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Title: *"Technology and the generation of international knowledge spillovers. An application to Spanish manufacturing firms"*

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Abstract:

Technology is among firms ownership advantages explaining their internationalisation as, now for decades, the *eclectic* approach has highlighted. The debate about the positive *versus* negative effects that foreign capital generates in the host economy has gained a new relevance today insofar as, on the one hand, the concept of systems of innovation allows us to rethink the interaction with the domestic/recipient economies and, on the other, the increasing internationalisation of the technological activities of multinational companies (MNCs) introduces new forms of that interaction. Therefore, the possibility of generation of external effects by MNCs today demands a new reformulation of the problem.

In this vein, one of the strengthening aspects commonly underlined is that foreign knowledge, not completely appropriable by the foreign firms, may spill over into domestic firms. However, since the findings of the empirical evidence are not fully confirmatory of the hypothesis, and taking into account the new conditions, this essay attempts to offer new light with research about the Spanish manufacturing firms. Two main issues are focused on this analysis. First, the importance of dynamics in the assessment of technological spillovers motivated by foreign direct investment (FDI), which is possible thanks to the availability of a panel data for manufacturing firms in Spain in the period 1991-1999. Second, the importance that technology may have for the generation of spillovers and to what extent the Pavitt taxonomy of industries is still useful for in depth analysis of such a learning process.

1. Introduction

Economic literature has paid increasing attention to the assessment and better understanding of the consequences FDI has in the host economies. Traditionally, there have been three positive effects FDI brings to recipient countries: first, the importance of FDI as flows of capital capable of complementing domestic savings in order to guarantee the level demanded for the economic development; second, the capacity of FDI to balance the external accounts and, thirdly, the incorporation of more advanced technology embedded in foreign companies. What is more specific in the current debate is the incorporation of both the national system of innovation and the internationalisation of technology approaches.

The existence of potential positive effects from FDI inwards has motivated numerous efforts by governments to attract production and technological facilities from abroad or to create the adequate conditions to be able to attract them. Technological learning is thought to be among the aforementioned effects. This phenomenon has been mostly analysed over the assumption of the technological superiority of foreign firms, derived from the firms' advantages incorporated in the *eclectic paradigm* and mostly applied to less developed economies. Moreover, there has been some kind of tacit hypothesis about how knowledge incorporated in technology may be transferred to their domestic counterpart.

In order to test the relevance of such hypothesis, empirical exercises have been made to demonstrate to what extent domestic firms effectively may learn from the presence of foreign capital in manufacturing industries, emphasising what are the key factors which determine such a process. The results achieved differ notably among countries as well as regarding the data availability in terms of both industry breakdown and time dimension. Available evidence on the issue hardly permits us to observe that technological spillovers due to the presence of foreign capital in the industry always occur. For this reason, there is still room for new research questions which can help to clarify our understanding of the phenomenon. The new trend in the internationalisation of technology, consolidated in recent years (Archibugi & Michie, 1995; Patel & Pavitt, 2000; Cantwell & Janne, 2000), introduces a new dimension insofar as the innovative strategies of MNCs are changing and establishing new relations with the host economies.

The level of technological development of countries is thus one of the differentiating aspects, and the existence of absorptive capacities in the host economy is seen as a crucial element. The analysis of the Spanish manufacturing industries may be considered as an interesting case of intermediate country since its catching up process is also revealed in its investment development path (Dunning & Narula, 1996; Campa & Guillén, 1996). In fact, foreign capital has historically had an important role in the evolution of the manufacturing industries and their technological improvement (Molero, 2003). Then, different technological behaviour of foreign firms in relation to the domestic companies is expected when comparing developed economies than when the comparison is done between developed and purely underdeveloped countries.

The analysis of spillovers carried out in this paper is based on statistical information from the ESEE Survey -*Encuesta de Estrategias Empresariales*[1]-, with data at the firm level for 18 manufacturing sectors in Spain and for a nine-year time span, going from 1991 to 1999. A dynamic perspective when approaching the problem gains relevance in the understanding of the issue of learning from foreign firms. The ability of local firms to absorb external knowledge spilling over from foreign agents is path dependent, that is, determining their present performance, and far away from automatic and mimetic

[1] This is a survey conducted yearly by the Spanish Science and Technology Ministry among the manufacturing firms with more than 10 employees. The sample represents around 22 per cent of manufacturing employment, covering the total number of firms with more than 200 employees and it is representative of the smaller firms. Authors acknowledge to *Fundación Empresa Pública* the access to the data from that source.

results. To this point, the availability of micro data for a period of nine years to capture the individual behaviour across time permits a more complete assessment of the spillovers following such an approach.

Moreover, it can be established as hypothesis that knowledge may spill over among units on the basis of the technological content of the industries. This provides justification for the analysis of spillover by the use of a division of the firms' data according to their technological classification; -in this research we shall use the well known one of the OECD (1997) which gathers the sectors in three groups: low, medium and high technological content. A further reflection on this classification drives us to consider that each group differs from the other not only in global "quantity" of technology incorporated in the production but also in the "qualitative" or organisational aspects. In other words, some kind of parallelism can be explored with innovation patterns.

