Determinants of FDI-induced externalities:

New empirical evidence for Mexican manufacturing industries

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Abstract

In this paper, I use unpublished and thus far unexplored data from the Mexican 1993 economic census to estimate whether the presence and operations of foreign-owned firms create externalities among Mexican manufacturing industries. Furthermore, I identify factors that stimulate these externalities. The new empirical results are important in three respects. First, the results offer no support for the concept of absorptive capacity being a determinant of positive externalities. Instead, the findings indicate the crucial importance of the presence or absence of direct competition between Mexican and foreign-owned firms for the creation of negative or positive externalities. Second, the level of geographical concentration of manufacturing industries is identified as a structural determinant of both positive and negative externalities. Finally, having controlled for the effects of the identified structural determinants of externalities, the remaining effect of FDI is the creation of negative externalities. This finding is in contrast to previous findings for Mexico, but more in line with recent findings from other host economies.

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1. Introduction

In the last few decades, the operations of multinational enterprises (MNEs) and foreign direct investment (FDI) have received increasing recognition as important determinants of national and international processes of economic development. This recognition is not only due to the unprecedented expansion of the volume of international capital flows, but also to the fact that the presence of FDI can have far-reaching direct effects on processes of economic development in host economies. These effects are usually referred to as the economic impact of FDI, including effects such as job creation, capital accumulation, human capital accumulation and the creation and diversification of export flows.

In recent years a growing controversy is arising concerning a specific indirect effect of FDI. This effect takes shape in the form of technological spillovers or technological externalities, referring to situations where the presence and/or operations of FDI unintentionally affect efficiency or productivity levels of domestic firms in the host economy. The body of empirical research into FDI-induced spillovers has grown rapidly, engaged in the identification and quantification of such externalities arising from international investment.

The findings from the initial attempts to statistically identify externalities from FDI suggest that the presence of FDI creates positive external effects in host economies. However, recent new empirical results seriously challenge these findings in two important ways. First, not only do they suggest that positive spillovers may be less prevalent as previously thought, but, more importantly, they also indicate that the presence of foreign firms may lead to significant negative externalities. In such cases,

domestic firms are negatively affected in their efficiency or productivity levels as a result of the operations of foreign affiliates. Second, recent empirical findings suggest that structural factors affect the occurrence of externalities. The sole factor that is commonly recognised relates to the concept of absorptive capacity, indicating that positive externalities from FDI may occur only when domestic firms possess a sufficient level of technological knowledge to absorb positive externalities from FDI. Having said so, the translation of this concept into empirical research appears open to different interpretations. As a result, empirical findings vary considerably. Furthermore, the problems with this structural factor indicate that there is a clear need to identify alternative determinants of FDI-induced externalities.

This paper examines these issues and presents empirical evidence on the occurrence of externalities from FDI in Mexico. The view that the presence of foreign affiliates creates positive externalities relies heavily on a body of empirical evidence from a set of empirical studies on externality effects of FDI in Mexico. However, as these studies are largely based on the analysis of data from the 1970 Mexican economic census, these positive findings may have become less relevant in discussions on contemporary effects of international investment in Mexico and elsewhere.

The empirical analysis in this paper corrects for this, using unpublished and thus far unexplored data from the Mexican economic census of 1993. The question that is addressed in this paper is three-fold. First, are there externalities occurring due to the presence of foreign investment in the manufacturing industries in Mexico? Second, does the concept of absorptive capacity offer an explanation for possible

structural differences in the occurrence of these externalities? Third, are there other structural factors that affect the occurrence of these externalities?

The remainder of the paper is constructed as follows. Section 2 consists of two parts. First, I introduce the concept of FDI-induced externalities and discuss the main mechanisms through which these externalities may arise. Second, I analyse the use of the concept of absorptive capacity and introduce the concept of geographical concentration or proximity of manufacturing firms as an alternative determinant of externalities from FDI. The third section contains a brief overview of some key findings of previous empirical research on externality effects of FDI in Mexico. Section four discusses the data and the empirical model. Section five presents the empirical findings. Finally, section six summarises and concludes.

2. FDI-induced externalities, absorptive capacity and geographical concentration

2.1. FDI-induced externalities

Technological externalities or spillovers can be said to arise '…when someone's actions affect anyone else in either a positive or negative way, and this effect is not (fully) paid for [in the case of a benefit] or fully compensated [in the case of a cost]' (Bureau of Industry Economics, 1994, p. 7)[2]. As Perez argues, as some of the effects of FDI on firms in a host economy are unintentional, and foreign affiliates are not compensated for the effects, such effects of FDI should be interpreted as representing externalities (Perez, 1996). Blomström and Kokko (1998) offer a more specific

[2] For related definitions, see Bator (1958), Meade (1952; 1973), Buchanan and Stubblebine (1962), Papandreou (1994).

definition, one that reflects the implicit or explicit use of the concept in most contemporary research on FDI and spillovers. They state that spillovers occur '….when the entrance or presence of MNE affiliates leads to productivity or efficiency benefits in the host country's local firms, and the MNEs are not able to internalise the full value of these benefits' (Blomström and Kokko, 1998, p. 3)[3]. Although this definition only refers to positive externalities, it can easily be applied to negative externalities as well. Negative externalities exist when the entrance or operations of FDI lead to productivity or efficiency loss among domestic firms, and foreign affiliates do not have to compensate domestic firms for their loss.

Important to consider here is that although these definitions of external effects of FDI refer to *technological externalities*, they do not exclude *pecuniary externalities* as such. The main difference between technological and pecuniary externalities rests on whether or not the effects of the actions of an economic agent are transmitted through the market mechanism (Viner, 1953, Scitovsky, 1954; Papandreou, 1994)[4]. Technological externalities refer to situations where the effects of the actions of an economic agent are not transmitted through the market mechanism, whereas pecuniary externalities refer to situations where the effects are transmitted through the market mechanism.

Given the fact that the use of the concept of technological spillovers in applied research on FDI-related externality effects is rather ambiguous, as pecuniary effects are considered as well, I will use the more general term of *FDI-induced externalities*.

