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Innovative and Absorptive Capacity of International Knowledge

An Empirical Analysis of Productivity Sources in Latin American Countries

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Abstract

This paper examines two sources of global knowledge spillovers: foreign direct investments and trade. Empirical evidence demonstrates that foreign direct investment and trade can contribute to overall domestic productivity growth only when the technology gap between domestic and foreign firms is not too large and when a sufficient absorptive capacity is available in domestic firms. The paper proposes the terms research and development and labor quality to capture the innovative and absorptive capacity of the country. The spillover effects in productivity are analyzed using a stochastic frontier approach. This productivity (in terms of total factor productivity) is decomposed using a generalized Malmquist output oriented index, in order to evaluate the specific effect in technical change, technical efficiency change, and scale efficiency change. Using country-level data for 16 Latin American countries for 1996–2006, the empirical analysis shows positive productivity spillovers from foreign direct investment and trade only when the country has absorptive capacity in terms of research and development. Foreign direct investment and trade spillovers are found to be positive and significant for scale efficiency change and total productivity factor change.

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An empirical analysis of productivity sources in Latin American countries

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Keywords

Technical Efficiency, Stochastic Frontier Analysis (SFA), Malmquist index.

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1. Introduction

Damijan et al. (2003) examine different channels of global technology transfer to transition countries. These authors study the impact of direct technology transfer through foreign direct investment (FDI), intra-industry knowledge spillovers from FDI, firms' own research and development (R&D) accumulation and R&D spillovers through trade for total factor productivity (TFP) growth of local firms. Using firm-level data for eight transition countries for the period 1994–1998, this research found that technology is being primarily transferred to local firms through direct foreign linkages.

In the specific context of Latin American countries, Ramirez (2010) estimates whether FDI flows and other relevant variables have had a positive and significant effect on private investment spending over the 1980–2002 period. On the other hand, Schiff and Wang (2010) examine the impact on TFP in Latin America and the Caribbean (LAC) and in other developing countries (DEV) of trade-related technology diffusion from the North, education and governance. The main findings are: i) education and governance have a much larger direct effect on TFP in LAC than in DEV, while the opposite holds for the North's R&D; and ii) education and governance have an additional impact on TFP in R&D-intensive industries through their interaction with trade-related technology diffusion from the North in LAC but not in DEV.

According to Suyanto et al. (2009), the mixed evidence of productivity spillovers leads to the celebrated argument that firm-specific characteristics or absorptive capacity may influence the ability of domestic firms in gaining productivity spillovers from FDI and trade. The most commonly used measure of absorptive capacity in the literature about this topic is the extent of R&D expenditure (Findlay, 1978; Glass and Saggi, 1998; Wang and Blomstrom, 1992).

Kathuria (2000) shows – in the context of the Indian manufacturing sector - that local firms that invest in learning or R&D activities receive high productivity spillovers, whereas the non-R&D local firms do not gain much from the presence of foreign firms. This result indicates that the productivity spillovers are not automatic consequences of the presence of foreign firms; rather they depend on the efforts of local firms' investment in R&D activities. Kinoshita (2001) finds similar evidence in a study on Czech manufacturing firms during 1995–98. Griffith et al. (2004) also confirm that R&D plays an important role in knowledge transfer, besides its role as a medium of innovation.

In this context, empirical evidence demonstrates that FDI and trade can contribute to overall domestic productivity growth when the technology gap between domestic and foreign firms is not too large and when a sufficient absorptive capacity is available in domestic firms, in terms of R&D and Labor Quality (Borensztein et al., 1998). There is evidence that positive developmental impacts of FDI flows are conditional on high levels of human capital and thus on the existence of 'good' infrastructure in recipient countries (Yamin and Sinkovics, 2009).

For Suyanto et al. (2009, p. 4), "the empirical studies usually assume that productivity advantage from FDI is exclusively contributed by technology transfers as is consistent with the use of conventional approach of production function. Technical and scale efficiencies are hardly studied in relation to productivity gains from FDI." In this context Smeets (2008) argues that the productivity spillovers from FDI and trade should be defined broadly, as they arise from new knowledge rather than from new technology only. Smeets defines knowledge as including technology; managerial, and production skills, which may contribute to technical efficiency and the ability to exploit scale efficiency.

This line of research finds its basis in the pioneer works of Farrel (1957) and Aigner et al. (1977), which searched for a measurement of efficiency through the decomposition of the growth of productivity. We make use of the stochastic frontier analysis (SFA) approach to estimate productivity spillovers in Latin American countries for the period 1996-2006. In a second step, we compute the Malmquist index to decompose total factor productivity (TFP) growth into technical efficiency change (TEC), technological progress (TP), and scale efficiency change (SEC). In this context Orea (2002) provides a parametric decomposition of a generalized Malmquist productivity index that takes scale economies into account. (See Section 3 for more details about this approach.)

This paper is organized as follows: in the next section we present a critical review of the theoretical and empirical studies on productivity spillovers. In Section 3 we develop the methodology of the analysis. Section 4 presents an empirical analysis using country level evidence from Latin American countries (we present the data sources, construction of variables, and the main empirical results obtained). Section 5 ends with a summary of the main conclusions and policy implications.

2. Background: Theory and evidence

According to Yao and Wei (2009), although FDI and trade are widely believed to have a positive effect on economic growth, the exact mechanism of how FDI and trade impact upon the development process of the newly industrializing economies is far from being well understood. Three approaches provide theoretical explanations regarding this issue: (1) industrial organization theories, (2) international trade theories, and (3) endogenous growth theories.

The industrial organization approach investigates explicitly the role of FDI and trade in technology transfer and the diffusion of knowledge, as well as the impact of FDI and trade on market structure and competition in host countries (Findlay, 1978; Das, 1987; Dunning, 1993; Aitken and Harrison, 1999; Cheung and Lin, 2004).

In particular, the effect of trade competition may result in either positive or negative productivity spillovers for domestic firms. Aitken and Harrison (1999) argue that, in the short-run, the presence of foreign firms in an imperfectly competitive domestic market may raise the average cost of production of domestic firms through the ‘‘market stealing” phenomenon. Foreign firms with a lower marginal cost have an incentive to increase production relative to their domestic competitors. The productivity of domestic firms will fall as they have to spread fixed costs over a smaller amount of output. However, in the long-run, when all costs can be treated as variable costs, there is a possibility for domestic firms to reduce their costs by allocating their resources more efficiently and imitating foreign firms’ knowledge (Wang and Blomstrom, 1992). If the efficiency effect from foreign presence is larger than the competition effect, there can be positive productivity spillovers.

