4
GDP per capita and level of knowledge (average over 2000-2002)

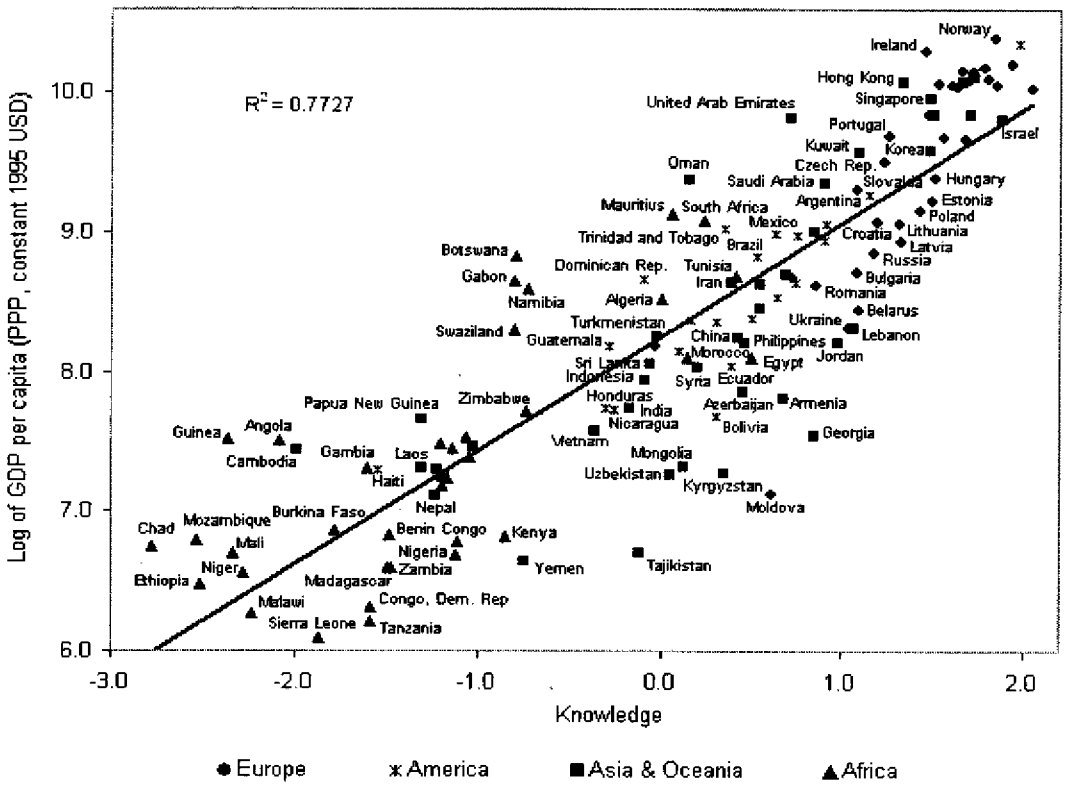
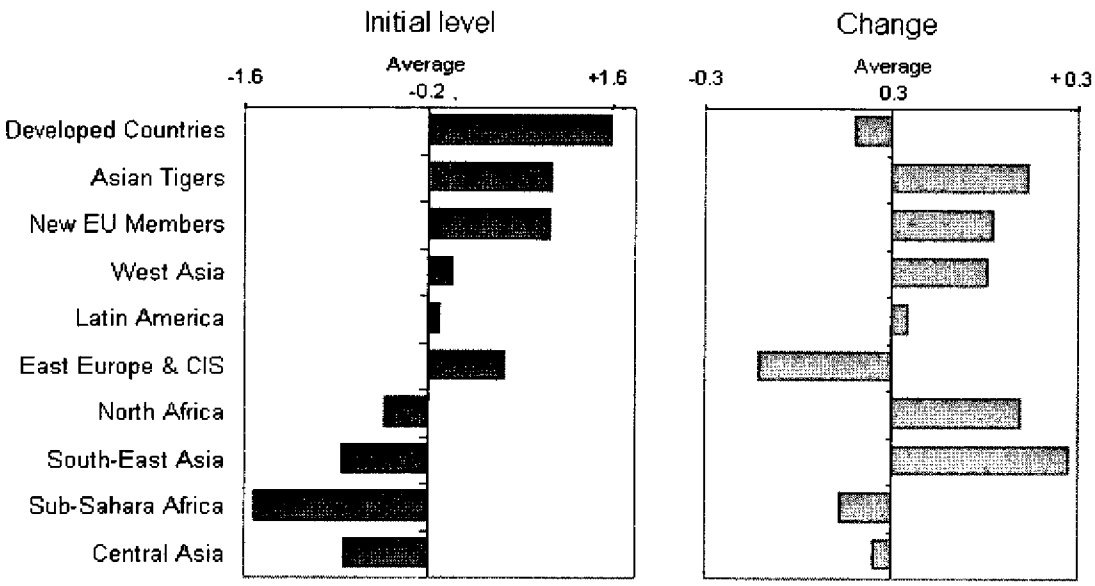


Figure 5
Knowledge by regions



Note: For definition of the knowledge variable see Table 4.

Source: See Appendix A1.

Openness is a different matter. First of all there is hardly any correlation between openness and per capita income (Figure 6). There are some high income countries with high levels of openness, Hong Kong SAR, Singapore, Belgium and Ireland may be mentioned. But other high income countries, such as Japan and the United States, are much less open. This being said, there is clearly a strong tendency towards increasing openness in most countries (Figure 7), driven to a large extent by increasing foreign direct investments (FDI). This tendency is especially strong for the former socialist countries in Eastern Europe and the CIS, which were the least open at the beginning.

Figure 6
GDP per capita and level of openness (average over 2000-2002)

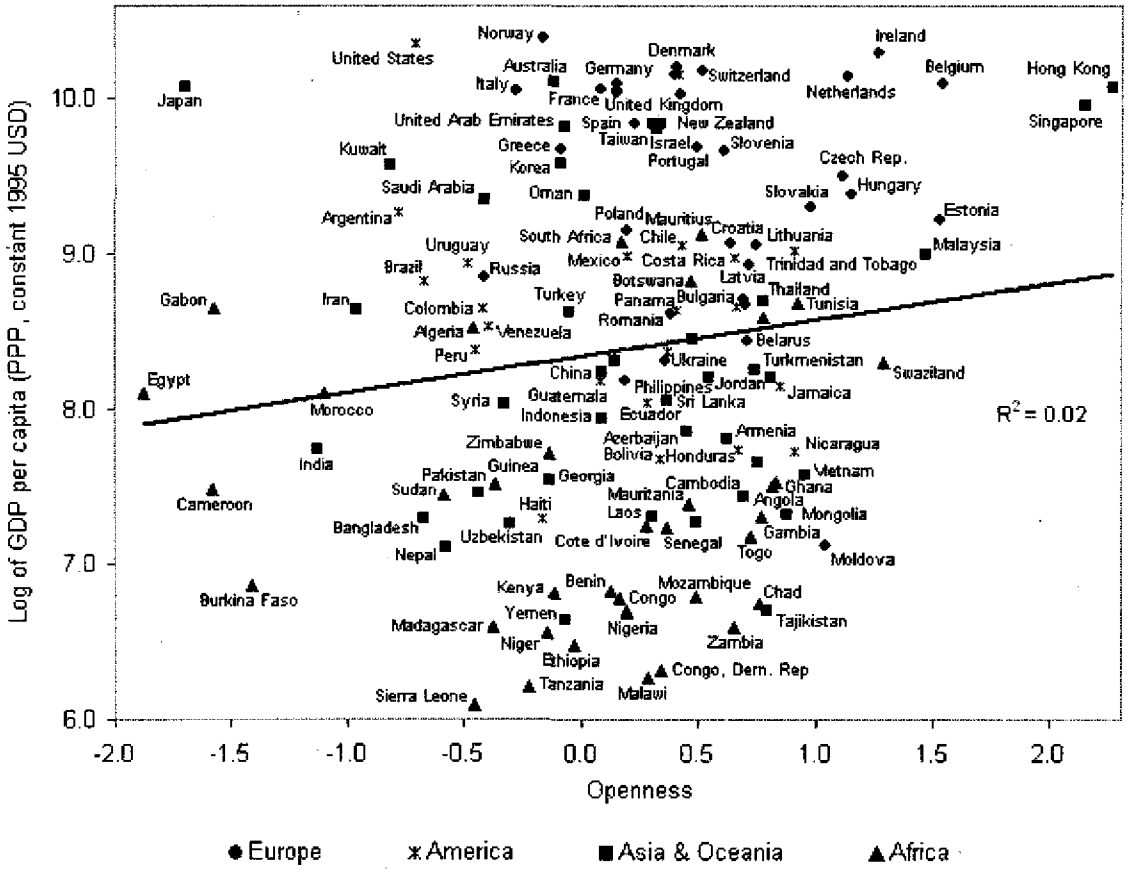
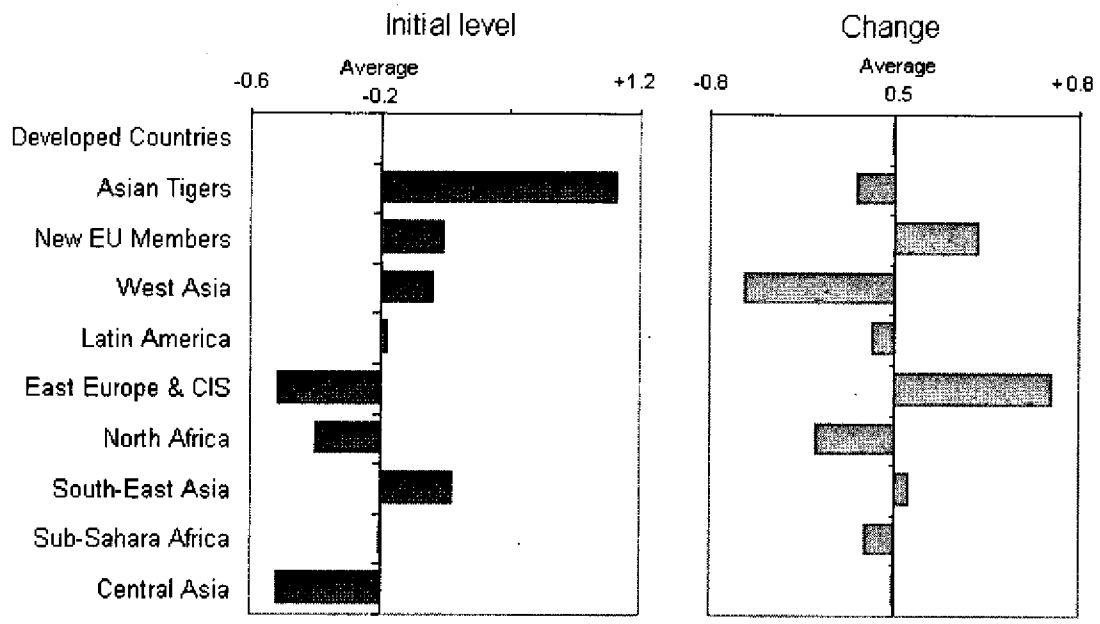


Figure 7
Openness by regions



Note: For definition of the openness variable see Table 4.

Source: See Appendix A1.

The financial system variable, in contrast, is strongly correlated with income, although less so than knowledge (Figure 8). It is also less dynamic than knowledge, in the sense that its mean change is close to zero (but positive). Traditionally, the developed countries and, in particular, the Asian Tigers have excelled along this dimension, and this continues to some extent to be the case, though the capabilities of the Asian Tigers have increased less than those of other high income countries (Figure 9). It also interesting to note that there is very little catch-up going on along this dimension. In fact, with an exception for the new EU member countries, the performance of other groups is inferior to that of the developed countries. The clearly worst performance is recorded by the African countries, which appear to fall behind the rest of the world in this dimension as well.

