Optimal foreign direct investment in the presence of human capital formation

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Abstract

This paper gives both theoretical arguments and econometric support to the notion of optimal FDI levels, from the viewpoint of human-capital formation in the host country. The optimality of a limited FDI level depends on the local incentives to get trained. Those incentives are formed in the face of uncertainty and asymmetric information between the multinational and its potential workers. Our estimates confirm the significance of a negative, non-linear impact of FDI per capita on tertiary schooling, both in developed and developing countries.

1 Introduction

The motivation for this paper comes from an analogy. That analogy links the perspective of developing countries on skilled migration with the incentives provided there by FDI. Both cases are perceived by the labor force in developing countries as an opportunity to improve their standards of living and their working conditions. Moreover, in order to access the pool of skilled migrants or the staff of reputed multinationals,

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these workers often need to qualify as educated labor force.[1] Even when not all of them will effectively migrate or work for a multinational, both realities induce on these workers an effort of human-capital formation with significant spillovers for the rest of their countries.

Furthermore, in order for the LDCs to take full advantage of such effort, the emigration quotas and the magnitude of the FDI inflows must provide the population with the right incentives, which will finally depend on the effective size of such quotas and the actual likelihood of being hired by the multinationals. Our framework tries to shed some light on the conditions of optimality for FDI inflows from the point of view of human-capital formation in the receiving economy. To that purpose, we are inspired by the literature on optimal emigration quotas (Mountford (1997), Docquier and Rapoport (2007), etc), though our empirical subject of analysis is well different and our theoretical approach also requires some specific features.

In principle, it is straightforward to understand that more FDI and better conditions of employability at higher wages should stimulate more human-capital formation in order to be selected by multinationals. That is, the relation between FDI inflows and educational investment is monotonically increasing in the context of a homogeneous local population. However, once we introduce some ability-heterogeneity among natives, differentiating the most from the least inherently capable workers, such relation becomes non-monotonic. Since a very large FDI staff implies a very high likelihood to be employed for the high-ability natives, they will tend to reduce their effort if multinationals hire many people. And the lower effort by the most capable will be accompanied (as a reaction) by more laziness by all others.

Therefore, and given that the multinationals will eventually learn about the relative productivity of the staff and release most of the initially unskilled hirings, it may be in the interest of the host country to limit the number of such hires to raise the human capital of unskilled workers. Especially because they will be redeployed again in the rest of the economy after working for a foreign affiliate. In other words, we suggest

[1] Abundant empirical studies suggest that multinational corporations tend to raise the demand for education in developing countries, as their plants are often more skilled-labor-intensive than the rest of the economy (see, for instance, Feenstra and Hanson (1997)).

that the above-mentioned relation between FDI per capita and schooling in LDCs has an inverted-U shape due to a clearly non-linear component, which implies the existence of an optimal FDI per-capita inflow from such perspective.

There is in principle no reason to expect that the multinational corporations will tend to maximize the aggregate efficiency units of the local human capital. That may not be the case even when such corporations are interested in the skill composition of their labor force, because there are also many other productive and strategic priorities for them. Therefore, it may be in the interest of the local government to use some instruments in order to internalize these external effects, which will spill over all the productive sectors.

Of course, human-capital accumulation is not the only priority to be taken into account by the government in the host country . Productive linkages with local sectors, technology transfer, etc. may be even more significant (see e.g. Markusen and Venables (1999)). Nevertheless, we tried to emphasize the potential non-monotonicity of the above-mentioned relation, together with some causal explanations for that seemingly confirmed finding.

On the other hand, Hoffmann (2003) explored in a two-country, general-equilibrium model the mechanics of the two-way causality between human-capital accumulation in LDCs and FDI. He considered homogeneous labor forces in terms of inherent abilities, and two different factors of production: skilled and unskilled labor, so that a considerable stock of skilled labor was required by multinationals to invest in the LDC. In contrast to his paper, in our model we take for granted the existence of some foreign inward investment under all circumstances, and the existence of labor-force heterogeneity (within the same factor of production) generates incentives to accumulate more or less human capital at the local level.

Our empirical estimates confirm the significance of both a positive, linear impact of FDI on tertiary schooling, and of a negative impact of FDI^2, both in developed and developing countries. This fact will allow us to measure the optimal FDI per capita in a representative country, and offer policy recommendations to the countries on each side of the curve. To the best of our knowledge, this is the first paper to incorporate a non-linear effect of FDI in the analysis of human capital accumulation. Zhuang (2008) used a difference-in-differences approach in which the reverse-causality problem was addressed using dummies of policy changes as independent variable, instead of FDI measured in dollars. On the other hand, Checchi et al. (2007) used explicitly an FDI variable as regressor, but only captured its positive linear effect on human capital formation.