On the other hand, Caves (1971, 1996) argues that firms must possess specific advantages in order to overcome the difficulties of doing business abroad. Specifically, Caves suggests that when multinational corporations establish subsidiaries overseas, they experience disadvantages in the form of access to resources and domestic demand, when compared to their local counterparts. In order to compete with the domestic firms, multinational corporations need to possess superior knowledge. With this superior knowledge, multinational corporations are often assumed to have higher performance levels than domestic firms, being more efficient and productive, in particular. The firms investing in foreign countries therefore have distinctive characteristics that may differ from firms in host countries. FDI is not merely a source of capital, it is also a conduit for technology transfer and human skills augmentation in host countries. As a result, the effect of competition, demonstration and learning-by-doing on local industry may lead to an increase in productivity (Blomstrom and Kokko, 1996; Blomström and Sjöholm, 1999).

Carstensen and Toubal (2006) show that the traditional determinants, such as market potential, low relative unit labor costs, a skilled workforce and relative endowments, have significant and plausible effects. In addition, transition-specific factors, such as the level and method of privatization and country risk, play important roles in determining the flows of FDI into the "transition economies" and help to explain the differing attractiveness of individual countries to foreign investors.

In international trade theories, the main focus is to examine why FDI occurs and how firms choose between exporting, FDI and licensing as an entry mode (Brainard, 1993). Empirical evidence underscores the importance of international trade as a vehicle of international knowledge spillovers to developing countries (Co et al., 1997; Gorg and Strobl, 2005). International trade works as a channel of technology transfer, either through imports of intermediate products and capital equipment or through learning-by-exporting into industrial countries (Jacquemin and Sapir, 1991; Kinoshita, 2001).

Kohpaiboon (2006) examines technology spillover from foreign direct investment (FDI) based on a cross-industry analysis of Thai manufacturing. The analysis is built around the hypothesis of Bhagwati that technology spillover is conditioned by the nature of the trade policy regime. The result, based on a two-equation model that allows for the two-way link between the foreign presence and productivity of locally owned industries, provides support for the hypothesis.

Finally Markusen and Venables (1999) have formally shown how it is possible for FDI to act as a catalyst, leading to the development of local industry through linkage effects.

The endogenous growth model considers FDI and trade as an important source of human capital augmentation, technology change and spillovers of ideas across countries and therefore FDI and trade is expected to have a positive effect on growth (Glass, and Saggi, 1998; Griffith, et al. 2004). The magnitude of spillovers depends on the extent to which local firms respond positively to the technology gap and invest in 'learning activities' (Grossman and Helpman, 1995).

Within the endogenous growth framework, Liu (2008) offers an explanation on how foreign direct investment (FDI) generates externalities in the form of technology transfer. A new insight gained from the theory is that the level and rate effects of spillovers can go in opposite directions. The negative level effect underscores the fact that technology transfer is a costly process—scarce resources must be devoted to learning. The positive rate effect indicates that technology spillovers enhance domestic firms' future productive capacity.

In the model of Wang and Blomstrom (1992), technology transfer channeled through FDI is considered as an endogenized equilibrium phenomenon which results from strategic interaction between foreign firms and local firms.

In an important effort to establish a framework that synthesizes the previous three theoretical approaches, Gachino (2007) incorporated four spillover channels: competition, linkage, labor mobility and demonstration effects. Technological spillovers occurring through each of these channels are further conceptualized in the same way – technological changes, learning and capability building. This author argues that firms respond to external stimuli, skills, knowledge or technology transferred by implementing dynamic technological changes. These technological changes include modifications, improvements, and extensions meant to improve efficiency and increase firm productivity.

Based on the previous studies, the present research focuses on whether there is evidence that FDI and trade facilitate technological progress in Latin American countries.

3. Methodology: Model specification and estimation techniques

This section proposes an assessment methodology for productivity spillovers in order to examine when spillovers from foreign direct investment (FDI) contribute to productivity growth. The spillovers effects from FDI will be analyzed using a stochastic frontier (SFA) approach (Kumbhakar and Lovell, 2003). This approach uses the stochastic frontier production function, following Battese and Coelli (1988, 1993, 1995), and a generalized Malmquist output-oriented index to decompose productivity growth (Orea, 2002).

3.1. Deterministic frontier production functions: The stochastic frontier-inefficiency model

Following Battese and Coelli (1995), the stochastic frontier approach (SFA) is used to estimate a production function and an inefficiency function simultaneously. The Battese–Coelli model can be expressed as follows:

$$y_{it} = f(x_{it}, t; \beta) \cdot \exp(v_{it} - u_{it}) \quad [1]$$

where y_{it} implies the production of the ith firm $(i = 1,2,...,N)$ in the tth time period $(t = 1,2,...,T)$, x_{it} denotes a $(1 \times k)$ vector of explanatory variables, and β represents the $(k \times 1)$ vector of parameters to be estimated. The error term consists of two components: v_{it} and u_{it}, which are independent of each other. In addition, v_{it} denotes the time-specific and stochastic part, with $idd\ N(0, \sigma_v^2)$, and u_{it} represents technical inefficiency, which is a normal distribution, but truncated at zero with mean $z_{it}\delta$ and variance σ_u^2.

The technical inefficiency effects, u_{it}, are assumed as a function of a $(1 \times j)$ vector of observable non-stochastic explanatory variables, z_{it}, and a $(j \times 1)$ vector of unknown parameters to be estimated, δ. In a linear equation, the technical inefficiency effects can be specified as follows:

$$u_{it} = z_{it}\delta + w_{it} \quad [2]$$

where w_{it} is an unobservable random variable, which is defined by the truncation of the normal distribution with zero mean and variance, σ_u^2, such that the point of truncation is $-z_{it}\delta$.

Equation $[1]$ shows the stochastic production function in terms of the original production value, and equation $[2]$ represents the technical inefficiency effects. The parameters of both equations can be estimated simultaneously by the maximum-likelihood method. The likelihood function is expressed in terms of variance parameters $\sigma_s^2 \equiv \sigma_v^2 + \sigma_u^2$ and $\gamma \equiv \sigma_u^2 / \sigma_s^2$e. If γ equals zero, then the model reduces to a traditional mean response function in which z_{it} can be directly included into the production function.

