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The Impact of Capital Market Integration on Educational Choice and the Consequences for Economic Growth

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1. INTRODUCTION

THE formation of human capital and its response to globalisation came up in the international economics debate about a quarter of a century ago. Starting with Findlay and Kierzkowski (1983), the primary focus at that time was on the link between trade liberalisation and the endogenous supply of skilled labour.[1] With the fast pace of growth of capital flows relative to goods trade in the last two decades (see Markusen, 2002, for a survey),

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[1] More recent contributions on this subject encompass Janeba (2003) and Kreickemeier (2009). Notable in this respect is also a recent paper by Bougheas and Riezman (2007), which sheds light on how the distribution of human capital affects the pattern of trade. While skill supply is exogenous in this setting, it is endogenised in a related study by Bougheas et al. (2009), which addresses the role of education policy as a determinant of an economy's comparative advantage.

more recent research strives to understand the interaction between capital market integration (CMI) and human capital formation (see Gradstein and Justman, 1995; Viaene and Zilcha, 2002a, 2002b). This interaction is also in the centre of this paper's interest. In particular, we target our attention towards the integration of *real capital markets* and its consequences for *higher education*.

An analysis of the impact of globalisation on higher education should pay attention to two features characterising most countries' education systems: first, whereas basic education is compulsory, the participation in higher education depends on individual choice; second, to a large extent the costs of both basic and higher education are covered by the public sector (OECD, 2006, Tables B3.1 and B3.2b). With increasingly integrated capital markets, two issues arise. Economic policy is faced with the problem of how public education expenditure should respond to changes in a country's openness. And individuals have to reconsider their decisions upon participation in higher education. It is the purpose of this paper to elaborate on these two types of adjustment to globalisation.

To accomplish this task, we lay out a one-sector small open economy model with three factors of production: physical capital, skilled labour and low-skilled labour. While the country's physical capital supply is exogenous under autarky, it becomes perfectly elastic at the world market interest rate in case of integrated capital markets. The supply of skilled labour depends on two factors: the total number of individuals participating in higher education and the quality of the education system determined by the level of public education expenditure. A key assumption of our analysis is that physical and human capital are complementary production factors, while low-skilled labour and physical capital are substitutes.[2] Under this capital–skill complementarity, the integration of capital markets alters both the individual incentives to participate in higher education and the level of public education expenditure optimally chosen by policy makers.

We show that capital inflows (outflows), which are triggered by CMI, raise (reduce) attainment in higher education for given public education expenditure. The result typically also holds when we account for welfare-maximising adjustment in public education spending. We provide an empirical assessment of these hypotheses in an econometric modelling approach that follows the causal channels identified in the theoretical analysis as closely as possible. Instrumental variable and system regressions are applied to test for these channels. The empirical results confirm our theoretical

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[2] See Griliches (1969) for early evidence and Goldin and Katz (1998), Krusell et al. (2000) and Duffy et al. (2004), for more recent support of this assumption.

prediction that an increase in net capital inflows stimulates participation in higher schooling.

Although the theoretic model is, for simplicity, static,[3] we also test whether the increased attainment in higher education triggered by higher net capital inflows promotes economic growth. In that regard, the paper offers a contribution to two strands of (empirical) research: the one on the nexus between human capital formation and economic growth (e.g. Glaeser et al., 2004) and the one on the relationship between capital inflows and economic growth (e.g. Borensztein et al., 1998; Smulders, 2004; Schularick and Steger, 2010).[4]

As mentioned earlier, this paper is not the first one to address the relationship between CMI and human capital formation. Gradstein and Justman (1995) present a static model where, due to capital–skill complementarity, two countries that compete for international capital funds choose excessive education subsidies. Viaene and Zilcha (2002a) analyse a dynamic setting where economic growth is driven by human capital formation that is fuelled by compulsory public education. They show that public education spending rises when capital markets integrate. Viaene and Zilcha (2002b) focus on the role of CMI for the income distribution in a similar context as in Viaene and Zilcha (2002a), allowing for skill differences in addition. In contrast to these contributions, we aim to examine the impact of CMI on individual choices to invest in education, also for given public policy. We have in mind higher secondary or tertiary education, which is non-compulsory. Moreover, we also provide an empirical assessment of the theoretical hypotheses, which suggests that higher net capital inflows lead to increased participation in higher education and thereby to higher economic growth.

The remainder of the paper is organised as follows. Section 2 presents the basic (static) model. Section 3 determines the equilibrium in a closed as well as a small open economy. Section 4 studies the impact of CMI on the incentives to participate in higher education for given public education spending and

[3] In the working paper version of this paper (available under http://ftp.iza.org/dp1863.pdf), we extend our model to a dynamic setting. There we assume that a link exists between the fraction of skilled labour in the economy and its productivity growth rate. However, there are no additional insights besides the result that an (endogenous) increase in net capital inflows triggers economic growth through the proposed channel. We omit the theoretical analysis here for the sake of brevity but test the additional result empirically.

[4] Borensztein et al. (1998) find that foreign direct investment stimulates technology transfer and thereby enhances growth, when the human capital level is above some threshold value. Schularick and Steger (2010) provide evidence that inflows of portfolio capital affected physical capital investment and economic growth in the first era of globalisation (1880–1914), but not in modern times. Smulders (2004) theoretically investigates the effect of CMI on growth through research and development investments. He shows that the country which is initially more advanced in terms of total factor productivity (TFP) typically wins from CMI, whereas the laggard country loses.

Section 5 examines optimal education policy. Section 6 presents empirical evidence on the main hypotheses derived from the theoretical analysis and, in addition, shows to what extent increased attainment in higher education triggered by higher net capital inflows promotes economic growth. Section 7 briefly summarises the main findings.

2. THE BASIC MODEL

Consider a static economy with a single homogeneous consumption good (the numéraire good) supplied under perfect competition. Output Y is produced according to the following constant-returns-to-scale technology:

$$Y = F(K, S, L) = A\left[bK^{\beta} + (1-b)L^{\beta}\right]S^{1-\beta}, \quad 0 < b,\ \beta < 1, \tag{1}$$

where TFP $A > 0$, indicates the technological state of the economy, K the physical capital input, and S and L are efficiency units of skilled and low-skilled labour, respectively. Note that equation (1) implies that physical capital and skilled labour are technological complements, in contrast to capital and low-skilled labour.[5]

There are two classes of individuals. Capitalists simply maximise their income by choosing the optimal allocation for their capital endowment. They do not work. In addition, there is a unit mass of workers, indexed $i \in [0, 1]$, who do not own capital. They choose whether or not to acquire higher education. Preferences of worker i are represented by the utility function

$$U(i) = \ln l(i) + \ln C(i), \tag{2}$$

where $C(i)$ is i's consumption level, $l(i) = 1$ if i remains low-skilled and $l(i) = 1 - e(i)$ if i is skilled. $e(i)$ may be interpreted as effort cost of acquiring education in terms of foregone leisure, $l(i)$. Assuming that effort costs are individual-specific captures the idea that workers differ in their learning abilities. For simplicity, suppose e is uniformly distributed on the unit interval.

The skill endowment of an educated worker positively depends on public education spending.[6] More precisely, let G be the level of public education expenditure and denote the mass ('number') of workers participating in education by $s = 1 - L$. An individual choosing education acquires G/s units of

[5] This is crucial for the theoretical results. The capital–skill complementarity embodied in equation (1) is well in line with empirical evidence (see the respective references in footnote 2). A Cobb–Douglas form of the production function facilitates the formal analysis.

[6] In most advanced countries, the bulk of higher education is indeed financed by the public sector. In 2005, the average share of public expenditure for tertiary education within the OECD and the EU19 was 73.1 and 82.5 per cent, respectively (OECD, 2008, Table B3.2b).

skilled labour.[7] When s individuals acquire education − each obtaining G/s efficiency units of skilled labour − total efficiency units of skilled labour are given by $S = G$. Thus, according to equation (1), $G > 0$ is necessary for the economy to be viable. If an individual remains low-skilled, (s)he is endowed with one unit of low-skilled labour. Workers inelastically supply their efficiency units of labour and all factor markets are perfectly competitive.

