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04-30

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On the Causal Links between FDI and Growth in Developing Countries

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December 2004

Abstract

We analyse the Granger-causal relationships between foreign direct investment (FDI) and GDP in a sample of 31 developing countries covering the period 1970-2000. Using estimators for heterogeneous panel data we find bi-directional causality between the FDI/GDP ratio and the level of GDP. FDI is found to have a lasting impact on the level of GDP, while GDP has no long run impact on the FDI/GDP ratio. In that sense FDI causes growth. Furthermore, in a model for GDP and FDI as a fraction of gross capital formation (GCF) we also find long run effects of shifts in the mean level of FDI/GCF. We interpret this finding as evidence in favour of the hypotheses that FDI has an impact on GDP via knowledge transfers and adoption of new technology.

Key words: Economic growth, foreign direct investment, Granger causality, panel data

1. Introduction

The inflow of foreign direct investment (FDI) increased rapidly during the late 1980s and the 1990s in almost every region of the world revitalizing the long and contentious debate about the costs and benefits of FDI inflows. On one hand many would argue that, given appropriate policies and a basic level of development, FDI can play a key role in the process of creating a better economic environment. On the other hand potential drawbacks do exist, including a deterioration of the balance of payments as profits are repatriated and negative impacts on competition in national markets. At present, the consensus view seems to be that there is a positive association between FDI inflows and growth provided receiving countries have reached a minimum level of educational, technological and/or infrastructure development. However, as in many other fields of development economics, there is not universal agreement about the positive association between FDI inflows and economic growth.

Even if one accepts the positive association there is still the question of causality. Does FDI cause (long run) growth and development or do fast growing economies attract FDI flows as TNCs search for new market and profit opportunities? Theoretically, neither of the links can be ruled out and this is probably the reason why the causality issue has been the topic of so many recent studies. As documented in Section 2, at least six studies precedes our study, and it is reasonable to ask if there is a need for yet another look at causality between FDI and growth in developing countries.

We aim at contributing to the existing literature in three dimensions: First of all we take a close look at the model specification. This is motivated by results obtained by Carkovic and Levine (2002) who argue that once country specific level differences, endogeneity of FDI inflows and—in particular—convergence effects are taken into account there is no robust impact from FDI on growth. In essence, Carkovic and Levine change the model specification from a relationship between FDI (as a percentage of GDP) and the growth rate of GDP to a relationship between FDI and the level of GDP. This change in model formulation makes sense for two reasons. The first is that the model for FDI and GDP-growth is a sub-model of the model for FDI and (log) GDP. Hence, in a statistical sense the levels-levels model encompasses the levels-growth model. A second reason for starting with a levels specification is that standard neo-classical growth models with well defined steady states predict a long run relation between the levels. Therefore, the levels-growth model would seem to exclude the neo-classical growth models by assumption, instead of including these models in conjunction with the endogenous growth models. Thus, when testing for Granger causal relationships between FDI and growth we specify a vector autoregressive model for the log of GDP and FDI as a percentage of GDP. We test for Granger causality using annual data and, therefore, include country specific trends in addition to country specific levels. This is a natural consequence of analysing the levels-levels model. Our empirical results, based on mean group estimations that allow for country specific heterogeneity of all parameters, indicates a strong causal link from FDI to GDP, also in the long run, whereby mean shifts in the FDI ratio causes changes in the level of GDP. GDP also Granger causes FDI, but we find no impact on the long run level of the FDI ratio. The result is at odds with other recent studies of Granger causality between FDI and growth. We conjecture that the main reason for the new result is the change in model formulation.

The second issue we address is the economic significance of FDI inflows, which is natural in light of our finding of statistical significance. In assessing the economic importance of FDI we use the standard Solow model as benchmark. In a Solow model in which capital's share is 1/3 the elasticity of steady state income with respect to the savings ratio is ½. Evaluated at a savings ratio of 20 percent this means that a one percentage point increase in the savings ratio causes a 2.5 percent increase in the steady state level of income. Our empirical results indicate that a one percentage point increase in the mean of the FDI ratio, on average, causes a 2.25 percent increase in the GDP level. Hence, FDI appears to be no more or no less growth enhancing than domestic investments.

Knowledge transfers and adoption of new technology are often emphasized as two of the main growth enhancing channels from FDI inflows. But the importance of these channels is not easily quantified in models using (log) levels of FDI or the FDI-to-GDP ratio.[1] Consequently, in an attempt of assessing the importance of such channels we reformulate the model and look at FDI as percentage of gross capital formation (GCF). The idea is that the FDI/GCF ratio "isolates" the knowledge and composition effects of FDI inflows as we condition on gross capital formation. We find FDI/GCF to Granger cause GDP indicating a statistical significant composition effect of FDI.

Finally, inspired by previous results about the impact of FDI on growth, we look for systematic patterns in the size of the long run impact of FDI/GCF on GDP. Based on simple graphical analyses (and regressions) we find no systematic relations between the total impact of FDI and development indicators such as the level of GDP per capita, education, trade or credit. Even though our sample of 31 countries is too small to make conclusive decisions we do think this is an interesting observation when policy makers and their experts design policies to attract foreign direct investments.

Following this introduction, Section 2 provides a brief literature review of the association between FDI inflows and economic growth. Section 3 discusses the model used for testing Granger-causality and Section 4 summarizes our empirical results. Section 5 concludes.