The paper is structured in four sections. Firstly, a brief outline of the most outstanding findings of this body of literature is given, highlighting what are the main empirical facts from previous works. Section two is devoted to the descriptive analysis of foreign firms in Spanish manufacturing industries, underlying what are their main technological characteristics which are divergent from domestic ones. Section three is devoted to the analysis of spillover, making use of panel data estimations and differentiating by the technology content. Finally, in section four the main concluding remarks are presented.

2. What do we know about knowledge spillover?

The inherent difficulties in the conceptual and methodological framework of technology transfer and spillovers give a notable value to the empirical works in this line, which contribute to a better understanding of the problem. One of the most interesting and controvertial questions about it is to what extent the potential positive effects occur thanks to the presence of foreign capital in industries. Most outstanding findings reveal at least three main forces which drive the existence of spillovers: a higher productivity level of foreign firms, which directly lead to productivity improvement in the industry, imitation of foreign technology –production and organisation- by the domestic firms and, even, the increase of efforts made by those local firms conducting activities of innovation in order to impede the "crowding out" effects due to efficiency differentials (Caves 1974; Blomstrom, 1989; Blomstrom & Kokko, 1998; Van Pottelbergh de la Pottery, 1997).

A methodological approach suitable to measure the existence of spillovers is based on the general conception of the importance of technological factors in the explanation of growth, through the decomposition of TFP. The idea is that there are external effects which also intervene among the explanatory factors of growth productivity at the industry level, together with the internal R&D capabilities of firms (Caballero & Lyons, 1990; Basu & Fernald, 1995). This is the basic assumption behind the exploration of the existence of technological spillovers; then, it is constructed around the role played by technology –in its broad sense- in the performance of firms. The fundamental ideas to be considered are shared by both, the new theory of growth framework, as well as the postulates of evolutionary economics.

Particularly, knowledge is not fully appropriable and, for this reason, external effects of spillovers may be expected and occur through different channels, such as technology transfer and interactive learning. Innovation may benefit others apart from the inventor and across countries through the transfer of technology which takes place mainly via the international trade interchanges, FDI operations and different ways of non-incorporated transfers, contributing to the reduction of the distance between countries (Verspagen, 1993; 1997). Among the conditions for the diffusion of technology we find the influence of technology in other sectors, which has to do with its level of penetration, the macro effects being higher the greater the impacts among industries (Freeman, 1991). Important enough is also the idea that imitation is not a cost-free activity but it requires previous investment even in the imitator firm in order to achieve returns from the technology developed by others, an aspect which brings us to consider the two existing faces of R&D (Nelson, 1968; Cohen & Levinthal, 1989). Finally, the tacit *versus* codified nature of knowledge is also of importance for the spillover assessment. The relative strength of each of these components introduces another element of possible difficulty for the transmission of knowledge among firms. In fact, the more tacit the technological knowledge is, the more complex and longer the learning process should be expected (Lundvall, 1998).

On the topic of international technology transfer, the effects that FDI generates in the local economies are one of the issues usually explored. From the empirical evidence, some results can be underlined. Two decades ago, pioneering analysis came to show the existence of positive spillovers in Canada (Caves, 1974) and Australian manufacturing (Globerman, 1979) as well as in Mexico (Blomstrom & Persson, 1983; Blomstrom & Wolf, 1994). Although spillovers were also found due to the activity of US multinationals in developed countries such as France, Germany, Japan and the UK (Nadiri, 1993), differences among industries seems to be crucial with the possibility even for negative spillovers (Cantwell, 1989).

Using firm panel data corresponding to the 1980's and the 1990's in the UK, the results came to confirm that FDI has influence on the competitive level of the local industry, technological distance being one of the determining factors (Cantwell, 1989; Perez, 1998). The technological capacities of domestic firms are found among the determinants for the occurrence of positive spillovers in British industries, the increase of competition being one of the most positive effects to encourage productivity levels (Liu et. al., 2000).

In developing countries, the distance to the world technological frontier and the huge variety of situations is found among those economies, reason why the kind of determinants for the generation of knowledge spillovers due to the presence of foreign capital in the manufacturing activities are much more heterogeneous. On the one hand, these are limited to certain industries, such as the Morocco manufacturing industries show (Haddan & Harrison, 1993), or to the export-oriented sectors in the Indonesian case (Blomstrom & Sjohölm, 1999). On the other hand, human capital seems to be especially important in Latin American countries, such as Uruguay and Argentina (Blomstrom, 1994; Narula & Marin, 2003), as well as due to location aspects in Venezuelan sectors (Aitken & Harrison, 1999). The capacity to absorb external knowledge as well as the availability of intangible assets are some of the key aspects found in the analysis of spillovers applied to some Central-Eastern European economies (Damijan, Knell,et al 2002).

3. Technological behaviour of foreign firms in the Spanish manufacturing industries. In what sense are there really superior?