Figure 8
GDP per capita and level of financial system (average over 2000-2002)

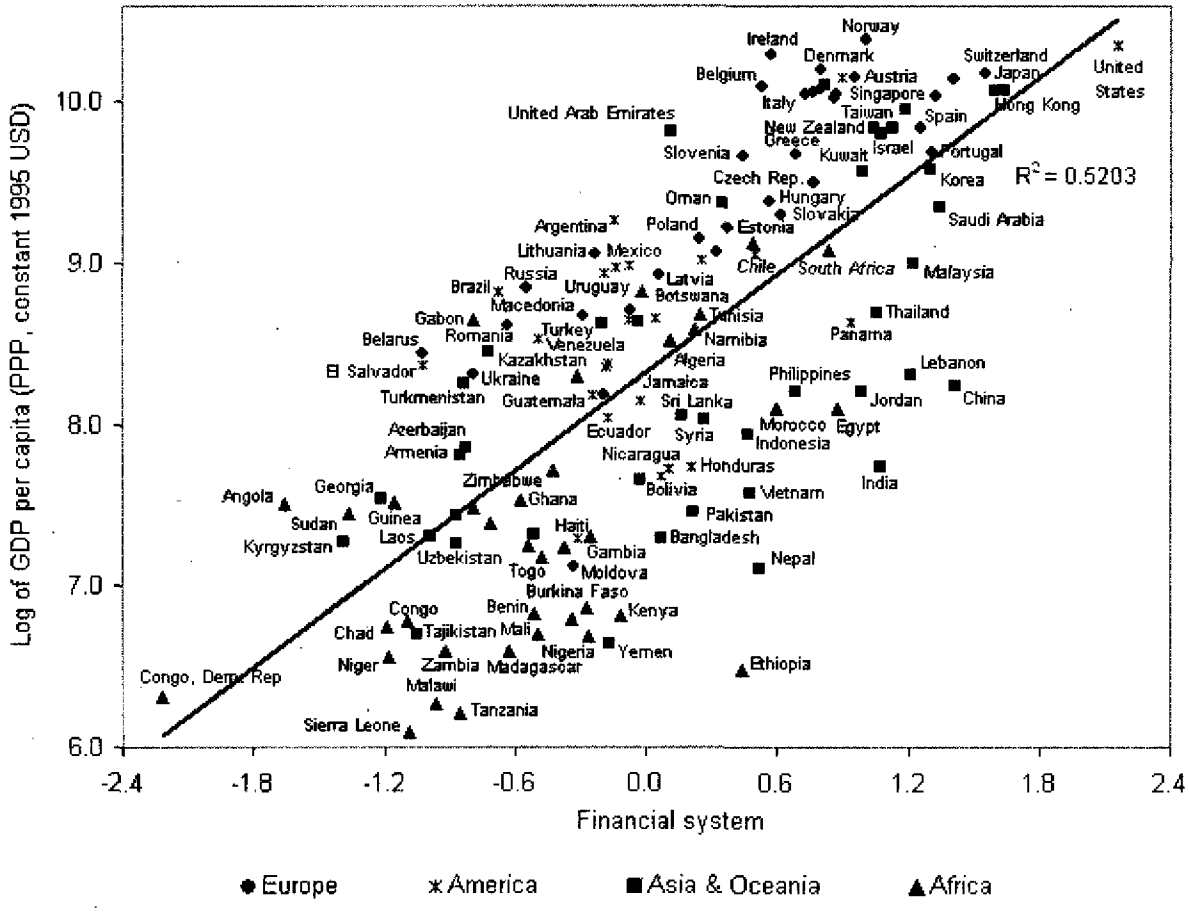
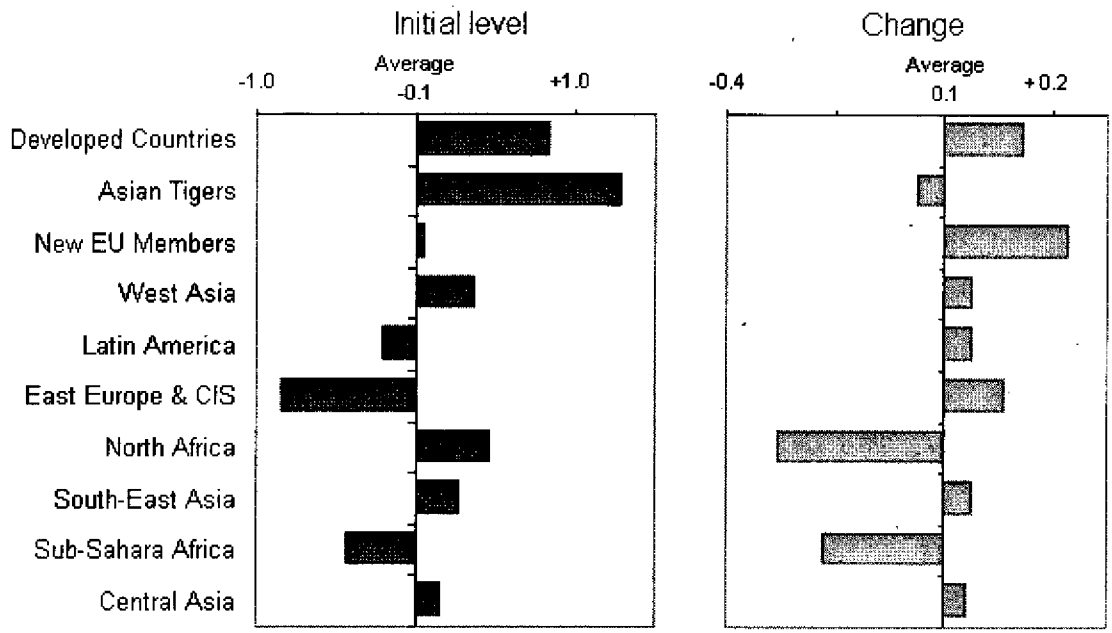


Figure 9
Financial system by regions



Note: For definition of the financial system variable see Table 4.

Source: See Appendix A1.

As with knowledge and finance, governance is closely correlated with development (Figure 10). High income countries, including new EU members, tend to score much better than developing countries in Africa, Asia and Latin-America. The main source of variation comes from a group of African countries, with much better governance than what should be expected, given their income levels. Hence, good governance is certainly not a sufficient condition for prosperity (although it may be a necessary one). In contrast to the three composite variables discussed so far, there is a general tendency towards decline in the quality of governance (Figure 11). This may be surprising, but it has to be remembered that in contrast to three composite variables already discussed, governance (and democracy) are measured through surveys. So what we are measuring is changes in perceptions, which, as previously pointed out, may fluctuate for other reasons. Still it is interesting to note that the two most pronounced high-income groups, the developed countries and the Asian Tigers, have a more favourable development than all other country groups but North Africa. The clearly worst performers along this dimension are the former socialist countries in Eastern Europe and the CIS joined by those from Central Asia. So in this case, too, very little catch-up is going on.

Figure 10
GDP per capita and level of governance (average over 2000-2002)

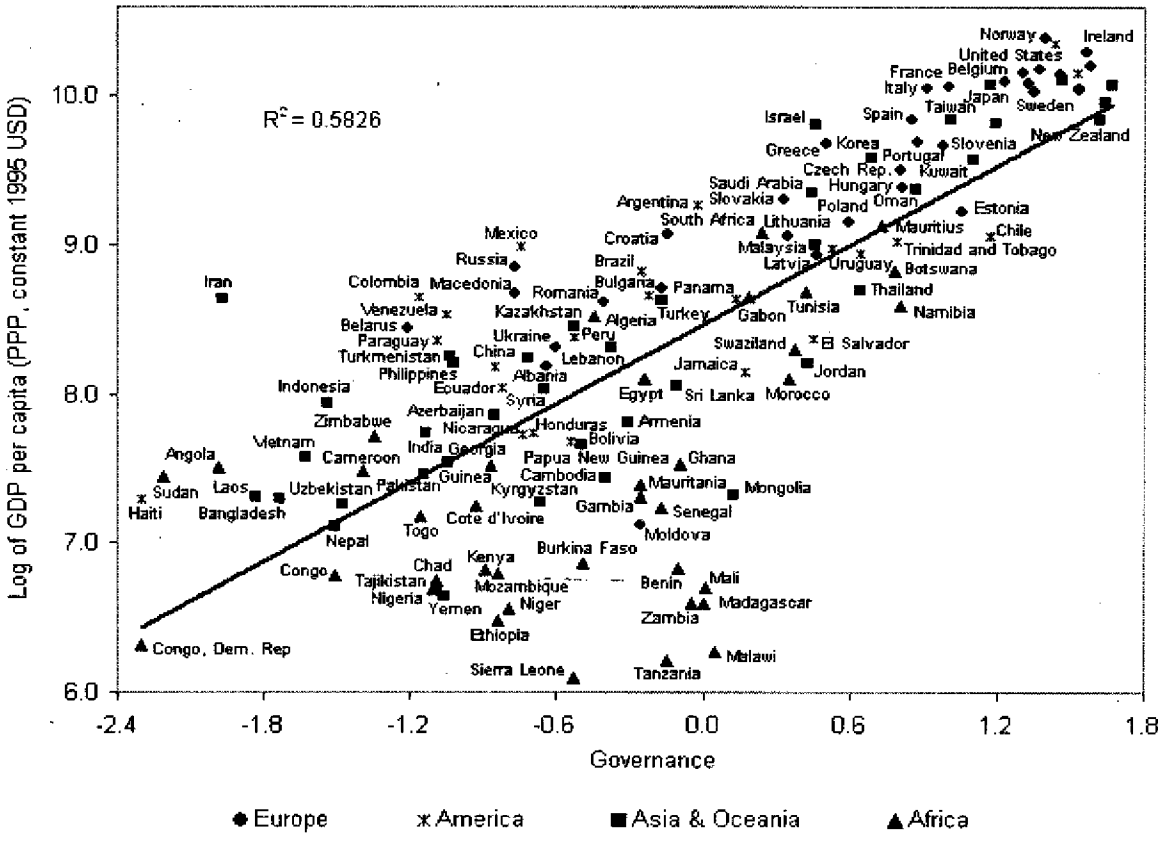
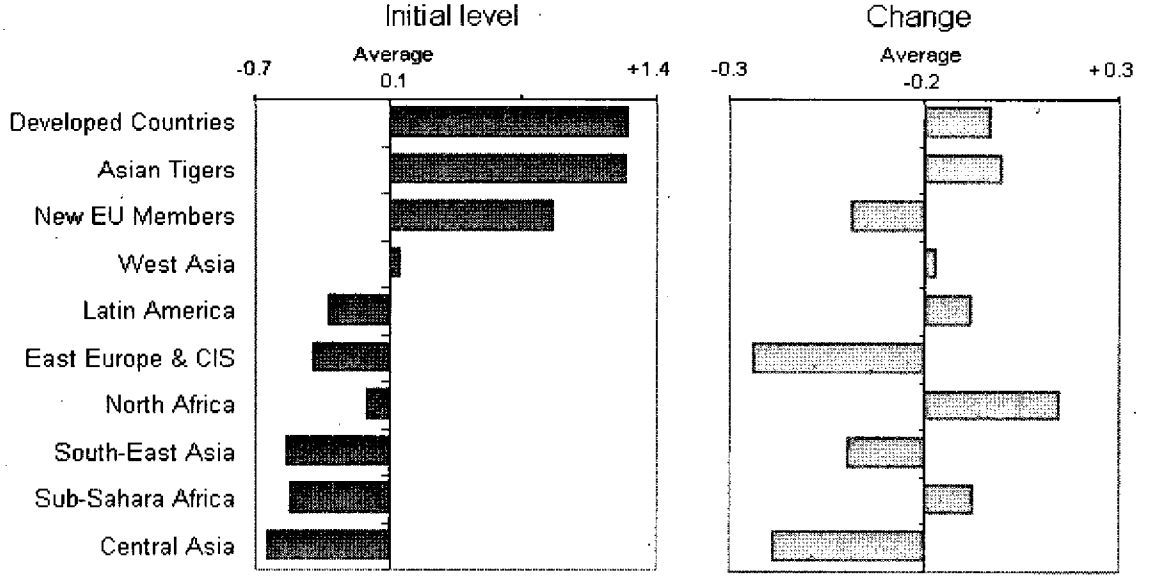


Figure 11
Governance by regions

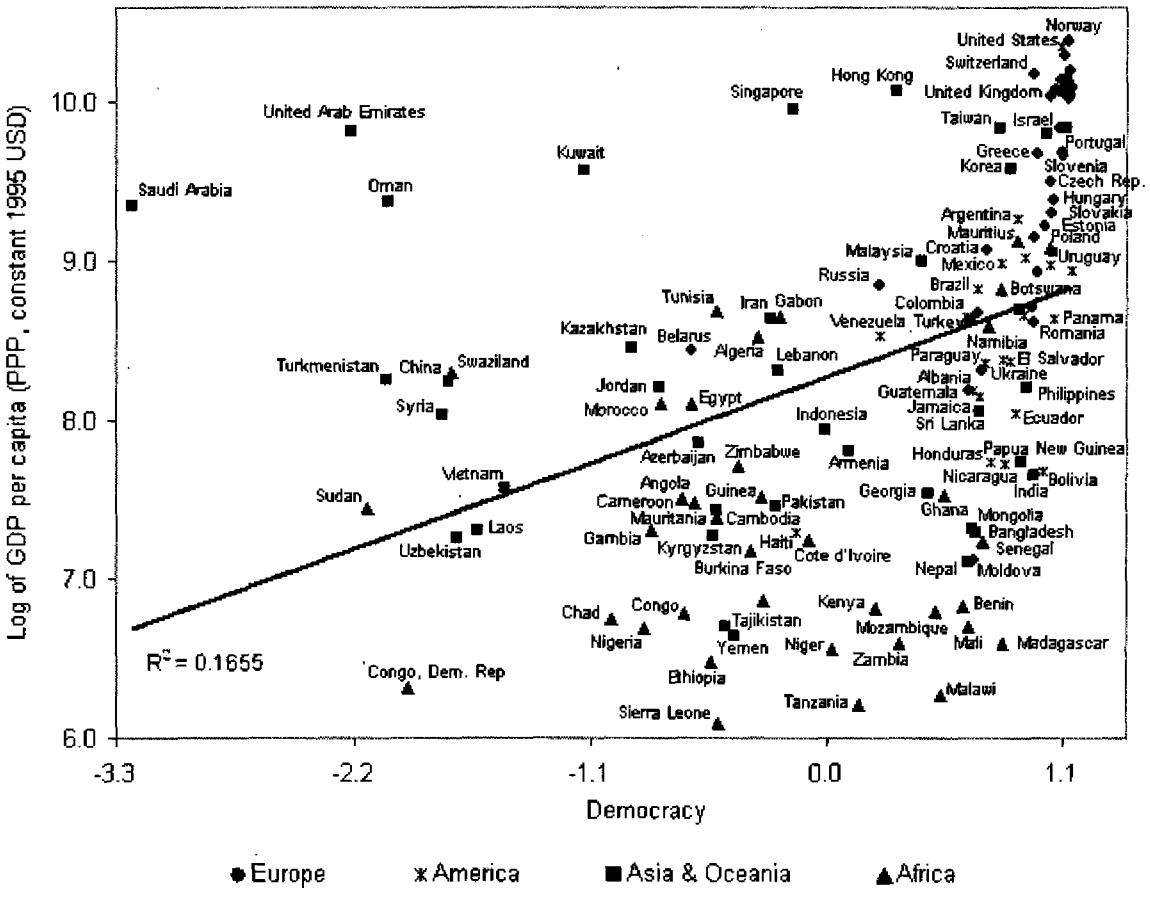


Note: For definition of the governance variable see Table 4.