Based on the theoretical model in Equations $[1]$ and $[2]$, we start with a flexible functional form, namely, a *translog* production function. By adopting a flexible functional form, the risk of errors in the model specification can be reduced. Moreover, the *translog* form is useful for decomposing the total factor productivity growth. The functional form of the *translog* production function is as follows:

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N} \beta_{nk} \ln x_{nit} \ln x_{kit} + \beta_t t + \frac{1}{2}\beta_u t^2 + \sum_{n=1}^{N} \beta_{nt} \ln x_{nit} t + v_{it} - u_{it} \quad [3]$$

where y implies output, x represents variables that explain output, t is time, i is firm. And u_{it} is defined as:

$$u_{it} = \delta_0 + \sum_{j=1}^{J} \delta_j z_{it} + w_{it} \quad [4]$$

where z is the set of explanatory variables that explain technical inefficiency. Given the specifications in equations $[3]$ and $[4]$, the technical efficiency of production for the ith firm at the tth year is defined as the ratio of the actual output of firm i, $\ln y_{it}$, to its potential output, $\ln y_{it}^p$:

$$TE = \frac{\ln y_{it}}{\ln y_{it}^p} = E[-u_{it} | (v_{it} - u_{it})] = E[(-z_{it}\delta - w_{it}) | (v_{it} - u_{it})] \quad [5]$$

where

$$\ln y_{it}^p = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N} \beta_{nk} \ln x_{nit} \ln x_{kit} + \beta_t t + \frac{1}{2}\beta_u t^2 + \sum_{n=1}^{N} \beta_{nt} \ln x_{nit} t + v_{it} \quad [6]$$

3.2. Decomposing productivity growth: A generalized Malmquist index

According to Orea (2002), if firm i's technology in time t can be represented by a *translog* output-oriented distance function $D_0(y_{it}, x_{it}, t)$ where y_{it}, x_{it}, and t are defined as above, then the logarithm of a generalized output-oriented *Malmquist* productivity growth index, $G_{0i}^{t,t+1}$, can be decomposed into TEC, TP, and SEC between time periods t and $t+1$:

$$G_{0i}^{t,t+1} = \mathrm{TEC}_i^{t,t+1} + \mathrm{TP}_i^{t,t+1} + \mathrm{SEC}_i^{t,t+1} \quad [7]$$

where

$$\text{TEC}_i^{t,t+1} = \ln D_0\left(y_{i,t+1}, x_{i,t+1}, t+1\right) - \ln D_0\left(y_{i,t+1}, x_{i,t+1}, t\right) \quad [8]$$

$$\text{TP}_i^{t,t+1} = \frac{1}{2}\left[\frac{\partial \ln D_0\left(y_{i,t+1}, x_{i,t+1}, t+1\right)}{\partial(t+1)} + \frac{\partial \ln D_0\left(y_{i,t+1}, x_{i,t+1}, t\right)}{\partial t}\right] \quad [9]$$

$$\text{SEC}_i^{t,t+1} = \frac{1}{2}\sum_{n=1}^{N}\left[\frac{\varepsilon_{i,t+1}-1}{\varepsilon_{i,t+1}}\varepsilon_{i,t+1,n} + \frac{\varepsilon_{it}-1}{\varepsilon_{it}}\varepsilon_{itn}\right]\cdot \ln\left[\frac{x_{i,t+1,n}}{x_{itn}}\right] \quad [10]$$

where $\varepsilon_{it} = \sum_{n=1}^{N}\varepsilon_{itn}$ is the scale elasticity such that $\varepsilon_{itn} = \frac{\partial \ln D_0\left(y_{it}, x_{it}, t\right)}{\partial \ln x_{itn}}$

If the output is only one, then a *translog* output-oriented distance function can be defined as

$$\ln D_0\left(y_{it}, x_{it}, t\right) = \ln y_{it} - \ln y_{it}^{p} - v_{it} \quad [11]$$

Given the technical efficiency measure in Equation $[5]$, the technical efficiency change (TEC) between periods $t+1$ and t can be estimated by following Coelli et al. (2005):

$$\text{TEC}_i^{t,t+1} = \ln TE_{i,t+1} - \ln TE_{it} \quad [8]$$

The technical progress (TP) index can be obtained from equations $[6]$, $[9]$, and $[11]$ as follows:

$$\text{TP}_{i,t+1,t} = \frac{1}{2}\left[\sum_{n=1}^{N}\beta_{tn}\ln x_{i,t+1,n} + \sum_{n=1}^{N}\beta_{tn}\ln x_{itn} + 2\beta_t + 2\beta_{tt}\left[(t+1)\right] + t\right] \quad [13]$$

From equation $[3]$, the scale elasticity can be written as

$$\varepsilon_{nit} = \beta_n + \frac{1}{2}\sum_{k=1}^{K}\beta_{nk}x_{nit} + \beta_{nt}t \quad [14]$$

The index of scale efficiency change then can be calculated by using equations $[10]$ and $[14]$.

4. Empirical analysis: Database, variables and results

This section examines the productivity spillovers from FDI in the Latin American countries by using a unique and extensive country-level panel data covering the period 1996–2006. The intra-country productivity spillovers are examined through the FDI and trade variables, and the roles of labor skills and R&D effort in extending spillovers from FDI and trade are evaluated to test the absorptive capacity of productivity spillovers.

4.1 Statistical source and variables

The statistical source used for this analysis is the World Bank's World Development Indicators (WDI). This database provides more than 800 development indicators, with time series for 209 countries and 18 country groups from 1960 to 2007. From the World Bank's World Development Indicators (WDI), we have temporal observations (T=10) for 16 Latin American countries for the period 1996–2006. We are able to form a balanced panel of data. (See descriptive statistics of the variables in Table 1.)

[INSERT TABLE 1]

Table 2 presents a summary of the key variables used to empirically validate the combined stochastic-inefficiency model (and the control variables used in the second step analysis).

[INSERT TABLE 2]

4.2 Empirical results

The indices of TEC, TP, SEC and G_0 are calculated using equations $[7]$ a $[14]$ and the average of these indices for the selected period (2001-2003) is presented in Table 3.

[INSERT TABLE 3]

Table 3 shows that the major contribution to productivity growth in the Latin American countries is from technological progress. In contrast, the Technical Efficiency Change Indices are relatively low, suggesting that this component does not contribute much to productivity growth.

As to the negative contribution of SEC to productivity growth, we find several explanations with regard to this issue in Ventura-Dias, Cabezas and Contado (1999). These authors find that, with the exception of Mexico, the majority of Latin American economies are fully exploiting comparative advantage rooted in abundant natural resource endowments. Mexico firstly and Central American countries more recently have developer manufacturing activities oriented to the United States market based on a second source of comparative advantage, low-paid unskilled labor. Only Argentina, Brazil and Chile have developed competitive industries that can be classified as raw material processing (pulp and paper, nonmetallic minerals) and scale-intensive industries (steel, basic chemicals).