The analysis of the technological spillovers is of interest for the Spanish case because of the traditional foreign technological dependence of the country (Sánchez, 1984, Molero, 1996, Buesa & Molero; 1998). The confirmation of the generation of learning effects on the domestic industry may give rise to a positive impact, which enable us to extract policy implications of reference for other economies with similar circumstances. Moreover, the technological dependence of the country is also revealed even now when examining the high amount of external technological payments (Sánchez, 2001). Nonetheless, the efficiency of that knowledge for economic competitiveness is today incomparable higher due to the important improvement experienced by the domestic absorptive capacities (Molero, 2003).

The reception of FDI flows has been explained in past decades by the macro stability of the country and has been largely conditioned by the catching up process and the reduction of the technology gap[2]. Moreover, FDI flows have been more likely in sectors with medium and high technological content. Although the weight of FDI in terms of its contribution to added value has not been equally distributed among industries, it should be noticed that the level of absolute penetration has been higher in industries technology-intensive. At the micro level, among other differences with domestic firms, MNCs in Spain are mainly focused on industries with high technological opportunities and give a greater importance to the external sources of knowledge, such as other firms, technological and research centres (Molero, 2000).

Making use of the data from the ESEE Survey, the importance of foreign owned firms is clear if we take into account that foreign capital is present in more than 20% of the manufacturing firms in Spain, representing more than 50% of the employment in manufacturing sectors[3]. Significant enough is the share of foreign owned firms on some of the performance variables, such as sales (67%), added value (60%) and exports (75%). It is also important to underline the role of foreign firm on research and development, which is more than half of the total business R&D financed activity. On the other hand, although there is not a uniform distribution of foreign firms across industries, there is a predominance of foreign firms in medium and high technological content activities. Particularly, in motor vehicles, chemicals and office machinery, foreign firms account for between 80% and 95% of employees. On the contrary, the presence of foreign

[2] It can be thought that although Spain is found among the countries with a low R&D effort, the foreign firms perform around 34 per cent of the total business R&D (see Molero & Álvarez, 2003). There is also a new role for technology in the competitiveness gains of the manufacturing sectors in the country, providing positive effects to reduce the gap, as the empirical evidence has shown (Sánchez & Vicens, 1994; Barcenilla & Lozano, 2003; Fonfría et al., 2000).
[3] In this work, a firm is considered as foreign when more than 10% of the capital assets of the company are owned by foreigners, criteria corresponding to the *V Manual of the International Monetary Fund*: to own more than 10 per cent of the company assets would manifest the aim of the establishment of a long term relationship.

owned firms usually is lesser in lower technological content industries, such as leather products, wood and wooden furniture.

Previous empirical evidence in this line confirms the technological superiority of the foreign firms analysed after the flows of FDI in the sixties and seventies, XX century, for which data were available from a Spanish Industrial Census in those decades (Molero, 2003). More recently, less accurate data have not permitted us to make a firm statement about that superiority in recent years. Therefore, it is important to carry out some statistical tests able to detect the dimensions in which the differences between foreigners and domestic are more evident in the generation and diffusion of technology. The existence of technological spillovers and to what extent these facilitate the learning process between the two groups of firms could depend on those differences. The information of the ESEE Survey allows for a descriptive analysis of the main technological and innovative features, this being of interest to observe whether there exist disparities, and to what extent they are, in the behaviour of both foreign and domestic firms in Spain.

The ESEE database has technological information referring to R&D activities, as well as to innovation performance and the acquisition of technology carried out by the firm. One of the aspects to understand the process of knowledge spilling among firms is related to the relative capacity of firms to obtain patents, either in the domestic market or in other countries[4]. One can think that the share of the number of patents permits to have an approximation of the potential generation of knowledge by the firms and its susceptibility to transfer. An index of relative technological activity (IRTA) is constructed in Table 1. It has been calculated for both domestic and foreign firms, differentiating by the place where the patents have been granted. Foreign firms present a higher propensity to patent in the total

[4] A limitation on data from ESEE is that international patents are aggregated and referred to those obtained abroad, being not possible to distinguish by type of patent (i.e. US or European Patent) which clearly would qualify the analysis.

number of industries high-technology-content, while domestic predominate over foreign ones in most of the medium and some low technological content.

> Table 1 about here . Index of Relative Technological Activity.

Two hypotheses can be established from the values obtained in such an indicator. On the one hand, considering patents as an indicator of technological activity and hence its possible transmission, there is a direct relationship between the values of the IRTA and the likelihood for the generation of knowledge spillovers from foreign units. On the other, assuming patents as a protection mechanism and then, as a measure of the appropriation of knowledge generated by firms, the higher the relative strength of foreign firms in patents, the lower the spillovers potential in that industry.