The rest of the paper is organized as follows: section 2 describes an illustrative model; sections 3 and 4 present the data and the estimation procedure; section 5 yields the results and section 6 contains an appendix listing the countries in our sample.

2 The Model

In our model the whole country, and not only the hired population, should benefit from the induced incentives generated by FDI. Therefore, there must be some element of uncertainty in the eligibility of potential candidates for a job. Otherwise the gains would be circumscribed to people who were initially qualified for their task. Therefore, some noise in the educational (or the political) system of the recipient country must play here a role, by preventing the firm from adopting a fully-informed recruiting policy.[2]

That same noise must be also responsible for some uncertainty on the part of the applicants. The less capable applicants would try to take advantage of the legal, procedural or political loopholes of the system, which are known by all of them only to the extent of assigning certain probabilities to some events.

2.1 Education as an instrument to be hired by multinationals

Our theoretical framework is a variation of Lazear and Rosen (1981)'s model of tournaments. This particular setting is meant to capture some crucial elements: the risk of selecting an inappropriate staff by

[2] In that respect, our model slightly resembles Stark et al. (1997)'s paper, though their article focuses on the literature of the migratory "brain drain" vs "brain gain."

the corporation; the subsequent incentives to make an effort that such reality induces on both skilled and unskilled individuals; and the consequent existence of an optimal FDI inflow from the point of view of the local human-capital formation.

Let us denote by l the aggregate population of our host country. The total size of the population is divided into a proportion 1/2 of high-ability types (let us call them type-2) and a proportion 1/2 of low-ability types (type-1). The former own θ efficiency units of labor ($\theta > 1$), whereas the latter own just one efficiency unit. However, the type of each individual is not observable to the employer. He needs to perform a selection process in order to choose the (presumably) best employees for the multinational firm, though such selection depends on an imperfect test.

Let the personal outcome of any individual i in that test depend on his own training effort (e_i) and an element of randomness (η_i), where the random variable η_i follows an uniform distribution over the interval $[-a, a]$, $a > 0$ $\forall i$. More specifically, let us denote by g_i the test score of individual i and assume that

$$g_i = e_i + \eta_i \tag{1}$$

That randomness (η_i) obscures the true type of the individual to the eyes of the employer, given that a good (or a bad) result in the test could be obtained (under different circumstances) by any of the two types. We can interpret the variance of η_i as an inverse measure of the quality of the educational system in the considered country. The magnitude of such variance is measured by the parameter a.

Despite the imperfections in the test, the multinational firm decides to recruit the best h scores, where h stands for the size of the local staff in the multinational corporation. That variable (h) will also determine the relative incentives of both types to get educated and, subsequently, the ex-post quality of the hired staff.

The way to be selected in the test is beating at least $l - h$ competitors, where l is the total number of candidates involved in the selection process. All workers will be interested in applying for a job in the multinational, given that the latter offers a wage higher than the one available locally ($w_F - w_H = \triangle w > 0$, where F and H stand for "foreign" and "home", respectively).

First of all, it is intuitive that - given identical preferences (in the form of disutility) with respect to effort - the high-ability types will exhibit a higher incentive to acquire education, since they will enjoy the same wage gap, but applied to a higher number of efficiency units of labor. Let us start showing this fact by obtaining the probability that any worker (of type i) gets a higher score than another worker (of type j):

$$P\left(g_i > g_j\right) = P\left(e_i + \eta_i > e_j + \eta_j\right) = P\left(\underbrace{\eta_i - \eta_j}_{\equiv r_{ij}} > e_j - e_i\right) = \int_{e_j - e_i}^{2a} \frac{1}{4a} dr_{ij} = \left(\frac{1}{2} - \frac{(e_j - e_i)}{4a}\right) \tag{2}$$

where we have considered an uniform, independent probability distribution for η_i and η_j (we have also assumed that a is big enough to ensure that probabilities are always positive and lower than one). Let us denote by γ the parameter measuring the intensity of the effort disutility by both types of individuals. Now we are ready to face the maximization problem faced by the individuals of both types:

$$\begin{array}{ll} \text{Max}_{e_2} & \text{Welfare}_2 = \left\{p_2\left(e_1, e_2\right)^{l-h} \theta \triangle w - \frac{1}{2}\gamma e_2^2\right\} \\ \text{Max}_{e_1} & \text{Welfare}_1 = \left\{p_1\left(e_1, e_2\right)^{l-h} \triangle w - \frac{1}{2}\gamma e_1^2\right\} \end{array} \tag{3}$$

