Capital flows to emerging markets

Adrian Penalver[*]

Working Paper no. 183

* E-mail: adrian.penalver@bankofengland.co.uk

This paper represents the views and analysis of the author and should not be thought to represent those of the Bank of England. I am grateful to comments from Andy Haldane, Simon Hayes, Victoria Saporta, Prasanna Gai, Hyun Song Shin, Paul Tucker and two referees.

Copies of working papers may be obtained from Publications Group, Bank of England, Threadneedle Street, London, EC2R 8AH; telephone 020 7601 4030, fax 020 7601 3298, e-mail mapublications@bankofengland.co.uk

Working papers are also available at www.bankofengland.co.uk/wp/index.html

The Bank of England's working paper series is externally refereed.

ISSN 1368-5562

Contents

Abstract

Capital flows to emerging market economies have occurred in cycles, with booms in lending often followed by financial crises. Economic theory, though, has had little to say on the optimal rate at which capital should flow. This paper extends the model of Barro, Mankiw and Sala-i-Martin (1995) to make it more appropriate for analysis of emerging market economies and calculates optimal capital flows based on an estimated Barro-style conditional convergence growth equation. Flows derived from the model are lower than actually observed over the estimation period (1988-97) but the results are sensitive to the parameters chosen.

Key words: Capital flows, emerging market economies, economic growth.

JEL classification: F21, F34.

Summary

Capital flows to emerging market economies have historically occurred in cycles of enthusiasm and despair. During the upswing, confidence is high and countries may overborrow relative to the set of profitable investment opportunities, thereby creating the conditions for a financial crisis and capital outflow. Countries might be better off if they borrowed at a steadier rate and avoided these cycles in capital flows. If borrowing exceeded this optimal rate, policy-makers could take steps to restrain capital inflows or promote them if borrowing fell below this rate. But what is the optimal rate of capital flows to emerging markets? Economic theory has had very little to say on the matter. To help answer the question, this paper investigates an open-economy growth model adjusted to make it appropriate for analysis of emerging market economies. This model is then calibrated using the results of a simple econometric equation and some assumptions about the other parameters. From this, estimates of optimal capital flows to a selection of emerging market economies are reported.

Two sorts of capital are used to produce output in the theoretical model. Some capital, such as factories, ships or pipelines, can be used as collateral for international loans. This is because the assets can be owned by foreign investors so that in the event the borrower defaults, an international lender can claim the collateral and recover the money. Other capital, such as human capital, cannot be used as collateral because the asset cannot be bought or sold. For example, a creditor cannot seize the education or health of a bankrupt debtor and sell it to someone else. The first sort of capital can be used to borrow money internationally, the second sort cannot.

A capital-scarce emerging market country will borrow to invest in the first sort of capital as much as it can. However, it needs to generate resources internally to invest in the second sort of capital. But citizens of the country will also want to consume now, so the growth rate is determined by the trade-off between the desire to consume now and investing to consume more in the future. Both forms of capital are assumed to be complementary in production, so the accumulation of capital that can be used as collateral will depend on the rate of investment in capital that cannot be used for this purpose. Therefore, the rate of international borrowing can be estimated by deriving the rate of growth in capital that cannot be used as collateral.

One feature of emerging markets is that a significant proportion of the labour force does not use

internationally collateralisable capital, for example those engaged in agriculture or rural industry. This paper extends a model by Barro, Mankiw and Sala-i-Martin by adding a 'traditional' sector which does not use collateralisable capital in production. Other things being equal, the larger the traditional sector, the slower the economy will grow. However, there are other fundamental factors which also determine the growth rates of emerging market economies. To help calibrate the model, an econometric equation is presented that estimates the effect of these factors. By combining the theoretical model, the econometric equation and some additional assumptions, estimates of capital flows to a selection of emerging market economies are calculated. These estimates provide a benchmark against which to compare observed capital flows. The capital flows derived from this exercise are lower than those observed over the estimation period (1988-97), suggesting that actual capital flows might have been too high. However, the results are sensitive to the parameters chosen. Therefore, larger flows than the benchmark are not necessarily a signal of overlending. They do suggest, however, that policy-makers should take a closer look at the fundamentals of the economies concerned. Substantially higher flows can be consistent with the theory, but require confidence in underlying parameter values outside the normal range. These results cannot replace judgment on the strengths and weaknesses of an economy's fundamentals, but they can suggest where these judgments need to be made.

1 Introduction

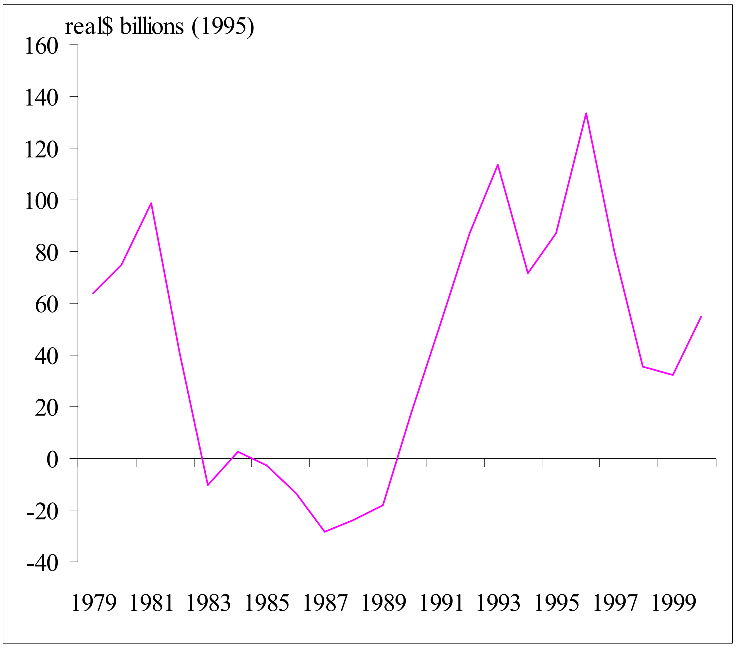
Capital flows to emerging markets have historically occurred in cycles of enthusiasm and despair. Chart 1 illustrates the past two episodes.(1) There was a boom in net flows to emerging markets in the late 1970s/early 1980s which peaked in 1981. The Latin American debt crisis then choked off the supply of capital to emerging markets for a number of years. Flows into Latin America did not pick up again until the 1990s at the same time as large-scale flows into emerging markets in Asia were occurring for the first time. Flows peaked in 1996 before the onset of the Asian financial crisis in 1997/98 led to another sharp drop. This pattern of enthusiasm for international capital flows followed by withdrawal has been repeated many times since the 18th century (see Lindert and Morton (1989) for an historical account). The financial crises which have generally followed these booms in capital flows have been very damaging to the economies concerned (see Hoggarth, Reis and Saporta (2002) for estimates of the cost). These crises might be less likely or less damaging if capital flowed to these economies more steadily and at a rate appropriate to their capacity to use it profitably.