Moreover, it is of interest to know about the potential technological superiority shown by foreign companies over domestic ones, which concedes space for the hypothesis of spillovers. In order to test whether being a firm owned by foreign capital, totally or partially, induces differentiated technological behaviour, a single statistical discriminatory analysis has been made. It permits us to confirm the existence of different profiles when considering the technological content of industries, as can be seen in Table 2. A kind of common profile is found, since R&D expenditures incurred by firms and the patents granted abroad are the two key aspects which make one group diverge from the other regardless of their technological content. Additionally, innovation in processes is still an important variable to distinguish the behaviour of foreign and domestic firms in both high and low technology industries. Nonetheless, the differences between the two groups seem to be more explicit in the low-technology-content industries, in which the acquisition of technology realised by firms in these industries is still an element of differentiation.

Among some of the main arguments habitually used due to their interpretative power we find, on the one hand, that ownership advantages are mostly shown abroad by foreign firms technologically active in their foreign locations. This is dependent on the kind of strategy followed by the R&D activity of MNCs abroad, in relation to the home-base exploiting *versus* augmenting knowledge strategy (Kuemmerle, 1987). In this sense, there is also another aspect of interest which has to do with the relationship of the foreign investment and the existing level of technological development in the domestic economy. In fact, the level of autonomy of the subsidiary in order to carry out R&D activities in the foreign location, independently of the headquarter's guidelines, is normally underlined in order to understand the extent of the generation of knowledge spillovers (Sanna-Randaccio & Veugleurs, 2003).

> Table 2 about here. Technological differences between foreign and domestic firms

4. The role of technological content in the generation of spillovers in the Spanish manufacturing firms

Past evidence has shown that spillovers in Spanish manufacturing industries are not so obvious and they do not occur in such an easy way. In fact, different empirical exercises have come to confirm that technology acquisition embodied in intermediate and capital goods still maintains some power in the explanation of the learning process of domestic firms (Álvarez et al. 2002). The structure of markets, such as competition level as well as the particular level of firms' openness, are also some of the key aspects in the assessment of MNCs in local companies. Positive horizontal spillovers were found among the firms with higher absorptive capacities, these latter expressed more in their export behaviour than in their R&D activities (Barrios & Strobl, 2002). However, the ability of foreign firms in the manufacturing industries does not seem to affect the innovative strategies of domestic units (Merino & Salas, 1996; 2001). Then, horizontal spillovers caused by the presence of foreign capital in the industry are not totally clear in the Spanish manufacturing sectors, this being very important to underline the role played by the absorptive capacities of firms, as well as the way the generation and diffusion of technology take place.

Bearing in mind such results, the question addressed here is to what extent the technological content and the assumption of existing different innovation patterns might also reveal a different spillover map. The classification of manufacturing industries by technology followed in this paper is the already traditional and revised OECD division, which is built over the R&D effort of each sector as a share of its performance (OECD 1997). This criterion, generally accepted, permits to classify the firms into three different groups of industries: low, medium and high technological content because, as already said, some kind of parallelism can be explored with innovation patterns.

The question is whether knowledge spillovers may differ according to the industrial technological content, an aspect which would help us to make an approach to its relevance in the explanation of technology transfer. Although the intrinsic difficulties are explicit and it will deserve further exploration, a speculative attempt can be made: Among low technology sectors, basic and traditional industries are found, these are technologically dominated by the suppliers because, according to Pavitt taxonomy, the way firms in these industries carry out their technology generation takes place mainly by acquiring from others (Pavitt, 1984). In medium-tech sectors, a more heterogeneous group of industries is found, ranging from the automobile industry to rubber and editing industries, characterised by the presence of high scale economies industries as well as specialised suppliers, that is, industries which either acquire technology from others or perform their own R&D. Finally, those industries in the category of high technological content are those with an activity very much dependent on the scientific advances and in which scientific knowledge plays a key role in the development of new products and processes.

This diversity in the generation and acquisition of technology carried out by the different industries opens up the possibility of conceiving the existence of different patterns in the diffusion and transfer of technology. Particularly, it may be thought that in terms of the embodied technology acquired by the different companies in industries, which constitute one of the channels through knowledge may spill over among firms. In order to test to what extent the spillover effects differ according to the features of the technology, the sample of manufacturing firms has been divided into three different groups, replicating the same set of estimates for each group. The achievement of different results would provide a higher consistency to the hypothesis built on the role played by the technological characteristics of firms in the explanation of knowledge spillovers.

The equation, in its general specification for the estimation coming from an homogenous production function of degree r $(\alpha+\beta+\gamma \neq 1)$ allowing for non-constant returns of scale, is the following:

$$y_{it} = \alpha\, l_{it} + \beta\, k_{it} + \gamma n_{it} + \kappa z_{it} + \delta v_{it} + \varepsilon_{it} \qquad (1)$$

where single letters in equation (1) are expressive of logarithmic growth rates for productivity (y) and production factors –labour (l), capital (k) and materials (n)- and where "κ" is the coefficient corresponding to the external effects of spillover; δv_{it} represents individual and time effects, ε_{it} being a random error term. Subscript $_{it}$ refers to the firm i in period t.

