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The West as an (almost) exclusive club*

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The past couple of centuries have brought unparalleled riches to the Western while leaving many developing countries behind. The most both elusive and important variable in economics, usually denoted by *A*, captures both the path to prosperity as well as the differences between the income of the world's rich and the poor countries. The question what explains differences in the level of productivity between countries and changes over time is the most important one facing economists. This is the topic of Edmund Phelps's recent book, *Mass Flourishing*, which describes the emergence and then gradual stagnation of what he calls a modern, or innovative, economy.

The objective of this paper is to review the performance of the West since the late 19th century by identifying convergence clubs[1] and monitoring their movements over time. Differences in the level of productivity between convergence clubs will be traced to differences in social institutions. An important question is whether the performance of the leading Western economies has deteriorated in the past couple of decades.

1. Dynamism and corporatism

Eggertsson (2007) describes how a society's institutions are chosen from a set of feasible institutions, defined by physical technology, our knowledge of social institutions, geography, climate and past institutions. The choice of a set of institutions affects economic outcomes, as seen in the relative performance of divided countries such as East and West Germany and Taiwan and mainland China (see Olson, 1986).Various factors can prevent a society from adopting the best set of institutions, such as the natural resources, the failure of collective action, the self-interests of ruling groups, beliefs in the efficiency of different institutions and culture and ethnic diversity.

A dictator, corrupt governments and industries benefiting from rent seeking may prefer a social infrastructure that generates lower average income (see DeLong and Shleifer, 1993). Culture may also be important. For example the societies of Scandinavia enjoy higher levels of trust than other European and American countries which enables them to run an extensive welfare state aimed at promoting participation in the labor market as first proposed by Alva and Gunnar Myrdal (1934).[2] Ethnic homogeneity may also be of help in these countries. Geography

[1] See Quah (1996), amongst others.
[2] See also Knack and Keefer (1997).

may affect exposure to western ideas and affect trade and specialization (see Nunn and Puga, 2007). Bloom and Sachs (1998) describe the disadvantages of the tropics for economic activity. An alternative explanation is proposed by Acemoglu, Johnson, and Robinson (2001) which is the effect of the disease environment during colonial times on the willingness of Europeans to settle in these countries, hence not bringing with them the institutions favorable to growth. In their place the Europeans set up extractive economies, especially in those areas that were densely populated and with preexisting institutions[3]. Sokoloff and Engerman (2000) trace the superior performance of the United States and Canada in comparison to other American countries to differences in relative factor endowments that made inequality greater in South America and the Caribbean and political power more concentrated. Higher levels of inequality created institutions intended to protect the interest of the few and limiting the access of most of the population to economic opportunities. Acemoglu, Johnson, and Robinson (2002) claim that trade with America emboldened a new mercantile class in the U.K. and the Netherlands which demanded capitalist institutions while Atlantic trade strengthened the central control in countries such as Spain and Portugal. A recent book by Acemoglu and Robinson (2012) continues this theme by distinguishing between extractive and productive institutions. A final factor determining the institutional setup is beliefs about the merits of different social systems may be important. Thus a Soviet type planning economy was admired in the 1950s into the 1960s, the German "Wirthschaftswunder" was widely acclaimed in the 1960s, Japan was supposed to "Number one" in the 1980s and currently Chinese state capitalism is supposed to make China the most powerful nation in the world. Edmund Phelps's latest book is on the emergence of innovative economies in the West. He describes how entrepreneurs constantly try new business ideas, most of which end up as failure, leaving only a few to become industry leaders. Such an economy requires a set of institutions that reward success and penalize failure, a culture of risk taking and financiers who are willing to finance new entrepreneurial ventures, in addition to consumers who are willing to experiment with new products (see Amar Bhidé, 2008). Such an economy benefits from the diversity of the outlook of entrepreneurs and its bankers and from urbanization and globalization which provide exposure to the discoveries and ideas of others. According to Phelps, recent decades have seen a decline of dynamism due to the emergence corporatist institutions in many Western countries that have attempted to affect both the distribution of income and the allocation

[3] See Acemoglu, Johnson and Robinson (2002).

of the factors of production. Unions, bureaucracies, red tape, the cost of starting a business, the cost of hiring and firing and lobbyists, to take a few examples, and cultural changes in some Western countries are to blame for the lower levels of dynamism.

There are examples of positive changes in institutions, such as Britain in the 17th and 18th centuries[4] and Singapore in the 20th century. But there are also examples of institutions deteriorating, which is one theme of Phelps's recent book. His main worry is the gradual strengthening of corporatist institutions in many Western countries, which is one example of society's institutions deteriorating. In his *The Rise and Decline of Nations*, Mancur Olson describes how stable societies with unchanged boundaries tend to accumulate more collusions and organizations for collective action over time. Such groups reduce efficiency and economic growth and make political life more divisive. In particular, distributional coalitions increase the volume of regulations and the role of government. In Phelps and Zoega (2013) we show how a set of corporatist institutions is inversely correlated with measures of economic performance, in particular reported job satisfaction.[5] Corporatism can be defined by the set of institutions and interventions in the functioning of a market economy that are intended to prevent capitalism from harming the objects of traditional values. Competition in the market place is deemphasized and in its place comes a sense of shared objectives for society. At the heart of corporatism is an intervention in what the economy produces. The intensity of resource allocation in the corporatist system can be measured by the size of tax revenue; the volume of recorded regulations; a large government sector; barriers to entry; red tape; and industrial policy. Corporatist doctrine also puts emphasis on who should benefit in society rather than just what should be produced. Retirement pension, unemployment benefits and subsidized health care are just few examples of the state using its powers to redistribute income. Neo-corporatism distinguishes itself from classic corporatism in not having the state taking the initiative in setting the direction of the economy but instead to have the initiative taken by powerful business interests. This type of corporatism has features such as selected success of businesses; cronyism; meritocratic standards; and lobbying.

[4] See Joel Mokyr (2005) on the role of journals, political fragmentation in the genesis of the first industrial revolution.

[5] In particular, job satisfaction -- taken from the *World Values Survey* – is positively correlated with labor freedom, freedom from corruption and measured protection of property rights and negatively correlated with an index of access to capital (implying that greater access to capital gives greater job satisfaction) and with the volume of regulation of credit, labor and goods markets. Moreover, job satisfaction is negatively related to barriers to entrepreneurship and positively correlated with the number of listed companies and market capitalization.

2. Convergence clubs

The emergence of the West and its possible decline can best be studied by looking at long-run data or output. The evolution of the world income distribution in a cross-section of countries and the mobility of individual countries within the distribution can be studied using kernel density estimation. Denote by y_i the GDP per capita in 1990 dollars for country i and transform the variable so that x_i denotes the country's per capita GDP relative to the average of GDP per capita across the countries:

$$x_i = {}^{y_i}/_{(\sum_{i=1}^{n} y_i/n)} \tag{1}$$

The transformation has a natural interpretation as the relative GDP per capita of the i^{th} country.[6] This normalization makes it easier to compare the densities between any two periods. The estimated distribution can then be used to assess whether it is multi-modal which would show up in a distribution with two peaks.

Following Bianchi (1997) the density distribution $f(x_i)$ is estimated in order to identify the location of each country within the estimated distribution. There may be different groups of countries, such as the group of low-income and the group of high-income countries. In this case the density distribution of the data is a mixture of distributions described by

$$f(x) = \sum_{j=0}^{m-1} p_j g_j\left(x; \mu_{j,} \sigma_j\right) \quad p_j \geq 0 \tag{2}$$

where p_j's are mixing proportions with

$$\sum_{j=0}^{m-1} p_j = 1 \tag{3}$$

and g_j are densities with first and second moments μ_j and σ_j. If the gap in the μ_j's is large relative to the σ_j's the modes in the distribution are said to be well separated and $f(x)$ is multimodal with m modes. If the gap is small relative to the variances the mixture components in the density are not well separated.

The density can be estimated non-parametrically by the method of kernels. Given a sample of n independent and identically distributed observations, a kernel density estimator of $f(x)$ is constructed as (see Silverman, 1986)

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[6] This transformation was proposed by Canova and Marcet (1995) to correct for potential problems of cross correlation for the countries, such as expansions and contractions of the world economy.

$$\widehat{f_h}(x) = (nh)^{-1} \sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) = (nh)^{-1} \sum_{i=1}^{n} K(u) \quad (4)$$

where $h > 0$ is the bandwidth and $K(u) = 1/\sqrt{2\pi}\ exp(-1/2u^2)$ is the Gaussian kernel. The bandwidth h determines the degree of smoothness of the density estimate, with larger values of h producing a smoother density estimate.[7] A critical bandwidth h_m, is defined as the smallest possible h producing a density with, at most, m modes. The bandwidths proposed by Silverman (1986) fall between the critical bandwidths for one and two modes in the distribution.

