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ARE CAPITAL FLOWS CONSISTENT WITH THE NEOCLASSICAL GROWTH MODEL? EVIDENCE FROM A CROSS-SECTION OF DEVELOPING COUNTRIES

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ABSTRACT

Are Capital Flows Consistent with the Neoclassical Growth Model? Evidence from a Cross-section of Developing Countries*

We identify the determinants of capital movements in an 'augmented-Solow' model where capital mobility is restricted to a subset of capital assets. We then test the prediction of the neoclassical model and find that it is consistent with the evidence on net capital flows in a cross-section of developing countries over the period 1960–82. We find that this is no longer true after 1982, however: the episodes of foreign debt repudiation and the world financial crisis of the early 1980s are the most natural candidates for an explanation of this pattern.

JEL Classification: F21, O30, O40
Keywords: growth theory, capital movements, developing countries

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NON-TECHNICAL SUMMARY

A well-known problem with neoclassical growth theory is that if perfect capital mobility holds, then the model predicts instantaneous convergence of an economy to its own steady state. This is because under diminishing returns the return to capital will be higher in countries with output and capital below their steady-state level. In turn, this will attract foreign capital inflows and generate an infinite rate of convergence. This convergence is 'conditional' in the sense that convergence in *per capita* income takes place according to the conditions of all those variables which affect the steady-state position of a country. The empirically-estimated coefficient of conditional convergence across countries has been found to be quite low, however, at around 2%. Moreover, the concept of conditional convergence in *per-capita* incomes, which underlies this 2% figure, has been criticized because the tests implemented to confirm it are plagued by Galton's fallacy of regression towards the mean (see Quah (1993)).

A solution that has recently been suggested for this counterfactual prediction of the neoclassical growth model by Barro, Mankiw and Sala-i-Martin (1995) is to assume that human capital cannot be used as collateral for external borrowing: this can be due to the difficulty of enforcing property rights on human capital or to the incompleteness of financial markets. In this case, the speed of international convergence implied by the neoclassical model is substantially lower.

This assumption is used here in the context of an augmented Solow model in order to identify the determinants of capital movements, and to derive a testable reduced-form equation for the amount of net foreign borrowing *per capita*. Under these conditions and given diminishing returns, a low level of initial *per-capita* income, associated with large initial stocks of human capital and high investment rates in human capital, is associated with relatively high returns on physical capital. As this can be financed through foreign borrowing, such characteristics of an economy will lead to relatively large inflows of foreign funds in a developing economy. These relations are consistent with models predicting conditional convergence.

Subsequently, empirical tests are conducted on a cross-section of 33 developing countries for which complete data was available. The objective is to analyse whether the allocation of capital flows across these countries has been consistent with the theoretical predictions put forward here. Industrial countries are excluded from the sample because capital movements in these

countries are explained, much more than in developing countries, by medium-term adjustment phenomena, rather than the determinants of the long-run growth rate considered here. The empirical model is estimated over the period 1960–88. Long-run net borrowing is proxied by IMF data on the current account balance cumulated over the period. As is usual with this literature, the proxies used for the initial stock of human capital include: the initial share of people aged 25 and over who have completed secondary education for educational attainment; and the initial *per-capita* number of physicians for health care performance. The secondary education enrollment rate is used as a proxy for investment in human capital. Lastly, because political instability weakens property rights, it has a negative impact on the effective rate of return on capital. The number of revolutions and coups during the period 1960–70 is therefore included in the regressions.

The results found are consistent with the augmented-Solow model with partial capital mobility over the period 1960–82: capital has been directed towards countries with initial low income levels, high human capital and low political instability. It was also found that during this period Asian countries borrowed less, in comparison to other continents, than the theory would predict. The model performs best during the years from 1960–72. The results are consistent with models of conditional convergence considering the determinants of capital flows instead of the growth rates. For this reason, the results of the paper are not marred by Galton's fallacy, but they do not have any obvious implication for the convergence controversy.

The inclusion of the post-1982 period weakens the results significatively. The signs are still correct but the coefficients become insignificant. In the sub-period 1982–8, the model performs very badly. This strongly suggests that the determinants of net capital flows to developing countries changed, not surprisingly, in the aftermath of the world debt crisis of the early 1980s and that they are no longer those predicted by the neoclassical growth model. One possible explanation for this phenomenon is that 'defensive lending' to the developing countries prevailed, after 1982, over lending according to market conditions in response to the widespread risk of default. If this is the case, a basic growth model such as the one given in this paper is not adequate to account for net capital flows after 1982.