The interest in the analysis will be, first of all, to capture the idea of the path dependence in the firms' learning processes. That is, absorbing external knowledge from others seems to be determined by their past behaviour, reason why a dynamic approach is defended. Secondly, the possibility of MNCs transferring technology and other organisation capabilities, either internally to the headquarters or to other subsidiaries in the same company, as well as externally to the industrial environment, to the domestic firms in that location, being this the main aspect to be explored in this paper. In this latter case, productivity improvements may be due to direct effects associated with changes occurring by a better use of the production inputs, as well as due to knowledge spillovers as such. These effects, when they happen between firms in direct competition, come to explain why horizontal technological spillovers occur.

An important aspect to be underlined has to do with the introduction of dynamic models in this kind of analysis, the reason why the estimation method should be adequate in this respect. The availability of panel data makes it possible to estimate the role played by the importance of the dynamics when understanding the learning process. As hypothesised, the time dimension may have implications in the achievement of different results, an element which is obvious when the results of both static and dynamic estimations are observed.

The model will be estimated first by making use of OLS as well as the *Within* estimators in the static version[5]. Secondly, the possibility of the estimation in a dynamic' version should require taking into account the inherent endogenous structure of the model. In that case, the dependent variable, present and lagged, may be correlated with the independent variables –inputs-, that is, past results may determine the demand of inputs in the present moment. This problem of simultaneity can be explicitly controlled by the increasingly advanced estimation methods, as will be seen later on. The idea is to test to what extent the changes in the variables affect the variation in the firms' results, as well as to eliminate the non-observable individual effects, the reason why the *generalised moments*

[5] Panel has been estimated making use of the *Within* estimator, in which deviations to the mean are taking - OLS is a biased estimator with panel data due to the potential correlation of the independent variables with the individual effects (Hsiao, 1986; Baltagi, 1995)-.

method(GMM) is applied, making use of the explanatory variables lagged one year as instruments which have the feature of not being correlated with the individual effects (Arellano & Bond, 1991; 1998; Arellano & Bover, 1995).

Two aspects, dealing with the existence of fixed effects, as well as the endogenous structure of the model or the predetermined relationship among the variables, are treated in the analysis through the introduction of lagged instrumental variables. If notable differences exist between the two methods, some dynamics characteristics may be confirmed in the nature of knowledge spillovers.

Equation (1) is translated to (2) for estimation purposes where, in addition to the role of production factors, horizontal spillovers are explicitly included among explanatory variables –noted by HS-, as well as the share of foreign capital in firms´ assets –FORCAP-. This last variable tries to capture to what extent the majority of foreign capital may be determinant of the external effects and firms' learning abilities. Also time and industry dummies have been included in order to consider other macro impacts not explicitly controlled in the estimation[6].

$$\log y_{it} = b_{it} + \alpha \log l_{it} + \beta \log k_{it} + \gamma \log n_{it} + \text{ê} HS_{jt} + \text{ì} FORCAP_{it} + \\ + \text{ç}\, d_j + \text{õ}\, d_t + \text{å}_{it} \qquad (2)$$

The main findings introducing the technological content perspective after having broken the sample of firms into three groups are summarised in Table 3, being complete results from the estimation in Annex II. They are as follow: Regarding low technology sectors, horizontal spillovers are shown in both the static and the dynamic approaches[7]. By contrast, the share of foreign capital in the firms' assets does not affect the level of the external dissemination of efficiency improvements. Furthermore, the industrial effects approached through industry' dummy variables do not manifest any deviation from that general tendency; an

[6] Precise definitions of variables are found in the Annex I.
[7] When two lags are considered, a higher coefficient has been obtained.

homogeneous behaviour existing throughout the industries in this group. It is important to bear in mind other features of those sectors, in order to achieve a better assessment and their implications. Thus, a first characteristic is that low technology industries are those in which the internationalisation of technological strategies by MNCs reach the higher levels; this process is basically driven by demand factors, being most of those technological activities being part of the support to production activities of the firms (Patel, 1995).

Secondly, these sectors mostly present a higher level of domestic competition in the Spanish market, as well as the existence of fewer barriers to entry (Buesa & Molero, 1998), aspects which suggest the importance of taking advantage of foreign firms know-how through a "learning by competing" process. Another factor to consider is the high relative weight of low-tech sectors in the Spanish economy –around 41 per cent of the manufacturing added value during the 90's, while in the four largest European countries, they only add up to less than one third. According to the historical evolution of the Spanish industry, these sectors have experienced a noticeable process of catching up with foreign firms which is confirmed by the indicator previously mentioned and reported in Table 1: According to this, in many of these industries the technological performance in terms of patents granted is higher in domestic than for foreign firms. On this basis, we can argue that this technological proximity has facilitated the spilling over of knowledge –reaffirming a *virtuous circles* hypothesis (Cantwell, 1989)- that, on the other hand, has a much more broad internationalised spread and is less controlled by the firm' headquarters.

