*FDI determinants and spatial spillovers across Mexico's states**

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Abstract

This paper studies the location pattern of Foreign Direct Investment (FDI) in Mexico for the period 1994-2004. An empirical model is specified based on recent FDI theories. This model is estimated using state-level data and employing spatial econometric techniques. Results suggest that higher education levels and lower delinquency rates are important determinants to attract FDI. Results also suggest a relationship of complementarity between inbound FDI to the host state and inward FDI to its neighboring states.

Keywords: FDI, Mexico, NAFTA, Spatial econometrics.

Code JEL: F21, C29, O54.

1 Introduction

In recent years, many developing countries have tried to attract Foreign Direct Investments (FDI) to compensate for their lack of capital for financing their economic activity. These countries consider FDI to be beneficial as a source of access to markets, technologies and other assets that are not available in the local economy (UNCTAD 2006). Thus, countries compete to propose the most attractive production conditions (i.e., legal environment and economic policies), and their policy-makers take measures to attract foreign capital.

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To improve Mexico's attractiveness, Mexican authorities implemented major liberalization reforms. First, Mexico signed the North American Free Trade Agreement (NAFTA) with Canada and the United States (US), which came into effect in January 1994. Second, obstacles to FDI were significantly removed with reforms to FDI regulations in 1989 and a new regulation in 1993. After the implementation of these reforms, Mexico became an attractive country for foreign investors to locate their operations. Mexico's principal advantage over other developing countries is the free access to Canadian and US markets. As a result, in 2004, Mexico was considered the tenth favored location for the largest world multinationals, which is ahead of Canada, Spain, Singapore and Japan, and the second favored location among the developing countries, only behind Brazil (UNCTAD 2006).

Empirical literature studying FDI effects in Mexico points out that FDI stimulates total factor productivity in Mexico (Aitken, Harrison, and Lipsey 1997; Tornell, Westermann, and Martinez 2004; Waldkirch 2010). Studies also find that economic activity with a strong foreign presence performs better and that the productivity levels of national firms converge to the levels achieved by foreign-owned firms in their sectors. However, FDI inflows in Mexico are also a source of negative effects. Indeed, FDI focuses on the export-oriented sector, having little contact with national activity, and thus limiting Mexico's industrialization process (Máttar, Moreno-Brid, and Peres 2002). Moreover, FDI contributes to a rise in income inequality (Feenstra and Hanson 1997).

Even though foreign investments are thought to benefit from cheap labor in Mexico (Love and Lage-Hidalgo 2000; Waldkirch 2003) to serve the North American rather than Mexican market (Graham and Wada 2000), literature studying the determinants of FDI inflows in Mexico is scarce, particularly literature related to FDI location determinants. Mollick, Ramos-Duran, and Silva

Ochoa (2006) analyze the determinants of FDI inflows in 22 Mexican states in the period of 1994-2001 and conclude that improvements in infrastructure (measured as telephone line density) are the main factors for attracting FDI. Nevertheless, these authors limit their analysis to the 22 highest ranking states by FDI amount. Jordaan (2008) employs a variety of panel techniques to estimate different empirical specifications. He finds that states' size, wages, level of schooling and infrastructure play a significant role to attract FDI.

The purpose of this paper is to study a broad issue, regarding inward FDI in Mexico, which has not yet received much attention. The paper empirically examines economic theory on multinational enterprises to determine: (1) the motivations for FDI in Mexico, and (2) the determinants of the geographical distribution of FDI at a regional level. Following previous work on spatial econometrics applied to FDI analyses (Baltagi, Egger, and Pfaffermayr 2007; Blonigen et al. 2007), interaction among Mexican states' characteristics, FDI motivations and spatial linkages are studied to explain the location pattern of FDI in Mexico. To the author's knowledge, this is the first study that analyzes spatial linkages for FDI across the Mexican states.

This paper is organized as follows. The next section briefly introduces the geographical and industrial configuration of inbound FDI in Mexico. Section three describes the theoretical background and is followed by a discussion on the empirical methodology in section four. Section five presents the results. Finally, conclusions are drawn in section six.

