How does foreign direct investment affect economic growth?[1]

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Abstract

We test the effect of foreign direct investment (FDI) on economic growth in a cross-country regression framework, utilizing data on FDI flows from industrial countries to 69 developing countries over the last two decades. Our results suggest that FDI is an important vehicle for the transfer of technology, contributing relatively more to growth than domestic investment. However, the higher productivity of FDI holds only when the host country has a minimum threshold stock of human capital. Thus, FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host economy. © 1998 Elsevier Science B.V.

Keywords: Foreign direct investment; Economic growth; Cross-country regression framework; Developing countries

1. Introduction

Technology diffusion plays a central role in the process of economic development.[2] In contrast to the traditional growth framework, where technological change was left as an unexplained residual, the recent growth literature has highlighted the dependence of growth rates on the state of domestic technology relative to that of the rest of the world. Thus, growth rates in developing countries are, in part, explained by a 'catch-up' process in the level of technology. In a typical model of technology diffusion, the rate of economic growth of a backward country depends on the extent of adoption and implementation of new technologies that are already in use in leading countries.

Technology diffusion can take place through a variety of channels that involve the transmission of ideas and new technologies. Imports of high-technology products, adoption of foreign technology and acquisition of human capital through various means are certainly important conduits for the international diffusion of technology.[3] Besides these channels, foreign direct investment by multinational corporations (MNCs) is considered to be a major channel for the access to advanced technologies by developing countries. MNCs are among the most technologically advanced firms, accounting for a substantial part of the world's research and development (R and D) investment. Some recent work on economic growth has highlighted the role of foreign direct investment in the technological progress of developing countries. Findlay (1978) postulates that foreign direct investment increases the rate of technical progress in the host country through a 'contagion' effect from the more advanced technology, management practices, etc. used by the foreign firms. Wang (1990) incorporates this idea into a model more in line with the neoclassical growth framework, by assuming that the increase in 'knowledge' applied to production is determined as a function of foreign direct investment (FDI).

The purpose of this paper is to examine empirically the role of FDI in the process of technology diffusion and economic growth in developing countries. We motivate the empirical work by a model of endogenous growth, in which the rate of technological progress is the main determinant of the long-term growth rate of income. Technological progress takes place through a process of 'capital deepening' in the form of the introduction of new varieties of capital goods. MNCs possess more advanced 'knowledge', which allows them to introduce new capital

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[2] Previous research on technology diffusion includes Nelson and Phelps (1966), Jovanovic and Rob (1989), Grossman and Helpman (1991) (chapters 11 and 12), Segerstrom (1991) and Barro and Sala-i-Martin (1995) (chapter 8).

[3] See Easterly et al. (1994) for a framework incorporating the roles of technology adoption through international trade and human capital accumulation as determinants of economic growth.!

goods at lower cost.[4] However, the application of this more advanced technologies also requires the presence of a sufficient level of human capital in the host economy. The stock of human capital in the host country, therefore, limits the absorptive capability of a developing country, as in Nelson and Phelps (1966), and Benhabib and Spiegel (1994). Hence, the model highlights the roles of both the introduction of more advanced technology and the requirement of absorptive capability in the host country as determinants of economic growth, and suggests the empirical investigation of the complementarity between FDI and human capital in the process of productivity growth.

We test the effect of FDI on economic growth in a framework of cross-country regressions utilizing data on FDI flows from industrial countries to 69 developing countries over the last two decades.[5] Our results suggest that FDI is in fact an important vehicle for the transfer of technology, contributing to growth in larger measure than domestic investment. Moreover, we find that there is a strong complementary effect between FDI and human capital, that is, the contribution of FDI to economic growth is enhanced by its interaction with the level of human capital in the host country. However, our empirical results imply that FDI is more productive than domestic investment only when the host country has a minimum threshold stock of human capital. The results are robust to a number of alternative specifications, which control for the variables usually identified as the main determinants of economic growth in cross-country regressions. This sensitivity analysis along the lines of Levine and Renelt (1992) shows a robust relationship between economic growth, FDI and human capital.

We also investigate the effect of FDI on domestic investment, namely, whether there is evidence that the inflow of foreign capital 'crowds out' domestic investment. In principle, this effect could have either sign: by competing in product and financial markets MNCs may displace domestic firms; conversely, FDI may support the expansion of domestic firms by complementarity in production or by increasing productivity through the spillover of advanced technology.[6] Our results are supportive of a crowding-in effect, that is, a one-dollar

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[4] It is most likely that a foreign firm that decides to invest in another country enjoys lower costs than its domestic competitors deriving from higher productive efficiency. The higher efficiency may owe partly to the combination of foreign advanced management skills with domestic labor and inputs. Several micro-studies have attempted to assess empirically the impact of FDI on the domestic economy. (See, for example, United Nations (1992), Aitken and Harrison (1993), and references therein).

[5] De Gregorio (1992) shows, in a panel data of 12 Latin American countries, that FDI is about three times more efficient than domestic investment. Blomstrom et al. (1992) also find a strong effect of FDI on economic growth in LDCs.

[6] An additional factor could be that policies offering preferential tax treatment and other incentives to induce inward FDI may introduce a distortion affecting domestic investment. If such distortion between the return to foreign and domestic capital were significant, it could have a large negative effect on growth, as in Easterly (1993).

increase in the net inflow of FDI is associated with an increase in total investment in the host economy of more than one dollar, but do not appear to be very robust. Thus, it appears that the main channel through which FDI contributes to economic growth is by stimulating technological progress, rather than by increasing total capital accumulation in the host economy.

The paper is divided into four sections. Section 2 presents a simple model to motivate our empirical investigation; Section 3 provides an account of the data used in the empirical analysis; Section 4 describes the regression results, and Section 5 presents some concluding remarks.

2. An illustrative framework

We consider an economy where technical progress is the result of 'capital deepening' in the form of an increase in the number of varieties of capital goods available, as in Romer (1990), Grossman and Helpman (1991) and Barro and Sala-i-Martin (1995).[7] The economy produces a single consumption good according to the following technology:

$$Y_t = AH_t^\alpha K_t^{1\alpha} \tag{1}$$

where A represents the exogenous state of 'environment', H denotes human capital, and K stands for physical capital. The state of environment comprises various control and policy variables influencing the level of productivity in the economy. We assume that human capital H is a given endowment. Physical capital consists of an aggregate of different varieties of capital goods, and hence capital accumulation takes place through the expansion of the number of varieties.

