Regional Intra- and Inter-industry externalities from Foreign Direct Investment:

New evidence from the 1993 Mexican census of manufacturing

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Abstract

Recent empirical research on FDI-induced externalities is engaged with the identification of the effects of geographical proximity between foreign-owned and domestic firms in a host economy on such externalities. In this paper, I elaborate on this, estimating externality effects in Mexican manufacturing industries that arise from intra- and inter-industry regional foreign participation. In extension of this, I empirically assess the presence of inter-regional spatial FDI-induced externalities. The main findings indicate that, when controlled for endogeneity, positive intra-regional FDI-induced externalities occur both within and between manufacturing industries. Furthermore, FDI-induced externalities also spill over between regions, albeit that such spatial externalities appear to be subject to a strong distance decay effect. These inter-regional externalities are only of the inter-industry type.

JEL Classification C21, F23, L60, O47

Key words FDI, Externalities, Mexico, regional

1. Introduction

In the last few decades, the operations of multinational enterprises (MNEs) and foreign direct investment (FDI) have received increased recognition as important determinants of national and international processes of economic development. The increased interest in FDI is reflected in the rapid expansion of empirical research on the statistical identification and quantification of externality effects that may arise from the presence and operations of foreign-owned firms in host economies.

Traditionally, empirical estimations of such FDI-induced externalities have focused on the identification and quantification of intra-industry externalities from FDI. The large volume of empirical evidence is not interpreted in a homogeneous way, however. Whereas some hold the opinion that positive intra-industry FDI-induced externalities are an important phenomenon (see Blomström and Kokko, 1998; 2003; Ewe-Ghee Lim, 2001), others conclude that the empirical evidence for the existence of such externalities is rather weak (Hanson, 2001; Kumar, 1996). Furthermore, not only may positive intra-industry externalities be less prevalent than thought initially, but recent empirical studies also provide evidence of the occurrence of negative intra-industry FDI-induced externalities (see Aitken and Harrison, 1999; Harrison, 1996; Haddad and Harrison, 1993; Konings, 2000; Djankov and Hoekman, 2000).

Partly in response to the contradictory evidence from traditional approaches towards the identification of FDI-induced externalities, some recent empirical studies have improved their estimations in two aspects. First, the scope of the estimation is enlarged by considering both intra- and inter-industry externalities. One reason for the inclusion of inter-industry externalities is that FDI may be less inclined to protect its ownership-specific advantages from domestic firms that operate in dissimilar industries (Kugler, 2000a, 2000b). The second reason for including inter-industry externalities is that FDI may have an active interest in the support and improvement of local suppliers in a host economy (Blalock and Gertler, 2002; Dunning, 1993, Lall, 1980).

Second, in line with the growing attention on effects of geographical concentration and geographical proximity in economic geography and international economics, several recent estimations of FDI-induced externalities assess the effect of geographical proximity between FDI and domestic firms. In addition to traditional estimations of externalities from FDI that focus on overall industry-wide foreign participation, these recent studies also incorporate externality effects from overall regional foreign participation.

The purpose of the present paper is to build on these recent developments in empirical studies of FDI-induced externalities. In the estimations of FDI-induced externalities in Mexican manufacturing industries, both the role of regional foreign participation and the distinction between intra- and inter-industry externalities are explicitly incorporated. The remainder of the paper is constructed as follows. In section two, I discuss previous empirical evidence of externality effects from regional foreign participation, both within and between regions. Section three describes the data and empirical model that is used for the present estimations. Section four presents the empirical findings. The main findings are two-fold. First, foreign-owned firms create positive intra- and inter-industry externalities within regions, once the estimations are controlled for endogeneity. Second, FDI-induced externalities between industries also spill over between neighbouring states, be it that they are subject to a strong distance decay effect. Finally, section five summarises and concludes.

2. FDI and regional intra- and inter-industry externalities

2.1. The importance of geography

The traditional way to statistically identify FDI-induced externalities is to estimate an empirical model that captures determinants of levels or growth rates of productivity of domestic firms in a host economy, including the cross-industry variation of industry-wide foreign participation as a right hand side (RHS) variable. An estimated significant coefficient of this variable is taken as evidence of the existence of FDI-induced externalities[1].

From an economic geography point of view, this general approach can be criticised for not considering effects that may arise from the type of geographical distribution of economic activity in the host economy. One issue is that the type of geographical distribution of economic activity in a country can uniquely create productivity effects in the form of agglomeration economies (Marshall, 1890)[2]. Geographical concentration of economic activity stimulates the creation of a thick labour market, the existence of specialised (non-traded) inputs and the transmission of knowledge flows. All of these create external economies accruing to firms located in the geographical concentration. Given the fact

[1] For important reviews, see Blomström and Kokko (1998; 2003), Hanson (2001a), also Caves (1996).

[2] See Eberts and McMillen (1999); also Hanson (2001b).

that empirical studies of FDI-induced externalities estimate determinants of productivity of domestic firms in a host economy, the non-consideration of effects of the geographical distribution of industries may create an omitted variable bias. The presence of such a bias would mean that the estimated effect of the presence of foreign-owned firms is biased and inconsistent.

The second issue relates to the effect of geographical proximity between foreign-owned and domestic firms on the occurrence of FDI-induced externalities. FDI-induced externalities can occur through a variety of mechanisms, including demonstration effects, inter-firm linkages and human capital accumulation and labour turnover (see Caves, 1996). These mechanisms are more likely to come into existence and be more effective when FDI and domestic firms are located in proximity.

