Assessing the Impact of Foreign Direct Investment on Domestic Manufacturing Firms' Productivity: A Database for Portugal

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30 September 2017

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ABSTRACT

The lack of a database that integrates a significant number of the variables necessary to empirically investigate the existence of externalities from FDI in Portugal represents an important limitation in this area. This paper presents a new balanced panel dataset with a total of 5,045 manufacturing firms (domestic and foreign) for the period 1995-2007. We use multiple imputation in Stata 13.0 to construct a large dataset containing several indicators taken from AMADEUS, *Quadros do Pessoal*, EU Klems and OCDE databases, that allow us to congregate variables that measure three dimensions: total factor productivity; foreign presence and factors that may influence the productivity of domestic firms, such as indicators of firm efficiency and R&D activities. Our panel dataset provides a set of useful 15 indicators for the analysis of externalities from FDI in 4,685 domestic manufacturing firms. We perform correlation analysis by technological groups based on Pavitt's Taxonomy. Results indicate that the foreign presence is positively and significantly correlated with the TFP growth. Moreover, the sign and magnitude of the coefficients for the control variables indicate that concentration, the stock of foreign knowledge and the technological gap potentially assist the TFP growth of domestic firms, but only in some technological groups.

Keywords: firm-level data, productivity, FDI Externalities, Portugal
JEL classification: F2, O3

1. INTRODUCTION

Since the 1990's, globalisation has mainly taken place through trade in goods and capital flows, with special emphasis on foreign direct investment (FDI). The tremendous growth in FDI flows is one of the most powerful causes of globalization. In 1982, the total global FDI flows amounted to $57 billion and, in 2014, reached $1.2 trillion (UNCTAD, 2015). In 2016, global flows of FDI were $1.75 trillion and UNCTAD predicts a modest recover for 2017–2018 (UNCTAD, 2017).

FDI exercises direct and indirect effects on host economies. The indirect effects consist of externalities which are appropriated by domestic firms without payment to the MNC. Accordingly, in the last two decades there have been important developments in terms of the empirical and theoretical literature on the impact of externalities from FDI on the productivity of domestic firms. However, the empirical evidence for Portugal is scarce and characterized by the use of different databases/data sources, variables and methodologies.

Our database is intended to be used in panel studies at the firm-level. There are several reasons for using panel data with this level of disaggregation. Firm-level data make possible to understand, on one hand, how strategies, technological competences or entry modes of MNCs impact in host economies and, on the other hand, how domestic firms characteristics, namely through efficiency measures, permit them to cope with foreign knowledge and technology (Harris, 2009; Giroud, 2011). Panel data allows controlling for firm fixed effects and time effects.[1] Furthermore, our time span is thirteen years, allowing for the study of dynamic effects, which is crucial since externalities from FDI need time to materialize.

Panel studies performed at firm-level for Portugal include Proença et al. (2002, 2006) and Crespo et al. (2012). However, the authors attain different conclusions concerning the occurrence of horizontal externalities.[2] The first study does not find significant externalities; while the second finds positive externalities and the last finds negative

[1] Firm fixed effects are used to ensure that MNCs' investment decisions are based on initial firm conditions that do not change over time. This approach helps to reduce the possibility of reverse causality, i.e, that the positive relationship between FDI and the productivity of domestic firms is because MNCs invest in the domestic firms with higher productivity. Moreover, year dummies prevent the situation where a positive relationship between foreign presence and the productivity of domestic firms is spurious, i.e, a mere consequence of business cycle forces.

[2] Horizontal externalities occur when the entry of the MNC generates positive externalities for local competitors.

externalities. One of the reasons for these different results may be the fact that the authors use different databases. Indeed, Proença et al. (2002, 2006) used data from Dun & Bradstreet and Crespo et al. (2012) used both Dun & Bradstreet and *Quadros do Pessoal* databases. Furthermore, with the exception of Crespo et al. (2009, 2012), the authors do not investigate the existence of vertical externalities.[3] Nevertheless, Crespo et al. (2012) find that the occurrence of externalities via backward linkages is conditioned on the existence of geographical proximity between foreign and domestic firms; and the authors do not find any significant evidence supporting the existence of externalities via forward linkages. [4,5]

Hence, to this date, research findings are far from sound and consensual concerning the existence and magnitude of firm-level externalities from FDI in the Portuguese manufacturing sector. One of the reasons may be that all previous attempts relied on incomplete and inconsistent databases to estimate externalities from FDI. For example, *Quadros do Pessoal* does not possess financial variables such as tangible and intangible assets that we use to proxy for physical capital and R&D expenditures. Thus, the lack of harmonised and detailed data deprived these studies of a robust and appropriate tool to assess the benefits of FDI on the Portuguese economy. We fill this gap by providing a balanced panel database with a significant number of the variables that we believe are needed to more throroughly empirically analyze the existence of externalities from FDI that can have an impact on the productivity of Portuguese manufacturing firms.

Our main data source is the AMADEUS database. Data from AMADEUS is compiled by the Bureau van Dijk Electronic Publishing (BvD). The dataset has financial accounting information from detailed harmonized balance-sheets of firms and their investors. It also provides the amount of foreign investment. This dataset is different from other datasets used by Portuguese researchers. Fundamental advantages include the detailed ownership information provided and the financial information from balance-sheets.

This paper is organized as follows. Section 2 describes the empirical model to analyze the existence of externalities from FDI at the firm-level, in order to identify the variables needed in the database, their relationship and the expected sign. Section 3 describes

[3] Vertical externalities occur when the linkages between MNCs and their local suppliers/customers (backward/forward linkages) generate positive externalities.
[4] Contacts between domestic suppliers of intermediate inputs and their multinational clients in downstream sectors.
[5] Contacts between foreign suppliers of intermediate inputs and their domestic clients in upstream sectors.

the construction of our database. Section 4 analyzes the findings on the correlation between the variables by technological groups of industries and Section 5 concludes.

2. EMPIRICAL MODEL

In this section, we start by describing the steps necessary to quantify the dependent variable and then identify the independent variables, in particular those related to foreign presence.

Departing from a cobb-douglas type of equation:

$$Y_{ijt} = A_{ijt} K_{ijt}^{\beta k} L_{ijt}^{\beta l} M_{ijt}^{\beta m} \tag{1}$$

where Y_{ijt} represents physical output of firm i in sector j and period t, K_{ijt}, L_{ijt} and M_{ijt} are the inputs of capital, labour and materials, respectively. A_{ijt} is the Hicksian neutral efficiency level (our concept of total factor productivity – TFP) of firm i in period t. For a given level of A, higher output levels demand higher inputs (K, L and M) levels.

We assume that $L = L^P + L^{NP}$, where where L^P stands for production workers (unskilled) labour and L^{NP} stands for non-production workers (skilled) labour. We proxy L^{NP} by the sectoral average of years of schooling since we do not possess information for individual firms.

Although we can observe Y_{ijt}, K_{ijt}, L_{ijt} and M_{ijt}, A_{ijt} is not observable and hence, needs to be estimated.

The estimation of A_{ijt}, depends on several different components such as skills, knowledge and firm-level capabilities, including managerial and organisational competences. We assume that A_{ijt} or TFP in logs is given by:

$$\ln(A_{ijt}) = \beta_0 + \varepsilon_{ijt} \tag{2}$$

where β_0 measures the mean efficiency level across firms over time; ε_{ijt} is the time- and producer-specific deviation from that mean.

Taking natural logs of (1) and inserting equation (2) we obtain a linear production function

$$y_{ijt} = \beta_0 + \beta_k k_{ijt} + \beta_{lP} l^P_{ijt} + \beta_{lNP} l^{NP}_{ijt} + \beta_m m_{ijt} + \varepsilon_{ijt} \tag{3}$$

where lower cases refer to natural logarithms. The error term ε_{ijt} can be further decomposed into an observable (or at least predictable); and an unobservable i.i.d. component, representing unexpected deviations from the mean due to measurement error, unexpected delays or other external circumstances, i.e, $\varepsilon_{ijt} = v_{ij} + u^q_{ijt}$. Hence, equation (3) becomes

$$y_{ijt} = \beta_0 + \beta_k k_{ijt} + \beta_{lP} l^P_{ijt} + \beta_{lNP} l^{NP}_{ijt} + \beta_m m_{ijt} + v_{ijt} + u^q_{ijt} \quad (4)$$

Since the firm-level productivity is $tfp_{ijt} = \beta_0 + v_{ijt}$ and rearranging the terms, we obtain[6]

$$tfp_{ijt} = y_{ijt} - (\beta_k k_{ijt} + \beta_{lP} l^P_{ijt} + \beta_{lNP} l^{NP}_{ijt} + \beta_m m_{ijt}) - u^q_{ijt} \quad (5)$$

And the estimated productivity is

$$\hat{tfp} = tfp_{ijt} + u^q_{ijt} \quad (6)$$

This empirical model allows us to address the simultaneity bias that occurs in the estimation of TFP, when unobserved productivity or TFP shocks, *i, j* and *t*, are correlated to the choice of inputs. Since the Olley-Pakes (1996) and Levinsohn-Petrin (LP) (2003) techniques, while controlling for the simultaneity bias, suffer from collinearity problems, Ackerberg et al. (2007) and, later, Wooldridge (2009) suggested modifications to the original LP approach aiming to correct the collinearity issue.

Defining the value added as $va_{ijt} = y_{ijt} - \beta_m m_{ijt}$, then it can be estimated through equation (4) as a residual

$$\hat{tfp}_{ijt} = va_{ijt} - (\hat{\varepsilon}^v_{jP}\, l^P_{ijt} + \hat{\varepsilon}^v_{jNP}\, l^{NP}_{ijt} + \hat{\varepsilon}^v_{jK}\, k_{ijt}) \quad (7)$$

[6] The productivity term is identified assuming that tfp_{ijt} is a state variable in the firm's decision problem (i.e. it is a determinant of both firm selection and input demand decisions), although u^q_{ijt} is either the measurement error or a non-predictable productivity shock (Olley and Pakes, 1996).

As described in section 2 of chapter 1, the literature on International Technology Diffusion has emphasized three channels for technology transfer: international trade of intermediate goods, international dissemination of the results of research and development (R&D) and FDI (Keller, 2004). In this theoretical framework, externalities from FDI (regarded as a set of intangible assets, codified and tacit knowledge and technologies) may have an impact on long-term growth (Romer, 1986, Lucas, 1988, Grossman and Helpman, 1991). The size of the impact of FDI depends on the degree of which the technology transfer to domestic firms leads to increasing returns in domestic production, via TFP growth.

Accordingly, and following the studies reviewed in section 4.2 of chapter 1, where the estimating equation [see equation (I.8)] assumes that increases in levels of FDI can lead to long-term changes in the TFP, our model corresponds to a production function augmented by foreign presence and control variables, as well as interaction variables

$$d\hat{tfp}_{ijt} = \beta_0 + \beta_1 \hat{tfp}_{ij(t-1)} + \beta_2 \sum_{m=0}^{2} f_{j(t-m)} + \beta_3 (f_{jt} * hfd_{ijt}) + \beta_4 (f_{jt} * rd_{ijt}) + \beta_5 (f_{jt} * mrdf_{jt}) +$$
$$\beta_6 (f_{jt} * s_{ijt}) + \beta_7 (f_{jt} * kl_{ijt}) + \beta_8 (f_{jt} * tg_{ijt}) + \beta_9 hfd_{ijt} + \beta_{10} rd_{ijt} + \beta_{11} mrdf_{jt} + \beta_{12} ds_{ijt} + \quad (8)$$
$$\beta_{13} tg_{ijt} + \beta_{14} kl_{ijt} + \gamma_t + \mu_{it}$$

Where the lowercases denote variables in logarithms and *f* is the measure of foreign presence (*hor, back* and *for*). We also include year dummies γ_t that account for possible changes in the growth of TFP due to stochastic shocks at firm or sectoral level over time and an error term μ_{it}. Our model (8) follows the models of technology diffusion.

