The North-South Institute · L'Institut Nord-Sud

Enough

Foreign Direct Investment quickens economic growth everywhere

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Enough FDI quickens growth everywhere

Abstract

It has proved hard to find evidence of a stable and important role for FDI promoting economic growth and helping poor countries catch up to rich ones. This is likely because FDI effectiveness depends on context, which the nearly universal linear empirical growth model obscures.

We use a partially non-linear model to discover an FDI threshold, below which FDI has no effect on growth, but above which it has a strong and substantial effect. We also discover that there is no starting-income threshold for FDI effectiveness. Rather, poorer countries benefit more from FDI.

We learn too that FDI helps poor countries catch up to rich ones, and is sometimes necessary for it. Nearly all countries with sufficient FDI, poor and rich, are converging in income. However, among countries without sufficient FDI, there is a convergence threshold. Those with a high enough starting income are converging, while the poorer ones are not.

Acknowledgements

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Summary

We study the relationships between FDI, growth, and cross-country income convergence in 128 countries over three ten-year periods each, spanning 1970 to 1999. We use a non-linear growth regression model which lets us distinguish the macroeconomic experience of each country individually. We learn the following.

- A country must receive a minimum amount of FDI before its macroeconomic growth rate responds. The FDI threshold is not high, occurring at 18 times per capita GDP. This is the level of inflow achieved by, for example, Nicaragua (1970-79), Madagascar (1970-79), Israel (1970-79), Cyprus (1990-99), and El Salvador (1980-89). Nevertheless, half the countries in our sample had at least one ten-year period in which FDI fell below the threshold.

- When FDI is in sufficient quantity, it makes a substantial contribution to economic growth. It increases the growth rate of GDP per capita by between 0.83 and 1.57 percentage points each year, depending on the actual amount of FDI.

- Countries do not need to surpass an income or development threshold before they can either attract enough or benefit from FDI at the macroeconomic level. Many initially poor countries receive FDI above the FDI threshold, while some initially rich countries do not receive enough FDI to make a difference in growth rates. Further, the beneficial effect of FDI, when it is sufficient, on growth is larger as starting income is lower. Poorer countries tend to benefit more from FDI, which is necessary if it is to help them catch up to richer countries.

- Among countries in which FDI is sufficient to be effective at the macroeconomic level, convergence is global. Given the other growth factors in the model, all these countries are growing to a common long-term income level. Poorer countries are catching up to richer ones. However, the rate of convergence is very slow, at 0.06 percent per year.

- Among countries in which FDI is not sufficient to be effective at the macroeconomic level, convergence is local, selective. That is, there is an starting-income threshold. Above it, countries are converging to a common long-term

income level. Below the starting-income threshold countries are not converging. The threshold occurs at 32 percent of the starting income of the U.S. Two-thirds of countries without sufficient FDI fall below the convergence threshold and so are not catching up to richer countries.

- FDI is, therefore, important for both growth and convergence, probably because it is the main channel of transmission of technology across countries. FDI is even necessary for convergence among the poorest countries which start out below the starting income threshold. However, even when FDI is sufficient to substantially enhance growth, the convergence rate across countries is too slow to matter in practice.

1 Questions about FDI

Foreign direct investment is supposed to advance economic growth in the receiving country. It would do this primarily by transferring technology from sending to receiving countries and, in the receiving countries, from foreign to domestic firms. Since richer countries tend to have more advanced technology than poorer countries, FDI is also supposed to help poor and middling countries eventually catch up to rich country income levels.

Governments everywhere and international institutions believe deeply that FDI does these things.

> [FDI] is especially important for its potential to transfer knowledge and technology, create jobs, boost overall productivity, enhance competitiveness and entrepreneurship, and ultimately eradicate poverty through economic growth and development. (The "Monterrey Consensus", United Nations International Conference on Financing for Development, 2002, p.5.)[1]

Yet, according to macroeconomic evidence across countries, FDI is not performing as expected or hoped (section 4). That evidence is ambiguous, careful studies coming to opposing conclusions. Where the effect of FDI on growth is found to be positive and statistically significant, it is economically unimportant, often actually harmful. There is no indication that FDI helps poorer countries catch up to, converge with, richer ones. This evidence does not support the attention FDI gets from policy-makers or the resources from governments and international institutions to attract it.

The failure to establish a stable and important role in economic growth and development for FDI likely is because its impact depends on context. Countries may need a well-educated labor force, extensive financial system, or minimum level of trade or development to benefit from FDI. This, too, is hard to establish, because nearly all studies use a linear empirical growth model to interpret data. The linear specification averages out the widely varying histories, structures and institutions of different countries. For example, it forces growth factors to operate

[1]The Consensus is named after the conference venue in Mexico. It was signed by more than fifty countries and by the heads of the United Nations (UN), International Monetary Fund (IMF), World Bank (WB), and World Trade Organization (WTO). The Consensus and supporting documents are available at http://daccessdds.un.org/doc/UNDOC/GEN/N02/392/67/PDF/N0239267.pdf

the same way in Haiti and the United States, severely limiting what we can learn about when and how FDI works.

Previous researchers tried to bypass the linear restriction of the growth model by somewhat arbitrarily splitting samples according to income level or adding new explanatory variables. In particular, they created multiplicative variables in which FDI interacts with the alternative domestic institutions identified above. Again, the results are tenuous and inconclusive.

We, instead, relax the linear constraint on the data, re-examining the role of FDI in growth and convergence using a partially non-linear cross-country empirical growth model. This model allows economic growth to respond to its non-linear determinants differently in different countries. Similar models have been used before to address convergence, but not to account for the role of FDI in growth or convergence. We use the model to look for thresholds in FDI and development (starting income), minimum levels needed in each country to increase growth and catch up to richer countries. We also look for complementarities between FDI and development.

Specifically, we begin to answer the following questions:

- Is a minimum amount of FDI needed in-country before it becomes an important factor in aggregate growth?
- Is a minimum level of development, starting income, needed before FDI becomes effective or countries converge?
- Does effective FDI help developing countries catch up to rich ones in income?

FDI may promote growth in certain countries, such as those with a sufficient amount of FDI or level of development. If it does, and if the way FDI promotes growth is by transferring new technology, it may also promote convergence among those countries. Or it may not, if richer countries benefit as much or more from FDI, in terms of growth, as poorer countries. Conversely, if FDI facilitates convergence among some countries, it must also promote growth at least in the poorer of those countries. Countries may also converge in income without the help of FDI if technology is transferred through other channels, such as trade, or if they already share a common aggregate technology.

2 Research strategy

We apply an econometric regression model of economic growth to a sample of macroeconomic data from a large number of countries over a long period of time.

As is usual, we start from the canonical empirical growth model of Mankiw, Romer, and Weil (1992), which is explicitly derived from the theoretical Solow growth model. We add to the model variables for the main channels of technology transmission across countries, namely trade and FDI.

We are chiefly interested in the contribution of FDI and starting income to growth, the latter being the convergence variable. In our version of the model these two variables are jointly related to growth in a non-linear way, to allow them to interact fully with each other and to distinguish their contribution to growth in each country. The other variables enter the model in the usual linear fashion.

Our data are taken from public sources (Table A-5). We have a sample of 128 countries (Table A-1) with observations from 1970 to 1999. (We describe our data completely in Appendix A.) We aggregated the annual observations into three ten-year period averages. These periods are long enough to eliminate the temporary effects of random shocks and business cycles. We experimented with five-year periods but found the results too volatile to interpret.

2.1 Model and interpretation

Here is the model:

$$GRO = \beta_0 + \beta_1 INV + \beta_2 POP + \beta_3 LIFE_0 + \beta_4 OPEN + g(GDP_0, FDI) + \eta \quad (1)$$

in which

GRO	is the rate of economic growth,
INV	the share of domestic investment in GDP per capita,
POP	the rate of growth of the population,
$LIFE_0$	initial life expectancy at birth,
$OPEN$	the share of exports plus imports in GDP per capita,
GDP_0	initial GDP per capita relative to that of the U.S.,
FDI	net inflows of FDI relative to GDP per capita,
$g()$	a non-linear function of inter-acting variables, and
η	the statistical error of the estimated model.

The linear part of the model covers domestic investment in physical capital (INV), the population growth rate (POP), life expectancy as a measure of investment in human capital ($LIFE_0$), and the share of international trade in the

economy ($OPEN$). We also include dummy variables for the three ten-year periods, though we do not report them. The non-linear part of the model covers starting income (GDP_0) and FDI (FDI). Starting income is the convergence variable since, within a group of converging countries, those that start out at a lower income must be growing faster and thereby catching up to the rest. Countries benefit from FDI here when there is a positive relationship between FDI and growth. They converge in income when there is a negative relationship between starting income and growth.