Source: See Appendix A1.

This is different for "democracy". On average democratic standards and practices seem to be on the increase around the globe, and all country groupings appear to catch up relative to the developed countries, that used to be (and still is) in the lead in this area (Figures 12 and 13). However, the relationship between democracy and development is weak at best. There are several countries with high levels of income that are not very democratic (with the Arab countries as the prime examples). Moreover, the income levels of countries with high democratic "performance" vary a lot (right part of the figure). Figure 14 illustrate this from a different angle, by plotting democracy (horizontal axis) against governance (vertical axis). As is evident from the graph the relationship between the two is rather weak, confirming the findings of previous research on this issue (Glaeser et al. 2004).

Figure 12
GDP per capita and level of democracy (average over 2000-2002)



Note: For definition of the democracy variable see Table 4.

Source: See Appendix A1.

Figure 13
Democracy by regions

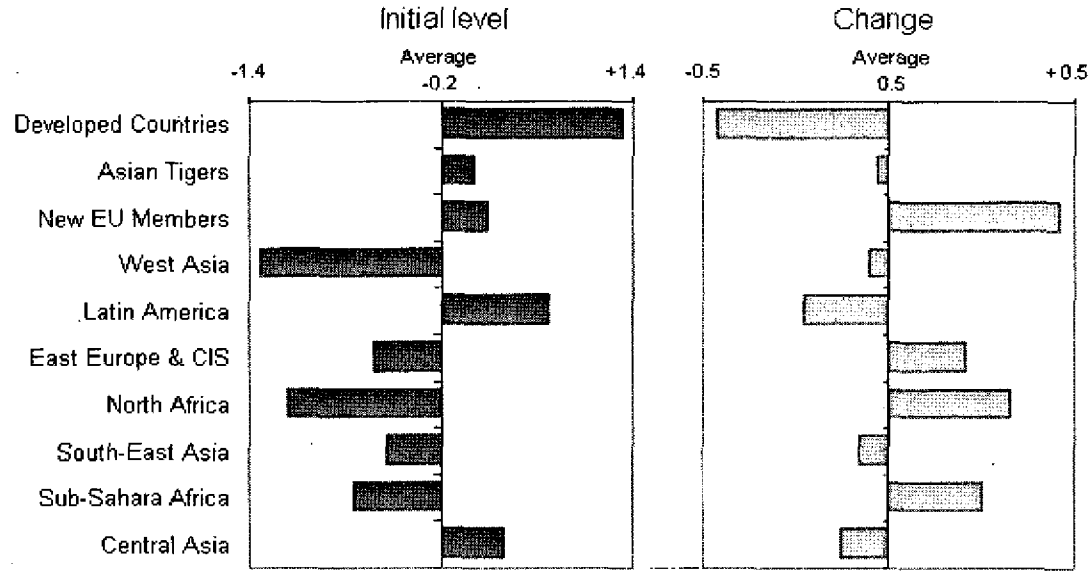
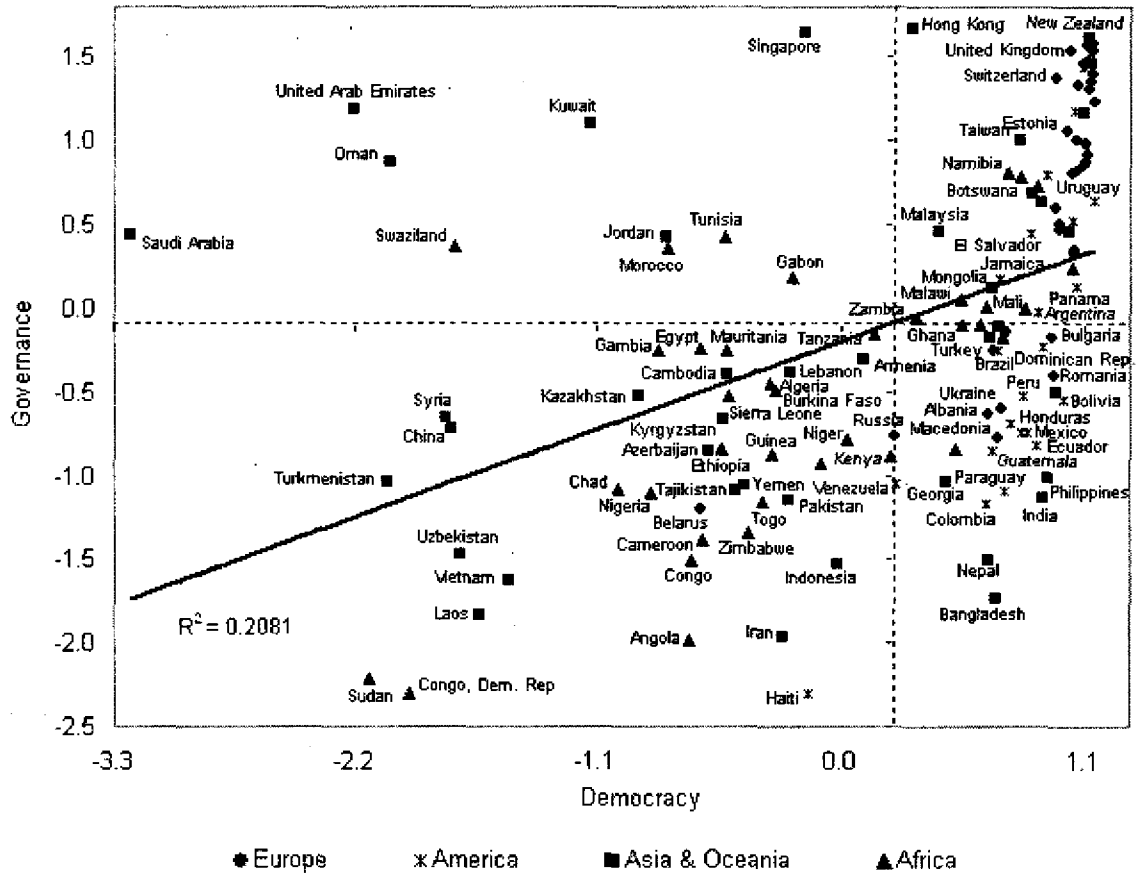


Figure 14
Levels of governance and democracy (average over 2000-2002)



Note: For definition of the governance and democracy variables see Table 4.

Source: See Appendix A1.

To sum up, there appears to be a very strong relationship between knowledge and development, and the same holds to some extent for the relationships between finance and development and governance and development. In contrast, openness and democracy are not strongly related to development, at least not as measured here. However, such simple correlations may mask more complex relationships, so in a second step we carry out a multivariate regression of the relationship between the five capabilities previously identified and GDP per capita. To test for the sensitivity of changing the definitions of the factors we use two different weighting schemes; first the most transparent one (in which only one link between an indicator and a factor was allowed) and second the broader version based on all significant correlations between indicators and factors (which led to broader but to some extent overlapping factor definitions). To test for the robustness of the results with respect to the composition of the sample we estimate the relationship with two different estimation techniques (OLS and a robust regression technique, iteratively reweighted least squares[26]). As is customary in the literature we also report versions including, in addition to the capabilities mentioned above, a battery of indicators reflecting geography, nature and history. Finally, since many of the variables included in the analysis were not significant following traditional statistical criteria, we also undertook a stepwise backward-selection regression in which the insignificant variables were gradually eliminated until the "best model" was found.[27]

Table 5 presents the results from the regression analysis. Beta-coefficients are reported, hence the role of a variable in the regression is reflected in the size of the estimated coefficient. The results are easily told. As before, Knowledge, Financial System and Governance, are positively associated with development (significant at a 1% level), while Openness and Democracy play no significant role. This finding is robust to changes in factor definitions, estimation techniques and inclusion of additional variables reflecting nature and history. Changes in factor definitions had more impact than differences in estimation technique, though, since it contributed to increasing the role of the Financial System variable at expense of the Governance variable (although both variables continued to be positively and significantly associated with growth).

It should be pointed out, however, that while the analysis presented above is a useful way to summarize the descriptive evidence, and test for the sensitivity of changing some of the underlying assumptions, it is not a test of causality. Arguably, there may be feedbacks from the level of development to some of the other capabilities. To test for a possible endogeneity bias in the estimates, due to a possible feedback from the level of development (the dependent variable) on capabilities, we conducted a Hausman (or Durbin–Wu–Hausman) test for endogeneity of the independent variables.[28] However, in the present case the test failed to provide evidence of endogeneity.

Table 5
Regression results - levels

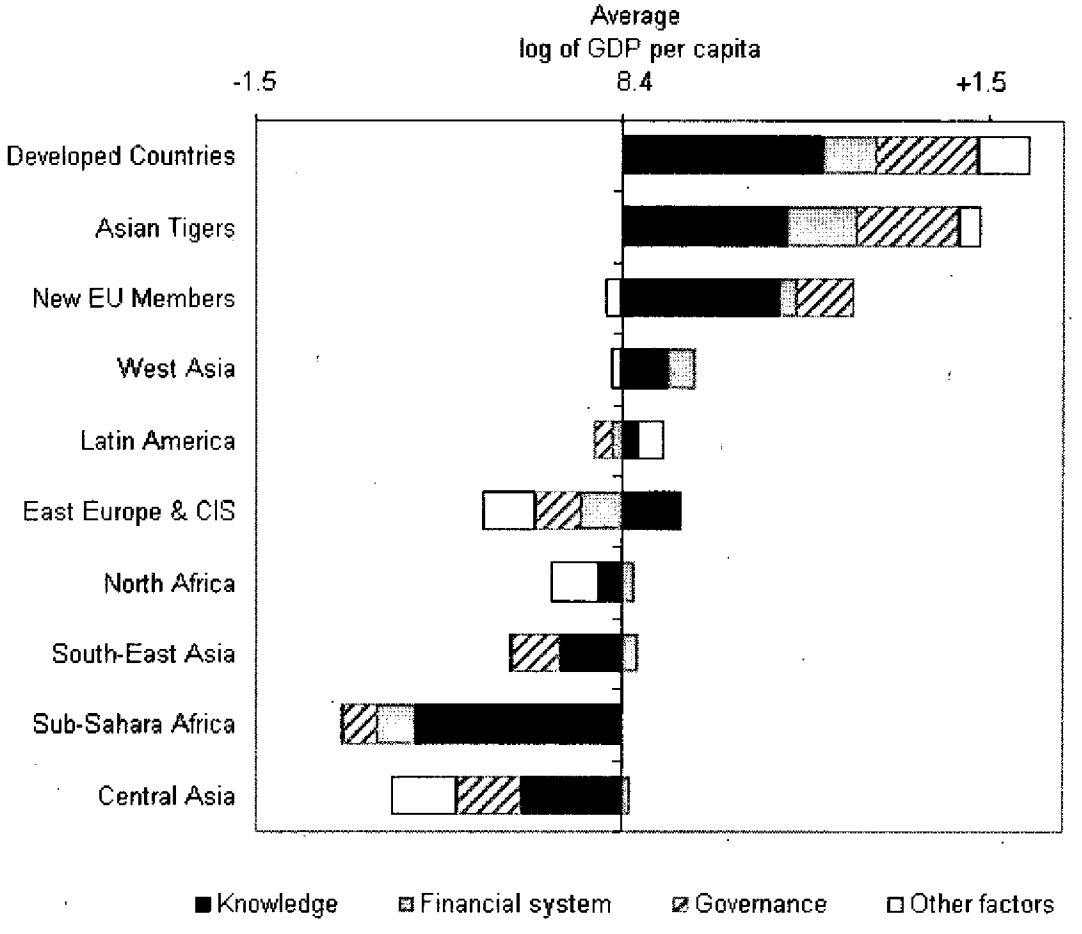
Construction method of the composite indicators	*One factor per variable*					*Significant loadings*				
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*
Constant	..	0.02	..	0.01	..	..	0.01	..	0.01	..
	..	(0.48)	..	(0.14)	..	..	(0.28)	..	(0.14)	..
Knowledge	0.61***	0.64***	0.60***	0.61***	0.57***	0.48***	0.51***	0.47***	0.48***	0.48***
	(12.11)	(13.16)	(8.75)	(8.28)	(11.46)	(11.37)	(11.74)	(9.05)	(7.89)	(11.32)
Openness	-0.03	-0.03	-0.01	-0.02	..	0.01	0.01	0.03	0.02	..
	(0.91)	(0.84)	(0.21)	(0.54)	..	(0.14)	(0.18)	(0.55)	(0.38)	..
Financial system	0.14***	0.13**	0.13**	0.14**	0.16***	0.39***	0.37***	0.39***	0.39***	0.40***
	(2.81)	(2.58)	(2.58)	(2.48)	(3.52)	(6.80)	(6.46)	(6.72)	(6.37)	(8.07)
Governance	0.30***	0.31***	0.28***	0.29***	0.27***	0.21***	0.23***	0.19***	0.20***	0.20***
	(5.50)	(6.07)	(4.84)	(5.21)	(5.05)	(2.82)	(3.37)	(2.62)	(3.00)	(3.84)
Democracy	-0.03	-0.03	-0.04	-0.03	..	0.002	0.003	-0.01	-0.01	..
	(0.77)	(0.78)	(0.92)	(0.77)	..	(0.04)	(0.08)	(0.10)	(0.16)	..
Longitude of country	..	..	-0.05*	-0.04	-0.06**	..	..	-0.07***	-0.07*	-0.08***
centroid	..	..	(1.68)	(1.07)	(2.00)	..	..	(2.62)	(1.90)	(3.10)
Latitude of country centroid	..	..	-0.04	-0.03	..	..	..	-0.04	-0.04	-0.05*
	..	..	(1.16)	(0.64)	..	..	..	(1.54)	(0.98)	(1.66)
Log of land area	..	..	0.04	0.03	..	..	..	0.02	0.02	..
	..	..	(0.86)	(0.54)	..	..	..	(0.60)	(0.33)	..
Log of mean elevation	..	..	-0.06	-0.06	-0.07**	..	..	-0.06	-0.06	-0.07**

Construction method of the composite indicators	*One factor per variable*					*Significant loadings*				
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*
	..	..	(1.41)	(1.21)	(2.09)	..	..	(1.52)	(1.24)	(2.40)
Access to ocean or navigable	..	..	0.05	0.05	..	..	..	0.02	0.02	..
river	..	..	(0.76)	(0.93)	..	..	..	(0.31)	(0.36)	..
Malaria ecology	..	..	0.02	0.01	..	..	..	0.02	0.01	..
	..	..	(0.45)	(0.20)	..	..	..	(0.44)	(0.23)	..
Cultural fractionalization	..	..	-0.04	-0.02	..	..	..	-0.04	-0.04	..
	..	..	(0.81)	(0.54)	..	..	..	(0.90)	(0.89)	..
Religious fractionalization	..	..	-0.001	-0.02	..	..	..	-0.02	-0.03	..
	..	..	(0.01)	(0.49)	..	..	..	(0.48)	(0.84)	..
Log of oil & gas deposits	..	..	0.08*	0.07	0.09**	..	..	0.09**	0.09**	0.08**
per capita	..	..	(1.79)	(1.52)	(2.59)	..	..	(2.19)	(2.04)	(2.34)
F	138.92	157.97	60.96	56.21	123.45	152.52	158.01	63.79	62.43	111.64
R^2	0.85	..	0.87	..	0.86	0.86	..	0.88	..	0.88
Observations	135	135	135	135	135	135	135	135	135	135

Note: Depended variable is log of average level of GDP per capita over 2000-2002 (PPP, constant 1995 USD). Absolute value of robust t-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. Standardized variables used in the estimates (beta values reported).