The situation in the high-tech group is precisely the opposite to the one just commented. First of all, no kind of horizontal spillovers have been found, nor in the static neither in the dynamic version of the analysis. Nevertheless, there are some impacts time lagged on firms highly controlled by MNCs. It is important to highlight that it is in this kind of sectors where the lowest level of internationalisation in the technological strategies of MNCs is shown. On the other hand, these industries have experienced a weaker level of development in Spain, having not been able to reduce significantly the competitive and technological distance with the international leaders. Again, a look at the last column of Table 1 can confirm the remarkable technological superiority of MNCs over Spanish enterprises in this kind of industries, -proxied by their patent propensity.

Interesting enough is the fact that industrial dummies allow us to underline the existence of at least one industry –electrical material and components, including machinery- whose behaviour is along the lines of higher externalities effect than the other industries in this group. Although with certain reservations, this sector is the one in which the technological content is among the lowest within high-tech. Furthermore, this is a sector which could be more adequately identified as a "specialised suppliers" type, according to the Pavitt typology of industries, while the others belong more to the "science-based" one. On the other hand, following the investment development path model, the situation of these high-tech firms confirms the position of the Spanish manufacturing industries, characterised by a greater capacity of competition in most of the sectors except in those with a high technological complexity. That technological distance makes the consolidation of the spillover processes more difficult. Another additional argument to the findings is related to a highest use of the mechanisms of knowledge protection in at least some of these industries, the transmission of it then being more difficult; as such, learning from others may be a more complex process in more science oriented industries.

Habitually, the medium technology industries show a kind of hybrid situation. On the one hand, static horizontal spillovers are found among those firms, although not confirmed in the dynamic perspective. Then, this group shares the pattern of spillover generation with both, low and high tech respectively, since there is a coincidence of the findings with each group. In the same manner, when considering the effects that the presence of foreign capital in the firms' assets has, it seems to gain relevance in a dynamic perspective, only when that foreign capital is present in the industry for a time span: a higher capital portion would increase the likelihood for knowledge spillovers. Those horizontal external effects are related to the technological capabilities of Spanish firms; the good technological performance of domestic firms is an aspect also shown by the IRTA values, the hypothesis of catching up and conceding space to foreign firms to learn from domestic ones being plausible [8].

Important enough is the particular behaviour of the "wood products" industry. According to the significance and sign of the dummy corresponding to this sector, it can be said that the external effects of learning in domestic firms are more intense than in the others. Considering the fact that this industry is the one with the lowest technology content inside the group, the tendency of the lower the technology content of the sector –and then the higher the catch up potential-, the greater the likelihood of spillovers is confirmed in this case. This is an aspect which is also related to the relative technological distance between Spanish and foreign firms and the remarkable gains on commercial advantage of the Spanish economy in those sectors (Alonso & Donoso, 1999), achieving a certain international specialisation –the example of vehicles is perhaps the most significant.

In synthesis, our basic hypothesis finds reasonable support on this empirical research. Firs of all, spillovers do happen and constitute a non-negligible way of upgrading the technological capacities and productivity of the Spanish manufacturing firms. There are some very significant differences among industries, an aspect which allows us to defend the argument built over the role of technology in the explanation of knowledge spillovers in favour of local firms. In fact, technological proximity appears as a critical element to stimulate externalities; thus, in those industries where the experience has consolidated a

[8] It should be noted that the HS variable adopts a negative and significant value in the dynamic estimation using two lags, at the 95% level of confidence –in Annex II-.

Spanish competitive background and a substantial catching-up process, spillovers are much more general: Historically, industries with low or medium technological content. On the contrary, the higher the technological level of the industries, the greater the distance between Spanish and MNCs, which provide a worse scenario for learning and catching-up. The weakness of those sectors is also confirmed by their relative lower development, as compared to the most industrialised European countries. Only those firms with a higher and more consolidated presence of foreign capital are more likely to generate and absorb positive knowledge spillovers.

5. Concluding remarks

Although it can be accepted that the measures to approach the phenomena of knowledge diffusion towards other agents different from the creator are still imperfect, attempts are being made in recent Economics literature to achieve a more subtle appreciation of the issue. In the present increasing globalisation of markets and production activities, one of the tasks of governments is to be able to attract foreign activities which generate not only added value and employment but also to spread the level of knowledge in the economy. This is especially important for economies falling behind the technological frontier since the establishment of foreign technologically superior companies in those territories may contribute to close the gap. Moreover the past evidence on the spillovers analysis, the hypothesis set out in this paper is that technology may be considered one of the determinants for the generation of external effects of knowledge transfer between foreign and domestic firms geographically close.

The findings for low technological content industries come to show that FDI induces greater positive effects on domestic firms the higher the absorptive capacities and the smaller the technological gap with the foreigners, reaffirming the existence of virtuous circles in the Spanish manufacturing industries. On the contrary, foreign firms in industries classified as high technological content still show a certain technological superiority over the domestic ones, making more difficult the knowledge transfer to the local agents via spillovers. The level of technology internationalisation in this type of industries is also behind the explanation. Although their patent propensity is higher in both international and domestic markets, this fact should be indicative of a greater protection since no knowledge spillovers among firms are found in this segment.