2 FDI distribution in Mexico

NAFTA and reforms on FDI regulation seem to be successful in attracting FDI, as FDI inflows increased substantially after their implementation. According to official data (available at INEGI), the average yearly FDI inflows/GDP ratio

has more than doubled since 1994 (2.61%) compared to 1989-1993 (1.25%). The average ratio for the 1994-2004 period is 3.2%, as 2001 was the most remarkable in terms of FDI attraction, with a 4.75% ratio. Waldkirch (2003) quantifies the effects of NAFTA on the volume of FDI inflows to 40%, which results from a vertical specialization by multinationals from Canada and the US. However, FDI increases should not only be attributed to liberalization reforms because a change in FDI definitions was made in 1994. Indeed, prior to 1994, investments related to transfers of stocks from nationals to foreigners, imports of fixed assets by maquila firms and transfers between subsidiary and parent companies were not counted as FDI (INEGI).

From 1994-2004, the US was the main source of FDI with around 60% of the total. Moreover, the US share as a source of FDI increased by more than 10% during this period. Spain has also considerably increased its share of FDI inflows. Spain accounted for about 1.4% of inbound FDI in 1994, while its share of accumulated FDI during 1994-2004 was almost 12.7%. In the meantime, other important sources of FDI in Mexico, such as Canada and Holland, maintained their share, while the shares of the United Kingdom, Germany, France and Japan has decreased.

Mexican authorities report FDI destination data on nine economic sectors: agriculture and fisheries, mining, manufacturing, electricity, construction, commerce, transport and communications, financial services and other services. Most FDI inflows go to the manufacturing sector. During 1994-2004, this sector share of FDI inflows was about 48%. However, the importance of this sector has decreased in favor of the financial services sector. Indeed, before 2001, the share of manufacturing was around 52.3%, and the share of financial services was 10.9%. Since then, the manufacturing share has decreased and the financial services sector has become the second economic sector in terms of FDI attraction

with a share of 25% of the overall FDI. The increase of FDI in financial services can be attributed to the 1999 implementation of a FDI deregulation that allows 100% foreign participation in the financial sector. This sector attained its highest share in 2001 with the acquisition of the biggest national commercial bank by a foreign group. According to UNCTAD (2002), this transaction accounted for more than 50% of 2001 FDI and contributed to making 2001 the most important year in terms of FDI inflows during 1994-2004. FDI shares in other sectors were quite stable during 1994-2004. Their importance and average shares were as follows: commerce (11.5%), other services (8.5%), transports and communications (6.1%), construction (1.3%), mining (0.9%), electricity (0.4%), and agriculture and fisheries (0.2%).

According to the spatial distribution of FDI inflows in Mexico, FDI is not equally distributed. Figure 1 illustrates the density distribution of FDI inflows during 1994-2004. During this period, more than 60% of the accumulated FDI inflows went to the Federal District (Mexico City), which is Mexico's capital as well as the country's richest entity. FDI is also unequally distributed among the rest of the Mexican states, particularly between the states located in the north and south of Mexico.

[Figure 1 here]

The map analysis suggests that FDI is concentrated in states located mainly near big markets, such as the Federal District and the US. However, to determine why FDI concentrates in these states, as well as to identify the motivations for FDI, a regression analysis based on economic theory is conducted.

3 Determinants of FDI location: theoretical background

There has been considerable progress in recent years in terms of theory regarding Multinational Enterprises (MNEs) and FDI location behavior. Dunning (1973) proposed that Ownership, Location and Internalization (OLI) advantages encouraged firms to undertake foreign investment. In this framework, location is perceived as an advantage that firms can obtain by locating production abroad (i.e., scale economies). However, OLI framework was not built on a formal setting. Since Markusen (1984) and Helpman (1984), Dunning's ideas have been incorporated into a general equilibrium theory of trade, which has led to the Knowledge-Capital (KC) model.

