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MULTINATIONALS AND DIFFUSION OF TECHNOLOGY BETWEEN DEVELOPED COUNTRIES[(*)]

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Abstract

This paper analyses the role played by foreign direct investment (FDI) as a mechanism through which technology flows between countries. After a short review of the existing literature it is observed that aggregate studies do not obtain evidence of the existence of technology spillovers amongst the OECD countries. These results oppose the presumption among many academics and policy-makers that FDI helps accelerate the process of economic development in host countries. The conclusion drawn is that spillovers have taken place, but that there is a problem of overlap between the variables used in these analyses which prevents their impact being captured properly.

JEL Classification: O3, O4, F2.

Key words: international technology spillovers, foreign direct investment, growth, OECD.

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1. Introduction.

In the last few years, foreign direct investment (FDI) has been considered to be a way by which countries obtain significant benefits. It is asserted that one of the most important of these is its role as a channel of access to new technologies and production processes (technology spillovers), particularly but not exclusively for the less advanced countries[1].

However, review of the different studies that have set out from that premise in an attempt to assess, at aggregate level, the impact of the technology transmitted by the multinationals on the recipient country's growth reveals certain doubts about this effect[2].

Results of this type clash, apparently at least, with the evidence that the subsidiaries of the multinationals exhibit higher productivity than the local firms, so it seems that their establishment is going to generate increased aggregate productivity. In this same respect, some studies conducted at firm or sector level have found evidence of intrasectoral dissemination of technology amongst multinationals and local firms. Accordingly, there is apparently some kind of problem in the more aggregate studies in the attempt to pinpoint the impact of the technology transfer that takes place from the foreign to the local firms.

In this study, therefore, our intention is to make further headway with this line of research by trying to find out the reasons why the aggregate studies do not find evidence of technology spillovers from the multinationals that enable countries to increase their productivity. The results point to the existence of correlation between some of the variables explaining the increase in productivity and the one that identifies the foreign technology transfer that causes technology spillovers not to be significant or to have a sign contrary to that expected.

In this respect, this study first of all carries out a brief review of the existing literature regarding the role of the technology spillovers transmitted via FDI in the growth of the recipient countries. It then goes on to describe the empirical framework in which the study is set. Next, we comment on the different procedures used in the literature to measure technology spillovers. Lastly, we provide and comment estimation results. To conclude, we offer a brief summary with the main conclusions.

2. FDI as a channel of transmission of technology spillovers.

The literature on technology spillovers basically points to two channels of incorporated technology transfer: trade and FDI[3]. The former has been widely studied and there is apparently certain agreement that, amongst the developed countries at least, it has acted as a mechanism through which technology has flowed in the form of the acquisition of capital goods and intermediate consumptions that have enabled importing countries to boost their productivity[4]. However, this level of agreement has not been achieved in the area of FDI.

Thus, we may find two types of studies depending on the degree of disaggregation used to carry out the analysis: microeconomic and macroeconomic. In this respect, amongst the former, which use the firm as the unit of analysis, we can find widely varying results[5]. Thus, Aitken and Harridson (1999) in the case of Venezuela, or Djankov and Hoekman (2000) in that of the Czech Republic, obtain a negative impact of the influx of multinationals on the productivity of the local firms. On the other hand, Branstetter (2001) finds positive evidence of spillovers obtained by means of the flows of FDI between the United States and Japan. Finally, Girma and Wakelin (2001) conclude that there have been no spillovers by way of FDI received from the United States in the British electronics industry.

From a sectoral standpoint, it is possible to find studies that consider a larger number of countries, although they focus on manufacturing sectors. Amongst these there seems to be general consensus with regard to the results attained, as authors such as Braconier and Sjöholm (1998), Baldwin, Braconier and Forslid (1999) or Hanel (2000) obtain evidence of technology spillovers that have a favourable effect on the recipient countries, although others, like Braconier, Ekholm and Midelfort (2001) come to the opposite conclusion.

At aggregate level there are few studies available[6], and what is more, they come to different conclusions. Thus, Hejazi and Safarian (1999) obtain evidence of positive spillovers transmitted by way of FDI between 6 of the countries making up the G-7. However, Lichtenberg and Van Pottelsberghe (2001) conclude that the FDI received has not acted as a channel of technology transfer when enlarging the sample to 22 OECD countries.

