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Openness and economic growth in developing countries

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**Openness and Economic Growth
in Developing Countries**

by

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Openness and Economic Growth in Developing Countries

Abstract

Openness appears to have a strong impact on economic growth especially in DCs, which typically exhibit a high share of physical capital in factor income and a low share of labor. In the neoclassical growth model with partial capital mobility, physical capital's share in factor income determines the difference in the predicted convergence rates for open and closed economies. With a 60 percent share as in developing countries, the convergence rates should differ by a factor of about 2.5. My regression results for a sample of open and closed DCs roughly confirm this hypothesis.

JEL: O41

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I Introduction and Summary*

The idea that openness is one of the most important determinants of economic growth is becoming increasingly popular among governments of developing countries (DCs). Casual observation seems to suggest that more or less outward oriented economies with few restrictions on international transactions have experienced a better economic performance than inward oriented economies with high tariff walls and strict controls of capital movements. Hence, market oriented economic policies, including the liberalization of international trade and capital flows, have been the centerpiece of recent reform efforts in parts of Latin America and South Asia.

Regardless of the emerging consensus on the benefits of openness among policy makers in DCs, mainstream economists have always had some difficulties to provide the theoretical and empirical justification for the presumed positive link between free trade and capital flows and the rate of economic growth. For a start, it is easy to prove in theory that there are static economic gains from openness. Unfortunately, it is not straightforward to generalize from this result to a dynamic context. By definition, static gains from openness imply a level effect, not a growth effect. Of course, a level effect can appear as a growth effect for a given period of time, since adjustment in real

* I thank Rolf J. Langhammer for helpful comments on an earlier version.

economies may take place over decades. However, the measured static gains of openness appear to be small in terms of GDP, according to most empirical estimates.¹

The dynamic gains from openness may be much larger. But identifying and measuring them obviously requires an alternative theoretical approach. The renewed interest in growth theory, mainly initiated by the seminal work of Romer (1986), seems to provide such an approach. So-called endogenous growth models allow for a direct and persistent link between openness and the growth rate, which is missing in the traditional neoclassical growth model (Solow 1956). E.g., Edwards (1992), Romer (1994), and Coe et al. (1995) use alternative endogenous growth models to explain a positive link between openness and the rate of economic growth as the result of the international diffusion and adoption of new technologies or new goods. Although convincing from a theoretical point of view, the major drawback of endogenous growth models is that they are difficult to reconcile with the growing body of empirical evidence on so-called conditional convergence.²

¹ This point has been emphasized by Krugman (1990) for the case of the United States. For surveys with a focus on DCs, see, e.g., Lal and Rajapatirana (1987) and Havrylyshyn (1990).

² See, e.g., Dowrick and Nguyen (1989) and Gundlach (1993) for convergence across OECD countries; Barro and Sala-i-Martin (1991, 1992) for convergence across U.S. states, European regions and Japanese prefectures; Jian et al. (1996) and Gundlach (1996) for convergence across Chinese provinces in the reform period; Bajpai and Sachs (1995) for convergence across Indian states; and Zini and Sachs (1996) for convergence across Brazilian states. For an overview, see Sala-i-Martin (1995).

Conditional convergence of per capita income is defined as the tendency for poor economies to grow faster than rich economies, once the determinants of their steady state are held constant. Contrary to endogenous growth models, conditional convergence of per capita income is predicted by the traditional neoclassical growth model. But this model also fails for empirical reasons: The actually observed rates of convergence in the range of 2 percent can only be explained if capital's share in income is about 75 percent and if economies are closed. However, capital's share in income is about 30 percent in OECD countries on average (Maddison 1987), and capital mobility is neither severely restricted across OECD economies nor within OECD economies. If so, adjustment to the steady state should be fast. Apparently, it is not.