2. Recent literature

During the last decade a number of interesting studies of the role of foreign direct investment in stimulating economic growth has appeared. In an excellent survey, de Mello (1997) lists two main channels through which FDI may be growth enhancing. First, FDI can encourage the adoption of new technology in the production process through capital spillovers. Second, FDI may stimulate knowledge transfers, both in terms of labour training and skill acquisition and by introducing alternative management practices and better organiza-

[1] de Mello (1999) looks at FDI impact on total factor productivity, which is one way of assessing the importance of the knowledge transfers. We take a different route that does not rely on TFP calculations.

tional arrangements. A survey by OECD (2002) underpins these observations and documents that 11 out of 14 studies have found FDI to contribute positively to income growth and factor productivity. Both de Mello and OECD stress one key insight from all the studies reviewed: the way in which FDI affects growth is likely to depend on the economic and technological conditions in the host country. In particular, it appears that developing countries have to reach a certain level of development, in education and/or infrastructure, before they are able to capture potential benefits associated with FDI. Hence, FDI seems to have more limited growth impact in technologically less advanced countries.

Four studies, relying on a variety of cross-country regressions, have looked into necessary conditions for identifying a positive impact of FDI on economic growth. Interestingly, they stress different, though closely related, aspects of development. First, Blomström *et al.* (1994) argue that FDI has a positive growth-effect when a country is sufficiently rich in terms of per capita income. Second, Balasubramanyam *et al.* (1996) emphasize trade openness as being crucial for acquiring the potential growth impact of FDI. Third, Borenztein *et al.* (1998) find that FDI raises growth, but only in countries where the labour force has achieved a certain level of education. Finally, Alfaro *et al.* (2004) draw attention to financial markets as they find that FDI promotes economic growth in economies with sufficiently developed financial markets. However, when Carkovic and Levine (2002) estimate the effects of FDI on growth after controlling for the potential biases induced by endogeneity, country-specific effects, and the omission of initial income as a regressor, they find, using this changed specification that the results of these four papers break down. Carkovic and Levine conclude that FDI has no impact on long run growth.

Another strand of the literature has focused more directly on the causal relationships between FDI and growth and, at least, six studies have tested for Granger causality between the two series using different samples and estimation techniques. Zhang (2001) looks at 11 countries on a country-by-country basis, dividing the countries according to the time series properties of the data. Tests for long run causality based on an error correction model, indicate a strong Granger-causal relationship between FDI and GDP-growth. For six counties where there is no cointegration relationship between the log of FDI and growth, only one country exhibited Granger causality from FDI to growth. Chowdhury and Mavrotas (2003) take a slightly different route by testing for Granger causality using the Toda and Yamamoto (1995) specification, thereby overcoming possible pre-testing problems in relation to tests for cointegration between series.[2] Using data from 1969 to 2000, they find that FDI does not Granger cause GDP in Chile, whereas there is a bi-directional causality between GDP and FDI in Malaysia and Thailand.

de Mello (1999) looks at causation from FDI to growth in 32 countries of which 17 are non-OECD countries. First he focuses on the time series aspects of FDI on growth, finding that the long run effect of FDI on growth is heterogeneous across countries. Second, de Mello complements his time-series analysis by providing evidence from panel data estimations. In the non-OECD sample he finds no causation from FDI to growth based on fixed effects regressions with country specific intercepts, and a negative short run impact of FDI on GDP using the mean group estimator.

Nair-Reichert and Weinhold (2001) test causality for cross country panels, using data from 1971 to 1995 for 24 countries. Like de Mello, they emphasize heterogeneity as a serious issue and, therefore, use what they refer to as the mixed fixed and random (MFR) coefficient approach in order to test the impact of FDI on growth. The MFR approach allows for heterogeneity of the long run coefficients, thereby avoiding the biases emerging from imposing homogeneity on coefficients of lagged dependent variables. They find that FDI on average has a significant impact on growth, although the relationship is highly heterogeneous across countries.

Choe (2003) uses the traditional panel data causality testing method developed by Holtz-Eakin *et al.* (1988) in an analysis of 80 countries. His results points towards bi-directional causality between FDI and growth, although he finds the causal impact of FDI on growth to be weak.

[2] By fitting the VAR in levels, problems with identifying orders of integration are avoided.

Finally the study by Basu *et al.* (2003) addresses the question of the two-way link between growth and FDI. Allowing for country specific cointegrating vectors as well as individual country and time fixed effects they find a cointegrated relationship between FDI and growth using a panel of 23 countries. Basu *et al.* emphasise trade openness as a crucial determinant for the impact of FDI on growth, as they find two-way causality between FDI and growth in open economies, both in the short and the long run, whereas the long run causality is unidirectional from growth to FDI in relatively closed economies.

The main message to take from this selective survey is that there seems to be a strong relationship between FDI and growth. Although the relationship is highly heterogeneous across countries the studies mentioned generally agree that FDI, on average, has an impact on growth in the Granger-causal sense.

3. The models

As can be deducted from the survey, the mechanics of testing for Granger causality are well known. Therefore discussions of the precise specification of the statistical models are often suppressed in empirical analyses. Unfortunately, this leaves room for confusion about the interpretation of the empirical results. To avoid this confusion we specify and discuss our choice of model in this section.

We consider bi-variate vector autoregressive (VAR) models for the log of GDP and FDI as a percentage of GDP, and for the log of GDP and FDI as a percentage of gross capital formation (GCF). Data for 31 countries over 31 years (1970-2000) were obtained from the World Development Indicators 2002 and from the UNCTAD FDI database. To ease the notation, let $x_{it} = [\log(GDP_{it}), FDI_{it} / GDP_{it}]'$, or $x_{it} = [\log(GDP_{it}), FDI_{it} / GCF_{it}]'$, where subscript i indexes countries ($i=1,\ldots,N$) while t indexes time ($t=1,\ldots,T$). The VAR-model for x_{it} is specified as[3]

$$x_{it} = A_{1i}x_{it-1} + A_{2i}x_{it-2} + A_{3i}x_{it-3} + \mu_i + \delta_i t + \lambda_t + \varepsilon_{it} \tag{1}$$

where A_{ji} are (2 x 2) matrices of parameters that are allowed to vary across countries, μ_i and δ_i are country specific (2 x 1) intercept and trend parameters, λ_t is a (2 x 1), mean zero, time specific component, assumed to be equal across countries, and ε_{it} is a (2 x 1) idiosyncratic error component assumed to be $iid(0,\Omega_i)$, with country specific, positive definite covariance matrices.

