Revised version

What Makes a Country Socially Capable of Catching Up?*

by

Pär Hansson & Magnus Henrekson**

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Abstract: In this study we test whether social capability promotes catching up, the hypothesis that there is technological spillover from leaders to followers. A simple model that captures the hypothesized interaction is presented and tested on an extended sample of countries. The stock of human capital and the degree of integration into the world economy are used to measure social capability. Both measures are important in determining the degree to which the catching-up potential is realized. We also find an independent effect of increased trade intensity and trade regime on productivity growth.

JEL Classification: O4 (O41 and/or O47)

Keywords: Catching up, Convergence, Human capital, International trade, Social capability, Technological spillover, Technology gap.

Trade Union Institute for Economic Research, FIEF
Wallingatan 38
S-111 24 Stockholm
SWEDEN

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**Correspondence may be addressed to either of the authors at the address indicated.

1. Introduction

In recent years there has been great interest in the question of whether there is convergence in income and productivity levels across countries. Generally, these studies are undertaken in either of two different traditions. First, in the neoclassical growth model pioneered by Solow (1956), the rate of return on investment and the rate of growth of output per capita are expected to be decreasing functions of the capital stock per capita. As a corollary, poor and rich countries would tend to converge in terms of levels of per capita income. Second, based on the premise that it is much easier for late-comers in terms of economic development and industrialization to imitate already existing technologies than it is for the technologically leading country(ies) to advance the technological frontier through innovation, one should expect a long-run tendency towards convergence of per capita income or productivity levels. This is often referred to as the catching-up hypothesis. At least in the simple versions of these two theories, an expected eventual income convergence implies that at any point in time poorer countries should be growing at a faster rate than richer countries.

Although the predictions of the two theories are identical, the theoretical points of departure are virtually antithetical. In neoclassical growth theory it is assumed that all countries have access to the same technology, whereas the catching-up hypothesis assumes that countries are at different technological levels and that diffusion of technology from leaders to followers is the main driving force towards convergence. The work presented in this paper follows the latter tradition.

The purpose of our paper is to test the catching-up hypothesis on as large a sample as possible. We try to operationalize the effect of the various modifications of the simple catching-up hypothesis which have been suggested in the literature. Notably, we suggest and test a model which incorporates the effect of differences between countries in their social capability to adopt technology from abroad.[1]

Our main finding is that the level of social capability is an important factor in determining the degree to which the catching-up potential is realized in different countries. In an extension of our basic model, an independent effect becomes evident, namely of increased trade intensity and trade policy orientation on productivity growth.

The paper is organized as follows. In section 2 the catching-up literature is reviewed, and it is found that studies incorporating the effect of social capability for a sample including both developing and developed countries are lacking. In section 3 a simple theoretical model is presented. The following section contains definitions and data descriptions. In section 5 we present our basic results, and in section 6 we extend the model in order to account for other potential effects of trade and trade policy. In the last section we state our conclusions.

2. The Catching-Up Hypothesis: Does Anything Remain to Be Done Empirically?

The idea of catching up can be traced back at least to Gerschenkron (1952), who argued that regarding the growth prospects of a country there may exist an advantage of "relative backwardness". The hypothesis says that when the productivity level is much higher in one or more countries compared to a number of other countries, the latter have an opportunity to embark on a catching-up process by borrowing superior production techniques from the more advanced economies. Hence, we should expect technologically less advanced countries to grow faster than the technologically leading country(ies). But, it should be stressed that this is a potentiality that need not be realized. Another necessary condition for catching up is a sufficient degree of "social capability", i.e., the laggard country must be sufficiently sophisticated to be able to adopt the superior technology. Therefore, one should expect catching up to be strongest in countries that are technologically backward, but socially advanced.

A major problem with the concept of social capability is its imprecision. As Abramovitz (1986, p. 388) puts it: "no one knows just what it means or how to measure it". Despite these problems he proceeds to enumerate a number of factors that are important determinants of a country's social capability: the level of education, the organization of firms, openness to foreign competition, the ease by which new firms can be established, the power of vested interests in opposing change, the functioning of the labor market and the degree of competitiveness in domestic product markets. Stern (1991) has identified a number of other factors that are potentially important, notably managerial competence and the quality of infrastructure including features of the social infrastructure such as honesty, benevolence of the bureaucracy, and how clearly property rights are defined.

The simple catching-up hypothesis has received strong support in a great many studies. Abramovitz (1986) and Baumol (1986) find a strongly significant negative correlation between the initial level of labor productivity and its rate of growth during the 1870–1979 period for the 16 developed countries studied by Maddison (1982).[2] On the other hand, De Long (1988) points out that Maddison's 16 countries is an *ex post* selection of countries that have developed successfully. Thus, convergence is practically guaranteed in the statistical analysis. De Long shows that an *ex ante* sample of nations relatively rich in 1870 and well-integrated into the world economy in 1870 have not converged.

But if catching up is caused by technological spillover to follower countries, one should actually expect convergence in total factor productivity (TFP) rather than in GDP per capita. An observed convergence in labor productivity or GDP per capita can be the result of different rates of capital accumulation per capita. If that is the case, convergence is falsely attributed to technological catching up. Catching up in TFP is examined by Dowrick and Nguyen (1989). They find TFP catching up for the period 1950–85 for all countries but the very poorest. Although Dowrick and Nguyen test TFP catching up, they have no data on the (relative) levels of TFP to measure the potential for catching up. Instead catching up potential in this and other studies is proxied by GDP per head relative to the U.S. at the beginning of the studied period.[3] Obviously, this study and other studies based on a sample restricted to the richest countries are subject to the *ex post* selection criticism.

A further criticism of tests of catching up in the group of industrialized countries is that starting from the 1970s it is unlikely that one country (the U.S.) can be called the undisputed technological leader for all industries. Rather, it is more likely that technological leadership in different industries resides in different countries. If this claim is correct, catching-up studies restricted to the richest countries should be made at a disaggregated level. Results from Hansson and Henrekson (1994) indeed indicate that the potential for catching up among the richest countries was depleted by the late 1960s in the tradables sector.