Therefore, Barro et al. (1995) suggest a neoclassical growth model for the open economy that allows for a relatively low rate of convergence in the presence of capital mobility. This model predicts that in adjusting to their steady state, open economies grow faster than closed economies. Open economies can acquire physical capital more quickly due to the availability of international financial markets. Hence, diminishing returns set in faster, and the speed of convergence to the steady state is higher. Yet for reasonable parameter values stemming from the U.S. economy, Barro et al. (1995) conclude that the speed of convergence is only marginally higher for open than for closed economies. Put differently, although capital mobility tends to raise the rate at

which poor open economies converge to their steady state, the quantitative impact of openness is held to be small, at least for industrialized countries.

My empirical findings for DCs point to a different conclusion. Physical capital's share in factor income is the crucial parameter that determines the difference in the predicted convergence rates for open and closed economies. For a large number of DCs, physical capital's share is about 60 percent rather than 30 percent as in industrialized countries. With a 60 percent share, the convergence rates for open and closed economies should differ by a factor of about 2.5. Hence, openness appears to have a strong impact on economic growth especially in DCs, which typically exhibit a high share of physical capital in factor income and a low share of labor. My regression results for open and closed DCs roughly confirm this hypothesis. I find that holding constant other determinants of the steady state, open DCs converge at a rate of about 5 percent to the steady state, while closed economies converge at a rate of about 1.5 percent.

2. Convergence to the Steady State in Neoclassical Growth Models: Closed and Open

Mankiw et al. (1992) develop a human capital augmented neoclassical growth model for the closed economy that takes the rates of saving, labor force growth and technological progress as exogenous. Output (Y) is produced under constant returns to scale with three inputs, capital (K), human capital (H), and labor (L), which are paid

their marginal products. Assuming a Cobb-Douglas production function, output at time t is given by:

$$(1) \quad Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta}, \quad 0 < \alpha + \beta < 1.$$

A , the level of technology, and L are assumed to grow exogenously at rates g and n . Hence, the number of effective units of labor, $A_t L_t$, grows at rate $g + n$. Assuming constant saving ($s_i = S_i / Y$) and depreciation rates ($\delta = D/K = D/H$), and defining k as the stock of physical capital per effective unit of labor ($k = K/AL$), h as the stock of human capital per effective unit of labor, and y as output per effective unit of labor ($y = Y/AL$), it can be shown that the evolution of k and h is governed by (Mankiw et al. 1992)³

$$(2a) \quad dk / dt = s_k y - (n + g + \delta)k \quad \text{and}$$

$$(2b) \quad dh / dt = s_h y - (n + g + \delta)h .$$

Furthermore, it can be shown that the economy converges to a steady state given by

$$(3a) \quad k^* = \left(\frac{s_k^{1-\beta} s_h^\beta}{n + g + \delta} \right)^{1/(1-\alpha-\beta)} \quad \text{and}$$

$$(3b) \quad h^* = \left(\frac{s_k^\alpha s_h^{1-\alpha}}{n + g + \delta} \right)^{1/(1-\alpha-\beta)} .$$

³ In the following, I delete time subscripts for convenience of presentation.

Approximating around the steady state, the speed of convergence for the closed economy (λ_{closed}) can be derived as

$$(4) \quad \lambda_{closed} = (n + g + \delta)(1 - \alpha - \beta),$$

where α and β are the production elasticities of physical and human capital (see equation 1). According to the underlying assumptions of perfect competition and constant returns to scale, the production elasticities should equal physical and human capital's share in factor income.

If the rate of converge actually is about 2 percent as estimated by most empirical studies,⁴ it follows that equation (4) can be used to infer an estimate for $\alpha + \beta$, conditional on $(n + g + \delta)$. The standard parameterization suggested in the literature is a rate of labor force growth of 1 percent, a rate of technological change of 2 percent, and a depreciation rate of 5 percent (Barro et al. 1995), so $n + g + \delta$ equals 8 percent.