Finally, Figure 1 shows the indices of TEC, TP, SEC and G_0 by country using the Hodrick and Prescott Filter.

[INSERT FIGURE 1]

1) FDI, absorptive capacity and productivity spillovers

The estimation results of a translog stochastic production frontier (see table 4) show that the coefficients of labor and capital have the expected positive signs (in models 4). The positive and highly significant coefficients confirm the expected positive and significant output effects of labor and capital. In contrast, the squared variable of labor $\left[\ln(L_t)\right]^2$ in models 1, 2 and 3 is negative and statistically significant at a 1% level, which indicates a decreasing return to labor. The same is not true of the squared capital. The squared variable of capital $\left[\ln(K_t)\right]^2$ in models 1, 2 and 3 is positive and statistically significant at a 1% level, which indicates an increasing return to capital. Furthermore, the estimated coefficient of the interacting variable between labor and energy $\ln(L_t) * \ln(E_t)$ in models 1, 2 and 3 is positive and significant at a 1% level, suggesting a substitution effect between labor and energy.

[INSERT TABLE 4]

A particular interest of this study is in regard to the estimated coefficients of the inefficiency function in the second part of Models in Table 4. The coefficient of the FDI is positive and significant at the 1% level, suggesting that countries with high FDI, on average, have lower efficiencies compared to those with low FDI.

In order to explain why the FDI could have a positive correlation to inefficiency, Nourzad (2008) suggests “the Bhagwati hypothesis,” which suggests that the efficiency-enhancing effect of FDI could depend on the degree of development of the host country.

According to Nourzad (2008), the results suggest that increased FDI increases potential output in both developed and developing countries, with the effect being more profound in the former. Nourzad also found that increased FDI reduces technical inefficiencies the more open the economy, but that this effect holds only for developed economies.

The negative and significant coefficient of the interacting variable between FDI and R&D in Models 1, 2, 3 and 4 in Table 4 implies a positive and significant efficiency spillover in Latin American countries. This result suggests that Latin American countries with high R&D effort gain more spillovers from FDI.

Given this result, it is possible to infer that countries with high R&D effort can reap benefits from foreign firms’ presence by upgrading their knowledge and fostering innovation. This finding confirms that firms’ absorptive capacity (or firm-specific characteristics) determine productivity spillovers from FDI, as argued in several previous studies, for example, by Kathuria (2000, 2001).

2) Trade, absorptive capacity and productivity spillovers

In table 5 the estimated parameters of the production functions have a similar sign and significance as in the baseline models shown in Table 4. The coefficient of trade is positive and significant at the

1% level, suggesting that Latin American countries with high trade, on average, have lower efficiencies compared to those with low trade.

The positive correlation between trade and inefficiency can be explained using the justification given by McCalman, Stähler and Willmann (2011). These authors develop an efficiency theory of contingent trade policies by modeling the competition for a domestic market between one domestic and one foreign firm as a pricing game under incomplete information about production costs[2].

Using this theoretical framework McCalman, Stähler and Willmann (2011) show that the foreign firm must price more aggressively to overcome its cost disadvantage. For these authors the resulting possibility of an inefficient allocation justifies the use of contingent trade policy on efficiency grounds[3].

However, the negative coefficient of the interacting variable between trade and R&D suggests that countries with high R&D effort gain more spillovers from trade firms.

From these findings, it may be inferred that domestic firms operating in an open economy with high R&D effort in Latin American countries will gain spillover benefits in an open economy. According to Suyanto et al. (2009) higher trade level is an inverse measure of the static competition that can protect inefficient firms. However, higher trade level can also be the result of the dynamic competition among firms of differential efficiency that removes inefficient firms from the industry according to Demsetz (1973) and Peltzman (1977). The first argument suggests that trade is associated with greater inefficiency, while the latter argument suggests that trade is associated with lower inefficiency.

[INSERT TABLE 5]

3) Sources of productivity growth and FDI and trade spillovers

.After obtaining the indices of Malmquist productivity growth (G_0), TEC, TP, SEC, the next step is to estimate the contribution of FDI spillovers on total factor productivity growth and its sources.

Using the indexes of TEC, TP, SEC, and G_0 obtained from the decomposition, we then estimate the impact of FDI spillovers on total factor productivity growth and this sources (see table 6).

[INSERT TABLE 6]

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[2] According to McCalman, Stähler and Willmann (2011) the cost the cost distributions are asymmetric because the foreign firm has to pay a trade cost.

[3] For McCalman, Stähler and Willmann (2011), contingent trade policy that seeks to maximize global welfare can avoid the potential inefficiency. These authors show how National governments make excessive use of contingent trade policy due to income-shifting considerations. As a result, the expected inefficiency of national policy is larger (smaller) for low (high) trade costs compared to the laissez-faire case. Finally, these authors conclude that in general, there is no clear ranking between the laissez-faire outcome and a contingent national trade policy.

Table 6 reveals that FDI contributes to SEC, TP and (G_0) (as shown by a statistically significant estimate of FDI variable on SEC, TP and G_0). Moreover, a negative and statistically significant estimate of Latin American countries on technical efficiency suggests that higher FDI may decrease TEC. The same relation is found for trade, which indicates that countries with a high trade level have higher SEC and G_0 than those with a low trade level.

The negative correlation between trade level (and also with FDI) and TEC may be due to several factors. For example Ventura-Dias, Cabezas and Contado (1999) argue that operating under very unstable macroeconomic and political conditions, Latin American enterprises, in general, have not had the incentives for long-term investments in human and capital resources. As a result, those activities are not likely to generate endogenous sources of innovation and accumulation in the long term, primarily through innovative inter-sectoral linkages.

A positive and significant estimate is found for Researchers in R&D, which indicates that countries with high numbers of researchers in R&D level have higher TC than those with low numbers of researchers (the opposite is found for Research & development expenditure).

Based on the existent empirical evidence, it is difficult to explain the negative contribution of R&D expenditure to TP that we have found. Nevertheless, in the specific context of Latin American economies, Cimolli and Katz (2003) suggest that the present pattern of production specialization — strongly biased in favor of industries featuring low domestic knowledge generation and value added content — and the inhibition of local R&D and engineering activities resulting from the rapid expansion of internationally integrated production systems could be pushing Latin American economies into a 'low development trap.'[4]

5. Conclusions and policy implications

The empirical analysis shows positive productivity spillovers from FDI and trade only when the country has absorptive capacity in terms of R&D; higher competition (in terms of trade) is associated with larger spillovers; and countries with high R&D effort gain more spillover benefits compared to those with less R&D effort. FDI and trade spillovers are found to be positive and significant for scale efficiency change and total productivity factor change.