Then, two facts have a relatively important strength in the explanation of knowledge transfer from foreign capital: on the one hand, the technological cataching up experienced by these sectors in the last decades; on the other, their improvement regarding competitiveness advantages in manufacturing industries in Spain. Both ideas come to concede a special role to the relevance of technological features and the distance existing between domestic and foreign agents to define the learning processes.

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Table 1. Index of Relative Technological Activitiy –IRTA-

Industries according to technological content	***Patents abroad***		***Patents in Spain***		
	IRTA(1) doméstic firms	***IRTA foreign firms***	***IRTA(1) doméstic firms***	***IRTA foreign firms***	
Low					
Basic Metals	0	3,8382	0	2,4035	F
Mineral products, non-metal	0,9016	1,2794	0,856	1,2018	F
Metal products	0,2359	3,1686	0,971	1,0413	F
Meat and meat products	0	0	0	0	-
Food and tobacco	1,3141	0,1086	1,468	0,3435	D
Beverages	1,3523	0	1,658	0,0768	D
Textiles	0,3121	2,9518	1,216	0,6968	f
Leather Products	1,3523	0	0	0	d
Pulp and products	1,3523	0	1,389	0,4542	D
Medium					
Machinery and equipments	0,5004	2,4181	0,612	1,5451	F
Motor vehicles	1,2103	0,4032	1,371	0,4790	D
Other transport equipment	1,3523	0	1,712	0	D
Wood products	1,3523	0	1,712	0	D
Plastic and rubber products	1,2941	0,1653	1,702	0,0148	D
High					
Chemistry and chemical products	1,1808	0,4867	0,766	1,3282	f
Office Machinery and Computers	0,1678	3,3620	0,212	2,1054	F
Electric material and components	0,0780	3,6167	0,780	1,3084	F
Other manufacturing	1,0835	0,7630	0,125	2,2282	f
Total	1	1	1	1	

(F) Higher propensity to patent in foreign firms
(f) Higher propensity to patent in foreign firms in one kind of patent at least
(D) Higher propensity to patent in domestic firms
(d) Higher propensity to patent in domestic firms in one kind of patent at least

(1) $IRTA_h = \dfrac{\Sigma_i P_{hj}}{\Sigma_{hij} P_{hij}}$

where: "P" is the number of patents, "h" the kind of patent, "i" the industry, and "j" the nationality of the firm, either domestic or foreign.

Table 2. Technological differences between foreign and domestic firms according to technological content

Variable	***High tech content***	***Médium Tech content***	***Low Tech content***
R&D Expenditures	0.77**	0.77**	0.62**
Patents in Spain	n.s.	n.s.	n.s.
Patents abroad	0.39*	0.51**	0.58**
Product Innovations	n.s.	n.s.	n.s.
Process' Innovation	0.43*	n.s.	0.44*
R&D Public Funds	n.s.	n.s.	n.s.
Licence Fee Revenues	n.s.	n.s.	0.41*
Licence Fee Payments	n.s.	n.s.	0.45*
Chi-squared	17.85	19.52	25.4
Cases rightly classified (%)	93.4	94.2	93.9
Number of observations	257	451	928
Wilks' Lambda	0.93	0.97	0.97

(**) Significant at the 99% confidence level
(*) Significant at the 95% confidence level
(n.s.) Not significant

Table 3. Horizontal spillovers in the Spanish manufacturing industries, according to the technological content

	Static		*Dynamics*	
Low Tech	Positive HS	Foreign capital non-significant	Positive HS	Foreign capital non-significant
Medium Tech	Positive HS	Foreign capital effect is negative	HS non-significant	Foreign capital non-significant with the exception of 2 lags, positive
High Tech	HS non-significant	Foreign capital non-significant	HS non-significant	Foreign capital non significant with the exception of 2 lags, positive

Source: own elaboration

ANNEX I. Definition of the variables

Variable	Description
$logy_{it}$	Logarithmic variation of sales, firm i
$logl_{it}$	Logarithmic variation of the total number of employees, firm i
$logk_{it}$	Logarithmic variation on the capital stock according to the accounting method, firm i
$logn_{it}$	Logarithmic variation of material purchases, firm I
HS_{jt}	Share of total sales in industry j by foreign owned firms
$FORCAP_{it}$	Share of foreign capital present in the assets of firm i

Note: All the monetary variables have been deflated making use of a specific prices index built on the basis of the information about prices changes contained in the ESEE Survey.