Another result is that net borrowing was positively correlated with growth only in the period 1960–72. After 1972, the correlation vanishes, which would contradict the prediction of the augmented-Solow model with limited capital mobility, and suggests that foreign borrowing did not promote growth during this period.

1. Introduction

The basic aggregate neo-classical model (one good, two factors) implies that, if capital is mobile, one should observe net capital inflows in countries where the (closed-economy) marginal product of capital is higher; under the law of diminishing returns, this should lead to interest-rate equalization, provided one considers risk-adjusted interest rates which approximate the marginal product of capital in different countries. In a two-factor setup, this amounts to say that capital should move from rich to poor countries.

If we abandon the two-factor neo-classical model we reach different conclusions on the pattern of capital flows. Indeed, several authors have argued that "capital does not flow from rich to poor countries" because the neo-classical proposition of the two-factor model, namely that per-capita income is a good proxy for the inverse of the marginal product of capital, is not supported by the data; moreover, they have shown that under alternative assumptions returns on capital need not be larger in poor countries (see, among others, Lucas, 1990; Gundlach, 1994).

Moreover, a well known problem with the neo-classical model is that it predicts that convergence occurs instantaneously if perfect capital mobility holds. This convergence is « conditional » in the sense that convergence in paer capita incomes takes place conditional on all those variables which affect the steady state position of the economy. However, the empirically *estimated* coefficient of international convergence is quite low, about 2 percent per year (see Barro-Sala-i Martin, 1992; 1995, ch.3). Moreover, this figure has been put into doubt because the tests implemented to estimate it are plagued by Galton's fallacy of regression towards the mean (see Quah, 1993). One possible explanation for the low speed of convergence among countries is the absence of international capital mobility, particularly in the developing countries; however, recent empirical studies tend to reject the hypothesis of no capital mobility in the developing countries (see Montiel, 1993; Bagnai-Manzocchi, 1996).

A solution to this puzzle has been suggested by Barro *et al.* (1995) who show in a theoretical model that the speed of convergence is substantially lower in the open economy if capital mobility only applies to a subset of capital assets, for instance to physical but not to human capital (*partial* capital mobility); their argument is that human capital cannot be used as collateral for external borrowing because property rights on human capital are hardly enforceable. Indeed, other scholars have pointed out that even in the closed economy the incompleteness of financial markets may hinder human capital accumulation (De Gregorio, 1993; Goldstein-Mussa, 1993; Ljungqvist, 1993). Although the evidence of a slow rate of conditional convergence is more easily accounted for in this setup, the implied speed of convergence in the neo-classical model might still be excessive (Barro *et al.*, 1995, p.114).

Other scholars have been concerned about the implications of capital mobility for growth and convergence (see Cohen, 1994). We explore this relationship in the opposite direction: an implication of partial capital mobility in the neo-classical model is that long run foreign borrowing should be consistent with the determinants of the growth rate of an economy, hence with the hypotheses underlying the concept of (conditional) convergence. In this paper, we build an open economy version of the augmented-Solow model featuring partial capital mobility. We identify the determinants of capital movements in this framework and derive a testable reduced form equation for the amount of per capita net foreign borrowing (section 2). We then conduct empirical tests on a cross section of developing countries to analyse whether the allocation of net capital flows across the developing countries has been consistent with the theoretical predictions (section 3). Sections 4 and 5 respectively contain the conclusions and the appendix.

2. An augmented Solow model with "partial" capital mobility

Consider an economy where output (Y) consists of a homogeneous good produced with raw labour, physical capital and human capital (L, K, H, respectively) according to a Cobb-Douglas function (we drop the time subscript):

$$Y = AK^{\alpha} H^{\beta} L^{1-\alpha-\beta} \tag{1}$$

where α and β are positive parameters. Y can be either consumed or invested in the accumulation of H or K. Exogenous technical change is ruled out. We can re-write this equation in intensive form as:

$$y = f(k;h) = Ak^{\alpha} h^{\beta} \tag{2}$$

where y, k and h are output, physical and human capital per worker, respectively. For simplicity, we assume that employment is equal to population: setting the initial employment level equal to unity, L grows according to a positive rate of growth of population (n):