Theory, though, gives us very little guidance on what this rate might be. Cohen and Sachs (1986), following Eaton and Gersovitz (1981), develop a model of the growth path of sovereign debt when there is the risk of repudiation. Sovereign debt, however, is only one component of capital flows to emerging markets and was largely absent prior to the Asian financial crisis when the debtors were primarily the private sector. Lucas (1990) pondered why capital *does not* flow from rich countries to poor ones, concluding that marginal rates of return are already equalised across the world with very little capital flow. Barro, Mankiw and Sala-i-Martin (1995) examine capital mobility in a neoclassical convergence growth model in which only part of the domestic capital stock can be used as collateral for international borrowing. The production function of their economy is probably more appropriate for developed countries and this paper extends their model to include a 'traditional' sector to make it more useful for analysis of emerging market economies.

Establishing a theory is only the first step towards estimating the optimal flow of capital to emerging markets. The second step is to calibrate the model. This can be done using estimates from an econometric model of conditional convergence growth rates. The estimated parameters

(1) Data are taken from the IMF's *International Financial Statistics*. Real capital flows are defined as the financial account of the balance of payments deflated by the US CPI. For this chart, the countries covered are those with data available over the full date range: Argentina, Brazil, Chile, Colombia, Mexico, Venezuela, Korea, Malaysia, the Philippines, Thailand and Turkey.

Chart 1: Real capital flows to emerging market economies



can establish steady-state levels of output per capita. Combined with assumptions on exogenous variables, these can yield estimates of the theoretically optimal rate of capital flows.

The paper is organised as follows. Section 2 presents the extension of the Barro, Mankiw and Sala-i-Martin model and how this contains implied capital flows. Section 3 reports the results of a simple growth regression to calibrate the model in Section 2 and Section 4 reports estimated capital flows. Section 5 concludes.

2 A simple extension of the Barro, Mankiw and Sala-i-Martin growth model

In Barro, Mankiw and Sala-i-Martin (1995) (henceforth BMS), output, y, is produced with collateralisable capital, k, and non-collateralisable capital, h. To provide intuition, BMS equate collateralisable capital with physical capital (such as factories, ships or pipelines) and non-collateralisable capital with human capital (such as health and education). This paper will use the same example. Assuming there are no restrictions on foreign ownership, international investors can seize physical capital to recover unpaid debts in the event of default. As a result, physical capital can be used as collateral to borrow internationally at the world real interest rate.[2]

(2) The the model is not particularly appropriate for sovereign borrowing because this is generally not collateralised. Morever, even if it is, sovereign immunity is an important limitation on the ability of investors to claim assets. In

Human capital, on the other hand, cannot be transferred from one person to another (except in the case of slavery) and cannot serve as collateral for loans. Human capital, therefore, must be accumulated by the economy internally. If the domestic rate of interest is higher than the world interest rate, which will be the case in a capital scarce economy, then the economy will always finance physical capital accumulation through foreign borrowing (or alternatively, the domestic physical capital stock is fully foreign owned through foreign direct investment). The rate of growth of the economy is determined by the rate it accumulates human capital.(3)

One feature of emerging markets is that a significant proportion of the labour force does not use internationally collateralisable capital, for example those engaged in agriculture or rural industry.(4) Most emerging market economies have a modern industrial sector (albeit potentially less productive than advanced industrialised countries) and a traditional, low productivity sector (for example, agriculture or rural industry). To analyse emerging markets in this model, the economy is assumed to have two sectors in the production function:

$$\hat{y}_t = A_i \left(\lambda \hat{h}_t\right)^{\phi} \hat{k}_t^{\alpha} + (1-\lambda)\,(\rho + \delta + \theta x)\,\hat{h}_t \qquad \textbf{(1)}$$

$0 < \alpha < 1$, $0 < \phi < 1$ and $0 < \alpha + \phi < 1$. ρ is the rate of time preference and δ is the rate of depreciation (common to both forms of capital). $\hat{y}$, $\hat{h}$ and $\hat{k}$ denote output, human capital and physical capital per unit of effective labour. Labour augmenting technological progress is assumed to occur at rate x (eg $\hat{k}_t = \frac{K_t}{Le^{xt}}$).(5) The first sector has Cobb-Douglas technology with decreasing returns to scale (as in BMS) and the second sector has constant returns to scale. A feature of this production function is that the modern sector is the only sector to use collateralisable capital and is the only driver of convergence because it has the potential for marginal rates of return above the steady-state cost of capital. Non-collateralisable capital $\hat{h}$ is split between the two sectors in a constant fraction λ. As such it is not a fully adequate model of development because it cannot take account of factor migration between sectors, particularly as there will be differences in the rates of return on non-collateralisable capital between the two.(6)

---

addition, in some jurisdictions, foreign investors may also find it difficult to claim assets from private debtors in default. Therefore, even though certain types of capital, such as physical capital, may be inherently collateralisable, in practice they may not be able to serve the purpose.