[3] See also Dunning (1993) and Caves (1996) for similar interpretations.
[4] For a full discussion of the controversies surrounding the original introduction of the concept of externalities by Marshall (1890) and Pigou (1924) and subsequent disagreements regarding its relevance and interpretations, see Mishan (1971) and Papandreou (1994).

These externalities may be of a technological or pecuniary nature and refer to both positive and negative effects.

2.2. Channels of externalities

Four main mechanisms that may facilitate FDI-induced externalities can be distinguished.[5] One mechanism refers to demonstration and imitation effects, where domestic firms learn from or copy new technologies that are used by foreign-owned affiliates (Aitken et al., 1997). If domestic firms can successfully implement this new knowledge in their production process resulting in enhanced efficiency, these effects represent externalities, as FDI is not compensated for this increase in host economy efficiency (Blomström and Kokko, 1998; Caves, 1996).

Second, buyer-supplier linkages between FDI and domestic firms may facilitate externalities in two ways. First, they may create positive externalities if foreign firms establish supportive linkages and the benefits of the support are not fully recovered by foreign-owned firms (see Lall, 1980). Second, if the presence of FDI forces domestic firms to become more efficient in order to become suppliers to foreign affiliates (disregarding any support), the increase in host economy efficiency can be interpreted as a positive pecuniary externality.

The third channel operates through the combination of processes of human capital accumulation and labour turnover. Domestic employees working in foreign affiliates can gain skills that are not available in domestic production technologies. If they subsequently substitute a domestic for a foreign employer and apply these skills

[5] For full discussions of these mechanisms, see Blomström and Kokko (1998), Kumar (1996) and Caves (1996); see also Hanson (2001)a.

and knowledge in domestic firms, efficiency improvements may arise (Blomström and Kokko, 1998). This represents a form of positive externalities, as domestic firms do not have to compensate FDI for their use of better qualified and skilled labour.

Finally, FDI's effect on the market structure or level of competition may lead to the occurrence of externalities. At present, this channel is the most disputed one, as there is disagreement concerning the type of effect. On the one hand, the presence of FDI can be assumed to increase competition, which may force domestic firms to become more efficient (Caves, 1996), thus representing a positive externality. On the other hand however, recent empirical findings indicate that the presence of FDI may also lead to negative externalities[6]. The explanation for this is that the increase in competitive pressure may lead to efficiency decreases, if FDI reduces the market share of domestic firms. Under this scenario, the decrease in volume of domestic production may lead to inefficiencies due to the loss of benefits from economies of scale (Aitken and Harrison, 1999), thus representing a negative externality.

2.3. Determinants of FDI-induced externalities

2.3.1. Absorptive capacity

The identification of separate channels that transmit externalities from FDI is helpful in understanding how domestic efficiency or productivity in host economies may be affected. However, it does not provide insight into the conditions that may stimulate positive externalities. As Blomström and Kokko (2003) argue, there appears to be a

systematic pattern, where various host industry and host country characteristics influence the incidence of externalities[7]. Reviewing the available empirical evidence, they conclude that '……the ability and motivation of local firms to engage in investment and learning to absorb foreign knowledge and skills is an important determinant of whether or not the potential spillovers will be realized' (Blomström and Kokko, 2003, p. 16).

Following the underlying concept of absorptive capacity by Cohen and Levinthal (1990)[8], the idea is that a host economy can only benefit from FDI-induced externalities when domestic firms possess a sufficient level of technological development – *a sufficient level of absorptive capacity* – that allows them to absorb foreign-owned technologies. For instance, the aforementioned demonstration effect from the presence of FDI can only occur when domestic firms have a sufficient level of technological knowledge that allows them to copy technologies from foreign-owned firms. If such knowledge is lacking, domestic firms will not be able to successfully copy these technologies; hence no positive externalities will materialize.

A good example of the possible effect of the level of absorptive capacity of domestic firms in a host economy is offered by Kinoshita (1999). His general estimations indicate that industry-wide foreign participation is not significantly associated with measured productivity of a sample of domestic plants in the Czech Republic (see Kinoshita, 1999). However, when distinguishing between domestic firms based on the level of R&D investment they make, the estimations indicate a significant positive association for those domestic firms that have relatively high

[6] For recent empirical evidence of a significant negative association between FDI and host economy productivity, see Aitken and Harrison (1999), Harrison (1996), Konings (2000), Djankov and Hoekman (2000) and Zukowska-Gagelmann (2000).
[7] See also Blomström et al. (1999).

levels of spending on R&D. Taking the level of R&D spending as an indication of the level of absorptive capacity of domestic firms, this result suggests a positive effect of the level of absorptive capacity on the occurrence of positive FDI-induced externalities (see Kinoshita, 1999).

Having said so, the majority of empirical studies rely on more indirect indicators of the level of absorptive capacity of domestic firms. Aitken and Harrison (1999) distinguish between small and large domestic firms, arguing that it is more likely that large firms will possess a sufficient level of absorptive capacity to benefit from the presence of FDI. Alternatively, the overall level of technological complexity of industries can be interpreted as an indication of the likelihood that externalities will arise (Kokko, 1994). The idea here is that externalities are more likely to arise in industries with a relative low level of technological complexity, as the difference in technological capabilities between foreign-owned and domestic firms is more limited in these industries compared to technologically complex industries. Finally, the size of the technological differences, or *technology gap*, between foreign and domestic firms appears to influence the occurrence of externalities (Wang and Blomström, 1992; Haddad and Harrison, 1993). Similar to the level of technological complexity of industries, FDI-induced externalities are more likely to arise in industries where the technology gap between foreign and domestic firms is limited.

2.3.2. Absorptive capacity or competition?

Although the factor of absorptive capacity is regarded as a factor structurally affecting the occurrence of externalities, empirical research suffers from the problem that the

[8] See also Nelson and Phelps (1966) and Keller (1996)

indirect indicators of this type of capacity are open to alternative interpretations. Important to consider here is that the concept of absorptive capacity was originally introduced into research on FDI-induced externalities with a focus on explaining the occurrence of positive externalities from FDI. However, as mentioned earlier, recent studies have found that the presence of foreign affiliates may also create negative externalities. Starting from the premise that the presence of FDI may lead to both positive and negative externalities, factors such as technological complexity and technological differences may need to be interpreted differently.