Obviously, besides not being conclusive, these results found at macroeconomic level contradict some of those obtained at microeconomic level. In fact, since the foreign firms are more productive than the local ones and sectoral spillovers do appear to exist, the aggregate productivity of the economy should be affected favourably by FDI even though, as pointed out by Barba and Tarr (2000), there will be a slight unfavourable effect on the productivity of the local firms. However, as a possible explanation Aitken and Harrison (1999) point to the existence of a negative impact, especially in the short-run, of the influx of multinationals on the local firms stemming from what is called a "market stealing effect". The idea, basically, is that the entry of a foreign subsidiary into a market operating in imperfect competition means that the subsidiary covers part of the demand that was formerly met by the local firms, which are forced to cut back production, with the resultant increase in their total average costs – through having to go on assuming the same fixed costs but with a lower level of output – which is reflected in their reduced productivity[7].

This explanation, however, produced for developing countries[8], does not seem to be applicable to developed ones, as there is evidence that the entry of new firms – many of them of foreign capital – is accompanied by increased sectoral and aggregate productivity, not only because the incoming ones are more efficient, but also because they force the less productive ones out of the market[9].

3. Empirical framework.

The model used here is a modified version of the one put forward initially by Benhabib and Spiegel (1994) to explain the increase in total factor productivity (TFP). It analyses the dual role played by the stock of technological knowledge as a determinant both of endogenous capacity to generate new knowledge and of technology absorption. Nevertheless, a direct measure of technology spillovers will be used here instead of identifying them with the distance in per capita income to the technological leader, as is done in the initial model[10]. The model, therefore, would be:

$$\Delta \log PTF_{it} = d + j \cdot T_{it} + b \cdot T_{it} \cdot S_{it} + e_{it} \qquad (1)$$

where *TFP* is total factor productivity, *T* the stock of technological knowledge of the economy – constructed as a combination of the human and technological capital stocks, *S* the technology spillovers transmitted by way of the FDI received and, finally, the subindices *i* and *t* the country and time, respectively.

Now, it seems reasonable to assume that the impact of the technology spillovers does not take place instantly, but does so in the long-run. In fact, the period of time passing between the actual entry of foreign investment and the time when the multinational reaches its steady-state size may be lengthy due to the building of the production pla nt – in the case of greenfield investment – or the adjustment costs that the multinational companies will necessarily have (adaptation of production systems, training workers in the production techniques, market prospecting, introduction of new products, etc). Therefore, it seems more appropriate to study the dynamic impact by adopting the autoregressive form, changing the basic model below:

$$\Delta \log PTF_{it} = a \Delta \log PTF_{it-1} + d^{sr} + j^{sr} \cdot T_{it} + b^{sr} \cdot T_{it} \cdot S_{it} + e_{it} \qquad (2)$$

so that the long-run coefficients may be calculated simply by using the expressions: $j^{lr} = j^{sr}/(1-a)$, $b^{lr} = b^{sr}/(1-a)$ [11].

The significance of this model lies in the fact that, compared with others, like that used by Coe and Helpman (1995), the stock of technological knowledge, and not its growth, is considered to be the factor that determines the increase in total factor productivity[12]. In this respect, we should remember that even in the event of its not undergoing any growth an increase in TFP is still feasible.

The model, therefore, distinguishes between the impact on the effectiveness of endogenous capacity to generate new knowledge and that possessed by the technology diffused by the multinationals, although this is subject to the technology-absorptive capacity with which the country is endowed. This last aspect means that for foreign technology to have an impact on productive efficiency not only must foreign investment exist but conditions for its absorption also have to prevail, which are identified in the model with the levels of human and technological capital – remember that technology absorption expenditures come under this head –. Thus, the model puts forward two variables with counteracting effects. If a country has a larger stock of technological knowledge, the larger its internal generation and absorptive capacity will be, although its external technological flows may possibly be smaller. However, even though they may be of a smaller amount, their impact on growth will be boosted by the increased absorptive capacity.