Neither the *ex post* selection problem nor the problem of identifying the technological leader is serious when the sample of countries is extended as far as data availability permits, such as when the Summers-Heston (1988,

1991) data is used. But in that case, as documented by several scholars (e.g., Baumol and Wolff (1988), Romer (1989a), and Barro (1991)), the growth rates are not found to vary systematically with initial income per capita alone.

In the tradition of neoclassical growth theory, this anomaly from the viewpoint of the original Solow model – where poor countries are predicted to grow faster due to transitional dynamics towards the steady state – has recently been "solved". In particular, Mankiw, Romer and Weil (1992), Barro (1991) and Barro and Sala-i-Martin (1992) add human capital as an additional factor of production in the Solow model and introduce a number of conditioning variables as determinants of each country's own steady state (fertility, savings rate, government expenditures, degree of political instability, type of economic system, market distortions, and continental dummies for Africa and Latin America). In that framework, initial income per capita provides a measure of how far removed each country is from its specific steady state, and the expected negative coefficient for initial income reappears. The interpretation of initial income (or productivity) in the catching-up literature is very different; there it measures the potential for faster growth thanks to adoption of superior technology from other countries. In short, the fundamental difference between the two approaches is that in neoclassical growth theory the level of technology (or at least its rate of change) is assumed to be equal across countries, whereas in the catching-up tradition the main premise is the difference in technology levels.

There is plenty of evidence that an assumption of equal technology across countries is unrealistic. Helliwell and Chung (1992) report evidence that rejects the hypothesis of constant rates of technological change across countries. Romer (1989b, p. 5), after a survey of the growth literature, concludes that "the neoclassical model … has little explanatory power in comparisons of growth rates across countries; most of the action is in the exogenous variation in the rate of technological change". Easterlin (1981) argues strongly that the transfer of technology is largely a person-to-person process, which also points towards the presumption that technology differs across countries as long as there are important differences in learning capability. These considerations lead us to conclude that the catching-up hypothesis is *a priori* a more fruitful approach.[4]

As already mentioned, a number of studies have tested the catching-up hypothesis on the Summers-Heston countries. Generally, no simple correlation between growth and initial income or productivity is found. However, few attempts have been made to operationalize the concept of social capability for an extended sample of countries,[5] although it has been dealt with explicitly for industrialized countries by Alam (1992) and Heitger (1993). However, the latter two studies treat social capability as an independent explanatory factor, rather than as a factor that interacts with the catching-up potential to determine the realization of catching up. In this paper we will try to fill that gap, but before we proceed to the empirics a simple theoretical framework will be presented.

3. The Model

The model we use to examine the catching-up process takes its point of departure in a quasi Cobb-Douglas production function with Hicks-neutral technical change. Total production in each country is assumed to be determined as:[6]

$$Y = A\mathrm{f}(K)L^{\delta} \tag{1}$$

where Y is GDP, K is the capital stock and L total employment. A denotes the technological level (the level of total factor productivity, TFP). As will become clear in the next section it is more appropriate to start out from GDP per employed:

$$y = \frac{Y}{L} = A\mathrm{f}(K)L^{\delta - 1} \tag{2}$$

Differentiation with respect to time and some rewriting gives us an expression for the relative growth of output per employed:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \mathrm{f}_K\left(\frac{\dot{K}}{\mathrm{Y}}\right) + \left(\delta - 1\right)\frac{\dot{L}}{L} \tag{3}$$

As we saw in the previous section, many authors have stressed the difference between potential technological spillover (dependent on the technological difference between the leading country and a follower), and the actual spillover (determined by the interaction between the technological gap and the follower's social capability). This idea can be formalized in a model that draws on Nelson and Phelps (1966).[7] Let us assume that in every period the relative change in the technological level is proportional to the technological gap:

$$\frac{\dot{A}}{A} = \Phi(s)\left(\frac{T - A}{A}\right), \quad 0 < \Phi \leq 1 \tag{4}$$

T denotes the technological level in the leading country, and s is the social capability. Φ measures the speed at which the technology in the leading country is absorbed by the less advanced country. Φ is assumed to be positively related to the social capability of the country, i.e., $\Phi'(s) > 0$.

If we postulate that T grows exponentially at the rate λ in (4) and then solve the resultant differential equation, we can see that A evolves as

$$A_t = \left(A_0 - \frac{\Phi(s)}{\Phi(s) + \lambda} T_0 \right) e^{-\Phi t} + \frac{\Phi(s)}{\Phi(s) + \lambda} T_0 e^{\lambda t} \tag{5}$$

As usual the second term on the right-hand side denotes the evolution of A in the steady state (A^*), while the first term captures the part of the evolution that is attributable to the out-of-steady-state effect. It is easy to show that the technological gap in the steady state will be:

$$G = \frac{T - A^*}{A^*} = \frac{\lambda}{\Phi(s)} \tag{6}$$

Figure 1 about here

From our assumptions it also follows that increased social capability in a country reduces the steady-state technological gap. Thus, a country with a greater social capability will have a higher equilibrium level of technology and a smaller technological gap than an otherwise identical economy. This result is depicted in *Figure 1*, where the two ($\dot{A}/A$)-schedules represent different rates of growth of A corresponding to a high (s_H) and low (s_L) social capability, respectively.

There are two interesting cases that may be used to shed some further light on the diffusion mechanism. First, consider two countries with the same social capability s_L, but with initially differing technological gaps G_1 and G_2, i.e., the two countries start out in points a and b, respectively. The country with the larger technological gap will grow faster than the country with the smaller gap, but both countries will eventually converge to point c, where $\dot{A}/A$ equals λ and the equilibrium gap is $\lambda/\Phi(s_L)$. Second, consider two countries with different social capabilities s_H and s_L, but with the same initial gap G_1. In this case the country with the higher s will have a faster

$\dot{A}/A$. Eventually, $\dot{A}/A$ approaches λ in both countries, and the technological gaps converge to the steady state values corresponding to the respective levels of social capability. The country with the higher s moves from d to e, while the country with the lower s moves from a to c.