According to the original interpretation of the effect of absorptive capacity, an industry that is characterised by a limited technological difference between foreign and domestic firms is more likely to experience positive externalities. However, the limited level of technological differences may also indicate that there will be a relative high level of direct competition between FDI and domestic firms. This competition effect may have a negative impact on host economy productivity. If this is the case, industries that are characterised by small technology gaps may experience negative externalities from the presence of FDI, due to the existence of direct competition between the two types of firms.

An example of empirical evidence that fits this alternative scenario is offered by Barrios (2000). Estimating FDI-induced externality effects for a large panel of Spanish manufacturing firms, he finds a structural difference between high tech and low tech industries. However, whereas in high tech industries there is no significant effect from foreign participation, in low tech industries the estimated significant effect is negative (see Barrios, 2000). The absorptive capacity hypothesis would predict a positive sign. However, when considering that it is likely that foreign and Spanish

firms are in direct competition in low tech industries due to the relative limited size of technological differences, the estimated negative externality effect can be interpreted as a negative competition effect.

A similar type of finding is presented by Zukowska-Gagelmann, who estimates externality effects from FDI for a large set of manufacturing plants in Poland for the period 1993-1997. Summarising the main results, Zukowska-Gagelmann states that 'FDI is found to have a negative impact on the performance of the most productive local firms in high competition industries. By contrast, the effect on the least productive state firms in low competition industries in positive' (Zukowska-Gagelmann, 2000, p. 223). Again, the difference in estimated effect of FDI can be explained by the presence or absence of negative externality effects from direct competition between foreign-owned and domestic firms, indicated by the size of the technology gap.

Finally, Castellani and Zanfei (2003) use a firm-level data base of manufacturing firms in France, Italy and Spain for the period 1993-1997. Their empirical findings are in support of the interpretation of the technology gap representing the presence or absence of direct competition. Their estimations indicate the significant presence of positive FDI-induced externalities, but only in those industries that are characterised by large technology gaps, suggesting the absence of negative (pecuniary) externalities that may arise when FDI and domestic firms are in direct competition for market shares.

Therefore, it appears that the expected effect of the level of technological differences or technological complexity may be to stimulate either positive and negative FDI-induced externalities, depending on whether it represents the capacity of

domestic firms to absorb technology, or alternatively indicates the presence of direct competition between domestic and foreign-owned firms.

2.3.3. Geographical concentration

Empirical estimations of externalities and productivity effects are not confined to research on FDI-induced externalities. In fact, contemporary research on externalities attaches great importance to the effect of the type of distribution of firms and industries over geographical space. From different strands of theory, the premise is that firms in a geographical concentration of economic activity may benefit from external economies that are unique related to the existence of the geographical concentration of activity.

. Marshall (1890) introduced the notion that geographical concentration of industries may lead to the occurrence of external economies, *agglomeration economies*, affecting the level of productivity of firms in an agglomeration of activity[9]. Several mechanisms or micro-foundations of agglomeration economies have been identified (see especially Duranton and Puga, 2003; also Hanson, 2001b). One of these mechanisms is labour market pooling, where firms in an agglomeration benefit from being able to change their labour force as needed, both in terms of quantity and types of skills. Second, an agglomeration allows for the existence of specialised local inputs. Again, firms benefit from being able to buy inputs in changing volumes, of different specifications and types. Finally, the level of geographical proximity between firms facilitates informational spillovers, which may

[9] For an extensive discussion of the concept of agglomeration economies and a review of empirical findings, see Eberts and McMillen (1999); also Duranton and Puga (2003).

lead to the creation of local pools of knowledge and cross-fertilisation of ideas (Lucas, 1988, 2001; Jacobs, 1969).

FDI-induced externalities and geographical proximity

Intuitively, it seems that the effectiveness of the channels of FDI-induced externalities will be enhanced by the level of geographical concentration of industries[10]. More precisely, geographical proximity between foreign and domestic firms that result from the agglomeration of firms may enhance the workings of the channels. For instance, demonstration and imitation effects are more likely to occur when FDI and domestic firms are located in proximity. A domestic firm is more likely to learn about a new technology when a foreign-owned firm is located in the same city as the domestic firm, as opposed to a situation where the foreign-owned firm is located elsewhere in the host economy.

The process of externalities arising through human capital accumulation and labour turnover is also likely to be positively affected by geographical concentration. It is more likely that domestic employees substitute a domestic firm for a foreign one if both firms are co-located. Also, if both types of firms are located in an agglomeration with a thick labour market (characterised by a high rate of labour turnover), workers will be substituting firms more frequently (see e.g. Angel, 1989), enhancing the likelihood of the occurrence of externalities.

The relation between geographical proximity and inter-firm linkages is a more commonly recognised one, being that proximity between firms enhances inter-firm

linkages (Scott, 1988). This means that, *ceteris paribus*, domestic firms are more likely to be employed as suppliers to FDI if they are located in proximity. Also, as in the case of labour turnover, if the agglomeration of activity leads to a further creation of networks of inter-firm linkages, the likelihood of domestic firms being employed as suppliers to foreign-owned firms will increase.

Finally, the factor of competition is the sole channel where the effect of geographical concentration may enhance the occurrence of negative externalities. The presence of FDI in an agglomeration will lead to an increase in the demand for regionally confined inputs, which will result in an upwards pressure on input prices. This will negatively affect profit levels of domestic firms, which is a form of negative pecuniary externalities.

In sum, the relation between geographical concentration and the channels of externalities from FDI primarily relate to the importance of geographical proximity between domestic and foreign-owned firms. All channels are likely to be more effective when the two types of firms are located in proximity. Furthermore, all channels except competition are likely to stimulate positive externalities. As for the negative competition effect, agglomeration of activity may enhance the occurrence of negative externalities.

3. Previous empirical research

Several empirical studies have addressed the question whether the presence of FDI has resulted in the occurrence of externalities in Mexico. Ramirez (2000) conducts a

[10] The possible effects of geographical concentration on FDI-induced externalities have remained largely unaddressed in empirical studies thus far. Exceptions are Aitken et al. (1997), Aitken and

longitudinal study of short and long term effects of FDI on measured labour productivity for the overall Mexican economy between 1960 and 1995. His findings indicate that changes in both the domestic and (lagged) foreign capital stock are positively related to changes in domestic productivity. He interprets this positive relation between changes in overall labour productivity and foreign capital stock as evidence of the occurrence of FDI- induced externalities in the Mexican economy (Ramirez, 2000, p. 157)[11].