If so, $\alpha + \beta$ should be about 75 percent in order to explain a rate of convergence of about 2 percent. At least for the United States, the sum of the predicted factor shares has roughly been confirmed: Jorgenson et al. (1987) estimate that physical capital's share in factor income is about 30 percent, and human capital's share in factor income is about 50 percent. Hence, using a broad concept of capital that includes human

⁴ See footnote 2 for references; a rate of convergence of about 2 percent has also been estimated for a cross section of 75 countries (Mankiw et al. 1992).

capital cures one of the apparent empirical inconsistencies of the traditional neoclassical growth model (Solow 1956).

The remaining problem for the human capital augmented neoclassical growth model arises from the implicit assumption of capital immobility. Capital immobility may or may not be a reasonable assumption in cross-country studies, but it is rather unlikely to hold across European regions or within countries such as the US, Japan, China, India, and Brazil.⁵ If capital mobility is perfect, adjustment to the steady state should be instantaneous; if capital mobility is high, convergence of per capita income should be rapid. Put differently, the observed convergence rates of about 2 percent are difficult to explain if capital is mobile, as it typically is at least within countries.

Therefore, Barro et al. (1995) suggest the assumption of imperfect capital mobility to bridge the apparent gap between theory and empirical evidence. They assume that physical capital is mobile across economies, but human capital is not. That is, goods and capital are tradable among economies, but labor cannot migrate. Moreover, they assume that physical capital can be used as a collateral for international borrowing, whereas human capital cannot. This further assumption introduces an asymmetry between the two stocks of capital.

Adjustment to the steady state level of physical capital will be fast due to the possibility of international borrowing, but adjustment to the steady state level of

⁵ For references, see footnote 2.

human capital will probably be slow. Hence physical and human capital are modeled as imperfect substitutes as inputs to production, and the relative size of the accumulated stocks of physical and human capital determines the fraction of broad capital that can be used as collateral. As it turns out, all these assumptions do not change the predicted steady state itself, but affect the rate of convergence. For the credit constrained open economy, the convergence rate is given by (Barro et al. 1995)

$$(5) \quad \lambda_{open} = (n + g + \delta) \left(1 - \frac{\beta}{1 - \alpha} \right).$$

The relation between the two rates of convergence for open and closed economies is given by

$$(6) \quad \frac{\lambda_{open}}{\lambda_{closed}} = \frac{\left(1 - \frac{\beta}{1 - \alpha} \right)}{(1 - \alpha - \beta)} = \frac{1}{1 - \alpha}.$$

The difference between the two convergence rates only depends on physical capital's share in income, which is the only mobile factor in the model. If physical capital's share in income is about 30 percent, which is the average for industrialized countries (Maddison 1987), the rate of convergence to the steady state is 1.5 times higher for the open economy than for the closed economy. Barro et al. (1995) argue that the quantitative impact of this difference is likely to be small, but such an interpretation deserves second thoughts.

Barro et al. (1995) predict a convergence rate of 1.4 percent for the closed economy and a convergence rate of 2.2 percent for the open economy, based on their parameterization of the model which relies on estimates for the U.S. economy. This theoretical result is largely in line with the empirical findings for convergence within countries, and for convergence across European regions and OECD economies. As indicated by equation (6), the relatively small difference between the two rates of convergence mainly reflects that physical capital's share in factor income is set to be about 30 percent. Nevertheless, even an apparently small difference in predicted convergence rates may reappear as a relatively large effect with regard to the time span necessary to close the gap between actual and steady state per capita income. That is, the Barro et al. (1995) results imply that the open economy would reach halfway to steady state more than half a generation (18 years) earlier than the closed economy.⁶ Whether this effect of openness is small is not self-evident, to say the least.