For instance, knowledge spillovers are facilitated by geographical proximity (Lucas, 1988, 2001). Therefore, demonstration effects from FDI are more likely to arise when domestic firms are located in its proximity[3]. Externalities from labour turnover can be assumed to be stimulated by proximity as well. If FDI and domestic firms are located in separate regions, the likelihood that domestic workers substitute a foreign-owned firm for a domestic firm is lower than when both firms are located in proximity. Finally, the relation between geographical proximity and inter-firm linkages is a more established one, as the common belief is that proximity between firms enhances inter-firm linkages (Scott, 1988). One of the reasons why FDI finds it difficult to use local suppliers is that it takes time and effort to identify such suppliers and develop relations with them (Dunning, 1993). Geographical proximity between the two types of firms will facilitate the identification and creation of such business relationships.

Summarising, traditional estimations of FDI-induced externalities do not consider the type of geographical distribution of economic activity in a host economy. This may create two problems. First, the estimations of FDI-induced externalities may suffer from omitted variable bias, creating biased estimates of externality effects from FDI. Second, geographical proximity is likely to affect the occurrence and level of FDI-induced externalities. These two reasons indicate that it is important to consider geographical concentration and proximity in such empirical estimations of FDI-induced externalities.

[3] See Aitken et al. (1997) for an empirical assessment of the importance of geographical concentration for the occurrence of demonstration effects from FDI in the form of market access spillovers.

2.2. Regional foreign participation and externalities from FDI

The approach in empirical research to detect the effect of geographical proximity on FDI-induced externalities is to include a variable in the estimated empirical model that, for a given host economy firm or industry, captures the extent of regional foreign participation[4].

An example of this is provided by Blalock and Gertler (2002). They estimate determinants of productivity for a large sample of Indonesian manufacturing plants for the period 1988-1996. In their estimations, they distinguish between intra- and inter-industry externalities. Intra-industry foreign participation is measured as FDI's share in total employment in the industry in the region of an Indonesian plant. Using input-output tables, inter-industry regional foreign participation is calculated as the foreign firms' share in related industries in the region of a given Indonesian plant. Their findings provide evidence of the existence of positive buyer-supplier externalities, indicated by a significant positive association between inter-industry regional foreign participation and Indonesian plant level productivity. In contrast, the estimated effect of intra-industry regional foreign participation carries opposite signs in alternatively specified models and fails to reach significance (see Blalock and Gertler, 2002).

Several researchers estimating FDI-induced externalities in the UK, producing mixed results, have adopted the inclusion of a regional foreign participation variable. Harris and Robinson (2002) and Haskel et al. (2002) estimate the impact of FDI on total factor productivity in the UK, using a large plant level data set obtained from the Annual Respondents' Database (ARD)[5]. In seven out of 20 industries, Harris and Robinson find an estimated significant effect of the variable capturing total regional foreign participation. In contrast, a similar variable fails to reach significance in the estimations presented by Haskel et al. (2002).

Girma and Wakelin (2002) offer empirical evidence of a significant positive influence of regional foreign participation in the UK. Using a different plant level data set, their analysis covers the

[4] An alternative way to detect the effect from geographical proximity is by estimating FDI-induced externalities in a host economy at different geographical scales; see Sjöholm (1998, 1999).

[5] See Harris and Robinson (2002) for full description of this data set.

period 1988-1996[6]. Girma and Wakelin (2002) focus on estimating the effect of intra-industry regional foreign participation. Their findings indicate that this variable caries a significant positive coefficient, although this effect only materialises in regions that do not have an assisted area status (see Girma and Wakelin, 2002). Similarly, Girma and Wakelin (2001) present an analysis of FDI-induced externalities for the electronics industry in the UK, using plant level data from the ARD data set for the period 1980-1992. Again, their findings indicate that the intra-industry regional foreign participation variable carries a significant positive coefficient. This time, the qualification to this result is that this effect only materialises for Japanese and European FDI.

In sum, assessing the empirical evidence with respect to the possible existence of some form of geographical component of FDI-induced externalities, two important features are particularly noteworthy. First, it appears that there may be a regional component to the occurrence of FDI-induced externalities, as several empirical studies have found a significant positive estimated effect of the regional presence of FDI. Second, in order to capture the full range of externalities from regional foreign participation, it is important to extend the empirical analysis to cover both intra- and inter-industry foreign participation. For a given domestic firm, regional foreign participation can take place in its own industry or in related industries. An empirical analysis that only considers regional externalities of the intra-industry type runs the serious risk of not identifying the second important regional source of productivity effects from foreign participation in related but dissimilar industries.

2.3. FDI and spatial externalities

An important criticism of the empirical studies reviewed in the previous section is that the interpretation of the effect of geographical proximity on the occurrence of FDI-induced externalities remains incomplete. By concentrating on the effect of foreign participation within regions, the estimations miss out on the possible identification of FDI-induced externalities that are transmitted between regions.

A qualitative indication that externalities from FDI may spill over between regions is provided by Potter et al. (2002). Survey results, based on responses from a random sample of 30 large foreign-

[6] The data source is the Onesource database on private and public companies (see Girma and Wakelin, 2001).

owned manufacturing firms in the UK, as well as from a sample of their suppliers and customers, indicate that positive FDI-induced externalities are not confined to the region in which a foreign-owned firm is located. Potter et al. (2002) conclude that the impacts from FDI in the form of knowledge transfers and learning processes 'do not just occur at the level of the locality or region but also at a larger national scale' (Potter et al., 2002. p. 304).