Aitken et al. (1997) offer evidence of the occurrence of externalities arising from demonstration effects related to knowledge and information about exporting practices to international markets[12]. They analyse a large sample of Mexican and foreign firms for the period 1984-1990, finding that those Mexican firms that are located in close proximity to foreign exporting firms are more likely to be engaged in exporting activities themselves. Such a positive relation does not exist when replacing the geographical concentration of foreign-owned exporting activity by overall exporting activity, suggesting an unique contribution from FDI to export activities by Mexican firms. An attempt to identify significant externalities from the presence of FDI through human capital accumulation and labour turnover was unsuccessful, however (see Aitken et al., 1996).

A study suggesting that the presence of FDI may lead to negative effects is presented by Grether (1999), who analyses the process of technology diffusion in the

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Harrison (1999) and Sjöholm (1999).

[11] Ramirez's findings need to be interpreted with caution, though. First, the influx of foreign capital represents a form of capital accumulation in the Mexican economy, which could have productivity enhancing effects without any positive externalities arising. Also, the dependent variable is defined as labour productivity for total manufacturing (Mexican and foreign-owned combined). Assuming that foreign firms produce at a higher efficiency level then domestic firms (see Dunning, 1993), an increasing share of foreign-owned firms in total manufacturing would then result in a higher level of aggregate labour productivity, irrespective of the occurrence of positive externalities.

Mexican economy, using the same database as Aitken et al. (1997). If demonstration/imitation effects from the presence of FDI exist, there should be a positive association between the industry-wide share of foreign participation and the rate of industry-wide technology diffusion, *ceteris paribus*. However, his results show a significant negative association between the two variables (see Grether, 1999), suggesting that foreign firms may be trying to prevent new technology being imitated and copied by domestic firms[13].

Findings from the 1970 sample

An important set of papers rests on the analysis of a database containing industry-wide data from the Mexican 1970 economic census, as first presented by Persson and Blomström (1983)[14]. The main database consists of data for 215 manufacturing industries, for which relevant variables such as value added and number of employees are distinguishable between foreign and domestic ownership.

One of the main findings from the empirical analysis of this database is that FDI in Mexico appears to be creating positive externalities. Controlling for various factors that affect productivity of domestically-owned shares of the industries, the level of industry-wide foreign participation is significantly positively associated with domestic industry-wide measured labour productivity (see Blomström and Persson,

[12] Aitken et al. (1997) refer to these demonstration/imitation effects as market access spillovers (see Aitken et al., 1997; also Blomström and Kokko, 1998).
[13] An alternative explanation for the negative association could be that the estimation suffers from selection bias. It could be that foreign firms prefer industries with large technological differences with Mexican firms, reflecting a low level of direct competition. If this is the case, the tendency of FDI to locate in low competition industries would show up in the estimation as a negative association between technology diffusion and industry-wide foreign participation.
[14] See also Blomström (1989) for more details of this database.

1983; Blomström, 1986; Blomström, 1989; Blomström and Wolff, 1994; Kokko, 1994, 1996; Blomström, Kokko and Zejan, 2000).

Furthermore, the positive relation between foreign investment and domestic productivity appears robust to alternative specifications of the empirical model. For instance, Blomström (1986) finds a significant positive relation between the share of industry-wide foreign participation and the level of overall efficiency of industries. Blomström and Wolff (1994) estimate whether foreign investment is associated with the rate of labour productivity growth between 1970 and 1975 and the rate of convergence of measured labour productivity between Mexican and foreign-owned manufacturing firms, finding that both dependent variables are significantly positively related to the industry-wide share of foreign investment (see Blomström and Wolff, 1994).

Second, the analysis of the 1970 database provides indications of the importance of structural factors influencing the occurrence of FDI-induced externalities. Blomström (1986) suggests that the efficiency-enhancing effect from FDI-induced externalities only applies to Mexican firms using modern technologies (approximated by large firms), whereas small firms, using relatively traditional technologies, are likely to remain unaffected by the presence of FDI. Also, from a study attempting to find factors affecting the extent to which foreign affiliates import new technologies into Mexico, Blomström et al (1994) find that there are structural differences between groups of industries regarding this extent to import technology.

Furthermore, Kokko (1994; 1996) finds that industry characteristics seem to influence the occurrence of externalities from FDI. His findings suggest that the simultaneous existence of large technological differences between foreign and

domestic companies and a relatively large industry-wide participation of foreign investment prevents the occurrence of externalities. Kokko (1994) interprets this finding as evidence of the existence of so-called ‘ “enclaves”, i.e. isolated segments of the market where technologies, products and plant sizes are very different from those used by local firms’ (Kokko, 1994, p. 291). In a related research on the effect of competition on labour productivity of both foreign and domestic firms, Kokko (1996) finds indications confirming his separation of industries with enclave characteristics, as his hypotheses are only confirmed for those industries that do not possess these characteristics (see Kokko, 1996).

In sum, the available empirical evidence suggests that the presence of FDI has created positive externalities among Mexican manufacturing industries. The evidence from the 1980s is somewhat less robust, but the evidence from the analysis from the 1970 sample indicates a robust positive association between foreign participation and Mexican measured productivity. Also, the hypothesis that absorptive capacity is an important structural factor influencing the occurrence of positive FDI-induced externalities is supported by the evidence from the 1970s that assess the effect of technological complexity and technological differences.

4. Data and model

4.1. Data

The data that is used for the empirical analysis in this paper consists for a large part of unpublished, and thus far unexplored, data from the 1993 Mexican economic census.

The data is available in the form of industry level data for manufacturing industries for 1993, at the 6-digit level, under the Mexican census classification system[15]. After an examination of the individual cell scores, 240 industries contain sufficient information and are used in the empirical analysis.

The database contains industry observations for two types of firms: private Mexican plants and private foreign-owned plants[16,17]. For each of the two types of firms, the following variables are available: value added, number of employees, number of white collar employees, number of blue collar employees, total assets at book value, number of establishments and total gross production. In addition to these variables, I have added the size distributions of plants within industries, based on relative size of total gross production and total number of employees[18]. These size distributions do only distinguish between the two types of ownership at the 4-digit industry level, however.

