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ABSTRACT

The paper provides a reconciliation of Lucas' paradox, based on fixed setup costs of new investments. With such costs, it does not pay a firm to make a "small" investment, even though such an investment is called for by marginal productivity conditions. Using a sample of 45 developed and developing countries we estimate jointly the participation equation (the decision whether to invest at all) and the FDI flow equation (the decision how much to invest). We find that countries which are more likely to serve as source for FDI exports than their characteristics project export lower flow of FDI than is predicted by their characteristics. This negative correlation suggests that the source countries with relatively low setup costs are also those with high marginal productivity of capital.

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1 Introduction

In an influential paper, Lucas (1990) asks: "Why doesn't capital flow from rich to poor countries?" Indeed, the law of diminishing returns implies that the marginal product of capital is high in poor countries and low in rich countries. Therefore, capital should flow from rich to the poor countries.

With standard constant-returns-to-scale production functions, when the wage (per efficiency units of labor) is higher in a rich country than in a poor country, then the return to capital must be lower in the rich country than in the poor country. Therefore, the existence of "huge" wage gap between rich and poor countries must be associated with an opposite gap in the rates of return to capital. Given that labor is not allowed to freely migrate from poor to rich countries, it follows that capital would flow in the opposite direction, thereby equaling the returns to capital and concomitantly wages too. The equalization of wages (indirectly through international capital flows) would eliminate the need to control migration. In practice, however, this is hardly the case. Even though barriers to international capital mobility are by and large being eliminated, the wage gap is still in force, and migration quotas from poor to rich countries have to be enforced.[1]

Lucas reconciled this paradox by appealing to a human capital *externality* that generates a Hicks-neutral productivity advantage for rich countries over poor countries. The average level of educational attainment is an external factor into the production function, that raises the productivity of labor, and more importantly, capital. As a result, capital flows, though equalize the rates of return to capital, fall short of equalizing the capita-labor ratio. Therefore, wages (per efficiency units) are not equalized. Labor of all skill levels has still strong incentives to migrate from poor to rich countries.

In this paper we provide yet another reconciliation of Lucas' paradox, based on fixed setup costs of new investments. With such costs, it does not pay a firm to make a "small" investment, even though such an investment is called for by marginal productivity conditions (that is, the standard first-order conditions for profit maximization). Put it

[1] Note also that despite the expansion of international trade in goods, still the Stolper-Samuelson (1941) factor price equalization theorem does not manage to eliminate the wage gap.

differently, the firm's investment decision is twofold now: marginal productivity conditions determine how much to invest, whereas a "participation" condition determines whether to invest at all. In such a framework, the Lucas paradox can be reconciled: rates of return to capital are equalized and concomitantly the wage gap remains in force.

When one looks at data on gross international capital flows of foreign direct investment (FDI), one is immediately struck by the lack of flows from many rich countries to many host countries. We looked at data on bilateral FDI flows in a sample of 45 countries, both developing and developed, over the period of years from 1981 to 1998. Out of 45 x 44 = 1980 source-host pairs of countries with potential bilateral FDI flows, we found that the number of pairs with actual flows is only 334! There were only 12 countries that made any FDI export over that period and most of these countries exported FDI to only one other country. These crude findings provide a prima facia suggestion for the existence of fixed setup costs of investment that nullify the potential of "small" capital flows that may have been called for by marginal productivity conditions.

We emphasize again that whether a cell of $s-h$ pair becomes active or inactive and how much flow is recorded in this cell in case it becomes active are jointly and simultaneously determined. Thus, the selection of pairs of countries into active and inactive cells is not exogenous. If one treats this selection as exogenous, the estimates of the determinants of FDI flows are biased. We therefore employ a Heckman selection-bias method in order to simultaneously estimate the determinants of FDI flows and the selection of countries into pairs of $s - h$ countries.[2]

The organization of the paper is as follows. Section 2 explains the way Lucas reconciles the paradox of the inadequacy of capital flows from rich to poor countries. Section 3 presents our model of fixed setup costs of investment. This model is used in Section 4 to provide an alternative reconciliation of Lucas' paradox. Section 5 presents the econometric approach. The data are described in Section 6. A crude examination of the potential for selection bias in the data is done in Section 7. Simultaneous estimation results of the determinants of FDI flows and whether they are formed at all are presented

[2] See Heckman (1979).

in Section 8. The results are interpreted and conclusions are drawn in Section 9. Section 10 concludes.

2 Lucas' Reconciliation of the Paradox

The law of diminishing returns implies that the marginal product of capital is high in poor countries and low in rich countries. Therefore, capital should flow from rich to the poor countries. But, it is hard to account in reality for any significant income-equalizing capital flows. Addressing the question: "Why doesn't capital flow from rich to poor countries?", Lucas (1990) employs a standard constant-returns-to-scale production function:

$$Y = AF(K, L), \tag{1}$$

where Y is output, K is capital and L is **effective** labor. The latter is used in order to allow for differences in the human capital content of labor between developed and developing countries. The parameter A is a productivity index which may reflect the average level of human capital in the country, external to the firm as in Lucas (1990). In addition, A may reflect the stock of public capital (roads and other infrastructure) that is external to the firm. In per effective-labor terms, we have:

$$y \equiv Y/L = AF(K/L, 1) \equiv Af(k). \tag{2}$$

The return to capital is:

$$r = Af'(k), \tag{3}$$

whereas the wage per effective unit of labor is:

$$w = A[f(k) - kf'(k)]. \tag{4}$$

Let a variable with an asterisk ($*$) stand for a rich (developed) country and a variable without an asterisk for a poor (developing) country. The function f is common to all countries. Initially, $r_0^* < r_0$. But when capital can freely move from rich to poor countries, then rates of return are equalized, so that:

$$r^* = A^* f^{*\prime}(k^*) = Af'(k) = r. \tag{5}$$

Lucas (1990) essentially assumes that $A^* > A$ (because of a human-capital externality). Hence, it follows from equation (5) that $k^* > k$ (because of a diminishing marginal product of capital). Therefore, employing equation (4) it follows that $w^* > \omega$.

That is, at equilibrium, workers can earn higher wages (per effective labor) in the rich country than in the poor country, and administrative means (migration quotas) are employed to impede the flow of labor from poor to rich countries. Yet there is no pressure on capital to flow in the opposite direction because rates-of-return on capital are equalized.

Note that with $A = A^*$, one cannot explain the puzzle posed by Lucas (1990), which is the existence of a pressure on labor to move from poor countries to rich countries without the existence at the same time of a pressure on capital to flow in the opposite direction.

The next section provides another explanation for this puzzle.

3 Lumpy Adjustment Cost of Investment

We employ a "lumpy" adjustment cost for new investment, in the form of a fixed setup cost of investment. This specification, which has been recently supported empirically by Caballero and Engel (1999, 2000), creates economies of scale in investment.[3]

Consider a two-period economy with a single, all-purpose good. In the first period there exists a continuum of N firms which differ from each other by a productivity index ε. We denote a firm which has a productivity index of ε by an $\varepsilon-$firm. The cumulative distribution function of ε is denoted by $G(\cdot)$, with a density function $g(\cdot)$.

[3] Economies of scale either in the production or investment technologies are also a key contributor to the gains from trade and economic integration. For example, based on estimates taken from a partial equilibrium analysis, the Cecchini (1988) Report assessed that the gains from taking advantage of economies of scale will constitute about 30 percent of the total gains from the European market integration in 1992.

We denote the initial net capital stock of each firm by $(1-\delta)K_0$. This consists of the net initial stock, K_0, of the preceding period, multiplied by one minus the depreciation rate, δ. If an $\varepsilon-$firm invests I in the first period, it augments its capital stock to $K=(1-\delta)K_0+I$ and its gross output in the second period will be $AF(K,L)(1+\varepsilon)$, where L is the labor input (in effective units). Naturally, $\varepsilon \geq -1$ so that $G(-1)=0$.

We assume that there exists a fixed setup cost of investment, C, which is the same for all firms (that is, independent of ε). If an $\varepsilon-$firm invests in the first period an amount $I=K-(1-\delta)K_0$ in order to augment its stock of capital to K, its present value becomes:

$$V^{+}(\varepsilon;K,L)=\frac{F(K,L)(1+\varepsilon)-wL+(1-\delta)K}{1+r}-[K-(1-\delta)K_0+C].$$

This firm chooses K and L in order to maximize its value. The first-order conditions

$$F_K(K,L)(1+\varepsilon)=r+\delta \tag{6}$$

and

$$F_L(K,L)(1+\varepsilon)=w \tag{7}$$

define the optimal K and L for an $\varepsilon-$firm, if it chooses to make a new investment at all. These are denoted by $K^{+}(\varepsilon;w,r)$ and $L^{+}(\varepsilon;w,r)$, respectively. Note, however, that an $\varepsilon-$firm may chose not to invest at all [that is, to stick to its existing stock of capital $(1-\delta)K_0$)] and avoid the setup lumpy cost C. In this case its labor input, denoted by $L^{-}(\varepsilon;K_0;w,r)$ is defined by:

$$F_L[(1-\delta)K_0,L](1+\varepsilon)=w. \tag{8}$$

Note that L^{-} depends on the initial stock of capital. Naturally, low $\varepsilon-$firms may not find it worthwhile to incur the setup cost C. In this case its present value is:

$$V^{-}[\varepsilon;(1-\delta)K_0,L^{-}(\varepsilon;K_0,w,r)]=\{F[(1-\delta)K_0,L^{-}(\varepsilon;K_0;w,r)](1+\varepsilon)-wL+(1-\delta)K_0^2\}/(1+r). \tag{9}$$

Therefore, there exists a cutoff level of ε, denoted by ε_0, such that an $\varepsilon-$firm will make a new investment if and only if $\varepsilon > \varepsilon_0$. This cutoff level of ε depends on K_0, w and r. We write it as $\varepsilon_0(K_0; w, r)$ and define it by:

$$
\begin{aligned}
& V^{+}\left\{\varepsilon_0(K_0;w,r);K^{+}\left[\varepsilon_0(K_0;w,r);w,r\right],L^{+}[\varepsilon_0(K_0;w,r);w,r]\right\} \\
= \; & V^{-}\left\{\varepsilon_0(K_0;w,r);(1-\delta)K_0,L^{-}[\varepsilon_0(K_0;w,r);K_0;w,r]\right\}.
\end{aligned} \tag{10}
$$

We continue to assume that labor is confined within national borders. Denoting the country's endowment of labor in effective units by $\tilde{L}_0$, we have the following labor market clearance equation:

$$
N\int_{-1}^{\varepsilon_0(K_0;w,r)} L^{-}[\varepsilon;K_0,w,r]g(\varepsilon)d\varepsilon + N\int_{\varepsilon_0(K_0;w,r)}^{\bar{\varepsilon}} L^{+}(\varepsilon;w,r)g(\varepsilon)d\varepsilon = \tilde{L}_0,
$$

where $\bar{\varepsilon}$ is the upper productivity level. Dividing the latter equation through by N, yields:

$$
\int_{-1}^{\varepsilon_0(K_0;w,r)} L^{-}[\varepsilon;K_0;w,r]g(\varepsilon)d\varepsilon + \int_{\varepsilon_0(K_0;w,r)}^{\bar{\varepsilon}} L^{+}[\varepsilon;K,r]g(\varepsilon) = L_0, \tag{11}
$$

where $L_0 \equiv \tilde{L}_0/N$ is the effective labor per firm.