Markusen (2002) suggests two different patterns of FDI: (1) horizontal and (2) vertical. Horizontal MNEs produce similar goods and services in different countries. Their main motivation is to access markets when trade costs are high. Vertical foreign investments refer to a fragmentation of the production process into stages of production that are each produced in different locations. Vertical FDI is motivated by the differences in factor prices, especially by differences in labor costs. "Complex FDI" versions of the KC model have been developed more recently. The literature mainly distinguishes between two types of these models: (1) complex horizontal or export platform FDI and (2) complex vertical or vertical specialization FDI. In an export platform FDI model (Ekholm, Forslid, and Markusen 2007; Baltagi, Egger, and Pfaffermayr 2007) a home country firm sets up a production plant in a region that benefits from better access and lower production costs than the home country, and the region serves as a production platform for exports to a group of "neighboring" regions. Finally, in complex vertical models, MNEs separate their production process into multiple vertical

activities and put them in locations offering the lowest costs (trade and/or production). Baltagi, Egger, and Pfaffermayr (2007) suggest that, with these complex modes of MNEs organization, host country characteristics are not the only determinants attracting FDI; the host neighbors' characteristics could also play an important role.

Concerning firm location decisions, New Economic Geography (NEG) models incorporate location theories into a formal model. Moreover, most of them analyze how economic integration affects the location of economic activity. NEG literature (Fujita, Krugman, and Venables 1999) points out the importance of agglomeration and dispersion forces to attract or discourage firms from locating in a given region. On the one hand, a firm has the incentive to locate in proximity to other firms, especially if they are its suppliers or customers, to take advantage of positive externalities as technological spillovers. On the other hand, congestion effects, as well as increases in wages and land prices, reduce the attractiveness of a region. Egger et al. (2007) and Hoffman and Markusen (2007) incorporate the KC model in a NEG framework to show how liberalization reforms influence FDI location decisions. These studies highlight the importance of factor prices and market size as major determinants of location decisions.

4 Empirical specification and theoretical hypothesis

This paper uses a panel of annual data on the inbound FDI of the 32 Mexican states for the period of 1994-2004. The year 1994 is chosen as the starting year for two major reasons: (1) FDI regulation reforms in late 1993 make the state-level data available and comparable, and (2) NAFTA was implemented

in 1994. The Mexican Ministry of Economy reports state level FDI data in the form of yearly inflows. However, some states do not always have positive FDI inflows, and a logarithmic transformation drops such observations from the sample. Dropping observations means not taking into account potentially useful information. Hence, the dependent variable is defined as the stock of FDI accumulated during the period of study. For the compilation of this stock, the perpetual inventory method is applied using FDI inflows as annual additions minus the accumulated consumption of FDI (see Appendix A for more details).

For each Mexican state $i = 1, \dots, N$ and for each time period $t = 1, \dots, T$, the empirical specification takes the following form:

$$FDI_i(t) = \beta X_i(t) + \varepsilon_i(t), \quad (1)$$

where $FDI_i(t)$ is the log of the stock of FDI in state i at year t , and $FDI_i(t)$ is then a $N \times 1$ vector of observations in a year t . $X_i(t)$ is the $N \times K$ matrix of observations on K exogenous variables in year t , and ε_i is the $N \times 1$ vector of disturbances. All variables are introduced in logarithmic transformations unless indicated otherwise.

According to economic theory, the FDI location decision depends on MNEs' strategies and on the host region's location advantages (Dunning 1973; Markusen 2002). Because FDI strategies can be summarized into market-oriented and resource-seeking FDI, a region's market size, resource endowments and geographical position will determine its location advantages. Independent variables included in K are then variables concerning location advantage differences among Mexico's states.