As we saw in the previous section there are a number of factors that may be important in determining the social capability of a country. Assuming there are n such factors, we may write $s = s(s_1,\ldots\ldots, s_n)$, and therefore $\Phi = \Phi(s_1,\ldots\ldots, s_n)$. In order to arrive at an equation that can be estimated empirically, we simply assume that each factor interacts directly and in a linear fashion with the technological gap in determining the rate of technological change. Following the empirical practice of many others[8] we measure the technological gap as $\log(\tau_i/\tau_l)$, where τ_i is the technological level in country i, and τ_l the technological level in the leading country. Given these simplifications $\dot{A}/A$ in country i is assumed to be determined as:

$$\frac{\dot{A}}{A} = \alpha + \sum_{j=1}^{n} \beta_j \log\left(\frac{\tau_i}{\tau_l}\right) s_j \tag{7}$$

where s_j denotes the j:th variable determining the social capability of absorbing technology from abroad. In the next section we will try to identify the potential s_j variables.

Inserting (7) into (3) gives us our basic regression equation:

$$\frac{\dot{y}}{y} = \alpha + \gamma_1\left(\frac{\dot{K}}{Y}\right) + \gamma_2\left(\frac{\dot{L}}{L}\right) + \sum_{j=1}^{n} \beta_j \log\left(\frac{\tau_i}{\tau_l}\right) s_j + \varepsilon \tag{8}$$

4. Definitions and Data Description

In order to estimate (8) empirically we must identify the potential s_j variables. As already noted a number of determinants of a country's social capability have been suggested. In practice, lack of data restricts the choice of s_j. An obvious candidate is the stock of human capital in a country; a larger stock of human capital makes it easier for a country to absorb the new products or ideas that have been discovered elsewhere.[9]

In order to construct the human capital variable we draw on data published in the *UNDP Human Development Report* (1990, 1991 and 1992). The stock of human capital, *HUM*, is defined as a weighted average of adult literacy rate in the population aged 15 or more (% 15+) during the period 1960–85 (*MLIT*) and mean years of schooling in the population aged 25 or more (25+) 1980 relative to the US (*RSCH80*). Mean years of schooling was highest in the US. The weights are the same as UNDP uses to calculate educational attainment in different countries:

$$MLIT = \frac{1}{3}(LIT60 + LIT70 + LIT85)$$

$$HUM = \frac{2}{3}\ MLIT + \frac{1}{3}\ RSCH80$$

In our view, although still a proxy, we believe this is a better measure than either the literacy rate or the enrollment rate in secondary schooling, which are the measures used in almost all other studies. Enrollment rates are flow rather than stock variables, and literacy is but one aspect of the level of human capital. Furthermore, among the developed countries the variation in literacy rates is extremely limited, despite the fact that there is substantial variation in educational levels even across countries at a higher level of development. At least to some degree, *HUM* avoids these limitations of other measures.

A second potential factor determining the level of social capability is a country's degree of integration into the world economy. Several arguments have been put forward why greater participation in international trade promotes catching up and growth.[10] First, it is commonly believed that international transfers of technology are related to trade flows. Imports of goods and services developed by trade partners bring about more effective use of existing resources in the importing country and thereby raises the country's productivity level. Second, there is the obvious argument that the greater the part of the economy that is exposed to international competition, the greater the exposure to superior technology and the greater the pressure to adopt such technology in order to remain competitive (Baumol, 1986; Alam, 1992). Third, Lewis (1955) argues that new ideas will be accepted more quickly in countries where people are accustomed to change, while in isolated countries a rapid absorption of new ideas is unlikely.

We use a straightforward measure to capture the effect of international integration on social capability: the trade intensity ratio, defined as the sum of exports and imports relative to GDP, *OP*. Obviously, this measure has its shortcomings as an indicator of a country's trade policy; other factors than the trade regime may influence a country's trade intensity. The trade intensity tends to be lower in large countries with a great deal of interregional rather than international trade. Countries may be unevenly endowed with some factors of production and because of that they have a higher trade intensity. For our purpose, those deficiencies are less severe. We consider trade as a channel of international technology transfers and then it probably does not matter whether the amount of trade is induced by differences in factor endowments, proximity, cultural ties or trade policies. Yet, we admit that the trade intensity ratio is a far from perfect measure.

Unfortunately, due to lack of data these are the only determinants of social capability that are amenable to empirical testing. In our view, empirical proxies for other determinants are too crude to merit inclusion in the estimations.[11]

The data source for all variables except *HUM* is Summers and Heston (1991). As the dependent variable we use GDP per worker, y, unlike most other studies which use GDP per capita. The catching-up hypothesis predicts convergence in TFP, not in GDP per capita. Lack of data on capital stocks forces us to use y as a proxy for TFP. Therefore the simplest test of catching up, that is, whether there is a negative correlation between initial TFP and subsequent growth in TFP across countries, cannot be carried out, and we have to use y instead. For this reason it is more convenient to formulate the model in terms of y throughout.

Assuming a constant marginal productivity of gross investment across countries, $\dot{K}/Y$ can be proxied by investment as a share of GDP, I/Y.[12] The growth rates used in the regressions for country i are calculated as averages over a period $t = 0$ to $t = T$ as

$$\frac{\dot{X}}{X} = \frac{(\log X_{iT} - \log X_{i0})}{T}$$

where X_i denotes Y_i or L_i. The same formula is also used to calculate the relative change in the trade intensity ratio, $\dot{OP}/OP$, which will be used in section 6. I/Y and OP are the respective arithmetic means during the studied period. τ_i/τ_l is proxied by initial y_i/y_l. The United States is taken to be the leading country in all regressions (subscript US). Due to data limitations only 81 countries can be included in the regressions. Appendix I contains a complete list of included countries.

Table 1 about here

In *Table 1* some descriptive statistics of the variables used are shown. It is noteworthy that (1) there are large variations between countries in all variables, (2) the rate of growth is on average considerably lower in the later period, and (3) there is a slow-down and in many cases even reversal of the process towards increased economic integration in the second period.