Note that no similar market clearance equation is specified for capital, as we continue to assume that capital is freely mobile internationally and its rate of return is equalized internationally.

We look at FDI flows in this paper because:

(i) This form of international flow is assuming a dominant role among all other forms of international flows in recent years, and it is the most stable among international capital flows; (ii) Fixed setup costs are most pronounced in the case of FDI.

4 An Alternative Reconciliation of the Paradox

Let us focus on the international differences in the abundance of effective labor relative to the number of firms, that is, L_0. We therefore assume at this stage that $K_0 = K_0^*$ and

$C = C^*$. Naturally, effective labor **per firm** is more abundant in the developing country. That is, we assume that:

$$\tilde{L}_0/N \equiv L_0 > L_0^* \equiv \tilde{L}_0^*/N^*. \tag{12}$$

We demonstrate that in this case that even though $r = r^*$ (by the capital mobility assumption), we nevertheless have $w < \omega^*$. That is, labor wishes to migrate from poor to rich countries even though capital moves freely from rich to poor countries.

To see this, suppose, on the contrary, that $w = w^*$. Then the demand for effective labor of an $\varepsilon-$firm is the same in both countries:

$$L^-(\varepsilon; K_0; w, r) = L^-(\varepsilon; K_0^*; w^*, r^*)$$

for the non-investing firms and:

$$L^+(\varepsilon; w, r) = L^+(\varepsilon; w^*, r^*)$$

for the investing firms. Furthermore, the cutoff productivity level is the same in both countries:

$$\varepsilon_0(K_0; w, r) = \varepsilon_0(K_0^*; w^*, r^*).$$

Hence, the demand for effective labor (per firm) is the same in both countries. Therefore, this cannot be an equilibrium because the supply of effective labor (per firm) is higher in the poor country. Thus, at equilibrium, the wage per effective unit of labor must be lower in the poor country than in the rich country.

It also follows that the higher wage in the rich country reduces the profit from investment and therefore the cutoff productivity level is also higher in the rich country:

$$\varepsilon_0(K_0; w, r) < \varepsilon_0(K_0^*; w^*, r^*). \tag{13}$$

(Recall that $K_0 = K_0^*$ and $r = r^*$.)

In fact, the wage differential must be high enough so as to push $\varepsilon_0(K_0^*; w^*, r^*)$ all the way to the upper bound $\bar{\varepsilon}$.[4] That is, no firm in the rich country makes new investment. To see this, note that for the investing firms, the capital-labor ratio is governed by equation (6). (Recall that with constant returns-to-scale, F_K depends on K/L only). Thus, with $r = r^*$, the capital-labor ratio for the investing $\varepsilon-$firm must be the same in both countries. But then equation (7) implies that the wage (per an effective unit of labor) must be the same in both countries, in contradiction to our conclusion that $w < w^*$.

To complete the picture, we briefly discuss also international differences in the setup cost (C). It is plausible that the setup cost is higher in poor countries than in rich countries. This is because the setup cost may reflect the level of public capital (transportation infrastructure, communication infrastructure, etc.) and the average level of human capital [as in Lucas (1990)]. The higher setup cost in the poor country induces fewer firms to make new investment (that is ε_0 shifts to the right). This exerts a further pressure down on wages in poor countries (and attracts less capital from rich countries).

Consider now the possibility of establishing a new firm. Suppose that the newcomer entrepreneur does not know in advance the productivity factor (ε) of the potential firm. She therefore takes $G(\cdot)$ as the probability distribution of the productivity factor of the new firm. The expected value of the new firm is therefore the maximized value (over K and L) of:

$$\bar{V}(w, r) \equiv \int_{-1}^{\bar{\varepsilon}} \max \left\{ \max_{\{K,L\}} \left[\frac{F(K, L)(1+\varepsilon) - wL + (1-\delta)K}{1+r} - C - K \right], 0 \right\} g(\varepsilon) d\varepsilon,$$

where C is the setup cost of establishing a new firm and that ε is revealed to the firm before it decide whether or not to make new investment. The lower wage (per effective labor) in the poor country makes the expected value of a new firm higher. Therefore:

$$\bar{V}(w^*, r^*) < \bar{V}(w, r).$$

[4] Evidently, if capital mobility is not as perfect as in the model, the rich country will continue to make new investment (that is, $\varepsilon_0^* < \bar{\varepsilon}$).

(Recall that $r = r^*$.) Thus, the poor country attracts more new firms. Assuming that newcomer entrepreneurs evolve gradually over time, eventually this process may end up with full factor price equalization. Naturally, the capital-labor ratios and $L \equiv \tilde{L}/N$ are equalized in this long-run steady state. All this happens even though labor is not internationally mobile. The establishment of new firms in the global economy may be an engine for FDI flows by multinationals, due to setup-cost advantage over domestic investors in the host country.

Generally speaking, firms will enter so that in the long-run equilibrium the number of workers per firm will be the same in both countries, and so will be the capital stock per worker. During the transition to this long-run equilibrium, wages remain unequal and FDI flows from the rich country to the poor country.

Our two-country model, which generates capital flows from the rich to the poor country, can be exstened in two ways. First, by assuming more than one industry, each country may have a setup-cost advantage in a different industry. Concequantly, we can have two-way FDI flows. Second, we may also consider an n-country model which gives rise to $n(n-1)$ potential bilateral flows.[5]

5 The Econometric Approach

The proceeding section presents a model of capital mobility distinguished by setup costs of investment. In the model an important vehicle, through which capital flows from one country to another, is foreign direct investment (hereafter: FDI), taking place either in order to acquire existing firms and investing in them (Mergers and Acquisitions FDI), or to establish new firms (Greenfield Investment FDI). Our empirical investigation is in the

[5] Helpman, Melitz and Yeaple (2003) pose the question of how a source country can simultaneously make both FDI and exports to the same host country. Their answer rests on productivity heterogeneity within the source country, and differences in the setup costs associated with FDI and exports. Their explanation is thus geared toward firm-level decisions on exports and FDI in the source country.

tradition of the often used gravity models,[6] with our adjustments for a selection bias into *source* and *host* countries. With n countries in the sample, there are potentially $n(n-1)$ pairs of source-host $(s-h)$ countries. In fact, as we show in the data section below, that the actual number of $s-h$ pairs is much smaller, less than thirty percent of the potential number. Therefore, the selection into $s-h$ pairs, which is naturally *endogenous*, cannot be ignored; that is, this selection cannot be taken as exogenous, which is the standard practice in most gravity models.

Denote by $Y_{i,j,t}$ the flow of FDI from source country i to host country j in period t. FDI flows from source country j to host country i are denoted by $Y_{j,i,t}$. Note that with this notation, $Y_{i,j,t}$ is always non-negative. But, it may well be zero, because typically, in a global economy, there are only a few countries which significantly export FDI.

The existence of a setup cost of investment makes investment "lumpy". This means that the conventional determinants of FDI flows (such as rate of returns differentials) have to be strong enough in order to generate a large FDI flow that surpasses a certain threshold. Otherwise, the observed FDI flow is practically zero. We argue that the sub-sample of FDI source countries is not a random sample of the countries global economy, if setup costs play a significant role in the determination of FDI flows. We now develop a simple econometric approach to study the effect of setup costs and correct for selection bias in the analysis of FDI flows.[7]

[6] Gravity models postulate that bilateral international flows (goods, FDI, etc.) between any two economies are positively related to the size of the two economies (e.g., population, GDP), and negatively to the distance (physical or other such as tariff barriers, information asymmetries, etc.) between them. For instance, using population as the size variable, Loungani, Mody and Razin (2002) find that imports are less than proportionately related to the host country population, while they are close to proportionately related to the source country population. Correspondingly, FDI flows increase by more than proportionately with both the source and the host-country populations.

[7] Correction for selection bias is rare in international economics literature. A notable exposition is Broner, Lorenzoni and Schmukler (2003) who applied the Heckman selection model in estimating the average maturity of sovereign debt. They take into account the incidental truncation of the data, since the average maturity is available only for countries which issue bonds to the world market. The missing observations cannot be treated as zero maturity. They show, as expected, that countries with weak macro

5.1 FDI Flows and the "Participation" Equation

To simplify, but without losing generality, let us assume that, in a world with *no setup costs,* potential FDI flows exhibit the following linear form:

$$Y_{i,j,t} = X_{i,j,t}\beta + U_{i,j,t}, \tag{14}$$

where $X_{i,j,t}$ stands for a vector of observed variables, such as per-capita income differentials between country i and country j (reflecting differences in the capital-labor ratio) that potentially can explain the pattern of FDI flows, excluding the effect of setup costs. The vector β is the *ceteris paribus* effect of $X_{i,j,t}$ on $Y_{j,i,t}$. The error term $U_{i,j,t}$, is a composite of (i) an unobserved time-invariant heterogeneity factor $(\theta_{i,j})$, and (ii) a i.i.d. random shock term which is i-j pairwise-specific $(\eta_{i,j,t})$, reflecting fluctuations in macroeconomic policy, political events, etc., that are unique to the i-j pair. That is:

$$U_{i,j,t} = \theta_{i,j} + \eta_{i,j,t}, \tag{15}$$

Let $Z_{i,j,t}$ be a *latent* variable, indicating the maximized profit (hereafter: π) from the direct investment made in host country j, by a firm in the source country i , in period t.

