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Foreign direct investment-led growth: evidence from time series and panel data

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This paper estimates the impact of foreign direct investment (FDI) on capital accumulation, and output and total factor productivity (TFP) growth in the recipient economy. Time series and panel data evidence are provided for a sample of OECD and non-OECD countries in the period 1970–90. Although FDI is expected to boost long-run growth in the recipient economy via technological upgrading and knowledge spillovers, it is shown that the extent to which FDI is growth-enhancing depends on the degree of complementarity and substitution between FDI and domestic investment.

1. Introduction

Recent developments in growth theory have been primarily theoretical, although significant progress has also been made in growth empirics. The former proposes the endogenisation of technological change, and hence output growth, through mechanisms that prevent the unbounded decline in the marginal productivity of capital in the course of the accumulation process. The latter developments are concerned chiefly with the estimation of cross-country and time series growth equations, and the methodology used is based on standard growth accounting, pioneered by Solow (1957) and Denison (1962, 1967).

In general, the search for the keys to economic growth has been arduous in the recent literature, particularly since De Long and Summers' (1991, 1992) study of the impact of capital equipment accumulation on output growth. Empirical work on cross-country and time series growth has been directed at dealing with two basic problems; namely, the lack of unconditional convergence of growth rates across countries and high estimates of the elasticity of output with respect to capital stocks. Although conventional neo-classical growth in the Solovian tradition predicts that the elasticity of output with respect to capital should be equal to the capital share in output, cross-country estimates point to a much higher value. High capital elasticities can nevertheless be explained on the grounds of simultaneity and omitted variable biases. As for the absence of unconditional convergence, in the sense of Solow–Cass–Koopmans, the problem has been dealt with by the advent of conditional convergence (Barro and Sala-i-Martin, 1992), once the variables affecting individual countries' steady states have been controlled for.

A recent approach in growth empirics is concerned with estimating growth equations using panel data (Islam, 1995; Blomstrom *et al.*, 1996), on the grounds that much of the difficulties encountered in cross-country estimations can be eliminated by correcting for country-specific differences in technology, production, institutions, culture, and socio-economic factors, which are expected to evolve through time. Hence, the time series dimension of cross-country growth processes can be acknowledged as much as unobservable cross-country effects that can be deemed to affect growth in the long-run. The problem of autocorrelation in time series analysis and heteroscedasticity in the estimation of cross-section equations can also be minimised (Hsiao, 1986; Matyas and Sevestre, 1996).

The focus of this paper is on cross-border externality-generating investment and knowledge transfers. The impact of cross-border externalities on growth deserves more careful examination than the traditional closed-economy growth-theoretic approach and international trade models have permitted (Grossman and Helpman, 1991). Primarily, the impact of foreign direct investment (FDI) on growth is expected to be twofold.[1] First, through capital accumulation in the recipient economy, FDI is expected to be growth-enhancing by encouraging the incorporation of new inputs and foreign technologies in the production function of the recipient economy. Second, through knowledge transfers, FDI is expected to augment the existing stock of knowledge in the recipient economy through labour training and skill acquisition, on the one hand, and through the introduction of alternative management practices and organisational arrangements, on the other. Also, FDI can be expected to promote technological upgrading, and hence diffusion, even without significant physical capital accumulation; in the case of, for instance, start-up, marketing, and licensing agreements; management contracts; and joint ventures in general (de Mello and Sinclair, 1995). As a result, foreign investors may increase productivity in the recipient economy and FDI can be deemed to be a catalyst for domestic investment and technological progress.

It can also be argued that the absorptive capacity of the host country affects the volume and type of FDI inflows. The latter depends on institutional factors, such as the recipient economy's trade regime, legislation, and political stability; and scale factors, such as balance of payments constraints and the size of the domestic market for the goods produced via FDI. The consideration of such (sometimes unobservable) country-specific effects, given new FDI-related and existing domestic production possibilities, and their evolution over time, allows for the examination of such FDI-driven cross-country or region-specific externalities or spillovers.

The paper is organised as follows. Section 2 summarises the expected impact of FDI on growth. Section 3 introduces the empirical analysis by focusing on the time series aspects of FDI and growth. Section 4 complements Section 3 by concentrating on cross-sectional evidence provided by panel data estimations. Section 5 provides further discussion on the results presented in the paper and concludes.

[1] See de Mello (1997) for further details.

2. The theoretical argument

FDI is conventionally defined as a form of international inter-firm co-operation that involves significant equity stake and effective management decision power in, or ownership control of, foreign enterprises. FDI is also considered to encompass other broader, heterogeneous non-equity forms of co-operation that involve the supply of tangible and intangible assets by a foreign enterprise to a domestic firm. Those broader collaborative associations include most types of quasi-investment arrangements, such as licensing, leasing, and franchising; start-up and international production sharing arrangements; joint ventures with limited foreign equity participation; and broad R&D co-operation.

In the presence of FDI, aggregate production in the recipient economy is carried out by combining labour and physical capital. The latter can be domestic (K_d) or foreign-owned (K_w). FDI affects growth directly, by increasing the stock of physical capital in the recipient economy, as K_w is accumulated, and indirectly, by inducing human capital development and promoting technological upgrading. It is also important to evaluate the extent of complementarity and substitution between domestic investment and FDI because a simplistic Schumpeterian view of FDI-related innovative investment that emphasises creative destruction through substitution may overlook the scope for complementarity between FDI and domestic investment. Under complementarity, innovations embodied in foreign investment may create, rather than reduce, rents accruing to older technologies (Young, 1993). Also, if FDI is expected to affect growth positively, it may be argued that it requires some degree of complementarity with domestic investment, at least in the short run, given that the existing factor endowments in the host country act as a FDI determinant.