Specifically, at each instant in time, the stock of domestic capital is given by:

$$K = \left\{ \int_0^N x(j)^{1-\alpha} \, \mathrm{d}j \right\}^{\frac{1}{(1-\alpha)}} \tag{2}$$

that is, total capital is a composite of a continuum of varieties of capital goods, each one being denoted by $x(j)$.[8] The total number of varieties of capital goods is N. There are two types of firms that produce capital goods: domestic and foreign firms that have undertaken a direct investment in the economy. The domestic firms produce n varieties out of the total number N, and the foreign firms produce $n\ast$ varieties:

$$N = n + n\ast \tag{3}$$

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[7] We follow closely the specification of Barro and Sala-i-Martin (1995) (chapter 6).
[8] This formulation is due to Ethier (1982).

We assume that specialized firms produce each variety of capital good, and rent it out to final goods producers at a rental rate $m(j)$. The demand for each variety of capital good, $x(j)$, follows from the optimality condition that equates the rental rate to the marginal productivity of the capital good in the production of the final good. This condition is:

$$m(j) = A(1 - \alpha)H^{\alpha}x(j)^{-\alpha} \tag{4}$$

An increase in the number of capital varieties requires the adaptation of technology available in more advanced countries to permit the introduction of a new type of capital goods. We assume that this process of technology adaptation is costly, requiring a fixed setup cost (F) before production of the new type of capital can take place. We assume that the fixed setup cost depends negatively on the ratio of the number of foreign firms operating in the host economy to the total number of firms (n^*/N). This assumption is intended to capture the notion that foreign firms bring to the developing economy an advance in 'knowledge' applicable to the production of new capital goods that may be already available in other countries. Thus, by making it easier to adopt the technology necessary to produce new capital varieties, foreign direct investment is the main channel of technological progress in this framework. In addition, we assume the existence of a 'catch-up' effect in technological progress to reflect the fact that it is cheaper to imitate products already in existence for some time than to create new products at the frontier of innovation.[9] This is implemented by assuming that the setup cost depends positively on the number of capital varieties produced domestically compared to those produced in the more advanced countries (which we denote by N^*). That is, in the countries with lower N/N^* imitation possibilities are larger and thus the costs of adopting new technology is lower. Thus, we postulate the following functional form for the setup cost:

$$F = F(n^*/N, N/N^*), \text{ where } \frac{\partial F}{\partial(n^*/N)} < 0 \text{ and } \frac{\partial F}{\partial(N/N^*)} > 0 \tag{5}$$

An alternative interpretation of Eq. (5) can be given in terms of 'quality ladders,' as in Grossman and Helpman (1991). The increase in the number of varieties could be interpreted as an improvement in the quality of existing goods. If the presence of foreign firms reduces the cost of improving the quality of existing capital goods, it will generate the same negative relationship between foreign direct investment and setup costs. Moreover, the catch-up assumption could be reinterpreted as meaning that the cost of improving an existing capital good is smaller the lowest is its quality. That is, upgrading an old typewriter is cheaper than upgrading a personal computer.

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[9]The importance of the 'technology gap' as a determinant of technological diffusion has been stressed in previous research, for example, Nelson and Phelps (1966).

In addition to the fixed setup cost, once a capital good is introduced, the owner must spend a constant maintenance cost per period of time. This is analogous to assume that there is a constant marginal cost of production of $x(j)$ equal to 1, and that capital goods depreciate fully. Assuming a steady state where the interest rate (r) is constant, profits for the producer of a new variety of capital j are:

$$\Pi(j)_t = -F(n_t^*/N_t, N_t/N_t^*) + \int_t^\infty [m(j)x(j) - x(j)]e^{-r(s-t)}ds \qquad (6)$$

Maximization of Eq. (6) subject to the demand Eq. (4) generates the following equilibrium level for the production of each capital good $x(j)$:

$$x(j) = HA^{1/\alpha}(1-\alpha)^{2/\alpha} \qquad (7)$$

Note that $x(j)$ is independent of time, that is, at every instant the level of production of each new good is the same. Moreover, the level of production of the different varieties is also the same due to the symmetry among producers. Substituting Eq. (7) into the demand function Eq. (4), we obtain the following expression for the rental rate:

$$m(j) = 1/(1-\alpha) \qquad (8)$$

which gives the rental rate as a markup over maintenance costs.

Finally, we assume that there is free entry, and hence, the rate of return r will be such that profits are equal to zero. Solving for the zero profits condition we obtain:

$$r = A^{1/\alpha}\phi F(n^*/N, N/N^*)^{-1}H \qquad (9)$$

where

$$\phi = \alpha(1-\alpha)^{(2-\alpha)/\alpha}$$

To close the model, we need to describe the process of capital accumulation, which is driven by saving behaviour.[10] We assume that individuals maximize the following standard intertemporal utility function:

$$U_t = \int_t^\infty \frac{C_s^{1-\sigma}}{1-\sigma} e^{-\rho(s-t)} ds \qquad (10)$$

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[10] Although, for simplicity, we do not introduce international trade in this model, this is not a closed economy because of the presence of foreign firms. However, with the proportion of foreign firms remaining constant in a steady-state situation, equilibrium conditions are analogous to those prevailing in a closed economy.

where C denotes units of consumption of the final good Y. Given a rate of return equal to r, the optimal consumption path is given by the standard condition:

$$\frac{\dot{C}_t}{C_t} = \frac{1}{\sigma}(r - \rho) \tag{11}$$

It is easy to verify that the rate of growth of consumption must, in a steady state equilibrium, be equal to the rate of growth of output, which we denote by g.

Finally, substituting Eq. (9) into Eq. (11), we obtain the following expression for the rate of growth of the economy:

$$g = \frac{1}{\sigma}[A^{1/\alpha}\phi F(n^*/N, N/N^*)^{-1}H - \rho] \tag{12}$$

Eq. (12) shows that foreign direct investment, which is measured by the fraction of products produced by foreign firms in the total number of products (n^*/N), reduces the costs of introducing new varieties of capital goods, thus increasing the rate at which new capital goods are introduced. The cost of introducing new capital goods is also smaller for more backward countries; that is, countries that produce fewer varieties of capital goods than the leading countries-countries with lower N/N^*-enjoy lower costs of adoption of technology, and will tend to grow faster. Furthermore, the effect of FDI on the growth rate of the economy is positively associated with the level of human capital, that is, the higher the level of human capital in the host country, the higher the effect of FDI on the growth rate of the economy.