Following our model we allow $Z_{i,j,t}$ to be determined by setup costs $(C_{i,j} + c_{i,j,t})$, in addition to $X_{i,j,t}$ and $(\eta_{i,j,t})$. Note that the setup costs consist of two elements: (a) time- invariant costs $(C_{i,j})$, reflecting persistent features of the $i-j$ pair, such as language, geographical distance etc., and (b) time-variant setup costs $(c_{i,j,t})$, such as communication and transportation costs. We assume that the vector $Z_{i,j,t}$, as a function of $X_{i,j,t}$, exhibits the following linear form:

$$Z_{i,j,t} = X_{i,j,t}\alpha + V_{i,j,t}, \tag{16}$$

where the vector α is the *ceteris paribus* effect of $X_{i,j,t}$ on $Z_{i,j,t}$. Note that in the case where $X_{i,j,t}$ affects the value of maximized profit, the same way as it influences $Y_{i,j,t}$ in equation (**??**) , then $\alpha = \beta$. The error term $V_{i,j,t}$, in the profit equation, is a composite of

economic stance are less likely to issue bonds. In this case the problem reduces to be the standard Tobin model.

(i) the unobserved setup costs $(C_{i,j} + c_{i,j,t})$ and (ii) the pairwise-specific π shocks $(\nu_{i,j,t})$:

$$V_{i,j,t} = -C_{i,j}(\theta_{i,j}) + \nu_{i,j,t}, \tag{17}$$

where $\nu_{i,j,t} = \eta_{i,j,t} - c_{i,j,t}$. We further assume that, for a *random* sample, the classical assumptions regarding the error term do hold. In particular, we assume that:[8]

$$\begin{aligned} E(U_{i,j,t} \mid X_{i,j,t}) &= E(U_{i,j,t}) = 0 \\ &\mathit{and} \\ E(V_{i,j,t} \mid X_{i,j,t}) &= E(V_{i,j,t}) = 0 \end{aligned} \tag{18}$$

It follows from equation (**??**) and equation (**??**) that:

$$cov(U_{i,j,t}, V_{i,j,t}) > 0. \tag{19}$$

Now, according to our model, FDI flows $(Y_{i,j,t})$ are positive, if and only if $Z_{i,j,t} > 0$. Denote by

$$D_{i,j,t} = \left\{ \begin{array}{lll} 1 & if & Z_{i,j,t} > 0 \\ 0 & otherwise. & \end{array} \right\} \tag{20}$$

Note that whereas $Z_{i,j,t}$ *is not* observed, the binary variable $D_{i,j,t}$ *is* indeed observed .

The fundamental parameters of interest in our analysis are β and $C_{i,j}$.

5.2 Setup Costs and Selection Bias

The population regression function for Equation (**??**) is:

$$E(Y_{i,j,t} \mid X_{i,j,t}) = X_{i,j,t}\beta \tag{21}$$

Many previous studies aimed at estimating the effects of X on Y in the context of international capital mobility (and also, similarly, in the context of goods mobility through international trade) typically ignore the effect of unobserved setup costs on the observed capital flows. However, the regression function for the *sub-sample* of countries, for which we do indeed observe positive FDI flows is :

$$E(Y_{i,j,t} \mid X_{i,j,t},\ D_{i,j,t} = 1) = X_{i,j,t}\beta + E(U_{i,j,t} \mid X_{i,j,t},\ D_{i,j,t} = 1) \tag{22}$$

[8] At this stage we ignore serial correlation in the error terms.

Note that the last term is no longer equal to zero. Furthermore, the term $E\left(U_{i,j,t} \mid X_{i,j,t},\ D_{i,j,t}=1\right)$depend on $X_{i,j,t}$, unlike the classical assumptions concerning regression functions applied to random samples.

To see this more clearly, one can substitute equations (**??**) and (**??**)into (**??**) , to get:

$$E\left(Y_{i,j,t} \mid X_{i,j,t},\ D_{i,j,t}=1\right) = X_{i,j,t}\beta + E\left[\left(\theta_{i,j}+\varepsilon_{i,j,t}\right) \mid X_{i,j,t},\ \left(-C_{i,j}-c_{i,j,t}+\varepsilon_{i,j,t}\right) > -X_{i,j,t}\alpha\right] \tag{23}$$

Now, one can verify directly from Equation (**??**) that the OLS estimator for β is indeed biased.

Figure 1 provides the intuition. Suppose, for instance, that $X_{i,j,t}$ measures the per-capita income differential between the ith source country and the jth potential host country, holding all other variables constant, namely per-capita income differentials between the ith source country and all the rest of the countries. Our theory predicts that parameter β is positive in this case. This is shown by the upward sloping line AB. Note that this slope is an estimate of the "true" underlying effect of $X_{i,j,t}$ on $Y_{i,j,t}$. But, recall that flows could be equal to zero if the set up cost are sufficiently high. The capital-flow threshold derived from the setup costs is shown as line TT' in Figure 1.

However, recall that the data include only those country pairs for which $Y_{i,j,t}$ is positive. This sub-sample is, therefore, no longer random . Moreover, as Equation (**??**) makes clear the *selection* of country pairs into this sub-sample depends on the vector $X_{i,j,t}$.

To see this, suppose, for instance, that for high values of $X_{i,j,t}$ (the specific level X^H in Figure 1) i-j pair-wise FDI flows are all positive. That is, for all pairs of countries potential $Y_{i,j,t}$ are higher than the threshold line. Thus, the observed average, for $X_{i,j,t} = X^H$ is also equal to the conditional population average, point R on the line AB. However, this does not hold for low values of $X_{i,j,t}$ (denoted by X^L). For those i-j pairs we observe positive values of $Y_{i,j,t}$ only in a non-random sample of the population. For instance, point S is excluded from the observed sub-sample of positive FDI flows. consequently, as predicted by our model, we observe only those with low setup cost (namely high $V_{i,j,t}$), among those with low $X_{i,j,t}$ .As seen in Figure 1, the observed conditional average is at point $M^{'}$, which lies above point M. The sub-sample OLS regression line is shown by the line $A^{'}B^{'}$, which understates the influence of the income per capita differentials on the flows of FDI.

To overcome the selection bias we employ a variation of the standard Heckman's selection model (Heckman (1979)) extended to the analysis of panel data (Kyriazidou (1996)). In the first stage we use a Probit analysis to estimate the Participation Equation, namely the likelihood of having positive FDI flows in our sample. In the second stage, we use estimates of unobserved set up costs are used to correct for selection bias in the estimates of the effect of the per-capita income differentials on FDI flows.

As standard in the literature, we assume that the i-j pairwise-specific errors $(\nu_{i,j,t})$ in the π equation are distributed normally. That is:

$$\nu_{i,j,t} \sim N\left(0,\ \sigma^2\right). \tag{24}$$

Then, the probability of surpassing the FDI-flow threshold (for the Probit) exhibits the following form:

$$\Pr(D_{i,j,t} = 1 \mid \cdot) = \Phi\left(X_{i,j,t}\alpha + \delta_{i,j}F_{i,j}\right), \tag{25}$$

where

$$F_{i,j} = \left\{ \begin{array}{ll} 1 & \text{if } i \text{ is the source country and } j \text{ is the host country} \\ 0 & \text{otherwise} \end{array} \right\}$$

We estimate Equation (**??**) by controlling for fixed-effects. Finally, the vector of estimated fixed-effects $(\delta_{i,j})$, from the Probit model, yields an unbiased estimator vector for the time-invariant element of the setup costs $(C_{i,j})$. Having these estimates, we get unbiased estimates of β, as well.

Figure 2 provides an intuition for our econometric strategy to back up estimates for the time invariant setup costs. On the horizontal axis we plot the error term in the π equation $(\nu_{i,j,t} - X_{i,j,t}\alpha)$. According to our model, there is a positive FDI flow from a source country i to a host country j, if and only if, $X_{i,j,t}\alpha - C_{i,j} - \nu_{i,j,t} > 0$. For both high and low values of $C_{i,j}$, there is a positive probability of observing FDI flows from source country i to host country j . However, the likelihood to observe a positive flow for high $C_{i,j}$ $\left(C_{i,j}^{H}\right)$ is lower than the likelihood for a medium-small $C_{i,j}$ $\left(C_{i,j}^{M}\right)$. Therefore, assuming that the stochastic properties of $\nu_{i,j,t}$ do not vary over time (in particular no serial correlation), it follows that the *frequency* of positive FDI flows between country pairs associated with $C^H_{i,j}$ is lower than the corresponding frequency associated with country pairs with $C^M_{i,j}$. Therefore, there exists a mapping from $C_{i,j}$ to the average $D_{i,j,t}$ (average over t) which can be used for estimating the time-invariant setup costs.

Summing up, our econometric approach yields unbiased estimates of two classes of determinants of FDI flows: (1) the effect of income per-capita differentials on FDI flows, and (2) the effect of setup costs on FDI flows.

6 Data

Our data is drawn from a sample of 45 countries, both developing and developed countries, over the period from 1961 to 1998. The data on FDI flows are for the period from 1981 to 1998 only. The FDI data are based on the OECD reports of FDI exports from 12 OECD source countries to 45 OECD and non-OECD countries. To the best of our knowledge, the only countries in our sample which do exports FDI but we miss these data are Taiwan and Hong-Kong. We handle this issue in section 9.