$$L = e^{nt} \tag{3}$$

The law of motion of human capital is given by:

$$H = s_h Y - \delta H \quad \text{or} \quad \dot{h} = s_h y - (n+\delta)h \tag{4}$$

where a dot over a variable indicates a time derivative; s_H is the constant fraction of output invested in human capital accumulation and δ the depreciation rate (common to human and physical capital). As far as k is concerned, we assume its

accumulation can be fully financed by external borrowing. If individual countries are "price-takers" on world financial markets, the arbitrage condition requires that the steady-state rate of return on physical capital in the domestic economy be equal to an exogenously *fixed* world interest rate (r, which is assumed to be positive):[1]

$$f_k(k^*;h^*) - \delta = \alpha A(k^*)^{\alpha-1}(h^*)^{\beta} - \delta = r \tag{5}$$

In order to derive a closed-form equation for the long run external asset position of this economy, we focus on the stationary equilibrium. The steady state level of k can be expressed as a function of r and h^*:

$$k^* = \left\{\frac{\alpha A}{r+\delta}(h^*)^{\beta}\right\}^{\frac{1}{1-\alpha}} \tag{6}$$

while h^* can be obtained from equation (4):

$$h^* = \left\{\frac{s_h A}{n+\delta}(k^*)^{\alpha}\right\}^{\frac{1}{1-\beta}} \tag{7}$$

We can use equation (7) in order to substitute for h^* into equation (6) and obtain a reduced form for k^*:

$$k^* = \left\{\frac{\alpha A}{r+\delta}\left(\frac{s_h A}{n+\delta}\right)^{\frac{\beta}{1-\beta}}\right\}^{\frac{1-\beta}{1-\alpha-\beta}} \tag{8}$$

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[1] An asterisk denotes the steady-state value of the variables.

Suppose that, at time t=0, this economy becomes open to capital flows. The assumption of *partial* capital mobility implies that per-capita net foreign borrowing in the steady state will be positive or negative depending on the difference between the steady-state value of k, which is dictated by the arbitrage condition (5), and the initial stock of physical capital per worker (the initial condition $k(0)$):

$$\left(\frac{B}{L}\right)^{*} = b^{*} = k^{*} - k(0) \tag{9}$$

where B is cumulated foreign borrowing (the negative of the cumulated current account balance):

$$B_t = -\int_0^t (current\ account)_\tau d\tau \tag{10}$$

This means that a country will be a net borrower (lender) on international capital markets if the steady state value of k is larger (smaller) that its initial value. Therefore, b^* (cumulated per-capita net foreign borrowing) can be expressed as:

$$b^{*} = \left\{\frac{\alpha A}{r+\delta}\left(\frac{s_h A}{n+\delta}\right)^{\frac{\beta}{1-\beta}}\right\}^{\frac{1-\beta}{1-\alpha-\beta}} - \left\{\frac{y(0)}{A\left(h(0)\right)^{\beta}}\right\}^{\frac{1}{\alpha}} \tag{11}$$

where the second expression on the right-hand-side of (11) corresponds to $k(0)$ as obtained from eq.(2).

From equation (11) one can easily check that b^* is a positive function of $h(0)$ and s_h, and a negative function of $y(0)$: intuitively, this means that the lower the initial level of per capita income *and* the larger the initial stock of human capital, the higher the initial marginal product of physical capital (the smaller $k(0)$); similarly, the higher the rate of investment in human capital the larger the steady state level of k. As in

equilibrium per capita net foreign borrowing equals the difference between k^* and $k(0)$, equation (11) has a straightforward interpretation. One can easily see that it also establishes a linkage with the results of other recent models (see Mankiw *et al.*, 1992; Benhabib-Spiegel, 1994; Barro *et al.*, 1995): as foreign borrowing is negatively linked to the initial level of income once the variables affecting the steady-state position of the economy are included, the model predicts that international capital flows depend on the same determinants as conditional convergence.

In the steady state, per capita gross output (*gdp*) and national income (*gnp*) are given by equations (12) and (13), respectively:

$$gdp^* = f(k^*; h^*) \tag{12}$$

$$gnp^* = f(k^*; h^*) - r\left[\, b^* + b(0) \,\right] \tag{13}$$

where $b(0)$ is the outstanding stock of per-capita foreign debt at time zero.