The empirical results show that intra-country productivity spillovers are present in the Latin American countries. Countries with R&D expenditure receive more productivity spillovers than those without R&D expenditure. Furthermore, technological progress is the major driver of productivity growth in the Latin American countries. The number of researchers in R&D has been found to be positive and significant for TP.

Despite the presence of positive spillovers from FDI and trade in countries with absorptive capacity, the policy implications of these findings are not straightforward. These results may support the

[4]In conclusion, Cimolli and Katz (2003) argue that new institutions and new forms of public-to-private interaction in the field of technology generation and dissemination seem to be a sine qua non condition for faster productivity growth and for the improvement of international competitiveness.

continuing fiscal and investment incentives provided by public and private institutions on R&D and human capital.

According to Bjorvata and Eckel (2006), with many countries competing for FDI and trade, particularly in the presence of an asymmetric competition among countries, there are undesirable welfare effects for developing countries.

Authors like Suyanto et al. (2009) suggest that policies for strengthening the absorptive capacity of domestic firms through investments in knowledge and human capital formation may be superior to policies that provide concessions for FDI and trade.

In this context more general policies should be pursued, that not only attract FDI but also benefit domestic firms, for example, building modern infrastructure, increasing and strengthening the institutions for accelerating and sustaining economic growth.

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TABLES AND FIGURES

Table 1 Descriptive statistics of variables by country: Mean 1996-2006.

country/mean	**Y**	**K**	**L**	**E**	**AVA**	**EVI**	**FDI**	**IVA**	**MT**	**R&D**	**SVA**	**RRD**	**SET**	**LFT**
Argentina	85,000,000,000	46,940,000,000	16,400,000	60,904.36	7.42	113.75	2.96	31.07	26.28	0.43	61.51	733.17	58.53	27.76
Bolivia	8,775,000,000	1,410,000,000	3,683,423	4,819.09	15.17	138.04	6.19	30.46	41.38	0.30	54.37	92.70	36.61	16.27
Brazil	665,400,000,000	108,300,000,000	84,800,000	195,304.73	5.96	131.97	2.97	27.40	18.86	0.87	66.63	409.85	19.15	7.16
Chile	79,300,000,000	17,990,000,000	6,280,403	26,002.64	5.42	131.20	6.47	39.76	53.06	0.57	54.83	495.63	41.33	25.20
Costa Rica	16,500,000,000	3,003,000,000	1,703,393	3,393.27	10.10	99.56	3.88	30.02	77.70	0.33	59.88	120.31	19.66	16.49
Ecuador	17,650,000,000	4,346,000,000	5,112,170	9,023.91	7.05	130.22	3.54	35.82	48.23	0.07	57.14	63.98	21.06	25.45
El Salvador	13,380,000,000	2,215,000,000	2,324,244	4,148.27	11.11	96.87	2.31	30.74	56.80	0.08	58.15	28.31	18.41	23.80
Guatemala	19,840,000,000	3,226,000,000	3,627,581	7,065.18	17.71	100.14	1.37	23.87	46.92	0.03	58.42	30.53	9.25	5.45
Honduras	7,570,000,000	1,879,000,000	2,332,121	3,416.09	16.14	105.08	3.79	30.28	110.45	0.05	53.57	70.03	15.72	5.45
Mexico	572,900,000,000	115,400,000,000	40,100,000	155,317.73	4.50	96.43	2.95	30.25	54.99	0.41	65.25	299.77	22.32	19.75
Nicaragua	4,003,000,000	926,500,000	1,871,618	2,899.00	20.63	101.84	5.56	28.59	62.18	0.06	50.78	70.03	17.77	5.45
Panama	12,080,000,000	2,265,000,000	1,307,084	2,551.45	7.37	99.68	7.19	17.79	34.61	0.32	74.84	107.21	43.28	18.10
Paraguay	7,499,000,000	1,327,000,000	2,536,386	4,052.64	18.93	137.76	1.52	22.25	56.01	0.09	58.82	81.36	21.06	25.45
Peru	56,480,000,000	11,610,000,000	12,200,000	12,417.64	8.12	141.56	3.22	31.38	29.31	0.11	60.51	227.77	33.12	30.46
Uruguay	22,490,000,000	3,050,000,000	1,567,053	2,879.18	8.85	114.26	2.21	26.00	31.69	0.27	65.15	290.09	34.43	16.98
Venezuela, RB	19,600,000,000	24,710,000,000	10,400,000	57,239.00	4.50	97.75	2.90	50.03	44.50	0.37	45.46	157.55	39.74	30.46
Total	119,279,187,500	21,787,343,750	12,265,342	34,465	11	115	4	30	50	0	59	205	28	19

Source: Authors' calculation from the World Bank's World Development Indicators (WDI).

Table 2 Key variables.

	Variables	Definition
Frontier model	Y_{NTx1} : GDP[1] (constant 2000 US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
	K_{NTx1} : Gross fixed capital formation[2] (constant 2000 US$)	Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2000 U.S. dollars.
	L_{NTx1} : Labor force[3], total	Total labor force comprises people who meet the International Labour Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.
	E_{NTx1} : Energy use[4] (kt of oil equivalent)	Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.
	T_{NTx1} : Time	Cyclical and Hicks neutral technological progress.
Inefficiency model	FDI_{NTx1} : Foreign direct investment[5], net inflows (% of GDP)	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy and is divided by GDP.
	MT_{NTx1} : Merchandise trade[6] (% of GDP)	Merchandise trade as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars.
	$R\&D_{NTx1}$: Research and development expenditure[7] (% of GDP)	Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.
	LTE_{NTx1} : Labor force with tertiary education[8] (% of total)	Labor force with tertiary education is the proportion of labor force that has a tertiary education, as a percentage of the total labor force.
	T_{NTx1} : Year	Time-varying inefficiency effect.
Control variables (second stage)	AVA_{NTx1} : Agriculture[2], value added (% of GDP)	Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator.
	IVA_{NTx1} : Industry[2], value added (% of GDP)	Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator.
	SVA_{NTx1} : Services[2], etc., value added (% of GDP)	Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator.
	EVI_{NTx1} : Export value index[12] (2000 = 100)	Export values are from UNCTAD's value indexes or from current values of merchandise exports.
	RRD_{NTx1} : Researchers in R&D[13] (per million people)	Researchers in R&D are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students (ISCED97 level 6) engaged in R&D are included.
	SET_{NTx1} : School enrollment[13], tertiary (% gross)	Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level[14]

[1]International Finance Corporation's micro, small, and medium-size enterprises database (http://www.ifc.org/ifcext/sme.nsf/Content/Resources).
[2]World Bank national accounts data, and OECD National Accounts data files.
[3]International Labour Organization, using World Bank population estimates.