We start by estimating the distribution of real GDP per capita for countries for which the Maddison data provide numbers in 1850[8,9] and show the distribution for selected years in Figure 1 below. The estimated distributions show the gradual emergence of two groups of countries; the high-income (*H*) and the low-income (*L*) countries. This trend was only interrupted by two world wars that saw the higher mode of the income distribution suppressed and the overall distribution become close to unimodal. In the figure one can see the higher income mode appearing in 1880 and becoming more pronounced in 1910 and 1930. What is happening over these years is the transition of countries from the group of *L* group to the *H* group. The peak of the distribution for the *H* group has become taller in 1990 and remains so in 2000 and 2010. In fact, more countries are leaving the *L* group for the H group than moving in the opposite direction.[10]

A table in the appendix lists the countries in the *H* and the *L* groups in 1880, 1910, 1930, 1970 and 2010. The list of *H* countries in 1880 included only Britain, the U.S., the British colonies of Australia and New Zealand and Belgium and the Netherlands. By 1910 this list had expanded considerably to include Canada, Denmark, Germany, Austria and France in addition to the agricultural economies of Argentina, Uruguay and Chile. By 1930 four other countries had joined the H group; Sweden, Norway, Venezuela and Czechoslovakia. By 1970 there were the additions of Japan, Finland and Italy and by 2010 Spain had joined the ranks of the *H* group. However, Argentina, Uruguay, Chile and Czechoslovakia had moved back to the *L* group by

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7 If the true underlying density has two modes, a large value of h_1 is expected because a considerable amount of smoothing is required to obtain a unimodal density estimate from a bimodal density. A large value of h_m would then indicate the presence of more than m modes. See Silverman (1981, 1983, and 1986).

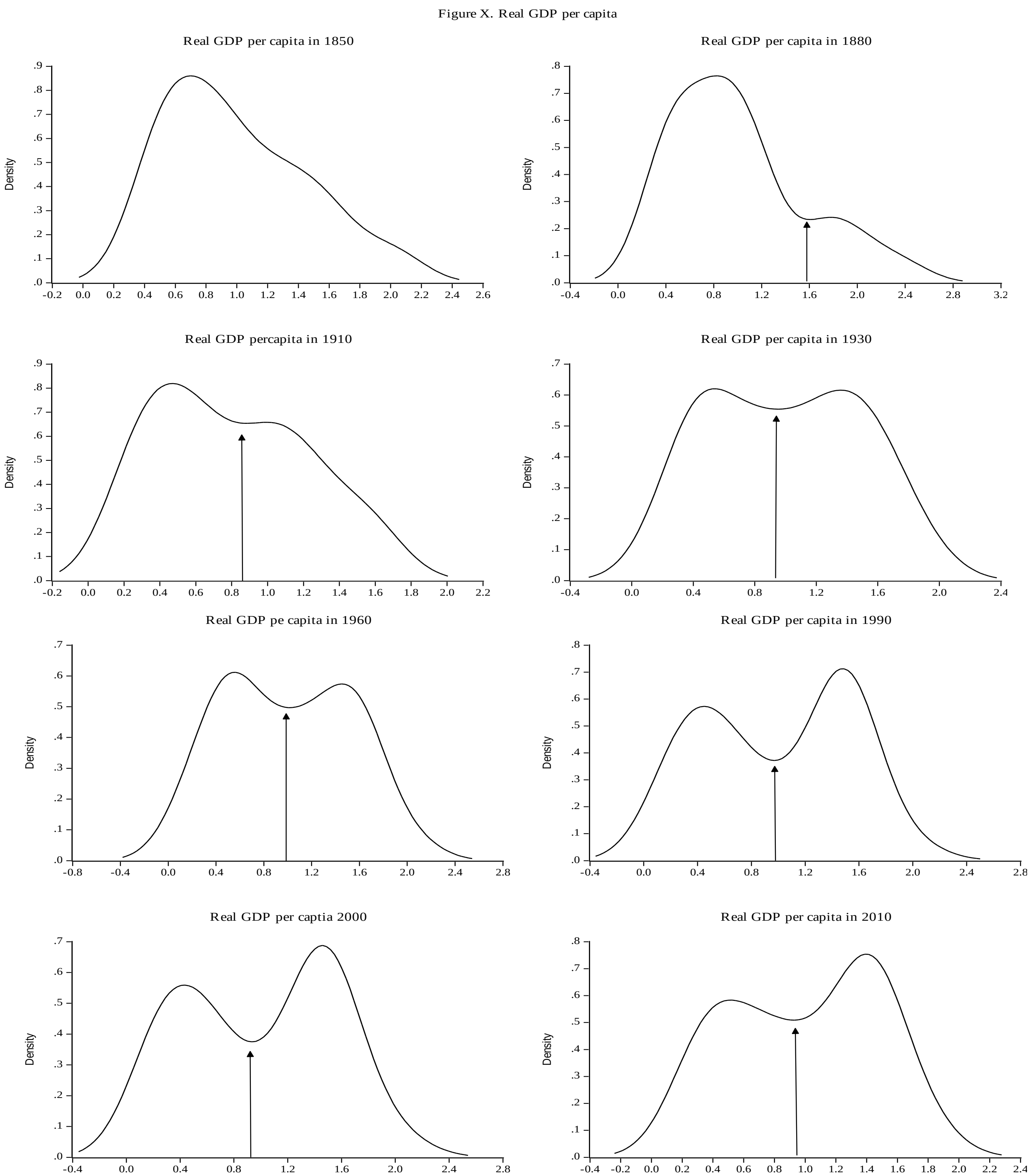
8 The countries are: Austria, Belgium, Denmark, Finland, France, Germany, Italy (centre-north), Holland, Norway, Sweden, England/GB/UK, Greece, Portugal, Spain, Australia, N. Zealand, Canada, U.S.A., Czechoslovakia, Argentina, Brazil, Chile, Colombia, Mexico, Uruguay, Venezuela, Cuba, Jamaica, China Indonesia (Java), Japan Sri Lanka and South Africa.

9 The numbers measure GDP per capita in 1990 Int. GK$.See Maddison Project, http://www.ggdc.net/maddison/maddison-project/home.htm.

10 The sample includes all the countries (except Ireland) that DeLong (1988) added to Baumol's (1986) sample in a study of income convergence.

1970.

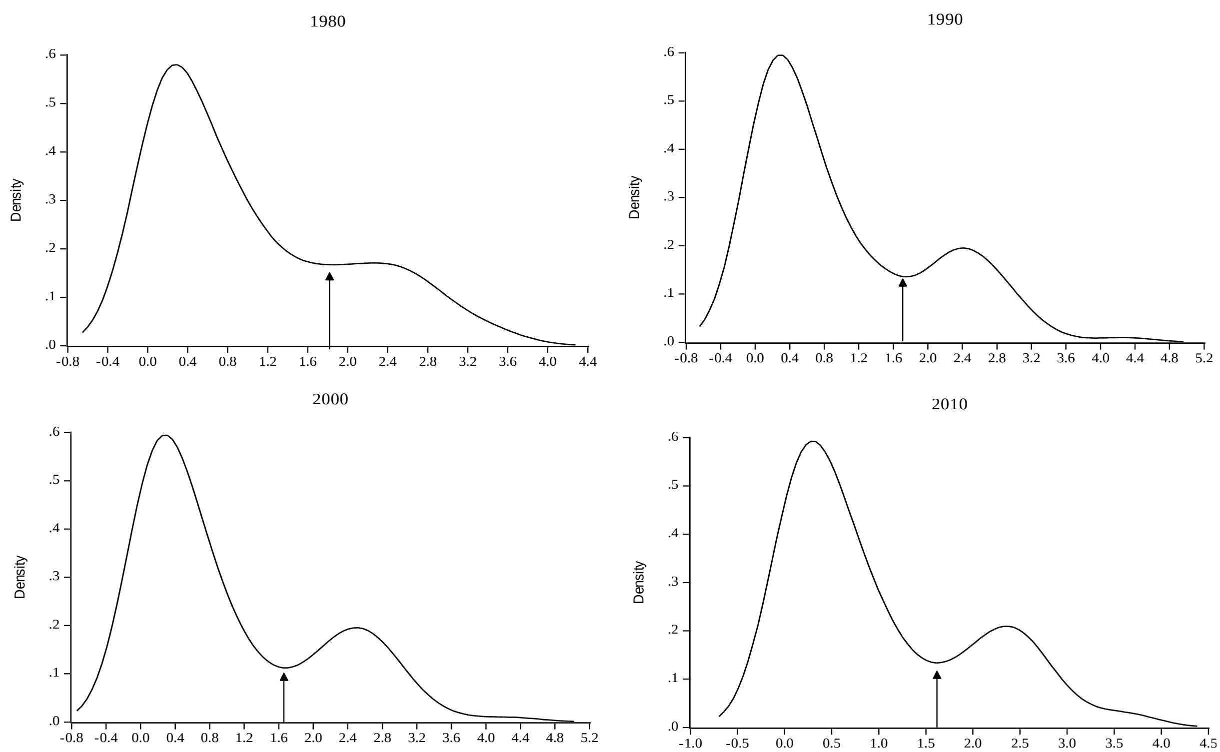
Figure 1. Real GDP per capita



The list of countries belonging to the *H* group has thus not changed much over the past century. There are only a handful of new members; Sweden, Norway, Japan, Italy and Spain when one only includes those countries for which Madison had numbers for in 1850.