We initially included in the model indicator variables for regions, major oil exporters, and countries with populations of less than a million. None of these was statistically significant in early estimations, so we dropped them.

There is no theoretical presumption that FDI will accelerate economic growth by transferring new technology to the receiving country. It depends on the starting technological gap between the sending and receiving countries. The greater the gap, the older the vintage of the technology transferred and the slower the speed at which it is transferred (Wang and Blömstrom, 1992). If the technology introduced is too old relative to the international standard, or the speed at which the technology is transferred too slow, it may not have an important impact on the macro-economy. So, whether FDI adds to the growth rate is an empirical issue, and this, rather than the fully linear model specification, may explain the difficulties previous studies have had in finding a positive role for FDI.

Theory does support the existence of an FDI-growth threshold. Given an initial technological gap, in-country transfers of technology from foreign to domestic firms, "spill-overs", increase with the amount of FDI. A minimum amount of FDI may then be needed before results are noticed at the macroeconomic level. This possibility has not been investigated so far.

There is also no theoretical presumption that FDI facilitates convergence. One of the sources of convergence is technology transmission from one country to another, and FDI is a central vehicle for that (Borensztein, Gregorio, and Lee, 1998).[2] However, even when the technology transferred by FDI increases growth

[2]The other source of convergence is domestic capital accumulation, captured in the model by the variable for domestic investment. Which of the two sources drives, or constrains, convergence depends on whether aggregate technology, the aggregate production function, is initially common to all countries or differs across countries (Bernard and Jones, 1996; Quah, 1996a; Romer, 1993). A country's aggregate production function encompasses, for example, its sectoral structure and industrial pattern and its capacity to research, develop, and implement new technologies. These indeed vary significantly from country to country. In that case, technology transmission across countries would be key

in each country, it is not necessarily the same technology in all countries. As mentioned, the vintage of the technology transferred depends negatively on the starting technological gap. With technological gaps contributing to income differentials (Borensztein et al., 1998), initially richer countries may then benefit more from FDI. If richer ones benefit at least as much as the poorer ones, they may always be richer. Then a minimum starting income may be needed for convergence.

If there are FDI or convergence thresholds in country experiences, we may split the sample at the threshold or thresholds and re-estimate the partially non-linear model on each sub-sample. This would yield insight into the relationship between FDI and convergence, following the logic outlined above. That would, in turn, reveal to some extent whether FDI contributes to growth, if it does, by transferring technology.

Splitting the sample by estimating the model beforehand is quite different and more informative than splitting the sample by starting income before estimating the model, as do some previous FDI studies. Our approach follows that of some previous convergence studies which use various non-linear model estimation techniques. However, they do not allow a role for FDI (section 4).

2.2 Related models

We initially followed practice in the growth regression literature of including a variable for education in the linear part of the model as the main measure of human capacity. Liu and Stengos (1999), in a model without FDI, found a linear relationship between education and growth, even though they allowed for a non-linear relationship. We found in early estimations of both a fully linear version and the partially non-linear version of the model that education is not statistically significant in our sample (subsubsection 3.1.1). We therefore excluded it from subsequent analysis.

Previous studies dealt with the difficulty of finding important relationships between FDI or starting income and growth in linear models in part by adding explanatory variables. These specify certain differences between countries, since linearity prevents the model itself from doing so. The same is true of panel estimation techniques which account for unobserved random or fixed differences across countries. Supplemental explanatory variables typical of studies focusing on either FDI or convergence are trade, the real exchange rate or black market exchange rate premium, government consumption, and political or social stability (Durlauf

to income convergence.

and Quah, 1999, Table 2). Convergence studies usually also add a variable for population health, such as life expectancy, while FDI studies add variables for the labor force participation rate, inflation, and the depth or sophistication of financial markets.

It is hard to know how seriously to take these extra explanatory variables as growth factors. Durlauf and Quah (1999) say they are essentially arbitrary, do not identify economic structure, are not mutually exclusive, are often correlated with each other, and are not ranked in order of importance for explaining growth. Most importantly for us, the extra terms hinder the purpose of understanding the role of FDI in growth and convergence. They have not helped find a strong positive contribution of FDI to growth. They do make it easier to find convergence, but at the same time they cloud what convergence means. For one thing, in the linear model the extra variables implicitly sort the sample into groups of similar countries, making it much more likely that convergence, if found, is local, among some but not all countries in the sample. For another, convergence is conditional on the other growth factors in the model. With many such factors, it would not be clear that poorer countries are in fact catching up to richer ones (Bernard and Durlauf, 1996; Durlauf and Johnson, 1995; Durlauf and Quah, 1999; Quah, 1999, 1996a).

We choose to limit our variables to those in the core growth and FDI models, with the addition of trade as an alternate channel of technology transmission. We rely on the partially non-linear specification of the model to identify differences in growth effects across countries. This strategy has the added benefit of clarifying interpretation of the results and permitting a greatly enlarged sample of countries.

2.3 Model estimation

We use and compare two methods to estimate the model of equation 1. The main one is partially non-linear and semi-parametric (PNSP), as described just below. The other is Ordinary Least Squares (OLS) on a modified version of the model, where we replace the non-linear element $g(GDP_0, FDI)$ with the linear elements $\beta_5 GDP_0 + \beta_6 FDI$. We do not use panel data techniques on the linearized model for the reason given earlier, and for easy comparison to the PNSP estimates.

The PNSP method uses the local-constant, leave-one-out kernel-smoothing estimator implemented in the "np" (non-parametric) package of the statistical software "R"(R Development Core Team, 2008). That estimator is described in Hayfield and Racine (2008) and references therein. Kernel-smoothing estimates regression functions by applying a weighting scheme to the data to smooth and

sum the contribution of each observation to the overall estimate. The estimator chooses the smoothing weights, the so-called bandwidths, with reference to the data through least squares cross-validation. This is a procedure that minimizes the residual sum of squares, a measure of the discrepancy between the data and the representation of the data made by the kernel-smoothing estimator.

A major advantage of the kernel-smoothing technique over the usual OLS and fixed or random effects panel linear models is that it avoids the problem of reverse causation that pervades the FDI literature.[3] That is, the effect of FDI on growth identified by the model will not be biased by the potential effect of growth on FDI, since all such inter-actions are accounted for in the estimation of the joint probability densities of growth, FDI, and initial GDP.

3 Resulting evidence

To summarize our strategy, we study a sample of 128 countries, with three observations to each country consisting of starting values or averages for the periods 1970-79, 1980-89, and 1990-99. In the following we report results for both OLS and PNSP estimates of equation 1. We tried two versions of the linear model, one with a multiplicative term, $GDP_0 \times FDI$, and one without. In the linear model the multiplicative term expresses one kind of inter-dependency between starting income and FDI. The multiplicative term is never statistically significant nor does it make an important difference to results from the rest of the model. So, we do not report the linear model containing the multiplicative term.

3.1 Preliminary lessons

Although education is usually included in empirical growth models as the primary measure of human capital, in our sample it is not a statistically significant growth factor. So, we exclude it from the model, and this allows us to increase the size of our sample substantially beyond the norm. In the expanded sample, the linear estimate finds that FDI increases the growth rate and that countries are converging to a common long-term level of income. However, these linear findings cannot say whether FDI helps growth equally in all countries, or whether all, or only some, countries are converging. A non-linear model is needed to answer those questions. The non-linear model represents the data much better than the linear

[3] An exception is Carkovic and Levine (2005), who use the Generalized Method of Moments linear panel estimator.

one, suggesting that FDI and convergence do operate differently in unlike countries.

3.1.1 Education does not help growth

We first estimated a linear version of the model with an education term, $EDUC_0$, the average years of schooling in the population aged 15 and above at the start of each period (Table A-5). The education variable is only available in 88 countries. Its coefficient is negative, so it appears to reduce growth, and it is not statistically significant (OLS(1) in Table 1). We confirmed this result in an early estimate of the non-linear version of the model, which we do not report. We excluded the education term thereafter, relying on life expectancy to measure human capital, because then we could substantially increase the size of our sample, by nearly half again above the norm in the literature. We need a large sample if we are to split it at identified thresholds and re-estimate the model on each sub-sample.

3.1.2 FDI helps growth and countries converge

Eliminating $EDUC_0$, we re-estimated the linear model on the larger sample of 128 countries (OLS(2) in Table 1). There are a number of important changes to the results. First, there is a small improvement in the growth model's representation of the data. The R^2 measure of the share of the changes in the data from observation to observation that is explained by the model increases from 25.4 percent to 27.5 percent. This despite the loss of a variable (R^2 usually increases slightly when an explanatory variable is added, regardless of its statistical significance).