To assess empirically the effect of FDI on economic growth, we utilize the following basic formulation:

$$g = c_0 + c_1 FDI + c_2 FDI \times H + c_3 H + c_4 Y_0 + c_5 A \tag{13}$$

where FDI is foreign direct investment, H the stock of human capital, Y_0 initial GDP per capita, and A is a set of other variables that affect economic growth. The variable FDI is measured as a ratio to GDP, and is conceptually analogous to the fraction of goods produced by foreign firms in the model, (n^*/N).[11] The initial GDP variable (Y_0) captures the role of the 'catch-up' effect (N/N^*).[12] The group

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[11] We assume that the average ratio of foreign direct investment to GDP over a decade FDI, which is a flow variable, is a good proxy for (n^*/N). Since FDI measures are available only from 1970, we can not construct a stock measure of FDI. Also, it is not possible to differentiate between FDI in the capital goods sector and in other sectors of the economy.

[12] The theoretical model described above implies that the 'catch-up' effect can be represented by an interactive term between initial income and human capital (Y_0^*H) in addition to the initial income (Y_0). We find that when both terms are included in the regressions the interactive term (Y_0^*H) is not significant, without much effect on the overall results. However, Benhabib and Spiegel (1994) find an interactive term in initial income and human capital to be significant for growth in a different framework.

of variables A comprises the control and policy variables that are frequently included as determinants of growth in cross-country studies. (See Barro and Sala-i-Martin (1995) (chapter 12)). These variables include government consumption, the black market premium on foreign exchange, a measure of political instability (political assassinations and wars), a measure of political rights, a proxy for financial development, the inflation rate, and a measure of quality of institutions.

3. Data

There are several sources for data on foreign direct investment. Two IMF publications provide data on net and gross foreign direct investment (International Financial Statistics, and Balance of Payments Statistics, respectively). Net FDI refers to inflows net of outflows, and gross FDI refers only to inflows, that is, foreign direct investment into the country. An OECD publication (Geographical Distribution of Financial Flows to Developing Countries) tallies gross FDI originated in OECD member countries into developing economies. The choice between these alternatives depends on which data set would correspond more closely to the FDI effect we are trying to uncover.

In the first place, it seems more appropriate to use gross data because we are interested in the effects of foreign direct investment in the host country via transfer of knowledge and other spillover effects; in addition, we would not expect the outflow of foreign direct investment to involve a similar negative growth effects for the source country (loss of knowledge). In the second place, in our framework, foreign direct investment flows from industrialized to developing countries to close the technological gap. Foreign direct investment taking place between countries with roughly the same level of technological development may respond to a large extent to other factors, including global firm strategy and market penetration, or to allow firms to circumvent trade restrictions and offset other advantages accorded to domestic producers. This type of foreign direct investment flows may not be expected to display higher than average productivity. For this reason we focus only on foreign direct investment received by developing countries. And furthermore, since flows of foreign direct investment between developing countries may also respond to factors other than the technological gap, we also exclude those flows. Therefore, the OECD measure of foreign direct investment, while having a partial coverage, appears to be the most appropriate for our purposes.[13] These data are available on a yearly basis from 1970.

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[13]Since balance of payments data from Balance of Payments Statistics do not provide information about the country of origin, it cannot be adjusted to include flows from industrial countries only. There are, in fact, significant differences between overall gross foreign direct investment in developing countries and foreign direct investment originated in OECD countries (OECD data). The correlation between these two measures, although positive, is weak (the correlation coefficient is 0.22).

National accounts data, such as the growth rate of income, initial income and government consumption, are all taken from Summers and Heston (release 5.5 of June 1993) which provides data up to 1989. This allows us to consider a 20-year period for the empirical investigation. The growth rate measure is the average annual rate of per capita real GDP over each decade, 1970–79 and 1980–89. Government consumption is measured by the average share of real government consumption in real GDP.

For the human capital stock variable we use the initial-year level of average years of the male secondary schooling constructed by Barro and Lee (1993). According to Barro and Lee (1994), this measure of educational attainment is the one most significantly correlated with growth. Data for the other explanatory variables, such as the domestic investment rate, the foreign exchange parallel market premium and the measures of political instability and financial development are also taken from Barro and Lee (1994).

4. Results

The purpose of our empirical investigation is to estimate the effects of FDI on economic growth, and to investigate the channel through which FDI may be beneficial for growth. In particular, as discussed in Section 2, we examine whether FDI interacts with the stock of human capital to affect growth rates. We also test whether the level of FDI has an effect on the overall level of investment in the country and on the efficiency of investment.

The main regression results indicate that FDI has a positive overall effect on economic growth, although the magnitude of this effect depends on the stock of human capital available in the host economy. However, the nature of the interaction of FDI with human capital is such that for countries with very low levels of human capital the direct effect of FDI is negative. The cross-country regressions also show that FDI exerts a positive, though not strong, effect on domestic investment, presumably because the attraction of complementary activities dominates the displacement of domestic competitors. This is an indirect effect of FDI on growth, since it operates through 'pulling in' other sources of investment. All regressions are based on panel data for the two decades 1970–79 and 1980–89, and were estimated using the seemingly unrelated regressions technique (SUR). We do not report cross-section regressions, which basically yield the same qualitative results as those of the panel estimation. The final sample consists of 69 developing countries, for which data on all the variables are available.

Table 1 reveals several interesting results for the effects of FDI on economic growth. Regression 1.1 shows that FDI has a positive impact on economic growth, after controlling for initial income, human capital, government consumption and the parallel market premium for foreign exchange. However, the coefficient of FDI in this specification is not statistically significant.