Figure 15 illustrates the implications of the above exercise for the differences in development levels across country groups. The crucial role of knowledge for development comes through rather strongly, with governance in the second place. There are some interesting differences across country groups, though. For instance, a high level of knowledge appears to be an important ingredient behind the ability of the new EU members to raise their levels of income to the present level. Similarly, for Sub-Saharan Africa the results point to lack of knowledge – not governance or finance – as the most important factor behind the current level of underdevelopment. For the former socialist countries in Eastern Europe and the CIS, however, it is the other way around. According to the analysis presented here, the current low levels of GDP per capita in these countries is not primarily caused by little knowledge, but a failure to develop a sufficient amount of complementary assets (financial system, governance) to exploit the potential given by existing knowledge resources.

Figure 15
Contribution of social capabilities to difference in levels of development over 2000-2002



Note: For definition of the variables see Table 4.

Source: See Appendix A1.

What are the (most) critical factors for catching up? A regression analysis

In this section we move one step further in our search for what the critical factors behind catch-up are. We will use the same tool as many previous studies in this area, e.g. a model of the Cornwall-Barro type. In this model economic growth (the dependent variable) is regressed on the scope for catching up in knowledge, measured by (the log of) GDP per capita of the country in question, and a number of other "conditioning factors". The expectation is that the less developed the country, the greater this scope will be, so the estimated coefficient of the log of GDP per capita variable is expected to be negative (implying slower growth in frontier countries than in technological laggards). This expectation has previously been confirmed by virtually every available study on the subject and is found to hold here as well, as will be shown below. However, as has been shown in section 2, this result does not hold unconditionally. Thus, although the potential for catch up is there, it requires a lot effort by poorer economies to tap into it. Exactly what efforts are most worthwhile ? This is what we are going to explore in the following.

First a note on variables and theories. We have, following the literature in this area, identified the following prime candidates for explaining why countries succeed or fail in exploiting the catch up potential:

- knowledge
- openness to foreign knowledge ,
- the development of the financial system,
- quality of governance and
- degree of democracy.

Moreover, we have developed synthetic measures for levels and changes of each of these. But is it the (initial) level or the change in this level during the period of investigation that matter for growth? This is of course a question that may be examined empirically, and we will do so in the following, but it is also an issue that theory may throw some light on. Take for instance the knowledge based approach to economic growth as outlined previously in this paper. According to this approach development implies an increase of knowledge along several complementary dimensions. Hence, levels of economic development and levels of knowledge development should be expected to be closely correlated, as has indeed shown to be the case (see the previous section), and so should changes in these two factors. Thus, following this approach economic growth (increasing economic development) should be positively correlated with a growing level of knowledge, but not necessarily with the initial level of this variable. In fact, since the latter may be seen as measuring the potential for catch up in knowledge (just as GDP per capita), the correlation with economic growth may well be negative. However, other theoretical approaches may yield different predictions on this point. For instance, one version of the knowledge based approach – that associated with so-called "new growth theory" (Romer 1990, see Aghion and Howitt 1998 for an overview) – argues that due to increasing returns to investments in knowledge, countries with higher levels of knowledge development may grow faster than those with less knowledge indefinitely.

Table 6
Regression results - growth

Construction method of the composite indicators	*One factor per variable*					*Significant loadings*				
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*
Constant	..	-0.01	..	0.00	..	..	-0.01	..	-0.02	..
	..	(0.10)	..	(0.08)	..	..	(0.21)	..	(0.26)	..
Log of the initial	-0.47**	-0.40**	-0.43**	-0.41**	-0.57***	-0.55***	-0.46***	-0.53**	-0.51***	0.70***
GDP per capita	(2.45)	(2.37)	(2.00)	(2.22)	(3.84)	(2.76)	(2.85)	(2.37)	(2.80)	(4.60)
Knowledge	0.01	0.00	-0.26	-0.18	..	0.03	0.03	-0.15	-0.06	..
	(0.05)	(0.00)	(1.13)	(0.92)	..	(0.18)	(0.21)	(0.81)	(0.34)	..
Openness	0.00	-0.05	0.03	-0.09	..	0.05	-0.05	0.08	-0.09	..
	(0.00)	(0.70)	(0.29)	(0.95)	..	(0.52)	(0.45)	(0.57)	(0.76)	..
Financial system	0.41***	0.27**	0.33*	0.19	0.37***	0.72***	0.56***	0.64***	0.48***	0.72***
	(2.92)	(2.58)	(2.33)	(1.64)	(2.68)	(3.99)	(4.51)	(3.32)	(3.30)	(4.58)
Governance	0.39***	0.41***	0.47***	0.48***	0.43***	0.10	0.24*	0.18	0.36**	0.28**
	(3.30)	(3.34)	(3.30)	(3.51)	(3.69)	(0.65)	(1.67)	(1.07)	(2.26)	(2.20)
Democracy	0.13	0.14	0.19	0.20*	0.13	0.11	0.09	0.09	0.09	..
	(1.16)	(1.58)	(1.50)	(1.80)	(1.53)	(0.96)	(0.86)	(0.65)	(0.71)	..
Δ knowledge	0.30***	0.29***	0.30***	0.26***	0.30***	0.22**	0.22***	0.21**	0.20**	0.22***
	(3.54)	(4.05)	(3.18)	(3.28)	(4.07)	(2.42)	(2.98)	(2.04)	(2.33)	(2.76)
Δ openness	0.10	0.12	0.13	0.13	0.12	0.10	0.13	0.14	0.15	0.14
	(1.18)	(1.48)	(1.41)	(1.36)	(1.47)	(1.11)	(1.56)	(1.42)	(1.52)	(1.60)
Δ financial system	0.25***	0.26***	0.21**	0.22**	0.24***	0.34***	0.37***	0.31***	0.33***	0.34***
	(2.69)	(3.11)	(2.21)	(2.48)	(2.62)	(4.03)	(5.14)	(3.37)	(4.09)	(4.31)
Δ governance	0.02	0.10	0.07	0.11	..	-0.08	0.06	-0.03	0.07	..
	(0.20)	(1.39)	(0.65)	(1.44)	..	(0.62)	(0.68)	(0.23)	(0.79)	..
Δ democracy	0.05	0.12	0.05	0.14*	..	0.15	0.18*	0.11	0.20**	..

Construction method of the composite indicators	*One factor per variable*					*Significant loadings*				
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*
	(0.47)	(1.46)	(0.43)	(1.66)	..	(1.22)	(2.04)	(0.88)	(2.02)	..
Longitude of country	..	..	0.11	0.11	0.10	..	..	0.08	0.06	..
centroid	..	..	(1.55)	(1.47)	(1.48)	..	..	(1.09)	(0.81)	..
Latitude of country centroid	..	..	0.10	0.03	..	..	..	0.08	0.00	..
	..	..	(1.25)	(0.34)	..	..	..	(1.01)	(0.02)	..
Log of land area	..	..	0.01	-0.02	..	..	..	0.02	-0.01	..
	..	..	(0.10)	(0.18)	..	..	..	(0.15)	(0.13)	..
Log of mean elevation	..	..	0.10	0.02	..	..	..	0.08	0.01	..
	..	..	(0.93)	(0.24)	..	..	..	(0.82)	(0.09)	..
Access to ocean or navigable	..	..	0.04	0.11	..	..	..	0.06	0.12	..
river	..	..	(0.28)	(0.89)	..	..	..	(0.48)	(1.05)	..
Malaria ecology	..	..	-0.07	-0.09	..	..	..	-0.03	-0.06	..
	..	..	(0.66)	(0.81)	..	..	..	(0.26)	(0.53)	..
Cultural fractionalization	..	..	-0.17*	-0.07	-0.16*	..	..	-0.17*	-0.06	-0.17**
	..	..	(1.73)	(0.80)	(1.92)	..	..	(1.68)	(0.69)	(2.04)
Religious fractionalization	..	..	0.06	0.04	..	..	..	0.03	0.00	..
	..	..	(0.74)	(0.51)	..	..	..	(0.30)	(0.01)	..
Log of oil & gas deposits per capita	..	..	0.12	0.06	0.11	..	..	0.11	0.08	0.11
	..	..	(1.32)	(0.65)	(1.40)	..	..	(1.19)	(0.86)	(1.39)
F	9.11	6.65	4.84	3.95	9.64	9.08	7.80	4.66	4.49	9.61
R^2	0.36	..	0.41	..	0.39	0.36	..	0.40	..	0.38
Observations	135	135	135	135	135	135	135	135	135	135

Note: Depended variable is annual growth of GDP per capita over 1992-2002 (PPP, constant 1995 USD). Absolute value of robust t-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. Standardized variables used in the estimates (beta values reported).

Table 6 presents the results from the regression analysis. As before we report estimates using two different estimation techniques (OLS and iteratively reweighted least squares), two different ways to define the composite indicators (one factor per variable and significant loadings) and with (and without) a battery of other indicators reflecting exogenous factors related to geography, nature and history. Since, as in the preceding section, many of these variables failed to be significant following traditional statistical criteria, we also report results for a "best model" in which these insignificant variables were gradually eliminated using a stepwise backward-selection method.[29] To test for a possible endogeneity bias in the estimates, due to a possible feedback from economic growth (the dependent variable) on capability changes, we applied the Hausman (or Durbin–Wu–Hausman) test for endogeneity referred to in the previous section. The test failed to confirm the existence of such endogeneity problems.

Since the results are very similar across the different specifications, we will summarize them as follows.[30] First, the (log of the) level of GDP per capita has a significant and negative impact on growth, indicating there is a potential for catch up by poorer countries (as suggested by the knowledge based approach). However, the ability to tap into this potential depends on other conditioning factors; growth of knowledge, good governance and a well functioning financial system. For the remaining composite factors the evidence is more mixed. On balance one is tempted to conclude that neither openness nor (degree of) democracy (or changes in these factors over time) appear to be very important for growth. Furthermore, the initial level of knowledge tends to be negatively correlated with growth (consistent with the knowledge based approach), although the relationship is generally not significant. Hence there is very little support for the idea backed by "new growth theory" that high levels of knowledge tend to perpetuate growth indefinitely, leading to divergence in income and productivity across the globe.

To illustrate the consequences of the estimated model, we include in Table 7 a calculation of the contribution of the variables in the core model to the growth of GDP per capita of various country groupings. As is evident from the table the model gets the qualitative features right. Potentially, because of a larger scope for imitation, low-income countries should be expected to grow more than two percentage points faster than the rich ones, assuming that other factors are the same. But other factors are not the same. In reality, the higher potential for diffusion that developing countries face is more than counteracted by a better financial system, better governance and faster growth of knowledge in the rich countries, so that in the end the difference in GDP per capita between rich and poor countries is widening instead of narrowing.