(3) It is not important for the model that collateralisable capital is restricted to physical capital. It is only required that certain types of productive domestic assets can be owned by foreigners and therefore can act as collateral on international loans.

(4) Workers in these industries obviously do use physical capital but not the sort that could be used to collateralise international loans.

(5) Labour-augmenting technological progress is determined exogenously.

(6) It can have the undesirable property that the traditional sector becomes a larger proportion of the economy over time. A model which allowed factor migration between sectors would avoid this but would unnecessarily complicate

Output is assumed to be produced by perfectly competitive firms. Since physical capital $\hat{k}$ is collateralisable, firms will borrow until the marginal product of physical capital equals the rental rate - in this case, the world real interest rate (denoted z)(7) plus depreciation (denoted δ).

$$\frac{\partial \hat{y}_t}{\partial \hat{k}_t} = \frac{\alpha A_i \left(\lambda \hat{h}_t\right)^{\phi} \hat{k}_t^{\alpha}}{\hat{k}_t} = (z+\delta) \qquad \textbf{(2)}$$

Rearranging for $\hat{k}$ yields

$$\hat{k}_t = \left(\frac{\alpha A_i}{z+\delta}\right)^{\frac{1}{1-\alpha}} \left(\lambda \hat{h}_t\right)^{\frac{\phi}{1-\alpha}} \qquad \textbf{(3)}$$

which, when substituted back into the production function (equation **(1)**) gives

$$\hat{y}_t = \left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} \left(\lambda \hat{h}_t\right)^{\frac{\phi}{1-\alpha}} + (1-\lambda)\left(\rho+\delta+\theta x\right)\hat{h}_t \qquad \textbf{(4)}$$

This is a production function in human capital and exogenous parameters.

$\hat{h}$ is accumulated as the residual after rental payments on $\hat{k}$, depreciation on $\hat{h}$ and consumption per unit of effective labour are deducted from output.

$$\dot{\hat{h}}_t = \hat{y}_t - (z+\delta)\hat{k} - (\delta+x)\hat{h}_t - \hat{c}_t \qquad \textbf{(5)}$$

Substituting for $\hat{k}$ using equation **(3)**

$$\dot{\hat{h}}_t = \hat{y}_t - \alpha\left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} \left[A_i\left(\lambda \hat{h}_t\right)^{\phi}\right]^{\frac{1}{1-\alpha}} - (\delta+x)\hat{h}_t - \hat{c}_t \qquad \textbf{(6)}$$

and then $\hat{y}$ using equation **(4)**

$$\dot{\hat{h}}_t = (1-\alpha)\left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} \left[A_i\left(\lambda \hat{h}_t\right)^{\phi}\right]^{\frac{1}{1-\alpha}} + \left[(1-\lambda)\left(\rho+\delta+\theta x\right) - (\delta+x)\right]\hat{h}_t - \hat{c}_t \qquad \textbf{(7)}$$

Equation **(7)** is a differential equation for $\hat{h}$ in terms of $\hat{h}$ and $\hat{c}$. Human capital accumulation is higher (albeit at a decreasing rate) the greater the existing stock of human capital and the lower the level of consumption.

the analysis.

(7) The world real interest rate could include a constant risk premium to reflect uncertainty although it is hard to interpret in a deterministic model such as this.

Human capital is not accumulated for its own sake but because of its capacity to generate future consumption. This choice between current and future consumption is made by an infinitely lived representative household which is assumed to have a constant relative risk aversion intertemporal utility function:(8)

$$J = \int_t^{\infty} e^{-\rho t} U(c_t) \tag{8}$$

where

$$U(c_t) = \frac{c_t^{1-\theta}}{1-\theta} \tag{9}$$

From the intertemporal utility function we get a differential equation for consumption per unit of effective labour

$$\frac{\dot{\hat{c}}_t}{\hat{c}_t} = \frac{1}{\theta}\left[f'\left(\hat{h}_t\right) - \delta - \rho - \theta x\right] \tag{10}$$

Consumption per unit of effective labour grows until the net marginal rate of return on investment in human capital $f'\left(\hat{h}_t\right) - \delta$ equals the effective rate of time preference $\rho + \theta x$. This determines the steady-state level of human capital per effective unit of labour, $\hat{h}^*$, when $\frac{\dot{\hat{c}}_t}{\hat{c}_t} = 0$. This, in turn, determines the steady-state level of output per effective unit of labour, $\hat{y}^*$ from equation **(4)**. From equation **(5)**, the steady-state level of consumption, $\hat{c}^*$, can be derived. The intuition behind the dynamics of the model can be seen from equation **(10)**. If the marginal rate of return on human capital is above the rate of time preference as the result of a shock, then households lower the level of their consumption to increase investment. This higher investment is rewarded with higher future output and therefore the rate of growth in consumption is higher.

Equations **(7)** and **(10)** form a system of differential equations in $\hat{c}_t$ and $\hat{h}_t$. The appendix shows how they can be solved for a constant rate of convergence back to the steady state:

$$\beta = \frac{1}{2}\left\{\begin{array}{c} \left[(\rho + (1-\theta)x)^2 + 4\left(\frac{1-\varepsilon}{\theta}\right)(\delta + \rho + \theta x - N)\left(\frac{\delta+\rho+\theta x - N}{\varepsilon} - \delta - x + N\right)\right]^{\frac{1}{2}} \\ -\rho + (1-\theta)x \end{array}\right\} \tag{11}$$

This is the rate at which human capital and consumption (per units of effective labour) return to

(8) The observant may note that θ is included in the marginal product of capital in the output of the traditional sector in equation **(1)**. This is a technical assumption which ensures that even though human capital cannot migrate between sectors over the transition path, in steady state, the marginal rates of return on human capital are the same in both sectors.

their steady-state levels if they are perturbed. $N = (1-\lambda)(\rho + \delta + \theta x)$ and $\varepsilon = \frac{\phi}{1-\alpha}$. Note that the convergence rate is independent of the level of technology A_i.