Therefore, this model has two major implications. Thus, first of all, so long as the stock of technological knowledge per worker is not nil, increase in the TFP is assured, although this will depend on the size of this stock. Secondly, the elasticities obtained are not directly comparable with those estimated in other studies based on modelizations similar to those of Coe and Helpman (1995). The reason for this is that the different stocks enter the production function not as just another productive factor, but as the determinant of the increase in aggregate efficiency.

In this respect, it should be observed that the elasticities associated both with the stock of domestic technological knowledge ($e_{TFP,T}$) and the international technology spillovers that are transmitted by way of FDI ($e_{TFP,S}$) may be calculated in an easy way given the functional form used. Specifically, the values of these elasticities in the mean of the variables would be:

$$e^{i}_{TFP,T} = \left(j^{i} + b^{i} \cdot \overline{S}\right) \cdot \overline{T} \qquad \text{with i = sr, lr} \qquad (3)$$

$$e^{i}_{TFP,S} = b^{i} \cdot \overline{T} \cdot \overline{S} \qquad \text{with i = sr, lr} \qquad (4)$$

4. Measurement of technology spillovers.

Technology spillovers have traditionally been identified with the stock of foreign technological capital that a country is able to turn to profitable use. In this respect, Griliches (1979) establishes the existence of two types of sources of externalities associated with R&D. On the one hand, we have the so-called “rent spillovers”, which come about as a result of market transactions in which the price does not properly reflect the technology incorporated in the good or service acquired. These are usually present in operations involving some kind of monetary transaction – trade, FDI, technological payments –. Furthermore, he refers to “knowledge spillovers”, consisting of transfers of technological knowledge between countries or sectors which may be used by the recipient to carry out its own research. The distinction between one type and the other appears clear from the conceptual point of view. However, this is not the case from an applied standpoint, so that it is very hard to distinguish between both types of spillovers.

Accordingly, the most common approximation for measuring the existence of “rent spillovers” is based on measures connected with trade, investment or other operations involving some kind of monetary transaction. While “knowledge spillovers” are usually approached by considering the technological or geographical proximity between the countries or sectors studied[13]. Thus, the most common approach consists of using a weighted sum of the stocks of foreign technological capital (R_{jt}), where the weighting factor (c_{ijt}) represents their channel of transmission (Griliches, 1979):

$$S_{it} = \sum_{j \neq i} c_{ijt} \cdot R_{jt} \tag{5}$$

Accordingly, focusing on the spillovers transmitted by way of FDI, of the few studies that analyse this phenomenon from the aggregate point of view, Hejazi and Safarian (1999) calculate these spillovers from the expression:

$$S_{it}^{HS} = \sum_{j \neq i} f_{ijt} \cdot R_{jt} \tag{6}$$

where f_{ijt} is the contribution of the FDI received by i from the country j in the period t out of the total FDI, and R_{jt} the stock of technological capital of country j. This indicator could therefore be interpreted as the technological capital stock of the "average" investor country. As may be seen, it is the indicator proposed by Coe and Helpman (1995) in order to analyse the spillovers of trade transcribed to the area of FDI. Furthermore, in the same way as Coe and Helpman (1995), the authors relativize this indicator later with the contribution of FDI to the GDP of the recipient economy.

Subsequently, Lichtenberg and Van Pottelsberghe (2001) use a modified version of this indicator which prevents the bias suffered by the earlier one because of the degree of disaggregation of the information used[14]:

$$S^{LP}{}_{it} = \sum_{j \neq i} \frac{FDI_{ijt}}{K_{jt}} \cdot R_{jt} \tag{7}$$

where FDI_{ijt} is the flow of FDI received by country i from country j in the period t[15], K_{jt} the stock of physical capital of country j, and R_{jt} the stock of technological capital of country j. The interpretation of this indicator would be related to the technological content of the investment received. Now, in this study we have opted for following the latter modelization in order to capture the spillovers transmitted by way of FDI. However, there are two differences. Instead of using flows of FDI, we have used the stock of FDI, which displays a much less volatile behaviour over time. In addition, the indicator has been relativized by the employment of the recipient country in order to obtain a measure of foreign technological capital per unit of labour as the determinant of efficiency.