Annex II. Estimations Results

Results for Low Technology industries

	OLS	*WITHIN*	*GMM*	*GMM (-1)*	*GMM (-2)*
Log l	0.62	0.85	0.32		
	(19.9)	(17.1)	(7.22)		
Log l(-1)				0.28	
				(4.94)	
Log l(-2)					0.24
					(5.66)
Log k	0.03	0.084	0.15		
	(1.66)	(3.51)	(6.92)		
Log k(-1)				0.13	
				(3.84)	
Log k (-2)					0.16
					(6.06)
Logn	0.99	0.70	1.17		
	(21.0)	(4.62)	(27.2)		
Log n (-1)				1.20	
				(17.3)	
Log n (-2)					1.02
					(14.7)
Hs	0.005	0.005	0.004		
	(3.73)	(2.15)	(3.60)		
Hs (-1)				0.003	
				(1.35)	
Hs (-2)					0.006
					(2.64)
Forcap	-0.001	-0.004	-0.0005		
	(-1.48)	(-1.15)	(-0.72)		
Forcap (-1)				-0.0004	
				(-0.25)	
Forcap (-2)					-0.001
					(-0.84)
Constant	5.00	--	3.58	3.97	4.81
	(22.4)		(21.2)	(9.43)	(11.1)
Time Dummy	Yes	Yes	Yes	Yes	Yes
Industry Dummies[(1)]	Yes	Yes	Yes	Yes	Yes
R2	0.81	0.39	0.10	0.21	0.29
Sargan Test			20.41	3.75	6.72
			(0.00)	(0.04)	(0.00)
Num of Observations	3825	3345	2118	1306	1487

(1)For simplicity, industry dummies are only reported when significant coefficients are obtained. Full results may be requested to the authors

Results for Medium Technology content

	OLS	*WITHIN*	*GMM*	*GMM (-1)*	*GMM (-2)*
Log l	0.65	0.64	0.46		
	(7.12)	(6.05)	(4.50)		
Log l(-1)				0.25	
				(641)	
Log l(-2)					0.18
					(2.71)
Log k	0.02	0.02	0.009		
	(0.06)	(0.38)	(0.25)		
Log k(-1)				0.15	
				(4.68)	
Log k (-2)					0.24
					(4.96)
Logn	1.00	0.88	1.34		
	(7.02)	(3.67)	(7.90)		
Log n (-1)				0.18	
				(9.13)	
Log n (-2)					0.89
					(6.60)
Hs	0.07	0.02	0.0009		
	(1.46)	(2.32)	(0.38)		
Hs (-1)				0.0001	
				(0.02)	
Hs (-2)					-0.008
					(-1.76)
Forcap	-0.005	-0.01	0.0004		
	(-1.17)	(-2.25)	(0.22)		
Forcap (-1)				0.001	
				(0.53)	
Forcap (-2)					0.008
					(2.30)
Constant	5.19	--	3.97	3.99	0.74
	(9.39)		(7.47)	(10.8)	(1.25)
Time Dummy	Yes	Yes	Yes	Yes	Yes
Industry Dummies(1)	Yes	Yes	Yes	Yes	Yes
G15Wood and wooden furnitures	-0.13	--	-0.14	-0.22	
	(-2.02)		(-3.65)	(-3.93)	
R2	0.73	0.31	0.10	0.12	0.25
Sargan Test			26.40	8.33	0.10
			(0.00)	(0.00)	(0.74)
Num of Observations	1840	1676	1057	1074	728

(1) For simplicity, industry dummies are only reported when significant coefficients are obtained. Full results may be requested to the authors

Results for High Technology content

	OLS	*WITH*	*GMM*	*GMM (-1)*	*GMM (-2)*
Log l	0.46	0.57	0.35		
	(3.97)	(3.85)	(9.87)		
Log l(-1)				0.17	
				(2.36)	
Log l(-2)					0.20
					(4.76)
Log k	0.17	0.28	0.11		
	(3.08)	(2.60)	(3.97)		
Log k(-1)				0.18	
				(4.23)	
Log k (-2)					0.20
					(5.14)
Logn	0.90	-0.13	0.99		
	(7.36)	(-0.44)	(12.0)		
Log n (-1)				0.96	
				(7.05)	
Log n (-2)					1.23
					(10.8)
Hs	0.005	0.007	0.0001		
	(0.86)	(0.67)	(0.05)		
Hs (-1)				-0.01	
				(-1.39)	
Hs (-2)					-0.005
					(-1.74)
Forcap	-0.004	-0.01	0.0003		
	(-0.79)	(-1.33)	(0.41)		
Forcap (-1)				0.008	
				(1.49)	
Forcap (-2)					0.004
					(2.17)
Constant	4.73	--	3.72	3.21	3.67
	(8.26)		(15.8)	(8.11)	(11.4)
Time Dummy	Yes	Yes	Yes	Yes	Yes
Industry Dummies (1)	Yes	Yes	Yes	Yes	Yes
G7 Electrical mat and comp.	-0.34	--	-0.19	-0.12	-0.16
	(-3.38)		(-6.19)	(-1.94)	(-2.47)
R2	0.66	0.30	0.08	0.10	0.10
Sargan Test			5.96	5.17	22.52
			(0.00)	(0.00)	(0.00)
Observations	1370	1229	1115	496	500

(1) For simplicity, industry dummies are only reported when significant coefficients are obtained. Full results may be requested to the authors