In any case, it should be noted that the effect of openness on the gap between actual and steady state per capita income will increase with physical capital's share in factor income. For example, if physical capital's share is about 60 percent, the convergence rate for the open economy is predicted to be 2.5 times higher than the convergence rate for the closed economy. Thus, openness matters especially for those economies that

⁶ Halfway to steady state is reached in t years according to $t = \ln(2)/\lambda$, with λ as the convergence rate. Hence, if $\lambda = 1.4$ percent for the closed economy, t equals 49.5 years; if $\lambda = 2.2$ percent for the open economy, t equals 31.5 years.

exhibit a relatively high share of physical capital and a correspondingly low share of labor in factor income. Such a functional distribution of income is typical for DCs.

3. Capital's Share in Factor Income in Developing Countries

I use National Accounts Statistics provided by the UN (1994) to calculate an average physical capital share in factor income for a large number of DCs. More specifically, I derive physical capital's share as consumption of fixed capital plus operating surplus, divided by GDP less indirect taxes plus subsidies. My final sample of DCs is limited for a number of reasons. Obviously, I can only include DCs which report detailed National Accounts Statistics to the UN. Furthermore, I exclude formerly socialist economies in Central and Eastern Europe and the successor states of the former Soviet Union. I also exclude DCs with a population of less than 1 million in 1992, DCs with less than three observations in 1980-92, and DCs with oil production as the dominant industry. Detailed results for average physical capital shares in factor income are presented in Table 1.

The average physical capital share for developing countries is about 60 percent, with a standard error of 12.4. This figure is substantially higher than the average figure reported for samples of OECD countries (Pritchett 1996, Maddison 1987). The variation of physical capital's share in factor income across DCs is negatively

Table 1 — Average Shares of Physical and Human Capital in Factor Income, Selected Developing Countries, 1980-1992

Country	Physical capital share (percent)	Human capital share (percent)	Broad capital share (percent)	Note: Real GDP per worker, 1990 (1985 international prices)
Algeria	53.0	..	-	12176
Benin	77.8	..	-	1903
Bolivia	65.6	11.3	76.9	5315
Botswana	64.6	23.5	88.1	6533 ^a
Burkina Faso	70.6	..	-	1058
Burundi	76.6	..	-	1062
Cameroon	68.2	..	-	2489
Chile	56.8	21.6	78.4	11854
Colombia	55.6	26.6	82.2	10108
Congo	61.2	..	-	4497
Costa Rica	46.5	28.7	75.2	10040
Ecuador	77.2	11.7	88.9	9032
Honduras	49.0	24.3	73.3	4464
Hong Kong	48.0	29.6	77.6	22827
Israel	42.1	21.9	64.0	23780
Jamaica	47.6	27.6	75.2	5146
Jordan	55.1	..	-	12634
Kenya	57.9	14.9	72.8	1863
Korea, Rep.	52.5	23.8	76.3	16022
Malawi	75.9	6.9	82.8	1217
Malaysia	60.4	13.7	74.1	12527
Mauritius	51.9	..	-	10198
Mexico	68.6	17.0	85.6	17012
Myanmar	56.7	..	-	1362 ^a
Namibia	45.8	..	-	9528
Niger	81.3	..	-	1043 ^a
Nigeria	79.2	..	-	2082
Nepal	41.1	..	-	2298 ^b
Panama	47.5	30.3	77.8	7999
Papua New Guinea	57.3	6.8	64.1	3020
Paraguay	68.2	19.8	88.0	6383
Peru	67.0	12.2	79.2	6847
Philippines	64.7	15.5	80.2	4784
Puerto Rico	53.5	..	-	26137 ^a
Rwanda	74.4	..	-	1539
Sierra Leone	80.2	3.3	83.5	2487
South Africa	41.9	37.1	79.0	9595
Sri Lanka	47.2	16.1	63.3	5742
Sudan	62.7	..	-	2333
Tanzania	84.4	4.0	88.4	1126 ^c
Thailand	71.5	18.8	90.3	6754
Trinidad and Tobago	43.2	..	-	19880
Turkey	71.2	..	-	8632
Uruguay	54.1	18.9	73.0	11828
Venezuela	63.6	15.4	79.0	17426
Zambia	52.7	..	-	2061
Zimbabwe	41.6	14.5	56.1	2437
<i>Unweighted average</i>	60.3	18.4	77.6	-
Standard error	12.4	8.4	8.4	-

^a1989; ^b1986 ; ^c1988.