While Figure 1 is informative in the sense of describing differences in living standards in the world, it does not describe differences in productivity. To do this one needs to work with output per employed worker instead of output per capita. Furthermore, a decomposition of cross country differences in output per employed worker would highlight the significance of differences in capital intensity and in productivity. Using the Penn World table one can find output per employed worker (in 2005 dollars) and investment series for 124 countries, which enables us to decompose differences in productivity into differences in capital intensity and productivity using the methodology of Hall and Jones (1999). The figure below shows the distribution of output per employed worker for a group of 120 countries taken from Penn World data and estimated with the bandwidths proposed by Silverman (1986).

Figure 2. Real GDP per employed worker



Again, the same picture emerges of the existence of two groups of countries; the low-productivity and the high-productivity countries. The gap between the mean value in the two distributions widened in the 1990s but then fell in the 2000s as shown in the table below.

Table 1. Mean normalized output per employed worker

Low-income	0.27	0.30	0.26	0.27
High income	2.40	2.40	2.55	2.30
Difference	2.13	2.10	2.81	2.03

One feature of the data is the low frequency of transitions between the two groups. Table 2 documents transitions between states when each country is classified based on which distribution it belongs to in each year.

Table 2. Transitions to the group of high-productivity countries

1980		1990		2000		2010	
		Hong Kong	2.11	Hong Kong	2.26	Hong Kong	2.69
		Singapore	2.20	Singapore	2.94	Singapore	3.68
				Malta	2.03	Malta	1.83
				Taiwan	2.12	Taiwan	2.43
						Czech.R.	1.70
						South Kora	1.98
Oman	2.17	Oman	2.17	Oman	1.99	Oman	1.87
		Saudi Arabi	2.38	Saudi Arabia	2.32	Saudi Arabia	2.11
		Seychelles	2.26	Seychelles	2.42	Seychelles	NA

Between 1980 and 2010 there are six countries that join the high output group: Hong Kong and Singapore in 1990, Malta and Taiwan in 2000 and the Czech Republic and South Korea in 2010. In addition the oil-producing countries and Oman and Saudi Arabia join in 1980 and 1990 and the Seychelles Islands, whose main industry is tourism, in 1990. Only two countries leave the high output club. These are Iran and Venezuela which belong to the high output club in 1970 but joined the low output club in 1980.

It is noteworthy that of the six countries that move from the low output to the high output group over these forty years, three are former British colonies; Hong Kong, Malta and Singapore. They meteoric rise of Singapore is interesting. Singapore was a colony of Britain since 1826 until independence in 1963.[11] Its subsequent leaders were educated in Britain, upheld the principle of property rights, fought corruption and promoted free trade, implemented polices to harness the

[11] Singapore was a part of Malaysia from 1963 to 965 but became an independent country in 1965.

global ideas flow and fostered foreign direct investment. Malta, being a British colony from 1802 to 1964, and Hong Kong, a colony from 1841to 1997, also have a strong British heritage.

The differences in output per employed worker reflect differences in capital intensity and productivity. The approach of Hall and Jones (1999) can be used to calculate the relative importance of productivity and capital in explaining differences in output per employed worker across countries and provinces. Starting with the Cobb-Douglas production function for the whole economy

$$Y = K^{\alpha} \left(AN\right)^{1-\alpha} \tag{5}$$

where N denotes the number of employed workers and K is calculated from investment data.[12] Now taking logs gives;

$$\log Y = \alpha \log K + \left(1-\alpha\right)\log A + \left(1-\alpha\right)\log N \tag{6}$$

Finally, rearranging gives a solution for A which can be calculated by assuming that the share of capital in national income is 1/3 (as in Hall and Jones, 1999):

$$\log A = \log Y - \frac{1}{2}\log\frac{K}{Y} - \log N \tag{7}$$

The distribution of the capital-output ratio is shown in the appendix. It is unimodal in all years which tells us that in terms of that variable there is only one group of countries. The bimodality instead shows up in the distribution of the productivity A is calculated as in equation (7) and shown in Figure 3.

[12] K is calculated by using data on gross capital formation in 1970, assuming that the rate of depreciation is 0.06 and calculating the rate of growth of output for the next ten years. Assuming that the K/Y ratio was stable one can then calculate the level of K in 1970. Then using data on investment and the assumed depreciation rate K, the series is extended until 2010.

Figure 3. Productivity

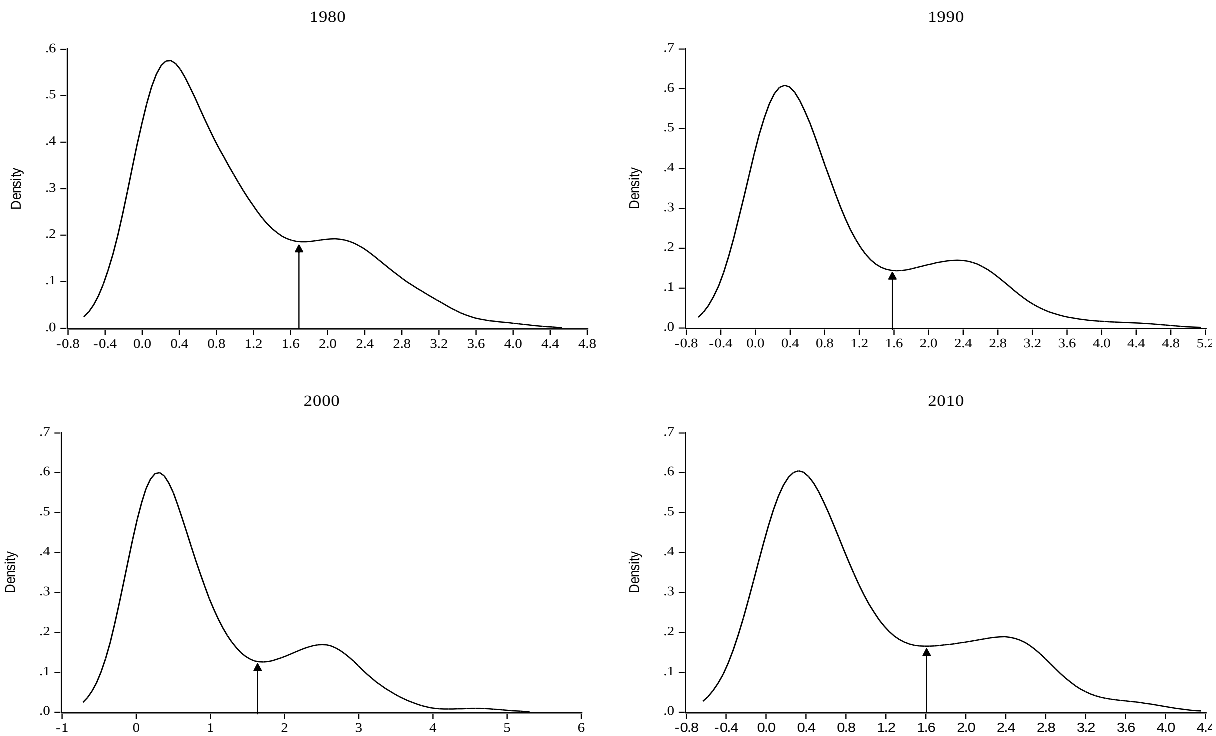


Table 1 shows the mean of the two distributions – one for low productivity countries and the other for high-productivity countries – for each of the four years and the difference between the means. The gap between the two groups widened between 1980 and 1990 and again between 1990 and 2000 but has fallen somewhat since then although it remains above its 1990 level.

Table 1. Mean normalized productivity

	1980	1990	2000	2010
Low-income	0.30	0.40	0.25	0.35
High income	2.15	2.40	2.50	2.40
Difference	1.85	2,0	2.25	2.05

Following the economic growth literature one can try account for differences in productivity across countries by differences in a set of institutions. In particular, differences in measured productivity A from equation (7) can be explained by a set of institutional variables, which we take from the *Fraser Institute*.[13] These variables measure economic freedom so that a higher value of each index is indicative of greater freedom.

The first institutional variable is a measure of bribes and favoritism on a scale from 0 to 10 where 10 where a higher number implies better performance, hence that these practices are less common. There is the quality of the legal system, again using the same scale. Next there is a measure of the enforcement of contracts on the same scale. Regulations and bureaucracy are important so a variable that measures the cost of starting a business is also included, a higher value implying a lower cost of doing business. Finally, there is a measure of taxes on trade where again a higher number implies lower taxes.[14]

Table 2 has the results of a regression where productivity A – taken from equation (7) – is explained by the institutions measuring the extent of bribes and favoritism; the quality of the legal system; the enforcement of contracts; the cost of starting a business; and taxes on trade.