4.2. Specification of the empirical model

The empirical model to estimate the occurrence of FDI-induced externalities in Mexican manufacturing industries is set up in the form of a partial labour productivity equation. Starting from a standard Cobb-Douglas production function:

[15] CMAP (Classificacion Mexicana de Actividades y Productos); for a description of this classification system, see Inegi (1994).
[16]Observations from Mexican state-owned companies were deleted from the database, for similar reasons as expressed in Persson and Blomström (1983).
[17]Information on the exact percentage of foreign ownership for individual plants that underlie the industry observations is not available. However, there are no foreign-owned plants in the database with less than 10% of total assets under foreign control. Therefore, the industry observations for foreign-owned plants are aggregates of foreign-owned plants with at least 10% of total assets in foreign hands.
[18] Taken from Inegi (1994).

(1) $Q = A\ K^{\alpha} L^{1-\alpha}$;

where Q, K and L are production, capital and labour respectively; A is an efficiency parameter;

Production can be expressed as a function of the capital-labour ratio κ:

(2) $Q = A \left(K/L\right)^{\alpha} L = L\ A\ \kappa^{\alpha}$;

dividing both sides by L gives the physical product of labour:

(3) $\left(Q/L\right) = A\ \kappa^{\alpha}$;

finally, stating (3) in log linear form produces the equation to be estimated:

(4) $\ln \left(Q/L\right) = \ln A + \alpha \ln \kappa$

The dependent variable is measured as the ratio of total value added over total number of employees in the Mexican-owned shares of manufacturing industries. The capital-labour ratio, labelled INVm in the empirical model, is measured as the ratio of total assets at book value over total number of employees in Mexican-owned shares of industries. The efficiency parameter A contains a set of factors that may further affect productivity levels of Mexican manufacturing firms: human capital, internal scale economies, external scale economies, market concentration and industry-wide foreign participation.

Human capital, labelled LQm, represents the level of labour quality in Mexican firms. It is measured as the ratio of total number of white collar employees over total number of blue collar employees in Mexican-owned shares of industries (see Persson and Blomström, 1983).

The variable SCALEm is included to control for productivity effects due to internal scale economies (see Haddad and Harrison, 1993; Chuang and Chi-Mei Lin, 1999). Due to the nature of the available data, a proxy for the industry-wide attainment of internal scale economies has to be used. The proxy is constructed using the concept of 'minimum optimal scale' (Cory, 1981) or minimum efficient scale (MES). The main idea of this concept is to capture the extent to which average production in an industry approaches the level of MES production. Here, MES is approximated by average gross production of the largest plant size in an industry. For a given industry, the variable SCALEm is calculated as the ratio of average gross production per Mexican plant over MES production of the industry.

The variable HERFI captures the level of market concentration per industry. Different levels of market concentration may lead otherwise identical industries to show different levels of productivity. Here, the cross-industry variation of industry-wide market concentration is measured as the sum of squared shares of plants in total production per industry (see Lommel, van. et al., 1977; also Curry and George, 1983).

GINI represents a measure of the type of geographical distribution of industries over the 32 states in Mexico. Research into productivity effects of location patterns of industries indicates that geographical concentration may have an independent effect on productivity levels through the occurrence of external economies (see Ebert and McMillen, 1999; also Duranton and Puga, 2003; Hanson, 2001b). To capture this, I have calculated Gini coefficients for the 6-digit manufacturing industries. Although usually applied to measure the level and type of inequality of income distributions (see Owell, 1977), the GINI coefficient can also be used to obtain an indicator of the type of distribution of industries over geographical

space[19]. Here, the level of inequality indicates the level of geographical concentration of an industry.

Finally, the variable FOR represents the industry-wide participation of foreign investment. Two indicators are used: FORemp is the ratio of number of employees working in foreign-owned firms over the total number of employees per industry; FORprod is the foreign firms' industry-wide share in total gross production. It is not possible to predict the sign of the coefficient of FORem or FORprod *a priori*. On the one hand, previous research on Mexico suggests that the coefficient will carry a positive sign. On the other hand, more recent estimations from other host economies suggest that a negative effect of the presence of FDI may be present. All the other RHS variables are expected to carry positive signs.

5. Results

5.1. Main model

To recapitulate, the empirical model to be estimated is

$$\left(Q/L\right)m = ß_0 + ß_1\,INVm + ß_2\,LQm + ß_3\,SCALEm + ß_4\,HERFI$$
$$ß_5\,GINI + ß_5\,FOR + \varepsilon$$

The estimation of this linear equation is by OLS. The results of the estimations are shown in table 1.

[19] See e.g. Krugman (1991)

Table 1. Mexican manufacturing productivity and FDI

RHS variable	FORem(a)	FORem(b)	FORprod
INVm	0.24 (6.66)***	0.23 (6.69)***	0.21 (6.22)***
LQm	0.27 (4.75)***	0.27 (4.69)***	0.29 (4.29)***
HERFI	0.08 (6.23)***	0.08 (6.38)***	0.09 (6.98)***
SCALEm	0.12 (4.82)***	0.11 (3.97)***	0.11 (3.99)***
GINI	--	0.21 (1.20)	0.42 (2.37)***
FORem	0.04 (2.98)***	0.03 (1.70)*	--
FORprod	--	--	-0.012 (0.68)
Constant	3.29 (17.43)***	3.30 (17.78)***	3.34 (18.01)***
Adj. R^2	0.72	0.72	0.72
F	118.47 (0.000)	101.98 (0.000)	96.67 (0.000)
N	240	240	240

Absolute values of T statistics in parentheses; ***, ** and * indicate significance at 1, 5 and 10% acceptance levels. Estimations heteroscedasticity-robust based on Huber/White/Sandwich method

Considering the general statistics of the estimations, the model appears to perform well. The adjusted-R^2 statistic indicates that over 70% of the variance of the dependent variable is explained by the RHS variables. Also, looking at the coefficients and signs of the control RHS variables, the results show significant effects with expected signs. Turning to the effect of foreign investment, the second column represents the results using FORem without the variable GINI in the estimation. This estimation contains the same RHS variables as in Persson and Blomström (1983) and Blomström (1989). The results suggest the occurrence of positive externalities, indicated by the significant positive association between measured Mexican productivity and industry-wide foreign participation.