The reason for including country specific trends in addition to the country specific intercept and the time specific component is that we model the log of GDP. If the growth rate of an economy has a non-zero mean then the log of GDP is trending. However, if the trend parameter, δ_i, is constant across countries, then the country specific factor, λ_t, can be redefined to include this common deterministic trend. In this case the result is a standard two-way error component model.

As is well known, in this model, Granger non-causality from FDI to GDP is formulated as the hypothesis

$$H_0(FDI \nrightarrow GDP): a_{12(ji)} = 0, \quad j = 1, 2, 3 \tag{2}$$

where $a_{12(ji)}$ are the (1,2)-elements in the A_{ji} matrices. If the hypothesis is rejected we say that FDI Granger causes GDP. The reverse hypothesis of Granger non-causality from GDP to FDI is given as

$$H_0(GDP \nrightarrow FDI): a_{21(ji)} = 0, \quad j = 1, 2, 3 \tag{3}$$

Most papers surveyed in Section 2 discuss Granger causality between FDI and *growth* rather than between FDI and the level of GDP. A reformulation of the VAR model, known

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[3] In the empirical analyses we found that third-order VAR models had good properties in terms of statistical measures such as information criteria and residual autocorrelation. Therefore, we have chosen present and discuss the specific VAR(3)-model rather than the general VAR(k)-model.

as the error-correction form, shows that if FDI Granger cause GDP, then it also Granger causes growth. Let

$$\Pi_i = -(A_{1i} + A_{2i} + A_{3i} - I), \Gamma_{1i} = -(A_{2i} + A_{3i}), \Gamma_{2i} = -A_{3i}$$

then the VAR-model is given by

$$\Delta x_{it} = \Gamma_{1i}\Delta x_{it-1} + \Gamma_{2i}\Delta x_{it-2} + \Pi_i x_{it-1} + \mu_i + \delta_i t + \lambda_t + \varepsilon_{it} \tag{4}$$

In this formulation the dependent variables are the changes in the log of GDP (the growth rate) and the changes in FDI.

Based on economic theory we expect a relationship between the level of GDP and FDI (to either GDP or GCF) as long as the economies are assumed to converge towards steady states. This is in parallel with the relationship between GDP and domestic investment. However, it is possible that economies do not converge towards steady states (e.g. AK-type models of growth) or that FDI has an impact on total productivity, such that a rise in the FDI ratio leads to permanent movements in the steady states. In the latter cases the relationship is between the growth rate of GDP and the FDI ratio. This is a sub-model of the VAR for the levels adding the restriction $\pi_{11(i)} = \pi_{21(i)} = 0$ and assuming that $\pi_{22(i)} \neq 0$. Hence, this is a testable hypothesis within the general VAR.

The error-correction form is a convenient formulation for many other purposes. First of all the hypotheses of Granger non-causality are unchanged by the linearity of the transformation. In the error correction form the hypotheses are

$$\begin{aligned} &H_0(FDI \nrightarrow GDP): \gamma_{12(ji)} = 0 \text{ and } \pi_{12i} = 0, \quad j = 1,2 \\ &H_0(GDP \nrightarrow FDI): \gamma_{21(ji)} = 0 \text{ and } \pi_{21i} = 0, \quad j = 1,2 \end{aligned} \tag{5}$$

Some authors (e.g., Zhang; 2001 and Basu *et al.*; 2003) separate the Granger non-causality hypothesis into two sub-hypotheses of short- and long-run causality. Short-run causality relates to hypotheses about zeros outside the diagonal in the Γ-matrices while long-run causality is about off-diagonal zeros in Π. In the present paper we follow the classical notion of Granger causality, and use (5) as the null-hypotheses, whereas we denote the hypotheses about off-diagonal zeros in Π as neutrality-hypotheses.

The neutrality-hypotheses are interesting because they can be used to relate the cross-country growth studies using long averages over time and the time-series and panel studies using annual observations. The relationship is given by the moving average representation of the model, which for large T can be approximated by

$$x_{it} = C_i(\mu_i + \delta_i t) + C_i(L)(\lambda_t + \varepsilon_{it}) + \text{(initial conditons)} \tag{6}$$

In this model the long-run impact of FDI on GDP is estimated by $c_{12(i)}$. This effect is akin to the estimated impact in cross-country growth models using long averages. The relation between C and Π is, assuming the latter is invertible, given by

$$C_i = -\Pi_i^{-1} = \frac{1}{|\Pi_i|}\begin{bmatrix} -\pi_{22(i)} & \pi_{12(i)} \\ \pi_{21(i)} & -\pi_{11(i)} \end{bmatrix} \tag{7}$$

From this relation the notion of neutrality is clear: if $\pi_{12(i)} = 0$ then $c_{12(i)} = 0$ and there is no long run impact from FDI to the level of GDP.[4] This shows that cross-country studies using long averages and time series studies using annual observations may well differ in their conclusion about causality. The first kind of studies is testing neutrality while the second is testing causality (possibly at the business cycle frequencies). It should be clear that the only direct relationship is that Granger non-causality implies neutrality. In the present paper we test for both Granger non-causality and neutrality.