3. An empirical assessment of the model

This section reports empirical tests of the augmented Solow model of capital flows (with partial mobility) in a cross section of 33 developing countries (7 African, 10 South American, 8 Central American, 8 Asian) over the period 1960 through 1988. [2] The sample has been selected excluding merely "oil-based" economies and small financial centers. Others developing countries have been excluded because of lack of data on human capital stocks or the current account balance (see the appendix for

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[2] Ghosh and Ostry (1993) show that capital flows have played a relevant role in consumption-smoothing for several developing countries. However they focus on *short-term* borrowing, not on long-term foreign borrowing as in this work.

further details). Of course, the limited coverage of the sample means that the results are just referred to these economies and no claim of universality is made.[3]

Industrial countries have been excluded from the sample for two reasons. First, some of them (notably the G-3 countries) cannot be considered price-takers on the world financial market, hence the assumption of an exogenously fixed rate of interest for international borrowing and lending is not viable; this means that r and the amount of external borrowing should be *simultaneously* determined if these countries were included in the sample. Second, when one averages the current account balance of the industrial countries for the periods 1960-74 and 1975-88, many countries shift from a positive to a negative balance or viceversa (France, Italy, the UK, the US, Belgium, Spain, Sweden and others; see Tesar, 1991). This sort of swings are related to medium-term adjustment phenomena, not to the determinants of the long-run growth rate which are analysed here.[4] In contrast to this, the sign of the current account balance is usually stable over time for the countries considered here (see table 5 in the appendix).

The dependent variable, long-run per capita *net* borrowing (b^*), is proxied by yearly IMF data on the current account balance expressed in current US dollars, divided by the size of the population and cumulated over 1960 through 1988 (as well as over shorter sub-periods).

The value of per-capita income in 1960, *income1960*, expressed in current "international" (PPP) dollars, is obtained from Summers-Heston (1991).

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[3] Levine-Zervos (1993) argue that this should always be the correct economic interpretation of cross-section regressions.

[4] Moreover, McKinnon (1980) argues that the current account balance of major industrial countries is to a large extent driven by government budgets Levine-Zervos (1993) argue that this should always be the correct economic interpretation of cross-section regressions.

Two types of proxies for the initial stock of human capital (*h(0)*) have been considered. First, the initial level of secondary educational attainment of the adult population (*secomp1960*) has been included as a proxy of educational standards across developing countries. It is well known and it has been recognized by Barro and Lee (1993) who provide the data, that this proxy does not account for the "quality" of education in different countries, but only for the "amount" of education received; nonetheless, it represents an improvement with respect to other proxies like the literacy rate (see Benhabib-Spiegel, 1994). Other kinds of proxies, like the primary educational attainment or the average years of total schooling, have been tried in alternative to the "stock" of secondary education, but they perform worse (similar results are found in a different context by Barro-Lee, 1994).

A second type of proxies for the initial stock of human capital is related to health-care.[3] Data on developing countries are extremely unsatisfactory and incomplete in this case, especially for the sixties. Hence, we have included the number of physicians over total population at the beginning of the sixties (*phy1960*), on which data are available for each country of the sample, as an admittedly rough index of the capacity of national health-care systems.

As far as the investment rate in human capital (s_h) is concerned, we have used as a proxy the secondary education enrollment rate in 1960 (*seced1960*), which is exogenous with respect to net foreign borrowing in the following decades; moreover, the secondary enrollment rate is "robustly" correlated with growth according to Levine-Renelt (1992). We have also made an attempt to include data on the secondary enrollment rate at the beginning of the following decades (the seventies and the eighties) in some of the regressions, although in this case exogeneity with respect to

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[3] Uzawa (1965) argues that "human capital" is only partially approximated by education and it includes other items such as health and some kinds of infrastructures and public goods.

foreign borrowing in the sixties cannot be taken for granted; however, the enrollment rates in 1970 and 1980 have turned out to be not significant.