BMS calibrate their model (which is considerably simpler with $\lambda = 1$ and therefore $N = 0$) with parameters $\rho = 0.02$, $\alpha = 0.3$, $\phi = 0.5$, $\theta = 2$, $x = 0.02$ and $\delta = 0.05$. These parameters result in a rate of convergence, $\beta = 0.021$: 2% of the difference between steady-state consumption and the perturbed level of consumption (per units of effective labour) is removed each period. If the proportion of human capital devoted to the modern sector is lowered to $\lambda = 0.4$, the rate of convergence slows to 0.008. This is intuitive - the smaller the relative size of the modern sector which, in this model, drives growth, the slower the rate of convergence, *ceteris paribus*.

2.1 Using this model to work out implied capital flows

One of the features of the model is that the stock of collateralisable capital, $\hat{k}_t$, is financed by foreign investors. It is either owned directly through equity or owned domestically but financed through collateralised borrowing. Therefore, within the context of this framework, implied capital flows are the change in the physical capital stock. There are two ways in which the physical capital stock can change in this model. If the country liberalises capital flows and the domestic interest rate is above the foreign interest rate, then there is a one-off jump to the convergence path, although in practice we would expect this to be spread out over a number of years. The physical capital stock then grows along the convergence path. A similar effect would occur if the country conducts economic reform which affect the steady-state level of output through the technology factor A_i. First, by increasing the marginal product of capital, there is an immediate incentive to borrow up to the new convergence path for capital. Second, the conditional growth rate is higher, resulting in faster capital accumulation. Positive reforms, then, lead to an initial surge in capital inflow, slowing to a steady but higher rate of inflow after the initial adjustment.

The convergence path of the debt stock can be obtained by differentiating equation **(3)** with respect to time and replacing k_t with d_t (for debt).

$$\dot{\hat{d}}_t = \left[\frac{\phi}{1-\alpha} \frac{\hat{d}_t}{\hat{h}_t} \right] \dot{\hat{h}}_t \qquad \textbf{(12)}$$

It is useful to think of the relationship in equation **(12)** as:

$$\dot{\hat{d}}_t = \left(\frac{\phi}{1-\alpha}\hat{d}_t\right) f(\frac{\hat{h}_t}{\hat{h}^*}) \quad \textbf{(13)}$$

Equation **(13)** says that the change in external debt is a function of two components. The first term is a scaling factor determined by the relative productivities of physical and human capital and the current debt stock and the second is the rate of growth of human capital which in this model is determined by the difference between the current level of human capital per effective unit of labour and the steady-state level (denoted $f(\frac{\hat{h}_t}{\hat{h}^*})$). In other words, the rate of growth of the debt stock is determined by how fast the economy is growing and how much physical capital is consistent with this growth rate. The absolute level of capital flows can then be calculated by adjusting for the growth rate of effective labour and the size of the labour force.

Therefore, to calculate implied capital flows for specific countries using equation **(13)** we need two things:

- the scaling factor (based on values for α, ϕ and $\hat{d}_t$) and
- the rate of growth of $\hat{h}_t$, which is derived from the current and steady-state levels of $\hat{h}$.

Section 3 uses an econometric model to estimate steady-state levels of $\hat{h}$. Assumptions need to be made about parameters to derive current values of $\hat{h}_t$ and the scaling factor.

3 Calibrating the model

As noted in the previous section, deriving a growth rate of human capital requires estimation of the steady-state level. This section explains how this can be done using econometric models of growth convergence based on the framework of Barro (1991). *Theories* of growth with constant convergence properties, such as that outlined in Section 2, yield relationships of the generic form

$$\ln(y_t) = (1 - e^{-\beta t})\ln(y^*) + e^{-\beta t}\ln(y_0) \quad \textbf{(14)}$$

where y^* and y_0 are the steady-state and initial level of y, respectively, and β is the constant rate of conversion.[9] Subtracting y_0 from both sides and averaging over T and as $T \rightarrow 0$, we get

(9) See Barro and Sala-i-Martin (1995) chapter 2 for details.

$$\frac{1}{T}\left[\ln(y_t) - \ln(y_0)\right] = \beta\ln(y^*) - \beta\ln(y_0) \qquad \textbf{(15)}$$

Estimated equations of conditional convergence of output per capita have been of the form:

$$\frac{1}{T}\left[\ln(y_T^i) - \ln(y_0^i)\right] = c + \upsilon.a^i - \beta\ln(y_0^i) + \varepsilon^i \qquad \textbf{(16)}$$

relating the average growth rate of output per capita (or output per worker) on the left to the initial level of output per capita and a constant plus a range of conditioning variables $c + \upsilon.a^i$ on the right. It can easily be seen that fitted values $\tilde{c} + \tilde{\upsilon}.a^i$ from estimations of equation **(16)** relate to the theoretical variable $\beta\ln(y^*)$ in equation **(15)**. In other words, the conditioning variables relate to the steady-state level of output per capita.

