High Tech Foreign Direct Investment and its Impact on Gross Domestic Product in Developing Countries.

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Abstract

Recent empirical studies concerning the impact of foreign direct investment (FDI) on the economic performance of developing countries have all been taking into account FDI as a whole. However, the theoretical literature on the topic argues that more attention should be devoted to distinguishing FDI by type, and suggests that FDI with high technological content play a peculiar role. This paper investigates the existence and the magnitude of this peculiar effect. This is a cross sectional study of (approximately) 30 developing countries, for which we estimate two equations. In the first, the share of high tech FDI is regressed on population and average years of schooling, as proxies for the resource endowments of the host country, and on inflation, as proxy for the degree of macroeconomic uncertainty affecting that particular country. In the second, we regress the level of per capita GDP on the share of high tech FDI. We find strong evidence that countries with larger factor endowments, in terms both of population and the stock of human capital, and countries that enjoy lesser uncertainty, are able to attract more FDI with a higher technological content. We also find some evidence pointing towards a positive relationship between the share of high tech FDI and the level of per capita GDP in the host country.

JEL classification: C31, F21, O14, O33, O57

1. Introduction

Among the various items that appear in National Accounts of countries across the world, one in particular has attracted increasing attention both by policy makers and academic scholars. This item is Foreign Direct Investment (henceforth FDI). Among the many issues that have been raised regarding FDI, two are of interest here: first, and foremost, is FDI a good or a bad thing for the economy of the host country, and then, quite naturally, given that even though with much controversy, many believe FDI to be a good thing, what are the factors that cause FDI.

To date, a large number of empirical studies have been carried out to try and shed some light on these issues, but, as it is so often the case with empirical research, its boundaries are being set by the limitations in the availability of data that are required to study the particular variable concerned. In the case of FDI, the area that those boundaries define, and that lends itself well to being investigated, is of pretty limited size. This is because countries, particularly those in the developing world, have only recently, in some cases very recently or not at all, started keeping records of FDI, as the latter becomes more widely recognized to be a quantity of crucial interest from the social, economic and policy making standpoints.

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It is probably because of these data limitations that a startling discrepancy has appeared between the empirical and the theoretical literature on FDI and its effects on the economies of the host countries. On one hand the theoretical literature has been stressing the heterogeneous nature of FDI's structure, particularly with respect to the type of technology embodied in the various components that make up FDI. For example, literature that belongs to the strand of the new, endogenous growth theories, has come up with models that establish a link between the degree of innovative and imitative activities, widely thought to be crucial of the economic performance of host countries, and the quality of technology that is transferred through FDI. Because of the data limitations discussed earlier, the empirical literature on FDI and economic growth, of which I shall provide a brief account presently, remains, to the best of my knowledge, totally silent on this topic. Indeed this literature invariably prefers to treat FDI in its entirety, as a scalar to be included in the cross sectional, time series or panel regressions that constitute the backbone of all these empirical studies.

The aim of this study is to fill the gap between the theoretical and empirical literature, by taking seriously the hints that the former has provided on the importance of distinguishing FDI by type according to the level of technology embodied in it. This is done by looking for empirical evidence both to support the suggestions made by the theory regarding the factors that spur FDI with high technological content, and on whether there exists a significant effect of the latter on the level of income that a receiving country has been able to achieve. The focus will be on developing countries, because the lack of significant R&D expenditures and consequent innovative activities in these countries, entails that transfers of technology through FDI may be a particularly important mode of getting them nearer to the technology frontier.

The paper is organized as follows: section 2 briefly reviews recent empirical literature on FDI and economic growth in developing countries; section 3 lays out the econometric model to be estimated and sketches the econometric challenges being faced in the estimation; section 4 details data, data sources and how the crucial variable "share of high tech FDI in total FDI" has been computed; section 5 illustrates the results of the estimation exercise, and finally section 6 mentions possible extensions and future line of work and draws conclusions.

2. A brief look at the existing empirical literature

Here we focus on the review of three papers that we feel are important precedents for this study.