where

$$\begin{array}{lll} p_2 = \frac{1}{4} + \frac{1}{2}\left(\frac{1}{2} + \frac{(e_2 - e_1)}{4a}\right) = & \frac{1}{2} + \frac{(e_2 - e_1)}{8a} & \\ p_1 = \frac{1}{4} + \frac{1}{2}\left(\frac{1}{2} - \frac{(e_2 - e_1)}{4a}\right) = & \frac{1}{2} - \frac{(e_2 - e_1)}{8a} & = 1 - p_2 \end{array} \tag{4}$$

We have denoted by p_i the probability that an agent has a higher score than another one, conditional on the type ($i = 1, 2$) of the former. In (3) we are incorporating the fact that, in order to be hired by the multinational, any candidate must defeat other $(l - h)$ potential workers. Therefore, by plugging the equations in (4) into the maximands given by (3) and taking the corresponding first-order conditions, we come up with the following reaction functions:

$$\begin{array}{ll} e_2 = & (l-h)\frac{\triangle w}{\gamma 8a}\theta\left(\frac{1}{2} + \frac{(e_2 - e_1)}{8a}\right)^{l-h-1} = (l-h)\frac{\triangle w}{\gamma 8a}\theta\left(\frac{1}{2} + \frac{z}{8a}\right)^{l-h-1} \\ e_1 = & (l-h)\frac{\triangle w}{\gamma 8a}\left(\frac{1}{2} - \frac{(e_2 - e_1)}{8a}\right)^{l-h-1} = (l-h)\frac{\triangle w}{\gamma 8a}\left(\frac{1}{2} - \frac{z}{8a}\right)^{l-h-1} \end{array} \tag{5}$$

Let us denote by z the term $(e_2 - e_1)$, so that $p_2 = p_1 + \frac{z}{4a}$. If we now subtract both terms in (5), we can characterize the distance between the optimal efforts made by both types as follows:

$$z = (l-h)\frac{\triangle w}{\gamma 8a}\left[\theta\left(\frac{1}{2} + \frac{z}{8a}\right)^{l-h-1} - \left(\frac{1}{2} - \frac{z}{8a}\right)^{l-h-1}\right]$$

Furthermore, we can close the system by imposing a consistency requirement, which guarantees that the workers' expectations are rational: the effective size of the staff must be equal to the sum of the probabilities to be hired. That requirement can be expressed as follows:

$$h = \frac{l}{2}\left[p_1^{l-h} + p_2^{l-h}\right] = \frac{l}{2}\left[\left(\frac{1}{2}+\frac{z}{8a}\right)^{l-h} + \left(\frac{1}{2}-\frac{z}{8a}\right)^{l-h}\right]$$

Therefore, our whole system can be characterized by the following pair of non-linear equations in z and h:

$$\left\{ \begin{array}{l} z = (l-h)\frac{\triangle w}{\gamma 8a}\left[\theta\left(\frac{1}{2}+\frac{z}{8a}\right)^{l-h-1} - \left(\frac{1}{2}-\frac{z}{8a}\right)^{l-h-1}\right] \\ h = \frac{l}{2}\left[\left(\frac{1}{2}+\frac{z}{8a}\right)^{l-h} + \left(\frac{1}{2}-\frac{z}{8a}\right)^{l-h}\right] \end{array} \right\} \tag{6}$$

2.2 Calibration and diagrammatic results

Since the system of equations expressed by (6) has no analytical solution, we need to solve it numerically for some plausible values of the parameters. In particular, we have followed Ghosh and Whalley (1998)'s parameterization with respect to the units-term in the disutility of effort function ($\gamma = 1$). Goldin and Katz (1999) suggest an average return to each year of college in the USA of 0.13 (year 2000), which amounts to a lower bound for $\theta = 1.52$.Finally, our results are not significantly sensitive to the choice of a, as long as this parameter value guarantees interior probabilities. We have chosen $a = 15$ and $l = 1$.