Education is financed by a proportional tax on wage income, with tax rate $\tau \in (0, 1)$. Public education expenditure is given by

$$G = \tau(w_S S + w_L L), \tag{3}$$

where w_S and w_L denote the wage rate per efficiency unit of skilled and low-skilled labour, respectively.

3. Equilibrium Analysis

Consumption (= disposable income) of worker i is determined by

$$C(i) = \begin{cases} W_S \equiv (1-\tau)w_S G/s, & \text{if skilled,} \\ W_L \equiv (1-\tau)w_L, & \text{if low-skilled.} \end{cases} \tag{4}$$

Denote the relative wage rate (per efficiency unit) of skilled to low-skilled labour by $\omega = w_S/w_L$. According to equations (2) and (4), an individual becomes skilled if and only if

$$e(i) \leq 1 - \frac{s}{\omega G} \equiv \hat{e}(s, \omega, G), \tag{5}$$

i.e. if the effort cost of education is below some threshold ability level, $\hat{e}$. As e is uniformly distributed on [0, 1], this implies that the share of skilled workers, s, is given by $s = \hat{e}(s, \omega, G)$. Using this in equation (5), we obtain the relationship

$$\omega = \frac{s}{(1-s)G}. \tag{6}$$

According to equations (4) and (6), relative disposable income, which can be interpreted as a measure for the dispersion of labour earnings, is given by $W_S/W_L = 1/(1 - s)$. Hence, any increase in the share of skilled workers is

[7] We could more generally assume that an educated worker obtains skill level G^θ/s^α, $0 \leq \alpha \leq 1$, $0 < \theta \leq 1$, implying $S = s^{1-\alpha}G^\theta$. This education technology would allow for the two extreme cases of education being a pure public good ($\alpha = 0$) or fully rival ($\alpha = 1$). Moreover, $\theta < 1$ implies that the marginal productivity of public education spending, G, is decreasing. We checked that, qualitatively, our results on educational attainment remain unaffected when allowing for $\alpha < 1$ and $\theta < 1$. For expositional reasons, we focus on the case where public education is a fully rival good and the marginal productivity of G is constant. We have also checked that the results of our analysis do not hinge upon the assumption of uniformly distributed effort costs.

associated with higher inequality of labour earnings. This is an implication of the fact that the marginal entrant into the higher education system has effort cost $\hat{e} = s$. Thus, if more individuals choose higher education, the compensation for becoming skilled must have increased.[8]

Denoting the rental rate of capital by r, it follows from equation (1) that demand for the three production factors is given by

$$r = A\beta b(S/K)^{1-\beta}, \tag{7}$$

$$w_S = A(1-\beta)\left[bK^{\beta} + (1-b)L^{\beta}\right]S^{-\beta}, \tag{8}$$

$$w_L = A\beta(1-b)(S/L)^{1-\beta}, \tag{9}$$

respectively. Using $S = G$ and $L = 1 - s$, equations (8) and (9) imply

$$\omega = \frac{1-\beta}{\beta(1-b)} \frac{bK^{\beta}(1-s)^{1-\beta} + (1-b)(1-s)}{G}. \tag{10}$$

After substitution of equation (6) for ω in equation (10) the following relationship between capital stock, K, and the share of skilled workers, s, is obtained:

$$(1-\beta)\left[bK^{\beta}(1-s)^{2-\beta} + (1-b)(1-s)^2\right] - \beta(1-b)s = 0. \tag{11}$$

Equation (11) determines s as an increasing function of capital stock K; we write $s = s(K)$.[9] This relationship reflects the capital–skill complementarity embodied in equation (1): if K increases, the relative marginal productivity of skilled labour increases as well (see equation (10)); hence, there is a higher incentive to acquire education.[10] In the autarky case, $K = \bar{K}$ is exogenous and the share of skilled workers (denoted s_{AUT}) is given by $s_{AUT} = s(\bar{K})$. Moreover, with $S = G$ and $K = \bar{K}$, condition (7) implies that the interest rate, r_{AUT}, is given by the function

$$r_{AUT}(A, \bar{K}, G) = A\beta b(G/\bar{K})^{1-\beta}. \tag{12}$$

The autarky interest rate, r_{AUT}, increases in public education expenditure, G, because each skilled worker becomes more productive when G is raised.

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[8] That the share of skilled workers is positively related to the skill premium and hence reflects the endogenous educational choice of heterogeneous individuals.

[9] $s(K)$ exists and is unique, as the left-hand side of equation (11) is positive for $s = 0$, negative for $s = 1$ and strictly decreasing in s.

[10] The capital–skill complementarity – modelled by the nested structure of equation (1) – is crucial for a positive impact of K on s. Under a simple CES production technology of the form $Y = \left[b_K K^{\rho} + b_L L^{\rho} + (1 - b_K - b_L)S^{\rho}\right]^{1/\rho}$, with $\rho \leq 1$, changes in K do not have an impact on the share of skilled workers s.

This again reflects the capital–skill complementarity. Moreover, not surprisingly, r_{AUT} is increasing in TFP, A, and, due to decreasing marginal productivity of capital, decreasing in $\bar{K}$.

In a small open economy, the consumption good is tradable, capital is mobile and labour is immobile. In this case, the capital stock, K_{SOE}, is endogenously determined while the capital cost $\bar{r}$ is exogenously determined at the world market. Using $S = G$ in equation (7), we obtain $K_{SOE} = \xi G$, where

$$\xi = \xi(A, \bar{r}\,) = [A\beta b/\bar{r}\,]^{1/(1-\beta)}. \tag{13}$$

Thus, K_{SOE} is increasing in TFP, A, and public education expenditure, G, whereas it is decreasing in the international capital cost, $\bar{r}$. The share of skilled workers in a small open economy is given by $s(K_{SOE}) = s(\xi(A, \bar{r})G) \equiv s_{SOE}(A, \bar{r}, G)$.

4. CAPITAL MARKET INTEGRATION AND EDUCATIONAL CHOICE WHEN EDUCATION POLICY IS EXOGENOUS

According to equation (11), $s_{SOE} > (=, <)\ s_{AUT}$ if $K_{SOE} > (=, <)\ \bar{K}$, which is equivalent to $\bar{r} < (=,\ >)\ r_{AUT}$. Due to capital–skill complementarity, the share of skilled workers under openness is higher than under autarky if and only if additional foreign capital can be attracted. This is the case if the international capital cost, $\bar{r}$, is lower than the domestic autarky interest rate r_{AUT}. We therefore have the following impact of CMI (i.e. of a switch from autarky to capital mobility) on educational choice.

Proposition 1: *Capital market integration raises (does not affect, reduces) the share of skilled workers if $\bar{r} < r_{AUT}$ ($\bar{r} =,\ > r_{AUT}$, respectively).*

Proof: Analysis in the text. **QED**

Both a higher TFP and higher public education expenditure increase the marginal product of capital, according to equation (7), and thus the autarky interest rate r_{AUT}, according to equation (12). If the international capital cost is below the autarky interest rate (i.e. if A and G are sufficiently high), CMI leads to capital inflows and thereby raises the relative productivity of skilled labour, according to equation (10). This enhances the incentives to acquire higher education. In contrast, if educational spending or TFP is comparably low, skill formation may be reduced by opening up to international capital markets, even if the domestic capital stock is low. The mechanism for this result is consistent with the fact that capital does not necessarily flow from advanced to less developed countries (e.g. Lucas, 1990), as less developed economies are typically not only characterised by a low physical capital stock but also by a low human capital stock and low productivity. Thus, there may be an outflow of capital from these countries after integration. Our analysis suggests that this triggers an adverse effect on skill formation.[11]

In the open economy, domestic capital input has to be financed at the cost required by the international capital market, $\bar{r}$. Proposition 2 shows how variations in international capital cost affect participation in higher education when the economy has opened up. Moreover, the proposition shows that opening up to the international capital market has consequences for the impact of education spending and factor productivity on skill formation.