The first is a cross-section study by Borensztein, De Gregorio and Lee (1998), which is the empirical section of a paper that also features an interesting growth model . These authors estimate the following basic equation:

$$g = c_0 + c_1 FDI + c_2 FDI * H + c_3 H + c_4 Y_0 + c_5 A$$

Where g is the rate of growth of per capita GDP, FDI is foreign direct investment and is measured as a ratio to GDP, $H$is the stock of human capital, Y_0 is initial GDP per capita and is meant to capture the role of the "catch-up" effect, and A is a group of control variables that are frequently included as determinants of growth in cross-country studies (see for an example, Barro and Sala-i-Martin, 1995, chp.12).

Borenzstein et al use a number of different data sources. For foreign direct investment, data come from an OECD publication, Geographical Distribution of Financial Flows to Developing Countries, while other national accounts data, such as the growth rate of income, initial income and government consumption are all taken from the so called Penn World Tables, by Summers and Heston. Finally, data on human capital are taken from Barro and Lee (1993), and consist of average years of male secondary schooling. The time interval considered is 20 years, from 1970 to 1989.

The main result of this study is that FDI is an important determinant of economic growth only when a country has a minimum threshold stock of human capital. In that case, the contribution to growth by foreign direct investment is found to be bigger than that of domestic capital.

The second, by De Mello (1999), estimates the impact of foreign direct investment on capital output, output and total factor productivity (TFP) by using both time series and panel data.

The second part of this study, the relevant one for our purposes, studies the impact of FDI on output and TFP growth by estimating the following two dynamic panel data equations:

$$x_h(t) = \theta_0 + \theta_1 FDI_h(t) + \theta_2 x_h(t-1) + \varepsilon_h(t)$$

Or, if unobservable country-specific growth determinants are to be taken into account, the term θ_0 becomes $\theta_{h,0}$, a time-invariant individual country effect term, to yield the following equation:

$$x_h(t) = \theta_{h,0} + \theta_1 FDI_h(t) + \theta_2 x_h(t-1) + \varepsilon_h(t)$$

In both equations, we have $x = y, k, TFP$, and $\varepsilon(t)$ is an error term. Because of the likely correlation between the regressors and the error terms, these equations are not estimated by using ordinary least squares, but by using instrumental variables. The instruments chosen are the lagged dependent variables and lagged values of the host country's per capita income as a share of the U.S. Per capita income. The study uses a sample of 32 countries that are divided into OECD and non-OECD countries. The period considered is 1970-90 and the source employed is the Summers and Heston data set.

The outcome of this analysis is a positive impact of FDI on output growth in all panels, and there is some evidence of substitutability between FDI and domestic investment. In more advanced economies, the more efficient technologies embodied in FDI may lead to a higher rate of technological obsolescence of the capital stock embodying older technologies. For the technological laggards, complementarity seem to prevail. This degree of complementarity suggests that those economies are either less efficient in the use of the new technologies embodied in FDI, or that the latter are not much more modern or productive than the ones existing in the recipient economy. Such findings call for further investigation of both what determines how much of technology is embodied in FDI, and of the effect of the extent of high tech FDI on the economic performance of the host country, particularly when the latter is a developing economy.

The last paper we want to review is by Nair-Reichert and Weinhold. This study has the merit of highlighting the serious problems that the kind of empirical work discussed here may suffer if some crucial aspects are not properly handled. In particular, these authors note that cross-section models, with their inherent lack of dynamic information, due to the complete absence of the time dimension, run a much increased risk of omitted variable bias. In other words ordinary least squares estimates can be biased in ways that are increasingly more difficult to predict, the more variables are included in the regression. Alternative estimation techniques, such as instrumental variable (IV) are often difficult to implement because of a lack of suitable instruments.

A further problem is that in a cross-sectional regression it may be difficult to understand which way the causation runs. Taking the case we are studying as an example, even if an equation that regressed FDI on output growth returned a positive coefficient for FDI, this fact alone would not imply yet that FDI causes growth, as it could well be the other way round. This problem is commonly known as