[4]International Energy Agency.
[5]International Monetary Fund, International Financial Statistics and Balance of Payments databases, World Bank, Global Development Finance, and World Bank and OECD GDP estimates.
[6]World Trade Organization, and World Bank GDP estimates.
[7]United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.
[8]International Labour Organization.
[12]United Nations Conference on Trade and Development, Handbook of Statistics, and International Monetary, International Financial Statistics.
[13]United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.
[14]Note: Break in series between 1997 and 1998 due to due to change from International Standard Classification of Education (ISCED76) to ISCED97. Recent data are provisional.
Source: World Bank's World Development Indicators (2009).

Table 3 Sources of productivity growth by sector for 1996-2006.

Sector Mean	**Technical Efficiency Change (TEC)**	**Technical Change (TC)**	**Scale Efficiency Change (SEC)**	**Total productivity Change** (G_0)
Argentina	-0.018	-0.598	8.943	8.328
Bolivia	0.003	1.131	-31.481	-30.347
Brazil	-0.001	0.072	-20.542	-20.471
Chile	0.004	-0.978	7.605	6.631
Costa Rica	-0.049	2.305	2.986	5.242
Ecuador	-0.044	1.126	-0.980	0.103
El Salvador	-0.039	1.447	5.427	6.834
Guatemala	-0.049	0.687	-5.285	-4.647
Honduras	-0.066	2.202	10.610	12.746
Mexico	-0.006	-0.873	24.829	23.950
Nicaragua	-0.022	0.873	-6.197	-5.347
Panama	-0.050	2.296	2.930	5.176
Paraguay	0.036	0.669	-48.384	-47.679
Peru	-0.053	4.175	-7.457	-3.336
Uruguay	0.006	2.843	-16.183	-13.334
Venezuela, RB	-0.053	-3.023	53.662	50.586
Total	-0.025	0.897	-1.220	-0.348

Source: Author's calculations.

Table 4 Maximum Likelihood Estimates of stochastic production frontier with inefficiency coefficient as function of FDI and Spillovers (by R&D and Labor skills).

	Variable	Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
Production frontier1	Constant	β_0	-27.22564 [31.62189]	13.06251 [29.14972]	-9.744519 [30.45277]	2.224334*** [0.662596]	1.845238*** [0.7073365]
	$\ln(K_t)$	β_1	-3.878797 [2.91302]	-6.060685** [2.913091]	-3.978034 [2.989339]	0.9214329*** [0.0380093]	0.965304*** [0.039755]
	$\ln(L_t)$	β_2	11.31664*** [2.928154]	6.373234** [2.640194]	7.922446*** [2.756052]	0.1023971** [0.0489112]	0.035645 [0.048911]
	$\ln(E_t)$	β_3	-0.8336474 [3.902221]	4.137326 [3.632856]	1.371627 [3.759156]	-0.0286705 [0.0581869]	0.006911 [0.059408]
	$[\ln(K_t)]^2$	β_{11}	0.4626481*** [0.1686924]	0.5463026*** [0.1729435]	0.451646** [0.1803403]		
	$[\ln(L_t)]^2$	β_{22}	-1.433836*** [0.2831406]	-1.014223*** [0.3055332]	-1.034772*** [0.3207719]		
	$[\ln(E_t)]^2$	β_{33}	0.1840744 [0.2445038]	0.4857334** [0.2367923]	0.3501664 [0.2404679]		
	$\ln(L_t)*\ln(K_t)$	β_{12}	0.0769518 [0.1456199]	0.1513515 [0.1486073]	0.0737517 [0.148731]		
	$\ln(K_t)*\ln(E_t)$	β_{13}	-0.7367614*** [0.2031064]	-0.8313027*** [0.2150417]	-0.6972762*** [0.2177063]		
	$\ln(L_t)*\ln(E_t)$	β_{23}	1.011279*** [0.2117392]	0.6528089*** [0.1981608]	0.7150243*** [0.2048636]		
	T_t	β_t	-0.5227036*** [0.1866401]	0.0111609*** [0.00423]			
	$\ln(K_t)*T_t$	β_{1t}	0.0234228** [0.0110004]				
	$\ln(L_t)*T_t$	β_{2t}	0.0376901*** [0.0119172]				
	$\ln(E_t)*T_t$	β_{3t}	-0.0618408*** [0.0160849]				
	T_t^2	β_{tt}	-0.0051394* [0.0027086]	-0.0053111* [0.0029266]			
Equation u_{it}	constant	δ_{u0}	-4.328997*** [0.4797635]	4.950119*** 0.7979365]	-4.546313*** [0.6643834]	-5.758383*** [1.00458]	
	FDI_{NTx1}	δ_{FDI}	0.6134197*** [0.1219802]	0.7214421*** 0.161151]	0.6777422*** [0.1430362]	0.8398162*** [0.2021684]	
	$FDI_{NTx1}*R\&D_{NTx1}$	$\delta_{FDIxR\&D}$	-1.737438*** [0.3882507]	-1.919297*** 0.5163247]	-1.699004*** [0.4369535]	-2.461248** [1.239592]	
	$FDI_{NTx1}*LTE_{NTx1}$	$\delta_{FDIxLTE}$	0.0015189 [0.0050572]	-0.0021701 0.0066998]	-0.0031846 [0.0061448]	-0.0001214 [0.0079937]	
Equation v_{it}	constant	δ_{v0}	-4.231141*** [0.2353143]	-3.829503*** 0.1963722]	-3.855063*** [0.2259758]	-3.366986 [0.14119]	

	Sigma	σ_V	0.12056450.014 1853	0.1473784 0.0144705	0.1455069 0.0164405	0.1857242 0.0131112	0.2173873 0.0116145
Wald chi2			14120.00	10799.55	10344.89	6736.84	8765.61
Prob > chi2			0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood			71.093044	60.943097	55.942379	34.67139	18.853981
Number of obs			176	176	176	176	176

Notes:
Model 1 is a translog production function. Models 2 and Model 3 represent a Hicks-neutral and a no-technological progress production functions, respectively. Model 4 is a Cobb–Douglas production function. Model 5 represents a no-inefficiency production function: lnsig2v: coefic. -3.05215 and std. err. 0.106855; lnsig2u: coefic. -12.28412 and std. err. 206.2603; sigma_u: coefic.0.0021505 and std. err. 0.2217808; sigma2: coefic. 0.0472619 and std. err. 0.0050745; lambda: coefic.0.0098925 and std. err. 0.2228764; Likelihood-ratio test of sigma_u=0: chibar2(01) = 0.00 Prob>=chibar2 = 1.000
Standard errors are in parentheses and presented until two significant digits, and the corresponding coefficients are presented up to the same number of digits behind the decimal points as the standard errors: * Denotes significance at 10%;** Denotes significance at 5%;*** Denotes significance at 1%; $^{*}p \langle 0.1: ^{**} p \langle 0.05; ^{***} p \langle 0.01$

Source: Authors' calculation.