However, when adding the variable GINI, representing the relative extent of industry-wide geographical concentration, the coefficient of FORem drops slightly in

value and is only significant at the 10% level. Furthermore, when substituting FORprod for FORem, the coefficient switches sign and the estimated effect of industry-wide foreign participation becomes insignificant. This suggests that, when controlling for the occurrence of agglomeration economies within industries, the separate positive effect of foreign participation on measured Mexican productivity disappears, or is less robust to say the least[20]. These results are in contrast to the set of empirical findings for Mexico for 1970, which shows robust positive associations between measured Mexican productivity and industry-wide foreign participation.

5.2. Determinants of FDI-induced externalities

To determine whether firm size influences the occurrence of FDI-induced externalities, I estimate the labour productivity equation for different Mexican firm sizes. The database allows a distinction between values for small and large Mexican firms with a cut-off point of 50 employees, for 4-digit industries (50 observations)[21]. Next, to determine whether technological complexity has a significant effect, I divide the 240 6-digit industries into low tech and high tech industries, and compare the estimated effect of foreign participation for the two groups. The indicator for technological complexity is similar to Kokko (1994), measured as the industry-wide ratio of total assets at book value over total number of employees in foreign-owned

[20] A possible disturbing influence on the results as presented in table 1 is that foreign investment may be endogenous to the empirical model (see Hanson, 2001b; Haddad and Harrison, 1999). In such a case, foreign investment is attracted to industries with particular productivity levels. To see if such a bias exists, I have run two alternative models. One estimation regresses the change of Mexican productivity between 1988 and 1993 on the control RHS variables for 1988 (taken from Inegi, 1989). Also, I have run the main estimation for 1993, substituting FORem88 and FORprod88 for FORem93 and FORprod93. The results of these alternative estimations, in terms of sign of coefficient of FORem and FORprod, do not differ with the results presented in table 1. However, these alternative estimations do only partly correct for the possible presence of endogeneity bias.

firms. In a similar fashion, I can assess the influence of the size of technological differences between foreign and Mexican owned firms. The indicator for the size of the industry-wide technology gap is similar to Wang and Blomström (1992), measured as the ratio of the industry-wide ratio of value added per employee in foreign firms over value added per employee in Mexican firms. Finally, I have grouped the industries into lowly and highly geographically concentrated industries, using the value of GINI as indicator. The set of results for the potential determinants of externalities are shown in table 2.

The second and third column contain the regression results for small and large Mexican firms. Except for the variable INVm in the regression of large firms, the RHS variables perform in a satisfactory manner. The difference in signs of some of the control variables between the two types of firms appears logical. For instance, productivity levels of large firms are more likely to be susceptible to forces of internal scale economies compared to small firms. On the other hand, small firms appear to benefit more from being located in geographical concentrations of activity. The opposite sign of HERFI would suggest that large firms possess sufficient capacity to deal with and benefit from market pressure, whereas small firms are not able to cope with too high a level of market competition[22].

Turning to the variable measuring industry-wide foreign participation, the results are not in support of the hypothesis that firm size reflects the level of absorptive capacity. The results for the two sub-samples do indicate that there is a

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[21] Aitken and Harrison (1999) use the same cut-off point of 50 employees.

[22] The insignificance of the estimated effect of INVm of large Mexican firms is likely due to an aggregation bias, caused by the use of 4-digit data. Large Mexican firms comprise all firms larger than 50 employees, ranging from the size class 50-100 employees to the class of more than 5,000 employees. This means that this group of firms consists of a variety of production technologies, with marked differences in capital intensity. This may have prevented the variable INVm from correctly capturing

Table 2. Determinants of FDI-induced externalities

	Firm size		**Techn. Complexity**		**Technology Gap**		**Geog. Concentration**	
Rhs var	***Small***	***Large***	***Low***	***High***	***Low***	***High***	***Low***	***High***
Invm	0.38 (2.27)**	0.10 (0.86)	0.26 (5.50)***	0.26 (4.75)***	0.26 (6.85)***	0.18 (3.65)***	0.25 (5.44)***	0.17 (3.78)***
LQm	0.48 (2.31)**	0.52 (2.93)***	0.19 (2.40)**	0.39 (5.74)***	0.29 (3.54)***	0.23 (3.69)***	0.23 (3.51)***	0.34 (4.02)***
HERFI	-0.23 (2.58)***	0.09 (1.86)*	0.10 (6.57)***	0.07 (3.04)***	0.08 (5.64)***	0.09 (5.33)***	0.07 (5.70)***	0.11 (6.30)***
SCALE	0.11 (0.52)	0.46 (2.52)**	0.12 (3.68)***	0.09 (2.53)**	0.09 (2.76)***	0.07 (1.99)***	0.09 (3.47)***	0.13 (3.23)***
GINI	0.46 (2.36)***	-0.07 (0.39)	0.14 (0.69)	0.34 (1.35)	0.48 (1.80)*	-0.14 (0.70)	0.15 (0.85)	0.95 (1.39)
FOR	0.15 (2.53)***	-0.09 (1.71)*	0.04 (2.38)***	-0.0004 (0.01)	0.01 (0.65)	0.05 (2.46)**	0.09 (1.90)**	-0.06 (1.83)*
Const.	3.09 (1.34)	-1.67 (0.89)	3.14 (13.96)***	3.52 (12.09)***	3.29 (14.97)***	3.11 (11.70)***	3.15 (12.30)***	3.53 (14.52)***
R^2	0.48	0.73	0.79	0.62	0.74	0.77	0.84	0.65
F	23.14 (0.000)	20.02 (0.000)	66.53 (0.000)	36.25 (0.000)	85.47 (0.000)	28.98 (0.000)	75.84 (0.000)	42.92 (0.000)
N	50	50	110	130	181	59	93	147

Absolute values of T statistics in parentheses; ***, ** and * indicate significance at 1, 5 and 10% acceptance levels. Estimations heteroscedasticity-robust based on Huber/White/Sandwich method.
In all estimations, FOR is measured as FORem.