endogeneity bias. Both the omitted variable bias and the endogeneity bias can be ameliorated by taking the time dimension into account, that is, by making use of panel data. With panel data, the analyst may include lagged dependent variables which may help to control for both biases. Still, Nair-Reicher and Weinhold argue, even panel data models may not solve all the issues raised by cross-section analysis, particularly if the traditional panel data fixed effect estimator is used. The application of this methodology rests on imposing homogeneity assumptions on the coefficients of the lagged dependent variables when in fact the dynamics are heterogeneous across the panel. Their suggestion is to use an alternative method of estimation, which they call Mixed Fixed and Random Model for causality testing in panel data.
Here we do not review the technicalities of this method, as they are beyond the scope of this review. We prefer to concentrate on describing the data used and the results obtained. The data comprise a panel of 24 developing countries for the interval 1971 to 1995. The source is World Development Indicators by the World Bank, except from the data on human capital, which is taken from Nehru et al. (1994) and is average years of schooling.
As for their results, Nair-Reichart and Weinhold adopt the following strategy: in order to put the advantages of their methodology in sharp focus, they present results from a non-dynamic panel study, from a dynamic panel estimated with the traditional fixed effect estimator, and from a dynamic panel estimated with their own mixed fixed and random estimator. The latter shows that while it is possible to speak on the whole of a positive causal relationship between FDI and growth, it is also true that this effect is quite different across countries. The paper concludes by stressing the need for future research to concentrate on country specific determinants of this relationship between investment (both foreign and domestic) and growth.
In addition to these studies that come out of the economics field, there is a strand of literature in sociology, known as capital dependency theory, that also researches the effects of FDI on growth in developing countries. See section 2 of my earlier theoretical literature survey for a thorough review of these works.

3. The econometric framework

As already discussed in the introduction, I want to contribute to the literature just reviewed, by bringing to the fore, as a novel element, the importance of FDI with high technological content in the economic process. In order to do so, I construct the variable "share of high tech FDI in total FDI", which I call η for brevity.
I run regressions which are centered on η , and I then contrast these regressions with similar ones where the only change will be that FDI totals replace η. The latter regressions will look much like those in the papers reviewed in section 2.
As a result of this exercise, I hope to gather enough evidence to be able to claim that the higher the share of FDI which embodies high technology, as defined below, the greater the impact the latter has on economic performance.
The equations to be estimated and the econometric issues that they raise will be discussed in this section, while I will delay a detailed description of η and the other variables that appear in the regressions, to the next section 4 concerning the data, because the choices that I have made as for

which variables to include and how to construct them were partly dictated by data availability (or lack thereof) and will be better understood along with the description of the data itself.

As a point of departure, in order to derive the first regression, I want to test the claim made by Glass and Saggi (1998) that among the factors responsible for spurring FDI with high technological content in a given country, are resource endowments in that country and the magnitude of the cost disadvantage suffered by multinational firms in that country relative to domestic firms.

Following Romer (1990) I consider two types of resources. One is labor services, measured by counts of people, in this case the population of the country concerned. The second is the stock of human capital, as measured by average years of schooling in that country. As for the cost disadvantage facing multinational firms, I assume that it can be represented by macroeconomic uncertainty in the country of interest. I take the inflation rate to be a proxy for this variable and I measure it by the GDP deflator. Thus the ensuing regression looks as follows:

$$\eta_i = \alpha_0 + \alpha_1 \ln pop_i + \alpha_2 H_i + \alpha_3 \ln GDPdefl_i + \varepsilon_1 \qquad \text{(R1)}$$

Where *population* and *GDP deflator* are in logs, η is "share of high tech FDI stock in total FDI stock for the secondary sector", to be accurately defined in section 4, and H is average years of schooling. The αs are coefficients to be estimated and ε_1 is a random error term. The subscript $i = 1, ..., 29$ indexes the number of countries included in the sample, while time-wise, all the observation refer to 1990, unless otherwise indicated.

The second equation I want to estimate serves the purpose of measuring the impact of FDI on economic performance, the same way as the literature reviewed in section 2 above.

Because I deal with a cross section in a specific year (1990), and because all the data concerning FDI refer to stock and not flow, I do not employ the growth rate of output (g) as the dependent variable. The growth rate of output for 1990 does not carry a much meaningful relationship with FDI stock in 1990 , while, if I were to take an average growth rate over a period of time, the choice of the time interval would be arbitrary and likely to be detached from the time interval involving FDI stock data, since it is difficult to gauge precisely the time interval over which the stock of FDI was formed.