5. Basic Results

We begin our empirical analysis by the simplest possible test of the catching-up hypothesis. This is reported in specification (i) in *Table 2*. The catching-up parameter β is insignificant. Thus, we can find no evidence of convergence in labor productivity across countries, so the simple catching-up hypothesis is not supported. This result is similar to that of other researchers, such as Baumol (1986), Barro (1991) and Dowrick (1992), although they test for convergence in GDP per capita rather than in labor productivity.

This result is not entirely unexpected; as is clear from equation (3), catching up affects the relative growth in TFP and therefore the possible effect on labor productivity of capital accumulation and labor growth should be controlled for, which we do in specification (ii). Here we obtain a highly significant catching-up effect. Specification (iii) is the empirical application of the theoretical model presented in section 3. The results show a clear effect of human capital on the capability of assimilating technology from abroad; the parameter is highly significant. The expected effect of international economic integration is also present, although the parameter estimate is less significant.[13] $\overline{R}^2$ increases in specification (iii) compared to specification (ii), which points to the importance of social capability.

Table 2 about here

In *Figure 2* we plot the partial association between growth in total factor productivity $(\dot{A}/A)$ and the interaction between initial technology gap and social capability. $\dot{A}/A$ and initial gap$\cdot$ social capability are calculated from specification (iii) as

$$\frac{\dot{A}}{A} = \frac{\dot{y}}{y} - 0.080\frac{I}{Y} + 0.142\frac{\dot{L}}{L} \text{ and}$$

$$\text{initial gap} \cdot \text{ social capability} = \log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot (0.013HUM + 0.007OP).$$

Figure 2 about here

The correlation in *Figure 2* between $\dot{A}/A$ and the interaction between the initial gap and social capability is –0.41, whereas the correlation between growth in total factor productivity and initial gap computed from specification (ii) is –0.37. This reaffirms that social capability plays an important role in catching up.

As we can see from the plot in *Figure 2* there are three outliers: Botswana, Egypt and Zambia. We carry out the diagnostic test DFFITS[14] to check whether these observations are influential and find that at least Zambia seems to have a significant effect on the regression line. In specification (iv) we therefore exclude Zambia. Unlike specification (iii), the coefficient for $\log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot OP$ is clearly significant. A closer inspection of the data for Zambia shows that the trade intensity ratio is higher than the average for the countries in the sample.[15] But according to World Bank (1987) the trade regime in Zambia during the studied period has been strongly inward-oriented (see Appendix I). The reason for the high *OP* in Zambia is that Zambia is a leading exporter of copper. It is reasonable to expect that trade in mineral and agricultural products do not further technology diffusion to the same extent as trade in manufactures, especially trade in machinery and transport equipment (SITC 7). The case of Zambia shows that to capture the effect on a country's catching-up performance, a better measure may be the trade intensity in manufactures or the trade intensity for products classified into SITC 7.

6. Extensions and Modifications

So far we have focused on international trade as a channel for the spread of technology from leading to follower countries. The familiar arguments of gains in productivity from international trade, dating back at least to Adam Smith, include specialization according to comparative advantage and realization of economies of scale. In our extended empirical model we also intend to capture these effects. It should be noted that the productivity gains are level effects and not rate effects. It is, however, difficult to disentangle static from permanent effects, since the once-and-for-all improvement in productivity in most cases is realized over a period of time. Furthermore, during the studied period in many countries international trade has increased continuously due to lower trade barriers, as a result of tariff negotiations within GATT and lower transportation costs.

International trade may also raise a country's productivity by increasing the availability of intermediate inputs.[16] Assume that the aggregate production function in a country is

$$Y = AL^{\delta}\sum_{i=1}^{n} x_i^{\alpha} \qquad 0 < \alpha, \delta < 1 \tag{9}$$

where the x_i's are intermediate inputs, i.e., various types of capital goods, and n is the number of inputs available. Since all available intermediates enter symmetrically into the production function, and if we for convenience assume that they have the same price, the demand of each intermediate is

$x_i = x$.

From these assumptions it follows that (9) can be simplified to

$$y = \frac{Y}{L} = AL^{\delta - 1} K^{\alpha} n^{1-\alpha} \quad (10)$$

where $nx \equiv K$ is the aggregate quantity of capital used. Differentiation with respect to time gives the following expression for the growth in labor productivity:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + (\delta - 1)\frac{\dot{L}}{L} + \alpha \frac{\dot{K}}{K} + (1-\alpha)\frac{\dot{n}}{n} \quad (11)$$

International trade increases the availability of various capital goods. We assume that the rate of growth in trade intensity ($\dot{OP}/OP$) is a proxy for $\dot{n}/n$, or that $\dot{n}/n$ is larger the more outward-oriented a country's trade regime is. Increased availability of various capital goods in a country may lower its development costs for new intermediate products.[17] This means that we expect that domestic technological progress is positively correlated with $\dot{OP}/OP$ and with the trade regime. The rate of growth in trade intensity may also capture the familiar productivity gains of increased international trade, further exploitation of comparative advantage and economies of scale. To test these hypotheses we add $\dot{OP}/OP$ or a measure of trade regime to our basic regression equation.

One measure of trade regime commonly used, e.g., in Roubini and Sala-i-Martin (1991), is a classification of countries into four groups: strongly outward-oriented, moderately outward-oriented, moderately inward-oriented and strongly inward-oriented. This categorization is from a World Bank study of developing countries (World Bank, 1987) and is based upon various measures of trade policy, tariffs, subsidies and quantitative restrictions. It is made for two periods: 1963–73 and 1973–85. Roubini and

Sala-i-Martin have extended the World Bank sample by 21 countries, mostly advanced industrial and strongly outward-oriented countries. We will use this classification and construct a dummy variable (*TR*) which takes values from one for strongly inward-oriented countries to four for strongly outward-oriented countries (see Appendix I). One shortcoming of this measure is that it is subjective. Despite that a great deal of effort has been made to derive a good classification, prior knowledge about growth performance may have affected the classification.