Second, there is a striking change in some of the estimated coefficients. The positive coefficient on domestic investment increases substantially in magnitude, and goes from statistically insignificant to highly significant. Similarly, the negative coefficient on starting income increases substantially in magnitude (in absolute value), and goes from statistically insignificant to highly significant. Finally, the positive coefficient on FDI becomes marginally statistically significant in the expanded sample, indicating that it does, indeed, enhance growth. Thus we already find in a linear growth model convergence and a role for FDI in growth without resorting to lots of supplemental explanatory variables or modeling unobserved country effects. The increase in sample size made the difference.

In neither of the linear models, with or without an education term, is the population growth rate statistically significant. In both of them life expectancy and the share of trade in the economy are positively related to growth and strongly statistically significant.

Table 1: Cross-country growth regressions
(Full samples)

	OLS(1)	OLS(2)	PNSP
Constant	−0.2125 ***	−0.2667 ***	
	(−3.414)	(−5.512)	
INV	0.0053	0.0088 ***	0.0082 ***
	(1.431)	(3.195)	(3.086)
POP	−0.0022	−0.0020	−0.0027
	(−0.933)	(−1.210)	(−1.347)
$LIFE_0$	0.0422 **	0.0571 ***	0.0442 ***
	(2.373)	(4.217)	(3.135)
$OPEN$	0.0086 ***	0.0085 ***	0.0091 ***
	(3.477)	(4.291)	(4.521)
GDP_0	−0.0029	−0.0076 ***	Not
	(−1.125)	(−3.664)	reported[a]
FDI	0.0012	0.0012 *	Figure 1
	(1.514)	(1.709)	
$EDUC_0$	−0.0001		
	(−0.053)		
nobs	264	382	382
R^2	0.2536	0.2751	0.3781
RSE	0.0253	0.0245	0.0005

Notes

1. The dependent variable is the growth rate (GRO). See equation 1 and Table A-5 for a description of this and the independent variables listed in this table.
2. "OLS" is the Ordinary Least Squares parametric linear regression model. "PNSP" is the partially non-linear, semi-parametric regression model.
3. The statistical significance codes are: 0.01 ***; 0.05 **; 0.1 *. The parentheses contain t statistics.

[a]Given the existence of a threshold in the effect of FDI on growth (subsection 3.2), non-linear convergence results mingling observations on both sides of the threshold are not meaningful.

3.1.3 Not all countries benefit

We then estimated the non-linear model as set out in equation 1. The linear part of the PNSP estimation nearly replicates the corresponding explanatory variables of the fully linear model (compare PNSP and OLS(2) in Table 1). There is the same pattern of coefficient signs (positive or negative) and significance, and differences in coefficient values are minor. However, the non-linear model represents the data much better. R^2 rises from the linear 27.5 percent to a non-linear 37.8 percent. Since the non-linear model allows for country differences in growth effects of FDI and starting income, the FDI benefit may not touch all countries equally, and not all countries necessarily converge to a common long-term income.

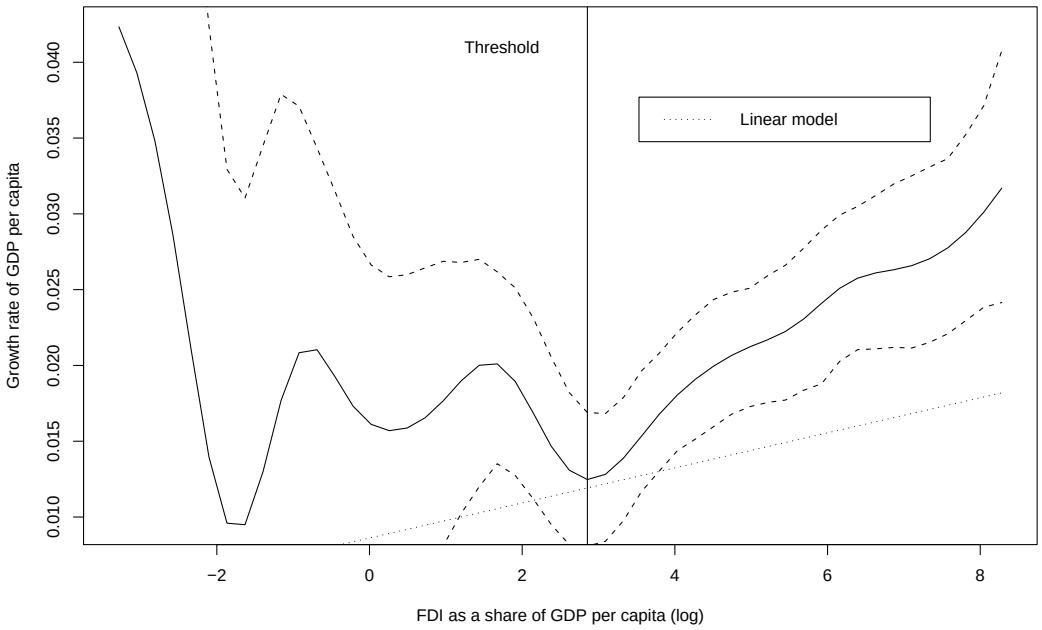
3.2 There is an FDI-growth threshold

The non-linear regression estimates confirm that the effect of FDI on growth varies across countries (Figure 1). We display this graphically. We also super-impose the linear estimate on the graph for comparison, when the linear estimate is statistically significant. For FDI, the linear estimate intersects the lower of the 95 percent confidence bands for the non-linear estimate and otherwise lies largely outside the non-linear confidence interval. Thus, the FDI-growth relationship is non-linear. That is, the increase in growth one would expect to see from a marginal increase in FDI depends on the current level of FDI in the country.

Further, there appears to be an FDI-growth threshold, a minimum amount of FDI needed in a country before FDI benefits macroeconomic growth. To the left of the threshold, which occurs at the value $ln(FDI/GDPpc) = 2.85$, the mean estimate of the relationship between FDI and growth fluctuates wildly. The confidence bands are wide and admit arbitrary horizontal lines throughout the subsample, indicating that the relationship is not statistically significant. On such a horizontal line, an increase in FDI would have no effect on growth. To the right of the threshold, the mean estimate and the confidence interval are upward-sloping throughout, indicating a statistically significant positive relationship.

The FDI-growth threshold is not high, corresponding to FDI at about 18 times per capita GDP. This is the average level of FDI inflow achieved by, for example, Nicaragua (1970-79), Madagascar (1970-79), Israel (1970-79), Cyprus (1990-99), and El Salvador (1980-89). Nevertheless, nearly half the countries in our sample experienced at least one ten-year period in which FDI fell below the threshold (Table A-2). These episodes account for one-third of our country-period observations.

Figure 1: FDI-growth threshold



To verify the existence of the threshold, we sorted our sample in increasing order of realization of FDI, dividing it at the threshold. We then returned both sub-samples to the original arrangement (country and period). We re-estimated the linear and non-linear models on each sub-sample, reporting the results below. We formally compared the estimates from the linear model in the two sub-samples. The test statistic for the null hypothesis that they are the same is $F(8,364) = 4.059$, yielding a p-value of 0.00012. The data strongly reject the null hypothesis and the linear estimates in the two sub-samples are statistically significantly different from each other.