Other variables could in principle explain the rate of external borrowing and lending. First, international capital flows can be affected by political instability or by distortionary policy regimes: if political instability is high in an individual country, a risk premium could be added to the rate of interest (r) to be paid by residents of this country: in equilibrium, this will reduce b^* (see equation 11). Similarly, if the distortions induced by policy are relevant, the productivity of the inputs can be negatively affected and b^* can be lower (consider, for instance, the effect of a lower value of A in eq.11). As a measure of political instability we have included the *number of revolutions and coups* over a decade (*rev*) used by Barro (1991): this variable evaluated over the sixties turns out to have a strong negative impact on b^*. Alternative measures of instability (the number of assassinations) or of distortion (the black market premium on the exchange rate) enter the regressions with non-significant coefficients.

Another kind of variables that could be related to foreign borrowing would require a modification of the basic model. If capital flows depend on the behaviour of the *terms-of-trade*, on the rate of *growth of per capita consumption* or on the average *rate of inflation*, then the augmented-Solow model with partial capital mobility does not provide an adequate description of the fundamental relationships underlying b^* Other potentially relevant variables include the *rate of growth of population*, that could have a negative impact on b* (see eq.11) and the *size of the population (or of national product)* if scale effects matter. However, we have checked that none of these variables has a significant influence on net capital flows, or a significant impact on the coefficients of the variables included in the regressions, in the sample of countries considered here.

Finally, we have included two kinds of dummies in the regressions: *regional dummies* for each of the four areas considered, and a dummy for the countries classified "*official borrowers*" by the IMF (see the appendix). Only the Asian dummy

enters the estimates with a significant (negative) coefficient. Therefore, only two additional variables, *rev1960-70* and the *Asian dummy*, are shown in the tables.

When b^* is computed over 1960-88 (table 1), the statistical performance of the model is rather poor, although all the coefficients are correctly signed; *rev1960-70* and the *Asian dummy* both enter with a negative coefficient, suggesting that political instability reduces capital inflows and that Asian countries have borrowed less than average.

Table 1: 1960-88

Dependent variable is b^* (cumulated per-capita net foreign borrowing) over 1960 through 1988

Constant	314.2 (1.7)	546.5 (2.26)	796.5 (3.08)
Income 1960	-0.44 (-0.51)	-0.34 (-0.45)	-1.1 (-1.43)
Secomp1960	51.53 (0.77)	55.29 (0.78)	75.9 (1.48)
Seced1960	12.55 (0.6)	2.74 (0.12)	16.75 (0.99)
Phy1960	773328 (1.41)	790294 (2.22)	1147256 (2.87)
Rev1960-70	--------	-871.4 (-2.47)	-1000 (-2.83)
Asian dummy	--------	---------	-806 (-2.31)
Adjusted R-squared	.27	.36	.46
F-statistic	3.9	4.63	5.59
Number of Obs.	33	33	33

Standard errors are consistent with heteroschedasticity according to White (1980). T-statistics in brackets.

The debt crisis of 1982-83 could be responsible for the unsatisfactory results of table 1[6]. If one interprets that crisis as the turning point of an "international debt cycle" as defined by Eichengreen (1990), the conditions and the availability of external resources for the developing countries could be radically different after 1982; for instance, Savvides (1991) argues that in the years following the debt crisis foreign lending to the developing countries has been to a large extent "defensive", i.e. intended to prevent widespread default by developing countries. If this is true, the period 1960-82 would represent a more uniform time-interval for the empirical analysis than 1960-88: the results shown in table 2 support this view. After a measure of political instability and the Asian dummy have been included, all coefficients (except that of *secomp60*) are significant at the 0.05 level,[7] and the model accounts for sixty percent of the variability of b^*.

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[6] When the regressions are performed on the period 1982-88, the coefficients on the different determinants of the capital flows are either insignificant or /and of the wrong sign.

[7] The coefficient of *income60* is only marginally significant at the 0.05 level.

Table 2: 1960-82

Dependent variable is b^* (cumulated per-capita net foreign borrowing) over 1960 through 1982

Constant	170.8 (1.34)	353.2 (2.16)	546.1 (3.23)
Income 1960	-0.46 (-0.74)	-0.37 (-0.71)	-0.96 (-1.97)
Secomp1960	40.9 (0.87)	43.94 (0.98)	59.7 (1.78)
Seced1960	18.1 (1.58)	10.34 (0.88)	21.04 (3.04)
Phy1960	628321 (1.29)	800453 (2.15)	920321 (2.69)
Rev1960-70	--------	-691.3 (-2.65)	-789.5 (-3.06)
Asian dummy	--------	---------	-615. 9 (-2.74)
Adjusted R-squared	.40	.49	.59
F-statistic	6.34	7.31	8.66
Number of Obs.	33	33	33

Standard errors are consistent with heteroschedasticity according to White (1980). T-statistics in brackets.