We employ 3-year averages, so that we have six periods (each consisting of 3 years). The main variables we employ are: (1) standard country characteristics such as GDP or GDP per-capita, population, educational attainment, geographical longitude and altitude, language, road length per country's area, telephone lines per-capita, etc.; (2) $s-h$ pair data such as $s-h$ FDI flows, geographical distance, common language (zero-one variable), $s-h$ flows of goods, bilateral telephone traffic, etc. The appendix provides more information on the data: Table A1 describes the list of the 45 countries in the sample and whether observed in the sample (at least once) as a source or host country; Table A2 describes the sources for our data. It is worth emphasizing again that though we have 45 countries in the sample and potentially 45 x 44 = 1980 $s-h$ pairs (for each of the six periods in the sample), there are only 540 $s-h$ pairs (12 source countries and 45 host countries) with positive flows.

7 A First Look at the Selection Bias Problem in the Data

As was already pointed out, the selection of countries into $s-h$ pairs is a key feature in the data. Out of 1980 potential $s-h$ pairs, we observe only 540 $s-h$ pairs in the data over a long period of years from 1981 - 1998. Therefore, in this section we take a first look into the $s-h$ selection pattern.

Consider first the sample of actual observations consisting of 540 $s-h$ pairs, 12 source and 45 host countries. This sample exhibits an asymmetry in the (relatively small) number of source countries and (relatively large) number of host countries. Moreover, in this self-selected sample, not every source country exports FDI to all host countries. Do all host countries import FDI from all source countries? This question is answered in Figure 3, which depict the fraction of host countries that import FDI from x source countries, $x = 1, 2, ..., 12$. If the answer is in the positive, then we should find just one column equalling 45 for $x = 12$ and all other 11 columns being of zero height. But as Figure 3 suggests, only 9 of the 45 host countries import FDI from all 12 source countries. Similarly, Figure 4 depicts the fraction of source countries that export FDI to x host countries, $x = 0, 1, ..., 45$. The figure suggests that no source country exports FDI to all host countries. Furthermore, most source countries export to just one host country.

Given the selection of source and host countries, we next examine whether the number of host countries each source country exports to and similarly the number of source countries each host country imports from are random or depend on country characteristics. Figure 5 illustrates the role of GDP per capita in host countries. The 45 host countries are classified into (at most) twelve groups along the vertical axis, according to the number of source countries from which they import FDI. For each such group of host countries, the average GDP per-capita is depicted along the horizontal axis. The figure shows that the higher the per-capita GDP in a host country, the larger is the number of source countries it imports from. A similar pattern is found with respect to educational attainment: the higher the level of educational attainment in a host country, the larger is the number of source countries it imports from; see Figure 6. No such pattern is found with respect to the characteristics of the source countries. The twelve source countries are classified into (at most) 12 categories, according to the number of host countries they export to. (Each category is a number between 1 and 45.) The average GDP per-capita and the average educational attainment of the source countries in that category does not seem to affect the number of host countries in each category; see Figure 7 and 8.

8 Estimation

The dependent variable in all the gravity equations is the log of the FDI flows, deflated by unit value of manufactured exports.

As a benchmark, we simply estimate the gravity equation (**??**) as is. That is: (1) we employ only actually observed $s-h$ pairs, namely we employ the subset of 540 pairs (for each of the six periods in the sample); (2) we ignore the "participation" equation (25) which explains the endogenous selection of $s-h$ matches, namely "zeros" were inserted into the no-flow cells among the 540 cells. The rationale for inserting "zeros" is as follows. Generally, when one observes no FDI flows between a pair of countries, it could be either because the two countries do not wish to have such flows even in the absence of fixed cost or because setup costs are prohibitive for low flows. But in the benchmark case which ignores setup costs, cells with no FDI flows "truly" indicate zero flows. This is why we assume a one-dollar value (with the log equalling zero) as a common low value for the value of the FDI flows in the no-flow cells. (All other positive flows have logarithmic value much exceeding zero.[9])

The estimation results for this benchmark case are described in panel A of Table 1. We make three alternative specifications (I, II, III). The difference between the first two specifications is that the first one has GDP as one of the size (gravity) variables, whereas in the second one population is the size variable. Specification II includes also GDP

[9]We performed robustness tests by replacing the zeros by large negative numbers. The conclusions are not meaningfully changed.

per-capita as an explanatory variable. Two findings clearly emerge: first, the coefficients (elasticities) of the GDP variable (in the first specification) in both the host and source country and the GDP per-capita (in the second specification) in both the host and source country are positive and significant. Second, the elasticity is significantly larger for the source country. We also find that countries that share a common language has significantly more (50%) FDI flows between them than countries that do not share a common language. Likewise, the coefficient of distance is negative and significant. Specification III employs source/host ratios of GDP per-capita, population and educational attainment. Contrary to the premise that capital flows from rich to poor countries, the coefficient of GDP per-capita ratio is negative and very significant with this specification. Likewise, contrary to Lucas' explanation, the coefficient of the ratio of educational attainment is insignificant.

The benchmark case treats the selection of the 540 $s-h$ pairs as *exogeneous*. That is, it ignores the fact that 33 countries in the sample of 45 countries may have not chosen to export FDI because of economic factors. In addition, the benchmark case ignores the role that setup costs may have played in generating no-flow pairs: both by reducing the number of source countries to 12, and by causing some zero flows from the remaining 12 countries. We now study in two stages the role of setup costs in the sample selection of countries into $s-h$ pairs. We first expand the sample to include all 1980 potential $s-h$ pairs. At this stage, we still ignore setup costs and insert a low common value for the log of the FDI flow (namely, zero) in the no-flow cells. The findings are presented in panel B of Table 1. The characteristics of the host countries drastically lose their explanatory power. For example, the elasticity of FDI with respect to GDP in the host country (Specification I) drops from 0.727 to 0.207. Likewise, the coefficient of the variable of educational attainment in the host country drops from 0.153 to 0.045. The relevance of the source country characteristics declines too but not as much as that of the host country characteristics. Therefore, the source country characteristics become more important relatively to the host country characteristics. FDI flows between countries with a common language, which were 50% more than between other countries in the benchmark case, are now only 22% higher. Similar findings are found in Specification III.

This first stage corrects the anomaly found in the benchmark case in Specification III: now the coefficient of source-host GDP per-capita ratio is positive and significant; namely, capital flows from rich to poor countries. In addition, the source-host educational attainment ratio becomes significantly positive in line with Lucas' hypothesis. Nevertheless, the coefficient of the common language variable is paradoxically negative and significant.

Finally, the complete picture and especially the role played by the unobserved setup costs are brought to the limelights in the second stage. We do this by jointly estimating the maximum likelihood of the gravity equation (14) for the full sample of 1980 $s-h$ pairs and the participation equation (25), which arises because of the existence of setup costs. The unbiased estimates of the coefficients of the gravity equation are presented in panel A of Table 2. The coefficient of GDP per-capita of the source country (Specification II), which was positive and significant both in the benchmark case and in the first stage, becomes now in the full economic model negligible and insignificant. On the other hand, the effect of the level of educational attainment in the source country is now twice as large as in either the benchmark case or the first stage. Likewise, the magnitude of the effect of common language more than doubles relative to either the benchmark case or the first stage. A similar increase is observed for the distance variable. The effect of the source-host GDP per-capita ratio (Specification III) disappears now, whereas the effect of the source-host educational attainment ratio tripled in size.

The estimation results for the participation equation are reported in panel B of Table 2. Unlike in the gravity equation, the magnitude of the effect of GDP per-capita in the source country (Specification II) is now almost ten times as high as that of the host country. Furthermore, the effect of the educational attainment in the source country is barely significant. Also, the common language variable is insignificant, but the coefficient of the distance variable is negative and significant. Notice that the correlation between the error terms in the gravity and participation equations (ρ) is negative and significant. This means that if the actual probability of a pair of countries to be a source-host pair is larger than what is predicted for this pair by the participation equation, then the actual FDI flow between this pair of countries is smaller than what is predicted by the gravity equation.

9 Robustness for some missing FDI export data

So far our results are derived from the full sample of countries. As we have already pointed out, the FDI data are based on the OECD reports of FDI exports from 12 OECD source countries to 45 OECD and non-OECD countries. The fact that only 12 countries in our sample serve as source for FDI export may reflect miss-reporting problems rather than zero FDI exports.

To guard against the possibility that the results presented in section 9 reflect miss-reporting we re-estimate the model using the sub-sample of only the countries for which we have FDI export data. This sub-sample contains 12 OECD FDI exporting countries.

We report our findings in Table 3 and Table 4. As both tables make clear, our findings, concerning the role of country characteristics and $h - s$ pair characteristics, in both the gravity and the participation equation, hold for this sub-sample as well.

10 Interpretation

The finding that there is a significant correlation (ρ) between the error terms in the gravity and participation equations indicates that the formation of an $s - h$ pair of countries and the size of the FDI flow between this pair of countries are not independent processes. Furthermore, being negative, this correlation is consistent with the hypothesis of setup costs of investment. If the setup cost of forming a certain $s - h$ pair of countries is high, it is less likely for one to observe the formation of this pair. The error term in the participation equation is thus negative. But then the error term in the gravity equation is positive. The unobserved heterogeneity in the gravity equation is affected only by the marginal productivity of capital. However, the unobserved heterogeneity in the participation equation is affected both by the marginal productivity of capital and by the setup costs of investment. The negative correlation implies that source countries with low setup costs (and, therefore, with positive "errors" in the participation equation) are also source countries with high marginal productivity of capital (and, therefore, with negative "errors" in the gravity equation). Indeed, when we control for source and host country fixed-effect, the error terms turn to be positively correlated. In other words, once the invariant unobserved heterogeneity is taken into account we find the more a country is likely to become a source for FDI exports, the more FDI exports do flow from this country.