Sources: PWT 5.6 (1994); UN (1994).

correlated with labor productivity: The statistically significant correlation coefficient is -0.49 for the log of the capital share and the log of real GDP per worker. That is, poor DCs tend to have a higher physical capital share than more advanced DCs.

To check the plausibility of high estimates for physical capital's share in factor income, I also calculate human capital's share in factor income. For an average physical capital share of about 60 percent, the upper bound of human capital's share is 40 percent once unimproved labor does not receive any return. But obviously, unimproved labor also receives a return, so human capital's share in factor income can be expected to be lower than 40 percent in DCs. That is, if physical capital is internationally mobile but human capital is not, then the relative lack of human capital in DCs is the very reason for their relative backwardness. Hence it seems reasonable to presume that the poorer the country, the lower is human capital's share in income. This implication is confirmed by the results of cross-country regression analyses (Mankiw et al. 1992, Gundlach 1995) which show that human capital is at least as important as physical capital in explaining international income differences.

Unfortunately, the calculation of human capital's share in factor income is not straightforward, because there is no National Accounts counterpart. One way to derive an estimate for human capital's share in the *total wage bill* is to focus on the rate of return to education and average years of schooling, thereby assuming that investment in education is the same thing as an increase in the stock of human capital. For

example, it would follow that investment in education raises income by a factor of three, if schooling is about 8 years on average and the social rate of return to secondary education is about 13 percent, where both figures represent worldwide averages (Psacharopoulos 1993). The derived multiplier of education in the range of three remains almost unchanged for different regions of the world, because the rate of return to education tends to decline with rising years of schooling: Sub-Saharan Africa comes up with a multiplier of 2.9, non-OECD Asia with 3.1, Latin America with 2.8, and the OECD with 3.0.⁷

Hence, income is predicted to be about three times higher with human capital than without. As a result, human capital's share in the total wage bill should be about two thirds. Multiplying this figure with labor's total share in factor income gives the share of human capital in factor income. If labor's share in factor income is about 70 percent as in OECD countries, human capital's share can be expected to be about 45 percent; if labor's share in factor income is about 40 percent as in DCs, human capital's share can be expected to be about 25 percent.

I use estimates of the social rate of return to education summarized by Psacharopoulos (1993) and average years of schooling from Barro and Lee (1993) to calculate human capital's share in factor income for some of the DCs listed in Table 1.⁸ For average

⁷ Calculated from Psacharopoulos (1993) as social rate of return to secondary education times average years of schooling, raised to the power of e .

⁸ For the remaining DCs, rates of return to education are not reported in Psacharopoulos (1993).

years of schooling below 5 years, I use the social rate of return to primary education; for more than 5 years of schooling, I use the social rate of return to secondary education. In cases where the respective social rate of return to education is not available, I use Mincerian rates of return to education.⁹ The results are presented in the second column of Table 1.

Overall, I find that human capital's share in factor income is only about one third of physical capital's share. Together, both shares account for about 80 percent of total factor income, i.e. 20 percent of total factor income may be accounted for by low-skilled labor that does not receive a return for human capital. This result for a broad share of capital in the range of 80 percent is roughly in line with other empirical studies (Mankiw et al. 1992, Gundlach 1995, Pritchett 1996) and the standard parameterization used for the U.S. economy (Barro et al. 1995). But the relative weight of physical and human capital in DCs seems to be completely the reverse of the relative weight usually applied in the context of industrialized countries. This reversal of weights has strong implications for the implied rates of convergence for open and closed DC economies.

⁹ The Mincerian rate of return to education can be interpreted as the average private rate of return to one additional year of education. I use this rate instead of the social rate of return for Kenya, Malaysia, Panama, Peru, and Sri Lanka.