If the time interval is reduced to 1960-72, the empirical performance of the model is still satisfactory (see table 3).

Table 3: 1960-72

Dependent variable is b^* (cumulated per-capita net foreign borrowing) over 1960 through 1972

Constant	27.9 (0.68)	64.9 (1.27)	122.3 (2.62)
Income 1960	-0.30 (-1.76)	-0.28 (-1.78)	-0.46 (-3.11)
Secomp1960	3.08 (0.25)	3.69 (0.3)	8.42 (1.03)
Seced1960	8.49 (2.07)	6.92 (1.62)	10.14 (3.81)
Phy1960	213020 (1.61)	247664 (2.19)	283665 (2.7)
Rev1960-70	---------	-139 (-1.89)	-168.6 (-2.32)
Asian dummy	---------	--------	-184.9 (-2.66)
Adjusted R-squared	.44	.48	.59
F-statistic	7.28	6.91	10.99
Number of Obs.	33	33	33

Standard errors are consistent with heteroschedasticity according to White (1980). T-statistics in brackets.

These empirical findings suggest that the augmented-Solow model with partial capital mobility is consistent with the evolution of per capita external borrowing in the developing countries over the period 1960-82, i.e. until the breakout of the world debt crisis. The coefficient of the initial level of per capita income is negative, while those of the proxies for the steady-state values of human and physical capital are positive, suggesting that *capital flows have been consistent with models predicting "conditional" convergence* (at least across major developing countries). Table 3 shows that the empirical performance of the model improves if we only consider the years before the first oil crisis of 1973. This could suggest that we re-estimate the equation after 1973 using 1973 as the starting year, with $y(0)$, $h(0)$ *and* s_I evaluated at the beginning of the seventies. However, this interpretation of the patterns of capital flows

does not fit the data: external borrowing between 1973 and 1982 has a stronger empirical relation with the initial conditions in 1960 than with those in 1973.

The evidence reported above shows that the determinants of net capital flows in the developing countries are consistent with a neo-classical growth model with partial capital mobility, at least until 1982. The results are consistent with models of conditional convergence, but from a different point of view that the usual ones as we consider the determinants of capital flows and not growth rates. For this reason, our results are not marred by Galton's fallacy, but they do not have any obvious implication for the convergence controversy. In particular, our results do not mean that capital flows have *actually promoted* growth and convergence[8]: in order for this to be the case, per capita net borrowing should be positively associated with the rate of growth of per capita output: table 4 suggests that this association was rather strong in the sixties, but not in the seventies and eighties.

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[8] Moreover, it could be the case that the amount of foreign borrowing in the developing countries is less than the amount predicted by this model, e.g. if only a fraction of $(k^*-k(0))$ can financed by capital inflows; nonetheless the allocation of foreign borrowing could be consistent with the neo classical growth theory.

Table 4

Right hand side variables	Dependent variable: Rate of growth of per-capita income 1960-72	Dependent variable: Rate of growth of per-capita income 1973-82	Dependent variable: Rate of growth of per-capita income 1983-88
Constant	0.005 (17.9)	0.089 (14.02)	0.28 (5.57)
Net foreign borrowing 1960-72	0.41E(-4) (6.14)	--------	--------
Net foreign borrowing 1973-82	--------	-0.9E(-5) (-1.13)	--------
Net foreign borrowing 1983-88	--------	--------	0.63E(-7) (0.004)
Adjusted R-squared	.18	-.003	-0.3
F-statistic	7.9	.89	0.36E(-4)

Number of observations: 33. Standard errors are consistent with heteroschedasticity according to White (1980). T-statistics in brackets.