I instead employ the log of GDP per capita (in constant 1995 U.S. $) as the dependent variable. Hence the second equation of the model might look as follows:

$$\ln GDPprc_i = \beta_0 + \beta_1 \eta_i + \varepsilon_2 \qquad \text{(R2b)}$$

Where the βs are the coefficients to be estimated and ε_2 is a (different) random error term. However, an OLS estimate of the coefficient β_1 attached to η_i would not be unbiased, because we assumed η_i to depend on the regressors of the first equation, population, average years of schooling and inflation, which are also likely to have an effect on GDP per capita. As a result, one of the crucial assumptions for unbiased OLS estimation, that the regressor η_i and the error term ε_2 be uncorrelated, would no longer hold. In order to overcome this potential flaw, I employ 2SLS estimation instead, and use H_i (average years of schooling) as the instrument in the IV estimation process. Therefore, regression 1 (R1) as reported above, remains unchanged and constitutes the first step in the 2SLS estimation procedure, while the second equation to be estimated in place of (R2b) is now:

$$\ln GDPprc_i = \beta_0 + \beta_1 \ln pop_i + \beta_2 \ln GDPdefl_i + \beta_3 \eta_i + \varepsilon_2 \qquad \text{(R2).}$$

R2 differs from R2b in that the same two regressors that appeared in regression R1, logpop and loggdpdeflator, have been included in R2 too. In fact, the 2SLS estimation procedure makes it mandatory to have whatever instruments are chosen, to appear in the first stage regression as well. If not, the estimated coefficients will be, in this case too, biased.

We recall that our aim is to gather evidence for the economy-fostering role played by the quality of technology embodied in FDI rather than the absolute level of FDI per se. To achieve this end, the second step in our strategy is to go through the same estimation procedure as just explained, but to replace the variable η with FDI stock total throughout the two equations R1 and R2.
Such strategy should shed light on any difference that might exist between η and FDI stock total, when everything else in the regressions is held constant. I thus estimate the following two equations:

$$\ln FDIsss_i = \gamma_0 + \gamma_1 \ln pop_i + \gamma_2 H_i + \gamma_3 \ln GDPdefl_i + u_1 \qquad \text{(R1')}$$

$$\ln GDPprc_i = \delta_0 + \delta_1 \ln pop_i + \delta_2 \ln GDPdefl_i + \delta_3 \ln FDIsss_i + u_2 \qquad \text{(R2')}$$

Where all the variables are as in (R1) and (R2), except that now $\ln FDIsss$,standing for FDI stock total in secondary sector (in logs), has replaced the variable η , "share of high tech FDI in total FDI". The subscript i still indexes countries, while the reference year, unless otherwise indicated, is still 1990.
The next section, section 4, provides an ample and detailed description of the variables included in the regressions and of the data and data sources employed. Regression results will be illustrated in section 5.

4. Description of variables and data

Starting with (R1), the dependent variable in that equation is "share of high tech FDI in total FDI", in short η. The variable η can be thought of as the ratio "high tech FDI / total FDI". In order to compute the numerator of this ratio, I needed to find FDI data classified by sector in a way that would enable me to decide which sector is high tech and which one is not. The only source of FDI data that came close to satisfying such a requirement was the United Nations World Investment Directory Therefore I have relied heavily on this source for getting FDI data. A drawback of this strategy is that, for the most crucial variable of this study, matters such as sample size, which countries to include in the sample, which year to take as reference year, have all been determined by the availability of suitable data in this single data source.
The U.N. World Investment Directory (henceforth W.I.D.) classifies FDI data according to the U.N. International Standard Classification (ISIC) revision 3. This is a very detailed and accurate classification of economic activities, which makes the task of selecting the high tech sectors, to be included in the numerator of η, far easier. To illustrate, under the item "Manufacturing" (item D in ISIC rev. 3) the reader can find the whole array of manufacturing sectors, apparently put in ascending order of technological content, starting with item 15, "manufacture of food products and beverages", all the way down to end with such items as item 32, "manufacture of radio television and communication apparatus", item 33, "manufacture of medical, precision and optical instruments, watches and clocks", item 34, "manufacture of motor vehicles, trailers and semi-trailers", item 35, "manufacture of other transport equipment", and item 36, "other manufacturing".
In choosing the criterion for picking high tech investments, I was unable to find any guideline in previous studies. Therefore I adopted the following simple approach. Since the sectors in ISIC rev. 3 are classified in ascending order of technological content, the only issue remained where to put the boundary between what is high tech and what is not. I decided to consider as high tech, investments classified under item 29, "manufacture of machinery and equipment", to item 36, "other manufacturing", inclusive. I have also added the subcategory "pharmaceuticals, medical chemicals etc." (item 2423 in ISIC rev. 3)

which fell on the wrong side of the boundary, because I felt it was a sector requiring a sufficiently sophisticated know-how, to warrant a move to the high tech group.