The introduction of FDI in standard Ramsey models yields interesting results. Under constant returns to domestic capital, the condition for saddle point-stability with FDI implies that negative consumption may not be avoided, and hence FDI may be immiserising (Bhagwati, 1973; Brecher and Diaz Alejandro, 1977; Calvo *et al.*, 1996) or dynamically inefficient.[2] On the other hand, as in the tradition of endogenous growth models, long-run growth can be achieved if the marginal product of capital can be bounded away from the rate of time preference as the stock of FDI increases, and the long-run growth rate depends positively on FDI. Increases in the stock of foreign-owned capital lead to temporary increases in the output growth rate if diminishing returns prevail in the aggregate. However, the FDI-led increase in the growth rate is permanent under constant returns. Long-run growth can also be shown to depend on the degree of complementarity between capital stocks embodying domestic and foreign technologies, and the volume of FDI as a share of GDP. Under linearity, the growth rates of the capital stock and output are constant and equal to the growth rate of

[2] The possibility of growth-enhancing FDI and saddle point stability is ensured if the open-economy determinants of FDI are examined further (de Mello, 1996).

consumption, and permanent increases in FDI lead to permanent increases in the output growth rate.

3. The time series aspects of FDI and growth

3.1 Preliminary considerations

For time series growth equations, empirical work has focused on the difficulty of lending support to the theoretical prediction that permanent changes in factor accumulation should lead to permanent changes in output (Jones, 1995), given the linearity hypothesis in a number of endogenous growth models. If growth rates can be increased endogenously, then long-run growth should not in principle admit approximations by processes with a constant mean, unless endogenous growth-enhancing accumulation processes are offsetting. In this respect, time series models provide a preliminary test of the linearity hypothesis, in so far as the greater the accumulation of reproducible inputs, the greater the growth rate of output. In other words, if a country's *per capita* growth rate exhibits little persistent change over time, so should its determinants, or their persistent movements must be offsetting. If, for instance, FDI generates significant externalities and spillovers in production, as suggested above, FDI-related capital accumulation should lead to an increase in output growth.

As far as empirical validation is concerned, the impact of FDI on capital accumulation, and output and TFP growth is estimated for a sample of 32 countries in the period 1970–90. The Data Appendix provides further details on data sources and definitions of the variables used in this paper. We start by testing the hypothesis of stationarity of the output growth and investment rates using the augmented Dickey–Fuller equation below

$$\Delta g_i(t) = \alpha_0 + \sum_{l=1}^{m} \alpha_l g_i(t-l) + \sum_{j=1}^{n} \alpha_j \Delta g_i(t-j) + e_i(t) \tag{1}$$

where g_i is the growth rate of i, n and m are chosen according to the Schwartz criterion to produce white noise disturbance terms e_i, and $i = y, k, k_w$, for $k = k_d + k_w$. Obviously, $g_i = FDI$, if $i = k_w$.

Country selection was primarily governed by the availability of physical capital data in the Summers and Heston data set. It is further based on the stationarity hypothesis, such that countries for which the output growth series are not I(0) by eq. (1) were eliminated from the sample.[3] The countries that satisfied both criteria were further divided into two groups: OECD and non-OECD countries. The distinction between OECD and non-OECD countries is all the more important here, since the impact of FDI on growth is expected to be stronger in the recipient

[3] Ben-David and Papell (1995) use Zivot and Andrews' (1992) methodology to test for structural break for both stationary and unit root data, whereas Jones (1995) uses only unit root tests. The Phillips–Perron test was also carried out here but the results were similar to the ADF tests reports for the vast majority of countries in the sample and therefore omitted.

economy than in the country of origin of FDI. If the advanced economies in the OECD group are the main net exporters of FDI, then the impact should be smaller in those countries than elsewhere. In short, the distinction between OECD and non-OECD countries proxies crudely for the distinction between technological leaders (capital exporters) and followers (capital importers).

However, three points could be raised in this respect. First, there is strong evidence that most FDI occurs across technologically advanced economies (Lucas, 1990). Second, FDI is very sensitive to balance of payments constraints and factors related to the macroeconomic performance and institutional features of the recipient economy, such as the degree of openness and trade regime, political instability and government intervention, the existence of property rights legislation, and ensuing law enforcement institutions, etc. Finally, the incorporation of new technologies in countries undergoing a process of industrialisation is likely to differ a great deal from that in industrial, technologically advanced economies.

In addition to the augmented Dickey–Fuller test in eq. (1), stationarity can also be assessed by testing for the existence of a deterministic time trend (t) in the series according to the equation below

$$g_i(t) = \beta_0 + \beta_1 t + \nu_i(t) \tag{2}$$

where ν_i is a white noise term.

In principle, if a country exhibits persistent movements in output growth rates and in capital accumulation (or FDI), then permanent changes in the former can be deemed to result from permanent changes in the latter. This is supportive of the linearity hypothesis, even if permanent changes in output or factor accumulation derive from FDI-related disembodied technological change.

The results of the estimations of eqs (1) and (2) are reported in Tables 1 and 2.[4] Stationarity of the relevant series can also be assessed by inspection of Figs 1 and 2 (FDI series on the secondary vertical axis). In the case of the OECD countries, both FDI and total investment were found to follow a time trend in Italy, Germany, UK, and USA, without a corresponding trend for output growth. For the remaining countries, FDI alone (Australia, Belgium, Finland, Spain, and Sweden) or total investment alone (Austria, Denmark, New Zealand, and Switzerland) seem to follow a time trend without a counterpart in output growth. Hence, for the OECD sample, there is no time series evidence of linear endogenous growth derived from FDI and/or capital accumulation in the period under examination.

For the non-OECD countries, in Table 2, in the case of Ecuador and Ivory Coast, there is a negative time trend in the case of FDI (and capital investment in the latter country) and a negative time trend in output growth. This finding is suggestive of a linear endogenous relationship between output growth and FDI. Both FDI and capital investment also appear to follow a time trend in the case of the Dominican Republic, Mexico, and the Philippines, without

[4] Ideally, the total capital stock in the economy should be disaggregated into domestic and foreign-owned capital, such that the analysis could be carried out for the two types of capital separately.