3.2.1 Insufficient FDI is ineffective

There are interesting changes to the linear outcomes of both the linear and non-linear models in the sub-sample of countries and periods with FDI below the growth threshold, compared to those of the full sample (Table 2). Life expectancy becomes statistically insignificant. So does FDI in the linear model, and its coefficient turns negative. The trade term remains strongly statistically significant, and its positive coefficient increases substantially in magnitude. Trade may substitute for FDI in promoting growth in countries where FDI is too small to be effective. Finally, in

Table 2: Cross-country growth regressions
(Sub-samples)

	FDI below threshold		FDI above threshold	
	OLS	PNSP	OLS	PNSP
Constant	−0.2211 **		−0.2444 ***	
	(−2.375)		(−4.472)	
INV	0.0106 **	0.0072 *	0.0092 ***	0.0101 ***
	(2.082)	(1.703)	(2.829)	(2.949)
POP	−0.0052	−0.0062 *	0.0005	0.0012
	(−1.474)	(−1.930)	(0.271)	(0.416)
$LIFE_0$	0.0378	0.0278	0.0524 ***	0.0471 ***
	(1.393)	(1.117)	(3.501)	(2.954)
$OPEN$	0.0132 ***	0.0140 ***	0.0058 ***	0.0056 ***
	(2.935)	(3.358)	(2.884)	(2.776)
GDP_0	−0.0079 *	Figure 6	−0.0055 **	Figure 5
	(−1.960)		(−2.294)	
FDI	−0.0001	Figure 2	0.0036 ***	Figure 3
	(−0.039)		(3.293)	
nobs	126	126	254	254
R^2	0.2766	0.5321	0.3311	0.3092
RSE	0.0303	0.0006	0.0199	0.0004

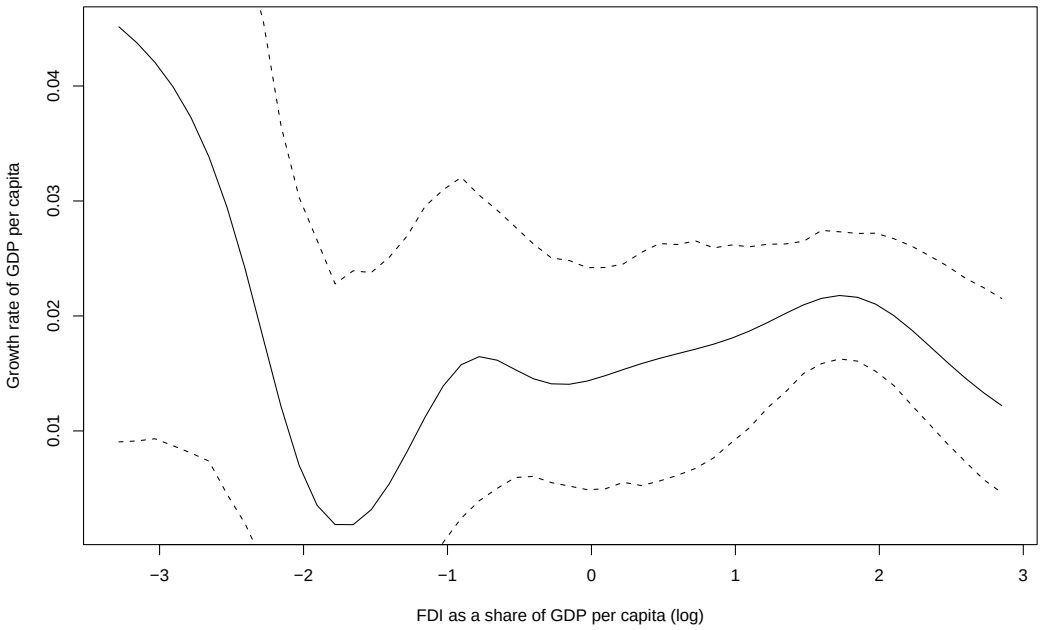
Notes

1. The dependent variable is the growth rate (GRO). See equation 1 and Table A-5 for a description of this and the independent variables listed in this table.
2. "OLS" is the Ordinary Least Squares parametric linear regression model. "PNSP" is the partially non-linear, semi-parametric regression model.
3. The statistical significance codes are: 0.01 ***; 0.05 **; 0.1 *. The parentheses contain t statistics.

the linear model starting income remains statistically significant and its coefficient negative, still indicating convergence, but its level of significance drops to marginal.

The fit of the non-linear model to the data in the below-FDI-threshold sub-sample is again, as in the full sample, much better than that of the linear model. The R^2 measure of fit nearly doubles from 27.7 percent for OLS to 53.2 percent for PNSP. The mean estimate of the FDI-growth relationship in the non-linear model

Figure 2: Contribution of 'below-threshold' FDI to growth



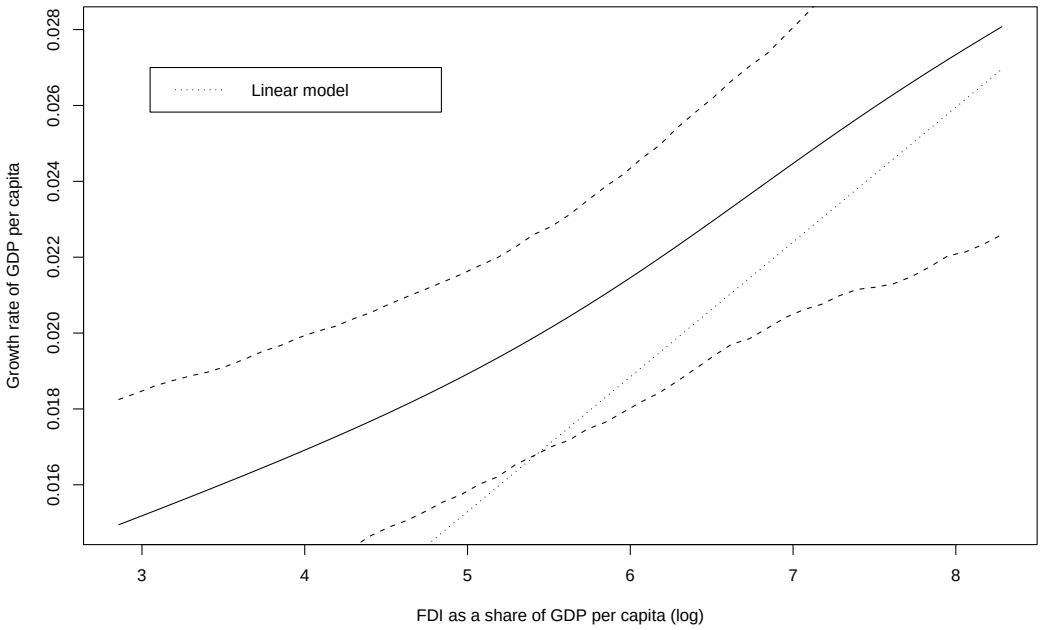
is highly non-linear (Figure 2). Since this sub-sample is small, 126 observations, we display confidence bands at the 90 percent level. Recall that the linear coefficient for FDI is not statistically significant, so we do not display it. The non-linear confidence bands contain arbitrary horizontal lines, such that FDI would have no impact on growth at all. We conclude, then, that the linear and non-linear models consistently show that FDI below the threshold is not effective for growth.

3.2.2 Sufficient FDI is effective

In the larger sub-sample with FDI above the growth-effect threshold, results for the linear model and for the linear part of the non-linear model are again largely the same and, moreover, qualitatively the same as the corresponding results from the full sample (Table 2). Domestic investment, life expectancy, and trade are all positive in sign and strongly statistically significant. Population growth changes sign in this sub-sample, appearing to increase growth, but remains statistically insignificant. Starting income remains negative in sign and strongly significant in the linear model.

As for FDI, in stark contrast to the results from both the below-FDI-threshold sub-sample and the full sample, it is positive in sign and strongly statistically sig-

Figure 3: Contribution of 'above-threshold' FDI to growth



nificant in the linear model. The magnitude of the FDI coefficient in the linear model also increases substantially. With FDI contributing to growth, the coefficients on trade in the two models fall back to about their levels in the full sample.

The fit of the linear model to the data in the above-FDI-threshold sub-sample (R^2 of 33 percent) is better than its fit in either the below-FDI-threshold sub-sample or the full sample (R^2 of nearly 28 percent in each case). As well, in the above-FDI-threshold sub-sample, the linear model fits the data marginally better than the non-linear model (R^2 of nearly 31 percent). The mean estimate for FDI of the non-linear model is nearly linear (Figure 3). It is different, though, in the sense of statistical significance, from the coefficient on FDI in the linear model, which intersects the lower 95 percent confidence band of the non-linear model. We conclude that the effect of FDI on growth when FDI exceeds its growth threshold is positive, nearly linear, and strongly statistically significant.

3.3 FDI helps poorer countries more

Our evidence does not support the possibility that, in addition to an FDI threshold, countries need to surpass an starting income or development threshold before they can benefit from FDI at the macroeconomic level. Recall that, in preliminary

analysis, a multiplicative term in the linear model, $GDP_0 \times FDI$, capturing one form of such a requirement, was not statistically significant. As already mentioned, the non-linear estimator accounts for all forms of interaction between starting income and FDI. Yet, FDI benefits growth in all countries and periods in which FDI exceeds its growth threshold, regardless of their starting income. Many poor and middling countries receive enough FDI to see growth respond (Table A-3). Conversely, most countries in which FDI under-reaches its growth threshold in some periods are low-income, but many are also lower-middle-, upper-middle-, or high-income (Table A-2).