For the estimations for the two groups of industries concerning technological complexity, technology gap and geographical concentration, I have tried several splitting points, such as the average and mean values of the determinants. For each of these values, a Chow test indicates whether the difference between the two groups of industries is significant. For each of the determinants, it proved possible to find several significant structural breaks. The results shown in table 2 are those for which Chow tests indicate the most significant structural break for a determinant.

difference in the estimated effect of foreign investment, but the difference is that whereas large firms are negatively affected by the presence of foreign firms, small firms seem to benefit from it, as indicated by the significant positively signed coefficient of FOR.

This result suggests that, instead of absorptive capacity, the difference in firm size is more likely to capture the presence or absence of direct competition between foreign and Mexican firms. For this, it is important to consider that economies of

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the effect of capital intensity on productivity for the group of large Mexican firms, leading to the insignificant result.

developing countries such as Mexico possess characteristics of a dual structure, where traditional and modern segments co-exist, with little or no direct competition between them (see Blomström, 1989). The dual structure, combined with the high likelihood that foreign firms are predominantly operating in modern segments, clarifies the difference in estimated effect between small and large Mexican firms. In the modern segments, composed of large Mexican and foreign-owned firms, negative FDI-induced competition externalities outweigh any positive externalities that may exist. In contrast, in traditional segments, consisting of small and medium Mexican firms, the industry-wide foreign participation creates positive externalities, whereas negative externalities from competition are likely to be non-existent, due to the absence of FDI in these segments.

The results for the determinant technological complexity are shown in the 4th and 5th column and are in line with previous findings (see Kokko, 1994; 1996). Whereas in low tech industries the variable FOR has a positive significant association with measured Mexican productivity, this effect is entirely absent in industries in the high tech sub-sample. Having said so, it is important to keep in mind that this determinant is a relatively indirect indicator of the level of absorptive capacity, based on the assumption that technological differences between foreign and Mexican firms are smaller in low tech industries industries.

Furthermore, similar to the explanation for the findings regarding firm size, the distinction between low and high tech industries could also reflect the effects of the dual characteristics in the Mexican economy. If modern segments of the Mexican economy predominantly operate in high tech industries and traditional segments operate in low tech industries, the suggested difference in effect of the presence of

foreign investment between the two types of industry could be caused by the presence or absence of direct competition between Mexican firms and FDI instead. In high tech industries, any positive externalities are cancelled out by negative externalities arising from the presence of FDI, whereas in low tech industries the absence of this negative competition effect allows positive externalities to materialize.

The results of using the more direct indicator of the size of technological differences between foreign and Mexican firms are shown in columns 6 and 7. Although there is a difference in estimated effect of foreign investment, again the findings are not in support of the absorptive capacity hypothesis. Whereas in industries with relatively small technology gaps the estimated effect of foreign investment is not significant, industries that are characterised by relatively large technological differences between foreign and Mexican firms show a significant positive association between foreign investment and Mexican measured productivity.

Again, instead of the concept of absorptive capacity, the presence or absence of direct competition between foreign and Mexican firms seems to offer a better explanation. The size of the technology gap is likely to be inverse related to the level of direct competition. Therefore, a large technology gap between FDI and Mexican firms would indicate a low level or complete lack of direct competition. This absence of competition would allow positive externalities to materialise, as suggested by the results in column 7.

Finally, the last two columns of table 2 contain the results for the determinant in the form of geographical concentration of industries. The results suggest that geographical concentration of industries stimulates negative externalities from FDI: industries that are geographically concentrated show a significant negative association

between FOR and measured Mexican productivity. On the other hand, industries that are less geographically concentrated appear to enjoy positive externality effects from FDI. As discussed in section 2.3., geographical concentration can stimulate both positive and negative externalities. The positive influence is that geographical proximity between foreign and Mexican firms may stimulate the workings of the channels of externalities in the form of demonstration effects, labour turnover and inter-firm linkages. The negative effect is that the presence of foreign firms in agglomerations of activity puts upward pressure on the prices of regionally confined production inputs, which lead to lower profit levels of Mexican firms. Based on the findings in table 2, it appears that the latter effect is occurring.

In sum, the results presented in table 2 do not offer evidence in support of the absorptive capacity hypothesis. Instead, they indicate the importance of the presence or absence of direct competition between foreign and Mexican owned firms. If there is direct competition between the two types of firms, negative competition externalities outweigh any positive externalities present. In the absence of competition, the presence of FDI may lead to positive externalities.

5.3. Geographical concentration, competition and FDI-induced externalities

A possible drawback of the empirical estimations presented in the previous section is that it assumes that the effect of the structural factors can be estimated independently. If both technological differences and geographical concentration affect FDI-induced externalities simultaneously, they both need to be included in the same empirical model, to capture all the effects and possible interrelations between them. Therefore, I

have re-estimated the main equation, adding interaction terms between industry-wide foreign participation and the determinants of externalities in the form of technological complexity (TECH), technology gap (GAP) and geographical concentration (GINI). This leads to the following empirical model:

$$\left(Q/L\right) = ß_0 + ß_1\,INVm + ß_2\,LQm + ß_3\,SCALEm + ß_4\,HERFI + ß_5\,GINI + ß_6 FOR + ß_7 FOR * TECH + ß_8 FOR * GAP + ß_9 FOR * GINI + ß_{10} FOR*GINI*GAP + ß_{11} FOR*TECH*GAP + ß_{12} FOR*TECH*GINI + \varepsilon$$

The results for both FORem and FORprod are shown in table 3.

The estimated effect of the industry-wide foreign participation is negative, both for FORem and FORprod. In the latter case, the estimated negative effect is significant. Due to the inclusion of the interaction terms, this variable needs to be interpreted differently from the previous estimations. Here, the variable FOR represents the effect of foreign participation, cleared from the effects of structural determinants. Therefore, the pure effect of foreign presence is the creation of negative externalities. This contradicts earlier findings for Mexico (see Persson and Blomström, 1983, etc), but is in line with recent findings for other host economies (see e.g. Aitken and Harrison, 1999).