Table 1 Time series analysis, OECD sample, 1970/90

Countries	Output growth	Trend	Capital investment	Trend	FDI	Trend
Australia	−0.09	−0.0004	0.27	0.0003	0.86	0.063†
	(−2.8862)†	(−0.463)	(−2.1219)*	(0.702)	(0.1833)	(6.892)
Austria	−0.15	−0.001	0.48	−0.003†	0.71	−0.016
	(−2.0254)*	(−1.442)	(−2.8086)†	(−9.116)	(−0.636)	(−1.143)
Belgium	0.08	−0.0005	0.12	−0.00003	0.70	0.039*
	(−2.1365)*	(−0.663)	(−2.0348)*	(−0.045)	(0.911)	(2.230)
Denmark	−0.18	−0.0002	0.52	0.002†	0.22	−0.018
	(−2.5963)*	(−0.280)	(−1.6133)	(3.408)	(−0.5158)	(−1.089)
Finland	−0.01	−0.003	0.50	0.0005	0.37	0.094†
	(−3.0477)†	(−1.939)	(−2.9027)†	(−0.862)	(−0.0311)	(2.839)
France	−0.003	−0.0005	−0.02	0.0001		
	(−2.2660)*	(−1.056)	(−2.3914)*	(0.238)		
Germany	−0.19	−0.000001	0.28	0.0008*	0.56	−0.053*
	(−2.2770)*	(−0.130)	(−2.3174)*	(2.043)	(−0.3812)	(−2.046)
Italy	−0.48	−0.0007	0.23	0.001†	0.93	−0.067†
	(−2.1885)*	(−0.780)	(−1.1141)	(3.001)	(−2.3796)*	(−3.226)
Luxembourg	0.09	0.0006	−0.71	−0.0008		
	(−2.2811)*	(0.575)	(−5.1017)†	(−0.807)		
New Zealand	0.10	−0.001	0.07	0.002†	0.49	−0.012
	(−3.2841)†	(−1.120)	(−2.2134)*	(2.645)	(0.6583)	(−0.623)
Netherlands	0.22	−0.0001	0.65	0.001	−0.43	−0.058
	(−2.0752)*	(−0.178)	(−1.3903)	(1.953)	(−0.3196)	(−0.892)
Spain	0.61	−0.0001	0.29	0.0008	0.61	−0.198†
	(−2.2814)*	(−0.0113)	(−1.4875)	(0.792)	(0.4561)	(−3.108)
Sweden	0.14	−0.001	−0.71	0.0004	0.73	0.087†
	(−2.4511)*	(−1.503)	(−3.3179)†	(0.492)	(2.4807)	(2.693)
Switzerland	−0.01	0.0003	0.81	0.002†		
	(−3.2121)†	(0.262)	(−1.8110)	(4.139)		
UK	0.08	−0.0006	0.63	0.001†	0.30	0.163†
	(−2.9344)†	(−0.591)	(−2.4388)*	(4.848)	(0.8711)	(3.791)
USA	−0.20	−0.0005	0.55	0.001*	0.93	0.163†
	(−3.2862)†	(−0.497)	(−1.7975)	(2.413)	(6.7763)	(16.573)

Notes: Numbers in parentheses are ADF(1) statistics (calculated without a constant or a time trend) and the coefficient reported is the α_1 coefficient in eq. (1). For the time trends, the numbers in parentheses are t-statistics and the coefficients reported are the β_1 coefficients in eq. (2). Capital stocks refer to producer capital (durables minus transport). Germany refers to former West Germany only. FDI data for Belgium also includes Luxembourg. In the case of France and Switzerland, there were too few observations in the FDI series for tests to be carried out. In the case of Denmark, the DF statistic is reported instead of ADF(1) for the FDI series. (*) significant at the 5% level, and (†) significant at the 1% level.

nevertheless a corresponding trend in output growth. In the case of Mexico, the positive trend in FDI may be offsetting the negative trend in capital formation, despite the fact that, in oil-exporting countries, the dynamics of FDI are expected to differ from the case of their non-oil-exporting counterparts. Important explanatory factors for the surge of FDI inflows in developing countries in recent years are foreign acquisition of domestic firms in reform-driven privatisation