Table 1
FDI and per capita GDP growth: panel of two decades (1970–89)

Independent variable	Regression number						
	1.1	1.2	1.3	1.4	1.5	1.6	1.7
	Coefficient (standard error)						
Log (initial GDP)	−0.0124	−0.0126	−0.0122	−0.0100	−0.0125	0.0061	−0.0111
	(0.0040)	(0.0043)	(0.0039)	(0.0041)	(0.0041)	(0.0044)	(0.0050)
Schooling	0.0162	0.0142	0.0128	0.0078	0.0058	0.0033	0.0005
	(0.0044)	(0.0043)	(0.0045)	(0.0044)	(0.0043)	(0.0042)	(0.0005)
Government consumption	−0.0969	−0.0870	−0.0811	−0.0818	−0.0817	−0.0668	−0.0435
	(0.0339)	(0.0330)	(0.0333)	(0.0326)	(0.0323)	(0.0323)	(0.0316)
Log (1 + black market premium)	−0.0183	−0.0180	−0.0185	−0.0188	−0.0125	−0.0104	−0.0113
	(0.0055)	(0.0054)	(0.0054)	(0.0060)	(0.0052)	(0.0054)	(0.0054)
FDI	0.6590		−0.8489	−1.0190	−1.3665	−1.4628	−1.8535
	(0.4689)		(0.7203)	(0.6883)	(0.6746)	(0.6612)	(0.6759)
FDI*schooling		1.0659	1.6231	1.3891	1.6639	1.6531	1.6365
		(0.3850)	(0.6086)	(0.5715)	(0.5743)	(0.5930)	(0.6365)
Sub-Saharan African dummy				−0.0188	−0.0200	−0.0197	−0.0253
				(0.0060)	(0.0060)	(0.0064)	(0.0068)
Latin American dummy				−0.0202	−0.0221	−0.0219	−0.0155
				(0.0057)	(0.0058)	(0.0067)	(0.0070)
Assassinations					−0.0024	−0.0092	−0.0050
					(0.0124)	(0.0128)	(0.0129)
Wars					−0.0077	−0.0024	−0.0002
					(0.0050)	(0.0057)	(0.0057)
Political rights (1 best, 7 worst)					−0.0032	−0.0023	−0.0001
					(0.0014)	(0.0014)	(0.0014)
Financial depth						0.0011	0.0031
						(0.0117)	(0.0117)
Inflation rate						−0.0119	−0.0087
						(0.0090)	(0.0092)
Institutions (1 worst, 10 best)							0.0056
							(0.0019)
R^2-adjusted, individual	0.28(69)	0.32(69)	0.33(69)	0.34(69)	0.37(69)	0.32(64)	0.39(58)
periods (No. of obs.)	0.08(69)	0.10(69)	0.08(69)	0.23(69)	0.19(69)	0.21(67)	0.15(60)
Education threshold			0.52	0.73	0.82	0.89	1.13
(No. countries > threshold)			(46)	(38)	(32)	(29)	(22)

Notes: The system has 2 equations, where the dependent variables are the per capita GDP growth rates over each decade. Each equation has a different constant term (not reported)[b]. Other coefficients are constrained to be the same for all periods. Estimation is by the SUR technique. The estimation allows for different error variances in each equation and for correlation of these errors across equations. Education threshold indicates that countries with secondary schooling above this threshold will benefit positively from FDI. The number of countries that satisfy it in 1980 for each regression is in the parenthesis.

Including the interaction between FDI and human capital improves the overall performance of the regression. The specification in regression 1.2 replaces the FDI variable by the product between FDI and human capital, and yields a coefficient that is positive and highly statistically significant. While this specification follows

fairly closely the framework developed in Section 2, the significance of the interaction term may be the result of the omission of other relevant factors, in particular, the FDI variable by itself. Thus, it is necessary to include FDI and secondary school attainment (our measure of human capital) individually alongside their product. In that way, we can test jointly whether these variables affect growth by themselves or through the interaction term. Such specification is adopted in regression 1.3, which shows that the coefficient on FDI is negative, although insignificant, while the interaction term is positive. The values of these regression coefficients indicate that all countries with secondary school attainment above 0.52 will benefit positively from FDI.[14] In our sample, 46 out of the 69 countries satisfy this threshold in 1980. Hence, for example, in an economy with a human capital stock of 0.91 years-which is the average value of the sample countries in 1980-an increase of 0.005 in the FDI-to-GDP ratio (equivalent to one standard deviation) raises the growth rate of the host economy by 0.3 percentage points per year.

We have also explored the interaction of FDI with indicators of distortions in the trade regime, as measured by tariffs, and in the capital account of the balance of payments, which was proxied by the parallel market premium for foreign exchange.[15] In both cases, however, the interaction term was not statistically significant. Thus, this type of distortion does not appear to have affected the nature of FDI flows in a significant way, at least as far as can be detected in this sample. We also incorporated in the regression an interaction term between human capital and initial income as suggested by the model, where the speed of convergence is increasing in the level of human capital, but the coefficient was not significant.

Regressions 1.4 to 1.7 include additional variables proxying for the other factors affecting economic growth. Regression 1.4 includes continental dummies for the African and Latin American countries. Regression 1.5 includes variables that measure political instability, such as per capita political assassinations per year, a dummy for wars on the national territory, and a measure of political rights. The measure of political rights is a subjective index for freedom of speech and the press, freedom to run for office and vote in each country, obtained from Gastil (1987) and other issues. In regression 1.6 we also controlled for the level of financial development and the inflation rate. Financial development is proxied by the ratio of the liquid liabilities of the financial system to GDP, which for most countries equals $M2/GDP$. King and Levine (1993) show that this measure is closely associated with long-run growth. Finally, regression 1.7 includes a measure

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[14]Meaning a male population above 25 years with an average of 0.52 years of secondary schooling. An example of an economy with secondary school attainment of 0.52 is the following: only 10 percent of the population above 25 years of age has ever attended secondary school; out of this group, only 75 percent completed secondary school (6 years), with the remaining going only through the first cycle (3 years). Then, secondary school attainment is $0.10 \times [3 \times 0.25 + 6 \times 0.75] + 0.9 \times 0 = 0.53$.