5. Data and estimation.

In this study we use data referring to 28 OECD countries – Belgium and Luxembourg appear aggregated and the Slovak Republic is not included – and the reference period runs from 1987 to 1999. Detailed explanation of the construction of the variables and the sources used may be seen in the appendix.

Use of the GMM estimator proposed by Arellano and Bond (1991) is common in the estimation of dynamic panel data models. However, as shown by Blundell, Bond and Windmeijer (2000), estimators of this type that try to eliminate individual effects by means of the conversion of the first differences model give unsatisfactory results in dynamic models, because the series are often autoregressive and the panels relatively short[16]. Therefore, Arellano and Bover (1995) and Blundell and Bond (1997) proposed the use of the *GMM system* estimator, which combines first differences equations with levels equations, so that the instruments used are levels variables for the former and first differenced variables for the latter[17].

First of all, we proceeded to the estimation of the basic model by using the *system GMM* estimator - column 1 of table 1–, which enables us to talk of a significant positive impact of the stock of technological knowledge on TFP but not of technology spillovers[18]. This result, therefore, coincides with that obtained by Lichtenberg and Van Pottelsberghe (2001) despite the use of an estimation model and technique different from those used by these authors.

[TABLE 1]

However, as stated above, this result is surprising inasmuch as the entry of subsidiaries whose productivity is higher than that of the local firms should have a positive effect on the TFP of the economy. This leads us to suspect that what we are detecting may be a problem stemming from the possible presence of colinearity between the variables used, something mentioned by Mohnen (2001) as the reason why these studies are often unable to reveal evidence of the existence of spillovers. We therefore repeated the estimations considering different combinations of variables in order to come up with one that would find a way round this problem. Thus, we first considered the stock of technological knowledge (T) as the variable representing endogenous technology generation capacity and we used both human capital per worker (H) and technological capital per worker (TC) as measures of foreign technology absorptive capacity. All the results point in the same direction as the initial ones: there are no technology spillovers. We even included the term that detects spillovers without interacting it with a variable that represents the absorptive capacity of the economy. But we reached the same conclusion again, although existence of spillovers would not be rejected at the 10% significance level.

All the possible combinations between technology generation capacity indicators and technology absorptive capacity indicators are carried out in the same table. But the results all led us to the same conclusion: there seem to have been no technology spillovers stemming from the influx of FDI in the economies analysed, and even when considering the role of human capital as an indicator of own technology development negative spillovers were obtained (see columns 5, 6 and 7 of table 1).

Therefore, there seems to be no combination of variables that will give rise to results that allow us to contend that the entry of FDI generates technology transfer towards the recipient economy and that this is reflected in an increase in TFP. However, in order to be certain that this conclusion is correct, we carried out estimations in which each one of the different variables considered previously (table 2) are included separately. When observing the results, it is surprising to find that individually the different measures used to detect spillovers show a significant positive impact on growth of TFP. This therefore appears to indicate the existence of some kind of overlapping between the different variables considered which prevents this impact being detected properly.

[TABLE 2]

In order to confirm whether this is what happens, we proceeded to evaluate the relationship between the stock of technological knowledge and the term that comprises technology spillovers. The result, which is set out in table 3 under the heading “Auxiliary Regression”, indicates that there is a significant positive relationship which could be the cause of the results obtained. This would mean that part of the variability of a variable – that of the spillover term apparently – is being captured by the stock of technological knowledge. To confirm this hypothesis and, further, to try and get round this problem, we replaced the stock of technological knowledge with the residual estimated in this regression ($\tilde{T}$) – column 1 of table 3 –. This residual would be capturing the part of the variability of the stock of technological knowledge that is not being explained by the technological spillover term. In fact, once the common part between both variables has been discounted, they both go on to show a positive impact on TFP. To study the soundness of this result, we repeated the same exercise but the other way round, i.e. we regressed the term incorporating the spillovers on the stock of technological knowledge, proceeding in a similar way (column 2 of table 3). In this case, the residual is not significant. Therefore, the conclusion that may be drawn from this analysis is that the term that captures spillovers overlaps with part of the variable that captures the inherent technology generation capacity of the economy, which prevents the possibility of its impact being estimated.