An example of an attempt to statistically identity the existence of inter-regional FDI-induced externalities is offered by Girma and Wakelin (2001). They estimate the effect of inter-regional intra-industry foreign participation, weighing this foreign participation variable with the distance between regions. Using this specification, the variable fails to become significant (see Girma and Wakelin, 2001)[7]. However, this finding needs to be interpreted with caution. First, Girma and Wakelin (2001) relate the distance decay effect to inter-regional FDI-induced externalities in one specific way. Their interpretation of the distance-decay effect is that it is inversely related to the squared distance in kilometres between UK regions. Anselin (1988) stresses that the choice of the distance decay parameter is somewhat subjective, implying the need to explore several specifications of this parameter in empirical estimations. Therefore, the finding in Girma and Wakelin (2001) cannot be taken as sufficient evidence to reject the occurrence of spatially transmitted FDI-induced externalities. Instead, it should be interpreted as the non-confirmation of the specific relation between geographical space and FDI-induced externalities that they hypothesise.

Furthermore, the empirical analysis in Girma and Wakelin (2001) falls short in covering the entire range of inter-regional FDI-induced externalities, due to their omission of a variable capturing inter-regional inter-industry foreign participation. Their estimation only considers inter-regional FDI-induced externalities that occur within industries. Not only does this specification not allow for the identification of the existence of inter-industry externalities, but it may also have caused omitted variable bias in the estimation of the effect of intra-industry inter-regional FDI-induced externalities.

An indication that inter-industry inter-regional FDI-induced externalities may be important is provided by Smarzynska (2002), who estimates productivity externalities from FDI, using a large plant-level database for Lithuania for the period 1996-2000. The estimations indicate that intra-industry externalities do not have a significant estimated effect, either for intra- nor inter-regional foreign participation. In contrast, the estimated effect of foreign participation in downstream industries is

[7] See also Driffield and Wakelin (2003) for similar type of result.

significant and positive, both for intra- as well as inter-regional foreign participation. Having said so, it is important to note that no controls are made for inter-regional distances in the construction of the variable capturing inter-industry regional foreign participation. This omission of a distance decay parameter may have affected the estimated externality effect of inter-regional foreign participation[8].

Summarising, the limited empirical evidence has two important features. First, again it is important to consider both intra- and inter-industry externalities when estimating FDI-induced externalities between regions, as this ensures a complete estimation of the entire scope of possible inter-regional externalities from foreign participation. Second, it is important to assess the effects of several distance decay parameters, to control for the effect of geographical space on spatial FDI-induced externalities.

3. Empirical model and data

The aim of the present paper is to empirically estimate the presence of FDI-induced externalities, both within and between regions. In the present paper, I adapt an empirical model originally estimated for Mexico by Persson and Blomström (1983) and Blomström (1989). The reason for selecting Mexico as host economy is that an important part of current empirical evidence of positive FDI-induced externalities consists of studies on this country. However, this evidence rests on the analysis of a database for 1970, which may have made the findings less relevant in contemporary discussions on externality effects of FDI[9]. Furthermore, the earlier studies for Mexico do not control for the geographical distribution of industries nor do they address the effect of geographical proximity on these externalities.

[8] The author's defence for omitting a distance decay parameter is that Lithuania is a small country (see Smarzynska, 2002). Whether this facilitates inter-regional FDI-induced externalities within the country in the sense that the distance decay parameter can be entirely omitted should be a matter of empirical verification, however.

[9] For a good overview of the set of empirical findings for Mexico from this database, see Blomström et al. (2000).

3.1. 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 2-digit manufacturing industries for 1993, for the 32 states of the Republic of Mexico[10]. The database contains industry observations for two types of firms: private Mexican plants and private foreign-owned plants[11]. 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 and total gross production. In addition to these variables, I have added the size distribution of plants within industries, based on relative size of total gross production and total number of employees[12].

3.2. 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:

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

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

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[10] The industries are (1) Food, Drinks and Tobacco, (2) Textiles, Clothing and Leather, (3) Wood and Wood Products, (4) Paper, Paper Products and Printing, (5) Chemicals, Rubber and Plastic Products, (6) non-Metallic Minerals, (7) Basic Metals, (8) Metal Products and Machinery & Equipment, (9) Other Manufacturing.

[11] 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.

[12] Taken from Inegi (1994).

Production can be stated 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:

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

Stating (3) in log linear form produces an equation that can be directly estimated:

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

Finally, this can be stated as a regional production function for individual industries:

$$(5)\ \ln\left(Q/L\right)_{ij} = \ln A_{ij} + \alpha \ln \kappa_{ij}$$

where i denotes industries and j denotes regions.

The first empirical specification that is estimated in the present paper is:

$$(\text{Eq.1})\ \left(Q/L\right)_{ij} = ß_0 + ß_1\,\kappa\,m_{ij} + ß_2\,LQm_{ij} + ß_3\,SCALEm_{ij} + ß_4\,DUAL_{ij} + ß_5\,SPEC_{ij} + ß_6\,URB_{ij} + ß_7\,FOR_{ij} + ß_8\,FIR_{ij} + \varepsilon$$

The dependent variable (Q/L) is measured as the ratio of total value added over total number of employees in the Mexican-owned share of a manufacturing industry per state. The capital-labour ratio κ is measured as the ratio of total assets at book value over total number of employees in the Mexican-owned share of an industry. The efficiency parameter A contains a set of factors that may further affect productivity levels of Mexican manufacturing firms: human capital LQm, internal scale economies SCALEm, regional specialisation SPEC, external scale economies URB, the dual economy variable DUAL and intra-regional intra- and inter-industry foreign participation FOR and FIR.