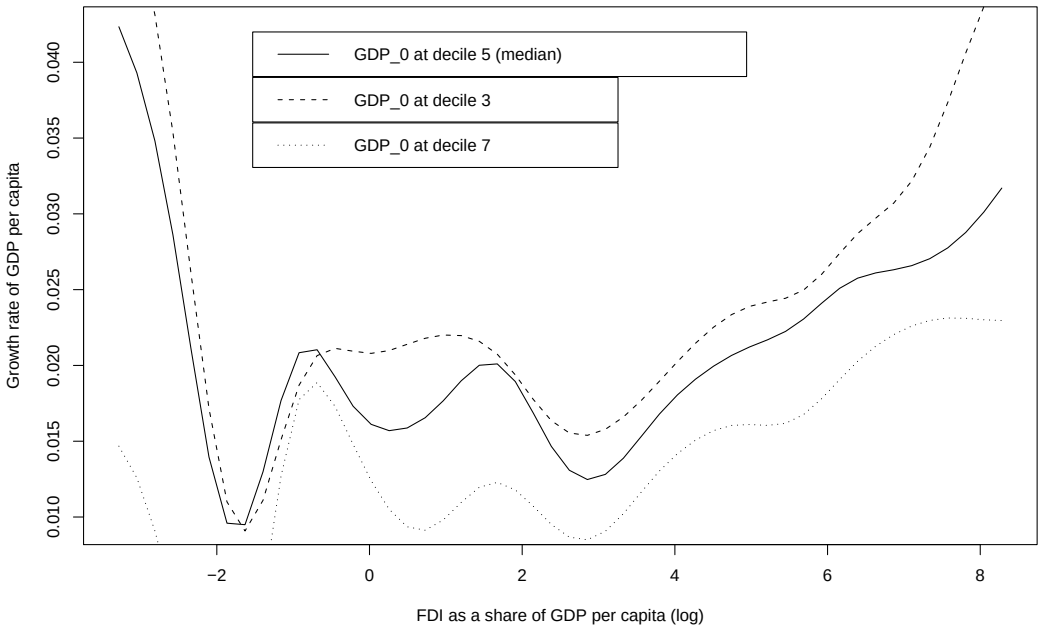
The non-linear results displayed above show the effect FDI has on growth in each country individually when all other variables, including starting income, are held constant at their median values in the data, the same value for all countries in the sample. To check the dependence of the FDI-growth effect on starting income, which represents the level of development, we estimated the non-linear model on the full sample twice more, holding starting income constant at the third and seventh data decile respectively, all other variables still at their median values (Figure 4). Changing starting income this way does not affect the location of the FDI-growth threshold. Everywhere above the threshold, the beneficial effect of FDI on growth is larger as starting income is lower. Poorer countries tend to benefit more from FDI.

3.4 Convergence depends on FDI and starting income

We compare convergence patterns between country-periods in which FDI exceeds the growth-effectiveness threshold and those in which it does not. In the former, where FDI exceeds the threshold, the mean estimate of the non-linear model is downward-sloping nearly everywhere. Given the other growth factors in the model, namely domestic investment, population growth, population health, and trade, nearly all countries are converging to a common long-term income level (Figure 5).[4] Where the mean estimate turns briefly upward-sloping over short intervals of starting income among the richer countries, the upturns are easily contained by the 95 percent confidence bands, such that they are not statistically

[4]In the non-linear model for the above-FDI-threshold sub-sample, the bandwidth obtained by least-squares cross-validation for the relationship between GRO and GDP_0 is about 0.44. This yields an excessively variable relationship, due to numerous local minima, which is a known tendency of the least-squares cross-validation method. We increased the bandwidth to 1.00 to smooth out some of the spurious local fluctuations and get a better overall perspective on the relationship, presented here.

Figure 4: Dependence on GDP_0 of the FDI-growth effect

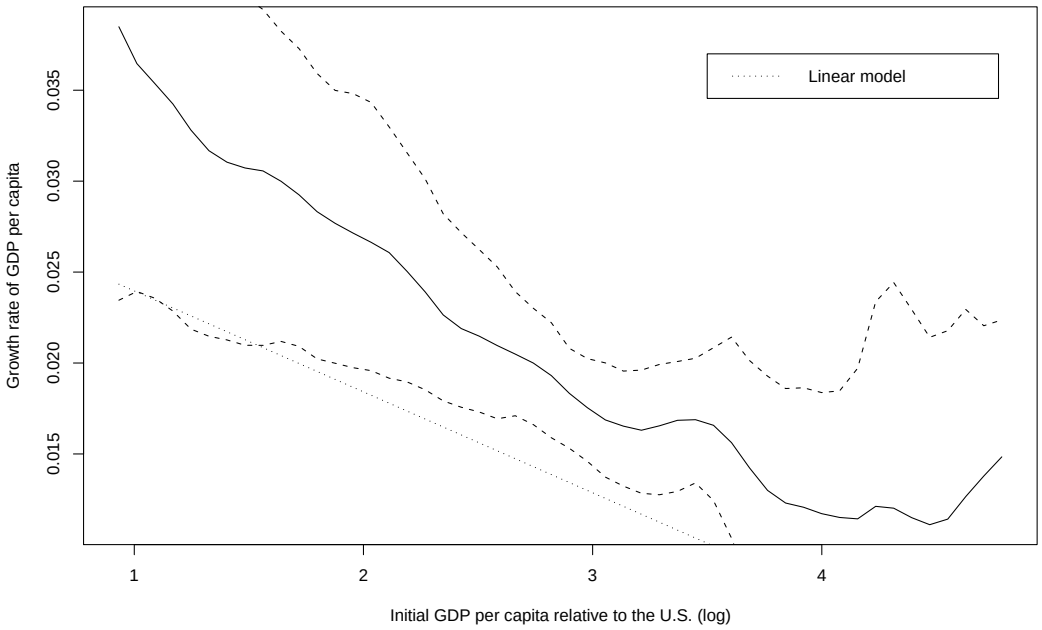


significant. The evidence accords with the conclusion that all countries receiving FDI in amounts sufficient to enhance growth are converging.

The linear model too finds a negative and strongly statistically significant coefficient on starting income, indicating convergence (Table 2). As always, though, the linear model cannot say whether all of the countries in the sub-sample are converging, especially as the starting-income coefficient lies nearly everywhere outside the lower confidence band of the non-linear estimate. Recall that the linear model fits the data a little better than the non-linear one.

Among countries and periods in which FDI falls short of the growth threshold there seems to be a convergence threshold, a minimum starting income beyond which countries converge in long-term income, but below which they do not (Figure 6). The linear estimate, which is statistically significant, intersects the lower 90 percent confidence band twice at the location of the apparent threshold. Below the convergence threshold, the confidence interval contains arbitrary horizontal lines, suggesting no statistically significant relationship between starting income and growth. Above the threshold the interval mostly slopes downward, with the mean estimate flattening out at the very highest income levels. The convergence threshold occurs at 32 percent of the starting income of the U.S. Two-thirds of

Figure 5: Effect of starting income on growth with 'above-threshold' FDI



countries without sufficient FDI fall below the convergence threshold and so are not catching up to richer countries.[5]

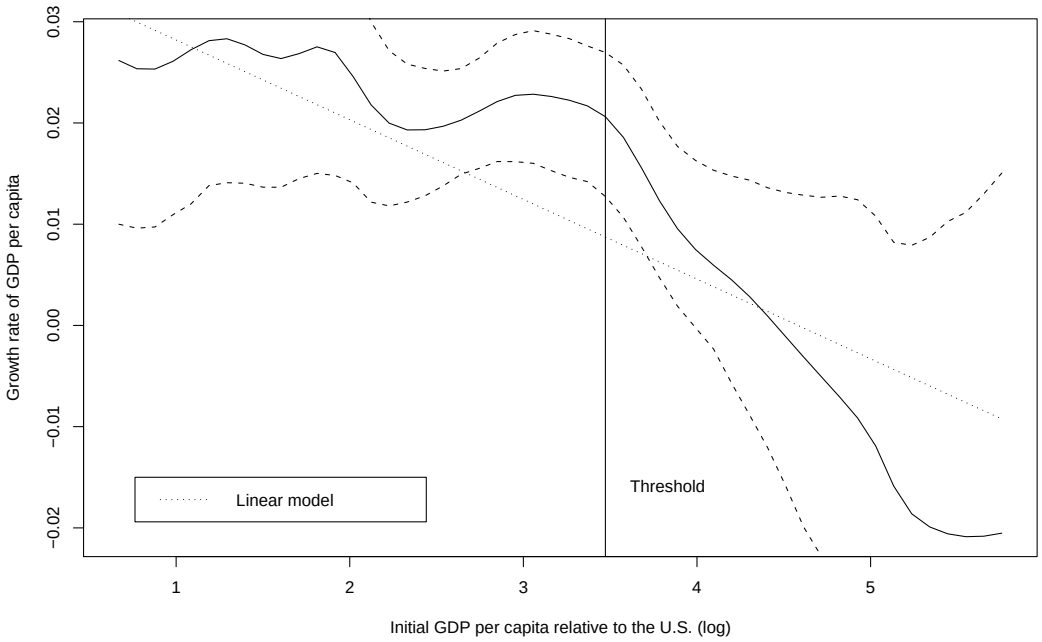
3.5 FDI is economically important

Among countries and periods in which FDI surpasses its growth-effect threshold, FDI at the median value for the group increases the growth rate of GDP per capita by between 0.83 percentage points per year (estimate of the non-linear model) and 1.57 percentage points per year (estimate of the linear model).[6] The two estimates

[5]This sub-sample, with FDI less than its growth-effectiveness threshold, is too small to be meaningfully divided further at the convergence threshold. The group with initial incomes higher than the convergence threshold consists of 42 observations.