Although the figures in table 4 must be viewed as simple "stylised facts" and interpreted with caution (other potentially relevant variables are not included in the regressions) the absence of correlation between capital inflows and growth in the seventies could perhaps be at the origin of the inability to repay, hence of the developing countries debt crisis of the early eighties. [9]

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[9] Reynolds (1986, ch.5) shows that the growth performance of the major Latin American and African countries considered here has worsened in the 1970's as compared to the 1960's (the only exception being Brazil), while the growth

4. Final remarks

This paper describes an open economy version of the augmented-Solow growth model, in which income differentials across countries are generated by the relative endowments of human and physical capital. The peculiar feature of the model lies in the assumption of "partial" capital mobility (originally due to Barro *et al.* 1995) which implies that physical but not human capital can be accumulated by borrowing abroad at the world interest rate. Under partial capital mobility, a low level of initial per capita income (and of political instability) associated with large initial stocks and investment rates of human capital leads to relatively large inflows of foreign funds in a developing economy. This is consistent with models predicting conditional convergence.

We estimate an empirical model derived from the augmented-Solow setup, in which per capita foreign borrowing depends on the initial level of individual income but conditionally on proxies for the educational attainment, health care standards and political instability: the data support the model over the period 1960-1982, but not after 1982 suggesting that the determinants of net capital flows in the developing countries have changed in the aftermath of the world debt crisis of the early eighties.

An explanation for this phenomenon is that "defensive lending" to the developing countries has prevailed over lending according to market conditions after 1982 in response to a widespread risk of default; if this is the case, a basic growth model such as the one suggested in this paper is not adequate to account for net capital flows over 1983-88. The cross section analysis provides another result, although preliminary, namely that no simple correlation can be found between net foreign

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performance of the Asian economies, i.e. the economies which comparatively received a lower amount of foreign capital, has improved in the same decades (the exception being Indonesia). On the disappointing record of the Latin American countries in the seventies, see also De Gregorio (1992).

borrowing and income growth in the seventies (while a strong positive correlation can be detected for the sixties).

5. Appendix

a) Composition of the sample

The sample of developing countries that has been selected includes developing countries classified as "Intermediate" by Mankiw, Romer and Weil (1992) *for which the IMF provides current account data from 1960* without relevant gaps. The "intermediate countries" sample is considered a reliable one by Mankiw, Romer, Weil (1992), because it excludes economies based only (or almost only) on the oil sector, and very small economies. The sample selected here also excludes small financial centers (like Bermudas, Singapore, etc.), and those countries for which incomplete or no data are available in the Barro-Lee (1993) dataset on education.

The sample consists of the following 33 countries: Kenya,Malawi, Mali, Senegal, Tanzania, Tunisia, Zambia (seven African countries); Costarica, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Panama (eight Central American countries) Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela (ten South American countries); India, Indonesia, Korea, Malaysia, the Philippines, Sri Lanka, Thailand and Israel (eight Asian countries). Averaged data on net foreign borrowing and per capita income for these countries are reported in table 5.

Eight countries are classified as *official borrowers* by the IMF (*World Economic Outlook*, October 1994), that is countries whose external debt in 1989 was for at least two thirds owned by international organizations (Malawi, Mali, Tanzania, Tunisia, Zambia, El Salvador, Honduras, Jamaica).

b) Definition and sources of the data:

1) Cumulated per-capita net foreign borrowing ($b^*_{0;\ t}$) is defined in equations (9) and (10) as the sum, over the relevant time interval, of the negative of the current account of the balance of payments (expressed in thousands of current US dollars) divided by the size of the population. Yearly data on the current account balance are taken from the International Financial Statistics of the IMF (CD-ROM version, series 77a.d). Yearly data on the size of the population are available in Summers-Heston (1991, variable n°1). In a few cases, the coverage of the current account data-set is incomplete: individual countries have been excluded from the sample if many observations were missing (this is particularly true of some countries over 1960-72), whereas if only few years were missing the average "per capita net foreign borrowing" of a particular country is computed from the available data. Further details are available upon request.

2) "Initial per-capita income" (*income*) is a proxy for $y(0)$; it is defined as a country's per-capita GDP in 1960 measured in current "international dollars", that is evaluated with the PPP index computed at International Comparison Project of the United Nations; the source is Summers-Heston (1991), variable CGDP (n°9). In the case of Indonesia, as *income* was not available for 1960, we have taken the value for the year 1962.

3) Data on the *stock* of education are taken from the database by Barro-Lee (1993) which is available upon request at the World Bank Growth Project. Barro and Lee provide data for a large sample of countries over 1960-85 at intervals of five years. The statistical significance of all the variables provided by Barro-Lee (more than 30) has been tested, and it has turned out that the share of people aged 25 and over who have *completed* secondary education (*secomp*) is the most significant variable.