4. Openness and Convergence Reconsidered

4.1 *Theory*

Depending on the size of physical capital's share in factor income, the neoclassical growth model outlined in section 2 predicts different rates of convergence to the steady state (see equations (4) and (5)). This difference matters in quantitative terms because for reasonable parameterizations, the model also predicts that convergence to the steady state will evolve over a relatively long time period. That is, although openness does not change the model's steady state itself, it changes the implied convergence rate. As a result, open economies are predicted to realize substantial GDP gains within a shorter time period than closed economies.

For instance, consider the standard parameterizations for the rate of technological change (2 percent) and the depreciation rate (5 percent), and an average rate of labor force growth of about 2 percent for low and medium income countries in 1980-1993 (World Bank 1995). For average shares of physical and human capital in factor income of about 60 and 20 percent as reported in the last section, the model would predict that the closed economy will experience a convergence rate of 1.8 percent per year (see equation (4)). By contrast, in this case the open economy is predicted to experience a convergence of 4.5 percent per year (see equation (5)).

These findings have two main implications. First, for both convergence rates, the time period is fairly long until adjustment to the steady state is completed (Table 2). It would take about 50 years for the open economy to reach 90 percent of the steady state GDP, and the closed economy would only reach 60 percent of the steady state GDP after 50 years of adjustment. That is, economic policies that influence the accumulation of physical and human capital have more than a short run impact on the growth rate, because transition to the steady state will take place over decades, even in the open economy. If so, the observed positive correlation between investment rates and growth rates does not necessarily support the relevance of capital externalities (De Long and Summers, 1991); it can reasonably be explained as reflecting off-steady state behavior of the economy.

Table 2 — Theoretical Adjustment to the Steady State for Open and Closed Economies (percent)

Years	Adjustment to the steady state (percent)	
	Open economy ($\lambda_{open} = 4.5$ percent)	Closed economy ($\lambda_{closed} = 1.8$ percent)
5	20.1	8.6
15	49.1	23.7
38	81.9	49.5
50	89.5	59.3
100	98.9	83.5

Note: The percentage of the steady state achieved for a given convergence rate (λ) after t years is given by $1 - \left[1 / \left(e^{\lambda t}\right)\right]$.

Second, a large portion of the adjustment to the steady state occurs within a relatively short time period, at least for the open economy. The open economy will reach halfway to steady state (50 percent) in about 15 years, while the closed economy will reach halfway to steady state in about 38 years (Table 2). Put differently, the open economy will reach halfway to steady state in about one generation earlier than the closed economy. As is self-evident, one would predict other time spans for other parameterizations of technological change, depreciation, and labor force growth. But, if physical capital's share in factor income is about 60 percent in a typical DC, it matters whether this country is open or not: independent of other variables, the two convergence rates will differ by a factor of 2.5 (see equation (6)).

This difference is large. For example, the open economy will reach a GDP level that is about twice as high as the GDP level of the closed economy after 15 years of transition to the steady state (see Table 2). Since both economies converge to the same steady state, this difference must decline over time. Still, even after five decades of transition to the steady state, the open economy will lead in terms of GDP by more than 30 percent compared to the closed economy. Hence at least in theory, it seems to follow that especially DCs can gain a lot from policies of external liberalization.

4.2 Empirical Evidence

If the theory underlying the neoclassical model is correct, those DCs that tend to be more open should have experienced a better growth performance, i.e. a higher rate of

convergence to the steady state. One major difficulty for checking the plausibility of the model is to find an appropriate empirical measure of openness. Several measures have been suggested in the literature.