As a measure of a state's market advantages, two variables are employed: (1) GDP per capita and (2) population. GDP per capita is related to purchase power, while population is related to market size. According to KC models, hor-

horizontal FDI will be high if countries' economies are similar in development, while differences among countries' development lead to vertical FDI (Markusen 2002). Because the main sources of FDI are developed countries, GDP per capita's coefficient sign is expected to reflect differences between vertical and horizontal FDI. However, GDP per capita can also be an indicator of an abundance of factor endowments that facilitate all types of FDI. Concerning population and market size, NEG models suggest that size matters not only for the potential market demand but also for the agglomeration incentives. Population's coefficient sign is then expected to be positive for both FDI motivations.

As endowment-related variables, skilled-labor, wages, agglomeration forces and available infrastructure in the host state are included. The average years of schooling for individuals over 15 is employed as a proxy of skilled-labor endowments. KC models also suggest that multinational enterprises require a certain level of skilled workers for production; skilled-labor endowments are then expected to have a positive influence on attracting FDI, as they did in Jordaan (2008).

Wages are usually employed by the literature as a measure of production costs. Thus, if the MNEs' motivation is the vertical type, wages are expected to be negatively related to FDI. However, if wages reflect the availability of skilled workers or the purchase power of the region, wages will have a positive influence on attracting FDI. Empirical literature has found both positive (Head, Ries, and Swenson 1995) and negative (Coughlin, Terza, and Arromdee 1991; Crozet, Mayer, and Mucchielli 2004) relationships between wages and FDI, with the Mexican case being negative (Jordaan 2008).

As mentioned before, NEG literature highlights the importance of agglomeration economies as a determinant factor in the location decision of a firm. Empirical literature usually finds a positive effect of agglomeration on FDI,

which suggest that concentration benefits are stronger than dispersion benefits. However, as suggested by Head, Ries, and Swenson (1995), these results can be due to the omission of relevant location variables rather than to agglomeration forces. In addition, there is no consensus, because of data availability, on how to measure agglomeration. For example, the literature employs measures of population, industrial, capital and firm density (e.g., Coughlin, Terza, and Arromdee 1991; Crozet, Mayer, and Mucchielli 2004. For the Mexican case, Jordaan (2008) and Mollick, Ramos-Duran, and Silva Ochoa (2006) employ manufacturing employment and activity densities, respectively, as measures of agglomeration. However, they do not find robust results concerning variables' statistical significance. To control for agglomeration, the ratio of industrial firms installed before the FDI year to the state's surface is employed. This variable has the disadvantage that firms cannot be classified by their nationality, but to the author's knowledge, it is the only yearly data available.

Improvements in infrastructure can be seen as a reduction in transport costs. From an NEG perspective, this reduction in transport costs benefits agglomeration in rich states to the detriment of poor states. Performances in infrastructure could create a negative effect for poor states, as FDI will be located in states offering economies of scale. Because telephone lines facilitate international communications, Mollick, Ramos-Duran, and Silva Ochoa (2006) consider them, following Martin and Rogers (1995), as a measure for international infrastructure. Thus, improvements in international infrastructure would reduce international trade costs and provide a positive incentive for vertical FDI motivation and a negative incentive for horizontal FDI.

As a proxy of investment environment or local governance and given the lack of other data for the period of study, the delinquency rate is employed. This variable would play a negative role in attracting FDI for any FDI motivation.

Recent literature suggests the importance of third regions' effects on FDI (Baltagi, Egger, and Pfaffermayr 2007; Blonigen et al. 2007). Indeed, FDI inflows in a given state may also be affected by FDI inflows in other locations, especially by neighboring locations. Ignoring this spatial dependence may cause biased results (Anselin 2001). In spatial econometrics literature, there are two classes of spatial links: (1) a spatial lag and (2) a spatial error. In this paper, the spatial lag model is implemented for the following reasons. First, in this model, inward FDI to a state depends on the state's characteristics but also on the inward FDI to neighboring states. This type of model is an appropriate tool for capturing the substitution or the complementarity of FDI across states (Blonigen et al. 2007). Finally, LeSage and Pace (2008) provide two econometrical motivations to include a spatial lag of the dependent variable in their study of origin-destination flows. The first motivation considers spatial dependence as a long-run equilibrium of a dynamic spatiotemporal process. In other words, a shock in a region is transmitted directly to its neighbors and indirectly to its neighbors' neighbors; the shock is reflected back to the region from its neighbors. In the equilibrium, the dependent variable in each observation depends on the exogenous variables and error terms in all other observations. The second motivation is founded on an omitted variables argument. Omitting variables that exhibit a spatial dependence leads to a spatial lag model (LeSage and Pace 2008). For the Mexican case, these spatial dependencies between Mexico's states are recently found in export activity (Escobar Gamboa 2010) as well as in economic development (Rey and Sastré-Gutiérrez 2010).