Proposition 2: *s_{SOE} rises if international capital cost ($\bar{r}$) declines. Moreover, an increase in public education expenditure (G) or in TFP (A) has no effect on s_{AUT}, but raises s_{SOE}.*

Proof: Use equation (11) together with the facts that $K = \bar{K}$ under autarky and $K = K_{SOE} = \xi(A, \bar{r})G$ in a small open economy. **QED**

Under autarky, higher public spending on education, G, has two counteracting effects on education decisions. On the one hand, it raises efficiency units per skilled worker and thereby increases the incentives to acquire education, all other things equal. On the other hand, however, the relative wage rate ω declines for given educational choice, according to equation (10). This second effect exactly offsets the first one. Thus, educational decisions in autarky do not depend on G.[12] In an open economy, there is an additional effect. An increase in G, by raising aggregate skill level S,

[11] In view of $W_S/W_L = 1/(1 - s)$, Proposition 1 further implies that CMI increases (reduces) the inequality of labour earnings, if it leads to an inflow (outflow) of mobile capital. This result is in line with the finding by Viaene and Zilcha (2002b, p. 319) that differences of labour earnings are reduced in the capital exporting country. Furthermore, a positive relationship between capital inflows and the inequality in labour earnings is consistent with the US experience in the 1980s, where a surge in net inflows of foreign direct investment was accompanied by a substantial increase in the skill premium. And the net outflow of foreign investment may contribute to explaining the slowdown in the increase of relative US wages in the 1990s.

[12] This outcome is a consequence of the specific form of the nested production technology in equation (1). With a Cobb–Douglas structure, demand for skilled relative to unskilled labour, $\omega = F_S/F_L$, is proportional to $1/S$, according to equations (8) and (9). By virtue of equation (6), this implies that s_{AUT} becomes independent of $S = G$. Under a more flexible nested CES technology of the form $Y = [[bK^{\beta} + (1 - b)L^{\beta}]^{\rho/\beta} + S^{\rho}]^{1/\rho}$, with $\rho \leq 1$, demand for skilled relative to unskilled labour would be no longer proportional to $1/S$, whenever $\rho \neq 0$, and s_{AUT} would positively (negatively) depend G if $\rho >$ (<) 0. (A formal proof of this argument is provided in a supplement, which is available from the authors upon request.) However, being interested in the differential impact of G under autarky and under mobile capital, the assumption of a Cobb–Douglas technology ($\rho \to 0$) is particularly attractive, because it allows us to illustrate in the simplest possible way how changes in G affect participation rate s through adjustments in the international capital allocation.

attracts capital to the economy. This raises the productivity of skilled labour and its relative wage so that the incentives to become skilled are higher than under autarky. It is this latter effect through changes in the international allocation of capital, which leads to a positive impact of higher public education spending on the incentive to participate in higher education in the open economy.

The comparative-static results in this section point to an important policy issue. Suppose an economy chooses an 'optimal' education spending level (according to some objective function) in autarky, G_{AUT}. How should the economy adjust public education expenditure to CMI? Moreover, will the share of skilled workers increase or decrease under optimal policy adjustment when capital becomes internationally mobile? Giving an answer to these questions is the purpose of Section 5.

5. OPTIMAL EDUCATION POLICY

To characterise the optimal education policy, conditional on the capital market regime (open or closed), we first have to specify the policy objective. We employ a Rawlsian welfare function. That is, education policy is optimal when utility of the low-skilled, $\ln W_L$, is maximised.[13] Using equation (3), the net wage of the low-skilled, $W_L = (1 - \tau)w_L$, can be written as $W_L = w_L - G/(\omega S + L)$. After substituting $S = G$, equations (6), (9) and $L = 1 - s$ and rearranging terms, the expression for W_L reads

$$W_L = A\beta(1-b)\left(\frac{G}{1-s}\right)^{1-\beta} - \frac{(1-s)G}{1-s+s^2} \equiv V(A,s,G). \tag{14}$$

Optimal education spending under autarky, denoted by G_{AUT}, is given by $G_{AUT} = \arg\max_{G \geq 0} V(A, s(\bar{K}), G)$. There exists an interior and unique solution for G_{AUT}, according to equation (14) and $\beta < 1$.

Under openness, $W_L = V(A, s_{SOE}(A, \bar{r}, G), G) \equiv \tilde{V}(A, \bar{r}, G)$. Welfare $\tilde{V}(A, \bar{r}, G)$ may be ever increasing in public education expenditure G, due to the positive interaction between G and capital inflow in an open economy. That is, there may be no interior solution for the optimal policy problem. However, the following can be shown.

[13] The main results of this section would be unchanged, when a utilitarian instead of a Rawlsian welfare criterion is imposed. (For further details on that matter, see Remark 3 in the working paper version of this article, which is available under the following link: ftp://ftp.iza.org/dps/dp1863.pdf.) The Rawlsian welfare function has an advantage in terms of easier analytical tractability.

Lemma 1: *If*

$$A < \frac{(\bar{r}/\beta)^{\beta}}{b(1-\beta)^{1-\beta}} \equiv \hat{A},$$

$\tilde{V}(A, \bar{r}, G)$ *has an interior and unique maximum.*

Proof: Available from the authors upon request. **QED**

Proposition 1 has shown how the impact of CMI on the share of skilled labour, s, depends on the pattern of capital flows for given public education expenditure, G. We now turn to the question how s changes after CMI when public education expenditure is adjusted optimally to $G_{SOE} \equiv \arg\max_{G \geq 0} \tilde{V}(A, \bar{r}, G)$. That is, we compare the share of skilled labour $s^* \equiv s_{SOE}(A, \bar{r}, G_{SOE})$ with the pre-integration level, $s_{AUT} = s(\bar{K})$. Moreover, we explore in which direction optimal adjustment of public education expenditure tends to go when we start from G_{AUT}, the optimal education policy under autarky. That is, we analyse whether $G_{AUT} < G_{SOE}$ or $G_{AUT} > G_{SOE}$.

To investigate how optimal policy setting influences the adjustment of educational choice to CMI, we first consider the case in which the cost of capital to be paid in the integrated capital market equals the autarky interest rate. That is, $\bar{r} = r_{AUT}(A, \bar{K}, G_{AUT})$, and consequently, $K_{SOE} = K_{AUT}$ and $s_{SOE} = s_{AUT}$. Proposition 3 can be derived.

Proposition 3: *Suppose* $A < \hat{A}$ *and* $\bar{r} = r_{AUT}(A, \bar{K}, G_{AUT})$. *Then* $G_{SOE} > G_{AUT}$ *and* $s^* > s_{AUT}$.

Proof: Available from the authors upon request. **QED**

Even if education spending was at its optimal level under autarky and the return to capital before integration was at the level required by the world market, there is an incentive for W_L-maximising governments to adjust their education policies. By raising public education spending above the autarky level ($G_{SOE} > G_{AUT}$), the economy can attract foreign capital (as $K_{SOE} = \xi G$), which in turn enhances incentives to acquire education (recall $s'(K) > 0$). In sum, the share of skilled labour increases under optimal policy adjustment, i.e. $s^* > s_{AUT}$.

To see how the results in Proposition 3 have to be modified if the autarky interest rate differs from the capital cost in the world market ($r_{AUT} \neq \bar{r}$), we need to understand how G_{SOE} and s^* are affected by changes in $\bar{r}$.