The benchmark case, which ignores the self-selection problem, provides no evidence for the commonly held view that capital flows from rich to poor countries, because the elasticity of FDI flow with respect to GDP per-capita in the host country was at least as high as that in the source country. Also, the benchmark case provides no evidence for Lucas hypothesis. In one case (Specification I and II) the elasticity of FDI flow with respect to educational attainment in the source country was positive and about equal to that in the host country. (Lucas' hypothesis suggests that this elasticity should be negative for the source country and positive for the host country). In another case (Specification III), the coefficient of the ratio of source-host educational attainment was not significantly different from zero. After correcting for the selection bias in the benchmark case, the coefficient of the ratio of source-host educational attainment (Specification III) is positive and significant.

If education, as measured by the average years of schooling is indeed a "good" measure for cross-countries differences in human capital then these findings are consistent with Lucas' hypothesis, however in a subtle way. On the one hand, in agreement with the Lucas' hypothesis, the higher the average years of schooling in a host country is, the more FDI exports flow into this country. On the other hand, it is worth noticing the it does not hold for the direction of trade. The higher the average years of schooling in a (potential) source country is the more likely this country is to export FDI flows. Hence, while FDI exports flow from educated into less educated countries, the higher the education level is the more FDI exports flow into the host countries.

11 Conclusion

The existence of setup costs of investment presents the firm with a twofold investment decision: whether to invest at all and how much to invest. Therefore, we estimate jointly a participation equation (the decision whether to invest at all) and a gravity equation (the decision how much to invest). We find that the error terms in these two equations are negatively and significantly correlated. The negative correlation suggests that source countries with relatively low setup costs are also those with high marginal productivity of capital. Indeed, controlling for source and host countries fixed (country) effect, the correlation between these errors terms turns out to be in fact positive. These findings provide supportive evidence for the existence and importance of setup costs of investment and especially to the different effects on the FDI flows of the marginal productivity and the setup costs conditions. We find that GDP per-capita differences between source and host countries are a significant determinant of the decision of whether to invest at all, but only marginal for the determination of the size of FDI flows. This suggests that capital does flow from rich to poor countries, but in a more subtle way than what may be inferred from the marginal productivity conditions. The evidence for the importance of setup costs of investment, and the subtle way in which the flow of capital from rich to poor countries, are consistent with our alternative reconciliation of the Lucas' Paradox.

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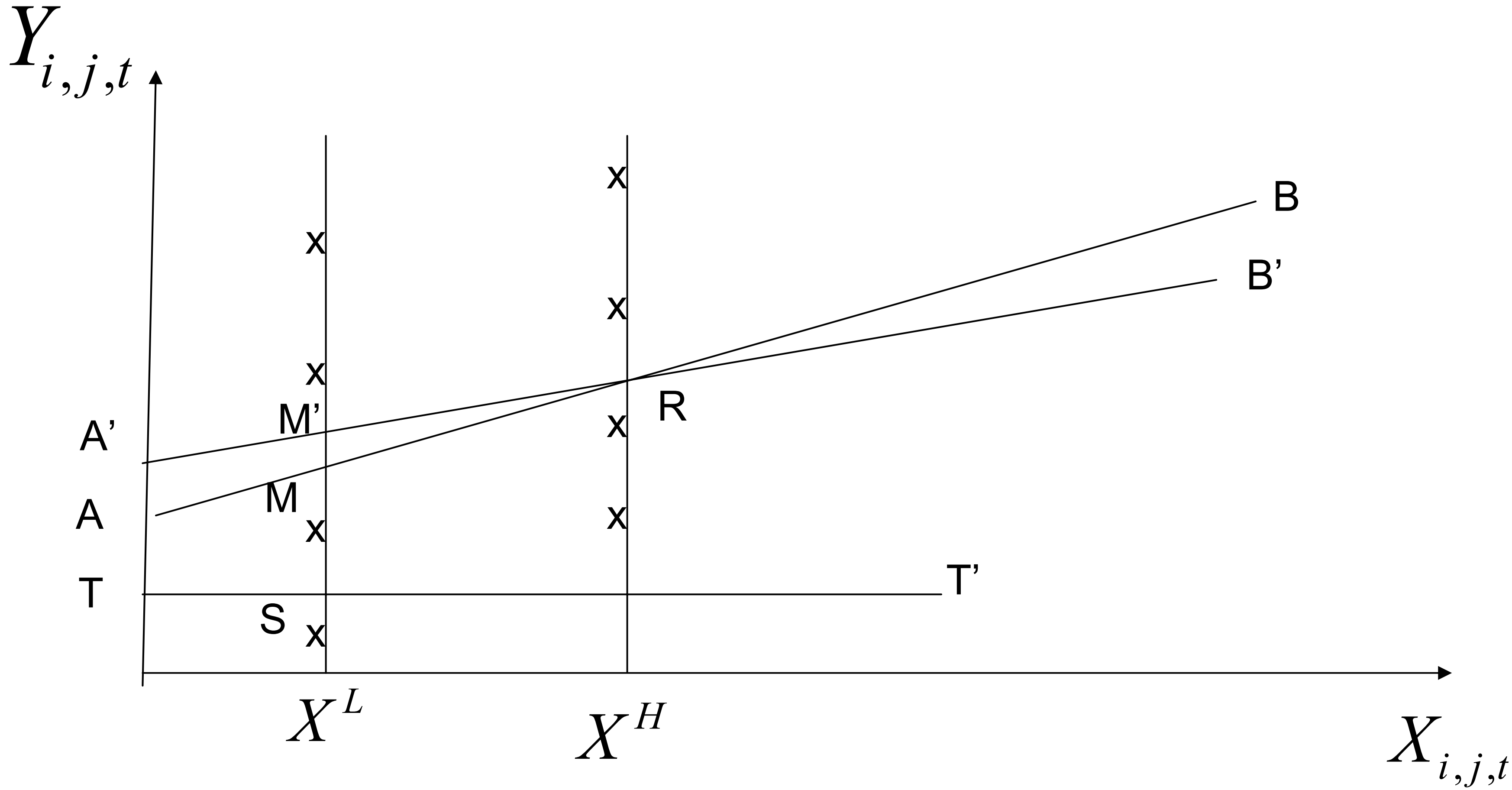


Figure 1: Selection Bias in the Presence of Setup Costs

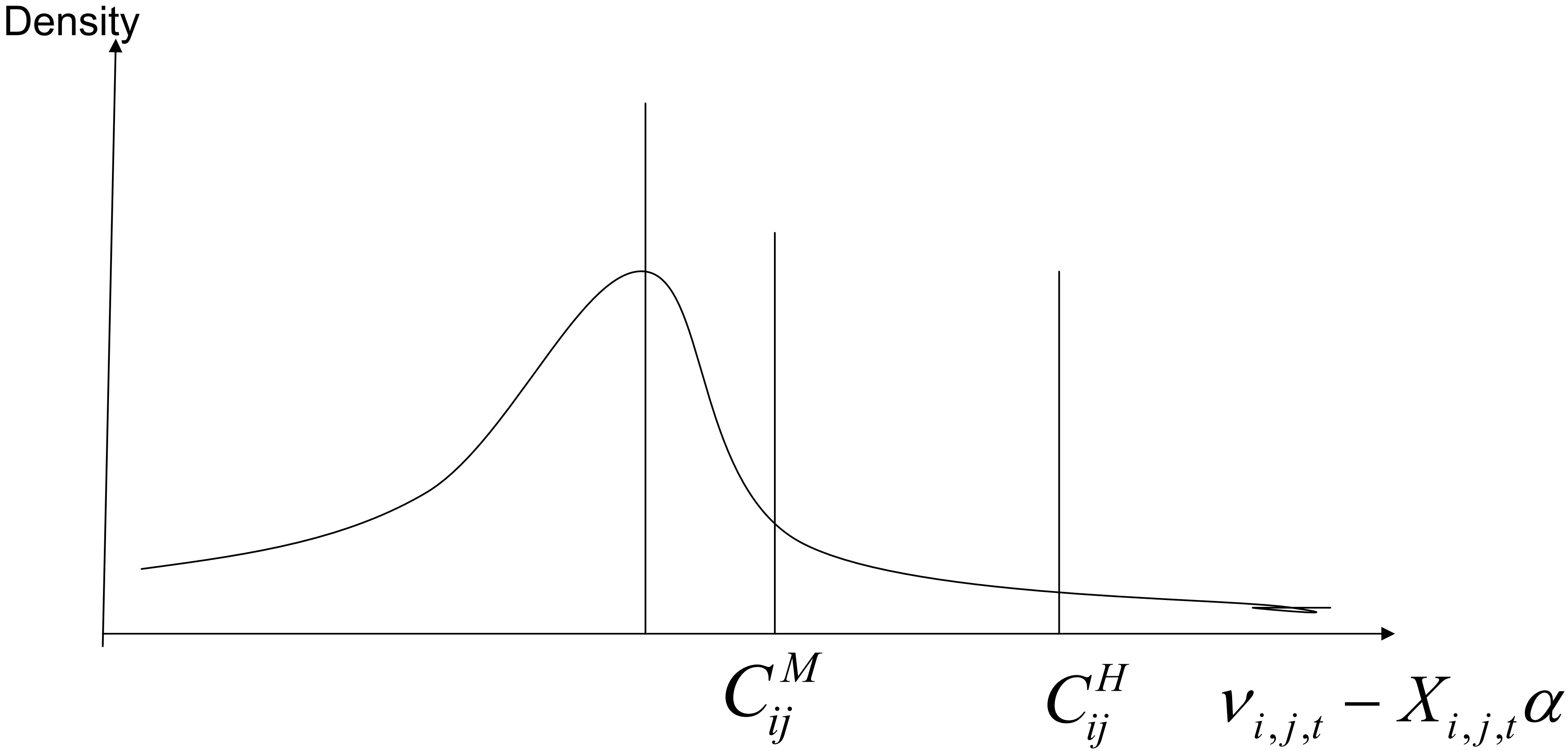


Figure 2: Backing Up Setup Costs

Figure 3:
The Fraction of Host Countries by
the Number of Source Countries Exporting Positive FDI Flows between 1981-98
Max. Number of Source Countries: 12
Total Number of Host Countries obs. = 270 (45 * 6)