Thus far I have talked about the ISIC Rev. 3 and the W.I.D. Classifications interchangeably. In fact the latter identifies the sectors of economic activity with a terminology that draws very heavily from ISIC Rev. 3, but nevertheless slightly differs from it. For our purposes it is sufficient to note that item D, "Manufacturing" of ISIC Rev. 3 is referred to as "Secondary sector" by W.I.D. All the sectors that precede this item are collected by W.I.D. under the term "Primary sector", while the sectors that follow item D, are grouped by W.I.D. under the term "Tertiary sector". This study sticks with the classifications and regroupings made by the W.I.D. Furthermore, since data for the primary and tertiary sector were not always available, I decided to base the computations on the figures from the secondary sector only. Hence, while the numerator of η, "high tech FDI", is computed with the criterion discussed above, the denominator, "total FDI", consists of the sum of FDI totals for the secondary sector.

Other important features concerning the variable η are as follows: the sample includes some 30 developing countries from three main regions: Latin America, East Asia and Eastern Europe. In the sample there are no countries from Africa or the Middle East, as I was not able to find any satisfactory data for those regions. Given the cross sectional nature of this study, I decided to work with FDI stock rather than flow, as the former gives a more accurate picture of past history for every given country. The data are mostly from 1990, the last year for which FDI stock for Latin America were available, so that the sample can include as many countries as possible. Where 1990 data were not available, I considered the year immediately preceding or following 1990. FDI stock data are often given as "approved FDI stock" and/or "actual FDI stock". The two sets of figures differ considerably. Because approved FDI data were more widely available than the actual data, I have chosen to use approved figures as much as possible, and resort to actual figures only when the former was not available.

The only countries for which I could find data for FDI stock both on an approved and actual basis, from the same source, were as follows:

Indonesia (secondary sector total 1994, in million U.S $): 65 (approved), 19 (actual)

Malaysia (secondary sector total 1990, in million ringgit): 35 (approved), 15 (actual)

The discrepancy between approved and actual figures does exist, as aknowledged also in the U.N. World Investment Directory:

"Many countries have a variety of sources for FDI data, including those collected by the central bank for balance-of-payment purposes and those collected by the board of investment or a similar institution for monitoring and investment promotion purposes…A typical occurrence is that data provided by those institutions are on approved FDI investments rather than on the investments actually implemented…In such cases, data on approved investments provide crucial information, but their limitations must be aknowledged. Normally, approved investments are larger than those actually implemented."

While I am ready to aknowledge the problems involved in using both approved and actual FDI data, I do know that this is the only way to keep the sample size from shrinking in a way that would make this study infeasible.

For a few countries (China, Mexico, Indonesia, Turkey), I could only find FDI totals for the secondary sector without the desired breakdown. In order to obtain a share, for these cases I employed as numerator data on "high tech manufacturing exports", from the World Bank[2]. Under the assumption that these are developing countries wherein not much high tech production originates from domestic capital,

[2] Since the high tech exports figure is a flow, the share η is computed by using FDI flow data (from the World Bank) as denominator.

the difference between high tech manufacturing FDI and high tech manufacturing exports ought, in theory, not to be large[3].
As for the other variables included in R1 and R2, data on population, GDP deflator (to measure inflation), and GDP per capita (the latter in 1995 constant U.S. $) all come from the World Bank publication “World Development Indicators” (various issues, but especially 2001). Finally the variable *H*, “average years of schooling”, comes from the Barro and Lee dataset on education.

5. Regression results

For the reasons discussed in section 3, I perform 2SLS estimation on equations R1 and R2, where R1 is the first stage of the estimation procedure, which goes on to feed R2 for the second stage.
The table below reports the regression results:

First-stage regressions:

Source	SS	df	MS
Model	.661869028	3	.220623009
Residual	.492606836	25	.019704273
Total	1.15447586	28	.041231281

Number of obs	= 29
F(3, 25)	= 11.20
Prob > F	= 0.0001
R-squared	= 0.5733
Adj R-squared	= 0.5221
Root MSE	= .14037