[TABLE 3]

In any case, the doubt still remains that part of the overlapping that takes place between both variables may be due to the fact that the stock of technological knowledge appears in both terms. We therefore repeated the same analysis but without considering the foreign technology absorptive capacity (columns 3 and 4 of table 3). The results continue to be the same, which allows us to affirm that spillovers have indeed had a positive impact on the TFP of the countries making up the OECD.

The procedure applied here will not offer one-off estimations of elasticity but it will allow us to know the intervals between which they vary. It will be those that lie between the values of the estimations in the model in which the variables are perfectly identified and those obtained from the residuals (table 4). Specifically, in the short-run these values range from 0.65% to 0.94% in the case of the stock of technological knowledge; and from 0% to 0.21% in that of spillovers. Long-run elasticities are somewhat higher, ranging from 0.78%-1.14% and 0%-0.26%, respectively.

[TABLE 4]

Finally, in order to get a closer look at what happened during the period analysed, we proceeded to perform a simple growth accounting exercise. Thus, in table 5 we show the intervals between which the contributions made by each of the factors considered to the growth of TFP during the period 1987-1999 would lie. The results indicate that, in the best of circumstances, the spillovers received by the OECD countries by way of FDI would have been directly responsible for practically 50% of the rise in TFP in the period, and indirectly for 12%. This therefore underlines their importance for growth.

[TABLE 5]

6. Conclusions.

In this study we make further headway in the knowledge of a fundamental question for economic growth: do the multinationals contribute to the growth of the recipient country by way of technology transfer? Although, a priori, the answer is affirmative (at least amongst the developed countries), in the studies found there is no consensus on the matter.

The basic aim was to try and find out what the causes are that have led to the fact that studies of the macroeconomic type, like the one conducted by Lichtenberg and Van Pottelsberghe (2001), do not find evidence of the existence of positive spillovers towards the recipient economies. This proves surprising, as the entry of firms whose productivity is higher than that of the local firms should raise the efficiency of the economy, a matter on which there is apparently a certain consensus judging by the review of the microeconomic studies.

For this purpose we started from a modified version of the model initially proposed by Benhabib and Spiegel (1994), which takes into account the dual role of the stock of technological knowledge: as a factor of both technology generation and absorption. The results point to a problem of overlapping between the variables employed in this type of analysis, irrespective of the measure used to detect the technology generation and absorptive capacity, which prevents the impact of technology spillovers on the growth of TFP being detected properly. By overcoming this problem, we obtain evidence that the dissemination of technology performed by the multinationals has had a significant impact on the increased efficiency of the recipient economies. In conclusion, it may be asserted that this phenomenon is responsible for up to 50% of the TFP growth in the OECD countries during the period 1987-1999.

APPENDIX

The variables included in this study and the sources used for their construction are set out below:

- Real Gross Domestic Product at market prices: calculated on the basis of OECD data: National Accounts. Volume I: Main Aggregates. For this purpose, 1990 was taken as the base year and it is expressed in dollars.

- Employment: obtained from the OECD publication: National Accounts. Volume I: Main Aggregates.

- Stock of physical capital: calculated from the accumulation of investment flows, according to the perpetual inventory method. The stock of initial capital refers to 1960, it is estimated by Harberger and Wisecarver's method (1977), using the gross fixed capital formation deflator as the price index. Lastly, the depreciation rates are taken from Beutel et al. (1992), Velázquez (1995) and EUROSTAT (1997). The series of Gross Fixed Capital Formation and its deflators are obtained from the OECD: National Accounts. Volume I. Main Aggregates.

- Stock of technological capital: constructed on the basis of the accumulation of R&D expenditures, using the perpetual inventory method and assuming a depreciation rate of 10%. The initial stock refers to 1973. The data used is taken from the OECD: Research and Development Expenditure in Industry; OECD: Basic Science and Technology Statistics; OECD: Main Science and Technology Indicators.

- Stock of human capital: calculated according to the methodology proposed in Martín et al. (2000). It is an indicator that takes into account the existence of quality differences between educational levels using expenditures per student:

$$H_t = \sum_{i=1}^{3} GPE_{i,1995} \cdot DUR_{i,t} \cdot PNE_{i,t}$$

where: $GPE_{i,1995}$ is the public and private expenditure per student at educational level i in relation to the total average cost of training of a university student in the European Union in 1995, considering all the educational levels that s/he has had to complete in order to obtain his/her degree.