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 the Mexican-owned share of an industry (see Persson and Blomström, 1983).

The variable SCALEm is included to control for productivity effects from 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 DUAL controls for the regional distribution of micro and small manufacturing firms in the country. As argued by Blomström (1989), the Mexican economy is characterised by a dual structure, where both traditional and modern segments co-exist within industries. Traditional segments, predominantly consisting of micro-sized and small firms, are characterised by low productivity technologies. In contrast, modern segments mainly consist of large firms and are characterised by relative high productivity levels, due to the use of modern technologies. To control for the structural difference in estimated productivity levels between the two segments, the empirical model contains the variable DUAL, measured for each industry as the ratio of the number of firms over the number of employees per state divided by the ratio of the number of firms over the number of employees in the aggregate national economy.

The variable SPEC is included to control for the effect of productivity effects from relative regional specialisation. Here, the variable is defined as the share of a 2-digit manufacturing industry in total state manufacturing employment, divided by the share of the 2-digit manufacturing industry in national manufacturing employment (see Duranton and Puga, 2000).

The variable URB controls for the presence of agglomeration economies[13]. The general approach in applied research on externalities from agglomeration is to use a variable measuring the size of total regional manufacturing or regional population (see Moomaw, 1988; Henderson, 1988; also Ebert and McMillen, 1999). In the present model, I use total number of employees per 2-digit manufacturing industry per state as the agglomeration variable.

Finally, the variables FOR and FIR capture intra-regional intra- and inter-industry foreign participation. FOR is measured as the foreign firms' share in the total number of employees of a 2-digit manufacturing industry. For a given industry in a region, FIR is measured as the share of foreign firms

[13] As discussed in section two, the empirical model needs to include a control for the presence of these externalities.

in the aggregate number of statewide manufacturing employees, excluding the particular industry. The advantage of this definition of FIR is that is simultaneously captures externalities from forward and backward linkages.

4. Empirical results

4.1. Intra-regional FDI-induced externalities

4.1.1. OLS results

The estimation of (Eq. 1) is OLS. The results are shown in table 1. The first estimation of (Eq. 1) is presented in column (1). The model performs reasonably well, judging from the significance of the RHS variables. The only RHS variable that shows an estimated insignificant effect is the variable FOR. However, the findings presented in column (1) do not control for state or industry fixed effects. To control for the regional and industry dimensions of the data, I have re-estimated the equation, including state and industry dummies. The results of this estimation are shown in (2). The F-test indicates that both the state and industry dummies are significant in the model. Comparing the results that include the fixed effects to the original estimation, there is an important difference, as the estimated negative effect of FOR now reaches an acceptable level of significance[14].

This suggests that the presence of foreign-owned firms is creating negative (pecuniary) externalities within Mexican-owned manufacturing industries[15]. This finding of negative FDI-induced externalities is in contrast to earlier findings for Mexico (see Blomström et al., 2000), but in line with recent findings for other host economies (see Aitken and Harrison, 1999, Harrison, 1996; Haddad and Harrison, 1993)[16].

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[14] Baldwin et al. (1999) similarly find that significant externalities only materialise when they control for both industry and country effects.

[15] See Aitken and Harrison (1999) for a discussion of negative FDI-induced externalities.

[16] For similar findings of negative FDI-induced externalities for aggregate Mexican industries, see Jordaan (2004a).

Table 1. Intra-regional externalities from FDI participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	FOR-OLS (1)	**FOR-OLS (2)**	**Productivity catch-up**	**FOR&FIR-OLS**	**Productivity catch-up**	**FOR-IV**	**FOR & FIR-IV**
κ	0.49 (16.03)***	0.40 (9.13)***	-0.04 (3.06)***	0.40 (9.21)***	-0.04 (3.51)***	0.40 (9.21)***	0.44 (10.30)**
LQm	0.25 (4.26)***	0.12 (1.22)	-0.01 (0.44)	0.10 (1.04)	-0.01 (0.17)	0.11 (1.20)	0.10 (1.12)
Scalem	0.05 (1.93)**	0.10 (2.04)**	-0.02 (1.27)	0.12 (2.28)**	-0.01 (0.72)	0.09 (1.87)*	0.07 (1.42)
Dual	-0.20 (4.94)***	-0.20 (3.60)***	0.001 (0.25)	-0.19 (2.37)***	0.01 (0.41)	-0.16 (3.03)***	-0.18 (3.29)***
Spec	0.10 (3.13)***	0.08 (2.48)***	-0.02 (1.34)	0.08 (2.51)***	-0.02 (1.11)	0.08 (2.53)***	0.08 (2.45)***
Urb	0.13 (3.35)***	0.22 (1.98)**	-0.04 (3.27)***	0.21 (2.71)***	-0.03 (2.91)***	0.24 (2.14)**	0.10 (1.93)**
FOR	-0.02 (1.27)	-0.04 (2.41)***	0.02 (1.84)*	-0.05 (2.66)***	0.01 (1.58)	0.08 (1.72)*	0.12 (2.38)***
FIR	--	--	--	-0.08 (1.16)	-0.02 (1.23)	--	0.16 (2.28)***
Constant	0.20 (0.35)	-1.28 (0.72)	1.71 (12.70)***	-0.89 (0.67)	1.69 (12.37)***	-1.71 (0.95)	0.66 (0.67)
State & industry fixed effects	No	Yes F = 2.24 (0.000)	No F = 1.14 (0.30)	Yes F = 2.32 (0.000)	No F = 1.03 (0.44)	Yes F = 2.36 (0.000)	Yes F = 2.22 (0.000)
Adj. R^2	0.76	0.86	0.17	0.87	0.20	0.86	0.86
F	77.27 (0.000)	17.43 (0.000)	5.76 (0.000)	18.01 (0.000)	5.84 (0.000)	17.50 (0.000)	18.05 (0.0000
N	169	169	168	168	166	166	166