Numerical analysis reveals that the impact of a change in $\bar{r}$ on optimal public education expenditure can go in both directions. According to Table 1, if $\beta = b = A = 0.5$, G_{SOE} first decreases but then increases with $\bar{r}$. Thus,

TABLE 1
Optimal Education Policy under Openness ($b = \beta = A = 0.5$)

$\bar{r}$	G_{SOE}	s^*
0.02	0.06	0.584
0.05	0.02	0.449
0.08	0.02	0.426
0.11	0.03	0.421
0.14	0.04	0.418

although CMI gives an incentive for the public sector to increase G when there is no interest rate differential, general results with respect to the optimal adjustment of G are difficult to obtain. A clearer picture results with respect to participation in higher education. Table 1 also illustrates the role of the world market interest rate for s^*, showing that s^* monotonically declines when $\bar{r}$ rises. Hence, although the impact of CMI on the optimal level of public education expenditures is in general ambiguous, the following consequences for the share of skilled workers can be derived.

Proposition 4: *Suppose* $A < \hat{A}$. *If* $\bar{r} < r_{AUT}(A, \bar{K}, G_{AUT})$, *then* $s^* > s_{AUT}$. *By contrast, if* $\bar{r} > r_{AUT}(A, \bar{K}, G_{AUT})$, *then* $s^* <, =, > s_{AUT}$ *is possible.*

Proof: Available from the authors upon request. **QED**

From Proposition 1, we know that $\bar{r} < r_{AUT}$ triggers capital inflows after CMI, thereby providing additional incentives for higher education if public education spending is held constant. According to Proposition 4, this result also holds when the education policy is optimally adjusted. Hence, even if education spending declines, the finding that CMI induces an increase in higher education extends to the case of endogenous education policy. In contrast, if $\bar{r} > r_{AUT}$, CMI leads to capital outflows and thereby reduces the incentive for higher education if G is held constant at its autarky level. In this case, even if G increases, the adjustment of public education spending is not necessarily strong enough to offset this negative effect on the demand for education. As a result, s may or may not remain below its autarky level.

6. EMPIRICAL ANALYSIS

a. Testable Hypotheses and Identification

The theoretical analysis suggests a set of testable hypotheses that can be summarised in the following way:

1. Net capital inflows (outflows) induce an increase (a decline) in participation rates for higher education (Proposition 1). In the empirical implementation, we employ logarithm of inflows minus logarithm of outflows as a measure of net capital flows. This variable is used as one determinant to explain participation in higher schooling. Under the null hypothesis, net capital inflows exhibit a non-positive impact on higher schooling. The corresponding alternative hypothesis is referred to as H_1^a.
2. A reduction in investment barriers (leading to lower capital cost) and an increase in public education expenditure stimulate participation in higher education through higher net capital inflows (Proposition 2). Moreover, changes in investment barriers may induce adjustments of public education expenditure with feedback effects on educational choice (Propositions 3 and 4). We refer to this hypothesis as H_1^b. Under the corresponding null hypothesis, a reduction in investment barriers and an increase in (endogenous) public education expenditure exhibit a non-positive impact on a country's higher schooling through net capital inflows.

We also test whether CMI is relevant for economic growth through the often hypothesised nexus between the average education level in the economy and income growth. We thus form the following hypothesis:

3. Net capital inflows induce an increase in the growth of GDP per worker through their positive effect on participation in higher education. We will test the corresponding null hypothesis of a non-positive impact of endogenous higher schooling on the growth of GDP per worker against its alternative hypothesis H_1^c.

For empirical inference, we first specify the average annual change of a country's higher schooling as a function of net capital inflows, treating the latter variable as endogenous as suggested by the theoretical model (H_1^a and H_1^b). We think of capital flows as ones of production capital and therefore use flows of foreign direct investment rather than portfolio investment. We also account for a possible endogeneity of public education expenditure. Finally, we run regressions of growth in GDP per worker on the change in higher schooling (H_1^c). There, we treat the change in higher schooling as well as changes in net capital inflows and public education expenditure as endogenous, using H_1^a and H_1^b as a guideline to formulate a proper econometric specification.

Two strategies are available to avoid an endogeneity bias of determinants of participation in higher education and economic growth. One is to search for one creative instrument for each endogenous variable in the model that is not directly related to outcome according to economic theory and plausible reasoning (see Acemoglu et al., 2001, for an example). However, in empirical macroeconomics, it is rarely the case that such an instrument is available, and even if economists agree on the suitability of an available instrument, a drawback of this approach is that inference about the statistical appropriateness is not feasible in a just-identified framework. An alternative approach is to use more than one instrument per endogenous variable and examine their relevance with statistical tests (see Sargan, 1983). Since widely accepted creative instruments are not available in our context, we have to rely on the second strategy and hence choose a set of instruments that seems suitable from the perspective of our theoretical model and adequate according to overidentification tests.

b. Data

In our empirical analysis, we rely on cross-sectional data for 79 countries as listed in the Appendix. Since it is our purpose to estimate growth models that allow for conditional convergence, we distinguish between two types of control variables: variables capturing (average annual) change for the period 1960–2000 and those representing initial levels. In the following, we briefly describe the variables of interest and the corresponding data sources. An overview of the associated descriptive statistics is given in the Appendix.

Regarding the schooling variables, we rely on data that are provided by Barro and Lee (2000). Specifically, we use the years of post-secondary education in the total population as a measure of higher schooling.[14] From the Penn World Table, we use data on the initial level and average annual growth of real GDP per worker (US dollars in 1996 constant prices, chain series), the initial level and average annual growth of the number of workers and the initial level of real domestic investment (US dollars in 1996 constant prices, chain series) per worker as a proxy for capital stocks.[15] Data on the level and the change in the share of public education spending are taken from the World Bank's *World Development Indicators*. To construct the net capital flow variable, we use information on average annual changes in outward and inward foreign direct investment from UNCTAD's *World Investment Report* (2002, and earlier years). Finally, we use data on the average annual change and the initial level of investment barriers from the Business Environment Risk Intelligence (BERI) to measure the change in investment cost (i.e. CMI) over time. BERI constructs

[14] Alternative measures would be enrolment rates in higher education or the share of population that completed higher education. According to the theoretical model, both measures are the same. In reality, however, they may differ and time spent in the education system matters for skill acquisition. Therefore, we think that years of higher schooling are an adequate measure for participation in higher education. In any case, we show in a sensitivity analysis that our results are qualitatively insensitive to the choice of alternative measures of higher schooling.

[15] With a chain series approach, the base year changes periodically. This avoids the potential bias of real growth figures associated with fixed-weighted approaches and a constant base year such as with the Laspeyres or the Paasche index formulas. This bias can be substantial with growth rates that are computed over long time spans.

an index from a survey conducted among analysts and professionals. In particular, it rests on sub-indices reflecting impediments to operations in a market associated with economic, financial sector and political barriers. The BERI index has also been used as a measure of foreign investment barriers in the studies of Blonigen et al. (2003, 2007), who are interested in the FDI decisions of multinational firms.[16]

c. Results

(i) Capital market integration and schooling

Table 2 summarises our findings with respect to the first and the second alternative hypothesis: the positive impact of an increase in net capital inflows on higher schooling (H_1^a) and the positive impact of a reduction in investment barriers and (endogenous) public education spending (H_1^b) on higher schooling through an increase in net capital inflows.

In the table, we summarise the results from five alternative regressions. Model (1) provides a baseline specification to assess the impact of net capital inflows on higher schooling. To cope with the endogeneity of capital flows, we employ a two-stage least-squares (IV-2SLS) estimator, using the following identifying instruments: initial level and change in primary schooling, the initial level in higher schooling, the initial level of net capital inflows, the change in public education expenditure and the reduction in investment barriers. Furthermore, we include the following set of control variables to determine higher schooling in the second-stage model: the change in the number of workers (to account for potential country size effects), the initial levels of public education expenditure, GDP per worker and the number of workers. Using this specification, we find a significant positive effect of the change in net capital inflows on higher schooling. The diagnostic tests suggest that net capital inflows indeed are endogenous and that the chosen instruments are relevant. However, the significant over-identification test indicates that some of the instruments might have an impact on their own in the second-stage model.