Stacking the observations in Equation 1 and adding a spatial lag variable ($W \cdot FDI$) to allow for spatial dependencies between Mexico's states on FDI, our model takes the following form:

$$FDI_i(t) = \rho W(t) \cdot FDI_i(t) + \beta X_i(t) + \varepsilon_i, \quad (2)$$

where W is an $N \times N$ spatial weight matrix of known constants, and ρ is the scalar autoregressive parameters of spatial lag.

W is constructed as follows. For any year t , a weight matrix W is defined as:

$$W(t) = \begin{bmatrix} 0 & n_{i,j} & n_{i,k} \\ n_{j,i} & 0 & n_{j,k} \\ n_{k,i} & n_{k,j} & 0 \end{bmatrix}, \quad (3)$$

where $n_{i,j}$ is the functional form of the neighboring relationship between Mexican states i and j . Matrix W is standardized so that the sum of every row of the matrix equals one. Note that diagonal elements are equal to zero to avoid a FDI observation predicting itself. Hence, $W \cdot FDI$ represents a linear combination of FDI values in neighboring states.

To ensure that the results are not sensitive to this functional form, four different spatial weighting matrices are constructed:

1. W_1 : only state pairs sharing a common border receive a positive weight: $n_{i,j} = 1$ if i and j are share a border; 0 otherwise.
2. W_2 : neighboring relationships are established according to the distance between states. The average distance between Mexican states is 883.42 kilometers (see Appendix A for details). This distance is employed as a threshold for neighboring relationships. Hence, only state pairs closer than 883.41 km receive a positive weight: $n_{i,j} = \left(1 - \left(\frac{distance_{i,j}}{883.41}\right)^2\right)^2$, if $distance_{i,j} \leq 883.41$; 0 otherwise.
3. W_3 : the functional form is defined as an inverse distance weight matrix

that assigns a positive weight to all state pairs: $n_{i,j} = \frac{1}{distance_{i,j}}$.

4. W_4 : it uses the same functional form as W_3 , but the distance measure between state pairs is the road distance (see Appendix A): $n_{i,j} = \frac{1}{road\ distance_{i,j}}$.

Among the third region effects, NEG and export platform FDI models show the importance of access to potential markets. Measures of access to Mexican and foreign markets are then included in the model. Because more than 85% of Mexican exports go to the US market, the distance to the US is employed as an inverse measure of access to foreign markets. The distance to the US is estimated as the weighted distance to the nearest border crossing. As a measure of access to the Mexican market, the distance to Mexico City is employed, as this city is Mexico's economic center.

The inclusion of spatial lag and market access variables is helpful for identifying the main motivations for FDI. Indeed, differences in market size and factor endowments would help us to differentiate between vertical and horizontal motivations, but they would not be useful for distinguishing between pure and complex horizontal or between pure and complex vertical motivations. To deduce the motivations for FDI in Mexico, the coefficient sign of the market access and spatial lag variables is employed. According to the motivations for FDI, these variables' influence would not be the same. Supposing that the host economy is divided into two states (i and j) with equal factor endowments, then for each type of FDI, the theoretical hypotheses for spatial lag and market access variables are as follows:

Pure horizontal FDI. In this case, a parent firm decides to open a filial to supply the local market. If the host economy is divided into two states (i and j), the parent firm will have two options: (1) to invest in state- i and supply state- i and state- j from this plant, or (2) to locate its operations in state- j and to

supply final goods to state- i and state- j from state- j . States would compete to attract this type of investment, so the spatial lag variable should play a negative role. Indeed, if the parent firm selects state- i from the existing two, then FDI to state- i will be at the expense of state- j . Location choice will be influenced by both the size of the state's market and its proximity to other states' markets. Proximity to foreign markets is not an important factor because production is supposed to be sold only in the domestic market.