$DUR_{i,t}$ is the duration of educational level i in year t.

$PNE_{i,t}$ is the percentage of population between 25 and 64 years of age that has completed educational level i in year t.

- Stock of technological knowledge: calculated as a combination of the stocks of human capital per worker (H) and technological capital per worker (TC). For this purpose, we have applied the principal components procedure to both variables expressed in logarithms. The result is:

$$T_{it} = H_{it}^{0.203} \cdot TC_{it}^{0.979}$$

- Stock of Foreign Direct Investment: obtained from the OECD publication: International Direct Investment Yearbook. Although it was occasionally necessary to use the flow to complete the series.

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Table 1. Estimation of the different approaches to explain TFP growth (1987-1999).

	1	2	3	4	5	6	7	8	9	10	11	12
TFP_{t-1}	0.20520**	0. 21170**	0.20619**	0.20439**	0.15226**	0.16802**	0.14952**	0.17612**	0.21464**	0.21561**	0.21024**	0.20779**
	(0.0875)	(0.0855)	(0.0874)	(0.0820)	(0.0754)	(0.0786)	(0.0727)	(0.0798)	(0.0872)	(0.0855)	(0.0876)	(0.0819)
T	0.00591***	0.00445**	0.00578***	0.00368**								
	(0.0021)	(0.0019)	(0.0021)	(0.0017)								
H					0.01378***	0.01359***	0.01379***	0.00807***				
					(0.0034)	(0.0033)	(0.0032)	(0.0029)				
TC									0.00560***	0.00466**	0.0060***	0.00387**
									(0.0021)	(0.0020)	(0.0022)	(0.0017)
T*S	-0.00061				-0.00188**				-0.00028			
	(0.0006)				(0.0008)				(0.0007)			
H*S		0.00048				-0.00199**				0.00051		
		(0.0009)				(0.0010)				(0.0009)		
TC*S			-0.00057				-0.00173**				-0.00051	
			(0.0007)				(0.0007)				(0.0007)	
S				0.00179*				0.00057				0.00179*
				(0.0010)				(0.0013)				(0.0010)
Sargan Test (degrees of freedom)	27.798 (135)	27.458 (135)	27.845 (135)	27.696 (135)	27.406 (135)	27.609 (135)	27.459 (135)	27.718 (135)	27.929 (135)	27.555 (135)	27.856 (135)	27.682 (135)
M1	-3.018***	-3.024***	-3.021***	-2.991***	-2.872***	-2.890***	-2.875***	-2.900***	-3.024***	-3.017***	-3.019***	-2.984***
M2	0.838	0.885	0.846	0.864	0.469	0.615	0.538	0.670	0.887	0.899	0.861	0.877

Note: standard errors in brackets. Confidence level: * 10%, ** 5%, *** 1%. M1 and M2 are tests for the lack of first-order and second-order serial correlation in the residuals.

Table 2. Estimation of the individual approaches to explain TFP growth (1987-1999).

	1	2	3	4	5	6	7
TFP_{t-1}	0.20130*** (0.0914)	0.15688** (0.0767)	0.20573** (0.0918)	0.20487*** (0.0964)	0.19502** (0.0951)	0.19154** (0.0938)	0.14912** (0. 0764)
T	0.00504*** (0.0015)						
H		0.01155*** (0.0028)					
TC			0.00532*** (0.0016)				
T*S				0.00124*** (0.0005)			
H*S					0.00224*** (0.0008)		
TC*S						0.00125** (0.0005)	
S							0.00367*** (0.0009)
Sargan Test (degrees of freedom)	26.988 (89)	27.876 (89)	26.878 (89)	27.949 (89)	27.841 (89)	27.962 (89)	27.773 (89)
M1	-3.022***	-2.897***	-3.019***	-3.139***	-3.098***	-3.138***	-3.028***
M2	0.813	0.521	0.831	0.862	0.782	0.857	0.714

Note: standard errors in brackets. Confidence level: * 10%, ** 5%, *** 1%. M1 and M2 are tests for the lack of first-order and second-order serial correlation in the residuals.