[15]We have also included the average level of tariffs as one of the regressors, but it was not significantly different from zero.

of quality of institutions from Knack and Keefer (1995). This measure is an average of Knack and Keefer's measures of quality of political institutions from the International Country Risk Guide of (a) government repudiation of contracts, (b) risk of expropriation, (c) rule of law, and (d) bureaucratic quality. Our main findings are robust to the inclusion of these other determinants of growth. In all cases, the interaction term between FDI and human capital is statistically significant, implying that the estimated effect does not result from the omission of other policy variables. However, the threshold for the value of the measure of human capital from which FDI starts having positive effects tends to increase as more additional variables are added to the basic regressions, and reaches a maximum value of 1.13 years, as reported in the last line of Table 1. In addition, as expected, the parallel market premium and the African and Latin American dummies enter with statistically significant negative coefficients, while the institutional quality is positively correlated with growth. In contrast, the measures of political instability, financial development, and the inflation rate turn out to be insignificant, which diverges from previous findings.[16]

Overall, the results from the regressions displayed in Table 1 show strong complementary effects between FDI and human capital on the growth rate of income. This result is consistent with the idea that the flow of advanced technology brought along by FDI can increase the growth rate of the host economy only by interacting with that country's absorptive capability. It is, however, puzzling that most specifications yield a negative coefficient for the FDI variable, with the implication that FDI makes a negative contribution to growth in countries with a low level of human capital. One could go as far as accepting that FDI makes no additional contribution to economic growth but it is hard to conceive situations in which, if the country has a very low stock of human capital, FDI would actually detract from economic growth. Most likely, the estimates result from the linearization of what is probably a nonlinear interaction between FDI and human capital. That is, it is likely that at very low levels of human capital the contribution of FDI to growth is close to nil and that it rises rapidly at higher levels of human capital. However, a linear least squares estimation of this function yields a negative intercept (at zero level of human capital). Nevertheless, the estimated effect of FDI on growth may be approximately correct for countries with nearly average values of human capital.[17]

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[16]One reason why the measures of political instability, financial development and inflation rates are insignificant in the regressions may be that the sample used in our regressions includes only developing countries.

[17]The estimation of a general nonlinear functional form is not a promising prospect, however. This would require to add higher order terms not only for the variables (such as FDI squared and schooling squared) but also for the interaction terms (such as FDI times schooling squared, etc.). This would not only reduce the degrees of freedom in the estimation but also probably cause significant multicollinearity problems.

The complementarity of FDI and schooling is illustrated in Fig. 1. The sample of 69 developing countries was divided into nine (3×3) groups according to the level of FDI and of human capital (measured by educational attainment). Countries in the group with the highest levels of FDI and human capital grew, on average, by 4.3 percent a year during the sample period 1970–89. In contrast, countries at the other end of the spectrum, those with the lowest levels of FDI and human capital grew only by 0.64 percent per year on average. The figure also shows that, for a given level of human capital, an increase in FDI raises the growth rates of per capita income, except for the economies with the lowest level of schooling.

It is noteworthy that other studies-with somewhat different focus-have also found an interaction effect between foreign financing and the level of human capital in the domestic economy. Cohen (1993) finds a positive interaction between human capital and the overall access to foreign financing of developing countries. Our model may, in fact, provide a rationale for his finding, at least as far as the FDI component of foreign financing is concerned. Romer (1993) finds a positive effect on economic growth from the interaction between secondary school enrolment and imports of machinery. He also finds a minimum threshold level for the interaction term to have a positive impact on growth. While imports of machinery and equipment may be one channel for the international transmission of
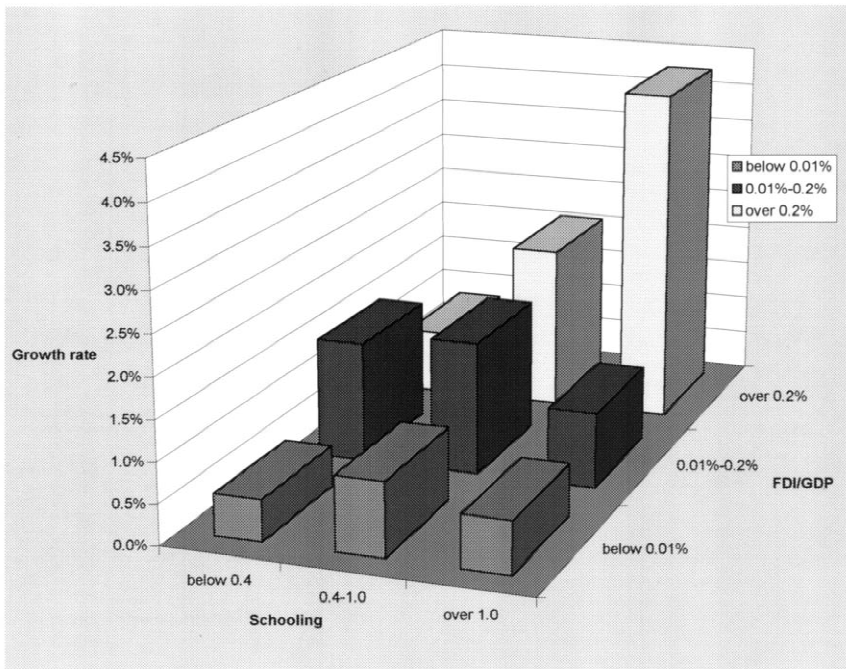

Fig. 1. Foreign Direct Investment, Schooling and Growth

technological advances, FDI has probably an even larger role, as it also allows the transmission of knowledge on business practices, management techniques, etc.

4.1. Does FDI crowd out domestic investment?

To further investigate the contribution of FDI to economic growth, we analyze its relationship with total investment. FDI could add economic growth simply by augmenting capital accumulation in the host country. This would require that FDI does not 'crowd out' equal amounts of investment from domestic sources by competing in product markets or financial markets (for example, under conditions of financial repression). In addition, FDI could increase economic growth if it is more productive, or efficient, than domestic investment.

To investigate these issues, we first analyze the effects of FDI on total fixed investment. Table 2 presents an estimation of the determinants of total fixed investment. Regressions 2.1 to 2.4 show that FDI increases total investment more than one for one. Since data on total investment include FDI, a coefficient equal to one would imply that FDI does not affect the total level of investment. The coefficients on FDI range from 1.5 to 2.3 according to the particular specification, and imply that FDI actually stimulates, or 'crowds in' domestic investment.[18] The interaction between FDI and human capital, however, turns out to be statistically insignificant for the determination of total investment (regression 2.2), suggesting that the complementarity between foreign and domestic investment is not sensitive to the productivity of FDI.

The complementarity between domestic and foreign investment, however, is not very robust to different specifications. Except for the baseline specification, the estimated coefficients are statistically insignificant. While multicollinearity and the overall poorer fit of the fixed investment regressions may account for the lack of robustness of the crowding-in effect, this result suggests that most of the effect of FDI on growth probably derives from efficiency gains rather than an overall higher induced level of investment.