Therefore, we run a different specification in model (2), where the change in public education expenditure appears in the second stage rather than being used as an identifying instrument of net capital inflows. The estimation results lend support to a positive impact of public education expenditure on participation in higher schooling.[17] In model (2), the impact of net capital inflows on

[16] In one of the robustness checks, we use an alternative measure of CMI: the change in the number of ratified bilateral investment treaties per country over the reference period. It turns out that the results are qualitatively insensitive to the use of this alternative measure of CMI.

[17] Note that this result cannot be explained by the theoretical model introduced in Section 2. However, as discussed in footnote 12, a positive direct impact of an increase in public education expenditure on participation in higher schooling could arise with a more flexible nested CES production technology.

TABLE 2

Net Capital Inflows Induce an Increase in Participation in Higher Education (H_1^a); Investment Barriers and Education Spending Work through Net Capital Inflows (H_1^b)

Explanatory Variables	*Dependent Variable is Average Annual Change in Years of Higher Schoooling*[a]				
	(1)[b]	*(2)*[c]	*(3)*[d]	*(4)*[e]	*(5)*[f]
Change variables (average annual change)					
Net capital inflows	1.0206*	2.1788**	2.0342***	2.0582**	–
	(0.6076)	(0.8707)	(0.7478)	(0.9464)	–
Reduction in investment barriers	–	–	0.0454	–	0.0392*
	–	–	(0.0354)	–	(0.0219)
Ln public education expenditure	–	0.0512**	0.0513**	–	0.0622*
	–	(0.0246)	(0.0216)	–	(0.0320)
Ln workers	0.0590	−0.0897	−0.0450	−0.0084	0.0666
	(0.1210)	(0.1875)	(0.1869)	(0.1574)	(0.1554)
Constant	−0.0504***	−0.0577***	−0.1076***	−0.0550***	−0.0922***
	(0.0073)	(0.0106)	(0.0413)	(0.0105)	(0.0274)
Level variables (initial period)					
Ln public education expenditure	0.0011***	0.0010**	0.0013***	0.0012***	0.0010**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Ln real GDP per worker	0.0032***	0.0038***	0.0036***	0.0033***	0.0035***
	(0.0010)	(0.0013)	(0.0011)	(0.0013)	(0.0012)
Ln workers	−0.0020	−0.0030	−0.0034	−0.0028	−0.0018
	(0.0033)	(0.0038)	(0.0038)	(0.0038)	(0.0033)
Observations (countries)	79	79	79	79	79
Estimation approach	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS	IV-2SLS
R^2	0.8002	0.6847	0.7127	0.6723	0.8099
Root mean squared error in higher schooling equation	0.0048	0.0060	0.0057	0.0061	0.0046
Exogeneity of net capital inflows (*p*-value of Hausman–Wu *F*-test)	0.0385	0.0004	0.0006	0.0009	0.1201
Instrument relevance (*p*-value of *F*-test)	0.0077	0.0504	0.1622	0.0887	0.0298

TABLE 2 *Continued*

Explanatory Variables	*Dependent Variable is Average Annual Change in Years of Higher Schoooling*[a]				
	(1)[b]	*(2)*[c]	*(3)*[d]	*(4)*[e]	*(5)*[f]
Instrument adequacy (p-value of Hansen J-statistic)	0.0230	0.3003	0.3339	0.2019	0.0202

Notes:
***, **, * indicates that coefficients are significant at 1 per cent, 5 per cent and 10 per cent, respectively.
[a]Using the variable labelled 'HYR' in the Barro and Lee (2000) dataset, all models use the following set of identifying instruments: both initial level of and change in primary schooling, initial level of higher schooling, initial level of net capital inflows. Reported standard errors (in parentheses) are robust to heteroscedasticity.
[b]Net capital inflows are endogenous. The following identifying instruments are used in addition to the ones mentioned in note a: change in public education expenditure, reduction in investment barriers.
[c]Net capital inflows are endogenous. The following identifying instrument is used in addition to the ones mentioned in note a: reduction in investment barriers.
[d]Net capital inflows are endogenous. The identifying instruments are the ones mentioned in note a.
[e]Net capital inflows are endogenous. The identifying instruments are the ones mentioned in note c.
[f]Ln public education expenditures are endogenous. The identifying instruments are the ones mentioned in note a.

participation in higher schooling is even stronger than in model (1). And the model diagnostics clearly support this specification against the previous one (see the insignificant over-identification test). As compared with model (2), model (3) extends the set of explanatory variables in stage two in order to see whether the reduction in investment barriers has an additional direct impact on participation in higher schooling. While the diagnostic tests support this model as well as model (2), it turns out that a reduction in investment barriers explains net capital inflows but does not contribute significantly to explaining the variation in the change in higher schooling. Implicitly, this indicates that there is no additional impact of investment liberalisation through national capital accumulation.

While models (1)–(3) treat the change in public education expenditure as exogenous, the theoretical model points to its possible endogeneity. Therefore, we employ two further specifications. Model (4) is similar to model (1) but omits the change in public education expenditure as an instrument of the change in net capital inflows. This can be viewed as a reduced-form strategy. Again, model (4) is supported by the diagnostic tests, and the change in net capital inflows affects participation in higher schooling in a significantly positive way. As an alternative, model (5) assesses the impact of a change in endogenous public education expenditure on the change in higher education. There, we explain public education expenditure in the first stage and replace the structural form of the change in net capital inflows by a reduced form, involving the reduction in investment barriers in the second stage.[18] Under this specification, both the change in public education expenditure and the reduction in investment barriers enter significantly. However, model (5) is rejected by the significant over-identification test. In view of the theoretical hypotheses, we refer to model (4) as the preferred one in the subsequent analysis. Using the parameters of model (4) and the information provided in the descriptive statistics of Table 6, net capital inflows induce an impact on participation in higher schooling of $0.0006 \times 2.0582 = 0.0012$ and, therefore, explain about 15 per cent of the average annual change in higher schooling (which is 0.0083).

(ii) Economic growth

Table 3 assesses the question of how net capital inflows affect growth of real GDP per worker through a change in *endogenous* higher schooling (H_1^c). In the treatment of endogenous higher schooling, we account for H_1^a and H_1^b as supported by the results in Table 2. According to H_1^a, higher schooling depends on net capital inflows which in turn depend on investment barriers and endogenous public education expenditure, according to H_1^b. We run four different

[18] With the instruments at hand, it is not feasible to estimate IV-2SLS models where the change of both net capital inflows and public education expenditure are simultaneously treated as endogenous in a structural way.

regressions referred to as models (6)–(9). In all specifications, in addition to the change in endogenous higher schooling, we include the change in the number of workers and initial levels of real capital stock of workers and real GDP per worker as determinants of the growth in real GDP per worker.[19]

To cope with the endogeneity of the higher schooling variable, we employ an instrumental variable two-stage least-squares (IV-2SLS) estimator in model (6) and a three-stage least-squares system (SYS-3SLS) estimator in models (7)–(9).[20] In the IV-2SLS regression, we apply a reduced-form approach with respect to endogenous net capital inflows and endogenous public education expenditure. The determinants of the latter two variables are used as instruments in the higher schooling first-stage regression. In particular, the reduction in investment barriers is included to account for H_1^b. The change in public education expenditure is not used as an identifying instrument, because of its endogeneity (see model (4) in Table 2). Details on the first-stage specification are summarised in the notes at the bottom of Table 3.