We expect that a country's trade regime (*TR*) affects productivity growth directly. We have argued that outward-orientation increases the availability of intermediate products, which may promote domestic technological progress and lead to higher productivity growth.[18] A further argument builds upon the writings of North (1990) and Rosenberg and Birdzell (1986). They emphasize the importance of benevolent institutions for economic growth, and it can be conjectured that growth-retarding institutions are more likely to be phased out in outward-oriented countries. We also expect that a country's trade regime (*TR*) interacts with the catching-up variable $\log(\tau_i/\tau_{US})$. Our hypothesis is that the catching-up process is faster the more outward-oriented a country is. In the regression equation we replace the average trade intensity (*OP*) with the trade regime variable (*TR*). Based upon these arguments we estimate the following equation:

$$\frac{\dot{y}}{y} = \alpha + \alpha_1 D + \gamma_1\left(\frac{I}{Y}\right) + \gamma_2\left(\frac{\dot{L}}{L}\right) + \beta_1 \log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot HUM + \beta_2 \log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot \begin{bmatrix} OP \\ \text{or} \\ TR \end{bmatrix} + \kappa \begin{bmatrix} \dot{OP}/OP \\ \text{or} \\ TR \end{bmatrix} + \varepsilon \qquad (12)$$

D is a dummy variable where *D* = 0 for the period 1963–73 and *D* = 1 for the period 1973–85.

The interpretation of the results from the model where we use average trade intensity (*OP*) and the rate of growth in trade intensity ($\dot{OP}/OP$) differs from the model which contains the trade regime variable (*TR*). In the former we test whether increased economic interaction with the world economy furthers technological diffusion and catching up, and whether increased trade with the rest of the world leads to faster productivity growth. The latter tells us about policy effects, i.e., whether a more outward-oriented policy has positive effects on the catching-up performance, and whether an inward-oriented policy has negative influences on domestic technological progress and fosters growth-retarding institutions.[19]

Table 3 about here

In *Table 3* we present the results from the estimation of equation (12). In specification (i) we have estimated our basic model in equation (8) for the period 1960–85 and added the rate of growth in trade intensity ($\dot{OP}/OP$). In the other specifications we have pooled the data from the periods 1963–73 and 1973–85. We can observe that $\dot{OP}/OP$ has a positive effect on the rate of growth in labor productivity, whereas the result for the trade regime variable is mixed. As in *Table 2*, our estimates confirm that openness promotes technological diffusion from leaders to followers; this is valid irrespective of whether openness is measured as average trade intensity (*OP*) or by our trade regime variable (*TR*). The result in *Table 2* concerning the importance of a country's stock of human capital for its capability to profit by superior technology from abroad also holds in *Table 3*, except for specification (iii) and (iv). The likely reason for this is collinearity between $\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot HUM$ and $\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot TR$; the correlation between those variables is 0.60, and if we exclude $\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot TR$ in specification (v) $\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot HUM$ is strongly significant.[20] The coefficient for the year dummy is negative and clearly significant, which means that our regressions confirm the well-documented productivity slowdown after the first oil-price shock.

7. Conclusion

In this paper we have tested the catching-up hypothesis on an extended sample of countries. In contrast to previous studies we have operationalized the concept of social capability, i.e., we have taken account of the fact that a lower level of technology in a country is not a sufficient condition for attaining a higher rate of technological change than initially more advanced countries.

We have presented a simple theoretical framework in which the effects of social capability on technological diffusion from leaders to followers is modeled. The main element in the model is the interaction between the technological gap and social capability.

Empirically, the level of technology has to be proxied by labor productivity. Two potential determinants of social capability are highlighted: the stock of human capital and the degree of integration into the world economy. Our measure of human capital is more appropriate than the ones used in other studies.

The basic regression results show that when capital accumulation and labor force growth are controlled for, there is significant catching up in labor productivity across countries. This effect is strengthened when the social capability interaction is accounted for, i.e., both a higher level of human capital and deeper integration into the world economy facilitate productivity growth by technological diffusion from leader to followers.

In an extension of our basic model, we try to capture gains in labor productivity from increased international trade that are likely to stem from other sources than catching up. These are specialization according to comparative advantage, realization of economies of scale, and, as emphasized by new growth theory, the greater availability of intermediate inputs resulting from increased international trade. This independent effect of international trade on productivity is measured by two alternative variables: the change in the degree of openness during the studied period and a subjective measure of trade orientation.

The results from this extended model confirm the previous findings of the importance of social capability for catching up. They also show that there is an independent effect of the change in trade intensity and trade regime on productivity growth.

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[1]Alam (1992) and Heitger (1993) are the only studies we know of where an attempt is made to include social capability. Alam studies Maddison's 16 industrialized countries and Heitger the OECD countries in the postwar period.

[2]In an even more recent study Wolff (1991) finds strong support for the catching up hypothesis for the group of seven countries during the same period.

[3]Among other studies that find support for the catching-up hypothesis one could mention Dollar and Wolff (1988), Dowrick (1989) and Dowrick and Gemmell (1991).

[4] Somewhat paradoxically the test equations are almost identical, despite the different theoretical points of departure.

[5]Dowrick and Gemmell (1991), in a test of catching up on the Summers-Heston countries, augment their econometric test equation in one instance by including a measure of education. However, the purpose of this inclusion is more limited, namely, to control for the quality of the workforce rather than to try to model differences in social capability and its interaction with catching-up potential.

[6]Unless expositionally necessary, time and country indices are suppressed throughout.

[7]A similar model is used by Edwards (1992).

[8]E.g., Dowrick and Nguyen (1989), Dowrick (1989), and Dowrick and Gemmell (1991).

[9]This was first suggested by Nelson and Phelps (1966). The importance of human capital in explaining cross-sectional variations in economic growth has recently been emphasized by a large number of researchers. See for example Barro (1991) and Mankiw, Romer and Weil (1992).

[10]For a broad review of the literature on trade and economic performance in developing countries, see Edwards (1993).