The TFP growth is assumed to depend on three sets of variables; variables that measure the foreign presence; interaction terms; and control variables, within a fixed effects dynamic model, including a time trend. These sets of variables are described as follows.

Variables related to foreign presence

Externalities from FDI may be horizontal or vertical. Horizontal externalities occur when the entry of the MNC generates positive externalities for local competitors. Vertical externalities occur when the links between MNCs and their local suppliers/customers (backward/forward linkages) generate positive externalities. Hence, we measure the foreign presence through three variables *hor, back* and *for* defined at sectoral level. Horizontal technology transfer occurs through contacts with local competitors (via demonstration/imitation, labour mobility, exports, competition, consulting and specialized services and coordination with local institutions). *hor* is a sectoral externality variable that measures the share of output by foreign firms in the total output of the industry, i.e, measures the presence of FDI on a given industry and is calculated in the following way[7]

$$hor_{jt} = \sum_{i} foutput_{it} \Big/ \sum_{i \in j} output_{it} \tag{9}$$

where $foutput_{it}$ is the output of firms with foreign capital operating in industry j at time t. Thus the value of the variable increases with the output of foreign firms.

Hirschman (1958) stated that lack of linkages in the developing economy leads to lack of industrial development. From a developmental perspective, it is generally assumed that linkages between MNCs and domestic firms are better than no linkages, and the more and deeper linkages are, the better it is for the host economy (Altenburg, 2001; Scott-Kennel and Enderwick, 2004).

MNCs in other industries appeared to foster broad linkages in the host economy by creating industries that supply the MNC and by inducing forward industries to use the multinational's output as inputs, the crowding-in effect of FDI (Wilkins, 1998).

The variable *hor* measures the presence of FDI in a given industry, then the higher its value the greater the increase in domestic firms' productivity. Thus, following (Barrios and Strobl, 2002) we expect a positive effect on domestic firm's TFP growth.

Vertical externalities occur when a MNC increases the demand for local inputs, leading to increased specialization in upstream sectors and, as a result, causing the reduction of costs in downstream sectors. If the MNCs are interested in maintaining the quality standards they are likely to provide technical support to local suppliers in order to improve the quality of inputs, or assist them in the introduction of innovations, training, creation of productive infrastructure, procurement of raw materials, as well as the introduction of new management techniques, among others (Lall, 1980).

[7] Aitken and Harrison (1999) suggest the inclusion of sectoral dummies to control for the possibility of selection bias. This bias arises from the fact that the positive effect of FDI in high tech firms do not necessarily indicate a spillover effect since MNCs typically locate in sectors with higher productivity.

Vertical technology transfer occurs through linkages with local suppliers (backward linkages) or local customers (forward linkages).

We define *back* as

$$back_{jt} = \sum_{k \neq j} \delta_{jk} * hor_{kt} \tag{10}$$

where δjk is the share of industry j's output supplied to industry with foreign presence *k*. The variable *back* is intended to capture the effect that multinational customers have on domestic suppliers. Both *j* and *k* are two-digit industries.

Forward linkages occur when the MNCs provide higher quality and/or cheaper inputs to their clients that produce final goods (Markusen and Venables, 1999). Better quality inputs supplied by foreign firms may increase the productivity of domestic firms in industry *j*.

Similarly, we define *for* as

$$for_{jt} = \sum_{k \neq j} \lambda_{kj} * hor_{kt} \tag{11}$$

where λ_{kj} is the share of inputs that industry *j* buys from industry k. The variable captures the contacts between domestic firms and their foreign suppliers.

Parameters δ and λ are obtained from the OECD Input-Output (IO) Tables.[8] We exclude the diagonal elements of the IO tables in the calculation of the weighted average, because intrasectoral effects are accounted for in the variable *hor*. Moreover, we focus on inputs for intermediate consumption; therefore we do not include the imports, exports or other components of final demand in the calculation of the IO coefficients.

As highlighted by Lin and Saggi (2007), the net effect of linkages can either be positive or negative when domestic suppliers serve the MNCs exclusively. Indeed, under these circumstances the technology transferred to domestic suppliers increases but the reduction of the rivalry among domestic suppliers tends to reduce the aggregate output level of the intermediate goods industry. In addition, Carluccio and Fally (2010) stress that a

[8] Another source for IO tables is World Input-Output Tables (www.wiod.org) but this source lacks data for one of the investor countries (Norway) which prevent us from using it for comparison.

decrease in the cost of inputs compatible with the foreign technology, while benefiting foreign firms and the most productive downstream domestic firms adopting the foreign technology, it negatively affects firms using the domestic technology. However, we assume that the higher the value of *back* and *for,* the greater the magnitude of vertical externalities and thus the greater the effect on the TFP growth of domestic firms. The increase in demand of high quality inputs by MNCs or due to the purchase of better quality inputs provided by foreign firms (Lall, 1980; Markusen and Venables, 1999). Hence, following Markusen and Venables (1999) we expect a positive coefficient for variables *back* and *for*.

Control variables

We include six control variables; *hfd* is the Herfindhal index that measures market concentration, *rd* is the value of R&D expenses proxied by firms' intangible assets, *mrdf* is the average value of sectoral foreign R&D expenditure, *s* measures the scale of operations, *tg* is the technological gap, and *kl* measures the capital intensity.

Concentration

The Herfindhal index indicates the market concentration and is calculated as

$$H_{it} = \sum_{g \in J} \left(\frac{X_{gt}}{\sum_{g \in J} X_{gt}} \right)^2 * 100 \tag{12}$$

where X represents the output of firm g (domestic or foreign) belonging to sector j, at time t. The output is proxied by firm turnover obtained from AMADEUS database, deflated by a Producer Price Index. The Herfindahl index also serve as a proxy of (the lack of) competition. Indeed, since this variable is calculated as a share (%), values close to 0 indicate markets under perfect competition, and a value of 100 denote the presence of monopoly rents.

If the impact of the variable *hfd* on the TFP growth is positive, it means that the market power can facilitate the access to the necessary resources for domestic firms to increase their productivity. Indeed, stronger industry concentration generates larger profits that can be re-invested, for example, in new technologies or in the production of more sophisticated products; however, if the sign is negative it implies that the monopolistic inefficiencies are causing a decrease in the rate of innovation (Sjöholm, 1999) and, thus, a loss of productivity. As a result, the expected sign of this variable is not predefined.

Domestic R&D expenditure

Endogenous growth theories predict R&D activities to be an important determinant of TFP growth since innovations can ultimately raise efficiency (Aghion & Howitt, 1998; Jones, 1995; Romer, 1990). The variable *rd* is included in our model to proxy the domestic firms' absorptive capacity. A certain level of absorptive capacity is required to absorb foreign technology (Liu and Buck, 2007). Domestic R&D expenditures influence domestic TFP in three ways. Firstly, R&D may be cost reducing, lowering the production costs. Secondly, firms may create and produce new products with R&D expenditures by using the same volume of factors. Finally, Kinoshita (2001) considers that R&D activities increase the capacity of domestic firms to imitate new technologies and uses it as a proxy for absorptive capacity (Cohen and Levinthal, 1989; Griffith et al, 2003). Thus, we expect positive sign for the coefficient of *rd*.

Average sectoral R&D expenditure of foreign firms

The variable *mrdf* is included in our model to proxy the average stock of foreign knowledge in each industry. Liu and Buck (2007) found evidence that foreign R&D activities had positive impacts on the innovation performance of domestic firms, if domestic firms possess the absorptive capacity to learn the foreign knowledge. Because innovations are a source of TFP growth, we expect a positive sign for the coefficient of *mrdf*.

Scale

Small firms have less capacity to benefit from foreign presence and are less capable to face competition (Aitken and Harrison, 1999). Yet, some studies [Dimeli and Louri (2001), Girma and Wakelin (2001) and Sinai and Meyer (2004)] find that only small domestic firms (and medium in the later case) benefit from positive externalities from FDI. Hence, the evidence on the impact of scale in firms' productivity appear to be inconclusive. Nonetheless, in the presence of increasing returns to scale, i.e., if there is a industry-specific optimal scale, then TFP increases with scale (Baldwin, 1996; Schoors and Van Der Tol, 2002) and we expect a positive coefficent for *s*.

Technological gap

The determinants of technology diffusion build on models by Nelson and Phelps (1966), Benhabib and Spiegel (2005), Romer (1990) and Aghion and Howitt (1992). Following Gerschenkron (1962) hypothesis, the technological progress is an increasing function of the technology gap (*tg*). We define a way to measure the speed of technology diffusion, i.e, to capture autonomous technological transfer from foreign firms to technologically laggard domestic firms (Griffith et al. 2004; Madsen et al. 2010). The indicator is a ratio of labour productivity between domestic firms and the presumptive foreign leader.[9] Therefore, the variable *tg* is constructed an inverse measure of the technological gap since values of this variable close to 1 mean a small gap and values close to 0 signify a large gap. Thus, and according to the catching-up hypothesis, if the value of *tg* is close to one, the gap is too small; which means that domestic and foreign firms possess similar levels of efficiency and, thus, the domestic firms are not prone to learn much from the MNCs. However, according to the technology-accumulation hypothesis, if the value of *tg* is close to zero, the gap is too large; which means that domestic firms do not possess the necessary "absorptive capacity" to incorporate the knowledge of foreign firms (Lapan and Bardhan, 1973; Wang and Blomstrom, 1992; Perez, 1997; Kinoshita, 2001). Thus, the expected coefficient of this variable is not predefined.

Capital intensity

Capital intensity represents a firm's commitment to modernization and upgrading of its productive capacity. In the long run, capital expenditures typically have a positive impact on firms' performance (Lee & Blevins, 1990; Lee and Xiao, 2011). The higher the capital intensity is, the higher the expected TFP (Buckley, Clegg, Zheng, Siler and Giorgioni, 2010). Hence, we expect a positive coefficent for *kl*.

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[9] There are two reasons for using labor productivity rather than TFP. First, because of correlation of tg calculated with TFP and the error term; second, for the sake of comparison with other empirical studies for Portugal that use the labour productivity

Interaction variables

These variables are included in our model to test the impact of foreign presence in the TFP growth of Portuguese manufacturing firms, given the values of concentration, absorptive capacity, sectoral average of foreign knowledge, scale, technological gap and capital intensity. Thus, we include the interaction variables labelled *F*hfd, F*rd, F*mrdf*, *F*s, F*tg* and *F*kl,* respectively. Wheren F stands for the measure of foreign presence in the same industry (*hor)*, in downstream (*back)* or upstream industries *(for).*

FDI and concentration

If the impact of the variable *F*hfd* is positive, it means that the impact of foreign presence in the TFP growth of Portuguese manufacturing firms is positive, given the values of market concentration. In other words, the influence of concentration on the referred impact is positive because the benefits of having market power ouweight the potential disadvantage of inneficiences from monopoly rents; and otherwise if the value of *F*hfd* is negative. Hence, the sign of *F*hfd* is not predefined.

FDI and absorptive capacity

From what was said above about the domestic firms absorptive capacity, we assume that the impact of foreign presence in the TFP growth of Portuguese manufacturing firms, given a certain level of absorptive capacity, is positive, i.e, that the coefficient of the variable *F*rd* is positive.

FDI and the average stock of foreign knowledge in the industry

Empirical literature provide evidence of positive impacts of foreign R&D activities on the innovation performance of domestic firms, as described above. Hence, we assume a positive impact of foreign presence in the TFP growth of Portuguese manufacturing firms, given a certain level of foreign R&D activities. The expected sign for the variable *F*mrdf* is positive.

FDI and scale

We assume a positive impact of foreign presence in the TFP growth of the Portuguese manufacturing firms, given a certain level of scale, because the adoption of an efficient scale of operations is important to increase the TFP. Consequently, we expect a positive sign for the variable *F*s*.

FDI and technological gap

For the Portuguese economy, Flôres et al. (2002) suggest that the externality effects are maximized when the technological gap is between 50%-80% while Proença et al. (2002) find that *tg* must be around 60%-95% in order to maximize the externalities.[10] Thus, the expected sign of *F*tg* is not predefined.