Table 2. Productivity explained in 2000

Variables	Coefficient	Standard error
Constant	-3.00	0.48*
Absence of bribes and favoritism	0.18	0.05*
Legal system	0.10	0.03*
Enforcement of contracts	0.07	0.04**
Cost of starting a business	0.09	0.05*
Taxes on trade	0.19	0.05*
Observations	84	
R-squared	0.75	
Wald F	48.0	

Oil exporting countries excluded. * significant at 5% level, ** significant at 10% level.

[13] http://www.freetheworld.com/.

[14] These variables all take a prominent role in Phelps's new book since each captures an element of what he calls corporatism. The intensity of resource allocation in the corporatist system can be measured by several variables, including the volume of recorded regulations; barriers to entry; and red tape. Corporatist doctrine also puts emphasis on who should benefit in society rather than just what should be produced. The intensity of income diversion can be measured by taxes on trade; and the quality of the legal system. Neo-corporatism distinguishes itself from classic corporatism in not having the state taking the initiative in setting the direction of the economy but instead to have the initiative taken by powerful business interests. This type of corporatism has features such as cronyism; bribes; the absence of meritocratic standards; and lobbying.

There are four coefficients that are significantly different from zero at the 5% level of significance and one at the 10% level of significance. The signs of the coefficients show that higher productivity is negatively associated with the prevalence of bribes and favoritism, the cost of starting a business, and taxes on trade and positively associated with the quality of the legal system and the enforcement of contracts. The scatter plots in Figure 4 show the relationship between each of the regressors and productivity. A higher score indicates a lower level of bribes and favoritism; greater integrity of the legal system; lower costs of starting a business; lower taxes on trade; and better legal enforcement of contracts. Together these variables explain 75% of the variation in the productivity data. Once controlled for the distribution of the productivity numbers becomes unimodal as shown in the right bottom panel of the figure.[15]

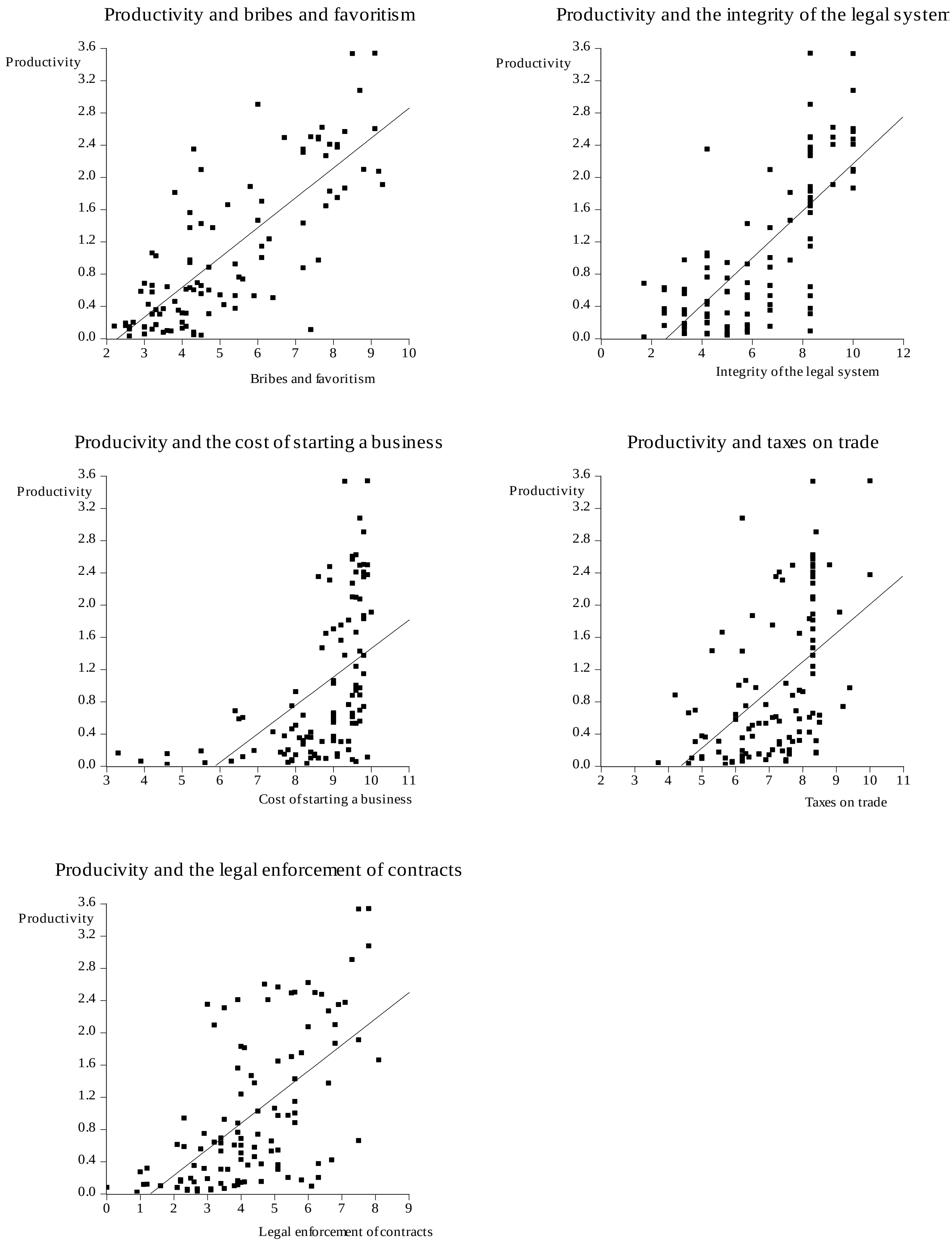
We conclude that a relatively small set of institutions can account for the differences between the group of high- and low productivity countries.

3. Economic growth in Britain

We now turn to the country where significant economic growth first appeared in the 18th century due to the favorable effects of free trade, the protection of property rights and the rule of law. A large literature exists on the reasons why Britain was the birthplace of the first industrial revolution (see Mokyr, 1990, to take one example).

[15] If, and to the extent, that important variables are omitted these estimates are of course subject to omitted error bias.

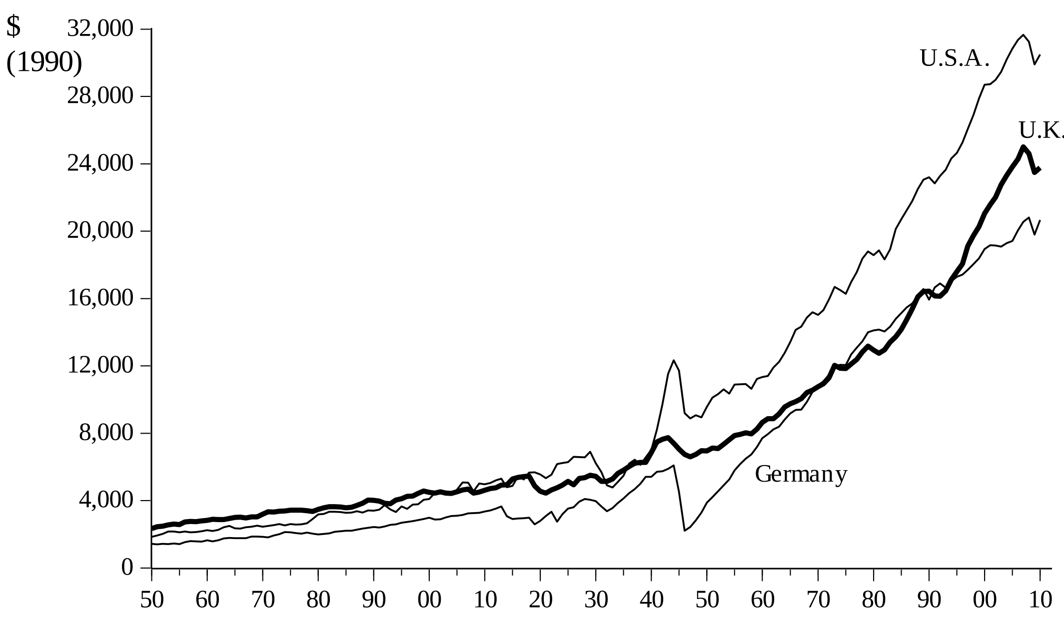
Figure 4. Institutions and total factor productivity



The is a large literature that describes the possible reasons why the industrial revolution took off in Britain. Crafts (1996) describes some of the social capital that existed at the time in Britain and helped foster growth.[16] He accredits Britain's superior growth performance to its ability to learn, adapt and improve upon technological discoveries made in other countries, an ability that is not easily captures by conventional measures of schooling. According to Mokyr (1993) British engineers were in high demand in other European countries due to their superior abilities. At the time, a large number of associations emerged in Britain that were designed to disseminate technological knowledge. In an economy open to free trade, receptive to foreign ideas, with well established property rights and engineering expertise, Britain came to excel at importing and improving upon foreign technological discoveries, what Mokyr (1993) has called "micro-inventions:"

The figure below shows data taken from Maddison[17] on real GDP per capita in Britain, the U.S. and Germany, starting in 1850.

Figure 5. Real GDP per capita in Germany, the U.K. and the U.S



Source: Maddison (GDP per capita in 1990 Int. GK$).