The model in Section 2 has a constant convergence rate, β, for *human capital per unit of effective labour*, $\hat{h}$. If we assume $T = 1$ and accept that this is sufficient approximation for $T \to 0$, and substitute h for y in equation **(15)** we get

$$\ln(\hat{h}_1) - \ln(\hat{h}_0) = \beta\ln(\hat{h}^*) - \beta\ln(\hat{h}_0) \qquad \textbf{(17)}$$

Recall from the definition of human capital per unit of effective labour that

$$\hat{h}_t = h_t.e^{-xt} \qquad \textbf{(18)}$$

so $\hat{h}_0 = h_0$ and $\hat{h}_1 = h_1.e^{-x}$. Substituting these values into equation **(17)**, we obtain:

$$\ln(h_1) - \ln(h_0) = x + \beta\ln(\hat{h}^*) - \beta\ln(h_0) \qquad \textbf{(19)}$$

Referring back to equation **(4)** we can get h_t in terms of y_t.(10)

$$\ln(h_t) = \frac{1-\alpha}{1-\alpha+\phi}\ln(y_t) + \frac{\phi}{1-\alpha+\phi}xt - \ln\left[\left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha+\phi}} A_i^{\frac{1}{1-\alpha+\phi}} \lambda^{\frac{\phi}{1-\alpha+\phi}}\right] - \frac{1-\alpha}{1-\alpha+\phi}\ln\left[(1-\lambda)(\rho+\delta+\theta x)\right] \qquad \textbf{(20)}$$

Substituting **(20)** into equation **(19)** and re-arranging gives:

$$\ln y_1 - \ln y_0 = x + \Psi - \beta\ln y_0 \qquad \textbf{(21)}$$

where $\Psi = \beta\left\{\ln\left[\left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} A_i^{\frac{1}{1-\alpha}} \lambda^{\frac{\phi}{1-\alpha}}\right] + \ln\left[(1-\lambda)(\rho+\delta+\theta x)\right]\right\}$, noting that

$$\ln(\hat{y}_t) = \frac{1-\alpha+\phi}{1-\alpha}\ln(\hat{h}_t) + \frac{\Psi}{\beta} \qquad \textbf{(22)}$$

(10) In units of labour not effective units of labour.

Equation **(21)** can be estimated in the form of equation **(16)**, yielding estimated values $\tilde{c} + \tilde{v}.a^i$ and $\tilde{\beta}$. Comparing equation **(21)** and the expected value of equation **(16)**, we get:

$$\tilde{c} + \tilde{v}.a^i = x + \Psi_i \qquad \textbf{(23)}$$

Evaluating equation **(21)** at the steady-state level, $y_0 = y_0^* = \hat{y}_0^*$

$$x = \ln y_1 - \ln y_0^* = x + \Psi - \beta \ln y_0^* \qquad \textbf{(24)}$$

As a result, $\ln y_0^* = \frac{\Psi}{\beta}$ and

$$\widetilde{\hat{y}}_0^* = \exp\left(\frac{\tilde{c} + \tilde{v}.a^i - x}{\tilde{\beta}}\right) \qquad \textbf{(25)}$$

where $\widetilde{\hat{y}}^*$ is the estimated equilibrium level of steady-state output per effective unit of labour.

To obtain values for $\tilde{c} + \tilde{v}.a^i$, Table A records the results of a very simple conditional convergence growth equation. The average growth rate of per capita GDP between 1988 and 1997 (GR) is regressed against a constant, the log level of GDP per capita in 1987 (LGDPSH87), log life expectancy in 1987 (LLIFEE87), an East Asian dummy variable (EA) and changes in the openness of the capital account (DCAP). In itself, it may seem odd that life expectancy drives growth in this model but it could be acting as an efficient proxy for other variables. For instance, longer life expectancy could make it worthwhile to invest in more education or vote for government policies with longer-term payoffs or act in way which protect your reputation. Details of the data used and other variables tried but discarded are contained in the appendix.[11]

The coefficient on LGDPSH87 suggest that countries in the sample converged on their steady-state level at a rate of around 1% per year. This is slightly lower than the average value from Sala-i-Martin's 32,500 regressions of 1.3% per year (Sala-i-Martin (1997)) but considerably lower than that resulting from the parameterisation of BMS in Section 2. These coefficients can be substituted into equation **(25)** to obtain estimates of the steady-state level of output per unit of effective labour (in this case, output per effective unit of population). The East Asian dummy variable and changes in capital restrictions variable were included in the regression to account for *short-run* influences on growth and therefore have been omitted from the calculation on long-run growth prospects. Finally, we need a value for the rate of labour augmenting technological progress. The results in the final column of Table B have been calculated on a benchmark value of

(11) The regression results are not the primary purpose of this paper and are not intended to make a contribution to the debate on the socio-economic causes of growth.

Table A: Conditional convergence regression

Dependent Variable: GR
Method: Least Squares
Sample: 1 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.506	0.162	-3.12	0.003
LGDPSH87	-0.010	0.003	-3.04	0.004
LLIFEE87	0.143	0.044	3.27	0.002
EA	0.030	0.006	5.06	0.000
DCAP	0.004	0.002	1.91	0.062
R-squared	0.46		F-statistic	10.16
Adjusted R-squared	0.41		Prob(F-statistic)	0.00
S.E. of regression	0.02			

$x = 0.01$, so

$$\widetilde{\hat{y}}_0^* = \exp\left(\frac{-0.506 + 0.143 * LLIFEE^i - 0.01}{0.01}\right) \qquad \textbf{(26)}$$

Table B also contains the actual average real growth rate between 1988 and 1997 and the fitted values for the growth rate from the regression equation. Reflecting the equation, differences in steady-state output per capita are due to differences in life expectancy at birth. South Africa, for instance, has life expectancy of 60 years, similar to that in Indonesia. Chile, on the other hand, has life expectancy of 73 years, not far short of developed-country levels. The substantial difference between Chile's output per capita in 1987 and its estimated steady-state level of output per capita explains why it has scope to grow very quickly, although the fitted value does not reflect this because Chile added restrictions on its capital account over the period. On the other hand, South Africa removed restrictions on its capital account but because of its very low life expectancy, the fitted growth rate is low. In Asia, only the Philippines has actual growth below fitted growth and, in this case, significantly below.