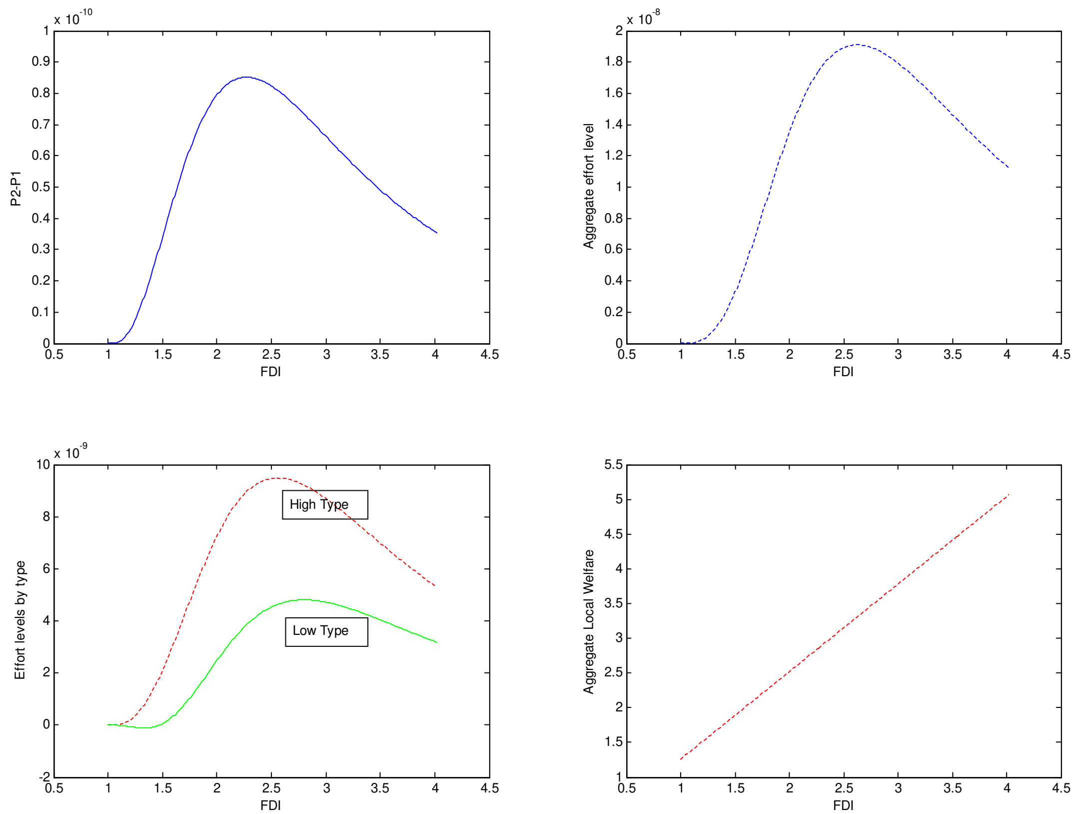
Since we are interested in the empirical implications of our numerical results, we have included in the horizontal axis a variable called FDI that can be defined as follows:

$$FDI \equiv h\left(\triangle w\right) \tag{7}$$

That definition means that there is free entry of foreign direct investors until profits completely disappear. Moreover, we have normalized (without loss of generality) the native wage w_H to zero. Such expression (7) also implies that FDI and $\triangle w$ follow an increasing relation, which conforms with the positive correlation found by Feenstra and Hanson (1997) in the Mexican data.

A second useful definition is

$$HC \equiv \frac{1}{2}\left[\left(\frac{1}{2}+\frac{z}{8a}\right)^{1-h}\theta + \left(\frac{1}{2}-\frac{z}{8a}\right)^{1-h}\right]$$



which refers to the aggregate stock of human capital accumulated in the economy as a result of the FDI inflows.

As a result, we can observe in the figure how the Aggregate Effort Level ($\equiv HC$) reaches a peak for an interior value of FDI (and of the wage gap $\triangle w$).

2.3 Interpretation of the figure

Higher wage gaps and FDI inflows are likely to induce additional training on the part of both high-ability and low-ability workers. However, as we know, the incentives are in principle stronger for the most capable people, given their extra units of effective labor, which translates into a higher wage per hour. That is the reason why, as FDI starts to reach significant values, the aggregate units of effort grow substantially and skilled workers increase their effort at a faster rate. By effort we mean here training and human-capital acquisition out of the job.

That situation will only last up to a certain point. When FDI (and the wage gap) is already quite high and multinationals hire most of the population, skilled types start to feel that the relative gains from additional effort are lower than their disutility. When they eventually decide to relax, everybody will also decide to do so.

Therefore, even when the first and fourth panels show us that the local government may consider subsidizing FDI as much as possible, because local welfare grows faster than firm losses, such government may as well wonder:

"Should we subsidize FDI so much, when that is finally reducing the educational achievement of our workers, and the corporations will end up releasing many uneducated, unskilled employees to the rest of the economy?".