FDI and capital intensity

Foreign firms usually use more capital-intensive technologies (Lall, 1978; Ferragina, 2013). The extent to which local firms benefit from this superior technology depends largely on their own technological capabilities as defined by capital intensity (Globerman, 1979; Liu et al., 2000). Therefore, we assume a positive impact of foreign presence in the TFP growth of Portuguese manufacturing firms, given a certain level of capital intensity, and expect a positive sign of *F*kl*.

[10] The difference in results may be due to the different proxies used for the variable *tg*.

3. CONSTRUCTION OF THE DATABASE

3.1.AMADEUS DATABASE

We construct a database to assess the existence and magnitude of externalities from FDI in Portugal. The previous section provided information on the variables to include. We now describe the sources and data collection and discuss the choice of proxies.

AMADEUS provides financial data on 250,000 firms in about 40 European countries including standardised annual accounts, financial ratios, sectoral activities and ownership. It provides comparable financial information for public and private firms across Europe with a focus on private firm information.

A major aspect in the construction of a database is data integrity. In other words, it is necessary to ensure that the database is in accordance with the rules and measures of statistical quality (Dyer, 1992). According to Fox et al. (1994), the four key factors that guarantee a database of high-quality are accuracy, timeliness, completeness and consistency. Hence, we gather evidence indicating the integrity of AMADEUS database. Bureau van Dijk (BvD) collects and harmonises the data from the mandated firm reports. In particular, in the Portuguese case, financial data come from *Informação Empresarial Simplificada* (IES).[11] This information is collected in a massive way by Coface, BvD's partner for Portugal, that send it to BvD for subsequent upload in SABI and AMADEUS databases.

The IES was approved by Order No 208/2007, of February 16, as amended by Ordinances No. 8/2008, of January 3, 64-A/2011, of 3 February and 26/2012 of 27 January. Before 2007, firms were required to provide the same information on their annual accounts to various public entities, through different means: deposit of annual accounts and the corresponding registration in the commercial register offices; delivery of annual statement of accounting and tax information to the Ministry of Finance (Autoridade Tributária e Aduaneira); and delivery of annual accounting information to INE and Banco de Portugal), for statistical purposes.[12, 13]

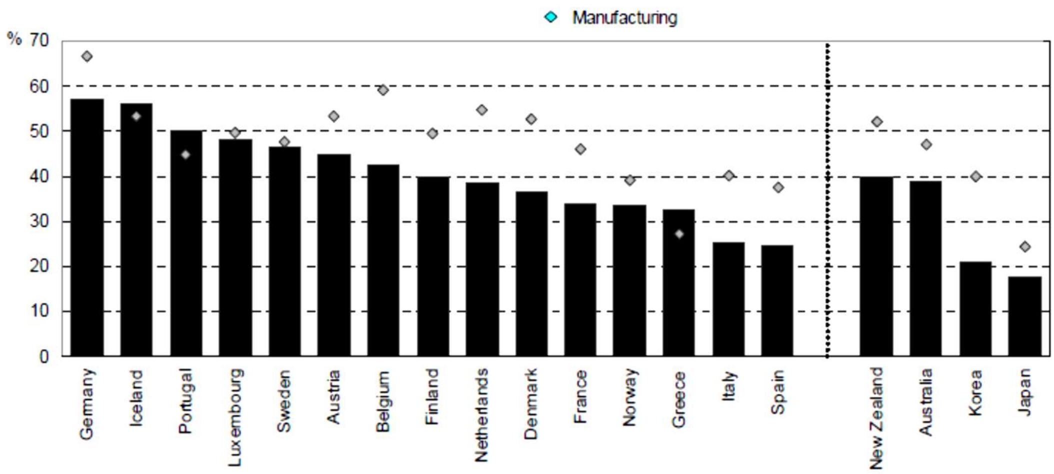
Thus, the fulfilment of each of these obligations entailed the need for firms to transmit substantially identical information on their annual accounts to four different entities

[11] Simplified Business Information
[12]Taxes and Customs Authority.
[13] Bank of Portugal.

through various means. With the creation of IES, all reporting obligations are transmitted electronically to a single entity in a single moment in time. Thus, we think the four parameters of quality are met. Indeed, the fact that Bureau van Dijk provides data for all European countries ensures the integrity regarding the coverage and consistency of the database and facilitates the comparison of the results between empirical studies for different European countries.

In addition, although the innovative density of services, i.e, the share of innovative firms in the total population of firms in the services sector in Portugal is higher than that of manufacturing, international comparisons of the results justify the analysis of this sector. Indeed, most authors focus on manufacturing, since, as Figure 1 shows, "In nearly all participating countries (..) the share of innovative service-sector firms in the population of service sector firms (*i.e.* the innovative density of service-sector firms) was below that of manufacturing firms" (Tamura et al, 2005, pp. 135-136).

Figure 1- Innovative density in the Manufacturing and Services (%)



Note: The Innovative density is calculated as the share of innovative firms in each sector as a % of firms in each sector.
Source: OECD based on data from Eurostat, CIS3 survey, 2004 and innovation survey of Australia, Japan, Korea and New Zealand, in Tamura et al. (2005)

For example, in Germany and Spain, 65% and almost 40% of the manufacturing firms are innovative *vis-a-vis* 55% and 25% of service-sector firms, respectively. The largest gaps, of 20%, are found in Belgium, Denmark and the Netherlands.

3.2. OTHER SOURCES

The construction of a database to measure externalities from FDI on manufacturing firms' productivity requires a set of variables both at national (to measure the representativeness) and firm-level, such as gross output, the number of employees, intermediate inputs, price indices, turnover, tangible assets, among others. Hence, we need to include these variables in our database. Since data sets from International organizations include only some of the variables needed, they are not suitable for studying the effects of FDI on the productivity of Portuguese manufacturing firms. Indeed, while IMF and UNCTAD databases provide information on FDI flows that are not consistent with one another, OECD and Eurostat provide data that complement the previous two. OECD provides data on flows and bilateral and sectoral positions while Eurostat provide FDI data by industry and by country of origin and destination.[14] However, even if we could match the information from these sources it still would not be enough for our purposes. National sources, such as *Banco de Portugal*, *Ministério do Trabalho e Segurança Social*, *Instituto Nacional de Estatistica*, *Ministério da Economia* and Dun & Bradstreet provide more comprehensive databases. However, the definitions, data treatments and nomenclatures differ. Moreover, some of these databases possess low coverage and are incompatible with each other and lack important financial variables (from balance sheet and income statement) needed for our aim. Therefore, we prefer to deal with information collected and processed by international institutions, such as Bureau van Dijck. The foremost advantage of BvD is to provide harmonised data concerning definition, nomenclature and data treatment that allow us to compare our results with other international studies. Still, the dataset from BvD (AMADEUS) needs some additional firm-level and aggregated variables. Indeed, besides the financial variables provided by AMADEUS we need information on Years of Schooling, Price Index, Intermediate Inputs, Gross Output and Gross Value Added.[15] Hence, we need to complement

[14] Moreover, OECD is deeply involved with the IMF in defining the methodology for FDI data collection (see for example the Survey of implementation of methodological standards for Direct Investment, SIMSDI [OECD/IMF, 1999]).

[15] Quadros do Pessoal database contains information on years of schooling of employees for each firm. We use the statistical mean of this variable for each industry. For Portugal, other authors (e.g, Crespo et al, 2008 and 2012; Proença et al., 2002 and 2006) proxy skilled labour by total earnings per worker hired by domestic firms. We think that 'years of schooling' is a more reliable proxy for absorptive capacity since higher salaries not always correspond to payment for skills. Blalock and Gertler (2008) use firm's investment in R&D as a proxy for absorptive capacity. However, Schmidt (2005) finds that the current level of R&D expenditure primarily endeavours to accumulate new knowledge and develop new products and processes. Over time, it also helps to

the information from AMADEUS with data from *Quadros do Pessoal* (QP) database and the EU Klems database in order to construct our database (See Table 1 for detailed information on the sources for each variable).

Table I1-Variables of our database

Variable	**Source**	**Description**	**Units**
plantid		Identification of firm	1-5045
year			1995-2007
nace		Industry codes	10-33
duf	AMADEUS	Dummy variable for nationality of capital, takes value 1 for	0-1
sharefor	AMADEUS	Share of foreign capital	10-100
codec	AMADEUS	Investor Country Code	1-19
		Variables to calculate the TFP	
va	AMADEUS	Value added	Euros
l^p	AMADEUS	Production workers (unskilled) labour proxied by the Number of	Units
k	AMADEUS	Capital proxied by tangible assets-depreciation	Euros
mat	AMADEUS	Purchases of materials	Euros
l^{np}	QP	Non-production workers (skilled) labour proxied by average years of schooling by industry/year	*84-565*
		Variables that measure foreign presence	
horiz[a)]	Constructed	Horizontal externality measure = Total turnover of foreign firms / sectoral turnover	Units
back[a)]	Constructed	Measure of externality via backward linkages $back_{jt} = \sum_{k \neq j} \delta_{jk} * hor_{kt}$, where the Input-Otput (IO) coefficient δ_{jk} was calculated using the IO tables from OECD	Units
for[a)]	Constructed	Measure of externality via forward linkages $for_{jt} = \sum_{k \neq j} \lambda_{kj} * hor_{kt}$, where the Input-Otput (IO) coefficient λ_{kj} was calculated using the IO tables from OECD	Units
		Variables that influence the impact of FDI on the TFP of domestic firms	
hfd	Constructed	Herfindhal index indicates market concentration $H_{it} = \sum_{g \in J} \left(\frac{X_{gt}}{\sum_{g \in J} X_{gt}} \right)^2 * 100$, where g is an index for the firms (domestic or foreign) belonging to sector J to which domestic firm i belongs. X represents the output of firm g, at time t.	
rd	AMADEUS	Net Intangible assets	
mrdf	Constructed	Average net Intangible assets for foreign firms by industry/year	
s	Constructed	Measure of scale = turnover / average turnover	
kl	Constructed	Capital intensity =capital / labour	

develop the skills and knowledge necessary to source external knowledge but immediately it can, at best, contribute to explore absorptive capacities for specific types of knowledge. Khordagui and Saleh (2013) argue that, in line with the education economics literature, cognitive ability [proxied by the Trends in Mathematics and Science Scores from the World Bank] is a more reliable measure of the quality of human capital than that of years of schooling. However this data is not available at firm or sector level.

tg	Constructed	Measure of technological gap = prod/prod for sectoral foreign
prod	Constructed	Labour productivity = turnover/ number of employees

Notes- All nominal variables are deflated by the PPI index. QP stands for Quadros do Pessoal. a) The variable *horiz* can be *hor, hoz* and *hoz1* according to the measure using turnover, tangible assets or the value added; the variable *back* is can be *b1, b2* and *bb* and the variable *for can be f1, f2* and *ff* , respectively.

The EU Klems Growth and Productivity Accounts include measures of output and input growth, and derived variables such as multifactor productivity at the industry level. The input measures include various categories of capital, labour, energy, material and service inputs. The measures are developed for 25 individual EU member states, the US and Japan and cover the period from 1970 to 2005.

Quadros do Pessoal (QP) correspond to our benchmark for the values of variables at sectoral level. Indeed, QP is a 25-year old administrative source of data with statistical purposes. The information comes from a questionnaire whose reply is mandatory, by Decree- Law No. 35/2004, for all entities with workers under legal labour contract. In 1995-2007 it covered a range of 192,000- 342,000 firms with 2.2- 2.9 million workers.

The information provided by QP includes, among others: Firm name (Name and Fiscal number); Location (Address, District, County and Town); Main Activity; Legal nature; Date of Establishment, Joint-Stock (private, public, foreign); Turnover and Number of Employees (in October of each year). It also includes data on employees: National Insurance Number; Professional Category and Occupation, Level of Qualification, Level of Education, Gender, Age, Nationality, Seniority in the Firm; Type of Contract (full time and part time); Wage; Extra benefits and Monthly hours paid (normal and overtime), among other information.