These country-specific steady-state levels of output per capita and assumptions about the remaining parameters can be used to calculate capital flows along convergence path. The estimates in Table C are based on the parameterisation $\rho = 0.05$, $\alpha = 0.3$, $\phi = 0.45$, $\theta = 2$, $x = 0.01$ and $\delta = 0.08$. The value of λ is determined by the proportion of industry in total production in each country. The assumed parameters and the average value of λ across all countries of 0.36 gives a convergence rate of 1% per year, consistent with the estimated convergence rate from the regression in Table A. The absolute model calculations reflect estimated capital flows per capita

Table B: Growth and steady-state output

	Growth		**Output**	
	Actual	Fitted	1987	Estimated steady-state
Argentina	1.7	1.6	7556	9665
Brazil	0.5	0.5	4351	2630
Chile	6.0	2.4	2555	13389
Colombia	2.0	2.2	1738	5496
India	4.0	1.4	262	534
Indonesia	5.6	4.4	649	939
Korea	6.4	4.8	5904	6806
Malaysia	5.7	4.7	2656	7128
Mexico	1.3	1.6	2998	7612
Philippines	1.3	4.8	988	2228
South Africa	-0.6	0.3	3681	989
Thailand	6.7	5.2	1495	4705
Turkey	2.2	1.3	2463	2351

and the country's population. A comparison of specific country estimates can help explain how the framework works. Capital flows to Argentina are estimated to be higher than Brazil, even though Brazil has over four times the population. This reflects the higher fitted growth rate for Argentina and that as a more advanced economy, it needs more capital per worker to grow at the same rate. India has a much larger population than Korea but a smaller proportion of its population employed in industry and much lower capital per worker. South Africa has a larger population than Colombia and a higher initial level of capital per worker but because output per capita is forecast to decline rather than grow, capital is expected to flow out of South Africa but into Colombia.

The decade average of real capital flows (in constant 1995 US dollars) as measured by the financial account of the balance of payments and net foreign direct investment are reported for comparison. In all cases, the model produces lower estimates of capital flows than were recorded in the financial account. Subsequent financial crises in Latin America and East and South East Asia suggest that these countries may have been overborrowing during this period. In some cases (Brazil, Chile, Indonesia, Malaysia and South Africa), the model suggests capital flows even less than the recorded flow of foreign direct investment.

3.1 Sensitivity

The results in Table C are sensitive to the parameterisation chosen. This section explores the impact of making different assumptions about the exogenous variables on the predicted capital

Table C: Calibrated estimates and actual flows (US$ billions (constant prices) - average 1988-97)

	Model	**IMF IFS financial account**	**FDI**
Argentina	2.9	5.8	2.8
Brazil	2.7	7.8	4.2
Chile	1.2	3.2	1.5
Colombia	1.2	2.5	0.2
India	3.2	7.0	0.9
Indonesia	2.0	5.1	2.3
Korea	3.5	5.6	0.4
Malaysia	1.5	4.7	3.8
Mexico	4.0	12.2	3.8
Philippines	1.3	4.2	0.8
South Africa	-0.4	1.2	-0.3
Thailand	2.3	9.3	1.7
Turkey	1.2	3.2	0.6

flows from the model. Since changing many of the parameters affects the convergence rate as well as the scaling factors, it is not possible to do a single partial sensitivity test while keeping the convergence rate constant. It is important to keep the convergence consistent with the empirically estimated rate, so an adjustment is taken via the depreciation rate to bring it back into line. As the qualitative impact of a given change in parameters will be broadly the same for each country, sensitivity analysis is only reported for Argentina.

Table D: Sensitivity of estimates to parameter changes

	δ	Flows	Financial account	FDI
Baseline	0.08	2.9	5.8	2.8
$\rho = 0.02$	0.10	3.1	5.8	2.8
$x = 0.005$	0.09	4.5	5.8	2.8
$\lambda = 0.5$	0.04	5.2	5.8	2.8

Table D shows the sensitivity of estimated capital flows to changes in the rate of time preference (and the world real interest rate), the rate of technological progress and the proportion of the economy that uses collateralisable capital. Capital flows are higher if the interest rate is lowered from 5% to 2% (requiring an offsetting rise in the rate of depreciation). This occurs because the stocks of capital are larger for any given level of output per capita when the rate of interest is lower. Therefore, more physical capital is accumulated to achieve the same growth rate. However, even making this considerable reduction doesn't increase capital flows to the level actually observed. Moreover, it is difficult to believe that an emerging market economy can borrow at a 2%

real interest rate even on collateralised loans. Lowering the rate of technological progress also increases estimated capital flows. This occurs because the rate of growth of per capita income is the same - as the convergence rate is kept constant - but the same growth rate requires more factor inputs. In this case, halving the rate of technological progress from 1% to 0.5% increases estimated net capital flows from \$2.9 billion a year to \$4.5 billion, although this too is insufficient to exceed the amount actually observed. Finally, capital flows are also higher, the larger the proportion of the economy that uses collateralisable capital. This is because the higher the proportion of the economy that uses physical capital, the more that is needed to be borrowed to generate the same growth rate. However, even increasing the proportion of human capital going to the modern sector to 0.5 from 0.36 is not enough for estimated capital flows to exceed actual flows in Argentina.

4 Conclusion

This paper has presented a simple conditional convergence growth regression and demonstrated the link to steady-state output per capita. By calibrating an open economy growth model, the convergence path of output was translated into estimates of capital flows. The capital flows derived from this exercise are lower than those observed over the estimation period (1988-97), suggesting that actual capital flows might have been too high. However, the results are sensitive to the parameters chosen. Therefore, higher flows than the benchmark are not necessarily a signal of overlending. They do suggest, however, that policy-makers should take a closer look at the fundamentals of the economies concerned, particularly if a country has recently undertaken reform. Substantially higher flows can be consistent with the theoretical and empirical analysis presented in this paper but require confidence in underlying parameter values outside the normal range. These results cannot replace judgment on the strengths and weaknesses of an economy's fundamentals and the impact on capital flows but it can suggest where these judgments need to be made.