In terms of the figure, the government may wonder whether $FDI = 2.5$ is better for the economy than $FDI = 4$.[3]

3 Data

We use data from the World Bank's World Development Indicators.[4] The data cover 167 countries, for the years 2000 and 2005. Based on the IMF country classification there are 28 developed and 139 developing countries in the data. Table 1 reports summary statistics of our main variables of interest, for the year 2005.

[3]When we considered higher values of FDI and $\triangle w$, given our parametrization we observed several "hills" and "valleys" along the evolution of HC in the graph. This fact could allow us to study how some countries are "trapped" in a low-level of human capital that subsequent additions of FDI may only deteriorate. Only a very significant push in FDI may draw these countries out of the trap.

[4]<http://data.worldbank.org/data-catalog/world-development-indicators> accessed March/25/2011.

Table 1: Summary Statistics, 2005

	All		Developed		Developing	
	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
Literacy rate	82.0	20.00	98.1	1.91	78.8	20.43
Schooling years	12.2	3.19	16.2	1.50	11.4	2.81
Secondary education	61.6	27.74	89.8	6.49	55.9	26.89
Tertiary education	27.7	24.9	61.9	17.32	20.8	20.13
FDI (Bill. USD)	10.2	31.99	36.3	64.72	5.07	16.04
FDI per capita (1000' USD)	0.730	1.4241	1.859	2.4399	0.506	0.9898
GDP (per capita)	8354.2	12527.32	31745	13235	3709.2	4835.14
Expenditure on education	15.2	5.11	12.9	3.16	15.7	5.31
Pupil-Teacher ratio	27.0	14.88	14.7	4.01	29.5	15.04
Mortality rate	35.7	33.38	4.2	1.11	42.0	33.15
Land (1000 sq. km)	740.2	1961.00	1072.9	268.58	674.2	1787.99
Observations	167		28		139	

Source: Authors' calculation, WDI data.

The variables secondary and tertiary education represent the gross enrollment ratio, which is the ratio of total enrollment regardless of age to the whole age group which officially corresponds to the relevant education level. These, as well as the literacy rate, are expressed in percentage points. For example, about 90% of the population aged 16–18 in developed countries are enrolled in some sort of high school.

FDI is the net flow of Foreign Direct Investment in billions of current USD. We also define FDI-PC which is FDI (in billions of USD) divided by the population (in millions); therefore, the FDI per capita, FDI-PC, is defined in thousands of current USD.

GDP per capita is also expressed in current USD. It is evident from the table that GDP per capita in developed countries is almost ninefold that in developing countries. Mortality rate is expressed in percentage points; and it is worth noting that in developing countries this is ten times higher than in developed countries. Finally, "Land" is the country's total area excluding "water bodies," i.e., lakes and major rivers. This is expressed in thousands of squared-Km.

4 Estimation

One of the main testable hypotheses suggested by our theoretical analysis is that the increase in foreign direct investment in a country induces an increase in the human capital of the country, exemplified by higher participation rates in higher education, but at a decreasing rate. Eventually, exceeding some (high) level of FDI, this will start inducing a decline in schooling attainment. To test this hypothesis we run the following regression by OLS

$$HC_i = \alpha + \beta_1 FDI_i + \beta_2 FDI_i^2 + \gamma X_i + \varepsilon_i \tag{8}$$

where HC_i, signifying human capital, is either the enrollment rate in tertiary education or the enrollment rate in secondary school in country i. We also consider the overall average years of schooling as a measure of human capital; this, however, is not the best measure of human capital because of its inability to distinguish between primary or advanced levels of schooling. Besides, we do not have previous (for the year 2000) levels of average schooling, which does not facilitate a comprehensive estimation of the relationship regarding this variable.[5] FDI_i represents the *per capita* FDI in country i, in thousands of USD. ε_i is the error term.

Other control variables are included in the vector X_i for country i. These control for macro variables in the economy, like GDP per capita, which is probably correlated with education outcomes as we expect richer countries to have more resources allocated to education; also they control for education input variables, like the log of public expenditure on education (per capita), the pupil-teacher ratio, the mortality rate, and a dummy variable which takes on the value 1 if country i is a developed country.

In the study of schooling, researchers generally include variables about education inputs. Two major measures of education inputs are the pupil-teacher ratio and the public expenditure on education. The pupil-teacher ratio is the number of pupils enrolled in primary school divided by the number of primary school teachers. The public expenditure on education is the government spending on educational institutions

[5] This simply means that we will not be able to carry out the "proxy-variable estimation" for this variable as it will become clear shortly.