Table 5 Maximum Likelihood Estimates of stochastic production frontier with inefficiency coefficient as function of trade and Spillovers (by R&D and Labor skills).

	Variable	Parameter	Model 1	Model 2	Model 3	Model 4
Production frontier1	Constant	β_0	-63.75117** [27.09068]	-46.10637 [29.30114]	-53.34125* [30.4911]	2.140026*** [0.6358066]
	$\ln(K_t)$	β_1	-0.1441388 [2.644289]	-0.8605591 [2.948618]	-0.0976849 [3.026257]	0.9157772*** [0.03715]
	$\ln(L_t)$	β_2	13.27632*** [2.485212]	10.43628*** [2.544593]	10.91683*** [2.693568]	0.1225255** [0.0498045]
	$\ln(E_t)$	β_3	-5.312538 [3.384722]	-2.565611 [3.627755]	-3.685716 [3.771481]	-0.0405479 [0.0561805]
	$[\ln(K_t)]^2$	β_{11}	0.1718158 [0.1616403]	0.2344044 [0.1777567]	0.2190375 [0.1823832]	
	$[\ln(L_t)]^2$	β_{22}	-1.730239*** [0.2589777]	-1.356151*** [0.2878417]	-1.293024*** [0.3031869]	
	$[\ln(E_t)]^2$	β_{33}	-0.1547828 [0.2251013]	0.1074325 [0.2372708]	0.0199565 [0.2443523]	
	$\ln(L_t)*\ln(K_t)$	β_{12}	0.1250482 [0.1313789]	0.1034678 [0.1361103]	0.0328078 [0.1420171]	
	$\ln(K_t)*\ln(E_t)$	β_{13}	-0.5156052*** [0.1898468]	-0.5572378*** [0.2134383]	-0.4847293** [0.2184586]	
	$\ln(L_t)*\ln(E_t)$	β_{23}	1.182345*** [0.1918807]	0.9118755*** [0.1966486]	0.9298185*** [0.2069266]	
	T_t	β_t	-0.4637614*** [0.1702002]	0.0144658*** [0.0044314]		
	$\ln(K_t)*T_t$	β_{1t}	0.0138253 [0.0098161]			

	$\ln(L_t)*T_t$	β_{2t}	0.0471882*** [0.0116229]			
	$\ln(E_t)*T_t$	β_{3t}	-0.0601819*** [0.0146426]			
	T_t^2	β_{tt}	-0.0019538 [0.0027455]	-0.0022101 [0.0029859]		
Equation u_{it}	constant	δ_{u0}	-5.223112*** [0.6244387]	-5.340834*** [0.7625763]	-4.696655*** [0.7706064]	-3.885253*** [1.230057]
	MT_{NTx1}	δ_{MT}	0.0400736*** [0.0078391]	0.0379042*** [0.0081021]	0.0333523*** [0.0078793]	0.0470576*** [0.0130393]
	$MT_{NTx1}*R\&D_{NTx1}$	$\delta_{MTxR\&D}$	-0.1398774*** [0.0478615]	-0.1312944** [0.0630352]	-0.1414705** [0.0665409]	-0.6226683*** [0.226363]
	$MT_{NTx1}*LTE_{NTx1}$	δ_{MTxLTE}	0.0011217** [0.0004378]	0.0010888** [0.0005149]	0.0007393 [0.0005251]	0.0004228 [0.0007061]
Equation v_{it}	constant	δ_{v0}	-4.269993*** [0.2090885]	-3.948264*** [0.1905863]	-3.857357*** [0.1974477]	-3.367329 [0.1319885]
	Sigma	σ_v	0.118245 0.0123618	0.1388818 0.0132345	0.1453401 0.0143485	0.1856923 0.0122546
Wald chi2			16458.78	12741.27	11842.23	8003.14
Prob > chi2			0.0000	0.0000	0.0000	0.0000
Log likelihood			71.852987	58.757756	52.907567	33.430661
Number of obs			176	176	176	176

Notes:
Model 1 is a translog production function. Models 2 and Model 3 represent a Hicks-neutral and a no-technological progress production functions, respectively. Model 4 is a Cobb–Douglas production function.
Standard errors are in parentheses and presented until two significant digits, and the corresponding coefficients are presented up to the same number of digits behind the decimal points as the standard errors: * Denotes significance at 10%;** Denotes significance at 5%;*** Denotes significance at 1%; $*p \langle 0.1: **p \langle 0.05; ***p \langle 0.01$