5 Appendix

5.1 Derivation of constant conditional convergence rate

From the main text we have two differential equations

$$\dot{\hat{h}}_t = (1-\alpha)\left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} \left(A_i\lambda^{\phi}\right)^{\frac{1}{1-\alpha}} \hat{h}_t^{\frac{\phi}{1-\alpha}}$$
$$+\left[(1-\lambda)(\rho+\delta+\theta x)-(\delta+x)\right]\hat{h}_t-\hat{c}_t \quad \textbf{(7)}$$

and

$$\frac{\dot{\hat{c}}_t}{\hat{c}_t} = \frac{1}{\theta}\left[f'\left(\hat{h}_t\right)-\delta-\rho-\theta x\right] \quad \textbf{(10)}$$

We can re-write equation **(7)** as:

$$\dot{\hat{h}}_t = (1-\alpha) M_i\hat{h}_t^{\varepsilon} + N\hat{h}_t - \hat{c}_t - (\delta+x)\hat{h}_t \quad \textbf{(27)}$$

where $M_i = \left(\frac{\alpha}{z+\delta}\right)^{\frac{\alpha}{1-\alpha}} . \left(A_i\lambda^{\phi}\right)^{\frac{1}{1-\alpha}}$

$\varepsilon = \frac{\phi}{1-\alpha}$

$N = (1-\lambda)(\rho+\delta+\theta x)$ so that

$\hat{y}_t = M_i\hat{h}_t^{\varepsilon} + N\hat{h}_t$

We can approximate the solution to this system of two differential equations through log linearisation. The accumulation equation for $\hat{h}_t$ can be written as:

$$\frac{\partial \log \hat{h}_t}{\partial t} \approx \frac{\dot{\hat{h}}_t}{\hat{h}_t} = (1-\alpha) M_i\hat{h}_t^{\varepsilon-1} + N - \delta - x - \frac{\hat{c}_t}{\hat{h}_t} \quad \textbf{(28)}$$

$$= (1-\alpha) M_i e^{-(1-\varepsilon)\log\hat{h}_t} + N - \delta - x - e^{\log\frac{\hat{c}_t}{\hat{h}_t}} \quad \textbf{(29)}$$

In region of the steady state $\overline{\hat{h}}, \overline{\hat{c}}$, $\frac{\partial \log \hat{h}_t}{\partial t} = 0$, so that

$$(1-\alpha)\,M_i e^{-(1-\varepsilon)\log\overline{\hat{h}}} - e^{\log\frac{\overline{\hat{c}}}{\overline{\hat{h}}}} = \delta + x - N \tag{30}$$

Similarly for consumption

$$\frac{\partial \log \hat{c}_t}{\partial t} \approx \frac{\dot{\hat{c}}_t}{\hat{c}_t} = \frac{1}{\theta}\left[f'\left(\hat{h}_t\right) - \delta - \rho - \theta x\right] \tag{31}$$

$$= \frac{1}{\theta}\left[(1-\alpha)\,\varepsilon M_i e^{-(1-\varepsilon)\log\hat{h}_t} + N - \delta - \rho - \theta x\right] \tag{32}$$

In the region of the steady state $\overline{\hat{h}},\ \overline{\hat{c}}$ $\quad \frac{\partial \log \hat{c}_t}{\partial t} = 0$, so that

$$(1-\alpha)\,\varepsilon M_i e^{-(1-\varepsilon)\log\overline{\hat{h}}} = \delta + \rho + \theta x - N \tag{33}$$

Taylor expansion

$$\frac{\frac{\partial \log \hat{h}_t}{\partial t}}{\partial \log \hat{h}_t} = -(1-\varepsilon)(1-\alpha)\,M_i e^{-(1-\varepsilon)\log\hat{h}_t} + e^{\log\frac{\hat{c}_t}{\hat{h}_t}} \tag{34}$$

which, in region of the steady state, using **(30)** and **(33)**, is equal to

$$\rho - (1-\theta)x \tag{35}$$

And similarly for the other partial derivatives.

$$\frac{\frac{\partial \log \hat{h}_t}{\partial t}}{\partial \log \hat{c}_t} = -e^{\log\frac{\hat{c}_t}{\hat{h}_t}} \tag{36}$$

Which in the region of the steady state is equal to

$$\delta + x - N - \frac{\delta + \rho + \theta x - N}{\varepsilon} \tag{37}$$

$$\frac{\frac{\partial \log \hat{c}_t}{\partial t}}{\partial \log \hat{h}_t} = \frac{1}{\theta}(1-\alpha)\,\varepsilon\,(\varepsilon-1)\,M_i e^{-(1-\varepsilon)\log\hat{h}_t} \tag{38}$$

in region of steady state is equal to

$$-\left(\frac{1-\varepsilon}{\theta}\right)(\delta+\rho+\theta x-N) \qquad \textbf{(39)}$$

and, finally,

$$\frac{\frac{\partial \log \hat{c}_t}{\partial t}}{\partial \log \hat{c}_t}=0 \qquad \textbf{(40)}$$

So the first-order Taylor expansion of this system is

$$\begin{bmatrix} \frac{\partial \log \hat{h}_t}{\partial t} \\ \frac{\partial \log \hat{c}_t}{\partial t} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \begin{bmatrix} \rho-(1-\theta)x & \delta+x-N-\frac{\delta+\rho+\theta x-N}{\varepsilon} \\ -\left(\frac{1-\varepsilon}{\theta}\right)(\delta+\rho+\theta x-N) & 0 \end{bmatrix} \begin{bmatrix} \log \frac{\hat{h}_t}{\hat{h}} \\ \log \frac{\hat{c}_t}{\hat{c}} \end{bmatrix} \qquad \textbf{(41)}$$

To derive the constant convergence properties of this system we need to solve for characteristic roots γ derived from the relationship

$$\gamma^2-[\rho+(1-\theta)x]\gamma+\left(\frac{1-\varepsilon}{\theta}\right)(\delta+\rho+\theta x-N)\left(\delta+x-N-\frac{\delta+\rho+\theta x-N}{\varepsilon}\right)=0 \qquad \textbf{(42)}$$

This has one positive and one negative root. The negative root corresponds to the negative of the convergence rate β so that

$$\beta=\frac{1}{2}\left\{\begin{array}{c} \left[(\rho+(1-\theta)x)^2+4\left(\frac{1-\varepsilon}{\theta}\right)(\delta+\rho+\theta x-N)\left(\frac{\delta+\rho+\theta x-N}{\varepsilon}-\delta-x+N\right)\right]^{\frac{1}{2}} \\ -\rho+(1-\theta)x \end{array}\right\} \qquad \textbf{(43)}$$

which is equation **(11)**.