(private and public) and educational activities (administration, subsidies, students, etc...). As all these are believed to affect education outcomes in a country, it is necessary to control for them in the regression analyses in order not to confound their effect with that of the FDI levels in the country.

Mortality rate is included in the regression because it conveys some information about poverty (as mortality rate is higher in poorer countries), but also this may affect educational choices: educational attainment is an investment decision, the return of which depends on the life-span [see Grossman (2005), Checchi, De Simone, and Faini (2007)].

4.1 Endogenous FDI

Although we believe that changes in the levels of FDI in some country affect the levels of education in that country, it is also equally convincing that the current levels of education affect FDI. Foreign companies might be attracted to invest in countries with higher potential, exemplified by a more skilled (educated) labor force. There also exist theoretical models that confirm this intuition of reverse causality between FDI and human capital (see Hoffman 2003). Therefore, FDI is suspected to be an endogenous variable in our main equation of interest. To show this, assume that

$$\varepsilon_i = z_i + \nu_i \tag{9}$$

where ν_i is a white noise (homoskedastic, serially uncorrelated error term) that is independent of variables included in the model, particularly FDI and FDI^2. And z_i stands for possible variables that are omitted from the regression, because they are either not available or unobservable, that might be correlated with our variable of interest, namely FDI. If that is the case, then our OLS estimates of equation 8 will be biased and inconsistent.

To address this concern we use two different methods. First, to control for z_i, the unobservable variables in the error term that may be correlated with FDI, we include a proxy variable. This variable, if not exactly z_i, has to be related to it. We choose the lag of the dependent variable as a proxy variable in our analyses.

For example, in the case of tertiary enrollment, we include in the regression an additional variable which is tertiary enrollment in the year 2000, recalling that our analyses focus on the year 2005. The inclusion of such a variable controls for differences between the countries in our cross-sectional data, that could not be otherwise captured by our included variables. The same idea applies for the other measure of human capital, secondary enrollment.

The second approach that we use is the instrumental variables approach (two stage least squares, 2SLS). The idea is to capture the part of FDI that is orthogonal to z_i, and measure its effect on the human capital measure. To do that we use the overall population density, defined as the number of residents per one square kilometer, as an instrument for FDI. In our sample we find that the correlation coefficient between FDI per capita and population density is about 0.45, confirming its relevance here. On the other hand, it is not very likely that land area has an effect on the level of education in a country, or an effect on the individual choice of investment in education, lending support to the "exclusion restriction," which simply means that the population density is not part of, or is not correlated with, the variables included in z_i. The use of a valid instrument allows us to estimate $\widehat{FDI}$ by running the following (first stage) regression by OLS:

$$FDI_i = \lambda_0 + \lambda_1 X_i + \lambda_2 Density_i + \omega_i \tag{10}$$

where $Density_i$ is the population density in country i. We then use the predicted $\widehat{FDI}$ in the main regression instead of FDI (the second stage).

One final point worth emphasizing is that we have in our main regression the variable FDI^2 also. If FDI is deemed endogenous as discussed above, then it follows that FDI^2 is also endogenous (essentially, any function of an endogenous variable is also endogenous). One will be tempted to use $\widehat{FDI}^2$ instead of FDI^2 in the second stage estimation. However, this is not correct, econometrically speaking.[6] Therefore, to get an instrument for FDI^2 we use a nonlinear form of the variables included in the first stage, and calculate

[6] Actually, this approach is referred to as the "forbidden regression," in the econometric literature. See Wooldridge (2002) for more details.

Table 2: The Effect of FDI on Secondary Enrollment

	OLS	Proxy	IV
FDI per capita	4.899** (2.08)	3.492** (2.07)	−1.600 (−.15)
(FDI per capita)^2	−.573** (−2.13)	−.492 (−2.56)	0.037 (.03)
ln (GDP per capita)	3.003* (1.95)	0.192 (.17)	5.059 (1.49)
ln (Public Expenditure)	−.777 (−1.40)	−.748* (−1.88)	−.237 (−.25)
Pupil-Teacher Ratio	−.512*** (−4.40)	−.238*** (−2.75)	−.513*** (−4.40)
Mortality Rate	−.367*** (−5.80)	−.185*** (−3.83)	−.350*** (−5.17)
Developed Country	1.567 (.40)	−3.046 (−1.08)	0.867 (.20)
Secondary enrollment 2000		0.514*** (11.39)	
R^2	0.81	0.90	0.79
Observations	164	161	164

NOTE.— t-statistics in parentheses. * is significant at the 10% significance level, ** at the 5%, and *** at the 1%. "Developed Country" is a dummy variable that takes on the value 1 if the country is developed and 0 otherwise. See text for details.