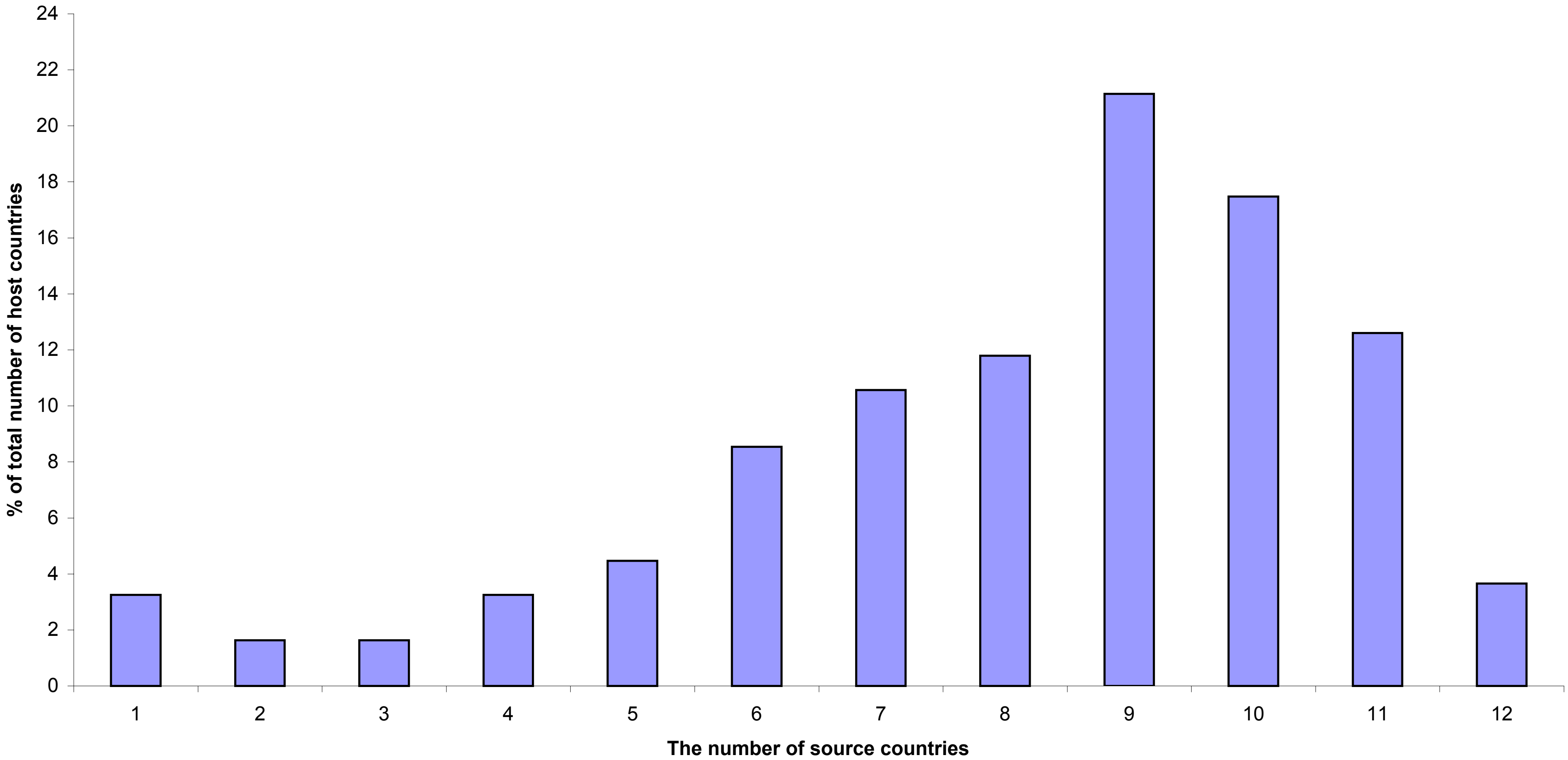


Figure 4:
The Fraction of Source Countries
by the Number of Host Countries Importing Positive FDI Flows between 1981-98
Max. Number of Host Countries: 45

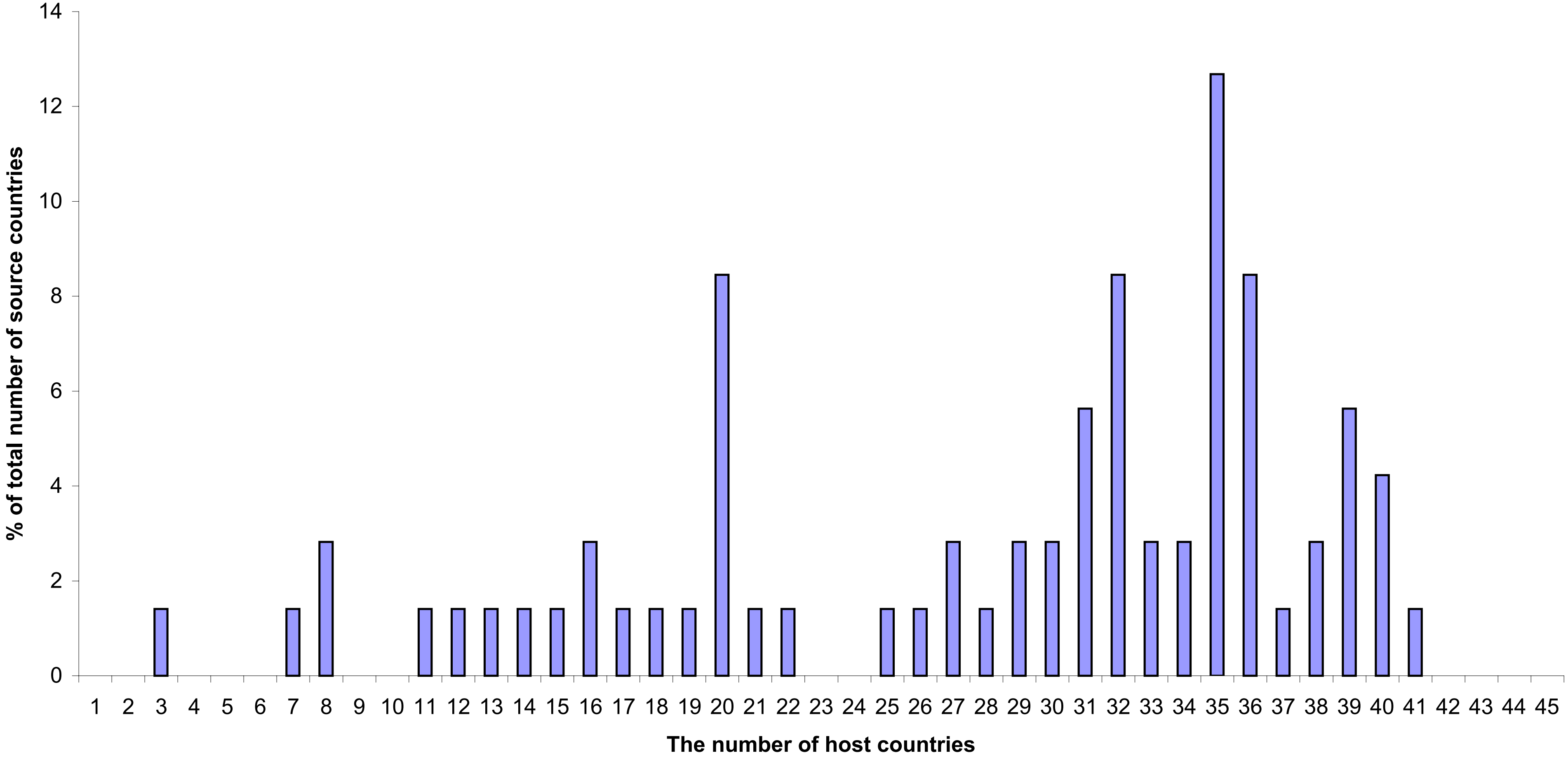


Figure 5:
The Number of Source Countries Exporting Positive FDI Flows by the GDP per Capita of the Host Country as Measured in 1981