Eta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Logpop	.0500932	.0191941	2.61	0.015	.0105623	.0896241
Loggdpdefl	-.0481375	.0179456	-2.68	0.013	-.0850972	-.0111778
Avgyrsschg	.0560041	.0113109	4.95	0.000	.0327089	.0792994
Cons	-.7217486	.3375175	-2.14	0.042	-1.416879	-.0266184

[3] I made a check by comparing the share η by using both high tech manufacturing exports and W.I.D. High tech FDI data. Although the results are not fully satisfactory (the difference exists indeed), I still do it this way, both because without those countries the sample would be too small, and because this difference can be ascribed more to the fact that FDI flow figures used here are actual flows, while the FDI stock figures used to compute η using the W.D.I. Source are often approved figures, than to high tech exports not being a good proxy for high tech FDI in developing countries. Put simply, the discrepancy is due more to denominator than to numerator differences.

Instrumental variables (2SLS) regression:

Source	SS	df	MS
Model	11.9849866	3	3.99499555
Residual	15.5561078	25	.622244312
Total	27.5410944	28	.983610516

Number of obs = 29
F(3, 25) = 6.06
Prob > F = 0.0030
R-squared = 0.4352
Adj R-squared = 0.3674
Root MSE = .78882

lngdpprc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Eta	3.738888	1.134952	3.29	0.003	1.401411	6.076365
Logpop	-.4358863	.1159695	-3.76	0.001	-.6747299	-.1970427
loggdpdefl	.2050393	.1130794	1.81	0.082	-.0278521	.4379307
Cons	13.33255	1.818822	7.33	0.000	9.586616	17.07848

Instrumented: shareofhightechfdiinsecondarysec (eta)
Instruments: logpop loggdpdeflator averageyearsofschooling

The output for R1 (first stage regression) is entirely as expected. All the coefficients attached to the three regressors are statistically significant at the 5% level, and all carry the signs predicted by the theory. So the resources population and human capital have a positive impact on the share of high tech FDI, while the GDP deflator, which is a measure of macroeconomic instability, has a negative impact on η.

If we move on to R2, the crucial result there is that the impact of the share of high tech FDI on the level of per capita income is positive and significant at the 5% level. We also notice that population has a negative and significant impact on the level of GDP per capita, possibly because population itself appears in the denominator of GDP per capita, so that when total GDP is held constant, a rise in population causes a fall in GDP per capita. Finally, the coefficient attached to the GDP deflator is positive but significant at the 10% level only.

5.1 Sensitivity Analysis

Our next step is to check that these results do not change dramatically if we modify some of the choices that were made in the conception of this model. Our sensitivity analysis will consist of rerunning the regressions R1 and R2 after making the following three changes:

1) substitute the adopted concept of high tech FDI with a more restrictive one. This will consider as high tech only FDI falling into categories from “radio TV and communication equipment” to “other manufacturing” (see Appendix). Call this new share *Sharenumrestricted*. Such a change will serve the purpose of checking whether our definition of high tech FDI is robust to a different choice of categories to be included into it.

2) exclude from the sample the four countries for which high tech FDI had been calculated differently, by using high tech exports in the numerator. Call this one *Sharewithoutfour*. In this way, we check that those four countries are not responsible for altering the results of the study.
3) when computing the high tech FDI share η, use the value of high tech exports in place of high tech FDI for the whole sample, instead of just the four countries for which detailed FDI data were not available. We let this share be *Hightechshare2*. This procedure provides a check on the robustness of using alternative criteria when detailed FDI data are not available.

Sensitivity analysis table - first stage regressions

Dependent variable:	Eta (1)	Eta (2)	Eta (3)	Eta (4)
logpop	0.05 (.0191941) [2.61] {0.015}**	.0397928 (.0108156) [3.68] {0.001}**	.0631743 (.0191447) [3.30] {0.003}**	.6540076 (.6846081) [0.96] {0.350}
loggdpdeflator	-.0481375 (-.0481375) [-2.68] {0.013}**	.0030457 (.0101) [0.30] {0.766}	-.0548133 (.0172935) [-3.17] {0.004}**	-1.237861 (.6283344) [-1.97] {0.062}*
averageyrsofschooling	0.06 (.0113109) [4.95] {0.000}***	.0186577 (.0063699) [2.93] {0.008}**	.0496233 (.0110383) [4.50] {0.000}***	1.127187 (.4686839) [2.41] {0.025}**
Number of obs	29	27	26	25
F (Prob > F)	11.2 (0.0001)***	7.01 (0.0016)**	12.32 (0.0001)***	3.12 (0.0480)**
Adj R-squared	0.52	0.41	0.58	0.21