In SYS-3SLS regression models (7)–(9), we do not run the full system of structural equations. Treating the growth rate of GDP per worker, higher schooling, public education expenditure and net capital inflows jointly as endogenous in a system of equations and accounting for their interdependence exceeds the possibilities in our dataset. To overcome this problem, we replace one of the endogenous variables by its reduced form. Accordingly, the results of models (7)–(9) are based on a system of three rather than four equations (see the table for details). In all SYS-3SLS models, we treat the growth rate of GDP per worker and that of higher schooling years as two structural equations. Model (7) additionally specifies the change in net capital inflows in a structural

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[19] In a robustness analysis, we have included the initial level of higher schooling as a separate control variable in the growth of GDP per worker regressions. However, a significant additional effect of this variable could not be identified, when controlling for the changes in higher schooling years and the number of workers as well as the initial levels of the capital stock per worker and the real GDP per worker. Therefore, we have excluded this variable in the models summarised in Table 3. It is also notable that in model (6) the initial level of primary schooling is used as an instrument for explaining the changes in higher schooling and thus affects growth indirectly.

[20] A SYS-3SLS approach allows us to explain the endogenous variables by different sets of explanatory variables. Hence, with SYS-3SLS we can account for the economic mechanisms identified in the theoretical model more adequately. For instance, we can exclude direct determinants of the growth in real GDP per worker equation from the growth in higher schooling equation, if they are irrelevant in the latter equation. Furthermore, we can allow endogenous variables to exert an impact on each other in a way that lies beyond the possibilities of IV-2SLS. SYS-3SLS is efficient and, in small samples, it can obtain parameter estimates that are (slightly) different from their IV-2SLS counterparts. The precision of the estimates is improved in terms of the root mean squared error in each equation (e.g. that one for the growth in GDP per worker). Note that the R^2-values of IV-2SLS and SYS-3SLS are difficult to compare. Therefore, the respective values are not displayed in Table 3. What matters is the comparison of standardised statistics such as the relevance of identifying variables. Also, standardised estimates such as the root mean squared errors of the equations are comparable across specifications. These are reported in the table.

TABLE 3
Net Capital Inflows Induce an Increase in Growth of GDP Per Worker through Participation in Higher Education (H_1^c)

Explanatory Variables	*Dependent Variable is Average Annual Change in ln Real GDP Per Worker (1996; chain series)*			
	(6)[a]	*(7)*[b]	*(8)*[c]	*(9)*[b]
Change variables (average annual change)				
Higher schooling years	3.9437***	4.3774***	2.2150**	1.8649***
	(1.2553)	(0.7637)	(0.9129)	(0.6648)
Total schooling years	–	–	–	0.1566***
	–	–	–	(0.0566)
Ln public education expenditure	–	–	0.6621***	–
	–	–	(0.1121)	–
Ln workers	−0.5046	−0.2645	−1.2278***	−0.4796
	(0.6870)	(0.3775)	(0.3772)	(0.3374)
Constant	0.1842***	0.2015***	0.1280***	0.1034***
	(0.0435)	(0.0346)	(0.0303)	(0.0318)
Level variables (initial period)				
Ln real capital stock per worker	0.0042**	0.0037	0.0081***	0.0040*
	(0.0021)	(0.0027)	(0.0026)	(0.0021)
Ln real GDP per worker	−0.0256***	−0.0277***	−0.0225***	−0.0156***
	(0.0058)	(0.0054)	(0.0041)	(0.0046)
Observations (countries)	79	79	79	79
Estimation approach	IV-2SLS	SYS-3SLS	SYS-3SLS	SYS-3SLS
Root mean squared error in growth of GDP per worker equation	0.0286	0.0201	0.0242	0.0022
Relevance of explanatory variables (p-value of F-test in growth of GDP per worker equation)	0.0003	0.0000	0.0000	0.0000
Relevance of explanatory variables (p-value of F-test in higher schooling years equation)	0.0293	0.0000	0.0000	0.0000

TABLE 3 *Continued*

Explanatory Variables	*Dependent Variable is Average Annual Change in ln Real GDP per Worker (1996; chain series)*			
	(6)[a]	*(7)*[b]	*(8)*[c]	*(9)*[b]
Relevance of explanatory variables (p-value of F-test in net capital inflow equation)	Reduced form	0.0247	Reduced form	0.0315
Relevance of explanatory variables (p-value of F-test in education expenditure equation)	Reduced form	Reduced form	0.0085	Reduced form

Notes:
***, **, * indicates that coefficients are significant at 1 per cent, 5 per cent and 10 per cent, respectively.
In this table, we use the variable labelled 'HYR' in the Barro and Lee (2000) dataset as an endogenous measure of higher schooling. Reported standard errors (in parentheses) are robust to heteroscedasticity.
[a]Higher schooling is endogenous, using the following instruments: initial level of higher schooling, initial level of ln public education spending, initial level of primary schooling, initial level and reduction in investment barriers, initial level of net capital inflows, initial level of ln number of workers. p-Value of Hausman–Wu F-test on exogeneity of higher schooling years is 0.0000. p-Value of Hansen J-statistic on instrument adequacy (over-identification) is 0.2044.
[b]Higher schooling and net capital inflows are endogenous, using the following explanatory variables. Higher schooling: change and initial level of net capital inflows, initial level of ln real GDP per worker, initial level of higher schooling, initial level of ln public education spending, initial level of ln capital per worker. Net capital inflows: initial level of ln real GDP per worker, initial level of primary schooling, initial level of higher schooling, initial level of ln public education spending, reduction in investment barriers.
[c]Higher schooling and education spending are endogenous, using the following explanatory variables. Higher schooling: initial ln GDP per worker, initial ln capital per worker, change in public education expenditure, change in ln number of workers. Public education expenditure: initial ln capital per worker, reduction in and initial level of investment bariers, initial level of net capital inflows.

way. The model accounts for the dependence of higher schooling on net capital flows which in turn depend on investment barriers. Endogenous adjustments in public education expenditure are employed in a reduced form.

In comparison to this, model (8) uses a reduced form for net capital flows and introduces a separate equation for the change in public education expenditure, instead. In particular, we account for the possibility that public education expenditure is adjusted in response to changes in investment barriers. Changes in public education expenditure are allowed to affect growth directly or through changes in the higher schooling variable.[21] Model (9) is similar to model (7), but additionally accounts for the total years of schooling in the population to see whether higher schooling exerts an impact on economic growth beyond education as such.

The estimation results reported in Table 3 draw a very robust picture. In all specifications, the growth in GDP per worker is significantly positively affected by the growth in higher schooling years. The treatment of higher schooling as an endogenous variable and the underlying choice of instruments is justified from an econometric point of view. In particular, the Hausman–Wu test in model (6) indicates that the average annual change in higher schooling should not be treated as exogenous, given the chosen specification (the corresponding test statistic is significant at 1 per cent). The instruments are relevant and adequate in the first-stage of model (6). They pass the Hansen *J*-test on over-identifying restrictions, indicating that the instruments need not be included in the second-stage model. Similarly, the explanatory variables are highly relevant in all equations of the SYS-3SLS models.[22]

Furthermore, as expected from the large body of research on Barro-type convergence regressions, we identify a significant negative impact of initial real GDP per worker on its growth (see Barro and Sala-i-Martin, 1995, for an overview). The initial level of capital stock per capita is positively related to growth in GDP per worker. The average annual change in the number of workers exhibits a negative impact that is insignificant in all models except of model (8). According to model (8), there is a direct impact of public education expenditure on the growth in GDP per worker, in addition to the effects on participation in higher schooling. This lends support to findings by Kneller et al. (1999) that higher productive expenditures (which include education spending as an important factor) promote economic growth. Finally, the results for model

[21] Note that, similar to model (6), model (7) does not account for a direct impact of public education spending on the growth in GDP per worker, as the change in endogenous public education spending is replaced by its explanatory variables in the respective reduced-form approach.

[22] To shed further light on that issue, we estimated an alternative model, where the average annual change in higher schooling was treated as exogenous (not reported for the sake of brevity). By disregarding the endogeneity of the change in higher schooling, the corresponding parameter estimate is severely downward biased, amounting to only 0.982.