Table 3. Estimations of TFP growth considering the overlapping betweeen the explanatory variables (1987-1999).

	1	2	3	4
TFP_{t-1}	0.1692** (0.083)	0.1692** (0.083)	0.1650** (0.081)	0.1650** (0.081)
T		0.0064*** (0.002)		0.0059*** (0.002)
T*S	0.0021*** (0.001)			
S			0.0037*** (0.001)	
$\tilde{T}$	0.0072*** (0.002)		0.0052** (0.002)	
$\tilde{T} * \tilde{S}$		-0.0006 (0.001)		
$\tilde{S}$				0.0012 (0.001)
Sargan Test (degrees of freedom)	27.839 (129)	27.645 (129)	27.372 (129)	27.260 (129)
M1	-2.964	-2.964	-2.963	-2.963
M2	0.629	0.629	0.631	0.631
AUXILIARY REGRESION				
	Dependent variable			
	T	**T*S**	**T**	**S**
T		1.3347*** (0.109)		0.8421*** (0.058)
T*S	0.3760*** (0.033)			
S			0.4733*** (0.0047)	

Note: standard errors in brackets. Confidence level: * 10%, ** 5%, *** 1%. M1 and M2 are tests for the lack of first-order and second-order serial correlation in the residuals.

Table 4. Elasticities (in %).

	Short-run		Long-run	
	Regression (1)	Regression (2)	Regression (1)	Regression (2)
T	0.94	0.65	1.14	0.78
S	0.21	0.00	0.26	0.00

Table 5. Contribution to the growth of TFP (1987-1999).

Domestic stock of technological knowledge	**Without spillovers**	**39.76%-100%**	**51.36%-100%**
	Additional effect with spillovers	**0%-11.6%**	
Foreign capital stock		**0%-48.64%**	**0%-48.64%**

[1] See the survey made by De Mello (1997).

[2] Lichtenberg and Van Pottelsberghe (2001) for instance do not find evidence of spillovers transmitted by FDI among 22 OECD countries.

[3] There are other channels that have been considered in the literature, such as the technological payments made by countries, publications in scientific and technical journals, migrations of scientists or engineers, or merely technological proximity between countries.

[4] See the summaries of the literature by Mohnen (2001) and Keller (2002).

[5] See Haddad and Harrison (1993) for Moroccco; Aitken and Harrison (1999) for Venezuela; Djankov and Hoekman (2000) and Kinoshita (2000) for the Czech Republic; Branstetter (2001) for the United States and Japan; Girma and Wakelin (2001) and Haskel, Pereira and Slaughter (2002) for the United Kingdom.

[6] We have only been able to find two studies.

[7] Aitken and Harrison (1999) point out that this effect could continue to take place even if the multinational transferred technology to the local firms.

[8] Aitken and Harrison's study (1999) is produced for the case of Venezuela.

[9] See Martín and Jaumandreu (1998).

[10] A more detailed explanation of these modifications can be found in Crespo, Martín and Velázquez (2001).

[11] As shown by Wickens and Breusch (1988), these expressions offer the same value for the long-run coefficients which would be obtained by estimating the dynamic equation specified by using as the instruments the set of all the explanatory variables in the original equation.

[12] Obviously, when we refer to the stock of technological knowledge we do so in relative terms, i.e. the stock of technological knowledge per worker, as otherwise we

would have a distortion brought about by a size of country effect in this variable. Therefore, this variable reflects a country's technology generation and absorptive capacity.

[13] In this respect, authors like Jaffe (1986), Park (1995) or Branstetter (2001) employ measures of technological proximity between sectors or countries in accordance with the patents used.

[14] The explanation for this bias may be seen in Lichtenberg and Van Pottelsberghe (1998).

[15] The authors use an order 4 moving average to offset the strong variations exhibited by this variable over time.

[16] Something that possibly happens in our case as both the stock of technological knowledge and the term that captures the spillovers are fairly stable over time, as they have to do with stocks.

[17] Blundell and Bond (1999) analyse the virtues of the use of the GMM system in the estimation of Cobb-Douglas type production functions.

[18] The results offered are those referring to the one step estimators, so that we avoid the downward bias in the error which is incurred when using two step estimators (Blundell and Bond, 1999).

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