Table 2 Time series analysis, non-OECD sample, 1970–90

Countries	Output growth	Trend	Capital investment	Trend	FDI	Trend
Dom. Rep.	−0.14	−0.002	0.76	−0.006†	0.26	−0.021*
	(−3.7842)†	(−1.024)	(−2.3968)*	(−3.981)	(−0.8999)	(−2.831)
Honduras	0.24	−0.002	−0.12	−0.0008	0.54	0.057†
	(−3.2605)†	(−1.291)	(−3.5383)†	(−1.149)	(−0.3210)	(3.185)
Mexico	0.17	−0.0001	0.52	−0.003†	0.66	0.102†
	(−3.0991)†	(−0.477)	(−1.3389)	(−2.758)	(−0.1414)	(4.333)
Panama	0.15	−0.0006	−1.13	0.001	0.21	−0.035*
	(−2.5313)*	(−0.218)	(−4.7711)†	(0.355)	(−2.1521)*	(−2.434)
Bolivia	0.51	−0.002	0.18	−0.001	0.36	−0.013
	(−2.0775)*	(−1.541)	(−2.2640)*	(−0.525)	(−2.0600)*	(−1.429)
Brazil	0.50	−0.002†	0.21	0.002	0.63	−0.053
	(−2.7002)†	(−2.783)	(−2.2952)*	(0.435)	(−0.7069)	(−1.710)
Chile	0.18	0.005	0.16	−0.04	0.61	−0.254†
	(−2.6934)*	(1.731)	(− −2.3780)*	(−1.927)	(−0.6819)	(−4.354)
Ecuador	0.68	−0.005†	0.16	−0.004	0.34	−0.039†
	(−2.4762)*	(−3.728)	(−2.6348)*	(−1.659)	(−2.266)*	(−3.537)
Paraguay	0.08	−0.003	0.17	−0.0008	0.62	−0.056
	(−2.7406)†	(−1.234)	(−3.3298)†	(−0.967)	(−0.4992)	(−0.759)
Peru	0.0006	−0.003	0.26	−0.002†	0.37	0.019
	(−3.8209)†	(−1.369)	(−3.6484)†	(−3.033)	(−1.7131)	(0.592)
Venezuela	0.11	0.001	0.48	−0.004†	−0.01	0.048
	(−2.5763)*	(0.569)	(−1.7348)	(−2.926)	(−2.309)*	(1.355)
Ivory Coast	0.39	−0.006†	0.79	−0.003†	0.31	−0.028*
	(−2.0156)*	(−2.398)	(−0.8391)	(−3.850)	(−0.8750)	(−2.011)
Kenya	−0.14	0.0004	0.27	−0.0009	0.46	−0.166
	(−2.6613)*	(0.273)	(−2.2280)*	(−1.158)	(−1.0845)	(−0.968)
Nigeria	0.42	−0.005	0.09	−0.01†	−0.09	−0.013
	(−2.6166)*	(−1.694)	(−2.3106)*	(−4.852)	(−0.6899)	(−0.393)
Sierra Leone	−0.38	−0.004	−0.70	0.0001	−0.01	0.12
	(−2.4507)*	(−1.363)	(−3.0149)†	(0.156)	(−2.2323)*	(1.311)
Zimbabwe	−0.14	−0.001	0.37	−0.005*	0.19	−0.142
	(−3.2551)†	(−0.475)	(−1.7668)	(−2.517)	(−1.5547)	(−0.584)
Philippines	0.41	−0.002	0.71	−0.004†	0.61	−0.277†
	(−3.1402)†	(−1.474)	(−2.0382)*	(−2.828)	(−0.805)	(−3.402)

Notes: As in Table 1. In the case of Panama, Bolivia, and Ivory Coast, FDI stock data are unavailable or available for short time spans.

programmes, globalisation and internationalisation trends in production, operations and investment, and increased economic and financial integration, among others.

The possibility that the variables under examination may be stationary around a trend is also taken into account by including a deterministic time trend in eq. (1), in addition to the drift term. The estimations (not reported but available upon request) show that the results reported in Tables 1 and 2 are robust to the exclusion

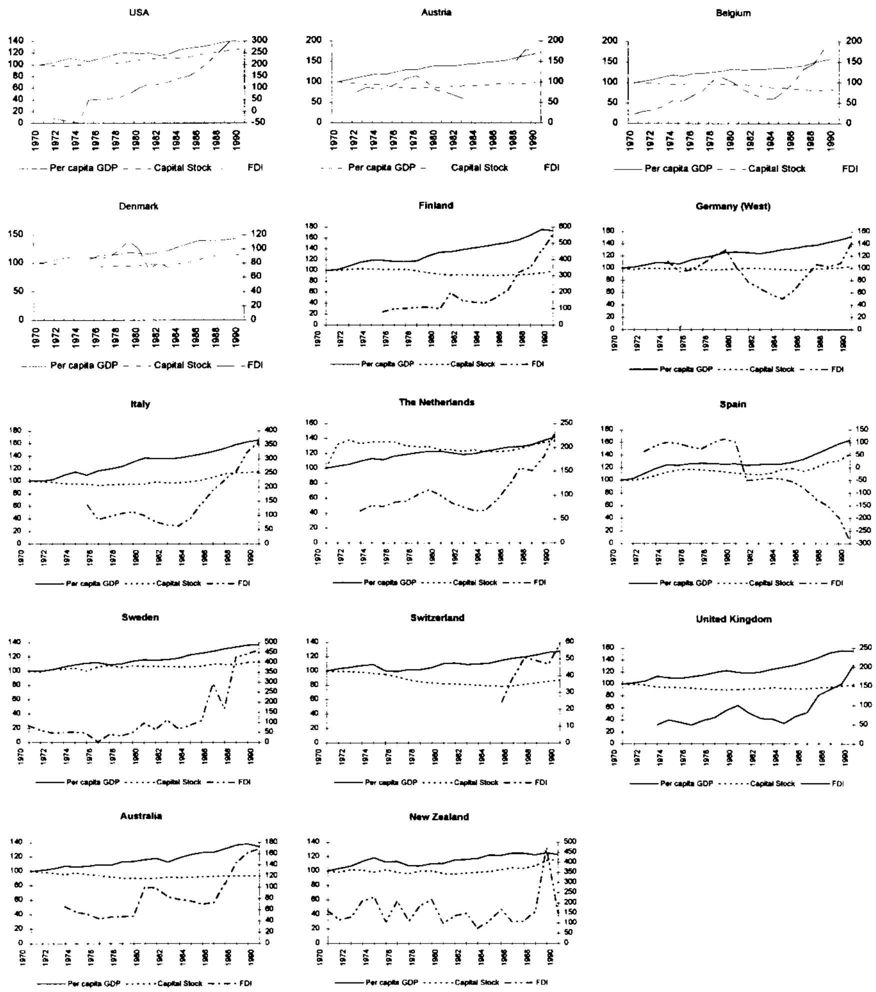

Fig. 1

of these trends in eq. (1), for the vast majority of countries in the sample.[5] The exceptions are Italy, for which the hypothesis of a unit root in the FDI series is accepted when a deterministic trend is incorporated; and Finland, the Dominican Republic, Bolivia, Paraguay, and Kenya, for which unit roots are found in the capital investment series. In the case of The Netherlands, the capital investment series becomes stationary when eq. (1) is estimated with a deterministic trend.

[5] Robustness of the stationarity results presented in Tables 1 and 2 was also assessed using additional test statistics, such as the Dickey–Fuller $\tau_{\alpha\tau}$, $\tau_{\beta\tau}$, φ_3, and φ_2 statistics (see Enders, 1995, for definitions of the test statistics). The results are nevertheless not reported in the paper due to space limitations.