[6]The median value of $ln(FDI/GDPpc)$ in the sub-sample where FDI exceeds the growth-effect threshold is 4.36. At that point, the slope of the curve showing the relationship between FDI and growth in the non-linear model is about 0.0019 (Figure 3). The equivalent slope in the linear model, given by the coefficient on FDI (which is independent of the level of FDI), is 0.0036 (Table 2). The estimated effect of FDI on growth is calculated as $s_{mFDI} \times mFDI$, with $mFDI$ the median value of FDI and s_{mFDI} the slope of the appropriate curve (linear or non-linear model) at median FDI.

Figure 6: Effect of starting income on growth with 'below-threshold' FDI



converge to the higher value as the amount of FDI increases. In sufficient quantity, then, FDI makes an important contribution to economic growth.

Among the same countries, with sufficient FDI, convergence is nearly global. However, the rate of convergence is very slow, at 0.06 percent per year, based on the median starting income. The initially poorest of these countries are converging at a slightly faster pace, at 0.11 percent per year, than the initially richer countries, at 0.03 percent per year.[7]

Among countries in which FDI is not sufficient to be effective at the macro-

[7] The estimated convergence rate is calculated as $ln(1+\alpha)/-T$, with α the slope of the curve relating starting income to growth (Figure 5 in the non-linear model and the coefficient on starting income in the linear model (Table 2)) and T the elapsed time period on which the regression model is estimated (9 years). In the non-linear model the slope of the curve depends on the starting income. We calculated the linearized slope over three starting income intervals using only the end-points. The three intervals are $ln(GDP_0) = [1.0, 2.0], [2.5, 3.5], [3.75, 4.5]$. The first interval represents the initially poorest countries, the last the initially richest, and the middle interval encompasses the median starting income ($ln(GDP_0) = 2.97$) in the sub-sample with FDI sufficient to enhance growth. It turns out that the linearized slope of the curve over the middle interval is about the same as the coefficient on starting income in the linear model.

economic level, convergence is local, selective. That is, there is an starting-income threshold. Above it, countries are converging to a common long-term income level. The rate of convergence is about 0.22 percent.[8] Below the starting-income threshold countries are not converging.

4 Related evidence

Previous empirical growth studies investigate the role of FDI and convergence in growth models largely separately. While most FDI studies include starting income as an explanatory variable, it is not discussed. Convergence studies do not include a term for FDI, despite its potentially important role transmitting technology across countries. A rare exception to this split in the literature is Blömstrom, Lipsey, and Zejan (1992).

4.1 FDI and growth

Cross-country evidence on whether FDI influences economic growth is contradictory. For example, two early influential studies find that FDI has a statistically significant impact on growth in all countries (Blömstrom et al., 1992) and in developing countries (Borensztein et al., 1998). However, a recent influential study of FDI in all countries found no such effect (Carkovic and Levine, 2005).

The studies which find a statistically significant effect of FDI on growth in one form or another find that it is often harmful. In Borensztein et al. (1998) the direct effect is negative, and the net effect, including an interaction term with schooling, is positive only for developing countries with high initial levels of general education. This is the case for two-thirds of their sample. In Alfaro, Chanda, Kalemli-Ozcan, and Sayek (2004) the direct effect of FDI on growth is positive, but the net effect, including an interaction term in FDI and the domestic financial sector, is negative for most countries in the sample. Alfaro (2003) studies the effect of FDI on growth within sectors of the economy. She finds that FDI in the primary sector has a statistically significant negative effect on growth, while in the manufacturing sector it has a statistically significant positive effect.

When the effect of FDI on growth is found to be statistically significant and positive, it is economically unimportant. In Borensztein et al. (1998) at the

[8] See footnote 7 for the way we calculate the convergence rate. Here we linearized the slope of the convergence curve of Figure 6 over the interval $ln(GDP_0) = [4.0, 5.0]$, which is above the convergence threshold value of 3.47.

sample mean for schooling, a moderate increase in FDI of one standard deviation of the data increases the growth rate by 0.003 percentage points each year. In Alfaro (2003) in the manufacturing sector, at the sample mean, a one standard deviation increase in FDI increases growth by 0.012 percentage points each year. By contrast we find that, among countries which surpass the FDI-growth threshold, a one standard deviation increase in FDI increases the growth rate, at the sample mean, by between 1.05 (non-linear estimate) and 1.98 (linear estimate) percentage points, an economically important amount.

The difficulty finding a robust relationship of any kind between FDI and growth probably arises because the potential role of FDI depends on context. That is, it may contribute to macroeconomic growth in some situations but not in others (Alfaro et al., 2004; Borensztein et al., 1998). For example, countries may need to attain a certain level of income before they can benefit from FDI. Studies investigating such a possibility divided countries by starting income level beforehand, and then checked for differences in estimated model parameters. Blömstrom et al. (1992) find in a small sample of developing countries that there is a statistically significant relationship between FDI and growth among middling countries, but not among poor countries (see also Blonigen and Wang (2005)).

Or, FDI may need some complementary domestic institutions to be present in sufficient extent or depth before it benefits macroeconomic growth. Countries may need to start out with a well-educated labor force (Borensztein et al., 1998) or a sophisticated financial system (Alfaro et al., 2004). These studies just cited indeed find supportive evidence for such dependencies using explanatory growth variables that multiply together FDI and a particular domestic institution. However, as already noted, the resulting direct and net effects of FDI on growth are often negative or economically unimportant. Further, Carkovic and Levine (2005) fail to find an effect of FDI on growth even after accounting for dependencies on education, domestic finance, or trade.

The search for context also motivated our own study. Our finding of an FDI-growth threshold, estimated rather than imposed beforehand, can explain previous difficulties in finding a strong and positive role for FDI in macroeconomic growth. Given the FDI-growth threshold, our evidence does not support the idea that countries need to reach a minimum level of development before they can benefit from FDI.

4.2 FDI and convergence

Most FDI studies find a statistically significant and negative coefficient on starting income, indicating that there is convergence to a common income level among at least some countries in the sample. An exception is Carkovic and Levine (2005) who estimate the FDI growth model on both pure cross-section (pooled) and combined time-series and cross-section (panel) constructions of the same data sample, and with various FDI interaction terms, in separate regressions. In most of the regressions they obtain conditional convergence with the pooled data but not with the panel data. In the regression where FDI interacts with starting income they do not obtain convergence.

In these studies, FDI is one of many explanatory variables, so its role in convergence is not clear. By contrast, our study, focusing on contributions to growth of starting income and FDI in the core empirical growth model, finds that both FDI and starting income thresholds play crucial roles in convergence. However, among countries that are converging, the rate of convergence is slow, at between 0.03 and 0.11 percent for those with FDI exceeding the growth-effect threshold. This is similar to the convergence rate of 0.07 percent found in the linear FDI models of Borensztein et al. (1998) and Alfaro et al. (2004). Convergence of manufacturing sectors only across countries may be faster at 0.24 percent per year, but that measurement is sensitive to the explanatory variables are included in the model (Alfaro, 2003).

As already noted, linear growth models with FDI cannot distinguish local from global convergence, except by imposing sample divisions and checking for differences in parameter values. Recall that Blömstrom et al. (1992) find in small samples that FDI has a positive effect on growth in middling countries but not in poor countries. One might think, then, that middling countries would be converging among themselves, as they all receive FDI from the rich countries, while poor countries might not converge among themselves or with middling or rich countries, since FDI is not effective in them. However, the case is the opposite: Blömstrom et al. (1992) fail to find convergence among middling countries, but do find it among poor countries. Poor countries may well share a low level of technology in the absence of effective FDI and thus grow to a common income level, though this is not what we found. It is harder to say why middling countries receiving effective FDI would be diverging, unless the effect of FDI on the macro-economy is too small.