Finally, it should be noted that in the empirical analysis below we find cointegration between GDP and FDI and this has implications for the computation and interpretation of the long run impact matrices Π_i and C_i, as both matrices have reduced rank. When Π_i has reduced rank - in our model rank 1 - it is convenient to write the matrix as a product of two matrices $\Pi_i = \alpha_i \beta_i'$, where α_i and β_i are both (2 x 1)-matrices. C_i is computed as $C_i = \beta_{\perp i}(\alpha'_{\perp i}(I - \Gamma_{1i} - \Gamma_{2i})\beta_{\perp i})^{-1}\alpha'_{\perp i}$, where $\alpha_{\perp i}$ and $\beta_{\perp i}$ are the orthogonal complements to α_i and β_i (Johansen; 1991). In the cointegrated model the test for neutrality can still be based on significance of the parameters in the autoregressive representation because a zero-

[4] Likewise, neutrality of GDP with respect to FDI is given from $\pi_{21(i)} = 0$.

row in Π_i corresponds to a zero-column in C_i. If, say, GDP is neutral for the long run level of FDI then $\alpha_{2i} = 0$ and it follows that $\pi_{21i} = \pi_{22i} = 0$ and $c_{11i} = c_{21i} = 0$. However, the interpretation of neutrality is somewhat different in cointegrated systems compared to stationary systems. In particular, even if neutrality of GDP with respect to FDI is accepted, it cannot be concluded that GDP has no impact on the long run level of FDI/GDP as they are both non-stationary. But, it can be concluded that the level of GDP carries no information about the level of FDI/GDP.

4. Empirical results

In this section we present the results of our empirical analysis.[5] The main part is devoted to a "large *T*" analysis in which the time series properties of the data are important. The essence of the large *T* assumption is that the time series dimension is assumed to be large enough to be useful in a random coefficient type model.[6] The main draw-back of the assumption is the sequence of pre-tests for stationarity and cointegration which will impact upon the final results of the Granger causality tests. The second approach to testing for Granger causality is a "large *N*" assumption, in which the time series properties are not analyzed explicitly. Instead, the cross-country dimension is assumed to be large enough to lead to asymptotic normality of the estimators regardless of the time series properties.[7] In the analysis the *structure* of the relationship between FDI and GDP is assumed to be equal across countries, i.e. the lag structure of the VAR and the time series properties (non-stationarity and cointegration) are assumed to be identical although the individual parameters are allowed to vary across countries.[8]

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[5] See Data Appendix for details on variable definitions and a list of countries used in this study.

[6] When both *N* and *T* tend to infinity, as is required for consistency, the precise condition is that $\sqrt{N}/T \to 0$ (Hsiao, Pesaran and Tahmiscioglu; 1999 and Larsson, Lyshagen and Löthgren; 2001).

[7] Here a sufficient condition for consistency and asymptotic normality is that $N/T \to 0$ as *N* and *T* tends to infinity (Alvarez and Arellano; 2003).

[8] This is in contrast to many of the causality studies mentioned in section 2 in which results are often given on a country-by-country basis.

4.1 Time series properties

Before testing for Granger causality we investigate the time series properties of the GDP and FDI series.[9] The tests are first performed on a country-by-county basis and subsequently the test statistics are combined to single panel data test statistics. This testing strategy allows all parameters to vary across countries, while preserving the assumption of common structures.

Tables 1 and 2 show the tests for unit-roots and cointegration of the series, log GDP, FDI/GDP and FDI/GCF. In the tables we report three test statistics that are all based on the same underlying sets of country specific tests. For each country we test for unit-roots and cointegration using the likelihood ratio test (Johansen; 1988, 1991). The reason for choosing the likelihood ratio test is that Johansen (2002, 2003) has developed a small sample correction of the test and, by simulation, show that the corrected test statistic performs well in samples of 25-30 observations as long as the time series are not too close to being integrated of order 2. Furthermore, Larsson, Lyshagen and Löthgren (2001) have shown that the standardized likelihood ratio statistic has a limiting normal distribution in heterogeneous panels. In Tables 1 and 2 the Larsson *et al.* test based on small sample corrected country specific statistics is given as "panel LR". The test statistic is computed as follows:

$$\text{panel LR} = \sqrt{N}\,\frac{\left(\frac{1}{N}\sum_{i=1}^{N} LR_i\right) - \mathrm{E}(Z_k)}{\sqrt{\mathrm{Var}(Z_k)}} \overset{d}{\underset{H_0}{\Rightarrow}} N(0,1)$$

where $\mathrm{E}(Z_k)$ and $\mathrm{Var}(Z_k)$ is the mean and variance of the limiting distribution of the country specific likelihood ratio test. These quantities are found by simulation, as the limiting distribution of the test for unit-roots is non-standard.

In addition to the panel LR tests we also report two tests, which are based on the *p*-values of the individual country test statistics.[10] The use of *p*-values in panel unit-root and cointegration tests was proposed by Maddala and Wu (1999). The idea of using *p*-values to test

[9] We selected the appropriate lag for each series using Schwartz' information criteria and sequential F-tests.
[10] The *p*-values are computed using the Gamma-distribution approximation proposed in Doornik (1998).

for significance of combined results in independent samples has a long history.[11] In Tables 1 and 2 we report two such test statistics. The first denoted "log p-value" is the inverse Chi-square method (Fischer; 1990) while the second is the logit method (George and Mudholkar; 1983):

$$\log p = -2\sum_{i=1}^{N} \log(p_i) \underset{H_0}{\overset{d}{\Rightarrow}} \chi^2(2N)$$

$$\text{logit } p = \sqrt{N}\, \frac{\frac{1}{N}\sum_{i=1}^{N} \log\left(\frac{p_i}{1-p_i}\right)}{\sqrt{\pi^2(5N+2)/\{3(5N+4)\}}} \underset{H_0}{\overset{d}{\Rightarrow}} t(5N+4)$$

The three test statistics are all based on the maintained hypothesis that the country specific errors are independent.[12]

[INSERT TABLE 1 ABOUT HERE]

Table 1 show that the null-hypothesis of a unit-root in each of the three series in first differences is rejected at conventional levels of significance. Hence, we find mean-stationary differences. In contrast the hypothesis of a unit-root in the levels of the series cannot be rejected.