Table 7
Actual and estimated growth of GDP per capita over 1992-2002

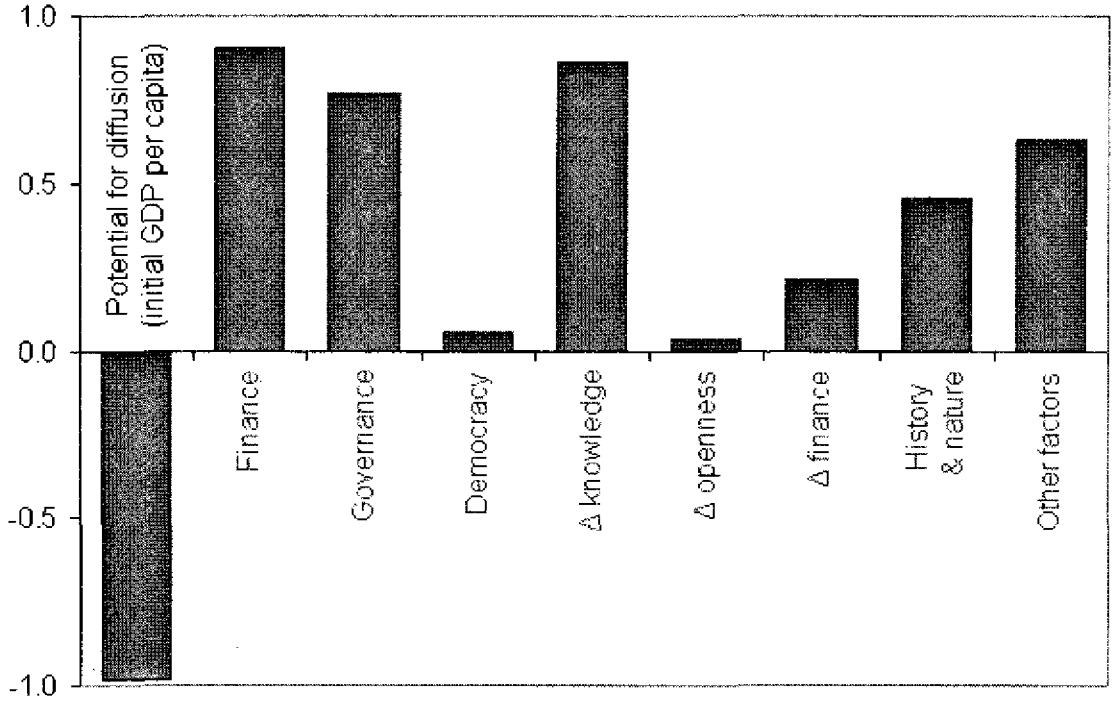
	Number of countries	*Initial GDP per capita*	*Actual GDP growth*	*Estimated GDP growth*	*Explanatory factors*								
					Constant	*Initial GDP per cap*	*Finance*	*Governance*	*Democracy*	*Δ knowledge*	*Δ openness*	*Δ finance*	*History & nature*
Developed Countries	22	19,661	2.2	2.3	1.4	-1.9	0.9	1.3	0.4	-0.2	0.0	0.2	0.2
Asian Tigers	4	15,536	3.3	3.3	1.4	-1.6	1.4	1.3	0.1	0.6	-0.1	-0.1	0.3
New EU Members	8	8,002	3.6	2.6	1.4	-0.8	0.1	0.9	0.1	0.5	0.2	0.3	0.0
West Asia	10	7,990	0.9	1.5	1.4	-0.4	0.4	0.1	-0.4	0.4	-0.4	0.1	0.3
Latin America	21	4,795	0.8	0.8	1.4	-0.1	-0.2	-0.3	0.2	0.1	-0.1	0.1	-0.2
East Europe & CIS	17	3,584	0.1	0.3	1.4	0.3	-0.9	-0.4	-0.1	-0.6	0.4	0.1	0.1
North Africa	5	3,313	1.4	1.9	1.4	0.3	0.5	-0.1	-0.3	0.6	-0.2	-0.4	0.2
South-East Asia	9	2,802	3.3	2.9	1.4	0.6	0.3	-0.5	-0.1	0.8	0.0	0.1	0.4
Sub-Sahara Africa	33	1,935	0.5	0.5	1.4	1.3	-0.5	-0.5	-0.2	-0.2	-0.1	-0.3	-0.4
Central Asia	6	1,531	2.3	2.2	1.4	1.2	0.2	-0.6	0.1	-0.1	0.0	0.1	0.0
High income	33	17,005	1.9	2.1	1.4	-1.6	0.7	1.1	0.2	0.0	0.0	0.2	0.2
Medium income	50	5,066	1.6	1.2	1.4	-0.2	-0.1	-0.1	0.0	0.1	0.0	0.1	0.0
Low income	52	1,938	0.8	1.1	1.4	1.2	-0.4	-0.6	-0.1	0.0	0.0	-0.2	-0.2

Note: Based on results of the stepwise backward selection regression (one factor per variable). GDP per capita is in PPP (constant USD) and annual growth rates. The income groups are defined by the initial income level as follows: high-income more than 10,000; medium income between 2,500 and 10,000; low income below 2,500.

Source: Own computations.

Three country groups that actually reduced the gap vis-à-vis with the developed world during this period (the "winners") were the Asian Tigers, South-East Asia and the new EU members, while three that clearly fell behind (the "losers") were the Latin American ones, the former socialist countries (CIS/Eastern Europe) and the countries from Sub-Saharan Africa. In Figure 16 we illustrate the reasons behind this difference in performance. Although the initial gap indicates a greater potential for the "losers", which are poorer on average, this was more than counteracted by the other factors taken into account by the model. Three factors stand out; a better (and improving) financial system, better governance and a growing knowledge gap. History and nature also contribute somewhat as do "other factors" (not included in the model, e.g, the predictive error).

Figure 16
Contribution to catching up in winner vs. looser regions



Note: Differences between contribution to growth in the winning (Asian Tigers, Sough-East Asia and the new EU members) and losing regions (Latin America, Eastern Europe and the CIS and Sub-Sahara Africa). Averages over individual countries based on results of the stepwise backward selection regression (one factor per variable).

Source: See Appendix A1.

Finally we conducted a sensitivity test of excluding from the sample countries with a high share of estimated data and frequent occurrence of military conflicts (see Appendix A3). This reduced the sample to 110 countries. Among the countries that were excluded in this way were many of the former socialist CIS member countries, Asian countries with a socialist/communist background, such as Cambodia, Laos and Vietnam, some Middle-East countries such as Lebanon, Saudi Arabia and United Arab Emirates and a several countries severely plundered by wars (mostly in Africa).[31] The results confirmed the importance of growing knowledge and good governance for growth. However, in some specifications, the financial system (and its improvement) failed to be significant, while democracy (and its

improvement) was. Hence, it is possible that the finding that democracy is not significantly correlated with development depends on the inclusion of the above countries, some of which, although not very "democratic", have arguably been successful in catch up recently.

Concluding remarks

The point of departure of this paper has been the finding that income gaps in the global economy are widening rather than narrowing. In fact, historical research shows that this is a long run trend. However, there have always been examples of countries that have defied the trend and managed to catch up with the much richer countries at the technology frontier, and this also holds for the period under investigation here. The reasons for this have been a matter of considerable controversy, though.

However, in recent years the quality and availability of data on different aspects of development have improved a lot, and this might give researchers in this area an opportunity for investigating the reasons behind the large differences in economic performance in more depth. Attempting to exploit this opportunity this paper starts with an overview of the different approaches in the literature to the explanation of these differences and in particular the empirical indicators and methods that these different approaches have highlighted. This led to the formulation of a synthetic empirical model and, with the help of factor analysis, the identification of set of "capabilities" which, according to the literature, might be assumed to be of critical importance for catch up.

The following "capabilities" were identified and measured with the help of data for twenty-nine different variables for 135 countries over the 1990s:

- knowledge
- openness to technology/knowledge from abroad,
- the development of the financial system,
- quality of governance and
- degree of democracy.

The first of these, knowledge, is a synthetic measure of some of the most critically important capabilities required in the global knowledge based economy. It includes among other things a skilled labour force, as reflected in educational standards/investments, R&D resources and a well-developed ICT infrastructure. The analysis conducted here suggests that knowledge capability is a must for countries that wish to succeed in catch up. There is a strong, significant and robust statistical relationship between (level and change of) GDP per capita on the one hand, and (level and change of) knowledge on the other. Historical and descriptive evidence also suggest that countries that have succeeded in catch up have given a high priority to the knowledge dimension of development. Note, however, the global knowledge based economy is a moving target. To defend a high place in the development hierarchy it is not sufficient to rest on past achievements. A country that wishes to retain its competitive position or, more ambitiously, catch up, needs to continuously invest in the generation of knowledge capabilities.

Albeit knowledge emerges from the analysis as a clear priority no. 1 for development, it is not sufficient. Well-developed knowledge capabilities need to be backed by a well-working financial system and good governance. Hence, one of the challenges in development is to be able to coordinate these different aspects of development in an efficient way. Sometimes it is asserted that this is mainly a question of successfully "westernising" the political system, e.g.,

adapting to institutional arrangements that have proved to be successful in the United States and other western democracies. This study finds little support for such assertions. Especially for poorer countries there seems to be little evidence suggesting that adherence to western democratic institutions matter for growth. Hence, there is no institutional "quick fix" to the problem of development. What is required, it seems, is the ability to continuously improve knowledge capabilities, through the mobilization of human, financial and administrative resources, and this appears to have been possible in systems with quite different institutional arrangements. This conclusion does not only rest on statistical evidence but is also supported by historical research (consider for instance the recent performance of countries such as China and Vietnam, the Asian Tigers before the 1990s or pre-world-war-two Japan). However, what holds for relatively poor countries that wish to catch up does not necessarily extend to countries further up the development ladder, and it is possible that the importance of differences in institutional arrangements increases with the level of development. It is also possible that there is a feedback from development on institutions, as suggested by Glaeser et al. (2004). These are clearly questions in need of further research.

Another result from the study, confirming previous research by Rodrik et al. (2004), is that there is virtually no support for the argument that differences in "openness" matter for growth. This holds regardless of whether a more "traditional" measure of openness, focusing on trade and FDI, was used or if this was substituted by a broader measure reflecting a number of other possible aspects of the "openness" concept. This finding clearly runs counter to arguments based on "new growth theories" emphasizing the openness dimension as perhaps the single most important one for development. Note, however, that the results reached here does not necessarily invalidate the argument, central to these theories, that flows of ideas across boarders are important for global growth. What the results imply, perhaps, is either that trade and FDI may not be the most efficient channels for such flows or that what matters for performance is not so much differential access to such flows as the ability to take advantage of them (knowledge capability). Again this is an issue that may require further research.

It is appropriate at this point to acknowledge the limitations of the analysis. What has been attempted, and also achieved, is to take a sweeping view of differences in development and capabilities across a large sample of different types of countries. To be able to measure the role of capabilities in development we need good indicators with broad coverage. Although the supply of indicators has improved in recent years, perhaps as a result of an increasing concern for the importance of many "non-economic" factors (e.g., factors traditionally not taken into account by economists), there is still relatively limited coverage, except perhaps for the last few years, and this sharply constrains the analysis. However, with time the quality and coverage of relevant indicators should be expected to increase, and this will provide new opportunities for making more precise assessment on what the critical capabilities for catch up are.[32]

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Notes

[1] Still another view, not considered in detail here, is the "structuralist" one according to which development should be seen as a transformation process through which the industrial composition changes and overall productivity increase along the route. Measures of development based on this perspective (see UNIDO 2004) naturally focus on the structure of output, the differing payoffs to success in different sectors/industries and the ability of a country to change its production structure towards the areas that are deemed to be the most promising. Successful catch-up and rapid structural change are no doubt closely related (Fagerberg 1996). But what is cause and what is effect? Attempts to explain the superior productivity growth of catching-up economies compared to other countries as resulting from reallocation of resources from low productivity to high productivity industries have at best explained a small part of the actual difference (Fagerberg 2000). Hence, it seems more likely that rapid structural change and successful catch up are both outcomes of more generic factors of the type discussed in the remaining of this paper.

[2] The number of observations differ between Tables 1-2 due to differences in data availability.

[3] Easterly and Levine (2001) provide a good overview of the more recent evidence on the subject.

[4] However, successful catch up may feed back on the political and legal system, such as for instance the evidence from the Republic of Korea and the Taiwan Province of China show.

[5] For instance, Glaeser et al. (2004) question the interpretation of the settler argument, suggesting that what the settlers brought with then was not so much their institutions as their human capital.

[6] An open question is if the concept technology only refers to knowledge about physical processes ("hardware"), or if it also includes knowledge about, say, how to organize/manage these ("software"). For our purpose the latter, broad interpretation of the term is the most meaningful. Arguably, mastery of physical processes is of dubious value if you don't know how to embed these in a well-organized production and distribution system.

[7] However, Thorstein Veblen (1915) is usually credited with initiating the approach. See Fagerberg and Godinho (2004) for details.

[8] The term "social capability" comes from Ohkawa and Rosovsky (1973).

[9] This list is based on Abramovitz (1986, p. 387-390) and, in particular, two papers he published during 1994, see Abramovitz (1994a p. 34-5, 1994b, p. 88).

[10] Trust and civic behavior were also found to be positively related to the degree of income equality and ethnic homogeneity.

[11] However, with increasing knowledge, the social and economic effects of such given conditions may change (learning to cope with diseases, for instance).

[12] We use only patents granted in the United States to assure consistency in terms of criteria for novelty, originality, etc.

[13] We consider both patent and article counts as very reliable sources quantitative data. Note, however, that the propensity to patent or publish varies considerably across scientific fields and sectors/industries and that many innovations are not registered by these means. Moreover, there can be an upward language/regional bias for English-speaking nations and/or countries with a close links to the United States. No attempt was made to correct for these possible biases.

[14] Another indicator, suggested by Clague et al. (1999), not included in our analysis due to lacking data for European countries, is "contract intensive money" (CIM) which reflects the trust in the legal and financial system of a country.

[15] The sources of the data include expert panels and surveys provided by the Transparency International, Amnesty International, Freedom House, World Economic Forum, PRS Group, Economic Intelligence Unit, Polity IV Project, various U.S. based State Agencies and others (see the Appendix A1 for details).

[16] Unfortunately, we cannot use indicators on constitutional rules and judicial independence proposed by La Porta, et al (2004) due to the limited country coverage (only up to 71 countries) and availability (only in 1995).

[17] Only 11 countries, mostly former Soviet republics, had less than 80 % of the observations required.

[18] See Appendix A1 for details on how this was done.