[16] The growth in 19th century Britain was quite modest by the standards of the 20th century. According to the numbers presented by Crafts, TFP growth in Britain between 1780 and1830 was similar to what Argentina experienced from 1960-1985 or 0.3% per year against 0.2% in Argentina.

[17] http://www.ggdc.net/maddison/maddison-project/home.htm.

Britain has the highest level of real GDP until 1905 when the U.S. becomes the leader. Germany grew more rapidly than Britain in the decades after WWII.

High productivity growth in Germany in the post-war period has been explained by delayed urbanization in Germany since Germany shifted resources out of agriculture and services later than Britain. Thus Broadberry (1993, 1997) finds that labor productivity in German manufacturing was already close to the British levels in the late 19th century while agriculture accounted for almost half of all employment in Germany in 1875 and less than a quarter in Britain in 1871. It follows that a significant part of the catching up of Germany to British overall productivity levels may possibly be attributed to urbanization and industrialization. Thus agriculture accounted for almost a quarter of employment in Germany in 1950 while the figure for Britain was just above 5%. Denison (1968) also concluded that urbanization abroad was the main cause of Britain lagging behind some of its European neighbors in terms of productivity growth in the period 1950-1962. Bean and Crafts (1996), in contrast, argue that Britain was also plagued by structural problems such as union behavior, generating a hold-up problem in Britain while others have mentioned the structure of British firms (such as Chandler, 1990). Broadberry and Crafts (1992) put the blame on a bargaining environment that allowed workers to maintain restrictive practices, and collusive agreements that limited the exit of inefficient firms.

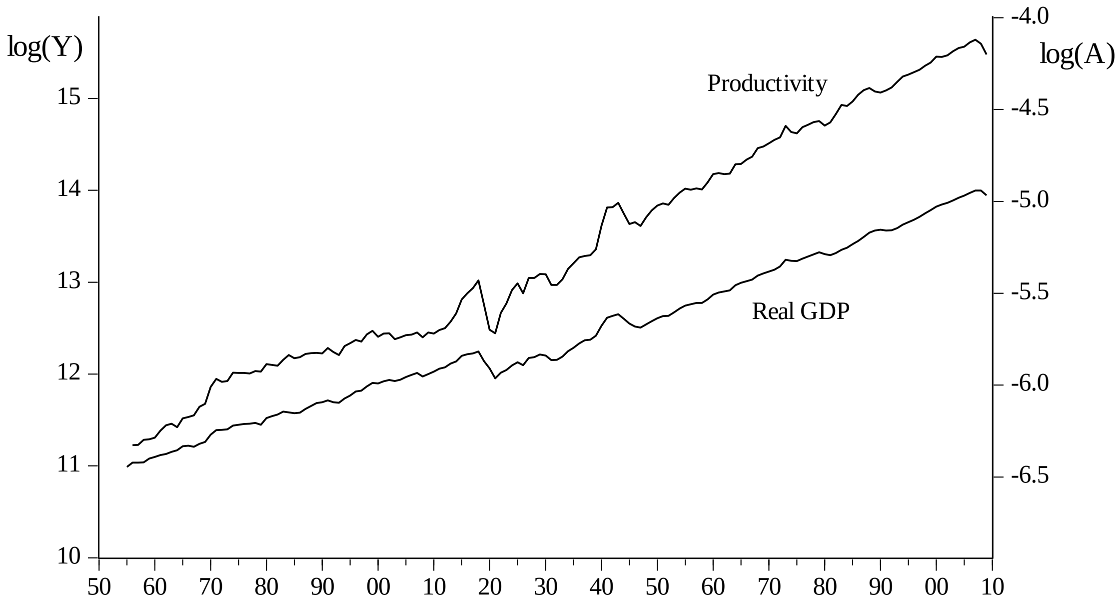
It is also not undisputed that the higher productivity levels of the U.S. in the early 20th century reflect a failure of Britain to attain similar growth rates. Following Habakkuk (1962) many economists have found that different factor endowments in the U.S. and Britain allowed different technologies to develop in the U.S. which could not be easily adapted in Britain. According to this thesis, American technologies were too capital- and resource intensive and too reliant on large markets for the European setting. This changed after WWII when American technology became more transferable.

The growth of output is in the long run primarily driven by technological progress. The figure below shows both real GDP in Britain as well as productivity calculated from equation (7).[18,19]

[18] The GDP numbers for 1270 - 1700 are from Broadberry (2011). Estimates up to 1700 apply to England. From 1700 - 1850 Great Britain, from 1851 onwards UK. Taken from www.bankofengland.co.**uk**/publications/.../threecenturiesofdata.xls.

[19] Labor share Mitchell (1988) and *Office for National Statistics*. Employment in heads Feinstein (1972) and Office for National statistics. Average weekly hours Mitchell(1988) and Office for National Statistics.

Figure 6. Real GDP and productivity in Britain in logs



Chained composite measure of GDP. Chained volume measure £mn, reference year 2006. Productivity calculated from equation (7) using the total number of hours worked as a measure of input.

From the figure one can spot several developments. First, there may have been a slight slowdown in growth of productivity at the end of the 19th century. Second, the trend growth of productivity is higher in the 20th century than in the 19th century. Third, productivity increased a lot during the two world wars. Fourth, there was a large fall in output, productivity (as well as hours of work) at the end of WWI and a slighter fall at the end of WWII.[20] Fifth, one can see a slight dip of productivity in 1926 due to the general strike, following years of austerity in the run up the adoption of the gold standard and also slight falls in the recessions of the early 1980s and the early 1990s and then the recent recession that reduced output in the financial sector.

The following equation can be estimated to test for regime changes between periods of high and low productivity growth:

$$log(A_t) = log(A_{t-1}) + g_t + \alpha \Delta log(N_t) + \epsilon_t \tag{8}$$

We first estimate one value for g, average growth of productivity A, and test for its stability

[20] Broadberry (1990) explains the fall in hours at the end of WWI and to a lesser extent WWII, by the wealth that accumulated during the war and increased the demand for leisure once the war was over. A similar effect could have reduced productivity.

over time and then subdivide the period 1857-2007 into four periods and test for the equality of growth rates across periods. In column (1) of Table 3 the average annual rate of growth of productivity *A* over the period 1857-2007 is 1.4%. The estimated coefficient is stable over time since it is not possible to find structural breaks.[21]

Table 3. Productivity growth by decade

Variables	(1)	(2)	(3)	Variables	(2)	(3)
Constant	0.014* (5.11)					
Δ(log(N))	0.31* (2.79)	0.39* (2.88)	0.32* (2.74)	1910s	0.014 (0.80)	
Time dummies				1920s	0.021 (0.89)	0.013* (2.65)
1850s		0.010 (0.73)		1930s	0.008 (0.91)	
1860s		0.021* (2.59)		1940s	0.022 (1.25)	
1870s		0.018 (1.95)	0.013* (2.48)	1950s	0.015* (2.87)	
1880s		0.003 (0.37)		1960s	0.022 (3.22)	0.017* (2.76)
1890s		0.007 (1.06)		1970s	0.014 (1.89)	
1900s		-0.002 (0.39)		1980s	0.015 (1.55)	
				1990s	0.016* (4.13)	0.016* (2.10)
				2000s	0.013* (3.33)	
Obs.	151				153	153
R-squared	0.05				0.10	0.04

t-ratios in parentheses. Significance at the 5% level indicated by *.

Column (3) has the estimated average growth rates for each decade. In spite of numerical differences between decades – and the large literature devoted to explaining episodes such as the climacteric in later 19th century – the differences between decadal growth rates are again not

[21] Testing for structural breaks in years 1900, 1950 and 1980 gives *F = 0.07* (*P=0.79*) for a break in 1900, *F=0.36* (*P=0.55*) for a break in 1950 and *F=0.045* (*P=0.83*) for a break in 1980, in all cases rejecting the hypothesis of a structural break in these years.

statistically significant.[22] When one replaces the decadal variables with dummy variables for the years 1850-1899, 1900-1949, 1950-1979, 1980-2007 we get the results shown in column (3) of the table. The first period is chosen as the golden age of Victorian growth. The period 1900-1948 as the period after technological leadership had been lost to the U.S.; then there is the post-war decades of interventionist policies and the post-Thatcher market economy. Once again there is not statistical difference between the growth estimates for the different periods.[23]

Following Nelson and Phelps (1966) we can distinguish between the discovery of new technologies and business practices and the local adoption of foreign ideas. These authors made the ability of a country in terms of technology adoption a function of its level of education and the technology gap between the technology leader and the country's level of technology;

$$\frac{\dot{A}}{A} = \Phi(E)\left(\frac{T-A}{A}\right) \tag{9}$$

where A is the level of domestic technology, T is the level of technology in the leading country, Φ measures the speed of adoption as a function of the level of education E[24]and T grows at rate λ. In the equation Φ measures the ability of a country to adopt new technologies while $T - A$ is a measure of the level of leading-edge technology that the country still has not adopted. It follows that the number of genuine innovations can be defined as the estimated residuals from the equation (9), which can be estimated as equation (10)

$$\frac{\dot{A}}{A} = \theta_i + \psi_i\left(\frac{T-A}{A}\right) + \varepsilon_i \tag{10}$$

where A is measure by the level of real GDP per capita taken from the Maddison data set and the countries included are countries included in the Maddison data set for the year 1850 and θ_i and ψ_i are country-specific coefficients. The leading country is defined to define the frontier which makes Britain the leader until 1905 and the United States ever since. Table 4 shows the results of the estimation of equation (10) for each of the countries.