The findings in Blömstrom et al. (1992) appear to conflict with more recent discoveries in the convergence literature of local convergence among coun-

tries which start their growth from a sufficiently high income level (Durlauf and Johnson, 1995; Hansen, 2000; Liu and Stengos, 1999; Quah, 1996a,b, 1997). These studies, applying various non-linear estimators of the core growth regression model, allow the data to identify the country groups, by starting income, which are converging. However, their models do not include FDI.

Durlauf and Johnson (1995) and Hansen (2000) have non-linear terms in starting income and initial literacy rate and make similar findings. The former identifies by regression three per capita income groups in 1960: those of less than $800, more than $4850, and in between. The poor countries converge to a low-growth steady-state, while the rich ones diverge. Of the countries in the middle, there is a further split between those with initial literacy rates above 46 percent, which are converging, and those with lower rates, which are not converging.

The Hansen (2000) study finds a single significant starting-income threshold value of $863 in 1960, above which countries converge. It then finds another split of the non-poor countries at a literacy rate of 45 percent, above which countries converge while below which they do not. Liu and Stengos (1999) have a more general threshold regression estimator, similar to the one we use, with non-linear variables in starting income and education. They find that countries with incomes in 1960 above $1800 are converging among each other, while the others are not. They also find that education has a positive, but linear, influence on growth.

Our study finds, in the non-linear model with FDI, that convergence is nearly global among countries with sufficient FDI. That is, poorer countries with sufficient FDI do not face an starting income or development threshold before they start catching up to richer countries. However, countries without sufficient FDI do face such a threshold. Among them, convergence is limited to those starting out with incomes above 32 percent of the starting income of the U.S. This is close to the thresholds found by Durlauf and Johnson (1995) and Hansen (2000) of 29 and 31 percent of U.S. starting income, respectively.

5 When and how FDI works

By our evidence, a country needs a minimum of FDI, at least 18 times per capita GDP, before growth responds. This is not a large amount, most of the countries in our sample having achieved it in at least one ten-year period. Beyond that minimum, FDI increases the growth rate by between 0.83 and 1.57 percentage points per year. This is a large impact which justifies the attention and resources governments devote to attracting FDI.

Countries do not need to surpass an income or development threshold before they can either attract enough or benefit from FDI at the macroeconomic level. Many initially poor and middling countries receive FDI in amounts exceeding threshold, while some initially rich countries do not receive enough FDI to affect growth. Further, the beneficial effect of FDI, when it is sufficient, on growth is larger as starting income is lower. Poorer countries tend to benefit more, which is necessary if it is to help them catch up to richer countries. FDI can be an important instrument for reducing poverty and financing development.

Among countries in which FDI is sufficient to be effective at the macroeconomic level, convergence is nearly global. That is, given the other growth factors in the regression model, nearly all these countries are growing to a common long-term income level. However, the rate of convergence is very slow, at 0.06 percent per year at the median starting income. The initially poorest countries are converging at a slightly faster rate, at 0.11 percent per year, than the initially richer countries, at 0.03 percent per year.

Among countries in which FDI is not sufficient to be effective at the macroeconomic level, convergence is local, selective. There is an starting-income threshold. Above it, all countries are converging to a common long-term income level. Below it, countries are not converging. The starting-income threshold occurs at 32 percent of the starting income of the U.S. Two-thirds of countries without sufficient FDI fall below the convergence threshold, and are not catching up to rich countries.

FDI, therefore, makes an important contribution to both growth and convergence. FDI is even necessary for convergence among the poorest countries which start out below the starting-income threshold. That FDI facilitates convergence suggests it quickens growth primarily by introducing new technology. However, even when FDI is sufficient to substantially enhance growth, the convergence rate across countries is too slow to matter much.

A Sample and data

Our sample consists of 128 countries (Table A-1), over the years 1970 to 1999, divided into three ten-year periods: 1970-79, 1980-89, and 1990-99. We start from 1970, instead of the usual 1960 in the literature, because that is when the FDI data series begins. Each observation is either a starting value of or an average for the ten-year period. We experimented with dividing the sample into seven five-year periods from 1970 to 2004, but the results were too noisy to tell a coherent story, probably reflecting the influences of business cycles and temporary shocks.

Our early regression model included variables for education and life expectance, as is usual in the convergence literature, to capture human capital. However, as reported, the education variable was not statistically significant, and so we dropped it from the model. Dropping education allowed us to expand the number of countries in the sample from 88, which is usual in previous studies, to 128. The 40 new countries are mostly poorer countries, and the expanded sample likely accounts for some of the differences in our results from previous studies.

We removed two outlier observations from the sample: China 1990-99 (for FDI) and Liberia 1990-99 (for GDP_0). The regression on this sample identified an FDI threshold, above which FDI increases the rate of growth. We confirmed our results by splitting the sample at the threshold and re-estimating the model on both sub-samples. From the 'above-threshold' sub-sample we removed a further two outlier observations: Congo DRC 1990-99 and Ethiopia 1990-99, both for GDP_0).

Nearly half the countries in our sample experienced at least one ten-year period between 1970 and 1999 in which the average amount of FDI fell below the threshold needed to benefit macroeconomic growth (Table A-2), as identified by the model estimated on the full sample. About 82 percent of the countries in the full sample experienced at least one ten-year period in which average FDI was above the growth threshold (Table A-3).[9] FDI falls below the growth-effect threshold in one-third of our country-period observations. Other than FDI itself, which identifies the threshold and divides the sample, the data do not differ much in nature between the full and sub-samples (Table A-4).

We obtained our data from the Barro-Lee database, the Penn World Tables, UNCTAD's FDI database, and the World Bank's World Development Indicators (Table A-5).

[9] Countries that appear in both sub-samples had some periods in which FDI was below the growth threshold and some in which it was above the threshold. Thus, the sum of countries in the sub-samples exceeds the number in the full sample.

Table A-1: Countries in the sample (128)

Algeria	Dominican Rep.	Lesotho	Saudi Arabia
Antigua	Ecuador	Liberia	Senegal
Argentina	Egypt	Macao	Sierra Leone
Australia	El Salvador	Madagascar	Singapore
Austria	Ethiopia	Malawi	Solomon Islands
Bahamas	Fiji	Malaysia	Somalia
Bahrain	Finland	Maldives	South Africa
Bangladesh	France	Mali	Spain
Barbados	Gabon	Malta	Sri Lanka
Belgium	Gambia	Mauritania	St Lucia
Belize	Germany	Mauritius	St Vincent
Benin	Ghana	Mexico	Sudan
Bermuda	Greece	Morocco	Suriname
Bolivia	Guatemala	Mozambique	Swaziland
Botswana	Guinea	Nepal	Sweden
Brazil	Guinea-Bissau	Netherlands	Switzerland
Brunei	Haiti	New Zealand	Syria
Burkina Faso	Honduras	Nicaragua	Thailand
Burundi	Hong Kong	Niger	Togo
Cameroon	Iceland	Nigeria	Tonga
Canada	India	Norway	Trinidad & Tobago
C. African Rep.	Indonesia	Oman	Tunisia
Chad	Iran	Pakistan	Turkey
Chile	Ireland	Panama	Uganda
China	Israel	Papua New Guinea	United Arab Emir.
Colombia	Italy	Paraguay	United Kingdom
Congo DR	Jamaica	Peru	United States
Congo	Japan	Philippines	Uruguay
Costa Rica	Jordan	Portugal	Vanuatu
Côte d'Ivoire	Kenya	Qatar	Venezuela
Cyprus	Korea, Rep.	Rwanda	Zambia
Denmark	Kuwait	Samoa	Zimbabwe

Table A-2: Countries without enough FDI in some periods (63)

Algeria	Denmark	Malawi	Sri Lanka
Antigua	Ethiopia	Maldives	St Lucia
Bahamas	Fiji	Mali	St Vincent
Bahrain	Finland	Malta	Sudan
Bangladesh	Gabon	Mauritania	Suriname
Barbados	Gambia	Mauritius	Swaziland
Belize	Guinea	Mozambique	Sweden
Benin	Guinea-Bissau	Nepal	Syria
Botswana	Haiti	Nicaragua	Tonga
Brunei	Iceland	Oman	Trinidad & Tobago
Burkina Faso	Israel	Paraguay	Uganda
Burundi	Jordan	Qatar	United Arab Emir.
C. African Rep.	Kuwait	Rwanda	Uruguay
Chile	Lesotho	Samoa	Vanuatu
China	Macao	Solomon Islands	Zimbabwe
Cyprus	Madagascar	Somalia	