[INSERT TABLE 2 ABOUT HERE]

Table 2 reports the test statistics for cointegration in the two models, [log GDP, FDI/GDP], and [log GDP, FDI/GCF]. The hypothesis of two-unit roots (no cointegration) is strongly rejected while the hypothesis of one unit-root cannot be rejected. This confirms the non-stationarity of the series and leads to the conclusion that both models have one cointegration vector.

[11] See Hedges and Olkin (1985) for references

[12] Larsson et al. (2001) do not derive the limiting distribution for the type of model we use. Instead they conjecture that the result holds for this kind of model. This is the reason why we have chosen also to include the two other test statistics. As seen from Tables 1 and 2 there are no discrepancies between the three test statistics.

The last row of Tables 1 and 2 reports the percentage of countries in which the null-hypothesis is accepted (Vote counting). We include this statistic to illustrate that the cointegration results are not uniform across countries. One of the differences between the present study and some of the previous studies is that we *assume* all countries have identical time series properties, whereas other authors using random coefficient models make use of vote counting and, thereby, *assume* that the countries have different time series properties. From Table 2 it appears that the null-hypothesis of no cointegration between log GDP and FDI/GDP is accepted for 22 of the 31 countries when testing at the five percent level of significance. For log GDP and FDI/GCF the fraction is even higher, as there are 23 countries for which we accept the null-hypothesis of no cointegration. So using a country-by-country selection procedure would lead us to look at models for first differenced data. In contrast the panel test statistics are strongly in favour of models for the levels with cointegration constraints.

4.2 Granger causality

Tables 3 and 4 give the results of the Granger causality tests. The regression results in systems (1a)-(1b) in Table 3, and (3a)-(3b) in Table 2 are based on the mean group estimator proposed by Pesaran and Smith (1995). The estimated elements of Π are averages of the country specific estimates; therefore the mean group Π-matrix does not have reduced rank even though each of the country specific matrices does. Note also that the row-wise elements of Π have identical *t*-values. This is because the variance of Π is determined by the variance of α, which is constant across the rows.

[INSERT TABLE 3 ABOUT HERE]

As seen from Table 3, the system [log GDP, FDI/GDP] has bi-directional causality, when tested at the five percent level. On purely statistical terms the causality from FDI/GDP to GDP seems best determined. In addition we find a strong influence from the levels (the cointegration relation). In contrast the lagged levels of log GDP and FDI/GDP do not carry information for the changes in FDI/GDP. Hence, the hypothesis of neutrality is accepted in the FDI/GDP relation.

In comparing the VAR-model results and cross-country regression results it is of interest to calculate the non-zero off-diagonal elements of the total impact matrix *C*. In the present model this is the element $\hat{c}_{12}$. The mean group estimate of $\hat{c}_{12}$ is 0.0225, implying that a one percentage point increase in FDI/GDP leads to a 2.25 percent increase in GDP in the long run. Given the sampling variation this corresponds surprisingly well to the impact of a one percentage point increase in the savings rate in a standard Solow model.

Using regressions (2a) and (2b) in Table 3 we look into the "robustness" of the mean group estimation. The two regressions are results of fixed effects estimations with country specific intercepts and trends in addition to time dummies. No information about the time series properties is imposed on the model.

The fixed effects results are surprisingly close to the mean group results. The point estimates are of the same order of magnitude and in all but two cases there is agreement with respect to the precision of the estimate in terms of statistical significance. There is also agreement about two-way causality and about neutrality in the FDI/GDP relation.[13] The main difference between the mean group and the fixed effects results is found in the estimated long run impact of FDI/GDP on log GDP ($\hat{c}_{12}$). In the fixed effects model a one percentage point increase in FDI/GDP leads to a 5.88 percent increase in GDP in the long run, i.e., more than twice the impact found in the mean group estimation with cointegration constraints. However, the hypothesis that the impact is "only" 2.5 percent cannot be rejected. Overall we find that the fixed effects regressions support the mean group results.

[13] This result does not hold for all specifications of the fixed effects model. If the trend slopes are assumed to be equal across countries we find no Granger causality from GDP to FDI/GDP. When the model is specified for the growth of GDP and FDI/GDP (i.e., replacing the lagged level of log GDP by the third lag of the difference of log GDP) we also find no causality from GDP to FDI/GDP. However, these models do not correspond to the mean group model.

Next, we turn to the results for log GDP and FDI/GCF. The idea is to quantify if FDI has a composition effect in addition to the increase in gross capital formation. As described in the introduction this is often assumed to be the main cause of the positive impact of FDI on GDP growth in developing countries.

[INSERT TABLE 4 ABOUT HERE]

Regressions (3a) and (3b) are the mean group estimates of the GDP; FDI/GCF system. In section 4.1 it was established that the two series cointegrate and, as for the GDP; FDI/GDP system, this restriction has been imposed on the mean group model. In the new system there is one-way causality from FDI to GDP as the hypothesis of Granger non-causality is accepted at the 15 percent level of significance. Moreover, in agreement with the first system we find neutrality of GDP with respect to the long run level of FDI/GCF.

The Granger causality and non-neutrality of FDI/GCF with respect to GDP is interesting as it implies an investment composition effect of FDI. A higher ratio of FDI in the gross capital formation has a positive impact on the long run level of GDP, and thereby on growth. The estimated long run impact of a one percentage point increase in the ratio ($\hat{c}_{12}$) is 0.004, which equals a 0.4 percent increase in GDP in the long run. Even though this effect appears small it can make quite a difference considering the distribution of FDI/GCF across countries and time. A move from the 25th percentile to the 75th percentile is a change in the FDI to GCF ratio of almost 8 percentage points (1.5 to 9.4 percent). Such a move would, according to the average impact, generate an increase in GDP of 3.2 percent. We think of this as an economically significant composition effect of FDI, which is somewhat surprising in light of the results for the FDI to GDP ratio.