The advantage of using Quadros do Pessoal lies in its hitherto stability, reliability and annual updating, while the disadvantage may stem from changes in the legislation that exert an impact on the data source.

3.3. DATA

Every firm in AMADEUS is allocated to an industry at two-digit level because the input-output tables are in this format. The sectoral codes follow NACE Revision 2 (see Table 2) that allow to compare our results with other international studies.

Table 2 - NACE Revision 2, Level 2 Classification

10 Manufacture of food products	22 Manufacture of rubber and plastic products
11 Manufacture of beverages	23 Manufacture of other non-metallic mineral products
12 Manufacture of tobacco products	24 Manufacture of basic metals
13 Manufacture of textiles	25 Manufacture of fabricated metal products, except machinery and equipment
14 Manufacture of wearing apparel	26 Manufacture of computer, electronic and optical products
15 Manufacture of leather and related products	27 Manufacture of electrical equipment
16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	28 Manufacture of machinery and equipment n.e.c.
17 Manufacture of paper and paper products	29 Manufacture of motor vehicles, trailers and semi-trailers
18 Printing and reproduction of recorded media	30 Manufacture of other transport equipment
19 Manufacture of coke and refined petroleum products	
20 Manufacture of chemicals and chemical products	

Source-EUROSTAT

Table 3 contains the variables available at AMADEUS. We collect information for 5,045 firms, starting with the larger ones to ensure the representativeness of the dataset, over the period 1995-2007. Our data set is a balanced panel comprising 65,585 observations for 24 manufacturing industries (from 10 to 33).

Table 3- Variables of AMADEUS database

Value added	Extr. And other revenue	Other fixed assets
Adress	Financial expenses	Other non-current liabilities
Auditors	Financial P/L	Other operating expenses
Aver. Cost of empl./year (Ths.)	Financial revenue	Other shareholders funds
Board members & officers	Fixed assets	P/L for period:
CAE Rev. 3 code(s)	Gearing (%)	P/L after tax
Capital	Gross Margin (%)	P/L before tax
Cash & cash equivalent	Gross profit	P/L for period
Cash flow	Industry/activities	Per employee ratios
Cash flow/turnover (%)	Intangible fixed assets	Profit (loss) before tax
Collection period (days)	Interest cover (x)	Profit margin (%)
Costs of employees	Interest paid	Profit per employee (Ths.)
Costs of employees/oper. Rev.(%)	Legal form:	Profitability ratios
Costs of goods sold	Liquidity ratio (x)	Return on capital employed (%)
Credit period (days)	Loans	Return on shareholders funds (%)
Creditors	Long term debt	Return on total assets (%)
Current assets	Material costs	Sales
Current liabilities	Mergers and acquisitions	Secondary code(s):
Date of incorporation:	NACE code(s)	Share funds per employee (Ths.)
Debtors	Net assets turnover (x)	Shareholders funds
Depreciation	Net current assets	Shareholders liquidity ratio (x)
Ebit	Non current liabilities	Solvency ratio (%)
Ebit margin (%)	Number of employees	Stock turnover (x)
Ebitda	Operat. Rev. Per employee (ths.)	Stocks
Ebitda margin (%)	Operating revenue/turnover:	Tangible fixed assets
Employees	Operating P/L	Taxation
Export turnover	Operating revenue / turnover	Total assets
Export turnover/Total turnover (%)	Operational ratios	Total assets per employee (Ths.)
Extr. and other expenses	Other current assets	Total shareh. funds & liab.
Extr. and other P/L	Other current liabilities	Work. capital per employee(Ths.)

Source-AMADEUS

If some firms are active in more than one industry, we allocate the firm to the first industry. We assume that the second activity is a secondary source of revenue and as such represents a negligible share of turnover (less than 10%). Firms with three NACE-sectors are omitted since we assume that multi-industry firms do not accurately represent the typical sectoral behaviour of a firm.

We aim to test the influence of foreign presence on the TFP growth of domestic firms. However, since the FDI decisions are likely to depend on firms' characteristics and their performance, a common problem of empirical studies is the inherent selection bias. The problem of sample selection bias has been largely dealt with in the econometric literature (see, for example, Amemiya, 1984, and Wooldridge, 2002). This bias (also referred as selection effect) is an error in choosing the individuals or groups to take part in a study, caused by a sampling bias, i.e, a non-random sample of a population that causes an under representation of some members. Several studies report that MNCs tend to acquire shares in the largest and most successful domestic firms [Djankov and Hoekman (2000), Evenett and Voicu (2001), Damijan et al (2003a,b)]. Therefore, the choice of a sample consisting predominantly of large firms (measured by turnover) may result in a misrepresentation, where the participants are not equally balanced or objectively represented and lead to misleading results.[16] Thus, our sample contains firms of all sizes to ensure that the data are not biased towards large firms.

Table 4 shows the most used dependent variables and proxies by previous studies.

Table 4- Most used dependent variables and proxies in the literature

Dependent Variable	Proxies
Gross output (level, growth)	Turnover or sales deflated by the index of output prices
Value added	Difference between the value of output and intermediate material inputs
TFP or labour productivity	TFP; Turnover or sales (deflated by the index of output prices) divided by the number of employees; Difference between the value of output and intermediate material inputs divided by the number of employees

Source-own analysis

[16] If the productivity differences are greater when including the smaller firms, then there is a problem of a sample selection that arises from endogenous stratification. For example, Harris (2002) found that foreign-owned plants are more productive than the UK-owned plants. Thus it is important to calculate sample weights for each firm to ensure that they adequately reflect the underlying distribution in the population.

Not every authors use the TFP as a productivity measure. For example, Blomstrom (1986) and Kathuria (2000) use an efficiency index that measures the distance between the average value added per worker of the firm and its sectoral "efficient frontier". Aitken and Harrison (1999) use the logarithm of the output and Haddad and Harrison (1993) estimate the growth of total output assuming that it depends on labour and capital.

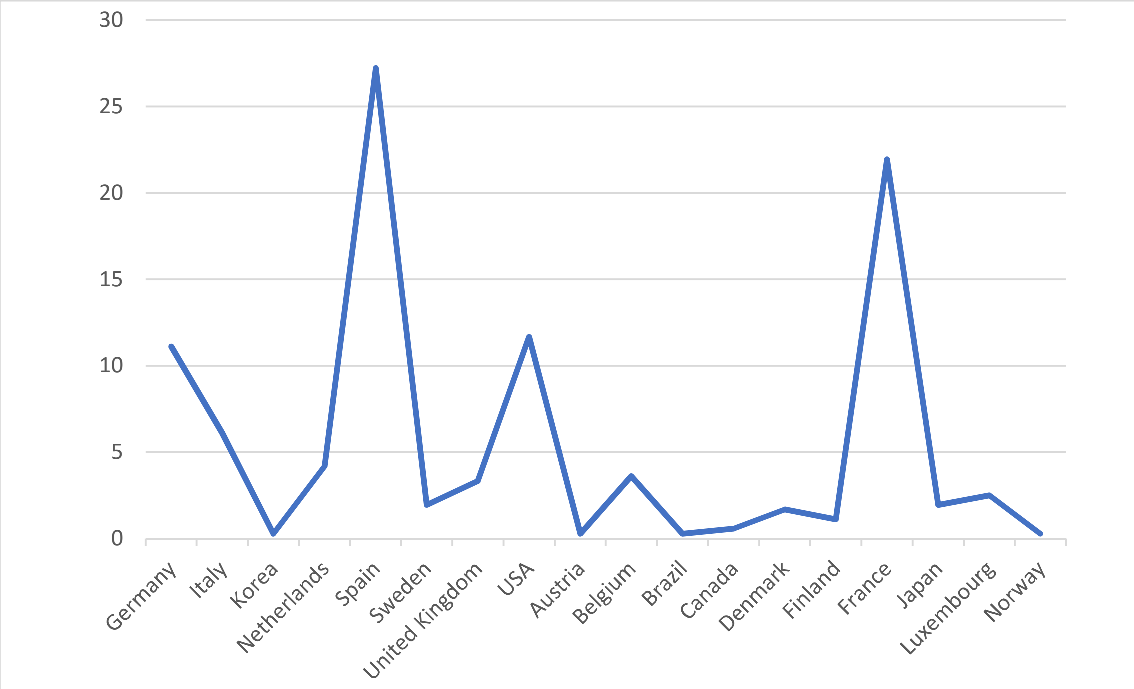
Regarding the impact on the results from using different measures for the dependent variable, in our view, since turnover in manufacturing sector consists mainly of sales, the use of sales or turnover leads to the same results, except for firms with a significant share of services in total turnover. However, we consider that the use of value added may produce different estimates, since the value added is calculated as the difference between the turnover (or sales) and the intermediate inputs. Thus, for the same amount of sales, the value added will be lower for less productive firms which makes TFP estimates, obtained by using the value added, an important indicator of firm performance. Nonetheless, the main advantage of using the real value added is that value added is directly comparable across industries, while real output (measured by turnover deflated by PPI) is not comparable because, conceptually, it is measured using different units in each industry. This is of particular relevance because our main focus is the productivity growth of domestic firms. Thus, in our view, the TFP shoul be estimated using the value added as in our equation (7); rather than using the real output.

Concerning the variables that measure foreign presence, *AMADEUS* contains information on ownership, including firm name and investor country. To find the firm's ultimate owners (UOs), BvD focuses on identifying the owners, if any, who exercise the greater degree of control over the firm.

We collected foreign firms with at least 10% of share of foreign capital. The threshold of 10% of foreign capital is the standard in the FDI literature. According to OECD (2008), the ownership of 10 per cent determines the existence of a direct investment relationship and implies that the direct investor is able to influence or participate in the management of the firm. Hence, we classify firms as foreign or domestic by including a dummy variable (*duf*) in our database that equals 1 if the firm is foreign (minimum of 10% of share of foreign capital) and 0 otherwise.

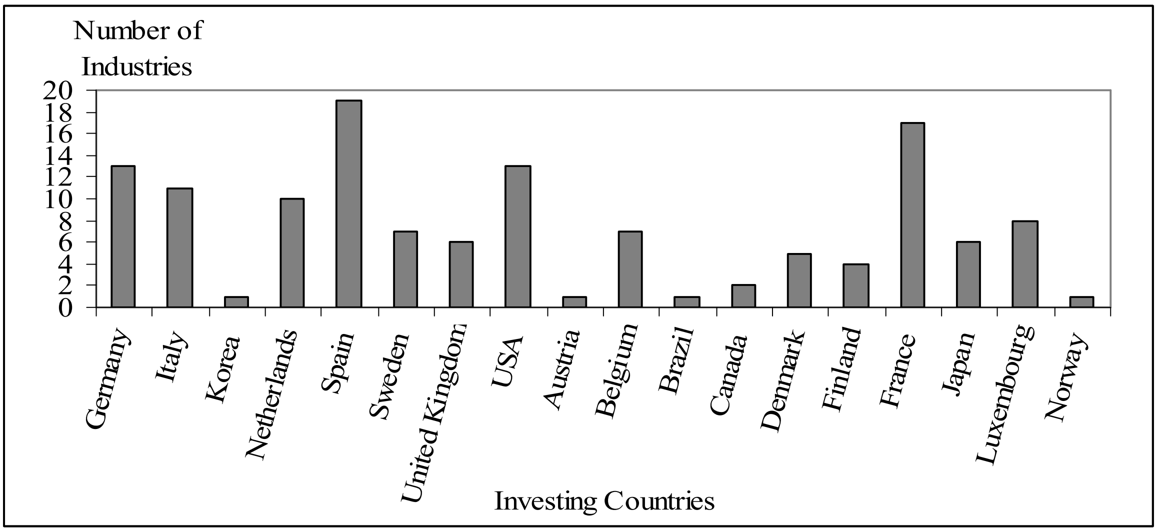
We gathered information on 18 investing countries (country codes are shown in Table D1 of Apendix D). Figures 2 and 3 shows the share of firms and number of industries, by investor Country. The mean of foreign capital for all manufacturing industries is 58%.