Absolute values of T-statistics in parentheses; *, ** and *** indicate significance levels of 10, 5 and 1%. Estimations are heteroscedasticity-robust using the Huber/White/Sandwich Method.
The F-value for state and industry effects is an F-test of whether state and industry dummies have coefficients equal to 0.

Having said so, the estimated effect of foreign participation needs to be interpreted with caution, as it may be affected by a bias caused by endogeneity of the variable FOR. Estimations of FDI-induced externalities are biased when there is a relation running from productivity to industry-wide foreign participation (Hanson, 2001). For instance, foreign firms may gravitate towards industries with high productivity levels (Aitken and Harrison, 1999). In such a case, an estimated positive association between industry-wide foreign participation and host economy productivity is biased, as it reflects both externality effects and the gravitation tendency towards industries with particular industries. In essence, when there is a line of causation running from the dependent variable to a RHS variable, the latter variable is endogenous to the empirical model and its estimated effects will be biased (Wooldridge, 2002).

One way to control for this problem is to estimate the effect of industry-wide foreign participation on productivity change. Even if measured Mexican industry productivity levels affect the variable FOR in 1993, an unbiased estimation of FDI-induced externalities may possibly be obtained by regressing Mexican industry productivity growth or convergence on 1993 industry-wide foreign participation. To obtain this, I regress a proxy of productivity convergence for the period 1993-1998 on the 1993 RHS variables. This proxy is calculated as the ratio of industry-wide value added over labour for 1998 divided by Mexican industry-wide value added over labour for 1993[17]. This ratio of productivity indicators reflects the extent of convergence of Mexican labour productivity in the five-year period towards the industry average. A negative association between this ratio and industry-wide foreign participation in 1993 would suggest the existence of positive externalities, with the presence of foreign firms lowering the difference between industry-wide labour productivity and labour productivity among Mexican firms.

The empirical findings for the productivity catch up estimation are shown in column (3). The negative association between the capital-labour ratio and the dependent variable indicates that internal scale economies have a positive effect on Mexican firms approaching industry-average labour productivity. In a similar fashion, the estimated negative effect of the variable URB suggests that Mexican firms benefit from urbanisation economies in approaching average industry productivity levels. Turning to the estimated effect of FOR, the findings indicate that the presence of FDI does not stimulate Mexican firms in approaching industry-wide productivity levels; in fact, the estimated association is positive. This positive association indicates that the presence of FDI creates a larger gap between industry-wide labour productivity and Mexican labour productivity, suggesting the occurrence of negative FDI-induced externalities. This finding is in line with the OLS results in the previous columns.

Finally, columns (4) and (5) present the estimations of the empirical models that contain both FOR and FIR. Column (4) contains OLS results for the 1993 levels estimation. The significant estimated effect of FOR indicates the presence of negative FDI-induced externalities. The estimated effect of FIR is similarly negative, suggesting that negative externalities from FDI may also be transmitted between industries. However, its estimated effect remains insignificant. Column (5) contains the results of the productivity catch up estimation. Whereas the positive sign of the estimated

[17] Industry-wide value added over labour for 1998 is taken from Inegi (1999).

effect of FOR suggests the presence of negative intra-industry externalities, the negative estimated effect of FIR suggests that inter-industry FDI externalities may positively stimulate Mexican firms to approach industry productivity levels. However, when both FOR and FIR are included, the estimated effects of both the variables fail to reach significance.

4.1.2. Intra-industry externalities from FDI: IV estimations

Thus far, the findings suggest the presence of negative intra-industry FDI-induced externalities. The estimations of determinants of productivity catch up that may control for the endogenous component of FOR offer particular support for this. However, it is important to consider that the productivity catch up estimation may suffer from several weaknesses. First, the component of the dependent variable that captures 1999 labour productivity does not distinguish between foreign-owned and Mexican-owned shares of industries[18]. This means that the productivity catch-up of Mexican firms may be mis-measured, if foreign firms alter their participation in industries.

A change in foreign participation would change industry productivity levels, altering overall industry productivity levels as a result. This problem may be exacerbated if foreign investment in 1999 is related to foreign investment in 1993. It may be that foreign firms follow previous investment patterns to minimise uncertainty (Krugman, 1999). In that case, the estimated positive association between FOR and productivity catch up may capture the positive effect of this uncertainty minimisation strategy rather than the existence of negative FDI-induced externalities.

Finally, another type of endogeneity may exist when FDI is attracted to industries with high productivity growth (Nair-Reicher and Weinhold, 2001). If such gravitation exists, there will be a bias in the estimated effect of FDI on productivity catch-up, as the positive association between industry-wide foreign participation would capture both externality effects as well as the effect of future productivity expectations on behalf of new FDI.