TABLE 4
Net Capital Inflows Induce an Increase in Participation in Higher Education (H_1^a), Robustness to Choice of Higher Schooling Measure

Explanatory Variables	*Dependent Variable is Average Annual Change in Years of Higher Schooling*		
	(4.1)[a]	*(4.2)*[b]	*(4.3)*[c]
Change variables (average annual change)			
Net capital inflows	2.0468**	2.8892	64.6326**
	(1.0384)	(2.4415)	(31.1202)
Ln workers	0.0083	0.7028	1.2679
	(0.1820)	(0.4999)	(5.2951)
Constant	−0.0563***	−0.0866***	−1.7341***
	(0.0110)	(0.0336)	(0.3325)
Level variables (initial period)			
Ln public education expenditure	0.0014***	0.2220***	0.0032**
	(0.0005)	(0.0633)	(0.0014)
Ln real GDP per worker	0.0028**	0.6253***	0.0022
	(0.0014)	(0.1701)	(0.0041)
Ln workers	−0.0042	1.1053*	−0.0140
	(0.0043)	(0.6349)	(0.0135)
Observations	79	79	79
Estimation approach	IV-2SLS	IV-2SLS	IV-2SLS
R^2	0.6788	0.6982	0.6565
Root mean squared error in higher schooling equation	0.0065	0.0200	0.2000
Exogeneity of net capital inflows (p-value of Hausman–Wu F-test)	0.0017	0.2590	0.0012
Instrument relevance (p-value of F-test)	0.0887	0.0887	0.0887
Instrument adequacy (p-value of Hansen J-statistic)	0.2477	0.0451	0.2874

Notes:
***, **, * indicates that coefficients are significant at 1 per cent, 5 per cent and 10 per cent, respectively.
In this table, we estimate the same specifications as in model (4) in Table 2, but using other schooling variables instead. Reported standard errors (in parentheses) are robust to heteroscedasticity.
[a]Using the change in higher schooling of males ('HYRM' in Barro and Lee, 2000).
[b]Using the change in secondary schooling years ('SYR' in Barro and Lee, 2000).
[c]Using the change in percentage of higher schooling attained ('LH' in Barro and Lee, 2000).

(9) indicate that an overall improvement in education is a stimulus for the growth in GDP per worker. However, the results also make clear that an increase in higher schooling years exhibits an additional positive impact.

d. Sensitivity Analysis

Our results on (i) the impact of net capital inflows on participation in higher schooling and (ii) the impact of the latter on the growth in real GDP per

TABLE 5
Robustness of Growth Regressions to Choice of Higher Schooling Measure

Explanatory Variables	*Dependent Variable is Average Annual Change in ln Real GDP per Worker (1996; chain series)*		
	(7.1)[a]	*(7.2)*[b]	*(7.3)*[c]
Change variables (average annual change)			
Higher schooling years	2.7419***	0.4029***	0.0818***
	(0.7055)	(0.1373)	(0.0246)
Ln workers	−0.4558	−0.3541	−0.4217
	(0.4564)	(0.3683)	(0.4626)
Constant	0.1422***	0.0619***	0.1490***
	(0.0306)	(0.0176)	(0.0348)
Level variables (initial period)			
Ln real capital stock per worker	0.0051**	0.0043**	0.0057**
	(0.0025)	(0.0021)	(0.0025)
Ln real GDP per worker	−0.0207***	−0.0096***	−0.0215***
	(0.0048)	(0.0031)	(0.0053)
Observations (countries)	79	79	79
Estimation approach	SYS-3SLS	SYS-3SLS	SYS-3SLS
Root mean squared error in growth of GDP per worker equation	0.0151	0.0123	0.0153
Relevance of explanatory variables (p-value of F-test in growth of GDP per worker equation)	0.0002	0.0005	0.0010
Relevance of explanatory variables (p-value of F-test in higher schooling years equation)	0.0000	0.0000	0.0000
Relevance of explanatory variables (p-value of F-test in net capital inflow equation)	0.0977	0.0244	0.0765
Relevance of explanatory variables (p-value of F-test in education expenditure equation)	Reduced form	Reduced form	Reduced form

Notes:
***, **, * indicates that coefficients are significant at 1 per cent, 5 per cent and 10 per cent, respectively.
In this table, we estimate the same specifications as in model (7) in Table 3, but using other schooling variables instead. Reported standard errors (in parentheses) are robust to heteroscedasticity.
[a]Using the change in higher schooling of males (‘HYRM’ in Barro and Lee, 2000).
[b]Using the change in secondary schooling years (‘SYR’ in Barro and Lee, 2000).
[c]Using the change in percentage of higher schooling attained (‘LH’ in Barro and Lee, 2000).

worker are very robust with respect to the use of alternative schooling measures. This conclusion is based on the results summarised in Tables 4 and 5. Whereas the results in Table 4 should be compared with model (4) in Table 2, those in Table 5 refer to the ones of model (7) in Table 3. Hence, all of the results in Table 4 are based on IV-2SLS and those in Table 5 are based on SYS-3SLS estimation.

In models (4.1) and (7.1), we use higher schooling years of males rather than that of the total population, being identical to models (4) and (7) in all other respects. This is to account for the fact that labour market participation of females varies considerably across different societies. The results are very similar to those of the baseline models. In models (4.2) and (7.2), the secondary (rather than post-secondary) years of schooling serve as a higher schooling measure. Again, the results are quite similar to those of our baseline regressions, with the main difference that the coefficient of the net capital inflow variable is insignificant in model (4.2).[23] Finally, in models (4.3) and (7.3), we rely on the percentage of higher schooling attained (i.e. the share of population that has acquired higher education) rather than the years of higher schooling. Since the units of measurement are different as compared with the originally employed higher schooling variable, the magnitude of the coefficients is not directly comparable to models (4) and (7), respectively. However, the results are qualitatively similar to the original ones. Overall, our finding of a (significantly) positive impact of (endogenous) net capital inflows on participation in higher schooling and of (endogenous) higher schooling on the growth in GDP per worker are robust with respect to the choice of the schooling measure employed.

In a further sensitivity analysis, we ran models (4) and (7) on two time subsamples of our data: 1960–85 and 1985–2000. The results are qualitatively robust, with the effects of interest − the impact of net capital inflows on participation in higher education and the impact of participation in higher education on growth − being stronger in the later period. In a final experiment, we checked for the sensitivity of the results with respect to using an alternative measure of investment liberalisation: the change in the number of bilateral investment treaties ratified over the sample period as notified to UNCTAD instead of the change in the BERI investment barrier index. When employing this alternative measure of CMI as an instrument in model (4), we obtain a parameter estimate for the change in net capital inflows of 1.7135 (as compared with 2.0582 in Table 2), which is significant at 10 per cent. Moreover, using this instrument in model (7) leads to a parameter estimate for higher schooling years of 3.3085 (as compared with 4.3774 in Table 3), which is significant at 1 per cent.[24]

[23] It is notable that part of secondary schooling is compulsory in many countries covered by our dataset. This implies that capital inflows have a less important effect on participation in secondary education, which may explain the insignificance of the respective parameter estimate.

[24] To keep the number of tables at a reasonable level, we do not report all details of the last two sensitivity analyses here. They are available from the authors upon request.

7. CONCLUSION

This research has been motivated by the surge in international capital flows in the last decades, the apparent complementarity between skilled labour and physical capital in the production process, and the evidence on human capital as an engine of economic growth. We have presented theory and empirics on the impact of CMI on participation in higher education as well as evidence on the consequences for economic growth. In particular, we have set up a simple small economy model to show that integration leads to an increase in the share of high-skilled labour in capital-importing economies, whereas the opposite occurs, if CMI leads to capital outflows. Furthermore, we have also analysed to what extent a government can use education policy in order to attract mobile capital and thereby stimulate educational attainment in an open economy.

Our empirical analysis largely confirms the main hypotheses derived in this paper. First, net capital inflows significantly affect participation in higher schooling. Second, changes in investment barriers and endogenous public education spending are important determinants of net capital flows and thereby affect participation in higher education. In addition, we find that capital flows significantly affect economic growth through their effect on higher education. The empirical results also suggest out that an adequate treatment of endogenous variables, like capital flows, education expenditure or participation in higher education, is important to obtain unbiased parameter estimates. In a sensitivity analysis, we have shown that the empirical results of our analysis are qualitatively insensitive to different measures of higher schooling or CMI.