[19] If necessary we reversed scale of the indicators to have all of them in an increasing order, e.g. we use teacher pupil ratio instead of the opposite.

[20] For a brief overview see Kline (1994).

[21] In the factor analytic terminology its "eigenvalue" should be higher than unity. This simple rule ensures that we will end up with less principal factors than the original number of variables. Note that the eigenvalue is sum of squares of the factor loadings of each factor. If divided by the number of variables, it reflects the proportion of variance explained by the factor (the last row in Table 4).

[22] A number of computational methods have been developed for factor analysis and rotation. In the following, we will apply principal component analysis and normalized varimax rotation. Note that we have also computed results for more sophisticated extraction methods and rotations (such as maximum likelihood factor analysis and (bi)quartimax rotation, etc.), but the solutions are broadly the same, so that we report only results of the former methods.

[23] Note that the rotation changes factor loadings (meaning of the factors) and distribution of the accounted variance across the factors, but it cannot change the amount of total variance explained by the solution.

[24] A correlation is significant if is it higher that is likely to occur by chance. The significance level of correlation coefficient depends on sample size. In a sample of 270 observations, an absolute value of the correlation coefficient above 0.15 is significantly different from zero at 1% level, which is the threshold used in the following.

[25] Some variables containing zeros or negative scale had to be rescaled to positive values. We used a simple rule by adding the minimum observed value in the sample, which delivers the transformation, to all of the observations in the sample.

[26] Iteratively reweighted least squares is a robust regression technique, which assigns a weight to each observation, with lower weights given to outliers (*rreg* command in Stata 8.2.).

[27] The aim of the stepwise procedure is to include only variables that contribute to the explanatory power of the model (above a chosen significance level). At each step the stepwise method also attempts to reintroduce already eliminated variables to control for a possibility that some of them might become significant later on. We specified the threshold for removal at 20% significance and the level for reintroducing a variable at 15%.

[28] The test is performed by first regressing each potentially endogenous explanatory variable on all exogenous variables (and iinstruments), and then including residuals from these regressions in the original model. If some of the residuals come out as significant in the original model estimate, we accept endogeneity of the variable and the model should be estimated by, say, two-stages least squares regression in order to obtain consistent results. For further details see Wooldridge 2002, pp 118-122.

[29] The log of the initial GDP per capita was always included (to test for "conditional convergence") .

[30] We place most emphasis on the results with one factor per variable, since the alternative method, significant loadings, leads to partly overlapping factors (and hence problems of interpretation).

[31] All of the excluded countries are marked with stars in Appendix A2.

[32] In this paper, an attempt was made to fill some of the most obvious "holes" in the data set through estimation, but it does of course introduce an element of uncertainty with respect to what the "true" statistics is. Precisely for this reason we have in this paper chosen to focus more on the understanding of global dynamics than on developments for specific countries on specific indicators. We have also attempted to supplement the statistical analysis with qualitative insights derived from historical analyses.

Appendix A1 (data & sources)

A brief overview of definitions, sources and time/country coverage of the indicators is given in the table below. The main source of data is the World Bank (World Development Indicators 2004), which combines various sources of data for a large sample of countries. The database has been complemented by data from other organizations such as UNCTAD (FDI Database), OECD (MSTI and Patent Databases), International Organization for Standardization (ISO), Heritage Foundation, Frazer Institute and others, and in addition datasets produced by research projects or scholars. National sources were only used for Taiwan Province of China if necessary and in a few cases for R&D data from developing countries.

We originally collected data for all independent states (app. 175 countries) and a large pool of indicators (app. 100 indicators). The screening revealed that a group of (mostly least developed) countries suffers from a lot of missing data. Similarly data for a large number of relevant indicators are available only for a group of high (medium) income countries and/or only for the most recent period (from the second half of the nineties). A closer look, furthermore, revealed that some indicators suffer from high volatility (primarily in developing world), methodological changes over the period or are merely variations of each other. These indicators were then skipped. In order to strike a balance between the need to bring rich evidence for as many countries as possible and data availability and methodological coherence, we selected 135 countries (see Appendix A3 for the full list of countries) and twenty-nine indicators on social capabilities (plus ten „fixed factors"). We use the indicators in the form of three-year averages (1992-1994 and 2000-2002) to limit influence of shocks and measurement errors occurring in specific years.

Although the selected indicators have broad coverage, in some cases there were missing values that had to be dealt with. A few missing observations among the fixed factors (geography, etc.) have been filled in from other sources or estimated on the basis of regional averages. Full coverage of the indicators for social capabilities, however, is available for only one third of the countries and six indicators. We use the *impute* procedure in Stata 8.2. to fill in the missing values (see the Stata 8.2. Manual for details). In each case we based the estimation on data for other indicators in the dataset.

In many cases only a few observations had to be estimated. But in some cases larger amount of data had to be estimated to keep the country or indicator in the analysis. The proportion of countries estimated for each indicator is given in the last column of the following table. Missing values were most frequent for stocks of human capital, market capitalization of listed companies and some of the governance indicators. R&D were not available for most of the low income countries. We assumed that a country with zero patents jointly with zero scientific articles has also zero R&D expenditures, which was the case for app. 40 of the least developed countries. The remaining missing R&D figures were estimated using the procedure described above. Countries with a lot of missing data (between 15% and 30%) include Turkmenistan, Uzbekistan, Lebanon, Kazakhstan, Saudi Arabia, Hong Kong SAR, Tajikistan, Azerbaijan, Macedonia, Burkina Faso, Georgia, Armenia, Cambodia, Kyrgyzstan, Laos, Mauritania, United Arab Emirates, Belarus, Ethiopia and Vietnam (these countries are marked with stars in Appendix 2). The proportion of missing data is rather continuous within our sample of 135 countries, so that we decided to skip only the most obvious „worst" cases to keep a broad sample. Using more conservative criteria would inevitably shrink coverage to a group of medium/high income countries, which is not the main focus of the paper.

It should be stressed that considerable care was taken to check the estimated data against observed figures in countries with similar characteristics (level of development, region, history, etc.). In some cases the estimated data would exceed the maximum observed value of an

indicator elsewhere. In such cases we truncated the data by replacing the estimated values by the maximum observed figure.

Finally some indicators deserved special care due to their nature or methodology. It is customary, for instance, to suppress the "home country advantage" of United States in the USPTO patent counts indicator, since the propensity of American residents to register inventions in their own national patent office is higher than that of non-residents. We adjusted this home base bias downwards based on a comparison between the Japanese and the United States patents registered at the European Patent Office (EPO), which represents a foreign institution both for American and Japanese inventors. We used an estimation method proposed by Archibugi and Coco (2004, p. 633):

$$Adjusted\ US\ patents\ at\ the\ USPTO = (JAP_{USA} * USA_{EPO}) / JAP_{EPO}$$

where JAP_{USA} represents patents granted to Japanese residents in the United States, while USA_{EPO} and JAP_{EPO} capture patents granted to Japanese and American residents at the EPO.

We also reversed the scale, while keeping the original range, for some of the governance indicators in order to have the indicator in increasing order (with low value signalling weak governance and vice versa). Note that this change of scale does not alter any property of the data but simplifies the interpretation of loadings in the factor analysis.

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Gross domestic expenditure on R&D (GERD): GERD is total (public and private) intramural expenditure on research and experimental development (R&D) performed on the national territory. R&D comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications.	% of GDP	World Bank (World Development Indicators), OECD (MSTI Database), RICYT and national sources	Full	14
USPTO patents: Number of patents granted by the U.S. Patent and Trademark Office (USPTO). A patent is assigned to a country according to the inventor's country of residence. When a patent was invented by several inventors from different countries, the respective contributions of each country is taken into account.	per capita	OECD Patent Database (based on the USPTO)	Full	..
Science & engineering articles: Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. The articles are from a set of journals classified and covered by the Institute for Scientific Information's Science Citation and Social Sciences Citation Indexes. Article counts are based on fractional assignments, so as the patent counts.	per capita	World Bank (World Development Indicators) and the U.S. National Science Foundation (based on Institute for Scientific Information - Science Citation Index and Social Sciences Citation Index)	Full	1
Personal computers: Personal computers are self-contained computers designed to be used by a single individual.	per capita	World Bank (World Development Indicators; based on the ITU - World Telecommunication Indicators Database)	Full	9
Internet users: Internet users are people with access to the worldwide network.	per capita	World Bank (World Development Indicators; based on the ITU - World Telecommunication Indicators Database)	Full	1

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Fixed line and mobile phone subscribers: Fixed lines are telephone mainlines connecting a customer's equipment to the public switched telephone network (PSTN). Mobile phone subscribers refer to users of portable telephones subscribing to an automatic public mobile telephone service using cellular technology that provides access to the PSTN. Subscription refers to the recurring fixed charge for subscribing to the PSTN.	per capita	World Bank (World Development Indicators; based on the ITU - World Telecommunication Indicators Database)	Full	..
ISO 9000 certifications: ISO 9000 is a family of standards approved by the International Standards Organization (ISO) that define a quality management and quality assurance program. The ISO 9000 certification confirms that the enterprise follows procedures for ensuring quality defined by a collection of formal international standards, technical specifications and handbooks.	per capita	International Organization for Standardization (ISO)	Full	..
Tertiary school enrolment: Gross enrolment is the ratio of the number of tertiary students of all ages (gross) expressed as a percentage of the tertiary school-age population. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.	% gross	World Bank (World Development Indicators), UNESCO and USAID (Global Education Database)	Full	1
Teacher-pupil ratio in primary education: Primary school pupil-teacher ratio is the number of primary school teachers (regardless of their teaching assignment) divided by the number of pupils enrolled in primary school.	ratio	World Bank (World Development Indicators), UNESCO and USAID (Global Education Database)	Full	5
Life expectancy at birth: Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	years	World Bank (World Development Indicators)	Full	1

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Average schooling years in population: The variable is constructed using each country's typical duration of years of schooling at each level, which is combined into a aggregate measure.	years	Barro and Lee (2000)	1990 and 2000	33
Higher school complete in population: Percentage of population who have successfully completed tertiary level of schooling. Each cycle of education has significant variation in duration across countries. The variable accounts of this variation by using information on the typical duration of tertiary level of schooling within countries.	%	Barro and Lee (2000)	1990 and 2000	33
Merchandise imports: Merchandise imports show the c.i.f. value of goods received from the rest of the world. Goods simply being transported through a country (good in transit) or temporarily admitted (except for goods for inward processing) are not included in the international merchandise trade statistics.	% of GDP	World Bank (World Development Indicators)	Full	..
FDI inward stock: Foreign direct investment (FDI) is defined as an investment involving a long-term relationship and reflecting a lasting interest in and control by a resident entity in one economy (parent enterprise) of an enterprise resident in a different economy (affiliate enterprise). FDI stock is the value of the share of capital and reserves (including retained profits) in the affiliate enterprise attributable to the parent enterprise, plus the net indebtedness of affiliates to the parent enterprises. Inward direction denotes a non-resident direct investment in the reporting economy.	% of GDP	UNCTAD (FDI Database)	Full	..
Interest rate spread: Interest rate spread is the interest rate charged by banks on loans to prime customers minus the interest rate paid by commercial or similar banks for demand, time, or savings deposits.	%	World Bank (World Development Indicators)	Full	17

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Market capitalization of listed companies: Market capitalization (also known as market value) is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year.	% of GDP	World Bank (World Development Indicators)	Full	29
Domestic credit to private sector: Domestic credit to private sector refers to financial resources provided to the private sector, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises.	% of GDP	World Bank (World Development Indicators)	Full	2
Physical integrity human rights: The variable is average score on a group of four rights known as the "physical integrity rights ": rights to freedom from extrajudicial killing, disappearance, torture, and political imprisonment. Extrajudicial killings are killings by government officials without due process of law. Disappearances are cases in which people have disappeared, political motivation appears likely, and the victims have not been found. Torture refers to the purposeful inflicting of extreme pain, whether mental or physical, by government officials or by private individuals at the instigation of government officials. Political imprisonment refers to the incarceration of people (including placing them under "house arrest") by government officials due to political reasons.	index (0 to 2)	Cingranelli and Richards (2004); based on the Amnesty International and the US State Department Country Reports on Human Rights Practices	Full	1
Impartial courts: The variable refers to the fact whether a trusted legal framework exists for private businesses to challenge the legality of government actions or regulation.	index (0 to 10)	Gwartney and Lawson (2004) – the Frazer Institute (based on the WEF Global Competitiveness Report; missing data filled from Kaufmann et. al 2003)	1995 and 2000-2002	20

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Law and order: Rule of law and order is the degree to which the citizens of a country are willing to accept the established institutions, to make and implement laws and adjudicate disputes. High score indicates sound political institutions, a strong court system, and provision for an orderly succession of power. Low score reflects tradition of depending on physical force or illegal means to settle claims.	index (0 to 10)	Gwartney and Lawson (2004) – the Frazer Institute (based on Political Risk Component of the International Country Risk Guide (ICRG) by the PRS Group)	1995 and 2000-2002	23
Property rights: The factor scores the degree to which a country's laws protect private property rights and the degree to which its government enforces those laws. It also accounts for the possibility that private property will be expropriated. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation - Index of Economic Freedom (based primarily on the Economist Intelligence Unit, Country Commerce and Country Reports)	From 1995 onwards	17
Regulation: The factor measures how easy or difficult it is to open and operate a business. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation - Index of Economic Freedom (based primarily on the Economist Intelligence Unit, Country Commerce and Country Reports)	From 1995 onwards	17
Informal Market: The factor relies on Transparency International's Corruption Perceptions Index (CPI), which measures the perceptions of well-informed people with regard to the extent of corruption, defined as the misuse of public power for private benefit. The extent of corruption reflects the frequency of corrupt payments, the value of bribes paid and the resulting obstacle imposed on businesses. For countries that are not covered in the CPI, the informal market score is estimated using information on the extent of smuggling, piracy of intellectual property, informal labour, etc. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 5)	Heritage Foundation- Index of Economic Freedom (based primarily on the Transparency International, Corruption Perceptions Index)	From 1995 onwards	17