In Jordaan (2004b), I specifically address the question whether the variable FOR is endogenous to an empirical model that estimates determinants of measured Mexican labour productivity, using national industry observations. The findings in Jordaan (2004b) indicate that there

[18] 1999 data that distinguishes between FDI and Mexican-owned shares of industries is unpublished and not available.

is a problem of endogeneity, as foreign firms gravitate towards low productivity, labour intensive, industries. Controlling for this, IV estimations indicate significant positive intra-industry FDI-induced externalities, contrasting OLS estimations that suggest the existence of negative externalities from FDI. To assess whether a similar endogeneity bias is also affecting the present estimations, I use the IV estimation presented in Jordaan (2004b) to obtain an instrument for the variable FOR in the present estimations[19]. For each state, I run the first stage regression of the IV estimation. With the results from these regressions, I calculate for each state the estimated number of employees working for foreign firms at the 4-digit industry level. After aggregating these values to 2-digit industries, I calculate the instrument for the variable FOR in the present estimation. The results of using the instrumented FOR values in the second stage of the IV estimation are shown in column (6).

The difference between the estimated effect of FOR from the OLS and IV estimations is similar of nature to the findings presented in Jordaan (2004b) for a national sample of industries. Instead of a negative effect, the IV estimation produces a significant positive effect of industry-wide foreign participation. This difference suggests that the OLS estimates are biased downwards, due to the tendency of foreign firms to locate in labour-intensive, low productivity industries. Controlling for this tendency, the IV results indicate that the presence of FDI leads to positive intra-industry externalities.

In extension of this finding, the estimated effect of FIR may also be affected by an endogeneity bias. Productivity levels of industries within a region may be related through inter-firm linkages and other relations. In such cases, the productivity levels of other industries in a state may influence the level of regional foreign participation in a given industry. For instance, if FDI in industry 4 is attracted to a state partly because they intend to use labour-intensive Mexican firms in say for instance industry 8, the endogeneity bias may affect the estimations of inter-industry FDI-induced externalities as well. To assess whether this is the case, I have taken the instruments for the number of employees working in FDI at the 4-digit level per state to calculate instrumented FIR values at the 2-digit state level. The results of instrumenting both FOR and FIR are shown in column (7).

The results in column (7) are cleared from any endogeneity bias that may have affected the estimated externality effects of FOR and FIR. A comparison of the IV results with the previous

[19] The instrument is the cross-industry variation of foreign participation shares in US manufacturing industries, as a proxy for the general FDI-intensity of manufacturing industries (see Jordaan 2004b for full discussion).

estimates indicates that the differences are strong. Instead of the presence of negative externalities, the IV estimation indicates that both the intra-industry and inter-industry presence of FDI create positive externality effects. Therefore, the conclusion is warranted that, when the endogenous components of both FOR and FIR are controlled for, the presence of foreign firms creates significant positive intra- and inter-industry externalities among manufacturing industries within regions in Mexico.

4.2. Inter-regional FDI-induced externalities

In order to estimate whether foreign participation leads to inter-regional FDI-induced externalities among Mexican manufacturing industries, the original empirical model needs to be augmented with RHS variables that capture inter-regional foreign participation. The equation becomes:

$$\text{(Eq. 2.)}\ \left(Q/L\right)_{ij} = ß_0 + ß_1 \kappa\, m_{ij} + + ß_2\, SCALEm_{ij} + ß_3\, DUAL_{ij} + ß_4\, SPEC_{ij} + ß_5 URBij + ß_6 FOR_{ij} + ß_7 FIR_{ij} + ß_8 FORregion_{ij} + 9FIRregion_{ij} + \varepsilon$$

The additional RHS variables FORregion and FIRregion capture the intra- and inter-industry inter-regional variation of foreign participation respectively. For a given industry in a given state, the values of FORregion and FIRregion are calculated from actual observations in a similar fashion as FOR and FIR, be it that they concern observations aggregated over states, excluding the given state.

As discussed in section two, in order to capture inter-regional externalities from FDI, the variables FORregion and FIRregion need to carry spatial weights to control for inter-regional distances. As the specification of the distance decay parameter is somewhat of an empirical issue (Anselin, 1988), I experiment in this paper with three alternative specifications.

First, I ignore any form of distance decay effect. In formula form, this amounts to:

$$FORnd_{ij} = \frac{\sum_{g \neq j}^{32} (employees foreign firms)industry - i}{\sum_{g \neq j}^{32} (total employees)industry - i}$$

$$FIRnd_{ij} = \frac{\sum_{h \neq i}^{9} \sum_{g \neq j}^{32} (employeesforeignfirms)}{\sum_{h \neq i}^{9} \sum_{g \neq j}^{32} (totalemployees)}$$

where

Industries i, h = 1, …..9

States j, g = 1, 2, ……32

Second, I specify the distance decay parameter as the distance in kilometres between the capital cities of each state (see Adserà, 2000; Greunz, 2003; Driffield and Girma, 2003)[20]. This specification amounts to:

$$FORdistance_{ij} = \sum_{g \neq j}^{32} \left(\left(\frac{(employeesforeignfirms)ind-i}{(totalemployees)ind-i} \right) * \left(1 / distancej-g \right) \right)$$

$$FIRdistance_{ij} = \sum_{g \neq j}^{32} \sum_{h \neq i}^{9} \left(\left(\frac{(employeesforeignfirms)}{(totalemployees)} \right) * \left(1 / distancej-g \right) \right)$$

Third, I apply spatial weights to the inter-regional foreign participation variables assuming that externalities from FDI can only be transmitted between neighbouring states. In effect, this specification means that, for an industry in a given state, I only consider FOR and FIR values of those other states in Mexico that share a common border with the given state. For these states, I calculate average values for FOR and FIR and include these in the equation. Foreign investment in non-neighbouring states is assumed to have no possible externality effect. The results of the empirical estimations with these alternative variables of intra- and inter-industry regional foreign participation are presented in table 2.