4.2. Is FDI more efficient than domestic investment?

To explore the possibility of higher efficiency of FDI, we test whether FDI has effects over and above those of aggregate investment in the growth equations. Table 3 presents the growth rate regressions that control for total fixed investment in addition to the other determinants of growth. The results do not differ qualitatively from those obtained without the inclusion of total fixed investment. The contribution of FDI to growth is evident only when the interaction between human capital and FDI is included. However, the requirements on human capital

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[18]This would be the case, for example, if FDI stimulated investment in activities that are complementary to the projects undertaken by the foreign firms.

Table 2
FDI and aggregate investment rates: panel of two decades (1970–89)

Independent variable	Regression number					
	2.1	2.2	2.3	2.4	2.5	2.6
	Coefficient (standard error)					
Log(initial GDP)	0.0346	0.0344	0.0356	0.0361	0.0324	0.0291
	(0.0102)	(0.0101)	(0.0105)	(0.0108)	(0.0115)	(0.0128)
Schooling	0.0197	0.0210	0.0045	0.0042	0.0007	0.0043
	(0.0109)	(0.0113)	(0.0105)	(0.0106)	(0.0106)	(0.0114)
Government consumption	−0.1217	−0.1283	−0.1367	−0.1276	−0.1256	−0.1224
	(0.0876)	(0.0887)	(0.0843)	(0.0869)	(0.0902)	(0.0905)
Log(1 + black market premium)	−0.0078	−0.0080	−0.0071	−0.0072	−0.0129	−0.0083
	(0.0118)	(0.0117)	(0.0105)	(0.0010)	(0.0116)	(0.01155)
FDI	2.2944	2.8230	1.5257	1.5477	1.2641	0.7833
	(0.9919)	(1.6257)	(0.9367)	(0.9456)	(0.9367)	(0.9442)
FDI*schooling		−0.5165				
		(1.2926)				
Sub-Saharan African dummy			−0.0647	−0.0653	−0.0454	−0.0449
			(0.0172)	(0.0177)	(0.0181)	(0.0197)
Latin American dummy			−0.0647	−0.0626	−0.0426	−0.0332
			(0.0158)	(0.0166)	(0.0185)	(0.0186)
Assassinations				−0.0103	−0.0228	−0.0186
				(0.0229)	(0.0226)	(0.0222)
Wars				0.0027	0.0160	0.0166
				(0.0102)	(0.0103)	(0.0102)
Political rights (1 best, 7 worst)				0.0006	−0.0016	−0.0006
				(0.0033)	(0.0033)	(0.0034)
Financial depth					0.0252	0.0148
					(0.0249)	(0.0248)
Inflation rate					−0.0364	−0.0389
					(0.00151)	(0.0151)
Institutions (1 worst, 10 best)						0.0111
						(0.0055)
R^2-adj, individual	0.23(69)	0.22(69)	0.26(69)	0.21(69)	0.17(64)	0.17(58)
periods (No. of obs.)	0.44(69)	0.43(69)	0.55(69)	0.53(69)	0.51(67)	0.55(60)

Notes: The system has 2 equations, where the dependent variables are the average ratios of investment to GDP over each decade. See note to Table 1.

are higher compared to those reported in Table 1. In the basic regression 3.3, the values of the coefficients (−1.461 for FDI and 1.647 for the interaction term) imply that the threshold level of education for which the effects of FDI turn positive is 0.88, which is satisfied by 29 countries in the sample. Note, however, that countries with school attainment below 0.88 would still benefit from FDI if the crowding-in effect on domestic investment were significant. For example, taking a value of 1.5 for the crowding-in coefficient-close to the average of the point estimates in Table 3-and using the parameter values estimated in regression

Table 3
Per capita GDP growth: productivity of FDI and domestic investment

Independent variable	Regression number							
	3.1 Coefficient (standard error)	3.2	3.3	3.4	3.5	3.6	3.7	3.8
Investment rate	0.1403	0.1279	0.1415	0.1422	0.1120	0.1028	0.0923	0.0880
	(0.0320)	(0.0309)	(0.0307)	(0.0425)	(0.0317)	(0.0311)	(0.0304)	(0.0323)
Log (initial GDP)	−0.0167	−0.0169	−0.0165	−0.0165	−0.0137	−0.0157	−0.0090	−0.0120
	(0.0038)	(0.0037)	(0.0036)	(0.0037)	(0.0040)	(0.0040)	(0.0043)	(0.0048)
Schooling	0.0133	0.0124	0.0098	0.0100	0.0069	0.0052	−0.0031	−0.0013
	(0.0041)	(0.0040)	(0.0041)	(0.0087)	(0.0040)	(0.0040)	(0.0039)	(0.0048)
Government consumption	−0.0840	−0.0781	−0.0663	−0.0664	−0.0711	−0.0719	−0.0612	−0.0375
	(0.0306)	(0.0301)	(0.0299)	(0.0300)	(0.0303)	(0.0305)	(0.0304)	(0.0299)
Log(1+black market premium)	−0.0169	−0.0160	−0.0165	−0.0166	−0.0155	−0.0120	−0.0098	−0.0100
	(0.0051)	(0.0050)	(0.0049)	(0.0050)	(0.0047)	(0.0050)	(0.0052)	(0.0051)
FDI	0.0605		−1.4607	−1.4639	−1.4928	−1.7599	−1.7933	−2.2058
	(0.4535)		(0.6728)	(0.6796)	(0.6581)	(0.6496)	(0.6398)	(0.6645)
FDI*schooling		0.7324	1.6473	1.6520	1.4953	1.7197	1.7101	1.8858
		(0.3658)	(0.5555)	(0.5818)	(0.5415)	(0.5476)	(0.5665)	(0.6132)
Investment rate* schooling				−0.0010				
				(0.0411)				
Sub-Saharan African dummy					−0.0124	−0.0166	−0.0154	−0.0218
					(0.0058)	(0.0057)	(0.0062)	(0.0065)
Latin American dummy					−0.0142	−0.0199	−0.0186	−0.0154
					(0.0055)	(0.0062)	(0.0064)	(0.0066)
Assassinations						−0.0022	−0.0071	−0.0039
						(0.0120)	(0.0124)	(0.0124)
Wars						−0.0067	−0.0025	0.0002
						(0.0049)	(0.0055)	(0.0056)
Political rights (1 best, 7 worst)						−0.0028	−0.0020	−0.0002
						(0.0013)	(0.0013)	(0.0014)
Financial depth							−0.0041	−0.0020
							(0.0112)	(0.0113)
Inflation rate							−0.0098	−0.0067
							(0.0087)	(0.0089)
Institutions (1 worst, 10 best)								0.0042
								(0.0019)
R^2-adj, individual	0.41(69)	0.41(69)	0.44(69)	0.43(69)	0.43(69)	0.44(69)	0.38(64)	0.40(58)
periods (no. of obs.)	0.13(69)	0.17(69)	0.16(69)	0.15(69)	0.23(69)	0.20(69)	0.22(67)	0.19(60)
Education threshold			0.76	0.76	0.88	0.93	0.97	1.10
(No. countries>threshold)			(36)	(36)	(29)	(29)	(29)	(23)