For a start, measures focusing on export performance as an indicator of openness (World Bank 1993) are problematic, for two reasons. The export share in output tends to be endogenous with regard to output growth, and it tends to decline with country size. Put differently, output growth may cause an increase in the output share of exports rather than the other way round, and such an increase is more likely to happen in small countries than in large countries. The Dollar index of openness (Dollar 1992), focusing on a country's relative price level in tradable goods, has been criticized for being a measure of real exchange rate divergence, which lacks credibility as a measure of openness. For instance, an increase in trade restrictions can move the Dollar index in either direction (Rodrik 1994). Other measures of openness, focusing on the absence of export or import quotas and a black-market premium over the official exchange rate (Sachs and Warner 1995), are somewhat difficult to reconcile with the concept of openness used in the neoclassical growth model outlined in section 2. This model identifies capital mobility as the decisive indicator of openness. However, the link between capital mobility and the absence or presence of quotas and black-market premiums is not straightforward: net capital flows have been surprisingly low between

countries with fairly liberal trade regimes and undistorted exchange rates (Feldstein and Horioka 1980).

Feldstein and Horioka measure the degree of international capital mobility by a regression of the investment share on the saving rate. The resulting so-called savings retention coefficient measures that fraction of an increase in domestic savings that ends up as domestic investment. If the savings retention coefficient equals 1, the economy is completely closed because an increase in domestic saving would lead to an identical increase in domestic investment. By contrast, if the savings retention coefficient equals 0, the economy is completely open because all additional domestic saving would end up as foreign investment.

Montiel (1994) uses the Feldstein-Horioka approach in a time series context and finds a surprisingly high degree of capital mobility in his sample of DCs. Choosing from a number of alternative specifications, his most preferred results indicate that out of a sample of 57 DCs, 33 can be considered as open and nine can be considered as closed, while the remaining cases remain statistically indecisive.¹⁰ These results seem to be fairly robust, since a number of factors are controlled for which may cause a potential downward bias in the estimated saving retention coefficient. Such factors are the possible impact of development aid, the potential endogeneity of the saving rate, and the specific time series properties of the data.

¹⁰ See Montiel (1994, Table 3, columns 3 and 6).

Unfortunately, Montiel's sample includes countries which do not provide detailed National Accounts Statistics that allow for a calculation of physical capital's share in factor income. I delete these countries from Montiel's sample of open and closed economies to control for data quality. My resulting sample consists of 13 open and 9 closed DCs. The DCs in Table 1 that can be identified as open according to Montiel's results¹¹ are Benin, Cameroon, Chile, Colombia, Costa Rica, Ecuador, Malaysia, Mauritius, Mexico, Paraguay, Peru, Sierra Leone, and Uruguay; the DCs that can be identified as closed are Honduras, Kenya, Malawi, Nepal, Niger, Nigeria, the Philippines, Venezuela, and Zimbabwe. For this sample of 22 DCs, I estimate the two rates of convergence for open and closed economies.

Mankiw et al. (1992) show that based on the production function given in equation (1), the rate of convergence (λ) can be estimated by regressing the log difference of output per worker at time t and some initial date 0 on the determinants of the steady state and the initial level of output. Augmenting such an equation by a slope and a level dummy for openness, I get

¹¹ Montiel (1994) suggests a benchmark value of 0.6 for the estimated savings retention coefficient to decide whether an economy is open or closed. Whenever his IV-estimate is close to 0.6, I use his OLS-estimate to decide whether an economy should be classified as open or closed.

$$\begin{aligned}
(7) \quad \ln(Y/L)_t - \ln(Y/L)_0 &= c + \left(1 - e^{-\lambda t}\right) \frac{\alpha}{1 - \alpha - \beta} \ln(\Delta K / Y) \\
&+ \left(1 - e^{-\lambda t}\right) \frac{\beta}{1 - \alpha - \beta} \ln(\Delta H / Y) - \left(1 - e^{-\lambda t}\right) \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) \\
&- \left(1 - e^{-\lambda t}\right) \ln(Y/L)_0 + OPEN - \gamma SLOPEN,
\end{aligned}$$

where c is a regression constant, $\Delta K / Y$ is investment in physical capital, and $\Delta H / Y$ is investment in human capital, both expressed as shares in output. $OPEN$ is a level dummy which equals 1 for open DCs and 0 otherwise, $SLOPEN$ is a slope dummy which equals initial income for open DCs and 0 otherwise. All other variables and parameters are defined as before.