When the robustness of the mean group results are tested using the fixed effects model we do not get the same agreement as found in the first system. In fact, it is seen from Table 4 that using the fixed effects estimator with country specific intercepts and trends in addition to time dummies, we find no causal relations when testing at the five percent level. If anything there is weak support for Granger causality from GDP to FDI, but there is still neutrality, whereby this is information at the business cycle frequencies. The Granger non-causality of FDI with respect to GDP is interesting because the point estimates in the GDP regressions (3a) and (4a) are of the same order of magnitude, thus it is an inflation of the estimated variances that generate the result. This indicates a potential outlier problem because outliers have quite different impacts on the mean group and fixed effects variance estimates. The suspicion is confirmed by a fixed effects regression that excludes Pakistan. Regressions (5a)-(5b) clearly shows that by excluding Pakistan we obtain close correspondence between the two estimators, and we find support for Granger causality from FDI to GDP, verifying the mean group results.

Summarizing, we find strong causal effects of FDI on GDP and even though the impact of FDI on GDP is not significantly larger that the expected impact of domestic investment in a Solow model we find a significant composition effect in the sense that a higher ratio of FDI in gross capital formation has positive effects on the level of GDP and hence on growth.

4.3 Searching for systematic variations in the impact of FDI on GDP

As noted in section 2, heterogeneity of the impact of FDI on GDP has been a recurrent theme in the cross-country literature. In this section we follow that literature and look for systematic variations in the estimated total impact of FDI on GDP. Specifically, we investigate (informally) if the impact varies with selected indicators of development.[14] We start the analysis by looking for variations in the impact across regions.

[INSERT FIGURE 1 ABOUT HERE]

Figure 1 plots the 31 estimated total impact coefficients ($\hat{c}_{12i}$), measured as percentages, against the three regions in the sample. The horizontal line in Figure 1 is the mean group estimate (0.4 percent). There are "outliers" in each of the three regions, notably Cameroon

[14] The correlation between the estimated country specific total impact of FDI/GDP and the estimated total impact of FDI/GCF is 0.92. Therefore we only report the results for FDI/GCF.

and Ghana in Africa, India and Pakistan in Asia and Brazil and Columbia in Latin America. However, not all of the “outlying estimates” are significantly different from the overall mean. For Ghana, India and Pakistan the mean group estimate is only just outside the 95 percent confidence band, while the mean group estimate is well inside the confidence band for Cameroon and Brazil.

The most interesting information one obtains from Figure 1 is that there seems to be no systematic differences in the total impact across regions. In particular the impact in African countries is not systematically lower than the impact in Asian or Latin American countries. Although this is not our prime concern in the present paper it shows that African countries would potentially benefit from increased FDI flows just as much as the countries in the two other regions.

Turning to the different development indicators, we present four cross plots in Figure 2. In each plot the horizontal line is the mean impact while the second line is the regression line. First, following Blomström *et al.* (1994) who found important interactions between the level of GDP per capita and FDI, we look for such a relationship in the first panel in Figure 2 by plotting the total impact against the log of GDP per capita in 1970. Second, we look for the human capital threshold proposed by Borenztein *et al.* (1998) by plotting the impact against secondary schooling in 1970. Third, we look at trade openness (imports plus exports as a percentage of GDP in 1970), which was emphasized by Balasubramanyam *et al.* (1996) and Basu *et al.* (2003). Finally, we follow Alfaro *et al.* (2004) by considering credit in 1970. As seen from Figure 2, there is no clear association between the impact of FDI and either one of the four indicators.[15]

[INSERT FIGURE 2 ABOUT HERE]

[15] We have also looked at indicators for institutional quality such as rule of law, control of corruption, political stability and regulatory quality etc. None of the institutional indicators are significantly correlated with the estimated impacts.

Needless to say, our sample of 31 countries is too small to make conclusive inference about systematic interactions. Yet, our results seem to support Carkovic and Levine (2002) in that the suggested thresholds are not easily found when country specific factors and the level of GDP are included in the model. On the other hand we differ from Carkovic and Levine in our finding of significant long run impact of FDI on GDP.

5. Conclusion

Many recent studies analyzing foreign direct investment and growth have shown a positive association between FDI and GDP. But there seems to be less clarity about the direction of causality, which is crucial for the formulation of economic policy. In this paper we therefore analyse the causal relationship between these variables in a sample of 31 developing countries covering three continents over the time period 1970-2000.

Using a levels specification, which is compatible with the standard neo-classical growth model, we find that, when allowing for country specific heterogeneity of all parameters, a strong causal link from FDI to GDP exist—also in the long run. Moreover, these results are confirmed using a fixed effects estimator. Assessing the economic importance of FDI we find, based on mean group estimates, that the impact of FDI on GDP corresponds to what is expected from a standard Solow model. Hence FDI appears to be growth enhancing much in the same way as domestic investment. However, it should be noted that the fixed effects model leads to more than twice the impact found in the mean group estimation. We furthermore analyse whether FDI has a composition effect in addition to the increase in gross capital formation, and our results suggest that a statistically significant composition effect exist in the sense that a higher ratio of FDI in gross capital formation has positive effects on the level of GDP and hence on growth.

Finally we discuss the often raised issue of heterogeneity of the impact of FDI on GDP. First we find no systematic differences in the total impact across regions. That is the expected gain from FDI to the African region should in principle equal the impact of FDI in either Asia or Latin America. Moreover investigations of whether the impact varies with selected indicators of development, we show that the suggested thresholds are not easily found when country specific factors and the level of GDP are included in the model. Overall it can be stated that, on average, FDI has a significant long run impact on GDP irrespectively of the level of development, a result differing significantly from conclusions obtained in earlier studies.