Sensitivity analysis table - Instrumental variables (2SLS) regressions

Dependent variable:	Lngdpprc (1)	Lngdpprc (2)	Lngdpprc (3)	Lngdpprc (4)
Eta	3.738888 (1.134952) [3.29] {0.003}**	11.80745 (5.860474) [2.01] {0.056}*	4.483534 (1.314594) [3.41] {0.003}**	.2371857 (.1006278) [2.36] {0.028}**
logpop	-.4358863 (.1159695) [-3.76] {0.001}***	-.7413428 (.2835016) [-2.61] {0.015}**	-.5599298 (.1383782) [-4.05] {0.001}***	-.4101693 (.1611384) [-2.55] {0.019}**
loggdpdeflator	.2050393 (.1130794) [1.81] {0.082}*	-.0318026 (.1751356) [-0.18] {0.857}	.2523171 (.1242024) [2.03] {0.054}*	.265017 (.1924444) [1.38] {0.183}
Number of obs	29	27	26	25
F (Prob > F)	6.06 (0.0030)**	2.28 (0.1058)	6.08 (0.0036)**	3.55 (0.0320)**
Adj R-squared	0.37	-	0.42	-0.08

*Notes: Tables show coefficient values with standard errors in round parentheses, t-statistic in square parentheses, and P-values in curly parentheses. The four regressions are one for each different eta: Eta (1) = from the basic model, eta (2) = Sharenumrestricted, eta (3) = Sharewithoutfour, eta (4) = Hightechshare2, as explained in the text. *=significant at 10%; **=significant at 5%; ***=significant at 1% level.*

A glance at the first stage regressions confirms signs and significance of coefficients in most cases. The exceptions are the coefficients of logpop in the eta (4) regression and of loggdpdeflator in the eta (2) case. It is especially important that the results regarding positivity and significance of coefficient go through for the human capital regressor represented by average years of schooling.

The second stage instrumental variable regression confirms positivity and significance of the coefficient attached to eta, the share of high tech FDI, measured in four different ways. This result, along with the one relative to human capital, confirms robustness of the double causal relationship from human capital to high tech FDI and from the latter to the level of GDP per capita that had been found in the basic R1 and R2 model.

5.2 Results when using FDI total instead of high tech FDI share.

The next step is to run regressions R1’ and R2’ and compare the output from that set of regressions with the results obtained for R1 and R2.

In the table below, we report the regression output for R1’ and R2’ together with the regression output for the R1 and R2 regressions, in order to facilitate comparison.

Comparison table - first stage regressions

Dependent variable:	Eta (R1)	Lnfdiss (R1’)
logpop	0.05 (.0191941) [2.61] {0.015}**	.6919342 (.3104) [2.23] {0.035}**
loggdpdeflator	-.0481375 (-.0481375) [-2.68] {0.013}**	-.1934593 (.2902107) [-0.67] {0.511}
averageyrsofschooling	0.06 (.0113109) [4.95] {0.000}***	.0545649 (.1829162) [0.30] {0.768}
Number of obs	29	29
F (Prob > F)	11.2 (0.0001)***	1.69 (0.1957)
Adj R-squared	0.52	0.07

Comparison table - Instrumental variables (2SLS) regressions

Dependent variable:	Lngdpprc (1)	Lngdpprc (2)
Eta (Lnfdiss)	3.738888 (1.134952) [3.29] {0.003}**	3.837508 (12.05882) [0.32] {0.753}
logpop	-.4358863 (.1159695) [-3.76] {0.001}***	-2.903897 (8.289389) [-0.35] {0.729}
loggdpdeflator	.2050393 (.1130794) [1.81] {0.082}*	.7674604 (2.523812) [0.30] {0.764}
Number of obs	29	29
F (Prob>F)	6.06 (0.0030)**	0.06 (0.9819)
Adj R-squared	0.37	-

Notes: in the R1-R2 regressions (central column) instrumented is shareofhightechfdiinsecondarysec (eta), Instruments are: logpop loggdpdeflator averageyearsofschooling; in the R1’-R2’ regressions (last column) instrumented is lnfdiss, instruments are logpop loggdpdeflator averageyearsofschooling. Information regarding coefficient values, standard errors etc. and significance levels is provided the same way as in the sensitivity analysis table.