Investment in human capital as a share of output ($\Delta H / Y$) is measured as the percentage of the working age population that is in secondary school, and taken from Mankiw et al. (1992). All other variables are taken from Summers and Heston (1991): Output per worker (Y/L) is real GDP per worker in 1985 international prices, investment in physical capital as a share of output ($\Delta K / Y$) is real gross domestic investment as a share of real GDP in 1985 international prices, and n is the implicit growth rate of the labor force derived from measures of real GDP and real GDP per worker. Time t is 1985, time 0 is 1960.

With only 22 observations at hand, a regression based on the specified convergence equation would result in a serious degrees of freedom problem. Therefore, I restrict the

convergence equation according to the empirical results in Mankiw et al. (1992, Tab. VI, intermediate sample) as

$$\begin{aligned}
 (8) \quad \ln(Y / L)_t - \ln(Y / L)_0 - 0.506 [\ln(\Delta K / Y) - \ln(n + g + \delta)] \\
 - 0.266 [\ln(\Delta H / Y) - \ln(n + g + \delta)] \\
 = c - (1 - e^{-\lambda t}) \ln(Y / L)_0 + OPEN - \gamma SLOPEN.
 \end{aligned}$$

That is, my regression equation uses the conditional growth rate as the new dependent variable. The conditional growth rate controls for differences among DCs in the two rates of factor accumulation and in the rate of labor force growth, which together determine the steady state. With this approach, I estimate the following regression coefficients and the implied rates of convergence (standard errors in parentheses):

$$\begin{aligned}
 \text{Conditional growth rate} = 2.53 + 3.62 \text{ OPEN} - 0.31 \ln(Y / L)_0 - 0.41 \text{ SLOPEN} \\
 (0.73) \quad (1.09) \quad (0.09) \quad (0.13)
 \end{aligned}$$

Number of observations: 22

$$\bar{R}^2 = 0.76 \quad \text{s.s.e.} = 0.22$$

$$\begin{aligned}
 \text{Implied } \lambda_{open}^{DC} : 0.051 \\
 (0.013)
 \end{aligned}$$

$$\begin{aligned}
 \text{Implied } \lambda_{closed}^{DC} : 0.015 \\
 (0.006)
 \end{aligned}$$

My empirical findings for the two rates of convergence confirm the difference between open and closed economies predicted by the neoclassical model of economic growth: Open DCs converge at a much higher rate to their steady state than closed DCs.¹² For DCs with physical capital's share in factor income of about 60 percent and human capital's share in factor income of about 20 percent, the model predicts a convergence rate of 4.5 percent for the open economy and of 1.8 percent for the closed economy. My point estimates closely resemble this prediction. Put differently, although openness does not change the steady state itself, it considerably shortens the time period until the steady state is reached. Taking the point estimates for the two convergence rates literally, the open economy would reach halfway to steady state in about 33 years earlier than the closed economy. Even after five decades of transition to the steady state, the open economy would lead in terms of GDP by about 40 percent compared to the closed economy.

Summarizing, openness along with factor accumulation matters for economic growth, especially in DCs. In qualitative terms, this finding may not come as a surprise. The

¹² See Sachs and Warner (1995) for a similar result. They also report that open DCs show-higher-than average growth, and therefore convergence. However, their empirical results are difficult to reconcile with the model they use. First, their estimated regression coefficients on initial income either do not allow for a calculation of the convergence rate (their Table 4) or imply an inconsistent convergence rate of about 9.6 percent (their Table 5). Second, the impact of openness is measured by a level dummy, although the underlying model suggests to measure the impact of openness by a slope dummy.

surprise is the quantitative importance of openness for the convergence rate, and hence the growth rate.

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