Note: See Table 1.

3.3, the threshold value of human capital becomes 0.76 years of post-primary education, which is satisfied by 36 countries in the sample.

In order to investigate whether the interaction effect is unique to foreign investment, or it applies to investment from all sources, we have also added an

interaction term between aggregate investment and secondary school attainment. In regression 3.4, the interaction term between aggregate investment and human capital is not statistically significant, while the rest of the coefficients are very similar to those obtained in specifications in which this term is not included. The same result obtains when the interaction term between domestic investment and secondary schooling is included in the other specifications reported in Tables 3 and 4. Therefore, we can conclude that the interaction between human capital and investment is a particular characteristic of FDI.

The above result may be indicative of differences in the technology involved in foreign direct investment. FDI may primarily flow to sectors where a process of technological innovation similar to that described in the model of Section 2 is present, and thus the interaction with human capital is an important factor in explaining the effects of FDI in economic growth. By contrast, domestic investment may largely fall on more traditional activities, and thus the interaction effect between aggregate fixed investment and human capital may not be sufficiently large to be detected in the regressions.

Regressions 3.5 to 3.8 include the additional determinants of economic growth, such as continental dummies, political variables, financial development, the inflation rate and the quality of institutions. The interaction term between FDI and human capital is always statistically significant, irrespective of the specifications. The inclusion of more additional variables into the basic regressions raises the threshold stock for secondary schooling, reaching a maximum value of 1.10 years (including the crowding-in effect) in regression 3.8, which is satisfied by 23 countries in the sample.[19]

4.3. Endogeneity problems?

It should be noticed that the cross-country regressions presented here may be subject to endogeneity problems. The correlation between FDI and growth rate could arise from an endogenous determination of FDI, that is, FDI itself may be influenced by innovations in the stochastic process governing growth rates. For instance, any omitted factors that raise the rate of return on capital will also increase both the growth rate and the inflow of foreign direct investment simultaneously.[20] In these circumstances there would exist a correlation between FDI and the country-specific error term, which would bias the estimated coefficients.

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[19]We also tested the robustness of the results to the effect of possibly influential observations in the form of those countries that have received the highest levels of FDI. The results (available from the authors) of regressions excluding the seven countries which received the highest levels of FDI over the sample period are very similar to those obtained for the whole sample, with threshold levels of human capital increasing only marginally.

[20]See Edwards (1990) for a discussion on the determination of foreign direct investment in LDCs.

Table 4
FDI and per capita growth: instrumental variables estimation

	Regression number								
	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9
	Estimation method								
Independent variable	3SLS Coefficient (standard error)	3SLS	3SLS	3SLS	3SLS	3SLS	3SLS	2SLS	2SLS
Investment rate		0.1177	0.1237		0.1094		0.0934	0.0791	0.1493
		(0.0324)	(0.0421)		(0.0315)		(0.0329)	(0.0576)	(0.0697)
Log(initial GDP)	−0.0092	−0.0133	−0.0138	−0.0115	−0.0150	−0.0106	−0.0116	−0.0084	−0.0032
	(0.0042)	(0.0040)	(0.0040)	(0.0042)	(0.0040)	(0.0050)	(0.0048)	(0.0058)	(0.0072)
Schooling	0.0071	0.0064	0.0099	0.0055	0.0051	−0.0007	−0.0025	−0.0023	−0.0104
	(0.0045)	(0.0041)	(0.0085)	(0.0044)	(0.0040)	(0.0052)	(0.0050)	(0.0074)	(0.0083)
Government consumption	−0.0814	−0.0705	−0.0707	−0.0848	−0.0743	−0.0416	−0.0346	−0.0224	0.0450
	(0.0329)	(0.0305)	(0.0302)	(0.0326)	(0.0306)	(0.0319)	(0.0305)	(0.0483)	(0.0551)
Log(1+black market premium)	−0.0166	−0.0156	−0.0159	−0.0127	−0.0122	−0.0111	−0.0094	−0.0046	0.0011
	(0.0050)	(0.0047)	(0.0047)	(0.0052)	(0.0050)	(0.0054)	(0.0051)	(0.0056)	(0.0063)
FDI	−1.4575	−1.8272	−1.5369	−1.7086	−2.0461	−2.4322	−2.6497	−1.8619	−4.1850
	(0.8253)	(0.7875)	(0.6625)	(0.8001)	(0.7649)	(0.7902)	(0.7680)	(1.7948)	(1.8170)
FDI*schooling	1.4791	1.5307	1.5589	1.5522	1.6031	1.7039	2.0154	1.8156	3.5432
	(0.6314)	(0.5972)	(0.5598)	(0.6344)	(0.6043)	(0.7092)	(0.6880)	(1.1105)	(1.2132)
Sub-Saharan African dummy	−0.0191	−0.0122	−0.0124	−0.0206	−0.0142	−0.0256	−0.0217	−0.0074	−0.0140
	(0.0060)	(0.0058)	(0.0058)	(0.0060)	(0.0058)	(0.0069)	(0.0066)	(0.0083)	(0.0102)
Latin American dummy	−0.0214	−0.0150	−0.0146	−0.0240	−0.0177	−0.0164	−0.0164	−0.0305	−0.0298
	(0.0058)	(0.0055)	(0.0056)	(0.0060)	(0.0058)	(0.0070)	(0.0067)	(0.0081)	(0.0096)
Investment*schooling			−0.0166						
			(0.0403)						
Assassinations				−0.0019	−0.0017	−0.0048	−0.0039	0.0054	0.0130
				(0.0125)	(0.0121)	(0.0130)	(0.0123)	(0.0127)	(0.0145)
Wars				−0.0088	−0.0027	−0.0004	−0.0006	0.0108	0.0166
				(0.0051)	(0.0013)	(0.0058)	(0.0056)	(0.0063)	(0.0074)
Political rights (1 best, 7 worst)				−0.0031	−0.0027	−0.0001	−0.0002	−0.0047	−0.0027
				(0.0014)	(0.0013)	(0.0014)	(0.0014)	(0.0018)	(0.0020)
Financial depth						0.0054	−0.0015		−0.0188
						(0.0120)	(0.0117)		(0.0170)
Inflation rate						−0.0079	−0.0062		−0.0110
						(0.0093)	(0.0088)		(0.0098)
Institutions (1 worst, 10 best)						0.0063	0.0045		0.0022
						(0.0020)	(0.0019)		(0.0031)
R^2-adj, individual	0.34(69)	0.43(69)	0.43(69)	0.38(69)	0.45(69)	0.39(58)	0.38(58)	0.38(69)	0.36(60)
periods (no. of obs.)	0.22(69)	0.23(69)	0.21(69)	0.18(69)	0.18(69)	0.14(60)	0.20(60)		
Education threshold	0.99	1.08	0.87	1.10	1.17	1.43	1.24	0.96	1.12
(No. countries>threshold)	(28)	(26)	(29)	(23)	(20)	(13)	(15)	(29)	(23)