[20] Distances in number of kilometres between state capital cities taken from http://www.trace-sc.com/maps_en.htm

Table 2. FDI and inter-regional externalities

	(1)	(2)	(3)	(4)	(5)
K	0.44 (10.30)***	0.44 (9.50)***	0.42 (8.87)***	0.42 (8.84)***	0.45 (9.54)***
SCALEm	0.07 (1.42)	0.08 (1.46)	0.07 (1.29)	0.07 (1.23)	0.07 (1.22)
DUAL	-0.18 (3.29)***	-0.19 (3.53)***	-0.18 (3.37)***	-0.18 (3.35)***	-0.17 (3.02)***
SPEC	0.08 (2.45)***	0.07 (1.64)*	0.07 (1.70)*	0.07 (1.69)*	0.07 (1.82)*
URB	0.10 (1.93)**	0.12 (2.51)***	0.08 (1.01)	-0.14 (0.28)	0.09 (1.68)*
FOR	0.12 (2.38)**	0.13 (3.06)***	0.12 (2.39)***	0.12 (2.39)***	0.13 (3.07)***
FIR	0.16 (2.28)**	0.13 (2.14)**	0.16 (2.26)**	0.16 (2.27)**	0.140 (1.76)*
FORnd	--	0.53 (2.07)**	--	--	--
FIRnd	--	-1.41 (0.96)	--	--	--
FORdis	--	--	0.01 (0.10)	--	-0.006 (0.18)
FIRdis	--	--	--	0.40 (0.45)	0.35 (2.35)***
FORborder	--	--	--	--	
FIRborder	--	--	--	--	
Constant	0.66 (0.67)	1.88 (1.84)*	1.62 (0.84)	6.24 (0.60)	1.15 (1.45)
State & industry effects	Yes F = 2.22 (0.000)	Yes F = 2.50 (0.000)	Yes F = 2.58 (0.000)	Yes F = 2.60 (0.000)	Yes F = 5.88 (0.000)
Adj. R^2	0.86	0.87	0.86	0.86	0.87
F	18.01 (0.000)	17.75 (0.0000	17.31 (0.000)	17.34 (0.000)	17.15 (0.000)
N	166	166	166	166	166

Absolute values of T-statistics in parentheses; *, ** and *** indicate significance levels of 10, 5 and 1%. Estimations are heteroscedasticity-robust using the Huber/White/Sandwich Method.
The F-value for state and industry effects is F-test of whether state and industry dummies have coefficients equal to 0.
For and Fir are always instrumented.
Fornd and Fimd are inter-regional intra- and inter-industry FDI participation omitted distance decay parameter; Fordis and FIRdis are calculated using distance decay parameter based on kilometres between state capital cities; Forborder and FIRborder are calculated using distance decay parameter based on the shared border principle.

Column (1) presents the estimation that omits any type of inter-regional foreign participation. Column (2) contains the results when inter-regional foreign participation is added, omitting any form of distance decay effect. The estimated effect of the variable FIRnd is insignificant, suggesting that externalities between industries do not spill over between states. However, the estimated effect of the

variable FORnd is significant and positive, suggesting that intra-industry externalities from foreign participation do spill over between states[21]. Furthermore, the estimated coefficient of FORnd is much larger compared to the estimated coefficients of FOR and FIR, suggesting that the intra-industry presence of foreign manufacturing firms in other states leads to a higher percentage increase in measured Mexican productivity levels compared to foreign participation within regions.

However, the variable FORnd does not take into account inter-regional distances at all. Effectively, this means that, for a given state, foreign investment in a neighbouring state is given equal weight to foreign investment located at large distances. This is a strong assumption, especially given empirical findings providing robust evidence that some form of distance decay effect affects spatial externalities (see especially Jaffe, 1993; also Audretsch, 2003; Howells, 2002). Therefore, the estimated effect of FORnd needs to be interpreted with extreme caution.

Alternatively, the estimated effect of FORnd could be interpreted as capturing a general competition effect. Such a positive association between the level of competition and measured productivity is in line with the traditionally predicted competition effect from FDI as discussed by Caves (1996). In any case, the estimated positive association does not provide sufficient evidence of the existence of spatial externalities, due to the omission of any form of distance decay effect.

The results presented in columns (3) and (4) contain inter-regional FOR and FIR variables, using distance between state capital cities as spatial weights. These results suggest that there are no spatially transmitted externalities from inter-regional FDI participation. Both the variables FORdis and FIRdis have estimated associations that are not significant. However, important to note is that the results suffer severely from multicollinearity[22]. One indication for this is that the estimated effect of URB ceases to be significant. VIF analysis indicates that the inclusion of either of the two spatially weighted variables indeed causes multicollinearity problems. For instance, the estimation including FORdis produces a total average VIF score of 8, with FORdis carrying the highest VIF score of 20.23; values well above those suggested by Chatterjee, Hadi and Price (2000). The presence of multicollinearity makes the estimated coefficients difficult to interpret[23].