[11]For example, Verspagen (1991) uses the per capita electricity generating capacity as a proxy for the quality of the infrastructure.

[12]Admittedly, a somewhat heroic assumption. However, this has also been done by, among others, Dowrick and Gemmell (1991) and Dowrick (1992). Dowrick and Gemmell have also tested whether the marginal productivity of capital differs between different stages of development; they cannot reject the hypothesis of constant marginal productivity of capital across countries.

[13]The heteroscedasticity consistent t-statistic of -1.55 indicates significance at the 6%-level in a one-tail test and significance at the 12%-level in a two-tail test.

[14]See Krasker, Kuh and Welsch (1983) for a description of the test.

[15]*OP* for Zambia is 0.56 and the sample average is 0.38. The technology gap and *HUM* is similar to the value for other less developed countries.

[16]The idea originates from Ethier (1982) and it has been used in several endogenous growth models.

[17]In an endogenous growth model, Grossman and Helpman (1991) assume that the development cost of a new intermediate product is lowered by increased trade. A major result in their article is that trade-promoting policies accelerate growth.

[18]A similar hypothesis is tested by Roubini and Sala-i-Martin (1991). They examine the relationship between degree of outward-orientation and annual growth rate of per capita GDP 1960-85. They also survey the recent development in the theoretical literature and find that no general conclusion can be drawn on the relationship between these factors.

[19]In our sample the correlation between *TR* and *OP* is 0.53, and the correlation between *TR* and $\dot{OP}/OP$ is also 0.53. Nevertheless, *OP* and $\dot{OP}/OP$ are almost uncorrelated, r = 0.02.

[20]The correlation between $\log(\tau_i/\tau_{US})\cdot HUM$ and $\log(\tau_i/\tau_{US})\cdot OP$ is 0.36.

APPENDIX I List of countries in the sample

Number	Country	Sample 1	Sample 2	TR6373	TR7385
1	Algeria		*		
2	Angola	*	*		
3	Benin		*		
4	Botswana		*		
5	Burkina Faso	*	*		
6	Burundi			1	1
7	Cameroon[1]	*		3	2
8	Cape Verde Islands	*	*		
9	Central African Republic		*		
10	Chad	*	*		
11	Comoros	*	*		
12	Congo		*		
13	Egypt		*		
14	Ethiopia	*		1	1
15	Gabon		*		
16	Gambia	*	*		
17	Ghana			1	1
18	Guinea	*	*		
19	Guinea-Bissau	*	*		
20	Ivory Coast			3	2
21	Kenya			2	2
22	Lesotho	*	*		
23	Liberia		*		
24	Madagascar			2	1
25	Malawi		*		
26	Mali	*	*		
27	Mauritania	*	*		
28	Mauritius		*		
29	Morocco		*		
30	Mozambique	*	*		
31	Niger		*		
32	Nigeria			2	1
33	Rwanda		*		
34	Senegal			2	2
35	Seychelles	*	*		
36	Sierra Leone	*	*		
37	Somalia		*		
38	South Africa	*	*		
39	Sudan			1	1
40	Swaziland	*	*		
41	Tanzania	*	*	1	1
42	Togo		*		
43	Tunisia[2]	*		2	3
44	Uganda		*		
45	Zaire		*		
46	Zambia			1	1
47	Zimbabwe	*	*		

Number	Country	Sample 1	Sample 2	TR6373	TR7385
48	Bahamas	*	*		
49	Barbados	*	*		
50	Canada	*	*	4	4
51	Costa Rica			3	2
52	Dominica	*	*		
53	Dominican Republic			1	1
54	El Salvador			2	2
55	Grenada	*	*		
56	Guatemala			3	2
57	Haiti		*		
58	Honduras			2	2
59	Jamaica		*		
60	Mexico			2	2
61	Nicaragua			2	2
62	Panama		*		
63	St Lucia	*	*		
64	St Vincent & Grenada	*	*		
65	Trinidad & Tobago		*		
66	USA			4	4
67	Argentina			1	1
68	Bolivia			2	1
69	Brazil			3	3
70	Chile			1	3
71	Colombia			3	2
72	Ecuador		*		
73	Guyana	*	*		
74	Paraguay		*		
75	Peru			1	1
76	Suriname	*	*		
77	Uruguay			1	3
78	Venezuela		*		
79	Afghanistan	*	*		
80	Bahrain	*	*		
81	Bangladesh			1	1
82	Burma	*	*		
83	China	*	*		
84	Hong Kong			4	4
85	India			1	1
86	Indonesia[2]	*		3	2
87	Iran	*	*		
88	Iraq	*	*		
89	Israel			3	3
90	Japan			4	4
91	Jordan	*	*		
92	Korea, South			4	4
93	Kuwait[3]	*	*		
94	Malaysia			3	3
95	Nepal	*	*		

96	Oman	*	*		

Number	Country	Sample 1	Sample 2	TR6373	TR7385
97	Pakistan			1	2
98	Philippines			2	2
99	Saudi Arabia	*	*		
100	Singapore[1]	*		4	4
101	Sri Lanka			1	2
102	Syria	*	*		
103	Taiwan	*	*	4	4
104	Thailand			3	3
105	United Arab E.	*	*		
106	Yemen, N-Arab	*	*		
107	Austria			4	4
108	Belgium			4	4
109	Cyprus	*	*		
110	Denmark			4	4
111	Finland			4	4
112	France			4	4
113	West Germany			4	4
114	Greece		*		
115	Hungary	*	*		
116	Iceland		*		
117	Ireland			4	4
118	Italy			4	4
119	Luxembourg			4	4
120	Malta		*		
121	Netherlands			4	4
122	Norway			4	4
123	Poland	*	*		
124	Portugal		*		
125	Spain			4	4
126	Sweden			4	4
127	Switzerland			4	4
128	Turkey			1	3
129	United Kingdom			4	4
130	Yugoslavia	*	*	2	2
131	Australia			4	4
132	Fiji	*	*		
133	New Zealand			4	4
134	Papua New Guinea	*	*		
135	Solomon slands	*	*		
136	Tonga	*	*		
137	Vanuatu	*	*		
138	Western Samoa	*	*		

*missing observation

[1]The observations on $\dot{OP}/OP$ are missing for Cameroon in 1963–73 and for Singapore in 1973–85. Therefore the number of observations in equation (3) of *Table 4* is 112 instead of 114.