Table A-3: Countries with enough FDI in some periods (105)

Algeria	Ecuador	Liberia	Singapore
Argentina	Egypt	Madagascar	Somalia
Australia	El Salvador	Malawi	South Africa
Austria	Finland	Malaysia	Spain
Bahrain	France	Mali	Sri Lanka
Bangladesh	Gabon	Mexico	St Lucia
Belgium	Gambia	Morocco	Sudan
Benin	Germany	Mozambique	Suriname
Bermuda	Ghana	Nepal	Swaziland
Bolivia	Greece	Netherlands	Sweden
Botswana	Guatemala	New Zealand	Switzerland
Brazil	Guinea	Nicaragua	Syria
Burkina Faso	Haiti	Niger	Thailand
Cameroon	Honduras	Nigeria	Togo
Canada	Hong Kong	Norway	Trinidad & Tobago
C. African Rep.	India	Oman	Tunisia
Chad	Indonesia	Pakistan	Turkey
Chile	Iran	Panama	Uganda
China	Ireland	Papua New Guinea	United Kingdom
Colombia	Israel	Paraguay	United States
Congo DR	Italy	Peru	Vanuatu
Congo	Jamaica	Philippines	Venezuela
Costa Rica	Japan	Portugal	Zambia
Côte d'Ivoire	Jordan	Rwanda	Zimbabwe
Cyprus	Kenya	Saudi Arabia	
Denmark	Korea, Rep.	Senegal	
Dominican Rep.	Lesotho	Sierra Leone	

Table A-4: Descriptive statistics for the data

Variable	Minimum	Median	Mean	Maximum	St dev
Full sample (382 obs)					
GRO	−0.096	0.015	0.015	0.163	0.029
$ln(INV)$	0.401	2.560	2.506	4.026	0.624
$ln(POP)$	−8.043	−3.816	−4.132	−1.830	0.886
$ln(LIFE_0)$	3.456	4.187	4.119	4.376	0.195
$ln(OPEN)$	1.451	4.107	4.050	5.801	0.706
$ln(GDP_0)$	0.571	2.927	2.923	5.756	1.134
$ln(FDI)$	−3.283	3.648	3.459	8.283	2.102
FDI-below-threshold sub-sample (126 obs)					
GRO	−0.084	0.011	0.015	0.163	0.035
$ln(INV)$	0.401	2.451	2.340	3.504	0.614
$ln(POP)$	−7.779	−3.746	−4.038	−1.830	0.878
$ln(LIFE_0)$	3.456	4.187	4.098	4.359	0.208
$ln(OPEN)$	2.394	4.486	4.279	5.563	0.699
$ln(GDP_0)$	0.670	2.811	2.841	5.756	1.217
$ln(FDI)$	−3.283	1.733	1.159	2.851	1.507
FDI-above-threshold sub-sample (254 obs)					
GRO	−0.073	0.017	0.016	0.081	0.024
$ln(INV)$	0.748	2.661	2.595	4.026	0.610
$ln(POP)$	−8.043	−3.828	−4.184	−2.896	0.889
$ln(LIFE_0)$	3.605	4.189	4.133	4.376	0.186
$ln(OPEN)$	1.451	3.967	3.946	5.801	0.677
$ln(GDP_0)$	0.933	2.972	2.981	4.785	1.075
$ln(FDI)$	2.858	4.360	4.587	8.283	1.265

Table A-5: Data sources

Variable	Description	Source
GRO	Growth rate, computed from PPP-converted GDP per capita, constant prices, percent	PWT (RGDPL)
INV	Investment share of PPP-converted GDP per capita at constant prices, percent	PWT (KI)
POP	Population growth rate, annual, percent	WDI
$LIFE_0$	Initial life expectancy at birth, years	WDI
$EDUC_0$	Initial average schooling years of the population aged 15 and up	BL (TYR)
$OPEN$	The sum of exports and imports divided by PPP-converted GDP per capita, constant prices	PWT (OPENK)
GDP_0	Initial PPP-converted GDP per capita, current prices, relative to that of the U.S., index, U.S. = 100	PWT (Y)
FDI	Net inflows of FDI, current US$, divided by GDP per capita, current US$, percent	WDI (main) and UNCTAD

Note: All variables except GRO are converted to natural logarithms.

Sources

BL Barro-Lee database (Jong-Wha and Barro, 2001): http://www.cid.harvard.edu/ciddata/ciddata.html

PWT Penn World Tables 6.2 (Heston, Summers, and Aten, 2006): http://www.pwt.econ.upenn.edu/

UNCTAD UNCTAD, FDI database: http://www.unctad.org

WDI World Bank, World Development Indicators Online: http://www.worldbank.org/

References

Alfaro, L. (2003, April). Foreign direct investment and growth: does the sector matter? http://www.grips.ac.jp/teacher/oono/hp/docu01/paper14.pdf. 19, 20, 21

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek (2004). FDI and economic growth: the role of local financial markets. *Journal of International Economics 64*, 89–112. 19, 20, 21

Bernard, A. B. and S. N. Durlauf (1996). Interpreting tests of the convergence hypothesis. *Journal of Econometrics 71*, 161–173. 6

Bernard, A. B. and C. I. Jones (1996, July). Technology and convergence. *The Economic Journal 106*, 1037–1044. 4

Blömstrom, M., R. E. Lipsey, and M. Zejan (1992, August). What explains developing country growth? Working paper 4132, National Bureau of Economic Research, Cambridge, MA. 19, 20, 21

Blonigen, B. A. and M. G. Wang (2005, April). Inappropriate pooling of wealthy and poor countries in empirical FDI studies. In T. H. Moran, E. M. Graham, and M. Blömstrom (Eds.), *Does foreign direct investment promote development?*, Chapter 9, pp. 221–244. Washington, DC: Institute for International Economics and Center for Global Development. 20

Borensztein, E., J. D. Gregorio, and J.-W. Lee (1998). How does foreign direct investment affect economic growth? *Journal of International Economics 45*, 115–135. 4, 5, 19, 20, 21

Carkovic, M. and R. Levine (2005, April). Does foreign direct investment accelerate economic growth? In T. H. Moran, E. M. Graham, and M. Blömstrom (Eds.), *Does foreign direct investment promote development?*, Chapter 8, pp. 195–220. Washington, DC: Institute for International Economics and Center for Global Development. 7, 19, 20, 21

Durlauf, S. N. and P. A. Johnson (1995). Multiple regimes and cross-country growth behaviour. *Journal of applied econometrics 10*, 365–384. 6, 22

Durlauf, S. N. and D. Quah (1999). The new empirics of economic growth. In *Handbook in macroeconomics*, Volume 15 of *Handbooks in economics*, pp. 235–308. Amsterdam: North Holland. 5, 6

Hansen, B. E. (2000, May). Sample splitting and threshold estimation. *Econometrica 68*(3), 575–603. 22

Hayfield, T. and J. S. Racine (2008). Nonparametric econometrics: The np package. *Journal of Statistical Software 27*(5). 6

Heston, A., R. Summers, and B. Aten (2006, September). Penn world table version 6.2. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. 29

Jong-Wha and R. J. Barro (2001). Schooling quality in a cross-section of countries. *Economica 68*, 465–488. 29

Liu, Z. and T. Stengos (1999). Non-linearities in cross-country growth regressions: a semiparametric approach. *Journal of Applied Econometrics 14*, 527–538. 5, 22

Mankiw, N., D. Romer, and D. Weil (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics 107*, 407–437. 3

Quah, D. (1999, July). Ideas determining convergence clubs. Working paper, Economics Department, LSE, London. 6

Quah, D. T. (1996a, March). Convergence empirics across economies with (some) capital mobility. *Journal of Economic Growth 1*(1), 95–124. 4, 6, 22

Quah, D. T. (1996b). Twin peaks: Growth and convergence in models of distribution dynamics. *Economic Journal 106*(437), 1045–1055. 22

Quah, D. T. (1997, March). Empirics for growth and distribution: stratification, polarization, and convergence clubs. *Journal of Economic Growth 2*(1), 27–59. 22

R Development Core Team (2008). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. ISBN 3-900051-07-0. 6

Romer, P. (1993). Idea gaps and object gaps in economic development. *Journal of Monetary Economics 32*, 543–573. 4

Wang, J.-Y. and M. Blömstrom (1992). Foreign investment and technology transfer. *European Economic Review 36*, 137–155. 4