Pure vertical FDI. In this case, the parent firm outsources part of its production process to a lower cost country. With two states as potential FDI hosts, the parent firm has the choice of location for its operations. Hence, states i and j are rivals when attracting this kind of FDI. The spatial lag coefficient should be negative, and the location decision, in this case, will not be influenced by the proximity to the Mexican market or foreign markets.

Export platform FDI. In this case, the parent firm decides to open a filial to supply a third country's market. The investment decision between states i and j will be influenced principally by the proximity to foreign markets. Once again, states i and j are rivals to attract FDI.

Vertical specialization FDI. In this case, the parent firm divides its production process into the production of multiple intermediate goods produced in different regions. If the parent firm already produces an intermediate good in state- i , it would be profitable to open a production plant in state- j to take advantage of the proximity to its customer or supplier plant located in state- i . This means that FDI to state- i would be a complement of FDI to state- j , and one can expect a regional agglomeration of FDI for proximity to supplier/customer reasons. If agglomeration forces extended to local or national firms, then proximity to other (Mexican or foreign) markets would have a positive influence on attracting FDI.

Table 1 summarizes the theoretical hypothesis explained in this section. The motivation for FDI can then be deduced from these variable estimates.

[Table 1 here]

Finally, Table 2 shows the descriptive statistics, and Appendix A presents a detailed description of variables and the sources of the dataset.

[Table 2 here]

5 Motivations and determinants of FDI in Mexican states

5.1 Estimation strategy

In addition to the heteroskedasticity problem present in multinational activity analyses (Egger 2010), there are some econometrical issues when estimating Equation 2. First, in constructing the dependent variable, an autocorrelation of the errors can be generated. A Wooldridge (2002) test for autocorrelation in panel data is conducted, but not reported, and results suggest the presence of autocorrelation. Hence, standard errors are corrected using the automatic bandwidth selection procedure of Newey and West (1994).

A second econometrical issue concerns the potential for omitted variables bias and heterogeneity bias. For instance, domestic investment, tax rates and fiscal incentives are usually cited as important determinants of inward FDI (Coughlin, Terza, and Arromdee 1991; Rodríguez-Clare 1996), but state-level data concerning these variables are not available for Mexico. In the presence of omitted variables and heterogeneity bias, the inclusion of fixed effects (being correlated with the explanatory variables) will produce consistent estimates (Wooldridge 2002). However, controlling for fixed effects makes it impossible to

estimate time-fixed variables, such as the distance to the US and Mexico City. Baltagi (2005) also suggests that controlling for fixed effects tends to give short-term estimates, while not controlling for these effects tends to give long-term estimates. Hence, estimates for both controlling and not controlling for fixed effects are computed.

The estimation of Equation 2 via least squares may lead to inconsistent estimates because of the spatially lagged dependent variable. To correct this bias, spatial the econometrics literature proposes a Maximum Likelihood (ML) or Instrumental Variables (IV) estimation approach (Anselin 2001; Kelejian and Prucha 1998). An IV approach advantage over ML estimation is that it does not require an assumption of normality, and it avoids the computational problems associated with ML for large data sets (Anselin 2001). Kelejian and Prucha (1998) propose using spatial lags of exogenous variables as instruments.

Equation 2 is then estimated using a two-step generalized method of moments (GMM) estimator by employing the first spatial lags of exogenous variables ($W \cdot X_i$) as excluded instruments for the spatially lagged dependent variable $W \cdot FDI$. Standard errors are corrected for both arbitrary heteroskedasticity and arbitrary autocorrelation.