[2]The observations on *OP* are missing for Tunisia and Indonesia. For this reason these countries are excluded from sample 1 but included in sample 2.

[3]We exclude Kuwait since it is a major oil-exporting country.

Figure 1 Technological Change as a Function of Technological Gap and Social Capability.

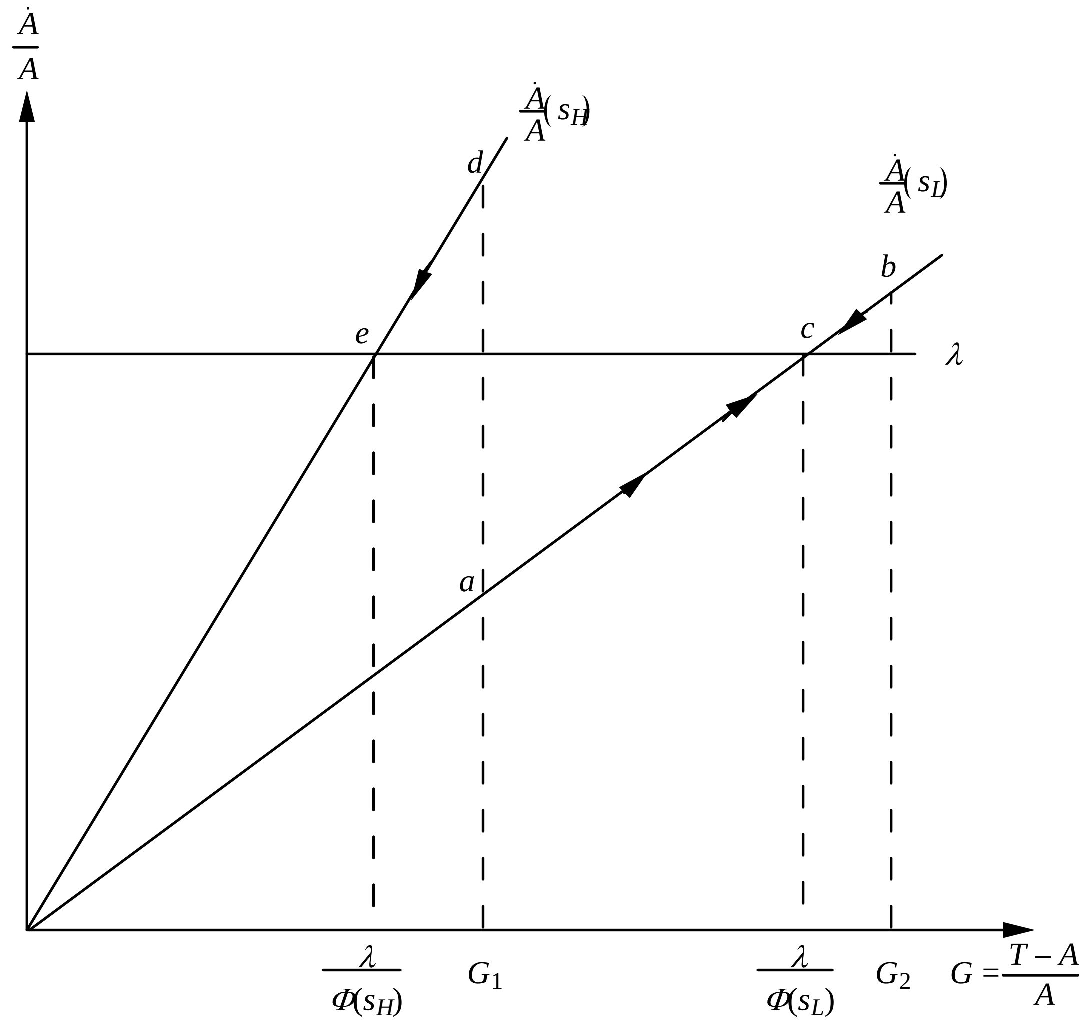

Table 1 Descriptive statistics.

Variable	*Period*	*Mean*	*Std Dev.*	*Min*	*Max*	*No. of Obs.*
	1960–85	0.041	0.017	0.007	0.099	81
$\dot{Y}/Y$	1963–73	0.050	0.022	0.004	0.111	81
	1973–85	0.031	0.022	–0.015	0.100	81
	1960–85	0.020	0.009	0.001	0.0037	81
$\dot{L}/L$	1963–73	0.019	0.009	–0.004	0.0036	81
	1973–85	0.022	0.009	0.0040	0.0042	81
	1960–85	0.185	0.084	0.018	0.372	81
I/Y	1963–73	0.184	0.093	0.016	0.386	81
	1973–85	0.188	0.084	0.020	0.454	81
	1960	0.260	0.219	0.030	0.809*	81
τ_i/τ_{US}	1963	0.271	0.226	0.024	0.857*	81
	1973	0.311	0.255	0.023	0.914*	81
HUM		0.558	0.279	0.053	0.991	81
	1960–85	0.384	0.284	0.055	1.646	81
OP	1963–73	0.330	0.252	0.045	1.412	81
	1973–85	0.449	0.343	0.055	1.958	81
	1960–85	0.011	0.036	–0.108	0.095	81
$\dot{OP}/OP$	1963–73	0.016	0.038	–0.093	0.101	81
	1973–85	–0.003	0.025	–0.093	0.058	81

*By definition the maximum is 1.000. We therefore report the second highest value instead.

Table 2 The Effect on the Rate of Growth in Labor Productivity of Catching Up, Social Capability and Growth in Factors of Production 1960–85.