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Index of democracy and autocracy: Institutionalized autocracies sharply restrict or suppress competitive political participation. Their chief executives are chosen in a regularized process of selection within the political elite, and once in office they exercise power with few institutional constraints. Institutionalized democracy is defined as one in which political participation is fully, competitive, executive recruitment is elective, and constraints on the chief executive are substantial. The variables ranges from autocracy to democracy in increasing order (Revised Combined Polity Score - POLITY2 variable)	index (-10 to 10)	Marshall and Jaggers (2002) - Polity IV Dataset	Full	1
Political constraint: The variable estimate the extent to which a change in the preferences of any one actor may lead to a change in government policy. It identifies the number of independent branches of government (executive, lower and upper legislative chambers) with veto power over policy change. The measure is then modified to take into account the extent of alignment across branches of government and to capture the extent of preference heterogeneity within each legislative branch (POLCONIII variable)	index (0 to 1)	Henisz (2002)	up to 2001	..
Legislative index of political competitiveness (LIEC): The variable reflects competitiveness of elections into legislative branches. Knowing the formal, constitutional rules governing countries is one way to characterize democracy; an important supplement is to know whether these rules are applied in practice. The Indices of Electoral Competitiveness (LIEC & EIEC) address both of these issues. The highest score of the LIEC index goes to countries elections in which multiple parties compete in elections and the largest party receives less than 75% of the vote. The lowest score goes to countries without or with unelected legislature. The score is supplemented by information on voting irregularities, whether candidate intimidation was serious enough to affect electoral outcomes, whether important parties boycott elections or the election results. etc.	index (1 to 7)	Beck, et. al (2001) – Database of Political Institutions (DPI)	up to 2000	1

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Executive index of political competitiveness (EIEC): The variable reflects competitiveness for post in executive branches in government. Besides the common features with the LIEC (see above), the EIEC takes into account a balance of power between legislature & executive, e.g. the method of the electoral college appointing, whether military has significant influence, whether the political system is presidential vs. parliamentary, etc.	index (1 to 7)	Beck, et. al (2001) – Database of Political Institutions (DPI)	up to 2000	1
Political rights: Freedom is the opportunity to act spontaneously in a variety of fields outside the control of the government and other centres of potential domination. Political rights enable people to participate freely in the political process, including through the right to vote, compete for public office, and elect representatives who have a decisive impact on public policies and are accountable to the electorate. Political rights can be affected by state actions, as well as by non-state actors, including terrorists and other armed groups. The standards are derived primarily from the Universal Declaration of Human Rights. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 7)	Freedom House – Index of Freedom in the World	Full	1
Civil liberties: Freedom is the opportunity to act spontaneously in a variety of fields outside the control of the government and other centres of potential domination. Civil liberties allow for the freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state. Civil liberties can be affected by state actions, as well as by non-state actors, including terrorists and other armed groups. The standards are derived primarily from the Universal Declaration of Human Rights. The scale of the indicator has been reversed into increasing order, while keeping its original range.	index (1 to 7)	Freedom House - Index of Freedom in the World	Full	1
Longitude of country centroid: Longitude is measured from the Prime Meridian with positive values going east and negative values going west.	degrees	Gallup, Sachs and Mellinger (1999) - CID Geography Datasets (missing data filled from Easterly and Sewadeh 2002)	Fixed factors	..

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Latitude of country centroid: Latitude is measured from the equator, with positive values going north and negative values going south.	degrees	Gallup, Sachs and Mellinger (1999) - CID Geography Datasets (missing data filled from Easterly and Sewadeh 2002)		..
Log of land area: Country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.	log of km^2	World Bank (World Development Indicators)		..
Log of mean elevation (above sea level)	log of meters	Gallup, Sachs and Mellinger (1999) - CID Geography Datasets		3
Access to ocean-navigable river: The proportion of the population in 1994 within 100 km. of the ocean or ocean-navigable river, excluding coastline above the winter extent of sea ice and the rivers that flow to this coastline.	%	Gallup, Sachs and Mellinger (1999) - CID Geography Datasets		3
Malaria ecology: Ecologically-based spatial index of the stability of malaria transmission based on the interaction of climate with the dominant properties of anapheline vectors of malaria that determine vectorial capacity.	index (0 to 100)	Kiszewksi, et. al (2004)		1
Cultural fractionalization: Fractionalization measures the probability that two randomly selected people from a given country will not belong to the same cultural group. The variable combines measures of ethnic and language fractionalization into a single indicator of cultural fractionalization. The ethic diversity is complemented by distance in languages tree diagrams between the ethic groups. If ethic groups in a country speak structurally unrelated languages, the cultural fractionalization will be the same as the ethic fractionalization. The more similar are the languages, the more will the cultural measure be reduced below the ethic fractualization index.	index (0 to 1)	Fearon (2003)		1

Indicator & definition	*Scaling*	*Source*	*Coverage over cca 1992-2002*	*% of countries estimated*
Religious fractionalization: Fractionalization measures the probability that two randomly selected people from a given country will not belong to the same religious group.	index (0 to 1)	Fearon and Laitin (2003), missing data filled from Alesina, et. al (2003)		..
Log of oil & gas deposits per capita: Oil & gas (hydrocarbon) deposits are the log of total BTUs (Basic Transmission Unit – a unit of energy equal to the work done by a power of 1000 watts operating for one hour) per person of proven crude oil and natural gas reserves in 1993.	logs	Gallup, Sachs and Mellinger (1999) - CID Geography Datasets (missing data filled from the CIA Fact Book)		3

Appendix A2 (composites of social capabilities)

Countries	*Knowledge*		*Openness*		*Financial system*		*Governance*		*Democracy*	
	1992-1994	*2000-2002*	*1992-1994*	*2000-2002*	*1992-1994*	*2000-2002*	*1992-1994*	*2000-2002*	*1992-1994*	*2000-2002*
<u>Developed Countries</u>										
Australia	1.8	1.7	-0.3	-0.1	0.7	0.8	1.4	1.5	1.1	1.1
Austria	1.4	1.7	-0.2	0.4	0.8	0.9	1.3	1.3	1.1	1.1
Belgium	1.5	1.8	0.9	1.5	0.4	0.5	1.4	1.2	1.2	1.1
Canada	1.7	1.7	0.0	0.4	0.9	0.9	1.6	1.5	1.1	1.1
Denmark	1.7	1.9	-0.2	0.4	0.6	0.8	1.5	1.6	1.1	1.1
Finland	1.5	1.9	-0.5	0.2	0.9	0.9	1.4	1.5	1.1	1.1
France	1.3	1.5	-0.4	0.1	0.7	0.8	1.2	1.0	1.0	1.1
Germany	1.3	1.7	-0.5	0.1	0.6	0.8	1.6	1.3	1.0	1.1
Greece	1.1	1.6	-0.3	-0.1	0.0	0.7	0.8	0.5	1.0	1.0
Ireland	1.1	1.5	0.9	1.3	0.1	0.6	1.5	1.6	1.1	1.1
Israel	1.4	1.9	0.0	0.3	0.6	1.1	0.5	0.5	1.0	1.0
Italy	1.3	1.6	-0.8	-0.3	0.0	0.7	1.0	0.9	1.1	1.1
Japan	1.4	1.7	-2.3	-1.7	1.5	1.6	1.4	1.2	1.1	1.1
Netherlands	1.4	1.7	0.5	1.1	0.6	1.4	1.5	1.5	1.2	1.1
New Zealand	1.5	1.7	0.1	0.3	0.9	1.0	1.5	1.6	1.0	1.1
Norway	1.5	1.8	-0.3	-0.2	0.8	1.0	1.6	1.4	1.1	1.1
Portugal	0.8	1.3	0.2	0.5	0.4	1.3	1.1	0.9	1.1	1.1
Spain	1.0	1.5	-0.4	0.2	0.7	1.3	0.9	0.8	1.1	1.1
Sweden	1.8	2.1	-0.3	0.4	1.0	0.9	1.3	1.4	1.1	1.1
Switzerland	1.6	1.8	0.0	0.5	1.5	1.5	1.5	1.4	1.0	1.0
United Kingdom	1.4	1.6	-0.1	0.1	1.3	1.3	1.7	1.5	1.0	1.0
United States	1.8	2.0	-1.1	-0.7	2.0	2.2	1.6	1.4	1.1	1.1
<u>Asian Tigers</u>										
Hong Kong SAR*	0.9	1.3	2.1	2.3	1.4	1.6	1.7	1.7	-0.1	0.3
Republic of Korea	1.0	1.5	-0.6	-0.1	1.6	1.3	0.6	0.7	0.8	0.9
Singapore	0.8	1.5	2.0	2.1	1.1	1.2	1.6	1.6	-0.1	-0.2
Taiwan Province of China	0.9	1.5	-0.1	0.3	0.8	1.1	1.3	1.0	-0.5	0.8

Countries	Knowledge		Openness		Financial system		Governance		Democracy	
	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002
New EU Members										
Czech Republic	0.9	1.2	0.3	1.1	0.6	0.8	1.0	0.8	0.3	1.0
Estonia	0.8	1.5	0.2	1.5	-0.5	0.4	1.1	1.1	-0.1	1.0
Hungary	1.1	1.5	0.2	1.2	0.2	0.6	1.2	0.8	0.3	1.1
Latvia	0.8	1.3	-0.1	0.7	-0.8	0.1	0.5	0.5	-0.2	1.0
Lithuania	0.8	1.3	0.0	0.7	-0.4	-0.2	0.7	0.3	-0.1	1.1
Poland	0.9	1.4	-0.6	0.2	0.8	0.2	0.7	0.6	0.1	1.0
Slovakia	0.7	1.1	0.1	1.0	0.5	0.6	1.1	0.3	0.2	1.0
Slovenia	1.1	1.7	0.4	0.6	-0.6	0.4	1.2	1.0	0.3	1.1
West Asia										
Iran	-0.3	0.4	-0.4	-1.0	0.0	0.0	-1.1	-2.0	-1.3	-0.3
Jordan	0.4	1.0	0.6	0.8	1.1	1.0	0.6	0.4	-1.2	-0.8
Kuwait	0.8	1.1	-0.8	-0.8	1.3	1.0	1.0	1.1	-1.9	-1.1
Lebanon*	0.5	1.1	0.1	0.1	0.4	1.2	-0.1	-0.4	-0.5	-0.2
Oman	-0.5	0.2	0.3	0.0	0.3	0.3	1.1	0.9	-2.7	-2.0
Saudi Arabia*	0.4	0.9	-0.1	-0.4	-0.1	1.3	0.5	0.4	-3.5	-3.2
Syria	-0.1	0.2	0.0	-0.3	0.2	0.3	-0.6	-0.7	-2.0	-1.8
Turkey	0.0	0.6	-0.6	0.0	-0.5	-0.2	-0.3	-0.2	0.6	0.7
United Arab Emirates*	0.4	0.7	0.2	-0.1	0.5	0.1	1.1	1.2	-2.0	-2.2
Yemen	-1.3	-0.7	0.9	-0.1	-0.2	-0.2	-0.8	-1.1	-1.0	-0.4
Latin America										
Argentina	0.8	1.1	-1.3	-0.8	0.1	-0.1	0.6	0.0	0.9	0.9
Bolivia	-0.1	0.3	-0.1	0.3	-0.4	0.1	-0.1	-0.5	0.8	1.0
Brazil	0.1	0.5	-1.4	-0.7	-0.1	-0.7	0.0	-0.3	0.6	0.7
Colombia	0.0	0.4	-0.7	-0.4	-0.3	-0.1	-1.2	-1.2	0.8	0.7
Costa Rica	0.5	0.8	0.3	0.7	-0.4	-0.1	0.4	0.5	1.0	1.0
Dominican Republic	-0.5	-0.1	0.4	0.7	-0.4	0.0	-0.1	-0.2	0.8	0.9
Ecuador	0.1	0.4	-0.2	0.3	-0.5	-0.2	-0.6	-0.8	0.7	0.9
El Salvador	-0.2	0.2	-0.3	0.4	-1.3	-1.0	0.3	0.4	0.8	0.9
Guatemala	-0.7	-0.3	-0.1	0.1	-0.4	-0.2	-0.4	-0.9	0.1	0.7
Haiti	-1.7	-1.5	-0.6	-0.2	-0.5	-0.3	-3.1	-2.3	-1.5	-0.1