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TABLES AND FIGURES

Table 1: Panel tests for unit-roots in the series

	First differences			Levels		
	log(GDP)	FDI/GDP	FDI/GCF	log(GDP)	FDI/GDP	FDI/GCF
Panel LR	15.40	26.28	27.46	1.28	1.28	1.17
	[0.00]	[0.00]	[0.00]	[0.20]	[0.20]	[0.24]
log p-value	252.43	412.37	428.24	64.19	63.35	60.98
	[0.00]	[0.00]	[0.00]	[0.40]	[0.43]	[0.51]
logit p-value	-12.30	-20.27	-21.08	-0.68	-0.69	-0.54
	[0.00]	[0.00]	[0.00]	[0.50]	[0.49]	[0.59]
Vote counting	38.71	12.90	6.45	96.77	96.77	96.77

Note: For series in first differences the null-hypothesis is a unit-root without drift against an alternative of mean stationarity. The models include 2 lags. For series in levels the null-hupothesis is a unit-root with drift against an alternative of trend stationarity. The models include 3 lags. *p*-values are reported in brackets.

Table 2: Panel tests for cointegration

	Model for log(GDP) and FDI/GDP		Model for log(GDP) and FDI/GCF	
	Two-unit roots	One unit-root	Two-unit roots	One unit-root
Panel LR	4.88	0.18	5.15	-0.17
	[0.000]	[0.860]	[0.00]	[0.862]
log p-value	117.5	49.64	123.21	46.93
	[0.000]	[0.871]	[0.000]	[0.922]
logit p-value	-4.46	0.307	-4.67	0.685
	[0.000]	[0.759]	[0.000]	[0.494]
Vote counting	70.97	100.00	74.19	100.00

Note: The null hypotheses are unit roots with drift. The alternative hypootheses are trend stationarity. *p*-values are reported in brackets.

Table 3: Regression results for the log GDP, FDI/GDP system

	Mean group estimation		Fixed effects estimation	
Regression	(1a)	(1b)	(2a)	(2b)
Dep. variable	dlog(GDP)	FDI/GDP	dlog(GDP)	FDI/GDP
dlog(GDP)(t-1)	0.253	3.644	0.198	3.544
	(6.86)	(2.42)	(5.01)	(3.07)
dlog(GDP)(t-2)	-0.107	2.064	0.002	1.068
	(2.89)	(1.38)	(0.07)	(0.69)
d(FDI/GDP)(t-1)	-0.009	-0.058	-0.003	0.062
	(2.59)	(1.20)	(2.73)	(0.78)
d(FDI/GDP)(t-2)	-0.007	-0.009	-0.003	0.052
	(2.06)	(0.19)	(3.24)	(1.09)
log(GDP)(t-1)	-0.192	-0.080	-0.203	-1.801
	(9.20)	(0,10)	(8.98)	(1.44)
(FDI/GDP)(t-1)	0.013	-0.480	0.007	-0.517
	(9.20)	(0.10)	(4.83)	(3.61)
Granger causality	0.000	0.019	0.000	0.010
Neutrality	0.000	0.920	0.000	0.150

Table 4: Regression results for the log GDP, FDI/GCF system

	Mean group estimation		Fixed effects estimation		Fixed effects, excluding Pakistan	
Regression	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
Dep. variable	dlog(GDP)	FDI/GCF	dlog(GDP)	FDI/GCF	dlog(GDP)	FDI/GCF
dlog(GDP)(t-1)	0.242	9.607	0.195	14.077	0.194	14.096
	(6.50)	(1.55)	(1.53)	(2.40)	(4.88)	(2.41)
dlog(GDP)(t-2)	-0.118	7.732	-0.003	4.159	-0.008	4.322
	(3.11)	(1.25)	(0.02)	(0.68)	(0.22)	(0.71)
d(FDI/GCF)(t-1)	-0.002	-0.060	-0.001	0.030	-0.001	0.030
	(2.30)	(1.15)	(0.65)	(0.45)	(3.12)	(0.45)
d(FDI/GCF)(t-2)	-0.001	-0.027	-0.001	0.078	-0.001	0.078
	(1.63)	(0.55)	(0.73)	(1.67)	(3.09)	(1.73)
log(GDP)(t-1)	-0.178	0.023	-0.197	-6.775	-0.198	-7.108
	(8.87)	(0.01)	(2.62)	(1.43)	(8.74)	(1.50)
(FDI/GCF)(t-1)	0.003	-0.527	0.002	-0.598	0.002	-0.599
	(8.87)	(0.01)	(1.19)	(5.48)	(4.93)	(5.59)
Granger causality	0.000	0.150	0.660	0.051	0.000	0.050
Neutrality	0.000	0.992	0.234	0.153	0.000	0.134