$\widehat{FDI}^2$ as follows:

$$FDI_i^2 = \mu_0 + \mu_1 X_i + \mu_2 Density_i + \mu_3 \widehat{FDI}_i^2 + \kappa_i \qquad (11)$$

where $\widehat{FDI}_i^2$ is simply the square of the predicted values in regression (10). The regression in (11) will give us the predicted value of FDI^2, or $\widehat{FDI^2}$, which we will use instead of FDI^2 in our main regression.[7]

5 Results

Table 2 shows the main results of our analyses for the secondary enrollment ratio. It shows results from the naive OLS estimation, the proxy-variable estimation, and the instrumental-variables estimation. The dependent variable in all regressions is the secondary enrollment ratio.

The first column reports the simple OLS regression of secondary enrollment against the relevant variables.

[7] Note that, for symmetry, we use the same variables in the first stage of both FDI and FDI^2, namely X, $Density$, and $\widehat{FDI}^2$.

It is evident from the table that GDP has a positive and significant effect on school enrollment. As expected, the pupil-teacher ratio and the mortality rate have a negative and very significant effect on school enrollment. The sign of the coefficient of public expenditures on education is counterintuitive, nonetheless it is not statistically different from zero in this regression.

The most interesting finding in this table is that FDI has the quadratic effect on secondary school enrollment, confirming our theoretical model. A positive β_1 and a negative β_2,[8] point to the fact that the schooling-FDI relationship can be described by an inverted U-shape graph.

The second column is an OLS regression that uses a lagged dependent variable, namely secondary enrollment in 2000, as a proxy for the unobservable variables in the error term that affect current enrollment and maybe related to FDI. Results from this regression are similar to these from the OLS regression, and also confirm the inverted U-shape relationship between schooling and FDI.

The last column reports the two-stage-least-squares regression output for secondary enrollment. Although the expected, positive effect of GDP and negative effect of mortality rate and pupil-teacher ratio is once again confirmed, the FDI coefficients are not statistically significant anymore (and their signs are counterintuitive).

Table 3 reports the analog results for tertiary enrollment. All estimation results point to the important observation that an inverted-U shape captures the relationship between FDI and tertiary enrollment.

Other variables, excluding public expenditure on education, also receive coefficients with the right intuitive sign, and are statistically significant. The instrumental variables estimation results (column 3) are now very statistically significant with the right signs. Table 4 reports results for the case of average years of schooling. As discussed earlier, this variable is more problematic measure of human capital, and a significant relationship is not expected in this case.

Both OLS and IV estimates of the effect of FDI on the average years of schooling are not statistically significant, although the sign of the IV estimates is in line of our previous results. Also, as mentioned

[8] These are the coefficients of FDI and FDI^2, respectively. See the previous section about the estimated relationship.

Table 3: The Effect of FDI on Tertiary Enrollment

	OLS	Proxy	IV
FDI per capita	3.940 (1.37)	2.027 (1.59)	34.527** (2.08)
(FDI per capita)^2	−.448 (−1.38)	−.154 (−1.07)	−3.997** (−2.15)
ln (GDP per capita)	4.506** (2.49)	.189 (.23)	−3.703 (−.73)
ln (Public Expenditure)	−3.172*** (−5.02)	−.239 (−.77)	−4.966*** (−3.86)
Pupil-Teacher Ratio	−.261* (−1.92)	−.050 (−.84)	−.259 (−1.47)
Mortality Rate	−.168** (−2.27)	−.018 (−.54)	−.223** (−2.21)
Developed Country	13.403*** (2.96)	−.448 (−.22)	19.196*** (2.92)
Tertiary enrollment 2000		1.100*** (24.70)	
R^2	0.68	.94	.42
Observations	164	156	164

NOTE.— t-statistics in parentheses. * is significant at the 10% significance level, ** at the 5%, and *** at the 1%. "Developed Country" is a dummy variable that takes on the value 1 if the country is developed and 0 otherwise. See text for details.

Table 4: The Effect of FDI on Average Years of Schooling

	OLS	IV
FDI per capita	−.101 (−.33)	.900 (.63)
(FDI per capita)^2	−.004 (−.10)	−.135 (−.86)
ln (GDP per capita)	.572*** (2.82)	.322 (.71)
ln (Public Expenditure)	−.011 (−.15)	−.071 (−.57)
Pupil-Teacher Ratio	−.021 (−1.39)	−.020 (−1.31)
Mortality Rate	−.044*** (−5.22)	−.045*** (−5.01)
Developed Country	1.399*** (2.75)	1.683*** (2.87)
Tertiary enrollment 2000		
R^2	0.75	0.73
Observations	164	164

NOTE.— t-statistics in parentheses. * is significant at the 10% significance level, ** at the 5%, and *** at the 1%. "Developed Country" is a dummy variable that takes on the value 1 if the country is developed and 0 otherwise. See text for details.