Countries	Knowledge		Openness		Financial system		Governance		Democracy	
	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002
Honduras	-0.8	-0.3	0.2	0.7	-0.2	0.2	-0.2	-0.7	0.8	0.8
Chile	0.6	0.9	0.1	0.4	0.4	0.5	0.9	1.2	0.1	1.1
Jamaica	-0.4	0.1	0.7	0.8	-0.2	0.0	0.2	0.2	0.8	0.7
Mexico	0.2	0.6	-0.5	0.2	0.4	-0.1	-0.1	-0.7	0.5	0.8
Nicaragua	-0.5	-0.3	0.5	0.9	-0.1	0.1	-0.8	-0.7	0.3	0.8
Panama	0.5	0.7	0.4	0.4	0.7	0.9	0.3	0.1	0.3	1.1
Paraguay	-0.4	0.3	-0.2	0.1	-0.2	-0.2	-0.1	-1.1	0.5	0.7
Peru	0.2	0.5	-1.0	-0.5	-1.4	-0.2	-0.9	-0.5	0.4	0.8
Trinidad and Tobago	-0.3	0.4	0.4	0.9	0.2	0.2	0.4	0.8	1.0	0.9
Uruguay	0.6	0.9	-0.6	-0.5	-0.8	-0.2	0.6	0.6	0.8	1.1
Venezuela	0.5	0.6	-0.4	-0.4	-0.2	-0.5	-1.0	-1.0	0.8	0.2
East Europe & CIS										
Albania	-0.3	0.0	0.0	0.2	0.1	-0.2	0.0	-0.6	-0.3	0.7
Armenia*	0.5	0.7	-0.9	0.6	-1.0	-0.9	0.1	-0.3	-0.2	0.1
Azerbaijan*	0.3	0.5	-1.1	0.4	-0.7	-0.8	-0.7	-0.9	-1.2	-0.6
Belarus*	0.8	1.1	-1.2	0.7	-1.2	-1.0	-0.1	-1.2	-0.7	-0.6
Bulgaria	1.0	1.1	-0.1	0.7	-0.4	-0.1	-0.1	-0.2	0.1	1.0
Croatia	0.8	1.2	-0.2	0.6	-0.5	0.3	-0.1	-0.1	-0.2	0.7
Georgia*	0.7	0.8	-1.4	-0.1	-1.6	-1.2	-0.8	-1.0	-1.0	0.5
Kazakhstan*	0.5	0.6	-0.7	0.5	-1.0	-0.7	0.1	-0.5	-1.1	-0.9
Kyrgyzstan*	0.1	0.3	-0.9	0.5	-1.1	-1.4	0.1	-0.7	-0.8	-0.5
Macedonia, FYR*	0.5	0.7	-0.6	0.7	-0.7	-0.3	0.3	-0.8	0.1	0.7
Moldova	0.5	0.6	-0.1	1.0	-0.8	-0.3	0.0	-0.3	-0.9	0.7
Romania	0.5	0.9	-0.9	0.4	-0.6	-0.6	-0.3	-0.4	-0.1	1.0
Russia	0.8	1.2	-1.8	-0.4	-1.4	-0.5	0.0	-0.8	-0.5	0.2
Tajikistan*	0.0	-0.1	-0.2	0.8	-1.0	-1.1	-2.2	-1.1	-1.6	-0.5
Turkmenistan*	0.4	0.0	0.1	0.7	-1.3	-0.8	-0.5	-1.0	-1.8	-2.1
Ukraine	0.8	1.0	-0.9	0.4	-1.5	-0.8	-0.5	-0.6	-0.6	0.7
Uzbekistan*	0.4	0.0	-1.0	-0.3	-0.8	-0.9	-0.6	-1.5	-1.6	-1.7

Countries	Knowledge		Openness		Financial system		Governance		Democracy	
	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002
North Africa										
Algeria	-0.4	0.0	-0.7	-0.5	0.1	0.1	-0.3	-0.4	-1.6	-0.3
Egypt	-0.1	0.5	-1.6	-1.9	0.5	0.9	-0.9	-0.2	-0.6	-0.6
Mauritania*	-1.9	-1.0	0.1	0.5	0.4	-0.7	0.0	-0.3	-2.3	-0.5
Morocco	-0.2	0.1	-1.3	-1.1	0.7	0.6	0.7	0.4	-0.9	-0.8
Tunisia	-0.2	0.4	0.8	0.9	0.1	0.3	0.3	0.4	-1.2	-0.5
South-East Asia										
Cambodia*	-2.3	-2.0	-0.4	0.7	-1.4	-0.9	-1.3	-0.4	-0.7	-0.5
China	-0.3	0.4	-0.2	0.1	1.8	1.4	-0.8	-0.7	-2.0	-1.8
Indonesia	-0.7	-0.1	-0.1	0.1	0.4	0.5	-1.1	-1.5	-1.5	0.0
Laos*	-2.1	-1.3	-0.2	0.3	-1.0	-1.0	0.0	-1.8	-1.8	-1.6
Malaysia	0.2	0.9	1.1	1.5	1.1	1.2	0.9	0.5	0.4	0.4
Papua New Guinea*	-1.6	-1.3	0.4	0.8	0.1	0.0	-0.2	-0.5	0.9	1.0
Philippines	0.1	0.5	0.0	0.5	0.3	0.7	-0.6	-1.0	0.4	0.9
Thailand	0.3	0.7	0.2	0.8	1.1	1.1	0.5	0.6	0.5	0.9
Vietnam*	-1.8	-0.4	0.2	1.0	-0.6	0.5	-1.4	-1.6	-2.0	-1.5
Sub-Sahara Africa										
Angola*	-2.2	-2.1	0.5	0.8	-1.7	-1.7	-1.4	-2.0	-1.4	-0.7
Benin	-1.9	-1.5	0.2	0.1	-0.3	-0.5	0.2	-0.1	-0.3	0.6
Botswana	-0.8	-0.8	0.6	0.5	0.2	0.0	0.8	0.8	0.6	0.8
Burkina Faso*	-2.7	-1.8	-1.5	-1.4	-0.5	-0.3	0.0	-0.5	-1.4	-0.3
Cameroon	-1.4	-1.2	-2.1	-1.6	-0.5	-0.8	-0.8	-1.4	-1.4	-0.6
Congo, Dem. Rep*	-2.0	-1.6	-0.6	0.3	-1.5	-2.2	-2.8	-2.3	-1.6	-2.0
Congo, Rep.	-1.4	-1.1	-0.2	0.2	-0.5	-1.1	-1.1	-1.5	-0.6	-0.7
Cote d'Ivoire	-1.4	-1.2	-0.2	0.3	-0.1	-0.5	0.1	-0.9	-1.2	-0.1
Ethiopia*	-2.0	-2.5	-1.1	0.0	0.3	0.4	-0.7	-0.8	-1.6	-0.5
Gabon	-1.1	-0.8	-0.2	-1.6	-0.7	-0.8	0.3	0.2	-1.0	-0.2
Gambia	-2.1	-1.6	1.1	0.8	-0.6	-0.3	0.0	-0.3	0.6	-0.8
Ghana	-1.3	-1.1	0.2	0.8	-0.9	-0.6	0.3	-0.1	-1.8	0.5
Guinea	-2.4	-2.4	-0.6	-0.4	-0.8	-1.2	-0.1	-0.9	-1.9	-0.3
Chad*	-3.0	-2.8	-0.5	0.8	-0.9	-1.2	-1.1	-1.1	-1.8	-1.0
Kenya	-1.2	-0.8	0.0	-0.1	-0.4	-0.1	-0.5	-0.9	-1.0	0.2

Countries	Knowledge		Openness		Financial system		Governance		Democracy	
	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002	1992-1994	2000-2002
Madagascar	-1.2	-1.5	-0.7	-0.4	-0.3	-0.6	-0.4	0.0	0.3	0.8
Malawi	-2.4	-2.2	0.2	0.3	-0.3	-1.0	-0.2	0.1	-1.6	0.5
Mali	-2.8	-2.3	-0.7	0.2	-0.4	-0.5	-0.5	0.0	-0.3	0.7
Mauritius	-0.4	0.1	0.4	0.5	0.5	0.5	0.9	0.7	1.0	0.9
Mozambique	-2.8	-2.5	0.2	0.5	-0.6	-0.3	-0.8	-0.8	-1.2	0.5
Namibia	-0.7	-0.7	0.9	0.8	0.0	0.2	0.8	0.8	0.9	0.8
Niger	-2.8	-2.3	-0.1	-0.1	-0.5	-1.2	-0.9	-0.8	-1.0	0.0
Nigeria	-1.7	-1.1	0.4	0.2	-0.5	-0.3	-0.4	-1.1	-1.7	-0.9
Senegal	-1.6	-1.2	-0.4	0.4	-0.2	-0.4	-1.2	-0.2	0.2	0.7
Sierra Leone	-2.3	-1.9	-1.6	-0.5	-1.3	-1.1	-2.0	-0.5	-1.6	-0.5
South Africa	0.1	0.2	-0.6	0.2	0.7	0.8	0.0	0.2	0.5	1.0
Sudan*	-1.8	-1.1	-1.3	-0.6	-1.2	-1.4	-1.6	-2.2	-1.5	-2.1
Swaziland	-1.0	-0.8	1.4	1.3	0.0	-0.3	0.6	0.4	-2.9	-1.7
Tanzania	-2.0	-1.6	-0.3	-0.2	-0.9	-0.8	-0.1	-0.1	-1.4	0.2
Togo	-1.5	-1.2	-0.1	0.7	-0.1	-0.5	-0.9	-1.2	-1.4	-0.4
Uganda	-1.6	-1.4	-0.9	0.1	-1.2	-0.8	-0.7	0.0	-0.9	-0.4
Zambia	-1.6	-1.5	0.1	0.7	-1.8	-0.9	0.0	-0.1	-0.3	0.3
Zimbabwe	-0.7	-0.7	-0.4	-0.1	0.3	-0.4	0.0	-1.3	-0.1	-0.4
Central Asia										
Bangladesh	-1.6	-1.2	-1.4	-0.7	-0.1	0.1	-1.3	-1.7	0.1	0.7
India	-0.6	-0.2	-1.8	-1.1	0.1	1.1	-1.7	-1.1	0.7	0.9
Mongolia	0.0	0.1	0.2	0.9	-0.7	-0.5	0.7	0.1	-0.2	0.7
Nepal	-1.8	-1.2	-0.9	-0.6	1.2	0.5	-0.2	-1.5	0.2	0.7
Pakistan	-0.9	-1.0	-0.6	-0.4	0.1	0.2	-0.4	-1.1	0.1	-0.2
Sri Lanka	-0.6	-0.1	0.2	0.4	-0.1	0.2	-0.4	-0.1	0.5	0.7

Note: For definition of the variables see Table 4. Countries with a high level of missing data (between 15% and 30%) and countries influenced by military conflicts are marked by stars.

Appendix A3: Regression results - growth (excluding countries with the most missing data and wars)

Construction method of the composite indicators	*One factor per variable*					
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Iteratively reweighted least sq.*
Constant	0.00	-0.05	0.00	-0.01	0.00	-0.05
	(0.69)	(0.66)	(0.41)	(0.12)	(0.53)	(0.69)
Log of the initial	-0.31	-0.24	-0.15	-0.18	-0.25*	-0.12
GDP per capita	(1.18)	(1.32)	(0.54)	(0.91)	(1.91)	(0.98)
Knowledge	0.02	0.08	-0.35	-0.06		
	(0.06)	(0.45)	(1.12)	(0.25)		
Openness	0.04	-0.01	0.14	-0.02	0.13	0.01
	(0.49)	(0.19)	(1.13)	(0.21)	(1.40)	(0.09)
Financial system	0.37**	0.17	0.25	0.07	0.20	0.04
	(2.43)	(1.62)	(1.60)	(0.60)	(1.64)	(0.41)
Governance	0.34***	0.33***	0.38**	0.33**	0.34***	0.32***
	(2.72)	(2.75)	(2.63)	(2.39)	(2.92)	(2.65)
Democracy	0.24	0.19	0.34*	0.28**	0.34**	0.32***
	(1.30)	(1.66)	(1.71)	(2.11)	(2.29)	(2.94)
Δ knowledge	0.30***	0.33***	0.33***	0.30***	0.42***	0.36***
	(3.48)	(3.83)	(2.93	(3.05)	(3.99)	(4.20)
Δ openness	0.06	0.03	0.02	0.04		
	(0.57)	(0.30)	(0.20)	(0.41)		
Δ financial system	0.14***	0.12	0.09	0.07		
	(1.31)	(1.26)	(0.77)	(0.66)		
Δ governance	0.10	0.19**	0.15	0.20**	0.18	0.22***
	(0.91)	(2.49)	(1.26)	(2.52)	(1.43)	(3.01)
Δ democracy	0.23	0.24**	0.20	0.24**	0.20*	0.27***
	(1.44)	(2.45)	(1.20)	(2.28)	(1.71)	(3.02)
Longitude of country centroid	..	..	0.15**	0.13*	0.14**	0.15**
	..	..	(2.40)	(1.82)	(2.49)	(2.19)
Latitude of country centroid	..	..	0.11	0.05		
	..	..	(1.33)	(0.63)		
Log of land area	..	..	0.03	-0.07		
	..	..	(0.17)	(0.72)		

Construction method of the composite indicators	*One factor per variable*					
Estimation method:	*Simple OLS*	*Iteratively reweighted least sq.*	*Simple OLS*	*Iteratively reweighted least sq.*	*Stepwise backward selection*	*Iteratively reweighted least sq.*
Log of mean elevation	..	..	0.17	0.07	0.13	0.03
	..	..	(1.18)	(0.75)	(1.42)	(0.41)
Access to ocean or navigable river	..	..	0.04	0.05		
	..	..	(0.28)	(0.36)		
Malaria ecology	..	..	-0.06	-0.04		
	..	..	(0.49)	(0.36)		
Cultural fractionalization	..	..	-0.12	0.02		
	..	..	(1.04)	(0.23)		
Religious fractionalization	..	..	0.09	0.03		
	..	..	(0.76)	(0.42)		
Log of oil & gas deposits per capita	..	..	0.15	0.09	0.13*	0.06
	..	..	(1.47)	(1.02)	(1.65)	(0.87)
F	6.88	5.06	4.05	2.80	7.14	5.46
R^2	0.32	..	0.39	..	0.36	..
Observations	110	110	110	110	110	110

Note: Depended variable is annual growth of GDP per capita over 1992-2002 (PPP, constant 1995 USD). Absolute value of robust t-statistics in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels. Standardized variables used in the estimates (beta values reported).

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About the cover illustration:
The graph on the cover, generated by means of fractal geometry model, simulates a pattern formed by three ring vortices playing catch up with one another (also called 'chaotic leapfrogging').

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