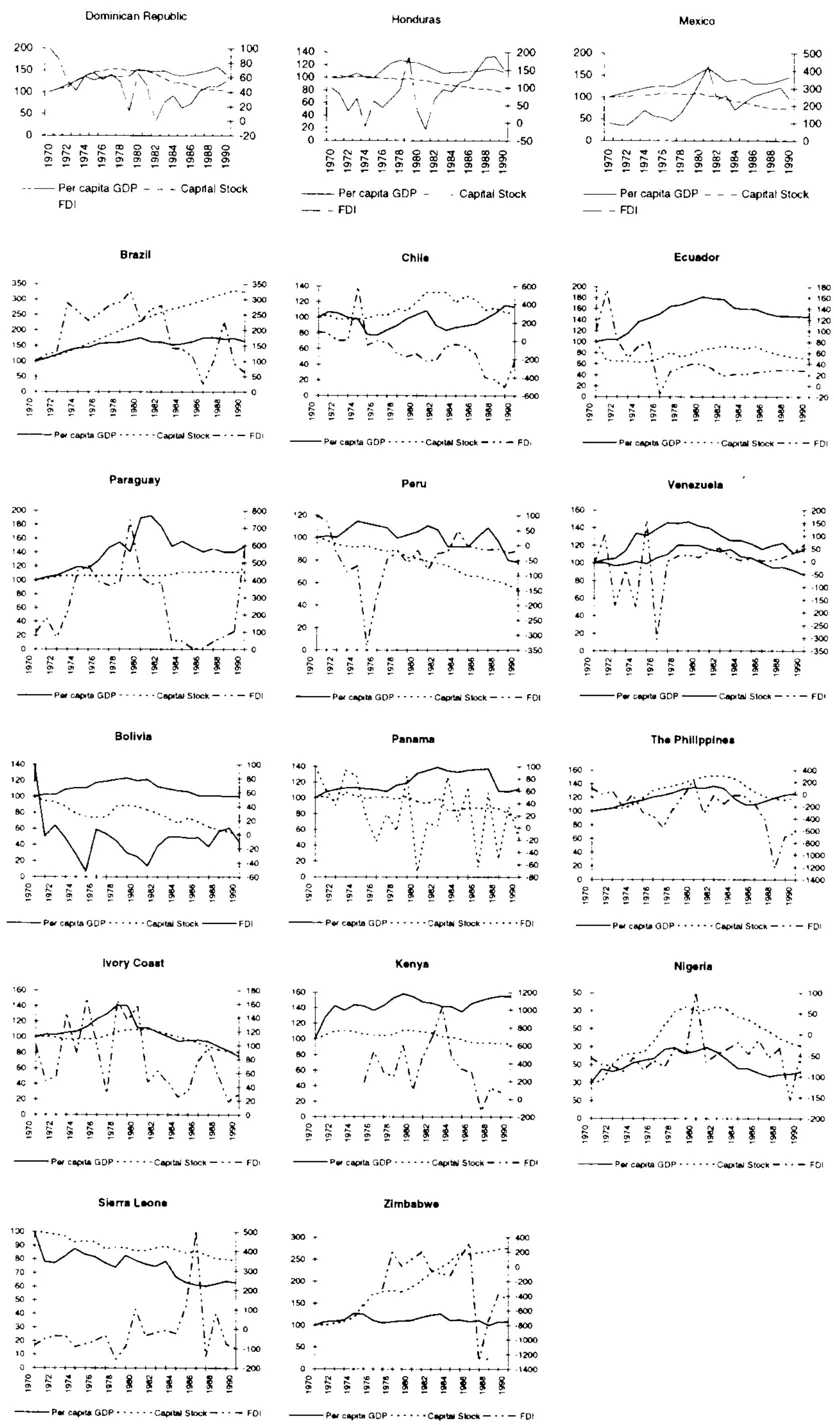
Dominican Republic
Per capita GDP
Capital Stock
FDI
Honduras
Per capita GDP
Capital Stock
FDI
Mexico
Per capita GDP
Capital Stock
FDI
Brazil
Chile
Ecuador
Paraguay
Peru
Venezuela
Bolivia
Panama
The Philippines
Ivory Coast
Kenya
Nigeria
Sierra Leone
Zimbabwe

Fig. 2

Table 3 Cointegration analysis, 1970/90. Dependent variable: $y(t)$

		Italy	Panama	Bolivia	Ecuador	Venezuela	Sierra Leone
k_w		−0.05	0.57	−0.36	−4.34	0.01	0.01
ML	$r = 0$	24.78†	10.6	20.47†	21.16*	17.9*	19.81*
Test	$r <= 1$	10.15†	4.625*	4.772*	9.335†	6.138*	6.077*
Trace	$r = 0$	34.93†	15.24	25.24†	30.5†	24.04†	25.89†
Test	$r <= 1$	10.15†	4.625*	4.772*	9.335†	6.138*	6.077*
α	y	−0.203	−0.0313	0.2099	0.015	−1.091	−0.919
Coeff.	k_w	−3.725	1.115	−1.536	0.193	−58.94	20.63
Resid.	y	−4.3039†	−2.4741*	−3.0278†	−2.6999*	−6.0589†	−2.4692*
	k_w	−3.6809†	−3.3617†	−3.1235†	−4.7874†	−3.7777†	−2.6862*

Note: r denotes the rank of $\Pi = \alpha\beta'$in the estimating equation

$$\Delta z(t) = \Gamma \Delta z(t-1) + \Pi z(t-2) + \Psi D(t) + u(t),$$

where $z = (y, k_w)$, D is a vector of deterministic elements (constant and time trend), and u is an error term. Variables are included in levels. (*) significant at the 5% level, (†) significant at the 1% level. ADF(1) statistics are reported to test whether the residuals are I(0).