Having said so, the presence of foreign firms may lead to positive externalities in those industries that are characterised by a relative large technology gap, indicating the absence of direct competition between FDI and Mexican firms. The interaction term GAP*FOR carries a significant positive coefficient both for FORem and FORprod, indicating that measured Mexican productivity is positively associated with the presence of foreign firms in those industries that meet this criterion.

Table 3. FDI-induced externalities: technology and geographical concentration

	FORem(a)	FORem(b)	FORprod(a)	FORprod(b)
INVm	0.24 (7.08)***	0.24 (7.30)***	0.23 (6.71)***	0.23 (7.04)***
LQm	0.29 (4.87)***	0.28 (4.65)***	0.29 (5.01)***	0.28 (4.79)***
HERFI	0.09 (7.64)***	0.09 (7.15)***	0.09 (7.78)***	0.09 (7.65)***
SCALE	0.09 (3.35)***	0.09 (3.58)***	0.10 (3.71)***	0.10 (3.85)***
GINI	0.29 (1.08)	0.31 (1.29)	0.20 (0.73)	0.29 (1.20)
FOR	-0.08 (1.46)	-0.02 (0.65)	-0.10 (1.90)**	-0.08 (2.81)***
Constant	3.22 (17.82)***	3.26 (18.36)***	3.22 (18.18)***	3.26 (18.94)***
GAP*FOR	0.04 (1.90)**	0.03 (3.21)***	0.05 (2.28)**	0.05 (2.96)***
GINI*FOR	-0.09 (1.48)	0.06 (1.25)	-0.12 (1.69)*	-0.12 (2.46)***
TECH*FOR	0.01 (0.84)	--	-0.0003 (0.30)	--
GINI*GAP*FOR	0.04 (2.37)**	0.04 (2.64)***	0.07 (2.51)***	0.07 (2.51)***
GINI*TECH*FOR	0.004 (0.15)	--	-0.01 (0.49)	--
GAP*TECH*FOR	-0.002 (0.57)	--	-0.0001 (0.03)	--
R^2	0.75	0.75	0.76	0.76
F	60.53 (0.000)	75.51 (0.000)	59.28 (0.000)	80.91 (0.000)
N	240	240	240	240

Absolute values of T statistics in parentheses; ***, ** and * indicate significance at 1, 5 and 10% acceptance level. Estimations heteroscedasticity-robust based on Huber/White/Sandwich method.
The interaction terms do not lead to problems of multicollinearity, as VIF (variance inflation factors) tests indicate that the estimations meet both criteria of no multicollinearity (see Chatterjee, Hadi and Price, 2000): both the largest VIF scores do not exceed the value of 10 (GAP*FORem*GINI = 3.24 in regression using FORem; GAP*FORprod*GINI = 8.18 in regression using FORprod) and the mean VIF values are not considerably larger than 1 (2.02 for regression using FORem; 1.98 for regression using FORprod).

Finally, the results indicate that the extent of geographical concentration of industries, or geographical proximity between foreign and Mexican firms, has an unique independent effect on the occurrence of externalities. On the one hand, as indicated by the significant negative coefficient of the interaction term GINI*FOR, the effect of the

presence of FDI in the form of negative externalities is enhanced in those industries that are geographically concentrated. On the other hand, an important qualification to the results presented in table 2 is that the results in table 3 suggest that geographical concentration also appears to stimulate the occurrence of positive externalities. This is indicated by the significant positive coefficient of the interaction term GINI*GAP*FOR. Of those industries where competition between foreign and domestic firms is absent (GINI*GAP industries), industries that are geographically concentrated experience additional positive externalities. This stimulating effect of geographical proximity can be explained by the enhanced effectiveness of channels of externalities in the form of demonstration and imitation effects, labour turnover and inter-firm linkages between foreign and Mexican firms.

6. Summary and concluding remarks

Based on unpublished and thus far unexplored data, this paper presents new empirical evidence on the occurrence of FDI-induced externalities in manufacturing industries in Mexico for 1993. The aim of the analysis is three-fold: to establish whether there are overall significant externalities due to the presence of FDI, to assess whether the concept of absorptive capacity is an important determinant of such externalities and to determine the effect of geographical concentration of industries.

The results indicate that, in contrast to previous findings for Mexico, the evidence for significant positive externalities from FDI is very weak. Indeed, when separating out the effects of the determinants, the net effect of the presence of foreign firms is the creation of significant negative externalities; a finding which is in line

with recent findings for other host economies. Of course, caution is required in the interpretation of this estimated effect, as it does not control for the possibility FDI is endogenous to the estimated empirical model. Having said so, the difference in findings between previous result and the present findings indicates that the previous empirical findings for Mexico need to be interpreted with caution as well.

Next, the empirical analysis addresses the influence of possible determinants of FDI-induced externalities. The differences in results for groups of industries distinguished on firm size, technological complexity of industries, technology gap and level of geographical proximity appear counter-intuitive when adopting the absorptive capacity hypothesis. Instead, there are strong reasons for substituting the alternative interpretation of the presence or absence of direct competition between foreign and Mexican firms for the absorptive capacity concept. The findings indicate that this absence or presence is crucial for the existence of positive or negative externalities: industries where we can assume direct competition to be present experience negative externalities from the presence of FDI, whereas in industries where the competition effect is absent, foreign firms may create positive externalities for domestic firms.

Finally, the paper argues for the concept of geographical concentration or geographical proximity between foreign and Mexican firms as a likely determinant of FDI-induced externalities. Positive externalities from FDI may be transmitted through the channels of demonstration/imitation, human capital accumulation and labour turnover, inter-firm linkages and the competition effect. The latter effect may also create negative externalities. As argued, it is likely that geographical concentration stimulates the occurrence of both positive and negative externalities, as it enhances

the existence and the workings of those channels. The empirical evidence is in support of this hypothesis, for both types of externalities. Negative FDI-induced externalities are enhanced in those industries that are geographically concentrated. However, in those industries where the competition effect between foreign and Mexican firms is absent, geographical concentration of industries further enhances the occurrence of positive externalities. Therefore, these findings indicate that geographical concentration may be an important alternative determinant of FDI-induced externalities. The implication of this finding is that the level of geographical concentration of industries, or more generally the type of distribution of industries over geographical space in a host economy, must be taken into account when estimating FDI-induced externalities, as it may influence both the occurrence and the type of those externalities.

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