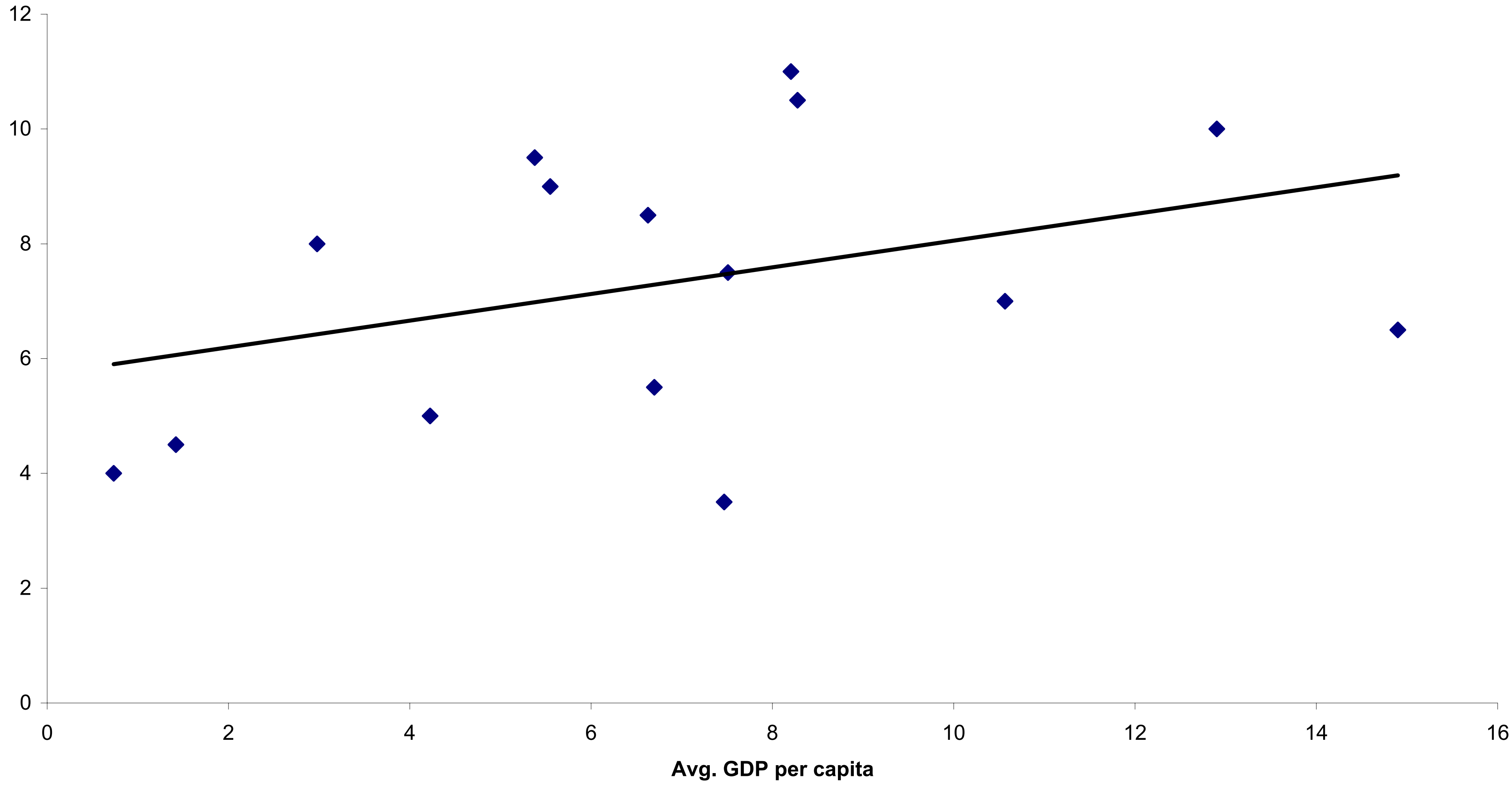
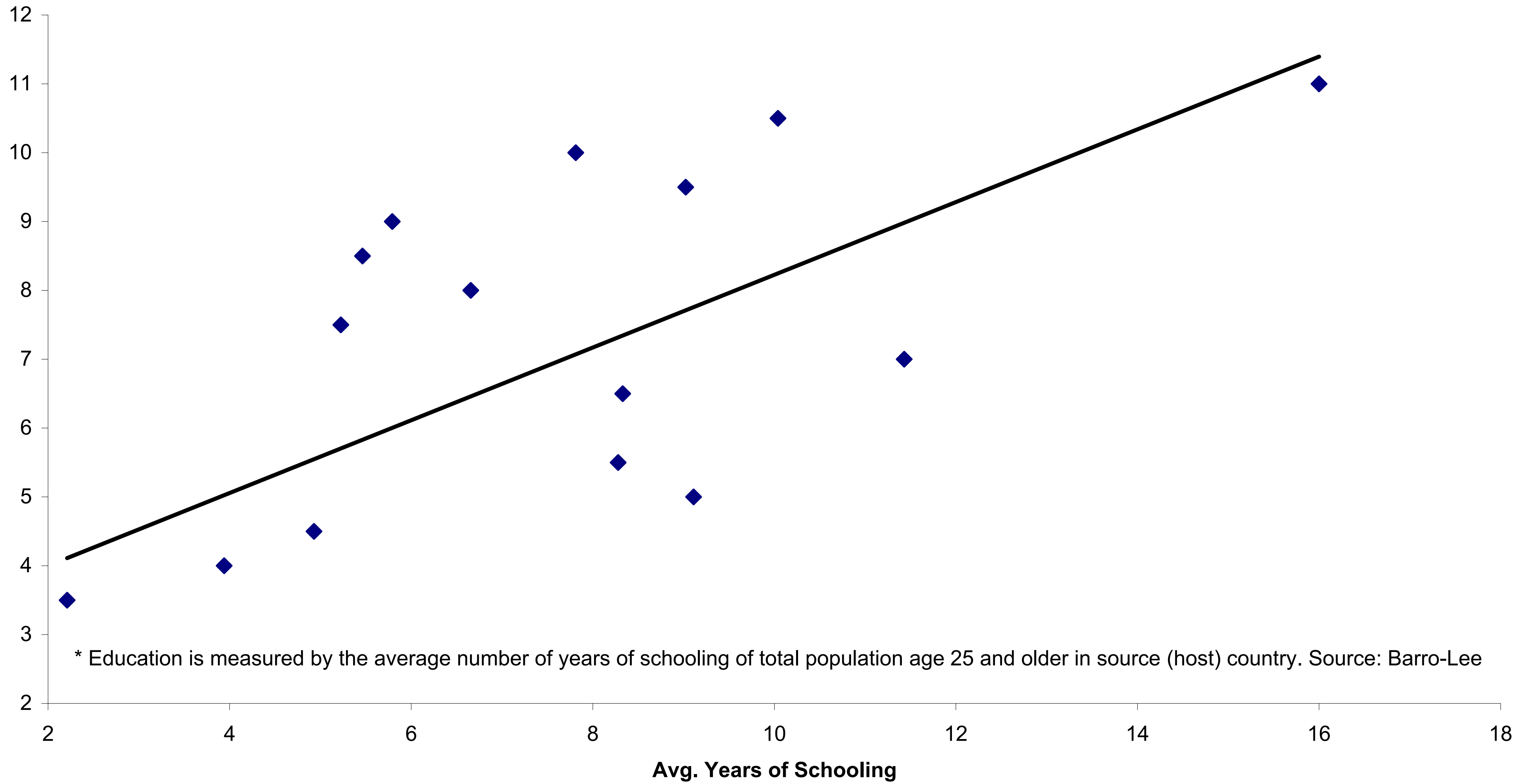


Figure 6:
The Number of Source Countries by the Average Years of Schooling in the Host Country*



* Education is measured by the average number of years of schooling of total population age 25 and older in source (host) country. Source: Barro-Lee

Figure 7:
The Number of Source Countries Exporting Positive FDI Flows by the GDP per Capita of the Host Country as Measured in 1981

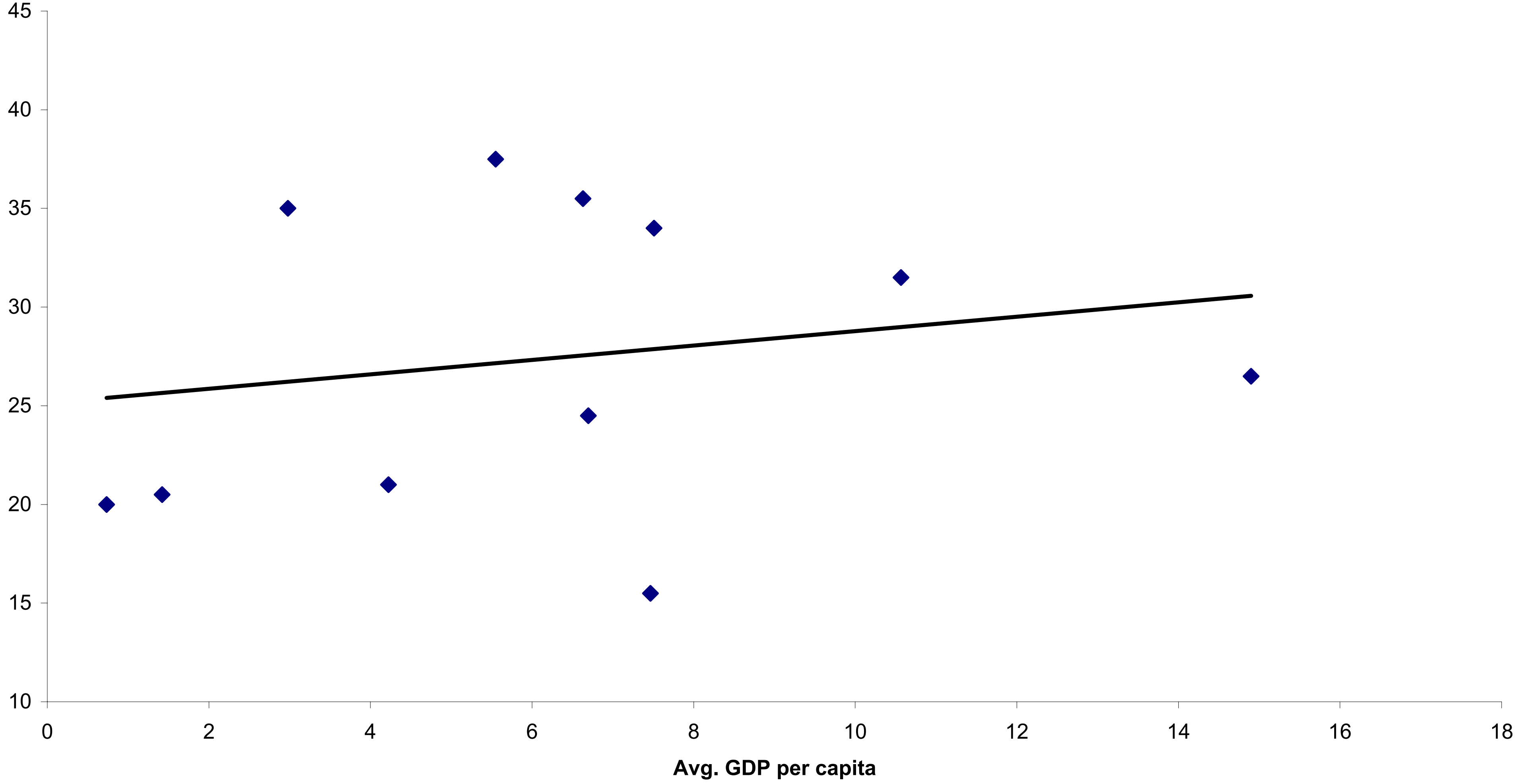
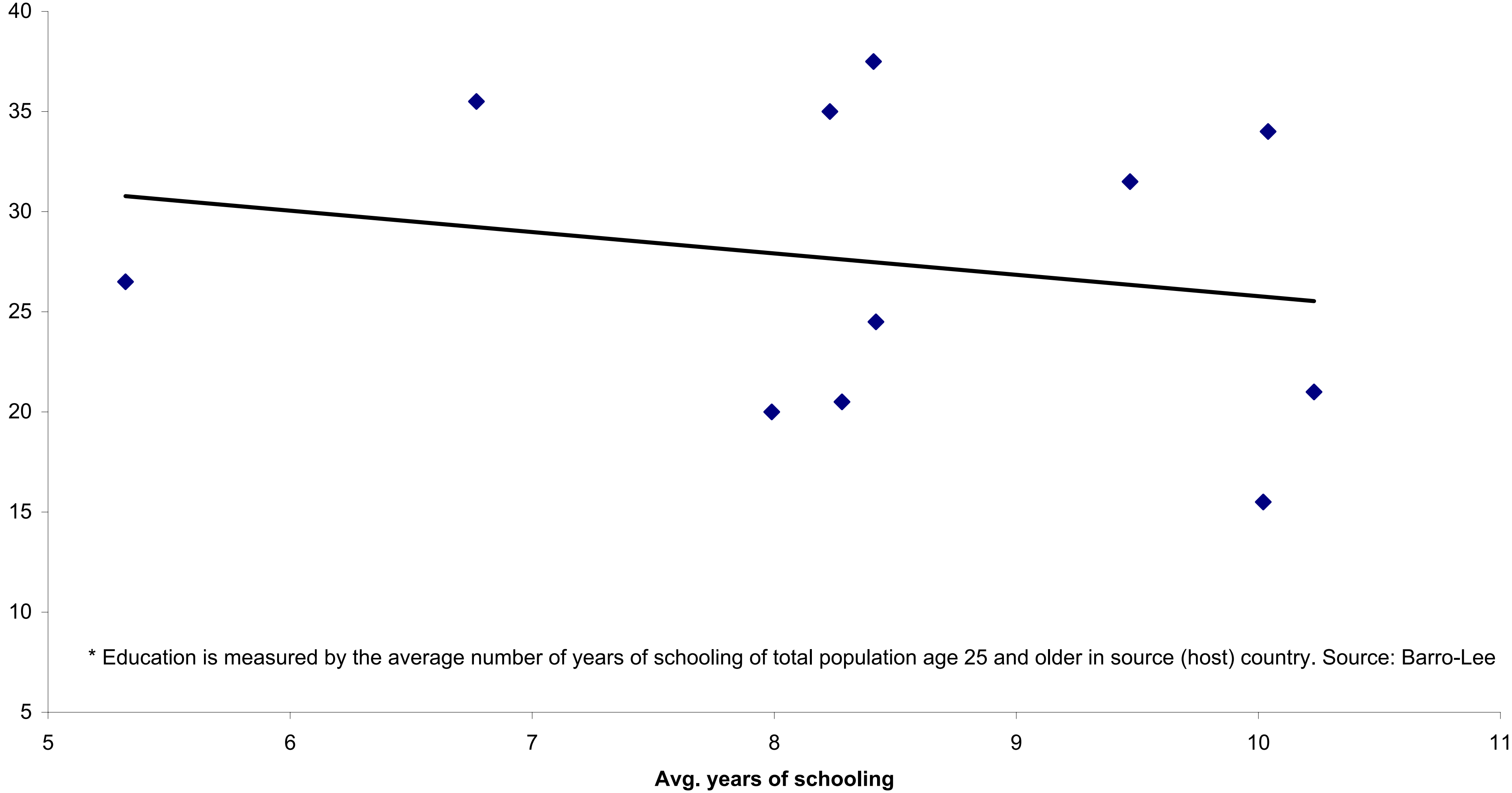