3.2 Further time series evidence

To extend the analysis of the time-series aspects of the growth-FDI nexus, the long-run impact of FDI on capital investment, and output and TFP growth is estimated.[6] The bivariate VAR models were estimated for the countries in Tables 1 and 2 for which the output growth, FDI, and capital accumulation series were found to be I(0). If the relevant variables are found to cointegrate, the impact of growth-enhancing accumulation on output and TFP growth can therefore be deemed to be permanent. The result of the estimations are reported in Tables 3, 4, and 5.

The objective here is also to test the conjecture put forward above that the growth-FDI nexus involves the impact of FDI on capital accumulation and technological change itself. The former assesses the scope for complementarity or substitutability between capital stocks embodying domestic and more efficient FDI-related technologies. The latter assesses the scope for knowledge or technology transfers between foreign investor and the recipient economy.

As for the results of the long-run time series analysis, all countries in Table 3 exhibit a time trend in their FDI series with the exception of Sierra Leone, Venezuela and Bolivia. The long-run FDI coefficients vary from 0.08 in Venezuela to −0.15 in Ecuador, which provides evidence that FDI can be growth-enhancing or depressing in the long-run. The negative sign of the FDI coefficient in most non-OECD countries can be attributed in principle to the macroeconomic instability

[6] We did not attempt to estimate a short-run VAR model for the countries in Tables 3, 4, and 5, given that short-run deviations from the long-run equilibrium depend on the transitional dynamics of the growth process. Under linearity, there is no transitional dynamics. As a result, in the presence of FDI inflows, output growth in the recipient economy adjusts automatically to its steady-state path.

Table 4 Cointegration analysis, 1970/90. Dependent variable: $k(t)$

		Panama	Bolivia	Ecuador	Sierra Leone
k_w		0.02	−0.18	−6.70	−0.01
ML	$r = 0$	10.18	9.804	13	10.95
Test	$r <= 1$	8.408†	0.5019	1.248	5.61*
Trace	$r = 0$	18.59*	10.31	14.25	16.56
Test	$r <= 1$	8.408†	0.5019	1.248	5.61*
α	k	−1.170	−0.396	0.019	−0.339
Coeff.	k_w	−3.079	−0.947	−0.089	−50.55
Resid.	k	−3.5039†	−3.1313†	−3.3623†	−3.8590†
	k_w	−3.1064†	−3.8024†	−6.3920†	−3.9153†

Note: As in Table 3, with $z = (k, k_w)$.

Table 5 Cointegration analysis, 1970/90. Dependent variable: $TFP(t)$

		Italy	Venezuela
k_w		−0.19	0.02
ML	$r = 0$	25.76†	13.27
Test	$r <= 1$	6.294*	5.341*
Trace	$r = 0$	32.05†	18.61*
Test	$r <= 1$	6.294*	5.341*
α	TFP	−0.032	0.296
Coeff.	k_w	−1.393	41.57
Resid.	TFP	−3.7818†	−3.1808†
	k_w	−3.2648†	−3.5121†

Note: As in Table 3 with $z = (TFP, k_w)$.

and severe international credit (and hence balance of payments) constraints that characterised most of the period under examination, particularly the 1980s (Cohen, 1994; van der Ploeg and Tang, 1994). By Table 4, FDI has a positive long-run impact on capital accumulation in Panama and Sierra Leone. No cointegration relationship was found for Bolivia and Ecuador. By Table 5, there is a positive long-run relationship between FDI and TFP growth in Venezuela, and a negative one in Italy.

4. Panel data evidence

4.1 Preliminary considerations

To complement the time series analysis above, we now turn to panel data estimations. This is because it is well known that, in the case of cross-country and time-series estimations, the correlation between the error term and the regressors in standard growth accounting-based, time-series production function estimations leads to simultaneity and omitted variables biases. The correlation between the *per capita* capital stock and the error term leads to capital elasticity estimates that are well above the capital share in output (Young, 1992, 1995).

With regard to the high estimates of the capital elasticity coefficient, they have been interpreted as evidence for the linear endogenous growth model (Romer, 1990) and explained on the grounds that capital should be understood in a broad sense to incorporate additional inputs (for instance, human capital) without diminishing returns (Mankiw *et al.*, 1992). This line of argument sustains that high capital elasticities incorporate the externalities generated by the use of additional inputs, such as knowledge and human capital accumulation (Benhabib and Jovanovic, 1991; Benhabib and Spiegel, 1994). In fact, cross-country regressions reveal very little of the role played by policy and institutions (Crafts, 1995).

In panel data estimations, however, the existence of unobservable growth determinants that are country-specific, such as the ones discussed above, can be acknowledged and taken into account in the estimation procedure. This can explain a great deal of the distinct time series patterns in Tables 3, 4, and 5 on the grounds of country-specific effects. The country-specific determinants of FDI may provide further insight into ulterior growth determinants that are unobservable in the time series analysis.

Let country-specific factors affect primarily TFP, such that, in the presence of FDI, TFP can be decomposed into a country-specific term (θ), and a term incorporating foreign knowledge transfers or technological change embodied in FDI ($\bar{\theta}$), which is exogenous to the recipient economy. If different countries are assumed to have the same technology and institutions, then $TFP = \theta + \bar{\theta}$. On the other hand, if country-specific growth determinants matter, which seems to be a more realistic conjecture, then $TFP_h = \theta_h + \bar{\theta}$, where h is a recipient country index. Country-specific factors may identify what Abramovitz (1986) referred to as a country's 'social capability'.

Rather than engaging in a growth accounting exercise, the impact of FDI on output and TFP growth, and capital accumulation can be estimated using the following equation

$$x_h(t) = \vartheta_0 + \vartheta_1 FDI_h(t) + \vartheta_2 x_h(t-1) + \varepsilon_h(t) \quad \text{(A)}$$

where $x = (y, k, TFP)$ and $\varepsilon(t)$ is an error term.

If unobservable country-specific growth determinants are to be taken into account, then eq. (A) can be estimated as follows

$$x_h(t) = \vartheta_{h,0} + \vartheta_1 FDI_h(t) + \vartheta_2 x_h(t-1) + \varepsilon_h(t) \quad \text{(B)}$$

where $\vartheta_{h,0}$ is a time-invariant individual country effect term.