[22] A Wald test gives *F=0.84* (*P=0.62*).

[23] The hypothesis that these four rates of growth are all equal cannot be rejected (*F= 0.14 (P=0.94*)).

[24] The solution to the differential equation is:

$$A(t) = \left(A_0 - \frac{\Phi}{\lambda + \Phi}T_0\right)e^{-\Phi t} + \frac{\Phi}{\lambda + \Phi}T_0 e^{\lambda t}$$

which implies that the equilibrium gap is;

$$\frac{T(t)-A(t)}{A(t)} = \frac{\lambda}{\Phi}.$$

Table 4. Estimated Nelson-Phelps equations

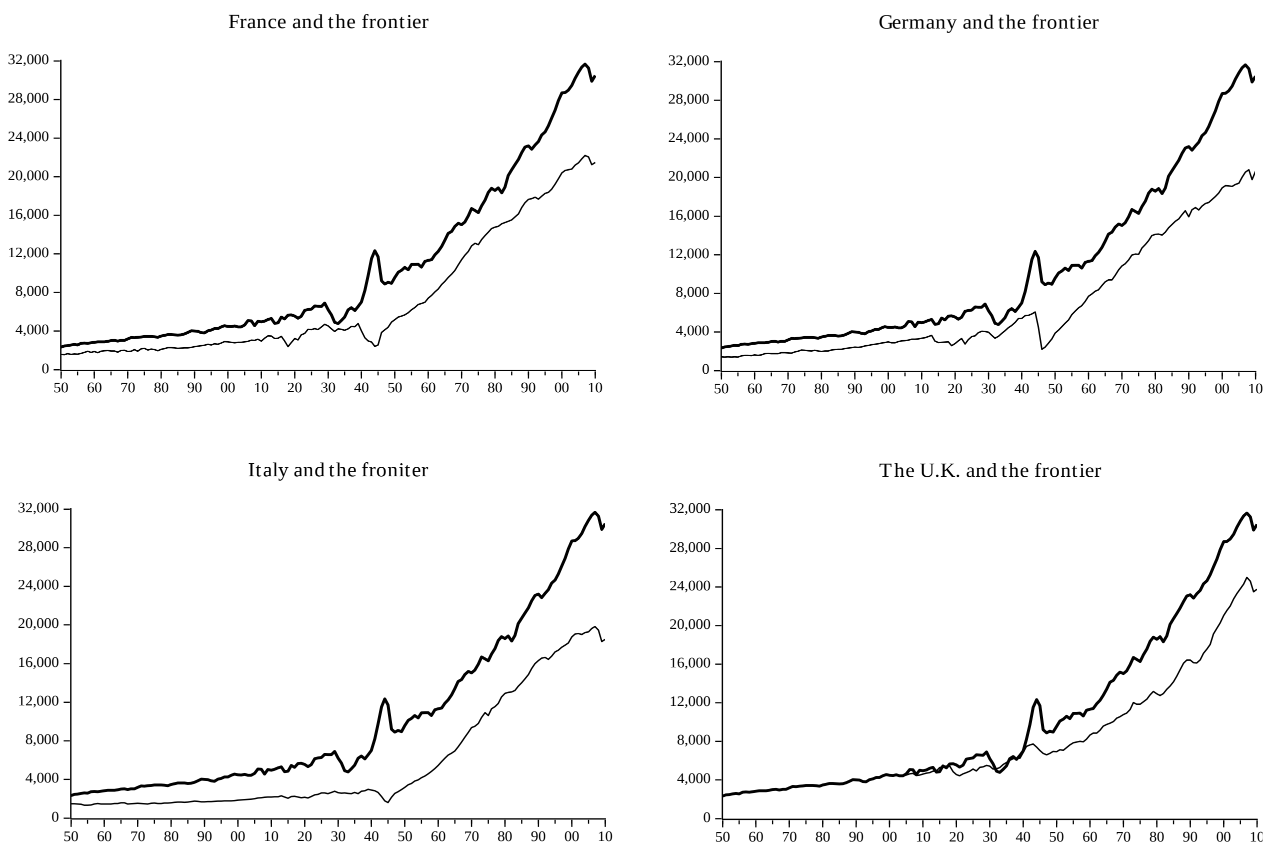
	θ		θ			ψ		ψ	
	1850-2010		1950-2010			1850-2010		1950-2010	
	estimate	t-ratio	estimate	t-ratio		estimate	t-ratio	estimate	t-ratio
Australia	0.608	1.09	-1.961	1.15	Australia	0.063	2.68*	0.128	2.39*
Austria	-0.537	0.45	0.664	1.39	Austria	0.031	2.51*	0.043	6.47*
Belgium	0.303	0.57	0.614	0.85	Belgium	0.034	2.93*	0.040	2.76*
Canada	0.607	0.72	-0.490	0.44	Canada	0.032	1.80**	0.102	2.37*
Chile	-1.930	1.14	-0.421	0.16	Chile	0.024	2.29*	0.013	1.04
Czech R.	-2.177	1.08	0.244	0.12	Czech R.	0.028	2.29*	0.012	1.01
Denmark	0.604	0.86	0.384	0.38	Denmark	0.025	1.60	0.065	1.81**
Finland	2.242	2.65*	0.790	0.84	Finland	-0.001	0.15	0.033	2.40*
France	-0.584	0.64	0.585	1.02	France	0.037	2.85*	0.042	3.44*
Germany	-0.758	0.66	-1.205	2.22*	Germany	0.037	2.47*	0.077	8.96*
Greece	-1.747	1.09	0.774	0.89	Greece	0.017	2.51*	0.015	3.36*
Ireland	2.527	3.01*	2.664	2.75*	Ireland	-0.001	0.12	0.003	0.45
Italy	0.373	0.49	0.455	0.83	Italy	0.010	1.81**	0.033	5.48*
Japan	1.992	1.69**	2.189	4.17*	Japan	0.002	0.43	0.019	5.37*
Mexico	-2.807	1.35	-1.304	0.40	Mexico	0.017	2.15*	0.012	1.02
Netherlands	-0.499	0.72	0.280	0.32	Netherlands	0.058	3.93*	0.057	2.42*
New Zeal.	0.643	1.10	0.989	0.88	New Zeal.	0.026	1.56	0.011	0.50
Norway	2.428	4.19*	1.820	4.67*	Norway	-0.004	0.62	0.025	2.81*
Portugal	1.743	1.75**	1.362	1.48	Portugal	0.001	0.22	0.010	2.18*
Spain	0.315	0.36	1.300	1.72**	Spain	0.009	1.78**	0.014	3.12*
Sweden	2.214	4.32*	0.377	0.38	Sweden	-0.003	0.54	0.060	1.98*
Switzerland	1.607	3.24*	1.846	5.53*	Switzerland	0.071	2.56*	-0.019	0.85
U.K.	0.968	3.08*	-2.084	1.26	U.K.	0.026	2.14*	0.107	2.51*
U.S.A.	1.139	2.48*			U.S.A.	0.088	2.61*		

Significance at the 5% level is indicated by a * while significance at the 10% level is indicated by **. Observations are 4809 for the longer sample and 2130 for the shorter sample. Equations estimated using weighted least squares.

The speed of convergence ranges between 0.5% and 10% for those countries where the estimated coefficient ψ is statistically significant from zero. The countries that have a statistically insignificant coefficient of the technology gap for the post-war period include; Argentina, Brazil, Chile, China, Czech Republic, Cuba, Indonesia, Ireland, Jamaica, Mexico, New Zealand, South Africa, Singapore, Sri Lanka and Switzerland. Of these the coefficient becomes statistically significant at the 10% level for Brazil since 1980, and Chile, Ireland, Mexico, New Zealand and