Figure 2- Share of firms (%) by investor Country



Source: author's calculations

Figure 3- Number of industries with foreign presence, by investor country



Source: author's calculations

Spanish and French firms represent roughly 49% of foreign firms in our sample. Spain and France invest respectively in 19 and 17 of all 24 manufacturing industries. Hence their investment is spread in 79% and 71% of all manufacturing industries in

Portugal, respectively. By contrast, Norwegian firms correspond to 0.3% of foreign firms in our sample and their investment represent only 4% of all manufacturing industries.

Since several authors stress the need to choose appropriate measures of foreign presence in order to capture externalities from FDI (e.g., Liu and Nunnenkamp, 2009; Barrios et al., 2011), we test alternative measures of foreign presence. Table 5 contains the most commonly used proxies for the variable *Hor*.

Table 5– Most used proxies for the variable hor in the literature

	Proxies
Foreign presence (Horizontal externality)	The share of assets owned by MNCs
	The share of foreign capital in firms' capital
	The share of foreign employment in the sector
	The share of MNCs sales in the sector
	The MNCs Value added

Source-own analysis

For example, Haddad and Harrison (1993), Chuang and Lin (1999) and Djankov and Hoekman (2000) calculate the variable *Hor* as the share of assets held by MNCs, Aitken and Harrison (1999) use the share of foreign capital, Kathuria (2000) uses the share of sales and Driffield (2001) uses the growth of foreign sales.

Relating to vertical externalities, because data on linkages between domestic and foreign firms are not available at firm-level, vertical linkages are usually calculated at sectoral level using the coefficients from input-output tables at two-digit level. The source of our IO tables is the OECD. IO tables describe the sales and purchases relationships between producers and consumers within an economy, i.e, the inter-industrial relationships. Following Barrios et al. (2011), we use the coefficients from the IO tables of home countries because the coefficients of IO tables for Portugal are not correlated with those for foreign countries (Appendix B describes the procedure to calculate the correlation between the IO tables of home and host countries).[17]

[17] IO tables reflect the inter-industry transactions. Hence, researchers use the IO coefficients (i.e. each industrial sector's purchases, per unit of output, of intermediate and investment goods from other sectors) to calculate the flows of technology. Thus, purchased inputs (both intermediate and investment goods, domestic as well as foreign) act as carriers of technology across industry and from one country to the other sectors (Papaconstantinou et al., 1996). The use of host country's IO coefficients imply that MNCs have the same production technology as domestic firms (Barrios et al, 2010). This challenges the assumption of externalities from FDI arising from contacts with MNCs that possess superior technology (eg, Markusen,

Following Haddad and Harrison (1993), Chuang and Lin (1999) and Djankov and Hoekman (2000) we include an alternative measure (*hoz*) by using the assets held by MNCs instead of output. The variables *b2* and *f2*, for backward and forward linkages respectively, are obtained by multiplying the coefficients δ_{jk} and λ_{kj} in equations (10) and (11) by *hoz.*

We also construct a second alternative measure of foreign presence using value added (*hoz1*). Alternative measures of backward and forward linkages are denoted by *bb* and *ff* and are obtained by multiplying the coefficients δ_{jk} and λ_{kj} in equations (10) and (11) by *hoz1.* See Appendix A for details on the construction of variables that measure the foreign presence and the alternative measures. Table 6 shows the control variables mostly used in empirical studies.

Table 6- Most used control variables and proxies in the literature

Variables	Proxies
Skilled labour	Total salaries and training costs; ratio of skilled workers on the number of unskilled workers; gross enrollment rate in higher education (or high school)
Technological gap	Ratio of turnover (sales) of firm i on the turnover (sales) of the foreign firm regarded as a leader in the respective industry
Capital intensity	Ratio of fuel and electricity on total employment
Concentration index	Herfindhal
Scale	Turnover on the average sales in the industry
R&D activities	R & D expenditures;R & D expenditures in the private sector as a % of GDP

Source-own analysis

Control variables include those variables that can influence domestic firms' efficiency. Among these, the following stand out: skilled labour, technological gap,

2004). Moreover, the International Business literature has provided evidence that the sourcing policy of a MNC depends largely on its nationality. For example, Japanese MNCs tend to purchase intermediate inputs from other Japanese MNCs which in turn influence the demand of their foreign affiliates for domestic inputs (Belderbos et al., 2001). In addition, Rodriguez-Clare (1996) shows that transport costs play an important role in the decision of sourcing domestically. According to Rodriguez-Clare (1996), MNCs from neighbouring countries are more likely to import inputs due to relatively low transport costs. To sum up, the evidence suggests that MNCs use similar production technology in the host country to that used at home; hence, it is likely that their supply strategies are also similar. Therefore, Barrios et al. (2010) suggest that before using host country IO coefficients, researchers should test their correlation with the IO coefficients of the investor country.

capital intensity, concentration index, scale and R&D activities. The skilled labour is proxied by the total salaries and training costs; or the ratio of skilled workers on the number of unskilled workers; or the gross enrollment rate in higher education (or high school); the technological gap is proxied by the ratio of turnover (sales) of firm *i* on the turnover (sales) of the foreign firm that is regarded as a leader in the respective industry; the capital intensity is proxied by the ratio of fuel and electricity on total employment; the concentration index is proxied by the Herfindhal index; scale is proxied by the turnover on the average sales in the industry; and finally, the R&D activities are proxied by the R&D expenditures; or the R&D expenditures in the private sector as a % of GDP. Thus, Table 6 provides measures that can be used in our applied analysis to the Portuguese manufacturing. Indeed, we use the same measures for concentration and scale; whereas we use alternative proxies for the rest of the variables due to data availability.

Table 7 reports the summary statistics of all the variables used in this research, classified into four groups: variables to estimate the TFP, variables of foreign presence, interaction variables and control variables.

Table I7- Basic statistics

(obs=65585)

	Mean	Std.Dev.	Min	Max	Skewness	Kurtosis
			Variables to estimate the TFP			
va	10.98	1.49	6.86	19.59	0.33	2.42
l^p	2.56	1.36	0.00	8.20	0.34	2.24
k	1.24	1.92	6.90	20.90	0.64	3.27
mat	12.71	1.54	7.29	21.63	0.29	2.53
l^{np}	5.95	0.21	4.00	6.00	-4.39	20.46
			Variables of foreign presence			
hor	-3.63	1.80	-7.44	-0.04	-0.71	2.74
b1	-7.86	2.88	-14.23	-0.26	-0.34	3.26
f1	-8.19	2.98	-14.27	-0.40	-0.32	3.01
hoz	-3.61	2.39	-9.34	-0.10	-1.23	3.55
b2	-7.84	3.28	-16.03	-0.49	-0.96	4.08
f2	-8.17	3.55	-15.97	-0.51	-0.83	3.31
hoz1	-3.69	1.82	-7.38	-0.06	-0.65	2.60
bb	-7.92	2.80	-14.11	-0.30	-0.35	3.40
ff	-8.26	3.00	-14.11	-0.38	-0.33	2.95
			Interaction Variables			
hor*hfd	-8.09	2.29	-13.37	-2.94	-1.09	3.39
hor*rd	3.20	2.30	-3.08	11.23	0.26	2.46
hor*mrdf	3.52	2.36	-1.13	9.93	0.07	2.01
hor*s	-5.37	2.13	-12.27	3.92	0.04	2.56
hor*kl	6.45	1.74	-1.81	13.44	0.11	2.90
hor*tg	-4.50	1.77	-8.88	-0.04	-0.70	2.78
b1*hfd	-12.32	3.23	-20.03	-4.24	-0.74	3.86
b1*rd	-1.03	3.10	-9.91	11.08	0.24	2.79
b1*mrdf	-0.71	3.21	-7.32	9.77	-0.05	2.71
b1*s	-9.60	3.03	-18.99	0.63	0.13	2.81
b1*kl	2.22	2.79	-8.45	12.57	0.25	3.36
b1*tg	-8.73	2.82	-15.67	-0.26	-0.32	3.32
f1*hfd	-12.66	3.45	-20.09	-4.13	-0.67	3.30
f1*rd	-1.37	3.03	-9.84	11.00	0.24	2.84
f1*mrdf	-1.04	3.29	-7.35	9.70	0.01	2.62
f1*s	-9.94	2.94	-18.93	0.72	0.09	2.76
f1*kl	1.88	2.72	-8.44	12.12	0.17	3.37
f1*tg	-9.06	2.94	-15.73	-0.49	-0.32	3.08
hoz*hfd	-8.08	2.98	-15.27	-2.48	-1.33	3.71
hoz*rd	3.21	2.59	-4.82	11.54	0.04	2.61
hoz*mrdf	3.54	2.79	-2.44	10.23	-0.42	2.46
hoz*s	-5.35	2.48	-13.94	4.38	-0.30	2.77
hoz*kl	6.46	2.13	-3.71	14.32	-0.66	3.46
hoz*tg	-4.48	2.38	-10.64	-0.21	-1.18	3.50

Notes-va is value added, lp and lnp are labour; k is capital and m are materials; hor, hoz and hoz1 are measures of horizontal externalities; and b1, b2 and bb, and f1, f2 and ff are measures of vertical externalities; hfd is concentration, rd and mrdf are R&D expenses of domestic and foreign firms, respectively; s is scale, kl is capital intensity and tg is the technological gap. Lower cases denote variables in logs. Source: own calculations in Stata 13.0.

Table I7- Basic statistics (cont.)

	Mean	Std.Dev.	Min	Max	Skewnes	Kurtosis
				Interaction Variables		
b2*hfd	-12.31	3.75	-21.91	-4.00	-1.17	4.39
b2*rd	-1.02	3.32	-11.72	11.38	-0.16	3.15
b2*mrdf	-0.69	3.54	-9.13	10.08	-0.56	3.37
b2*s	-9.58	3.28	-20.78	0.96	-0.38	3.23
b2*kl	2.23	3.05	-10.36	12.91	-0.45	3.96
b2*tg	-8.71	3.24	-17.42	-0.49	-0.92	4.09
f2*hfd	-12.64	4.10	-21.90	-4.02	-1.04	3.50
f2*mrdf	-1.02	3.79	-9.07	10.00	-0.48	2.88
f2*s	-9.92	3.40	-20.70	1.05	-0.31	2.97
f2*kl	1.90	3.19	-10.34	12.78	-0.42	3.54
f2*tg	-9.04	3.53	-17.49	-0.64	-0.82	3.34
hoz1*hfd	-8.16	2.32	-13.29	-3.27	-1.02	3.21
hoz1*rd	3.13	2.32	-3.00	11.20	0.28	2.47
hoz1*mrdf	3.46	2.38	-0.88	9.89	0.10	1.98
hoz1*s	-5.44	2.09	-12.12	3.99	0.07	2.59
hoz1*kl	6.38	1.74	-1.72	13.43	0.14	2.88
hoz1*tg	-4.56	1.80	-8.87	-0.06	-0.64	2.63
bb*hfd	-12.39	3.17	-19.96	-4.10	-0.71	3.93
bb*rd	-1.10	3.03	-9.79	11.04	0.20	2.85
bb*mrdf	-0.77	3.14	-7.25	9.73	-0.04	2.84
bb*s	-9.67	2.91	-18.93	0.65	0.07	2.75
bb*kl	2.15	2.70	-8.45	12.40	0.20	3.43
bb*tg	-8.79	2.75	-15.68	-0.30	-0.32	3.45
ff*hfd	-12.72	3.48	-19.95	-3.99	-0.68	3.23
ff*rd	-1.43	3.06	-9.72	10.97	0.23	2.81
ff*mrdf	-1.11	3.32	-7.23	9.66	-0.01	2.59
ff*s	-10.00	2.93	-18.92	0.74	0.12	2.74
ff*kl	1.82	2.74	-8.37	12.08	0.15	3.33
ff*tg	-9.13	2.97	-15.76	-0.51	-0.34	3.02
f2*hfd	-12.64	4.10	-21.90	-4.02	-1.04	3.50
			Control variables			
hfd	-4.47	0.76	-6.57	-0.06	-0.46	3.61
rd	6.82	1.75	2.57	13.15	0	2.21
mrdf	7.15	1.00	5.26	10.88	0	2.64
s	-1.74	1.81	-8.48	7.40	0	2.90
tg	-0.87	0.45	-4.20	0	7	-0.89
kl	10.07	1.11	5.59	17.30	1	5.17

The average means for each group of variables range from -3.63 (variables of foreign presence) to 8.01 (control variables). The mean standard deviation of four groups of variables ranges from 1.15 (control variables) and 2.88 (interaction variables). The lower average minimum is -13.37 (interaction variables) and the larger average maximum is 15.26 (variables to estimate the TFP). The standard deviation is lower than the mean for variables to estimate the TFP and control variables; it is larger than the mean for the variables related to foreign presence (which suggests that the mean values have a higher variance); and almost similar to the mean of interaction variables.