Equations (A) and (B) are dynamic panel models, which are estimated by IV, due to the likely correlation between the regressors and the disturbance terms. As for the choice of instruments, the difficulty lies in the requirement that they should not be country-specific but correlated with the regressors. Nevertheless, to reduce the expected sensitivity of the results to the instruments chosen, we take a conservative approach and use the lagged dependent variables as the main instruments, together with current and lagged values of the recipient economy's *per capita* income as a share of the US *per capita* income. The latter variable is expected to proxy for the differences in marginal capital productivities, given the differences in capital endowments across countries and the technological gap between technological leaders and followers. The latter also proxies for the scope for technological transfers in FDI. Accounting for such technological gaps, or 'idea' gaps in the sense of Romer (1993), is expected to correct for excessively high elasticities in the case of technological laggards.

4.2 The results

By Table 6, there is a positive impact of FDI on output growth in all panels, with and without country-specific terms. The finding is suggestive of a dominant complementarity effect between FDI and domestic investment. Contrary to the case of Tables 3 and 5, the findings in Table 6 with respect to output growth are consistent with those for TFP growth, by which FDI appears to have a positive impact on technological change, in the OECD panel. In the non-OECD panel, however, there seems to be a negative relationship between FDI and TFP growth, when group

Table 6 Panel data estimations (fixed-effect estimations)

	$y(t)$ equation		$k(t)$ equation		$TFP(t)$ equation	
Samples	A	B	A	B	A	B
All countries* (672 obs.)						
ϑ_1	0.01	0.006	0.02	0.01	−0.004	0.001
	(0.0025)	(0.0029)	(0.0049)	(0.0060)	(0.0041)	−(0.0049)
ϑ_2	0.19	0.14	−0.57	−0.45	0.58	0.41
	(0.0160)	(0.0150)	(0.0247)	(0.0276)	(0.0208)	(0.0221)
$\bar{R}^2$	0.20	0.36	0.07	0.53	0.54	0.64
OECD (273 obs.)						
ϑ_1	0.02	0.03	0.003	−0.001	0.01	0.03
	(0.0031)	(0.0036)	(0.0023)	(0.0015)	(0.0037)	(0.0036)
ϑ_2	0.04	0.01	−0.003	0.01	0.008	0.004
	(0.0139)	(0.0146)	(0.0112)	(0.0065)	(0.0178)	(0.0154)
$\bar{R}^2$	0.09	0.10	0.01	0.71	0.12	0.44
Non-OECD (357 obs.)						
ϑ_1	0.03	0.01	−0.00	0.02	0.02	0.01
	(0.0060)	(0.0059)	(0.0121)	(0.0130	(0.0112)	−(0.0123)
ϑ_2	0.16	0.09	−0.56	0.30	0.55	0.30
	(0.0198)	(0.0134)	(0.027)	(0.0243)	(0.0288)	(0.0256)
$\bar{R}^2$	0.17	0.66	0.53	0.7	0.51	0.74

Note: Estimations carried out by IV, columns (A) and (B) refer to estimates without and with group dummy variables, respectively. The common intercept in column (A) is not reported. Instruments include the lagged dependent variables and *per capita* income as a share of the USA *per capita* income. The numbers in parentheses are standard errors. * Includes France and Switzerland, and dummy variables for African and Latin American countries separately.

dummy variables are incorporated in the equation. It can be inferred that in technological followers, FDI reduces TFP growth by fostering producer capital accumulation, given the complementarity effect, although the converse cannot be inferred in the case of technological leaders.

Also, by Table 6, FDI seems to have a positive impact on producer capital accumulation in the broad panel, but not in the OECD (without group dummies) and non-OECD panels. In the latter, however, after the introduction of country effects, the relationship between FDI and capital accumulation becomes positive. The results lend support to the hypothesis of some degree of substitutability between FDI and domestic investment, whereby in more advanced economies, the more efficient technologies embodied in FDI may lead to a higher rate of technological obsolescence of the capital stocks embodying older technologies. In the same vein, complementarity seems to prevail in technological laggards. In this respect, it can be argued that the degree of complementarity between old and new technologies found in technological followers, after country-specific effects were accounted for, suggests that those economies are either less efficient in the use of the new technologies embodied in FDI-related capital accumulation, or that the latter are not much more modern or productive than the ones existing in the recipient economy. Those country-specific effects may include, for instance, protectionist trade and investment policies implemented to safeguard indigenous industries from foreign competition, which would distort social and private returns to capital investment and hence the efficiency of FDI.[7] Foreign investors can then be deemed to select the technologies embodied in FDI-related capital accumulation depending on the specific productive and institutional characteristics of the recipient economy, in which case, FDI may be a less important vehicle for cross-border knowledge transfers than previously thought.

The fixed-effect estimates above rely on the assumption of homogeneity of the different panel groups for a common slope to be imposed in pooled regressions. The fixed-effect estimator also reduces biases due to omitted variables, particularly when group dummies are incorporated in the regression (Matyas and Sevestre, 1996). Nevertheless, in dynamic panels with a large time dimension, ignoring group heterogeneity produces serially correlated disturbances and hence inconsistent parameter estimates (see Pesaran and Smith, 1995, for further details). The biases in this case tend to overestimate the average short-run effects and underestimate the average long-run effects in fixed-effect estimations, and cannot be eliminated by using the IV method or by considering autocorrelation correction. Instead, the average effects in dynamic panels with changing slopes across groups can be consistently estimated using the mean group procedure.

[7] Kawai (1994) points out that FDI may not be a good determinant of TFP growth due to the fact that foreign production may occur in oligopolistic sectors or that there may be a time lag before FDI-induced productivity gains creep in.