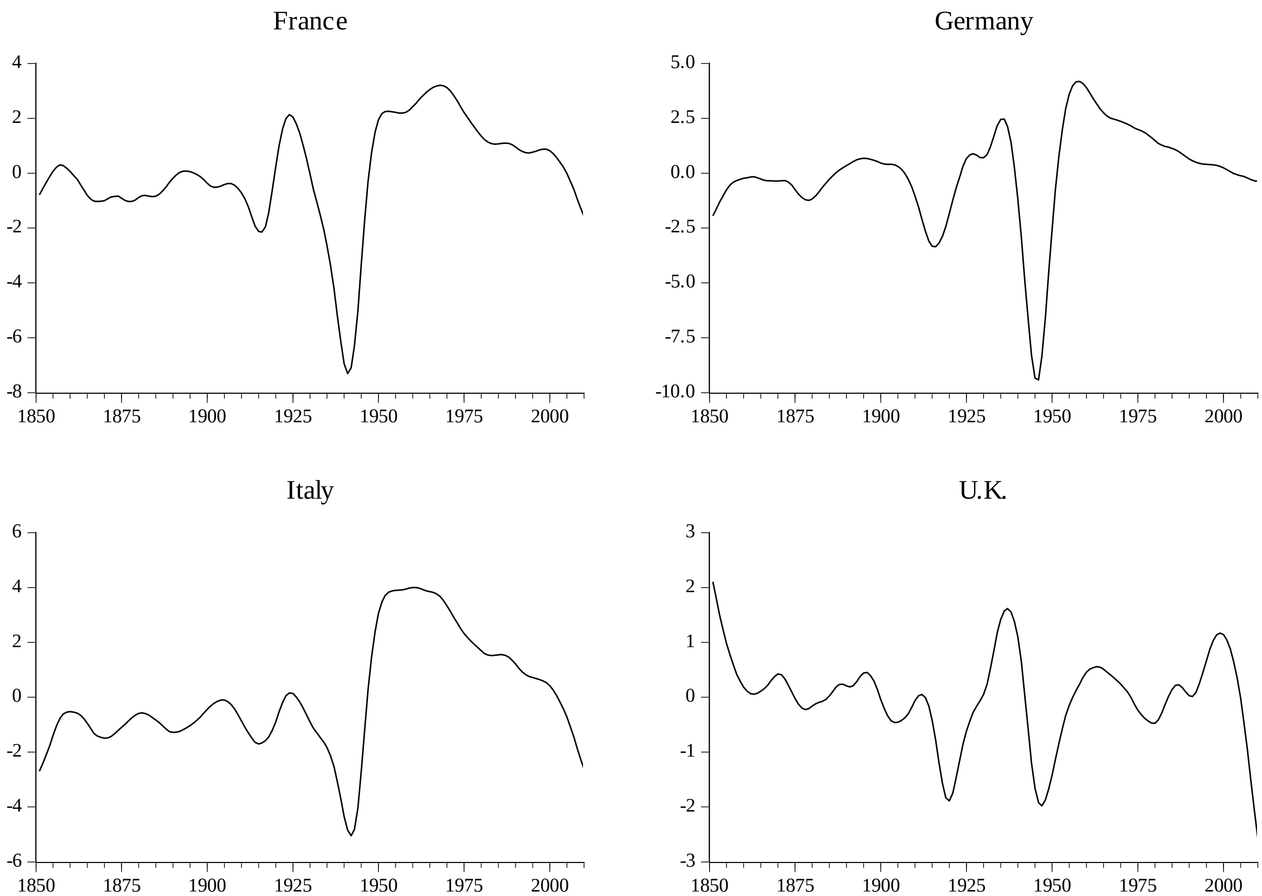
Switzerland since 1990. These cases can be explained by growth not falling when the technology gap diminishes or not rising when it increases. The cases of China and Singapore are clear in that growth in these countries has still not diminished although the gap has fallen, in the case of Singapore almost disappeared. In the figure below the gap between the level of GDP per capita in four European countries and the productivity frontier – defined as productivity in the U.S.

Figure 7. The productivity frontier and productivity in four European countries



The speed of convergence in Europe and also in Japan was much greater in the post-war period than in the first part of the 20th century. This is consistent with the findings of Nelson and Wright (1992) who found that American technology was more appropriate for Europe as factor-price differences narrowed and European markets became more integrated. The figure above reveals how the gap between each of the four countries' GDP per capita and the productivity frontier fell in the first two decades following the war and then increased again. What remains, that is the residual from equation (11), is shown in Figure 8 below.

Figure 8. Residual from estimated equation (11) – indigenous innovation



France and Germany share high growth in the 1930s – that is growth not explained by the catching up to the U.S. productivity frontier -- an output collapse at the end of WWII and then a strong recovery of productivity growth lasting into the 1970s and a slowdown ever since. Italy did not share the positive experience in the 1930s but also enjoyed the post-war boom. The plot for Britain is different, there is a much higher level of indigenous innovation in the 19th century – when the U.K. defined the frontier which made all growth indigenous, then the productivity boom in the1930s lasting into the 1940s, then a slowdown at the end of the war leading, a period of robust growth in the 1950s followed by a slowdown. What makes the U.K. plot different is the growth in output per capita in the 1980s and 1990s in addition to the 19th century growth.

Using the same sample of 30 countries taken from the Penn World tables, defining U.S. productivity as the technology frontier, and again using the productivity estimates from equation (7) yields the results for equation (10) reported in the table below.

Table 5. Estimation of equation (10)

	Estimate		t-ratio
Constant	-0.583		1.6
$100 * (T - A)/A$	0.027		6.1
Observations:	1123	F-statistic	2.85
Cross sections:	29	Durbin Watson	1.91
R-squared	0.06		

Estimation method: Fixed effects estimator. Growth of productivity is written in percentages.

The coefficient of the technology gap is 0.027 so that 2.7% of the gap between the U.S. and each of the other countries is closed per year on average.

4. The future: Institutions and technology

Some observers of the latest technology innovations in the West have doubted its significance and lasting effect on productivity growth once their effects on productivity in the production of IT equipment and the applications of IT equipment to other industries have been exhausted.[25] Gordon (2012) claims that inventions since 2000 have mainly taken the form of much smarter entertainment and communication devices without having a big impact on productivity or the standard of living in the way that electric light, cars or indoor plumbing did. That Adam Smith apparently did not notice the beginning of what has been called the first industrial revolution

[25] See Gordon (2000) and Gordon (2012), amongst others.

should teach us humility in the prediction of future technological developments. Two types of uncertainties have to be recognized. First, technological innovations take a long to be implemented through a series of micro-inventions (see Mokyr, 1990). Second, new technologies affect the evolution of institutions as described by Eggertsson (2007).

The lag between the invention of new technology and its application may be long due to a long learning process and adjustment costs, the latter taking the form of the reorganization of industry in terms of location and networks. It took about half a century of innovations and costly investment before electricity had made its full impact on productivity in the United States. Thus the replacement of power of water and steam by electricity required the reorganization of the production process when each factory acquired its own electrical motors.[26] Crafts (2004) finds that steam had its peak impact about a hundred years after its invention.

Technology may gradually affect the institutions of the economy and the political system. However, this may also taka a long time. Organizations for collective actions, such as unions, take a long time to emerge and to change. The effect of the first industrial revolution on organizations and institutions took was delayed and much greater than what could have been anticipated. The first modern trade union, the *Amalgamated Society of Engineers* in Great Britain, was founded in 1851, a century after the beginning of the Industrial Revolution. In the U.S. union membership grew fastest in the 1930s and 1940s, long after the industrialization of the country.[27]

The essence of the latest technological innovation is to facilitate communications between people and increase access to data. The effect is to both instantly connect people who would otherwise not have had the possibility to exchange ideas and experiences and to allow them to gather information online without intermediaries such as newspapers, television anchors or political parties. Thus the marginal cost of gathering and spreading information has fallen dramatically. This brings us to some very Phelpsian ideas. The more people are engaged in innovation the more innovations there will be. By connecting hundreds of millions of people in countries such as China to the rest of the world the effective world population is greatly increased due to the internet and the micro-inventions such as Facebook and Twitter. Increased communications between people may also further foster innovations and improve the standards

[26] See Eggertsson (2007), Devine (1983) and David (1990).
[27] Both examples are taken from Mancur Olson (1982).

of education. Big changes in the evolution of the organization of businesses and institutions may occur.

Competition in markets may increase by making consumers more informed about the existence of different products, their price and quality. The imperfectly informed consumer of Phelps and Winter (1970) can now compare supermarket prices online and buy groceries without ever leaving his home. Clearly, a price increase in one supermarket will more quickly make customers turn elsewhere. Someone considering buying a car in the European Union's single market can now compare prices in different countries with the effect of local monopolies not being able to extract as large a monopoly rent. Consumers can now read online product reviews and watch programs where products are compared. They can plan their vacation by checking out hotels online, observing cities through "google-map," compare prices and make reservations at home.

The educational system is gradually being transformed. Universities post lectures online making them tradable goods. This may increase competition in education by both allowing people to listen to lectures offered in foreign schools and universities as well as to learn about the quality of teaching in different universities. New in-class teaching methods are being developed which allow teachers to constantly monitor students' progress and intervene quickly when they get into trouble. Internet schools have emerged such as the Kahn Academy (https://www.khanacademy.org/) where online lectures in history, economics, finance, the sciences and mathematics are offered. Students and professors now access almost all data online, use online journals and can buy books over the internet. Teachers use programs to detect cases of plagiarism.

The new technology allows people who reside in different cities and countries to work together as if they were sharing an office. Using Skype they can have face-to-face meetings at almost zero cost. Using Dropbox they can keep documents in a place accessible to both. People working away from their office can access all their data files from remote locations. These developments may have an effect on the evolution of cities, making it less important for people to live at close quarters. They also enable creative individuals in otherwise backward or repressive countries to connect with like-minded people.