5.2 Regression equation

The dependent variable (GR) is the average annual growth rate of per capita GDP between 1988 and 1997 for 53 countries. This was calculated from real GDP at market prices (constant 1995 US$) and population taken from the World Development Indicators database (2000a).

Table E: Conditional convergence regression

Dependent Variable: GR
Method: Least Squares
Sample: 1 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.506	0.162	-3.12	0.003
LGDPSH87	-0.010	0.003	-3.04	0.004
LLIFEE87	0.143	0.044	3.27	0.002
EA	0.030	0.006	5.06	0.000
DCAP	0.004	0.002	1.91	0.062
R-squared	0.46		F-statistic	10.16
Adjusted R-squared	0.41		Prob(F-statistic)	0.00
S.E. of regression	0.02			

There is no theory about the appropriate conditioning variables and there has been an important debate about the robustness of parameter estimates. Levine and Renelt (1992) report that the statistical significance of conditioning variables is highly sensitive to the choice of other variables. This casts doubt on the validity of results from any given equation, even when highly significant. Furthermore, there are in principle an infinite number of socioeconomic, political and environmental variables which could be included. Researchers in this field have used a range of variables from primary school enrolment rates and export shares to black market exchange rate premia and indices of coups and revolutions. As discussed by Doppelhofer, Miller and Sala-i-Martin (2000), there are so many potential variables that it is impossible to 'include all the suggested regressors and let the data sort through them' (page 3). To address the concern of Levine and Renelt, Doppelhofer *et al* develop a 'Bayesian averaging of classical estimates' approach to cull through the set of potential regressors and produce a ranking of variables statistically most associated with economic growth. The approach in this paper has been to take the set of variables with the highest posterior inclusion probability (or proxy) from their list where the data are readily available and then work down to a model with significant coefficients. Ultimately, only average life expectancy and changes in capital controls remained significant in the chosen sample. The log of life expectancy at birth in 1987 was taken from the World Bank Development Indicators database (2000a). A change in capital account restrictions between 1973 and 1998 is calculated by Quinn (1997). An additional dummy variable was added to reflect the unusually rapid period of growth in East Asia. The use of a dummy variable to account for East Asian growth is an admission that there is an unidentified omitted variable. Variables tried but discarded include: the Sachs and Warner openness index, various indicators of schooling, changes in the terms of trade, military expenditure, mining share of GDP and the investment share. To avoid any endogeneity problems between the conditioning variables and growth, the conditioning variables pre-date the growth sample.

The LGDPSH87 variable implies a convergence rate of around 1% per year. This is slightly lower than the average value from Sala-i-Martin's 32,500 regressions of 1.3% per year (Sala-i-Martin (1997)).

The LLIFEE87, DCAP and EA variables are all the right sign and of plausible magnitude. The LLIFEE87 coefficient implies that a 10% increase in life expectancy, say from 60 to 66, would increase the average growth rate by 1.4 percentage points a year. The capital account measure suggests that a country which opened its capital account by 1 index point on Quinn's scale would grow 0.4 percentage point faster growth rate than an economy that did not change. Being an East Asian economy increased the growth rate by 3.0 percentage points, *ceteris paribus*.

References

Barro, R J (1991), 'Economic growth in a cross section of countries', *Quarterly Journal of Economics*, Vol. 106, No. 2 (May), pages 407-43.

Barro, R J, Mankiw, G and Sala-i-Martin, X (1995), 'Capital mobility in neoclassical models of growth', *American Economic Review*, Vol. 85, No. 1 (March), pages 103-15.

Barro, R J and Sala-i-Martin, X (1995), *Economic growth*, McGraw-Hill.

Cohen, D and Sachs, J (1986), 'Growth and external debt under risk of repudiation', *European Economic Review*, Vol. 30, No. 3 (June), pages 526-60.

Doppelhofer, G, Miller, R I and Sala-i-Martin, X (2000), 'Determinants of long-term growth: a Bayesian averaging of classical estimates (BACE) approach', *NBER Working Paper*, No. 7750.

Eaton, J and Gersovitz, M (1981), 'Debt with potential repudiation: theoretical and empirical analysis', *Review of Economic Studies*, Vol. 48, pages 289-309.

Hoggarth, G, Reis, R and Saporta, V (2002), 'Costs of banking system instability: some empirical evidence', *Journal of Banking and Finance*, Vol. 26, pages 825–55.

International Monetary Fund (2002), International Financial Statistics Database.

Levine, R and Renelt, D (1992), 'A sensitivity analysis of cross-country growth regressions', *American Economic Review*, Vol. 82, No. 4 (September), pages 942-63.

Lindert, P and Morton, P (1989), 'How sovereign debt has worked', in Sachs, J (ed), *The international financial system, 1: developing country debt and economic performance*, University of Chicago Press, Chicago.

Lucas, R (1990), 'Why doesn't capital flow from rich countries to poor countries?', *American Economic Review*, Vol. 80, No. 2 (May), pages 92-96.

Quinn, D (1997), 'Correlates of change in international financial regulation', *American Political Science Review,* Vol. 91, No. 3 (September), pages 531-51.

Sala-i-Martin, X (1997), 'I just ran four million regressions', *NBER Working Paper,* No. 6252.

World Bank (2000a), World development indicators CD-Rom.

World Bank (2000b), *World development report 1999/2000*, Oxford University Press.