Figure 8:
The Number of Host Countries by the Average Years of Schooling in the Source Country*



* Education is measured by the average number of years of schooling of total population age 25 and older in source (host) country. Source: Barro-Lee

Table 1:
The OLS "Gravity" FDI Equation
Dependent variable: FDI (prices adjusted - in logs)

	Specification I		Specification II		Specification III	
	OLS*	OLS*^	OLS*	OLS*^	OLS*	OLS*^
Variables	(i)	(ii)	(iii)	(iv)	(v)	(vi)
GDP of the host country	0.727	0.207				
	(0.031)	(0.012)				
GDP of the source country	0.926	0.700				
	(0.033)	(0.012)				
GDP per capita - host			0.904	0.270		
			(0.053)	(0.019)		
GDP per capita - source			1.656	0.794		
			(0.169)	(0.019)		
S-H GDP per capita					-0.514	0.318
					(0.053)	(0.016)
Average years of schooling - host	0.153	0.045	0.074	0.019		
	(0.018)	(0.007)	(0.025)	(0.009)		
Average years of schooling - source	0.154	0.168	0.123	0.128		
	(0.026)	(0.007)	(0.026)	(0.009)		
S/H avg. school years ratio					-0.002	0.092
					(0.100)	(0.042)
Population - host			0.701	0.199		
			(0.032)	(0.012)		
Population - source			0.897	0.686		
			(0.034)	(0.012)		
S-H population gap					0.061	0.250
					(0.029)	(0.010)
Same Language	0.489	0.221	0.564	0.219	0.506	-0.130
	(0.089)	(0.032)	(0.091)	(0.032)	(0.110)	(0.039)
Distance	-0.005	-0.002	-0.004	-0.002	-0.002	-0.002
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Observations	2796	9843	2796	9843	2796	9843
Adj R-square	0.412	0.399	0.419	0.402	0.1074	0.0945

Note:
* Replacing missing values (log(0)) with zeros. (Bechmark case)
^ Including all possible S-H pairs. (Stage one)
All specifications include year fixed-effects.
( ) Standard errors in parenthesis

Table 2:
The Complete Gravity Model: FDI Flows and Selection into S-H Pairs
The Full Maximum-Likelihood

Variables	(i)	(ii)	(iii)
Panel A: Flows Equation: Dependent variable: FDI (prices adjusted - in logs)			
GDP of the host country^	0.624		
	(0.036)		
GDP of the source country^	0.567		
	(0.072)		
GDP per capita - host^		0.762	
		(0.054)	
GDP per capita - source^		0.002	
		(0.207)	
S-H GDP per capita gap^			-0.091
			(0.100)
Average years of schooling - host	0.151	0.087	
	(0.016)	(0.023)	
Average years of schooling - source	0.232	0.295	
	(0.029)	(0.025)	
S/H avg. school years ratio			0.298
			(0.112)
Population - host^		0.583	
		(0.036)	
Population - source^		0.557	
		(0.059)	
S-H population gap^			0.345
			(0.060)
Same Language	1.249	1.209	0.596
	(0.082)	(0.085)	(0.124)
Distance	-0.006	-0.006	-0.003
	(0.001)	(0.001)	(0.001)

Table 2:
The Complete Gravity Model: FDI Flows and Selection into S-H Pairs
The Full Maximum-Likelihood

Variables	(i)	(ii)	(iii)
Panel B: Selection Equation: Dependent variable: Positive FDI flows (=1)			
GDP of the host country^	0.162		
	(0.016)		
GDP of the source country^	0.755		
	(0.019)		
GDP per capita - host^		0.264	
		(0.030)	
GDP per capita - source^		1.928	
		(0.073)	
S-H GDP per capita gap^			0.398
			(0.015)
Average years of schooling - host	0.029	0.000	0.024
	(0.009)	(0.014)	(0.035)
Average years of schooling - source	0.265	0.058	
	(0.011)	(0.015)	
S/H avg. school years ratio			0.000
			(0.000)
Population - host^		0.174	
		(0.018)	
Population - source^		0.673	
		(0.020)	
S-H population gap^			0.244
			(0.010)
Same Language	-0.044	0.024	-0.298
	(0.045)	(0.049)	(0.036)
Distance	-0.003	-0.001	-0.002
	(0.000)	(0.000)	(0.000)
rho	-0.501	-0.585	0.657
	(0.094)	(0.077)	(0.082)
sigma	1.580	1.610	2.408
	(0.055)	(0.056)	(0.149)
lambda	-0.791	-0.943	1.582
	(0.174)	(0.154)	(0.294)
Observations	9843	9843	9843
Log likelihood	-5554.4	-5276.1	-7524.5

Note:
^ in logs
All specifications include year fixed-effects.
( ) Standard errors in parenthesis

Table A2: Data Source

Variables:	*Source:*
Import of Goods	*Direction of Trade Statistics*, IMF
FDI Inflows	*International Direct Investment Database*, OECD
Unit Value of Manufactured Exports	*World Economic Outlook*, IMF
Population	*International Financial Statistics*, IMF
GDP	*World Development Indicators*, World Bank
Distance	Shang Jin Wei's Website: www.nber.org/~wei
Bilateral Telephone Traffic	*Direction of Traffic: Trends in International Telephone Tariffs*, International Telecommunications Union
Education Attainment	Burro-Lee Dataset: www.nber.org/N...
Roads	…..
Language	…..
Longitude and Altitude	….

Table A1: List of Countries, by Observed Source/Host Status

Country	Observed as Source[1]	Observed as Host
Argentina	+	+
Australia	+	+
Austria	+	+
Belgium		+
Brazil		+
Canada	+	+
Chile		+
China		+
Columbia		+
Denmark		+
Ecuador		+
Egypt		+
Finland		+
France	+	+
Germany	+	+
Greece		+
Hong Kong		+
India		+
Ireland		+
Israel		+
Italy	+	+
Japan	+	+
Korea		+
Kuwait		+
Malaysia		+
Mexico		+
Netherlands	+	+
New Zealand		+
Nigeria		+
Norway	+	+
Peru		+
Philippines		+
Portugal		+
Saudi Arabia		+
Singapore		+
South Africa		+
Spain		+
Sweden	+	+
Switzerland		+
Taiwan		+
Thailand		+
Turkey		+

United Kingdom	+	+
United States	+	+
Venezuala		+

[1]We have information on whether a country is a source country only for OECD countries.