[21] Girma and Wakelin (2002) find a similar positive effect of intra-industry inter-regional foreign participation for the UK.

[22] This problem prevents the inclusion of both FORdis and FIRdis in the same estimation.

The results presented in the final column of table 2 are from the inclusion of the inter-regional foreign participation variables where the distance decay effect is calculated based on the common border principle. These results suggest that, for a given industry in a state, the presence of foreign firms in neighbouring states in the same industry does not create FDI-induced externalities. However, the variable representing foreign participation in other industries in neighbouring states carries an estimated positive sign, significant at the 1% acceptance level. This suggest that Mexican firms do benefit from FDI-induced externalities originating from neighbouring states, from foreign firms that are operating in dissimilar but related industries. Compared to the findings in columns (3) and (4), this estimated effect would suggest that there are spatial externalities from FDI, although these externalities are subject to a strong distance decay effect as they only materialise between neighbouring states. As such, the strength of the distance decay effect is in line with for instance Jaffe et al. (1993), who find that knowledge spillovers peter out after a relative short geographical distance.

In sum, the findings for inter-regional FDI-induced externalities indicate two important issues. First, it appears important to incorporate some form of spatial decay parameter into the analysis, in order to correctly estimate the presence of inter-regional FDI-induced externalities. When inter-regional distances are omitted, the findings indicate that inter-regional FDI-induced externalities are of an intra-industry nature. When inter-regional distances are included, the estimated inter-regional externality effects from foreign participation are either insignificant or indicate that inter-regional externalities occur between, rather then within, industries.

Second, the difference in estimated effects based on the two alternative distance decay parameters indicates that it is important to consider various distance decay parameters. If we adopt the

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[23] In the case of FIRdis, the average VIF score is 34 and FIRdis carries the highest VIF score of 465. Omitting the URB variable does not solve the problem. The estimation that includes FORdis and omits URB produces an average VIF value of 18, with FORdis having a VIF score of above 20. The values for the estimation that includes FIRdis and omits URB are an average VIF value of 98, with FIRdis having a score of 465. In contrast, the VIF statistics for the estimation that includes URB without either FORdis or FIRdis has an average VIF score of 4, with URB carrying a VIF score of 3.95.

distance decay parameter based on distances between capital cities, the conclusion is that there are no spatial externalities. However, the findings from the shared border assumption suggest that FDI-induced externalities of an inter-industry nature do occur between neighbouring states. This reflects the fact that FDI-induced externalities are subject to a relative strong distance decay effect, which is not picked up by the distance decay parameter in the form of distance between state capital cities.

5. Summary and conclusions

Recent empirical studies of FDI-induced externalities pay more attention to geographical aspects surrounding such externalities. Additional RHS variables are included in empirical models to control for externality effects of intra-regional intra- and inter-industry foreign participation. Moreover, some attempts have been made to identify externalities from FDI that are transmitted between regions.

The aim of the present paper is to empirically estimate FDI-induced externalities in Mexican manufacturing industries. In the empirical specifications, I try to correct for two problems that previous research may have suffered from. First, the majority of studies do not include all possible types of regional FDI-induced externalities. Not only does this mean that the entire range of such regional externalities remains unidentified, it may also have produced omitted variable bias in estimated externality effects of those foreign participation variables that are included in the estimated empirical models. Second, studies of inter-regional FDI-induced externalities appear to have adopted spatial decay effects in a rather loose manner, which may have led to a too readily discarding of the occurrence of such spatial externalities.

One set of empirical findings in the present paper concerns intra- and inter-industry externalities from FDI among Mexican manufacturing industries within regions. The difference in findings between the OLS and IV estimations indicates that the OLS estimations are subject to an endogeneity bias, caused by a tendency of foreign firms to gravitate towards low productivity, labour intensive, industries. Controlling for this bias, IV estimations indicate that the presence of foreign-owned firms creates positive intra-regional externalities, both within and between Mexican manufacturing industries.

The second set of findings addresses the occurrence of FDI-induced externalities between Mexican regions. The use of a distance decay parameter to weigh inter-regional foreign participation is

important. If inter-regional distances are ignored, the estimations suggest that there are significant positive FDI-induced externalities of the intra-industry type. The use of distance decay specifications also indicates that there may be spatial externalities, however, the estimations using spatial weights indicate that such spatial spillovers occur between rather then within industries.

In conclusion, the empirical findings in the present paper carry two important implications for future empirical research on FDI-induced externalities. First, estimations of both intra-regional intra- as well as inter-industry foreign participation may be subject to an endogeneity bias, as is the case in the present paper. In contrast to the negative findings from the OLS estimations, the IV estimations indicated that for types of intra-regional FDI participation create positive externalities. This difference indicates the important effect that endogeneity can have in such estimations. Furthermore, it means that other empirical attempts that do not test and control for the presence of endogeneity need to be interpreted with caution, as their findings may be affected by the endogenous components of the regional foreign participation variables.

Second, estimations of inter-regional FDI-induced externalities are sensitive to the specification of the distance-decay parameter. One issue is that the present findings differ strongly based on the inclusion or exclusion of a distance decay parameter. Given the fact that spatial externalities are subject to decay effects, the inclusion of a distance parameter is to be preferred. Furthermore, it seems that a certain amount of flexibility is required in the choice of distance parameter. As the present findings indicate, it is fruitful to consider more than one specification of the distance decay parameter, to explore the existence of decay effects in processes of spatially transmitted FDI-induced externalities.

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