Variable	*Parameter*	(i)	(ii)	(iii)	(iv)
$\log\left(\frac{\tau_i}{\tau_{US}}\right)$	β	0.001	–0.006		
		(0.33)	(–2.89)		
		[0.35]	[–2.51]		
$\log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot HUM$	β_1			–0.013	–0.012
				(–2.85)	(–2.92)
				[–3.12]	[–2.92]
$\log\left(\frac{\tau_i}{\tau_{US}}\right) \cdot OP$	β_2			–0.007	–0.008
				(–1.98)	(–2.63)
				[–1.55]	[–2.04]
$\frac{I}{Y}$	γ_1		0.128	0.080	0.095
			(5.53)	(4.02)	(5.10)
			[3.80]	[3.38]	[4.65]
$\frac{\dot{L}}{L}$	γ_2		–0.056	–0.142	–0.038
			(–0.29)	(–0.75)	(–0.22)
			[–0.31]	[–0.85]	[–0.28]
Constant	α	0.022	–0.012	–0.005	–0.009
		(5.53)	(–1.44)	(–0.73)	(–1.51)
		[7.77]	[–1.08]	[–0.70]	[–1.62]
$\overline{R}^2$		–0.011	0.280	0.320	0.405
n		81	81	81	80

Note: Parentheses ( ) give *t*-statistics, brackets [ ] give White's (1980) heteroscedasticity consistent *t*-statistics.

Figure 2 Partial Association between Growth in Total Factor Productivity and Initial Technology Gap•Social Capability.

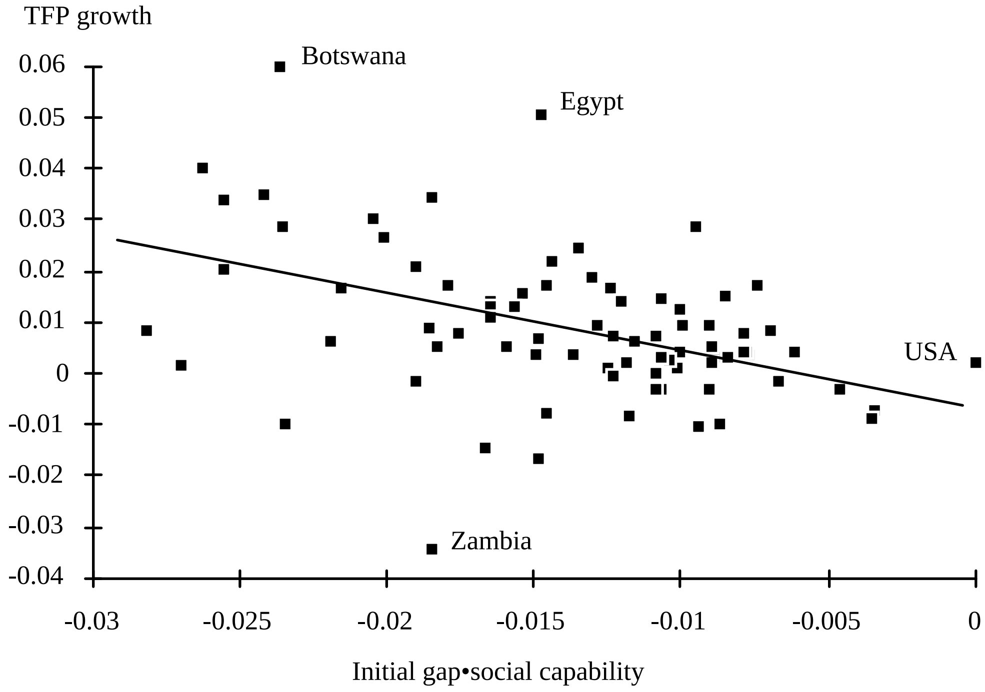

Table 3 The Effect on the Rate of Growth in Labor Productivity of Catching Up, Social Capability, Growth in Factors of Production,the Change in Openness, and the Trade Regime, 1960–85 or 1963–73 and 1973–85.

Variable	*Parameter*	(i)	(ii)	(iii)	(iv)	(v)
$\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot$ *HUM*	β_1	–0.013	–0.016	–0.000	0.003	–0.019
		(–2.89)	(–3.42)	(–0.04)	(0.60)	(–4.01)
		[–3.31]	[–3.69]	[–0.04]	[0.60]	[–4.60]
$\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot$ *OP*	β_2	–0.009	–0.008			
		(–2.51)	(–2.50)			
		[–2.18]	[–1.99]			
$\log\left(\frac{\tau_i}{\tau_{US}}\right)\cdot$ *TR*	β_2			–0.005	–0.005	
				(–4.40)	(–5.03)	
				[–3.96]	[–4.78]	
$\frac{\dot{OP}}{OP}$	κ	0.102	0.118		0.115	
		(2.00)	(2.33)		(2.02)	
		[1.76]	[2.32]		[2.01]	
TR	κ			0.002		0.007
				(1.25)		(4.16)
				[1.27]		[4.57]
$\frac{I}{Y}$	γ_1	0.066	0.085	0.096	0.098	0.046
		(3.17)	(4.61)	(3.86)	(5.05)	(1.92)
		[2.78]	[4.38]	[4.41]	[4.54]	[2.01]
$\frac{\dot{L}}{L}$	γ_2	–0.021	–0.181	–0.121	–0.133	–0.120
		(–0.11)	(–1.06)	(–0.75)	(–0.82)	(–0.72)
		[–0.12]	[–1.25]	[–0.81]	[–0.90]	[–0.86]
D	α_1		–0.018	–0.019	–0.018	–0.021
1963–73 = 0			(–5.87)	(–7.06)	(6.08)	(–7.01)
1973–85 = 1			[–5.88]	[–6.08]	[–6.25]	[–7.21]
Constant	α	–0.069	0.001	–0.010	–0.004	–0.014
		(–1.05)	(0.22)	(–1.41)	(–0.69)	(–1.94)
		[–1.01]	[0.23]	[–1.34]	[–0.61]	[–2.02]
$\overline{R}^2$		0.346	0.411	0.573	0.584	0.501
n		81	162	114	112	114

Note: Parentheses ( ) give *t*-statistics, brackets [ ] give White's (1980) heteroscedasticity consistent *t*-statistics.