APPENDIX

Country Sample

Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Botswana, Brazil, Cameroon, Canada, Chile, China, Colombia, Republic of Congo, Costa Rica, Cyprus, Denmark, Arab Republic of Egypt, El Salvador, Finland, France, Gambia, Germany, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Islamic Republic of Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Republic of Korea, Malawi, Malaysia, Mali, Mexico, Mozambique, Netherlands, New Zealand, Nicaragua, Niger, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, RB Venezuela, Zambia, Zimbabwe.

Table A1 summarises the descriptive statistics of the variables employed in the empirical analysis.

TABLE A1
Descriptive Statistics

Variables	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
Dependent variables				
Average annual change in years of higher schooling ('HYR' in Barro and Lee, 2000)	0.0083	0.0068	−0.0003	0.0276
Average annual change in net inward foreign direct investment flows	0.0006	0.0023	−0.0051	0.0098
Average annual change in ln real GDP per worker (1996; chain series)	0.0176	0.0146	−0.0120	0.0595
Average annual change in ln education spending	0.0270	0.0390	−0.1785	0.1245
Independent variables				
Average annual change in ln (number of) workers	0.0014	0.0044	−0.0088	0.0159
Average annual change in total years of schooling ('TYR' in Barro and Lee, 2000)	0.0717	0.0354	0.0126	0.1854
Average annual change in years of primary schooling ('PYR' in Barro and Lee, 2000)	0.0330	0.0232	−0.0163	0.0867
Average annual reduction of investment barriers	1.0085	0.0218	0.9395	1.0731
Initial level of average years of higher schooling ('HYR')	0.0877	0.1194	0	0.5300
Initial level of average years of total schooling ('TYR')	3.6165	2.6735	0.1670	9.5550
Initial level of average years of primary schooling ('PYR')	2.7553	1.9212	0.1300	7.3160
Initial level of ln education spending	25.4173	2.3324	20.4331	31.0808
Initial level of ln real GDP per worker (1996; chain series)	8.8593	0.9466	6.7365	10.5837
Initial level of ln (number of) workers	−0.9353	0.2012	−1.3513	−0.5021
Initial level of ln real capital stock per worker (1996; chain series)	6.7963	1.5555	2.3888	9.1671
Initial level of investment barriers	35.0989	4.9847	20.3571	45.3429
Dependent variables used in robustness analysis				
Average annual change in years of higher schooling of males ('HYRM' in Barro and Lee, 2000)	0.0082	0.0068	−0.0004	0.0287
Average annual change in years of secondary schooling ('SYR' in Barro and Lee, 2000)	0.0300	0.0223	−0.0372	0.0880
Average annual change in years of higher schooling attained ('LH' in Barro and Lee, 2000)	0.2320	0.2157	−0.0077	0.9718

TABLE A1 *Continued*

Variables	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
Independent variables used in robustness analysis				
Average annual change in the number of bilateral investment treaties ratified (UNCTAD)	0.5816	0.7591	0	4.7000
Initial level of average years of higher schooling of males ('HYRM')	0.1101	0.1386	0	0.6020
Initial level of average years of secondary schooling ('SYR')	0.7768	0.9219	0.0120	5.0770
Initial level of average years of higher schooling attained ('LH')	2.6035	3.8748	0	20

REFERENCES

Acemoglu, D., S. Johnson and J. A. Robinson (2001), 'The Colonial Origins of Comparative Development', *American Economic Review*, **91**, 1369–401.

Barro, R. J. and J.-W. Lee (2000) 'International Data on Educational Attainment: Updates and Implications', manuscript, Harvard University.

Barro, R. J. and X. Sala-i-Martin (1995), *Economic Growth* (New York: McGraw-Hill).

Blonigen, B. A., R. B. Davies and K. Head (2003), 'Estimating the Knowledge–Capital Model of the Multinational Enterprise: Comment', *American Economic Review*, **93**, 980–94.

Blonigen, B. A., R. B. Davies, G. Waddell and H. Naughton (2007), 'FDI in Space: Spatial Autoregressive Relationships in Foreign Direct Investment', *European Economic Review*, **51**, 1303–25.

Borensztein, E., J. de Gregorio and J.-W. Lee (1998), 'How Does Foreign Direct Investment Affect Economic Growth?', *Journal of International Economics*, **45**, 115–35.

Bougheas, S. and R. G. Riezman (2007), 'Trade and the Distribution of Human Capital', *Journal of International Economics*, **73**, 421–33.

Bougheas, S., R. Kneller and R. Riezman (2009), 'Optimal Education Policies and Comparative Advantage', GEP Research Paper No. 2009/02, University of Nottingham.

Duffy, J., C. Papageorgiou and F. Perez-Sebastian (2004), 'Capital–Skill Complementarity? Evidence from a Panel of Countries', *Review of Economics and Statistics*, **86**, 327–44.

Findlay, R. and H. Kierzkowski (1983), 'International Trade and Human Capital: A Simple General Equilibrium Model', *Journal of Political Economy*, **91**, 957–78.

Glaeser, E. L., R. La Porta, F. Lopez-de-Silanes and A. Shleifer (2004), 'Do Institutions Cause Growth?', *Journal of Economic Growth*, **9**, 271–303.

Goldin, C. and L. F. Katz (1998), 'The Origins of Technology–Skill Complementarity', *Quarterly Journal of Economics*, **113**, 693–732.

Gradstein, M. and M. Justman (1995), 'Competitive Investment in Higher Education: The Need for Policy Coordination', *Economics Letters*, **47**, 393–400.

Griliches, Z. (1969), 'Capital–Skill Complementarity', *Review of Economics and Statistics*, **51**, 465–68.

Janeba, E. (2003), 'Does Trade Increase Inequality when Skills Are Endogenous?', *Review of International Economics*, **11**, 885–98.

Kneller, R., M. F. Bleaney and N. Gemmell (1999), 'Fiscal Policy and Growth: Evidence from OECD Countries', *Journal of Public Economics*, **74**, 171–90.

Kreickemeier, U. (2009), 'Trade, Technology and Unemployment: The Role of Endogeneous Skill Formation', *Canadian Journal of Economics*, **42**, 639–64.

Krusell, P., L. E. Ohanian, J.-V. Ríos-Rull and G. L. Violante (2000), 'Capital–Skill Complementarity and Inequality: A Macroeconomic Analysis', *Econometrica*, **68**, 1029–53.

Lucas, R. E. (1990), 'Why Doesn't Capital Flow from Rich to Poor Countries?', *American Economic Review*, **80**, 92–96.

Markusen, J. R. (2002), *Multinational Firms and the Theory of International Trade* (Cambridge, MA: MIT Press).

OECD (2006), *Education at a Glance* (Paris: OECD).

OECD (2008), *Education at a Glance* (Paris: OECD).

Sargan, J. D. (1983), 'Identification and Lack of Identification', *Econometrica*, **51**, 1605–33.

Schularick, M. and T. M. Steger (2010), 'Financial Integration, Investment, and Economic Growth: Evidence from Two Eras of Financial Globalization', *Review of Economics and Statistics*, forthcoming.

Smulders, S. (2004), 'International Capital Market Integration: Implications for Convergence, Growth, and Welfare', *International Economics and Economic Policy*, **1**, 173–94.

UNCTAD (2002), *World Investment Report 2002* (New York: United Nations).

Viaene, J.-M. and I. Zilcha (2002a), 'Public Education under Capital Mobility', *Journal of Economic Dynamics and Control*, **26**, 2005–36.

Viaene, J.-M. and I. Zilcha (2002b), 'Capital Markets Integration, Growth and Income Distribution', *European Economic Review*, **46**, 301–27.