Table 7 Mean group estimations

	Means of country-specific short-run FDI impact on the growth rate of:		
Samples	$y(t)$	$k(t)$	$TFP(t)$
All countries* (32 countries)	0.004 (0.0227)	0.02 (0.0295)	−0.016 (0.0034)
OECD (15 countries)	0.026 (0.0067)	0.002 (0.0031)	0.012 (0.0060)
Non-OECD (17 countries)	−0.016 (0.0037)	0.03 (0.0538)	−0.040 (0.0582)

Note: The coefficients reported are based on separate regressions for each country in the sample, 1970–90. The numbers in parentheses are standard errors, calculated assuming cross-country independently distributed regression coefficients. The means are unweighted. * Includes France and Switzerland.

Parameter estimates using the mean group estimator for heterogeneous panels are reported in Table 7. It is noticeable that the aggregate parameter estimates using the fixed-effect estimator are fairly similar to the means of the country-specific regressions in the case of the OECD sample. In the case of the non-OECD sample, aggregate estimates differ from the average of individual country coefficients. Although this discrepancy suggests the existence of a heterogeneity-related bias, the finding is not surprising, given that heterogeneity is likely to prevail in the latter sample, given the diversity of countries pooled together in the aggregate fixed-effect estimations. In the full sample, the homogeneity of the OECD countries is likely to have reduced the bias, given that the parameter estimates reported in Tables 6 and 7 are fairly similar.

5. Discussion and Conclusion

General problems in modern growth empirics offer new challenges to the growth theorist. The problem of simultaneity and omitted variable biases in growth equations has been investigated more thoroughly in recent years, in particular as far as the high estimates of the capital elasticity in cross-country equations are concerned. Nevertheless, the problem of sensitivity of the estimates to the instruments chosen to reduce the simultaneity bias in growth equations has not been addressed to the same degree of depth and deserves more careful analyses in the near future. In fact, the solution to these problems lies in the revision of the whole methodology that permeates growth empirics, which is based on 1960s growth accounting or national accounts-type intertemporal investment equations, such as the ones used in Ramsey-type dynamic optimisation problems. The latter too are sensitive to the assumptions regarding depreciation and savings behaviour. Country-specific effects are not commonly accounted for in growth empirics and, as seen above, can play an important role in acknowledging unobservable growth determinants. In addition, attention should be focused on the biases in fixed-effect estimations of heterogeneous panels with a large time dimension which cannot be reduced or eliminated by using instrumental variables or autocorrelation correction.

Whether FDI can be deemed to be a catalyst for output growth, capital accumulation, and technological progress seems to be a less controversial hypothesis in theory than in practice. For most of the countries for which our methodology could be applied, it seems that the growth–FDI nexus is sensitive to country-specific factors that are unobservable in time series analysis. The results reported in this paper suggest that, if FDI is growth-enhancing in the long run, via both knowledge transfers and the accumulation of capital stocks embodying newer technologies, then this impact is likely to be lower in technological leaders than laggards (Grossman and Helpman, 1991). As a result, the impact of FDI on growth seems to depend inversely on the technological gap between leaders and followers, even though there is evidence that the bulk of FDI occurs across technologically advanced economies.

The degree of substitutability between capital stocks embodying old (domestic) and new (FDI-related) technologies seems to be higher in technologically advanced, rather than developing recipient, economies. The rate of technological obsolescence of the capital stock embodying old technologies is possibly increased in technologically advanced economies in the presence of FDI. Alternatively, it can be argued that the degree of complementarity between old and new technologies found in developing economies, after country-specific effects were accounted for, suggests that those economies may: (i) be less efficient in the use of the new technologies embodied in FDI-related capital accumulation; (ii) have difficulty to assimilate capital and technology-intensive improvements; or (iii) that the latter are not much more modern or productive than the ones existing in the recipient economy. Foreign investors can then be deemed to select the technologies embodied in FDI-related capital accumulation depending on specific productive and institutional characteristics of the recipient economy. In this case, FDI may be a less important vehicle for cross-border knowledge transfers and the elimination of technological gaps between leaders and followers than previously thought.

Country-specific factors (institutions, trade regime, political risk, policy, etc.) may have inhibited the elimination of technological gaps between leaders and followers, such that success in technology or knowledge transfers seems to be affected by institutions.[8] When heterogeneity is taken into account, the conclusions are less clear-cut in the case of non-OECD countries, which are more likely to exhibit significant cross-country diversity, than in the case of their more homogeneous OECD counterparts.

[8] See Romer (1993) for an interesting discussion of the role played by FDI-related knowledge transfers in closing the idea gap between developed and developing countries.

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Data Appendix

Output: Summers and Heston gross national income series in the period 1970–90. *Per capita* GDP as a share of US *per capita* GDP is also available in the Summers and Heston data set.

Capital Stock: Summers and Heston producer capital series (durables minus transport equipment stocks) in the period 1970–90. In the case of Brazil, the producer capital series is available from Hofman (1992).

Foreign Direct Investment (FDI): net FDI flows (inflows minus outflows) are available from IMF's Balance of Payments statistics. When disaggregated series are available, gross FDI inflows are used. Unfortunately, the availability of FDI data is limited and time series for most countries start in the late 1960s and early 1970s, which prevents the consideration of a longer time span. For most developing countries, data on FDI stocks is not available. When needed, the FDI stock series were constructed using the perpetual inventory method with a constant annual depreciation rate of 10%. Also, it can be argued that the FDI measures available from individual countries' national accounts can only be taken to be a crude proxy for the impact of foreign technologies and spillovers on growth, given that they are financial flows that may capture (or obscure) operations of foreign investors (typically MNCs) in the recipient economy. Also, FDI flows are sensitive to cross-country differences in the treatment of re-invested earnings and fluctuations in intra-firm transactions. The role of tax havens and offshore banking centres also pose additional measurement complications. However, such flow variables are the ones currently available and most widely used in this line of research.

Total Factor Productivity (TFP) growth measured as the difference between *per capita* output growth and the *per capita* capital accumulation, both domestic and foreign-owned.