The effects of the new technologies can also be found in political organizations and political activity. Organizations of collective action may now take less time to organize and these can better keep in touch and serve their members. Unions have websites where members can access different services and monitor union activity.[28] Political parties can access potential voters and the latter can more easily contribute money. The cost of gathering information in order to make a decision on voting or current affairs has fallen dramatically. A president who wants to take a country to war will now not only have to be concerned about several television news anchors and newspaper editors but a the whole adult population following events in real time and having access to a whole array of viewpoints by both sensible and not so sensible observers. The effectiveness of expressing extremist views has increased leading to political fragmentation. Such fragmentation is now visible in the Middle East where Egypt is close to a state of anarchy following mass protests in early 2011. Clearly, unmonitored information on the internet can be informing and misleading, lacking any moderation by an editor, the information may in some cases challenge prevailing powers but also sometimes be deceptive and destabilizing. Meanwhile Syria is fighting against the dissemination of information and the formation and organization of opposition groups over the internet by sometimes disabling mobile phone networks, landlines and the Internet in addition to monitoring internet use and arresting individuals for reporting information online. Passwords of social media sites are extracted through torture.[29]

Protesters in the streets of Cairo and Tunis used Twitter and Facebook in coordinating their moves and sharing information. Research by Ingmar Weber and Venkata Garimella used computers to study millions of tweets in Egypt from June 2012 to June 2013 and measures whether the two camps – the secular and the Islamic – have become more polarized in what they tweet, that is whether the tweets were on topics that unite or divide the two groups of Egyptians. The results suggested a significant increase in polarization over the past year.[30] The polarization effect can have terrible consequences when like-minded extremists connect across borders reinforcing their perceptions of the world, prejudices and views. One recent example is that of the Norwegian Anders Breivik who killed over sixty teenagers and a total number of 79 people, most of whom were teenagers pending a weekend in a summer camp in July 2011. He would have found it difficult to locate and interact with like-minded Norwegians in Oslo. Using the new technology he could study data on population development, read philosophy and interact with British extremists who shared his world view. Not surprisingly he posted a justification for the

[28] See Diamond and Freeman (2002).
[29] See Ian Thomson, 29 November 2012, "Syria cuts off internet and mobile communications," The Register.
[30] See Gillian Tett, "Tweets apart," *Financial Times*, 6 September.

murders on Youtube in addition to a 1500 page long online document. According to Breivik, the main motive behind the murders was to promote the online distribution of his document where he explains the threat posed by Marxist and Islamic elements to Western culture. He practiced shooting before the incident by playing the *World of Warcraft* and *Call of Duty: Modern Warfare*. The use of these computer games is what Breivik had in common with a socially fragile individual who was captivated by warfare video games[31] who committed the Newtown massacre in December 2012.

In an attempt to monitor the communications of like minded extremists and hence prevent the occurrence of terrorist acts, the CIA and the NSA have engaged in mass surveillance programs, recently revealed by the leaks of Mr Edward Snowden. The leaks were instantly known to the outside world, both friends and foes, and the fate of Mr Snowden could be followed online. The world is thus trying to find a balance in order to ensure positive and constructive interactions on the internet and monitoring or preventing acts of violence.

5. Conclusions

There is a complex relationship between technology and institutions. While the study of each country's economic history is needed in order to understand the evolution of institutions; a rather simple pattern emerges in the data on productivity and real GDP per capita. Already during the first industrial revolution one can see the emergence of two groups of countries, the high and the low GDP per capita countries. The 1910 this group includes Britain, the U.S., the British colonies of Australia and New Zealand and Canada, in addition to Austria, Belgium, Denmark, France, Germany and the Netherlands. This list of countries belonging to the high productivity group has not changed much over the past century when only countries for which Madison had numbers for in 1850 are included. There are only a handful of new members; Sweden, Norway, Japan, Italy and Spain. Using a larger data set of 124 countries one can add Hong Kong, Singapore, Malta, Taiwan, the Czech Republic and South Korea to this list.

A set of five institutional variables is sufficient to make the distribution of productivity in a sample of 124 countries unimodal, hence eliminating the clear distinction between the two sets of groups. These are, perhaps not surprisingly, a measure of bribes and favoritism, a measure of the

[31] New York Times, 28 February, 2012.

quality of the legal system, a measure of the enforcement of contracts, the cost of starting a business and taxes on trade.

Studying the long-run growth performance of the British economy one is struck by the difficulty of finding statistically significant breaks in the growth of productivity. The British history draws attention to the importance of paying attention to each country's institutional structure, factor endowments and economic history.

The question remains whether a decline has set in for productivity growth in the West. There is at this point uncertainty about the effect of the new technologies on institutions in the West in addition to the unavoidable uncertainty about the extent and nature of future technological discoveries. That Adam Smith may not have noticed the beginning of what has been called the first industrial revolution should make us hesitate before proving a definite answer to this question. The new technologies may affect and be affected by the institutions of corporatism in many western countries. Vested interests may resist the introduction of the new technologies slowing down growth while the new technology may make existing organizations of collective actions splinter.

As a final thought, Robert Solow is quoted as saying that we can see the computer revolution everywhere except in the productivity statistics. In view of the pervasive effect the internet/computer/cellphone revolution is having on people's lives one might conclude that there is something wrong with the productivity statistics.

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Real GDP per capita, 1850 sample									
1880		1910		1930		1970		2010	
Rich countries									
Australia	2.40	N. Zealand	1.62	USA	1.93	USA	1.93	USA	1.84
N. Zealand	2.10	Australia	1.58	Netherlands	1.74	Sweden	1.64	Norway	1.69
Britain	1.95	USA	1.51	Britain	1.69	Denmark	1.63	Australia	1.54
USA	1.79	Britain	1.40	Denmark	1.66	Canada	1.55	Sweden	1.52
Belgium	1.72	Canada ↑	1.24	Belgium	1.54	Australia	1.55	Canada	1.50
Netherlands	1.64	Belgium	1.24	N. Zealand	1.54	Netherlands	1.54	Netherlands	1.46
		Argentina ↑	1.16	Canada	1.49	France	1.47	Austria	1.45
		Netherlands	1.15	Australia	1.46	N. Zealand	1.44	Britain	1.43
		Denmark ↑	1.13	France	1.41	Germany	1.40	Belgium	1.42
		Germany ↑	1.02	Uruguay	1.33	Britain	1.39	Denmark	1.42
		Austria ↑	1.00	Sweden ↑	1.31	Venezuela	1.37	Finland	1.40
		Uruguay ↑	0.95	Argentina	1.27	Belgium	1.37	Japan	1.32
		Chile ↑	0.91	Germany	1.23	Norway	1.29	France	1.29
		France ↑	0.90	Norway ↑	1.12	Austria	1.25	Germany	1.24
				Austria	1.11	Japan ↑	1.25	N. Zealand	1.14
				Venezuela↑	1.07	Finland ↑	1.23	Italy	1.12
				Czech. ↑	0.91	Italy ↑	1.21	Spain ↑	1.01
Theshold	**1.6**		**0.85**		**0.9**		**1.00**		**0.90**
Poor countries									
Denmark	1.22	Sweden	0.77	Finland	0.83	Argentina↓	0.94	Greece	0.89
France	1.19	Norway	0.66	Italy	0.82	Czech.sl. ↓	0.83	Portugal	0.86
Uruguay	1.17	Italy	0.66	Spain	0.81	Spain	0.81	Chile ↓	0.84
Austria	1.17	Czeh.sl.	0.61	Greece	0.70	Greece	0.80	Czeck.R.	0.78
Germany	1.12	Finland	0.58	Japan	0.57	Portugal	0.70	Uruguay ↓	0.69
Canada	1.02	Spain	0.58	Mexico	0.50	Chile ↓	0.67	Argentina ↓	0.62
Chile	0.98	Mexico	0.51	Portugal	0.49	Uruguay ↓	0.67	Venezuela	0.59
Spain	0.92	Greece	0.49	Colombia	0.46	Mexico	0.56	China	0.48
Argentina	0.90	Japan	0.40	S. Africa	0.44	S. Africa	0.52	Mexico	0.46
Italy	0.89	Portugal	0.37	Sri Lanka	0.39	Jamaica	0.50	Colombia	0.43
Norway	0.85	Sri Lanka	0.37	Indonesia	0.34	Colombia	0.40	Brazil	0.41
Sweden	0.83	S. Africa	0.35	Brazil	0.32	Brazil	0.39	Sri Lanka	0.32
South Africa	0.81	Venezuela	0.27			Cuba	0.25	S. Africa	0.31
Greece	0.71	Indonesia	0.25			Sri Lanka	0.19	Indonesia	0.28
Finland	0.65	Colombia	0.24			Indonesia	0.16	Jamaica	0.22
Cuba	0.62	Brazil	0.23			China	0.10		
Portugal	0.53								
Japan	0.48								
Sri Lanka	0.47								
Brazil	0.42								
Colombia	0.40								
Venezuela	0.38								
Indonesia	0.37								
Jamaica	0.30								

Figure A1. Capital-output ratios