Note: three-stage least squares (3SLS) estimation was done on a system of two equations for the periods 1970–79 and 1980–89, using as instruments: the lagged value of FDI, the log value of total GDP, the log value of area, and continental dummies for East Asia and South Asia. The two-stage least squares (2SLS) estimation was done on the cross-section of countries for the period 1980–89 using the same instruments.

Although, in principle, the endogeneity problem can be avoided by applying instrumental variable techniques, the fundamental problem is that there are no ideal instruments available. A good instrument would be a variable which is highly correlated with FDI but not with the error term in these regressions. Nevertheless, we have tried to control for the endogeneity problem by using as instruments the lagged values of FDI, a log value of total GDP, a log value of area, continental dummies for East Asia and South Asia, and the measures of political stability and quality of institutions, and the other explanatory variables in the regressions.

The results of this instrumental variable estimation are reported in Table 4.[21] Regressions 4.1 to 4.7 show that the instrumental variable estimation yields qualitatively similar results to those obtained by SUR estimation. The estimated coefficients on FDI are still significantly negative, and the interactive term with human capital is significantly positive. The requirements on human capital, however, are more stringent as they typically imply a minimum of just over one year of post-primary education. We also carried out the instrumental variable estimation on a cross-sectional sample for the second decade, 1980–89, which is reported in regressions 4.8 and 4.9. In this case, we used the value of FDI over the first decade, 1970–79 and other instruments for the two-stage least squares estimation. The coefficients on the FDI and the FDI interactive terms show a similar qualitative pattern.

5. Conclusions

There is a good a priori case to presume that FDI is more productive than domestic investment. As Graham and Krugman (1991) argue, domestic firms have better knowledge and access to domestic markets; if a foreign firm decides to enter the market, it must compensate for the advantages enjoyed by domestic firms. It is most likely that a foreign firm that decides to invest in another country enjoys lower costs and higher productive efficiency than its domestic competitors. In the case of developing countries in particular, it is likely that the higher efficiency of FDI would result from a combination of advanced management skills and more modern technology; FDI may be the main channel through which advanced technology is transferred to developing countries.

Different types of economic distortions, however, may jeopardize the role of FDI as a means for advanced technology transfer. For example, because of protectionist trade policies, FDI may be the only way to gain access to domestic

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[21]Because the data on FDI are available only from 1970, we have used the initial value of FDI over the period 1970–72 as an instrument for the first decade. For the second decade, the lagged value of FDI over the period 1975–80 was used as an instrument. The rationale for the inclusion of total GDP and country area as instruments is that they represent the effect of market size and of the abundance of natural resources, respectively, which have been often mentioned as important determinants of FDI in previous literature.

markets by firms that would otherwise have been exporters to the host country. Similarly, governments may offer a set of incentives to foreign investors to stimulate the inflow of FDI, with the objective of increasing foreign exchange reserves or of developing certain sectors considered strategic from an industrial policy viewpoint. These policies may result in a flow of FDI that does not respond to higher efficiency but only to profit opportunities created by distorted incentives. These considerations make the empirical evaluation of the performance of FDI an appealing question. We investigated these issues in a sample that comprises FDI flows from industrial country into developing countries

The most robust finding of this paper is that the effect of FDI on economic growth is dependent on the level of human capital available in the host economy. There is a strong positive interaction between FDI and the level of educational attainment (our proxy for human capital). Notably, the same interaction is not significant in the case of domestic investment, possibly a reflection of differences of technological nature between FDI and domestic investment. We also found some evidence of a crowding-in effect, namely that FDI is complementary to domestic investment. This effect, however, seems to be less robust than our other findings.

Some caution must be exercised, however, in the interpretation of the size of the effect on economic growth of FDI. Our data measures the international flow of resources for foreign direct investment, as recorded in balance of payments statistics. This is, however, only part of the resources invested by a multinational firm, because some part of the investment may be financed through debt or equity issues raised in the domestic market. Thus, our measure of FDI underestimates the total value of fixed investment made by a multinational firm and the coefficients on FDI may be proportionally overestimated. To the extent that this bias in the measure of FDI is uniform across countries and over time, the qualitative results are not affected.

Finally, the results of this paper suggest some directions for further research. The results suggest that the beneficial effects on growth of FDI come through higher efficiency rather than simply from higher capital accumulation. This suggests the possibility of testing the effect of FDI on the rate of total factor productivity growth in recipient countries. In addition, given the robustness of the effect of interactions between human capital and FDI, it might be interesting to explore the effects of FDI on the level of human capital. As we have argued above, FDI is a vehicle for the adoption of new technologies, and therefore, the training required to prepare the labour force to work with new technologies suggests that there may also be an effect of FDI on human capital accumulation.

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