Figure 1: Cross-plot of total impact of FDI/GCF on GDP and Regions

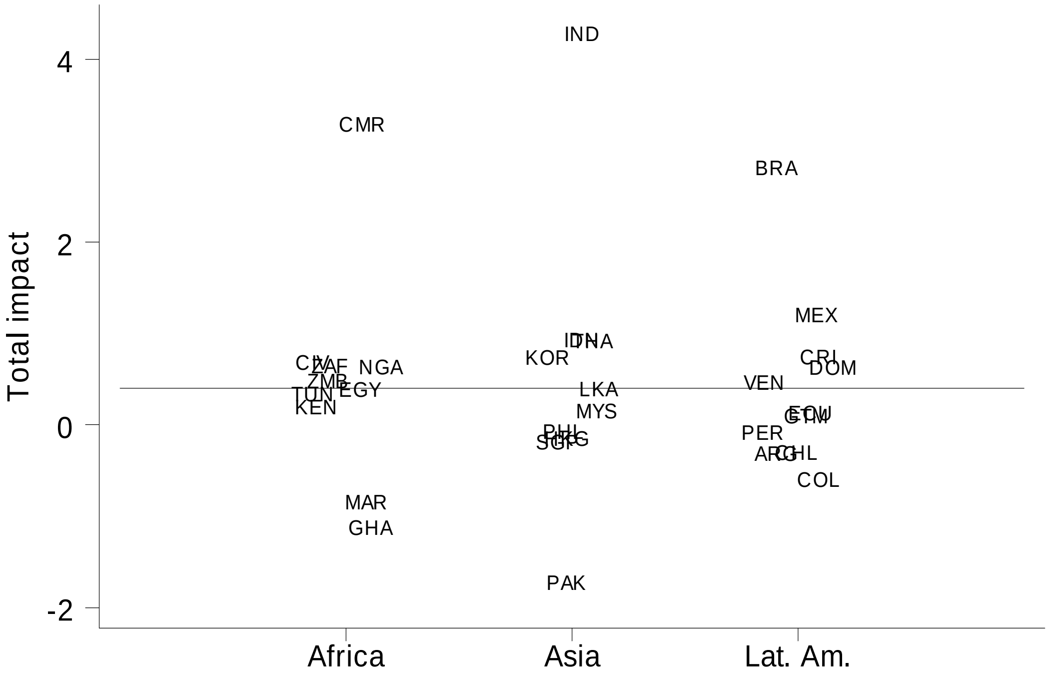
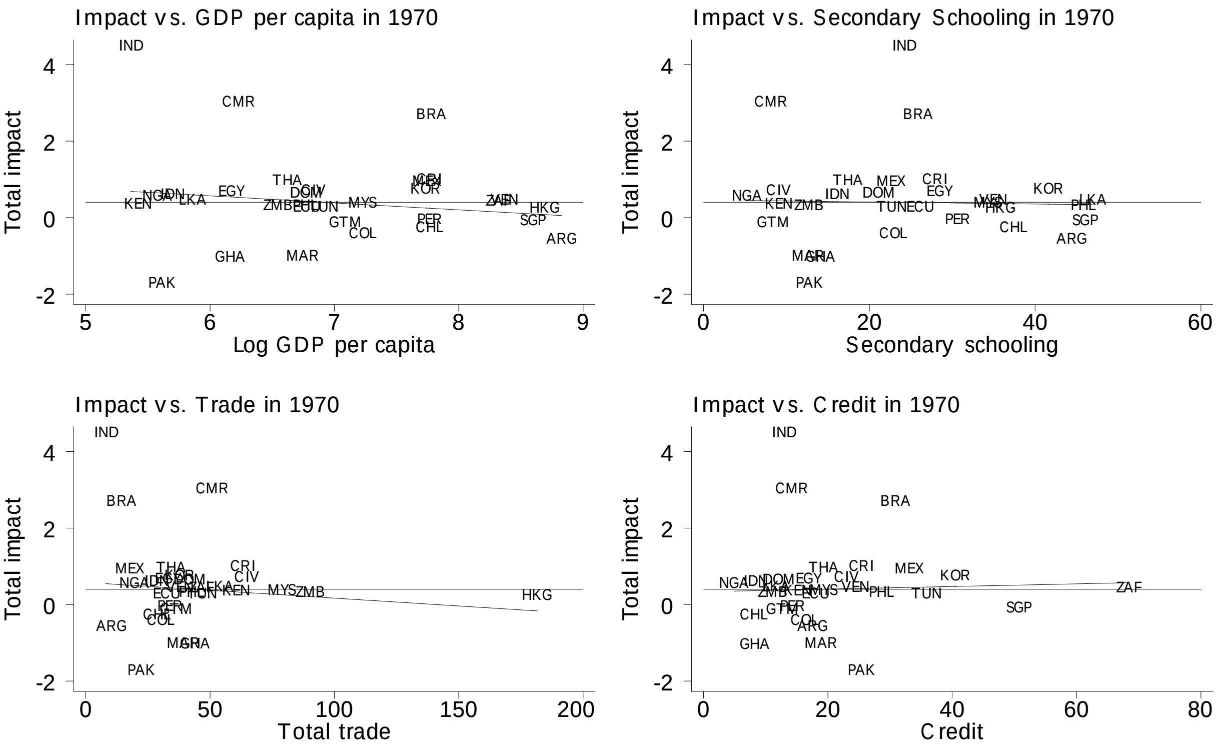


Figure 2: Cross-plots of the total impact of FDI/GCF on GDP and threshold indicators



DATA APPENDIX

Table A1: List of countries

ASIA	LATIN AMERICA	AFRICA
INDIA	ARGENTINA	EGYPT
PAKISTAN	BRAZIL	MOROCCO
SRI LANKA	CHILE	TUNISIA
HONG KONG	COLOMBIA	CAMEROON
INDONESIA	COSTA RICA	Cote D'Ivoire
KOREA, SOUTH	DOMINICAN REPUBLIC	GHANA
MALAYSIA	ECUADOR	KENYA
PHILIPPINES	GUATEMALA	NIGERIA
SINGAPORE	MEXICO	SOUTH AFRICA
THAILAND	PERU	ZAMBIA
	VENEZUELA	

Foreign direct investment figures are obtained from the World Development Indicators (WDI) 2002 from the World Bank and UNCTADs FDI/TNC database. Foreign direct investment is net inflows of investment, and is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Differences between the two databases occur,[16] and in this paper we have selected the WDI as the primary data source and the UNCTAD FDI/TNC database as the secondary data source. Further information about FDI data can be found on UNCTADs FDI homepage http://www.unctad.org/Templates/Page.asp?intItemID=1923&lang=1 and on the World Bank WDI data homepage http://www.worldbank.org/data/wdi2002/index.htm.

Information on Gross domestic product (GDP), gross capital formation, secondary school enrolment rates, trade volume and domestic credit to the private sector are all obtained from the WDI 2002.

[16] UNCTAD collects national official FDI data, and this information is the main source for the reported data on FDI flows. These data are complemented by data obtained from other international organizations including the World Bank, as well as UNCTAD's own estimates.