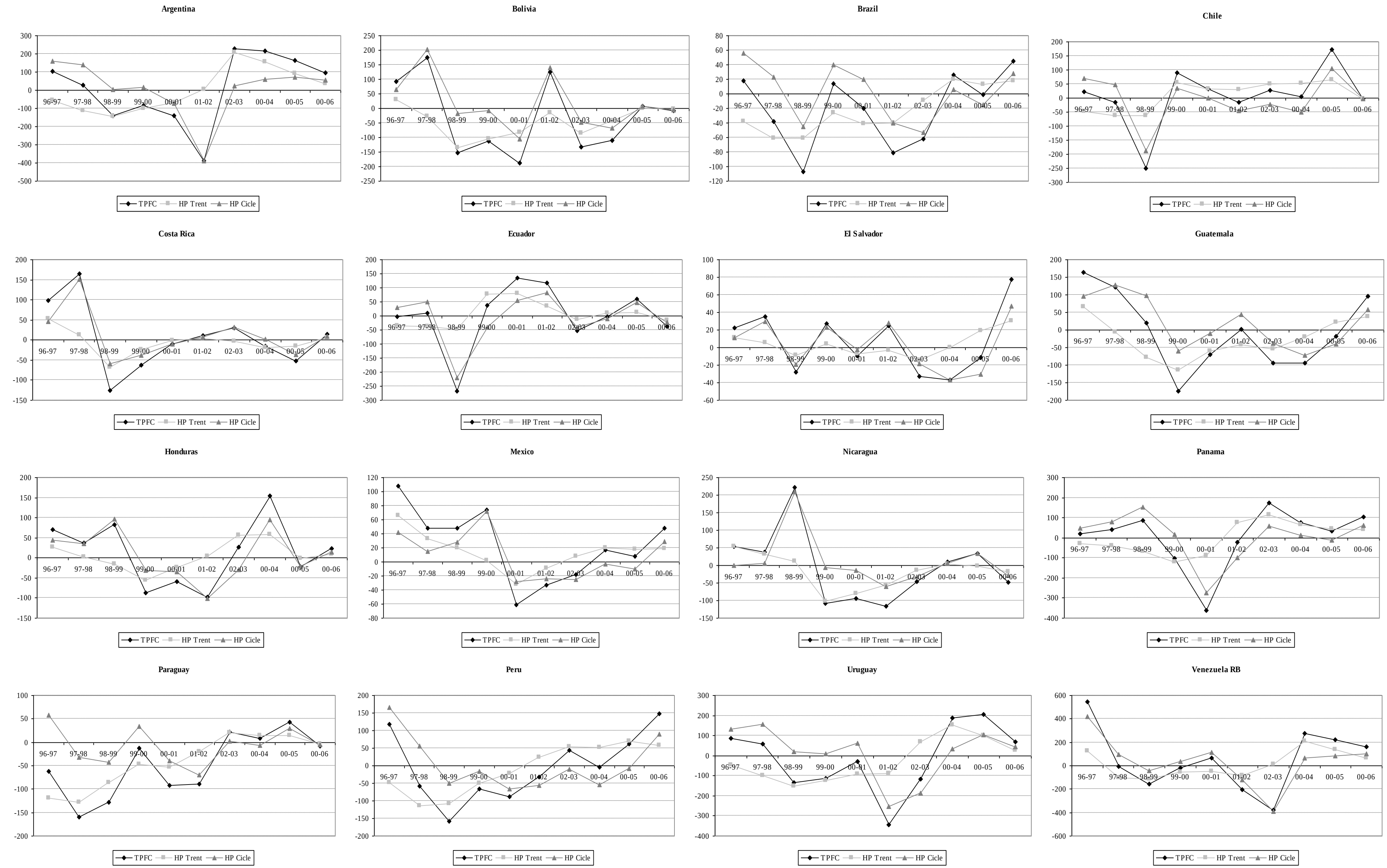
Source: Authors' calculation.

Table 6 Sources of productivity growth and spillovers: 1997-2005.

Dependent Variable	SEC		TP		TEC		G_0	
Sources product. & FDI spillovers	**Model FE**	**Model RE**	**Model FE**	**Model RE**	**Model FE**	**Model RE**	**Model FE**	**Model RE**
Independent variables	Coef/E. St.	Coef/E. St.	Coef/E. St.	Coef/E. St.	Coef/E. St	Coef/E. St	Coef/E. St	Coef/E. St
FDI_{NTx1} : Foreign direct investment	5.877959 [4.478186]	7.699713* [4.335772]	0.1022834** [0.0476449]	0.1800723*** [0.0602199]	-0.0118866 [0.0074611]	-0.0154555** [0.0073282]	5.968356 [4.471485]	7.86433* [4.327804]
MT_{NTx1} : Merchandise trade	0.8951474 [0.6119442]	1.030092* [0.6015853]	0.0037336 [0.0065107]	-0.0131566 [0.0083555]	-0.0008391 [0.0010196]	-0.0008214 [0.0010168]	0.8980418 [0.6110285]	1.016114* [0.6004797]
$R\&D_{NTx1}$: Research & development expenditure	22.3687 [85.03727]	-2.857874 [85.73711]	-6.025811*** [0.9047393]	-6.041163*** [1.190811]	0.0181406 [0.1416801]	0.04199 [0.1449097]	16.36103 [84.91002]	-8.857051 [85.57955]
LTE_{NTx1} : Labor force with tertiary education	0.7145777 [1.786074]	0.2487539 [1.778848]	-0.0407188** [0.0190026]	-0.0090431 [0.0247066]	-0.0005725 [0.0029758]	-0.0007888 [0.0030065]	0.6732863 [1.783401]	0.238922 [1.775579]
Control variables								
AVA_{NTx1} : Agriculture, value added	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)	(dropped)
IVA_{NTx1} : Industry, value added	1.250211 [3.278244]	2.006595 [3.200899]	0.0174974 [0.0348783]	-0.0673268 [0.0444576]	-0.0018926 [0.0054619]	-0.0006553 [0.00541]	1.265816 [3.273339]	1.938613 [3.195017]
SVA_{NTx1} : Services, etc., value added	0.7648675 [3.173707]	1.303565 [3.103752]	0.1488787*** [0.0337661]	0.066263 [0.0431083]	-0.0019491 [0.0052877]	-0.0005158 [0.0052458]	0.911797 [3.168958]	1.369312 [3.098049]
EVI_{NTx1} : Export value index	0.4479707 [0.5297272]	1.106331*** [0.3433629]	0.0231497*** [0.0056359]	-0.0125423*** [0.004769]	-0.0008023 [0.0008826]	-0.0009962* [0.0005803]	0.470318 [0.5289346]	1.092792*** [0.3427319]
RRD_{NTx1} : Researchers in R&D (in ln)	-5.127533 [20.66532]	-3.014281 [20.57651]	0.4586041** [0.2198651]	0.9032746*** [0.2857891]	0.0114921 [0.0344304]	0.0014447 [0.0347777]	-4.657436 [20.6344]	-2.10956 [20.5387]
SET_{NTx1} : School enrollment, tertiary	0.1818811 [1.267745]	0.322796 [1.229769]	-0.0106004 [0.0134879]	-0.0499516*** [0.0170804]	0.0005303 [0.0021122]	0.000842 [0.0020785]	0.1718109 [1.265848]	0.2736863 [1.227509]
Constant	-217.2321 [283.756]	-356.9921 [264.4889]	-11.14535*** [3.018973]	-0.8447519 [3.673511]	0.2826265 [0.4727644]	0.2318622 [0.4470295]	-228.0948 [283.3314]	-357.605 [264.0029]
Number of obs	128	128	128	128	128	128	128	128
R-squared	0.0497	0.0436	0.5688	0.3935	0.0423	0.0404	0.0493	0.0439
Hausman test	Prob>chi2 =	0.9563: RE	Prob>chi2 =	0.0000: FE	Prob>chi2 =	0.9885: RE	Prob>chi2 =	0.9628: RE
$*p < 0.1$; $**p < 0.05$; $***p < 0.01$								

Source: Author's calculations.

Figure 1 Hodrick Prescott Filter of TPFC.



Source: author's calculations.