The analysis of data distribution reflects firm heterogeneity along the lines of Melitz (2008); and a check on values for skewness and Kurtosis, especially in the case of the variable l^{np} (non-prodction or skilled labour) necessary to estimate the level of TFP; and the alternative measures of foreign presence, indicates that data are not normally distributed. However, we do not need univariate normality of either the dependent or the independent variables, only the residuals need to have a normal distribution. The reason is that, even though the dependent variable is normally distributed, the residuals may fail the assumption of normality. Nonetheless, normality only assures that the p-values for the t-tests and f-test will be valid, but it is not required in order to obtain unbiased estimates of the regression coefficients. However, we need a robust procedure to estimate the level of the TFP, such as the semi-parametric methods [e.g, Olley and Pakes (1996) or Levinsohn and Petrin (2003)]; and a robust procedure to estimate the existence of externalities on the TFP growth of domestic firms, such as the General Method of Moments (GMM).[18]

In the next section we will analyze the relationship between the TFP growth and two sets of independent variables across technological groups according to Pavitt's taxonomy. This taxonomy shows how technological trajectories aiming to increase the competitiveness and the productivity of domestic firms shape their linkages with foreign firms. Indeed, as seen in section 2 of Chapter 1, the convergence of income between countries depends on the level of international technological diffusion, because the main sources of technological changes leading to increases in the TFP stem from the MNCs' advanced technology. In this context, the adoption of a new technology by the domestic firms is more likely to occur if MNCs demonstrate that the technology is successful and if the goods produced are similar (Barrios and Ströbl, 2002). Though intra-sector

[18] We consider that normal distributed data possess a kurtosis value of 3 and a skewness value of 0.

heterogeneity may be substantial, some industries share the technological opportunities, nature of knowledge, appropriability conditions and market structure. Pavitt taxonomy groups industries according to the nature and sources of technological change, of production systems and market structures. Thus, it is a robust conceptual and versatile tool to identify patterns of technological innovation and, therefore, to analyse the opportunities of technological catch-up caused by the foreign presence in the host economy.

4. CORRELATIONS ACROSS TECHNOLOGICAL GROUPS

4.1. PAVITT'S TAXONOMY

Based on data relative to 2000 important innovations for the UK over the period 1945-1979, Pavitt (1984) ranked industries according to the production and use of innovation. The author assumes that the results reflect the behaviour of the manufacturing industries in most industrialized countries. The types of industries vary according to the production and use of innovation (where the producer of innovation may not coincide with its user), the main industry in which the firm innovates, the source of technology (internal or external to the firm), and the characteristics of the innovative firms (such as firm size and the diversification of innovation).

Thus, according to these features, Pavitt (1984) identifies three types of industries: production intensive, science-based and supplier-dominated industries. The first group is divided into scale-intensive and specialized suppliers industries.

Firms in scale-intensive industries (e.g. motor vehicles and other transport equipments) are characterized by their relative large size, producing a relatively large share of process innovations (compared to product innovations), and the main source of technology relies on production engineering of their suppliers and R & D. The major appropriation mechanisms are the trade secret, know-how and process patents. The consumers are price sensitive and the technological trajectories (process and product) aim at cost reduction.

In specialized suppliers industries, firms are relatively small and the consumers are sensitive to their performance (e.g. Machinery and Equipment). These firms innovate internally and through their consumers and produce a relatively large share of product innovations. The key mechanisms of appropriation are design, know-how, patent and the knowledge of customers.

Firms in science-based industries (such as electronics) are characterized by relative large size and produce roughly the same share of process and product innovations. The sources of process innovations are internal and external (from suppliers). The key mechanisms of appropriation are know-how, trade secret and patents. Hence, it is expected that firms in science-based and specialized suppliers industries are more technologically intensive than firms in the remaining industries.

In supplier-dominated industries, firms are characterized by a relative small size, limited resources regarding engineering and internal R & D and rely on suppliers to innovate. Since consumers are price sensitive, their technology is efficiency-seeking. This type of firms can be found in traditional industries (such as textiles, clothing and footwear).

Pavitt's taxonomy has evolved over time, since it was originally proposed. In this article we follow the adaptation of O'Mahony and Van Ark (2003) and Bogliacino and Pianta (2010) which is shown in Table 8.

Table I8- Classification of industries by technological groups, Portugal

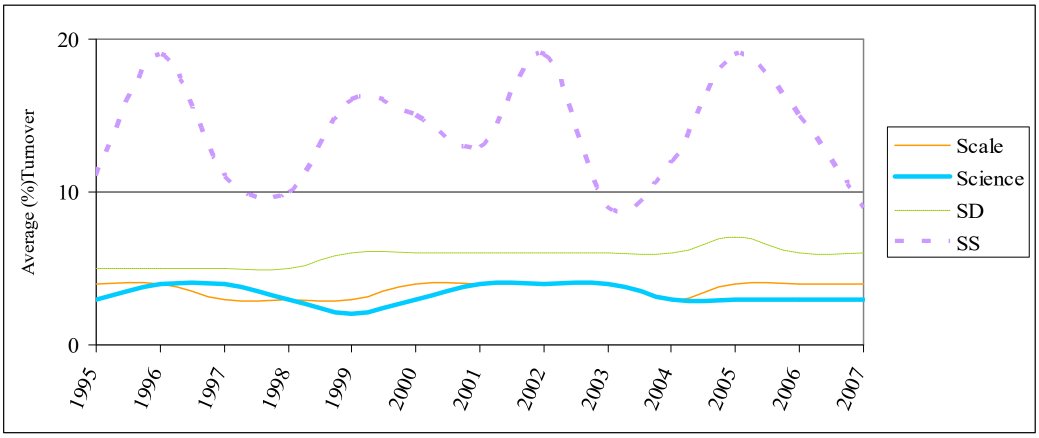
Scale intensive	Specialized suppliers	Science based	Supplier dominated
NACE codes-10,11,12,19,22,23,24,25,29 and 30	NACE codes-28,32 and 33	NACE codes-20,21,26 and 27	NACE codes-13,14,15,16,17,18 and 31
Food, Beverages and Tobacco, Coke And Refined Petroleum, Rubber and Plastics, Other Non-Metallic Minerals, Basic Metals, Fabricated Metal Products, Motor Vehicles and Other Transport Equipment	Machinery and Equipment, Other Manufacturing and Repair and Installation of Machinery and Equipment	Chemicals, Pharmaceuticals, Computer and Electronics and Electrical Equipment	Textiles, Wearing Apparel, Leather, Wood, Paper, Printing and Reproduction of Recorded Media and Furniture

Source: own analysis based on Pavitt (1984), O'Mahony and Van Ark (2003); and Bogliacino and Pianta (2010)

According to the characteristics of each technological group, described in the beginning of this section, in the first column we include the scale intensive industries (NACE codes 10, 11, 12, 19, 22, 23, 24, 25, 29 and 30), that are characterized by low and medium low technology. In the second column we include the specialized suppliers industries (NACE codes 28, 32 and 33), that are characterized by medium low and medium high technology. In the third column we include the science based industries (NACE codes 20, 21, 26 and 27), that are characterized by medium high and high technology. Finally, in the fourth column, the supplier dominated industries (NACE codes 13, 14, 15, 16, 17, 18 and 31) that are characterized by low and medium low technology.

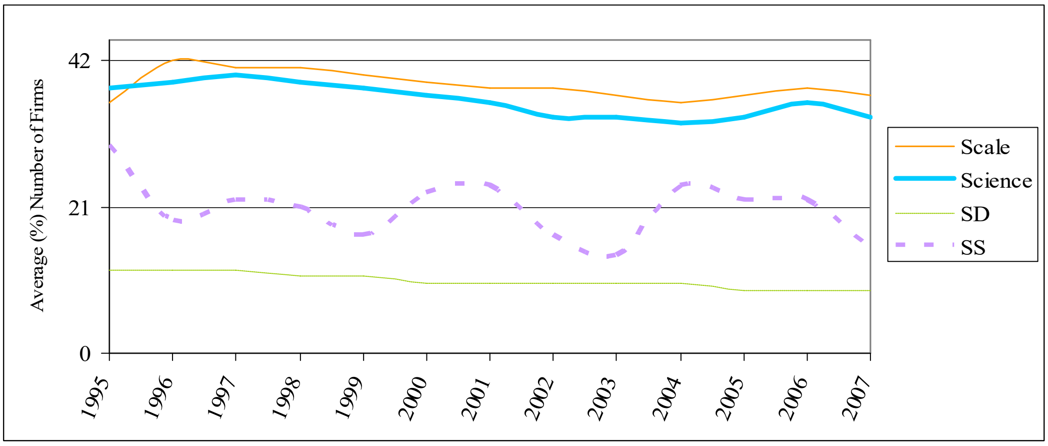
Figures 4 to 6 show the representativeness of our sample by technological group compared with total values from *Quadros do Pessoal*.

Figure 4-Representativeness of our database (Turnover %), by Technological groups



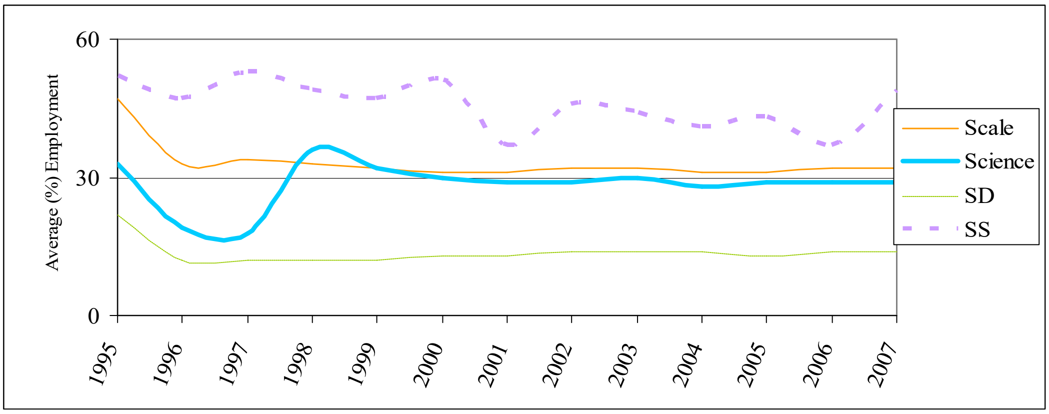
Source: author's calculations

Figure 5-Representativeness of our database (Number of firms %), by Technological groups



Source: author's calculations

Figure 6-Representativeness of our database (Employment %), by Technological groups



Source: author's calculations

Regarding turnover, the most representative technological group is the specialized suppliers with an average of 14%; while the groups of science-based and scale-intensive industries represent 3-4% on average, in 1995-2007. The supplier dominated industries represent 6% on average in the same period. Concerning the number of firms, scale-intensive and science-based industries represent on average 36-38%; while supplier dominated and specialized suppliers represent 10-21%, on average. Finally, as regards the employment (measured by the number of employees), the specialized suppliers represent 46% on average; followed by science-based and scale-intensive industries with 29-33% and the supplier dominated industries represent 14%.