Table 5: Optimal FDI Levels: that Maximize Human Capital Variables

	OLS	Proxy	IV
Secondary Education	4.275	3.549	—
Tertiary Education	4.397	6.581	4.319
Average Schooling	—	—	3.333

NOTE.— Entries are "optimal" FDI levels that maximize each measure of human capital: secondary education, tertiary education, and average schooling. Simulated values are based on estimation results (coefficients of FDI and FDI^2 from Tables 2–4.

earlier, since we do not have the lagged value of schooling (in 2000) we could not carry out a proxy variable estimation for this variable.

5.1 Optimal FDI

Given that the relationship between human capital and FDI is described by the following equation:

$$\widehat{HC} = \alpha + \hat{\beta}_1 FDI + \hat{\beta}_2 FDI^2 + \hat{\gamma} X$$

it is possible to find the "optimal FDI," that is, the level of FDI at which one of the human capital variables is maximized. The maximum HC is attained at FDI^* which satisfies:

$$\begin{aligned} \hat{\beta}_1 + 2\hat{\beta}_2 FDI^* &= 0 \\ FDI^* &= \frac{-\hat{\beta}_1}{2\hat{\beta}_2} \end{aligned}$$

which is the first order condition. Substituting some of our significant (and meaningful) estimates of $\hat{\beta}_1$ and $\hat{\beta}_2$ from Tables 2–4 in the above equation, we find optimal FDI levels under each scenario. These are described in the following table:

Strikingly, and despite the different measures of human capital used, and the different methods employed, our analyses seem to point to an optimal FDI level around 4 (thousand USD per capita). For example, for tertiary education, and using the IV approach, the optimal FDI is about 4.32. The following graph plots

Table 6: Average Human Capital in High FDI and Low FDI Countries

	Low FDI		High FDI	
	Mean	Std. Dev.	Mean	Std. Dev.
Secondary Enrollment	58.8	27.86	84.2	9.00
Tertiary Enrollment	26.1	24.75	45.9	23.13
Average Schooling	12.0	3.21	14.5	2.50

NOTE.— "Low" FDI defines countries (151 in number) for whome the FDI per capita is below 2 (i.e., 2000 USD), and "High" FDI defines (13) countries above that level.

FDI (per capita) levels of the countries in our sample, around a horizontal line at the 4.3 level:

Given our previous estimates, Sweden, for example, seems to have the right level of FDI net flows. Equally clear from the graph is that many countries cluster at much lower levels of FDI per capita than the "optimal" one. If we calculate the simple average human-capital variables for countries with FDI per capita above and below, say, 2 we find the following:

Table 6 draw a clear fact: countries with high (above $2,000 per capita) FDI attain higher levels of schooling under any and every measure of human capital used. On the one hand, this proves the existence of the optimal FDI point, at least in regards to human capital in the host country. On the other hand, however, this may point to the possibility that many countries are caught with a "low-human-capital-trap," where the FDI level is not sufficiently large to mobilize them to the maximum potential human capital.

6 Concluding Remarks

As a conclusion, we should emphasize the concave, inverted-U shape of the relation between FDI per capita and human-capital formation. This relationship is clearer in the case of tertiary education, which may reveal that FDI tends to be skill-biased and raise inequality in most LDCs. There is a clustering of many countries around a lower-than-optimal level of FDI. We conjecture that some of these countries may be affected by a low-human-capital trap, as suggested by some of our simulations. Proving the effective existence (or inexistence) of those traps is an interesting avenue for future research.

7 Appendix

Countries included in our samples are:

Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, The Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Dem. Rep. of Congo, Congo Rep., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Fiji, France, Gabon, The Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong (SAR China), Hungary, Iceland, India, Indonesia, Islamic Rep. of Iran, Iraq, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Rep. of Korea, Kyrgyz Republic, Lao P.D.R., Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macao SAR, Macedonia FYR, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands Antilles, The Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Rwanda, Samoa, Sao, Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Slovak Republic, Slovenia, Solomon Islands, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, R.B. de Venezuela, West Bank and Gaza, Rep. of Yemen, Zambia, Zimbabwe.

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