4) Data on "secondary education enrollment rates" (*seced*) are taken from the World Development Report of the World Bank (various issues); the variable is defined as the ratio of the number of people of *all ages* enrolled in secondary school to the size of the population of secondary school age (12 to 17 years).

5) Data on the number of physicians over total population (*phy*) are also derived from the World Development Report and the year of observation for each country is chosen as close as possible to 1960. This variable is defined as the inverse of "population per physician", whose estimates are provided by the World Bank, and included as a proxy for health-care standards (contributing to the stock of human capital).

6) Data on the number of revolutions and coups over a decade (*rev*) are obtained from the Barro (1991) dataset.

7) The rates of growth of per capita income in "international" dollars are computed from the dataset by Summers-Heston (1991), variable CGDP (n°9).

Table 5

Country	nfb 1960-72	nfb 1973-82	nfb 1983-88	income ratio 1960-72	income ratio 1973-82	income ratio 1983-88
Africa						
kenya	2,4718	23,3315	9,7902	0,0592	0,0679	0,0523
malawi	6,0103	20,6482	11,5681	0,0412	0,0414	0,0332
mali	3,6243	11,7989	14,8774	0,0375	0,0311	0,0287
senegal	5,4203	36,5489	42,4807	0,0993	0,0797	0,0690
tanzania	0,8871	16,7435	14,7640	0,0316	0,0333	0,0297
tunisia	13,4337	54,4152	56,1480	0,1321	0,1774	0,1793
zambia	-12,7390	54,9544	41,7586	0,1194	0,0866	0,0456
Central America						
costarica	29,8963	154,4092	112,1272	0,2237	0,2540	0,2209
dominican rep.	9,6794	51,6888	32,7852	0,1346	0,1562	0,1306
el salvador	4,1955	18,9433	25,6981	0,1411	0,1400	0,1037
guatemala	5,4755	27,5846	35,2833	0,1711	0,1683	0,1330
honduras	6,7708	47,9868	66,5743	0,0906	0,0901	0,0748
jamaica	40,5083	97,5850	101,6125	0,2009	0,1920	0,1461
mexico	10,9841	80,7109	-23,1810	0,3044	0,3496	0,3028
panama	26,7380	90,7181	-147,9914	0,1859	0,2221	0,2216
South America						
argentina	1,6795	31,5128	79,3863	0,3364	0,3089	0,2438
bolivia	5,0065	27,6796	43,5802	0,1168	0,1288	0,0898
brazil	5,3325	73,9868	20,5874	0,2205	0,1890	0,2433
chile	13,0060	114,4743	91,9489	0,3290	0,2735	0,2317
colombia	9,0776	17,1135	34,3446	0,1814	0,2077	0,2005
ecuador	9,0174	58,0599	42,2151	0,1394	0,1915	0,1603
paraguay	6,8862	51,9204	83,4998	0,1172	0,1395	0,1379
peru	4,3345	46,4246	38,7129	0,2240	0,2192	0,1705
uruguay	2,4447	83,4675	23,3892	0,3888	0,3642	0,2904
venezuela	-15,9349	-42,5416	-107,1817	0,3097	0,4414	0,3470
Asia						
india	1,4701	0,2232	5,4041	0,0536	0,0438	0,0425
indonesia	2,2562	3,5598	17,7990	0,0530	0,0820	0,1001
israel	70,8565	259,1115	79,7379	0,4445	0,5767	0,5657
korea	8,0665	59,6300	-97,0018	0,1123	0,1941	0,2486
malaysia	1,3960	36,4747	20,7649	0,1792	0,2563	0,2786
philippines	0,6459	25,3188	12,3226	0,1163	0,1296	0,1120
sri lanka	3,9318	14,1754	20,4836	0,1125	0,1037	0,1160
thailand	2,0818	24,4304	26,9340	0,1115	0,1342	0,1547

"Nfb" is the average value of per capita net foreign borrowing per year (in current dollars; source IMF); "Income ratio" is the average value of per capita income (expressed in current "international" dollars) as a percentage of the US per capita income of the same year (source: Summers-Heston, 1991).

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