This result is completely different from the previous one. In the first stage regression, among the three regressors, population is the only one that retains its positive and significant impact, while the coefficients attached to human capital and inflation are no longer significant at any level. Even more importantly, in the second stage regression none of the regressors has any significant impact on the level of GDP per capita, least of all the total FDI stock of the secondary sector.

The message is at the same time startling and clear: the double positive relationship that feeds from resources endowments (particularly human capital) and macroeconomic stability into foreign direct investment and from the latter into the level of per capita income is by no means a foregone conclusion. On the contrary, it surfaces only when we put the share of high technology FDI in the middle of this chain, while it disappears if the FDI total is considered instead.

The conclusion just drawn, while startling, should not surprise those that have followed developments in the theory of economic growth over the last decade. The latter has long identified technological change as the root cause of long run economic growth. In developing countries, the sole engine of technological change are the technology transfers from the developed regions, given the almost total lack of any significant local R&D activity. Most likely, the vehicle that permits these technology transfers is foreign direct investment, which in turn is attracted to a developing country if the latter is well endowed with resources and can provide a stable environment.

6. Conclusions and suggestions for future work

The evidence gathered in this study, suggests the following conclusions:

Developing countries must try and attract not just any kind of foreign investment, but that particular type of foreign investment that features high levels of technology. FDI carried out in order to perform extractive activities, in countries that are rich in natural resources, or productive activities with a low technological content, in countries with a cheap labor force (good examples may be agricultural products such as bananas or tobacco, or textile), to name but a few, are not the kind of FDI that, on this evidence, is conducive to high levels of per capita income.

Furthermore, one good way to attract high tech FDI, that has emerged in this study, is to grow a good stock of human capital and to make sure that the macroeconomic context is as stable as possible.

The results just described fine tune the analysis of the impact of FDI on economic output carried out in earlier studies, by moving the focus of attention away from FDI in its entirety, to the high technological content of FDI.

The caveat is that this is a cross sectional study, and as such it may suffer from all the problems noted by Nair-Reicher and Weinhold. However, these problems should be ameliorated, if not eliminated, by the fact that, in our two stages least squares estimation, we instrument the crucial variable eta with our measure of human capital, that is, average years of schooling.

Future work may advance knowledge on this topic in several ways. An obvious one would be to remake the analysis carried out here, but with improved data, as they become available. The time dimension could be introduced, by considering FDI flow data for an interval of time, for those countries that have them. If not enough countries have these data, one might restrict the study to one of the three regions considered here, East Asia for instance. The addition of the time dimension may well shed some further light even with the restriction to one region only.

Another possible extension might involve replacing GDP as the dependent variable with others such as domestic investment or employment, in order to explore the effect of high tech FDI on these important quantities.

Yet another possibility is to run all the regressions discussed thus far on a sample of developed countries, such as the group of OECD countries, and then compare results with those obtained for the developing countries. It would make an interesting research agenda to investigate whether there exists a different type of impact of high tech FDI and total FDI on GDP, than that seen for the developing world. Such a different impact, if proven, could then be explained by the presence of significant R&D activities in most OECD countries. The latter implies that in OECD countries, FDI is by no means the sole carrier of technological change, since not only do OECD countries approach the technology frontier, but they move it forward as well.

The extensions suggested here should keep researchers keen on this topic for a long time, so that enough research output can be produced to aid policy makers in their quest for a more wealthy future for their countries.

Appendix - Classification of Economic Activities found in U.N. World Investment Directory FDI data:

PRIMARY SECTOR
Agriculture
Mining and quarrying
Petroleum
SECONDARY SECTOR
Food, beverages and tobacco
Textiles, leather and clothing
Paper
Chemicals
Basic chemicals
Pharmaceuticals, medic. chem. etc.
Coal and petroleum products
Rubber products
Non-metallic mineral products
Metals
Mechanical equipment
Electrical equipment
Radio, tv and communication equip.
Medical, precision and optical instr.
Motor vehicles
Other transport equipment
Other manufacturing
TERTIARY SECTOR
Electricity, gas and water supply
Construction

Distributive trade
Hotels and restaurants
Transport and storage
Communication
Finance and insurance
Real estate
Other services
Other unspecified
TOTAL

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