In the last decade, empirical work inspired on Pavitt's taxonomy has been encouraged by the rapid diffusion of the Community Innovation Survey (CIS) in Europe which allowed expanding the set of factors used to describe the dominant technological trajectories followed by innovating firms in the economies. These works have focused on the distinction between product and process innovation, the relevance of organizational innovation, the composition of R&D expenditures and the patterns of interactions of innovative firms with other firms and institutions (e.g, Veugelers and Cassiman, 1999; Mairesse and Mohnen, 2002; Reichstein and Salter, 2006).

A key aspect of Pavitt's taxonomy is the focus on *vertical linkages* as a way of resource interchange that enhances the competitiveness of the economy. According to the Home Market Hypothesis, university-industry links are more important on science-based industries; upstream linkages in related production technologies are more important for scale intensive and supplier-dominated industries, while downstream linkages are more relevant to shape the competitive position of specialised suppliers (Laursen and Meliciani, 2000; Castellacci, 2007).[19] Since the nature of science-based firms requires more diversity of R&D activities than the strictly required for current output, these industries provide more technological opportunities for suppliers, rivals and customers (Pavitt et al., 1989).

Bearing this in mind, we now perform an analysis of the correlation between the dependent variable *TFP* and the independent variables of equation (8) by technological groups, with special emphasis on measures of foreign presence, in order to ascertain what groups of industries potentially benefit from externalities from FDI.

[19] First proposed by Corden (1970) and developed by Krugman (1980), The Home Market Effect integrates the New Trade Theory and is derived from models with returns to scale and transportation costs. It mainly consists of a hypothesized concentration of certain industries in large markets.

4.2. CORRELATION BETWEEN VARIABLES

There may be important common features in each technological group that shape a positive (or negative) correlation between the TFP growth and the foreign presence and other control variables. Bearing this in mind, we perform an analysis of bilateral correlations in the context of Pavitt's taxonomy. However, because the correlation analysis is not multivariate, it is just illustrative, hold some limitations and does not imply causality.

For example, in scale-intensive and science-based industries, the main source of knowledge and innovation is internal R&D (Bratti and Leombruni, 2009; Pellegrino *et al*. 2012). Mohnen and Hall (2013) find substantial positive impacts of product innovation on productivity. Therefore, science based industries rely heavily on the R&D activities and have the highest rates of productivity growth when compared to suppliers dominated and specialised suppliers groups (Bogliacino and Pianta, 2009).

The exploitation of economies of scale and the higher exposure to better technologies can enhance productivity in the manufacturing sector (Isaksson, 2007). For that reason, during the 1960's, it was expected that scale intensive and science-based sectors were likely to facilitate the catching up (Gerschenkron, 1962). Accordingly, Silva and Teixeira (2011), supported by empirical results for 'relatively less developed' countries in 1979-2003, conclude that substantial benefits have accrued to countries that allocated resources to more technologically advanced industries.

One example of successful adaptation of foreign technology to build productive capacity and integrate into the global economy is Thailand. From the mid-1990s onwards, when the comparative advantage in cheap labour got eroded, the leading exports have changed to science-based and scale-intensive products such as computer and electronics and electrical appliances. As a result, Thai economy grew at an average rate of 7.3-7.8 per cent a year, during the last three decades.

According to Moreira (1997), in Portugal, a great share of FDI flows in the manufacturing had been directed to scale intensive (metals, food and beverages) and science-based industries (computer and electronics). Thus, we expect that scale intensive and science based industries show a greater positive association between domestic firms and foreign presence variables and the TFP growth.

Table 9 compares the Pearson correlation coefficients between the TFP growth of the domestic firms with the control variables in our empirical model, for the manufacturing sector and by technological groups. This coefficient is a measure of the strength of the linear relationship between two variables.

Table 9- Correlation coefficients between the control variables and the productivity growth, for the manufacturing sector and by technological groups

	hfd	rd	mrdf	s	tg	kl
Manufacturing sector	-0.0562*	-0.0987*	0.0488*	-0.1250*	-0.4021*	-0.1942*
Scale intensive	-0.0137	-0.0530*	0.0860*	-0.0761*	-0.3336*	-0.1895*
Specialized	0.0715*	-0.2686*	-0.0608*	-0.2989*	-0.6536*	-0.3247*
Science based	-0.0390*	-0.2396*	0.0766*	-0.1167*	-0.3297*	-0.6765*
Supplier dominated	-0.1469*	-0.1066*	0.0778*	-0.1836*	-0.3513*	-0.3105*

Note-variables are in logs. * denotes significance level of 0.05. Correlation only for domestic firms.
Source: Own calculations in Stata 13.0

All coefficients are significant at 5% level, except for the concentration measure in the scale intensive industries.

The coefficients are negative for the relationship between the variable *hfd* (concentration) and the TFP growth for the manufacturing and for most of technological groups, except for the specialized supplier's industries, which is positive and significant (0.0715). As stated in section 2, the expected sign for the correlation between this variable and the TFP growth is not predefined, because the Herfindahl index measures firms in relation to their industry and it is also an indicator of the degree of competition between them. In the specialized suppliers industries, the sign of the impact of the variable *hfd* on the TFP growth is positive, implying that the market power can facilitate the access to the necessary resources for domestic firms to increase their productivity. For the remaining technological groups, it appears that the monopolistic inefficiencies are causing a decrease in the rate of innovation and, thus, a loss of productivity. Thus, the overall effect in the manufacturing sector is negative (-0.0562).

Contrary to what was expected, the coefficients are negative for the relationship between the variable *rd* (a proxy for the absorptive capacity of domestic firms) and the TFP growth for the manufacturing and for all the technological groups. This may point to the fact that much firms' performed R&D do not impact directly on their productivity growth.

We confirm the sign of correlation coefficients between the variable *mrdf* (a proxy for the average stock of foreign knowledge) and the TFP growth, except in the specialized suppliers industries which is negative (-0.0608). This seems to reveal that, in these industries, the average stock of foreign knowledge does not have influence on domestic firms' productivity growth.

Contrary to what is expected, the coefficients are negative for the relationship between the variable *s* (scale) and the TFP growth for the manufacturing and all the technological groups. This implies that small firms may benefit more from the foreign presence than large firms.

As stated in section 2, the expected sign for the correlation between the variable *tg* (technological gap) and the TFP growth is not predefined, because if the technological gap is too low, foreign firms will transmit few benefits to the domestic firms; but the gap cannot be too high, otherwise domestic firm would not be able to absorb the foreign knowledge. Because this measure is constructed as a ratio of labour productivity of domestic firms to the labour productivity of the presumptive foreign leader in each industry, the larger the variable tg the more technologically sophisticated is the domestic firm (the lower the distance to the technological leader). Thus, because all the coefficients are negative, it appears that if the technological gap is too low, foreign firms will transmit few benefits to the domestic firms.

Our expectations about the sign of correlation between the variable *kl* (capital intensity) and the TFP growth were not fulfilled. Indeed, all groups show negative coefficients which appears to imply that labour intensive domestic firms benefit more from TFP increases than the capital intensive firms.

Table 10 reports the correlation coefficients between the TFP growth and the alternative measures of foreign presence (turnover, capital and value added, as explained in section 3.3) in the manufacturing sector, and by technological groups.

Table 10- Correlation coefficients between measures of foreign presence and the productivity growth, for the manufacturing sector and by technological groups

	Measure of foreign presence	horiz	back	for
Manufacturing sector	Turnover	0.1451*	0.0891*	0.0805*
	Capital	0.0583*	0.0413*	0.0334*
	Value Added	0.1280*	0.0820*	0.0705*
Scale intensive	Turnover	0.2226*	0.2567*	0.2605*
	Capital	0.2127*	0.2619*	0.2659*
	Value Added	0.1975*	0.2483*	0.2522*
Specialized suppliers	Turnover	0.2776*	0.1388*	0.2428*
	Capital	0.1510*	0.0868*	0.1506*
	Value Added	0.2603*	0.1373*	0.2246*
Science based	Turnover	0.3164*	0.0056	-0.0368*
	Capital	0.3398*	-0.0884*	-0.2137*
	Value Added	0.3065*	0.0008	-0.0431*
Supplier dominated	Turnover	0.2313*	0.1052*	0.1123*
	Capital	0.2223*	0.1088*	0.1168*
	Value Added	0.2198*	0.0980*	0.1050*

Note-variables are in logs. * denotes significance level of 0.05. Correlation only for domestic firms. Source: Own calculations in Stata 13.0

As expected all coefficients are positive (except for vertical externalities in science based industries, using capital as the measure of foreign presence) and significant at 5% level (except for foreign presence in downstream industries in science based industries, using turnover and the value added as measures of foreign presence).

The negative results (-0.0884 and -0.2137, respectively for externalities via backward and forward linkages) for vertical externalities in science based industries (using capital as the measure of foreign presence) indicate that differences in technology between countries prevent domestic suppliers/clients to establish linkages with foreign firms in upstream and downstream sectors.

5. CONCLUSION

Externalities from FDI may have an impact on domestic firms' productivity. However, the correct evaluation of these effects requires an adequate database with relevant variables. Hitherto, there were no attempts to construct such a database for Portugal. Hence, the purpose of this article is to describe the construction of a database to estimate externalities from FDI at horizontal and vertical level in Portuguese manufacturing firms.

The *status quo* of databases used in the previous studies for Portugal is characterized by the fact that international sources do not possess the necessary variables, while national sources, although providing more comprehensive data, lack similar definitions, data treatment and nomenclatures. AMADEUS, on the other hand, has been widely employed by researchers to estimate externalities from FDI in European countries due to its integrity and broad geographic reach. Thus, based on AMADEUS, we propose the construction of a database for the Portuguese economy containing 5,045 firms over the 1995-2007 period. The database contains three original types of variables; those needed to calculate the TFP, another set of key variables related to foreign presence and, finally, the control variables. The sample of foreign firms contains firms with at least 10% (and a mean of 58%) of foreign capital. Nearly half of foreign firms are Spanish and French that invest in more than 70% of the manufacturing industries. We construct our variables for backward and forward externalities using the IO tables for home countries since the foreign technology expressed in the technical coefficients is different from the domestic.

Before performing the empirical analysis, we analysed the correlations between the TFP growth and the variables related to foreign presence and the control variables, for the manufacturing sector and by technological groups, based on Pavitt Taxonomy. This exercise aimed to provide some indications on what relationships to expect when we estimate the impact of foreign presence and other control variables on the TFP growth of domestic manufacturing firms. Bearing this in mind, we grouped the industries according to the nature and sources of technological change, in order to identify patterns of technological innovation and, therefore, to better gauge the opportunities of technological catch-up caused by the foreign presence in the host economy.

Correlation results indicate that the foreign presence is positively and significantly correlated with the TFP growth. Furthermore, the sign and magnitude of the coefficients for the control variables indicate that the concentration, the stock of foreign knowledge and the technological gap potentially assist the technical efficiency of domestic firms, but only in certain technological groups. Indeed, only concentraded industries in specialized suppliers seem to benefit from positive effects of market power; However, the specialized suppliers is the only technological group that experience a decrease in the TFP due to the stock of foreign knowledge.

Overall, it appears that monopolistic inefficiencies cause a decrease in the rate of innovation and, thus, a loss of productivity of domestic manufacturing firms; secondly, a substantial amount of the firms' R&D activities do not impact directly on their productivity growth; thirdly, small firms may benefit more from increases in their TFP than large firms; fourthly, if the technological gap is too low, foreign firms will transmit few benefits to the domestic firms; and finally, capital intensive firms seem to experience decreases in their TFP.

Regarding implications for the empirical research, the correlations results may point to the occurrence of positive and significant externalities from FDI (both horizontal and vertical) in the manufacturing industry, and a positive impact of concentration and the stock of foreign knowledge and a negative impact of the technological gap (constructed as an inverse measure) on the TFP growth of domestic manufacturing firms, i.e, preliminary analysis of data seem to support the catching-up hypothesis described in section 2, rather than the technology-accumulation hypothesis. The results suggest that technologically backward firms are able to exploit the technologies developed by foreign firms and experience higher TFP increases than the technological sophisticated ones. If this is the case, then there is some expectation on productivity convergence due to foreign presence in the Portuguese manufacturing sector.

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APPENDIX A

Construction of variables

We describe how we constructed the variables that proxy the foreign presence at horizontal level (*hor*) and vertical level (*back* and *for*). We start by calculating the variable *hor* as indicated in equation (I9) and whose basic statistics are in Table 7. Alternative measures hor, *hoz and hoz1 were* constructed, using turnover, tangible assets and value added, respectively.

Next, we used the OECD IO tables to calculate the coefficients δ_{jk} and λ_{kj} of equations (10) and (11). Since we have only two years available for all countries (1995 and 2000), we use the coefficient of 1995 for years 1995 to 1999 and the coefficient of 2000 for years 2000 to 2007. We are assuming that these coefficients are constant over time.

Table A1 shows that the IO tables from OECD are not fully harmonized regarding the currency.

Table A1-Description of the OECD Input-Output Tables

Country	1995 Table	1995 Currency	2000 Table	2000 Currency
Germany	total use	millions DEM	basic prices	millions EUR
Italy	basic prices	millions EUR	basic prices	millions EUR
Korea	total use	millions KRW	basic prices	millions KRW
Netherlands	basic prices	millions EUR	basic prices	millions EUR
Portugal	total use	millions EUR	basic prices	millions EUR
Spain	total use	millions ESP	basic prices	millions EUR
Sweden	basic prices	millions SEK	basic prices	millions SEK
UK	basic prices	millions GBP	basic prices	millions GBP
USA	producer prices	millions USD	producer prices	millions USD
Austria	basic prices	millions EUR	basic prices	millions EUR
Belgium	basic prices	millions EUR	basic prices	millions EUR
Brazil	basic prices	Thousand BRL	basic prices	Thousand BRL
Canada	basic prices	millions CAD	basic prices	millions CAD
Denmark	basic prices	millions DKK	basic prices	millions DKK
Finland	total use	millions FIN	basic prices	millions EUR
France	total use	millions FRF	basic prices	millions EUR
Japan	producer prices	millions JPY	basic prices	millions JPY
Luxembourg	basic prices	millions EUR	basic prices	millions EUR
Norway	basic prices	millions NOK	basic prices	millions NOK

Source: author’s analysis

Indeed, in addition to the Euro, other currencies serve as reference in IO tables from Canada, Denmark, United Kingdom, Japan, Korea, Norway, Sweden, USA, and Brazil. However, for our analysis what matters is the ratio between the intermediate consumption of each sector to total manufacturing intermediate consumption.

The manufacturing sectors in the OECD IO tables are classified according to classification ISIC Rev.3, as shown in Table A2. We allocate another code of our own designation when we introduce the technical coefficients in Stata 13.0.

Table A2- Equivalence of ISIC Rev.3 codes used in OECD Input-Output tables into NACE Revision 2 codes

ISIC Rev.3	Description	Our codes	NACE Rev. 2
15-16	Food Products, Beverages, and Tobacco	4	10-12
17-19	Textiles, Textile Products, Leather, and Footwear	5	13-15
20	Wood and Products of Wood and Cork	6	16
21-22	Pulp, Paper, Paper Products, Printing, and Publishing	7	17-18
23	Coke, Refined Petroleum Products, and Nuclear Fuel	8	19
24ex2423	Chemicals Excluding Pharmaceuticals	9	20
2423	Pharmaceuticals	10	21
25	Rubber and Plastics Products	11	22
26	Other Non-Metallic Mineral Products	12	23
271 2731	Iron & Steel	13	24
272 2732	Non-Ferrous Metals	14	24
28	Fabricated Metal Products, Except Machinery and Equipment	15	25
29	Machinery and Equipment, N.E.C.	16	28
30	Office, Accounting, and Computing Machinery	17	26
31	Electrical Machinery and Apparatus, NEC	18	27
32	Radio, Television, and Communication Equipment	19	33
33	Medical, Precision and Optical Instruments	20	32
34	Motor Vehicles, Trailers, and Semi-Trailers	21	29 e 30
351	Building and Repairing of Ships and Boats	22	30
353	Aircraft and Spacecraft	23	30
352, 359	Railroad Equipment and Transport Equipment N.E.C.	24	29
36-37	Manufacturing Nec; Recycling	25	31

Source: author's classification based in EUROSTAT

In order to calculate the coefficients δ_{jk} in equation (10), for example for sector 4, we divide each matrix *element* by the *column* sum (see Table A3). In other words, we calculate: a4-4/ΣJ-4 , ... , a25-4/Σaj-4, where the a_{ij} are the technical coefficients from the IO tables. However, we exclude the main diagonal coefficients (in this example, we exclude the element a4-4) because they are included in the calculation of the variable *Hor*.

Table A3- Example of a matrix to calculate the Backward coefficients

Sectors	4	....	25
4	a_{4-4}	.....	a_{4-25}
......	.....	......	......
25	a_{25-4}	....	a_{25-25}
X	$\sum a_{j-4}$	.....	$\sum a_{j-25}$

Source: author's analysis

Likewise, we calculate the coefficients λ_{kj} in equation (11) for sector 4, by dividing each matrix *element* by the line *sum* (see Table A4). In other words, we calculate: a4-4/Σa4-i , ... , a4-25/Σa4- We exclude the main diagonal coefficients because they are included in the calculation of the variable *Hor*.

Table A4- Example of a matrix to calculate the Forward coefficients

Sectors	4	....	25	Y
4	a4-4	.....	a4-25	∑a4-i
......	.....	......	......	.....
25	a25-4	....	a25-25	∑a25-i

Source: author's analysis

Subsequently, we need to convert the coefficients in OECD tables which now have our own codes (4 to 25) into NACE Revision 2 (10-33). Since some coefficients gather together two or more industries, we need to allocate them to every industry of NACE Rev.2.

Hence, we summed the IO coefficients for sectors 10-12 in the table of domestic production at basic prices for 2006, from Portuguese National Accounts, and calculate the share of each sector in the total of the three sectors. We proceeded using the same methodology for the remaining aggregated sectors as shown in Table A5.

Table A5- Criteria for conversion of OECD coefficients for aggregated sectors into NACE sectors

Sector codes Our codes	Nace Rev. 2	Shares (%)
4	10	87
	11	12
	12	1
5	13	27
	14	54
	15	19
7	17	34
	18	66
21	29	89
	30	11

Source: author's analysis

We are assuming that the shares from foreign countries do not differ much from the Portuguese and that they are stable over time.

Next, we multiply each share by the respective IO coefficient. We performed these calculations for each of the 18 foreign investors in the Portuguese manufacturing industries. We obtain the average *back* and *for* coefficients by summing the coefficients of each investor Country and dividing by the number of investors in the industry.

For example, in industry 10, our sample contains 10 investor countries. In order to calculate the average backward coefficient, we sum the coefficients back $_{11\text{-}10}$, ... , back$_{33\text{-}10}$ for the respective countries and divide by 10.

To calculate the forward coefficients, we proceed similarly. The average forward coefficient for sector 10 is obtained by summing the coefficients forw$_{10\text{-}11}$, ... forw$_{10\text{-}33}$, for all investor Countries and dividing by the number of countries.

The basic statistics for coefficients backward (Cba) and forward (Cfo) for 1995 and 2000 are shown in Table A6.

Table A6- basic statistics for coefficients of backward and forward externalities, 1995 and 2000

Year	Variable	Obs	Mean	Std. Dev.	Min	Max
1995	Cba	5045	0.17	0.23	0.0006	0.86
1995	Cfo	5045	0.49	0.30	0.0006	0.89
2000	Cba	5045	0.19	0.20	0.0006	0.82
2000	Cfo	5045	0.41	0.26	0.0007	0.83

Source: author's calculations in Stata 13.0

We obtain three measures of foreign presence in downstream industries *b1, b2* and bb, by multiplying the IO coefficients by *hor, hoz* and *hoz1*, respectively. The same procedure was performed to obtain three measures of foreign presence in upstream industries *f1, f2* and *ff.*

APPENDIX B

Correlations between Input-Output tables

Researchers use the IO coefficients to calculate the flows of technology. The use of host country's IO technical coefficients implies that MNCs have the same production technology as local firms (Barrios et al, 2010). This procedure challenges the assumption of externalities from FDI arising from contacts with MNCs that possess superior technology (e.g., Markusen, 2002). The International Business literature has provided evidence that the sourcing policy of a MNC depends largely on its nationality. Moreover, the evidence suggests that MNCs use similar production technology in the host country to that used at home, hence, it is likely that their supply strategies are also similar. Therefore, Barrios et al. (2010) suggest that before using host country IO coefficients, researchers should test their correlation with the IO coefficients of the investor country to conclude whether the domestic coefficients are a good proxy of foreign technology.

We calculate the correlation between the IO tables from OECD. Our database contains foreign investors from 18 countries. Hence, we assign numbers from 1 to 19 for Portugal and each of investor countries, as shown in Table B1.

Table B1- Country codes

Code	Country	Code	Country
1	Germany	11	Belgium
2	Italy	12	Brazil
3	Korea	13	Canada
4	Netherlands	14	Denmark
5	Portugal	15	Finland
6	Spain	16	France
7	Sweden	17	Japan
8	United Kingdom	18	Luxembourg
9	USA	19	Norway
10	Austria		

Source: author's analysis

We calculate the variables *back* and *for* as explained in Appendix A. Then, we calculate the partial correlation of these coefficients for country 5 (Portugal) with the respective coefficients for the foreign investor countries. Tables B2 and B3 show the correlation of Cba and *Cfo*, respectively.

Table B2- Partial correlation between the variables that proxy backward linkages for foreign investor countries with the respective variable for Portugal

Variable	Corr.	Sig.	Variable	Corr.	Sig.	Variable	Corr.	Sig.
Cba1	-0.2616	0.671	Cba8	0.4157	0.486	Cba14	0.1903	0.759
Cba2	0.3823	0.525	Cba9	-0.7392	0.153	Cba15	-0.5894	0.296
Cba3	0.8286	0.083	Cba10	0.1093	0.861	Cba16	0.1326	0.832
Cba4	0.3106	0.611	Cba11	-0.0024	0.997	Cba17	0.4846	0.408
Cba6	0.5922	0.293	Cba12	0.3350	0.582	Cba18	-0.2226	0.719
Cba7	-0.2266	0.714	Cba13	-0.3351	0.581	Cba19	-0.0984	0.875

Note- the numbers of each *Cba* correspond to country code. Source: author's calculations in Stata 13.0

Regarding the variable that proxies backward linkages, the only countries where the coefficient is strongly correlated with Portugal are Korea and Spain. Moreover, this variable has a significant negative correlation with the coefficients for the USA and Finland.

Table B3-Partial correlation between the variables that proxy forward linkages for foreign investor countries with the respective variable for Portugal

Variable	Corr.	Sig.	Variable	Corr.	Sig.	Variable	Corr.	Sig.
Cfo1	-0.8405	0.075	Cfo8	-0.7834	0.117	Cfo14	0.8612	0.061
Cfo2	0.4994	0.392	Cfo9	0.8180	0.091	Cfo15	0.6906	0.197
Cfo3	0.8133	0.094	Cfo10	0.8628	0.060	Cfo16	-0.8357	0.078
Cfo4	0.5700	0.316	Cfo11	0.2743	0.655	Cfo17	0.6162	0.268
Cfo6	-0.0507	0.935	Cfo12	-0.7581	0.138	Cfo18	0.8356	0.078
Cfo7	0.8288	0.083	Cfo13	-0.2057	0.740	Cfo19	-0.8071	0.099

Note- the numbers of each *Cba* correspond to country code. Source: author's calculations in Stata 13.0

The variable that proxy forward linkages for Portugal (C5) is strongly correlated with the ones for Korea, Netherlands, Sweden, USA, Austria, Denmark, Finland, Japan, and Luxembourg. However, it has a significant negative correlation with the coefficient for the UK, Germany, Brazil, France, and Norway. Hence, we chose to use home countries' IO tables instead of those for Portugal.