Finally, following Blonigen et al. (2007), a time-trend variable is included to deal with time-series variation. This variable is preferred over a time-fixed variable because it captures time variation rather than national conjuncture. Indeed, Mexico's conjuncture evolution could lead to similar FDI variations for all states, and these variations could be attributed to spatial linkages.

5.2 Empirical results

To identify if there is spatial dependence of FDI among Mexican states, Moran's I and Geary's C statistics are computed for the dependent variable. Table 3

shows these statistics' values as well as their Z-scores and their p-values under the null hypothesis of spatial independence. Results suggest the presence of significant positive spatial autocorrelation for the four weighting matrices. Indeed, Moran's I is always positive, Geary's C is always smaller than 1, and p-values for both statistics are always lower than 0.05.

[Table 3 here]

Model specification without the spatially lagged dependent variable (Equation 1) is estimated as a benchmark. First, Equation 1 is estimated without controlling for fixed effects. Presented in column 1 of Table 4, results suggest that important determinants for attracting FDI into Mexican states are the development of the state, the population size, the presence of skilled-labor, low wages, infrastructure, low rates of delinquency and access to both US and national markets. The industrial agglomeration of the states is not a significant factor for attracting FDI. When state-level fixed effects are included (column 2), only years of schooling, wages, delinquency and infrastructure are significant. Surprisingly, this last variable's coefficient sign changes, as does the GDP per capita coefficient. This can be explained by the fact that fixed effects employ the time-series of the data (Baltagi 2005), and lagging states (less attractive ones) would experience better improvements in infrastructure and GDP per capita.

[Table 4 here]

We can suspect that a correlation between a state's GDP per capita and the other independent variables could lead to biased results. GDP per capita is then dropped from the specification, and the model is estimated. Results, drawn from columns 3 and 4 of Table 4, do not have any important alteration compared to the entire specification. However, even if the results are in line with the theory and with previous results for the Mexican case (see Jordaan

2008), failing to take significant spatial dependencies into account creates bias in the results (Anselin 2001).

The model in Equation 2 is then estimated with a two-step generalized method of moments (GMM), and results are presented from columns 5 to 8 in Table 4. Without controlling for fixed effects (columns 5 and 7), the coefficient's sign and significance matches the coefficients obtained in previous regressions. Only distance to Mexico City lost its importance. Concerning the spatial lag relationship, results suggest a positive relationship or complementarity between FDI invested in neighboring states and FDI invested in the average state.

When controlling for fixed effects, the coefficient's value and the significance of the spatially lagged FDI increase considerably. This result can also be interpreted as an agglomeration tendency of multinational firms over time. When controlling for fixed effects and spatial dependency, infrastructure and wages become non-significant. Only years of schooling and delinquency continue to be significantly correlated to inbound FDI.

The spatial lag relationship, together with the negative correlation between FDI and the distance to both the US and Mexico City, supports the idea that most of the inbound FDI in Mexican states is of a complex vertical FDI type or vertical specialization. This result also suggests that these agglomeration externalities extend between MNEs, local firms and international firms. However, for attracting FDI, the stronger importance of the distance to the US compared to the distance to Mexico City suggests that MNEs' main motivation is to serve the US market rather than the national market.

5.3 Sensitivity tests

Blonigen et al. (2007) find that the spatial interrelationship is sensitive to the weighting matrix. This idea is applied to this paper's case. To carry out

sensitivity tests, the alternative weighting matrices are employed. Neighboring relationships are supposed to go beyond sharing a common border. Hence, alternative specifications assign a weight that decreases with distance. These alternative weighting matrices, then, capture a higher spatial correlation.

Table 5 shows the results of using alternative weighting matrices. As shown in columns 1 and 2, when the spatial relationship is limited to a distance of less than 883.412 km, the spatially lagged FDI coefficient increases. When the neighboring relationship is extended to all states (columns 3 and 4), the coefficient's value increases considerably. Hence, attracting FDI into a state would lead to an increase in the attractiveness of the whole country.

[Table 5 here]

To check for the sensibility of the distance measures coefficient, an alternative weighting matrix is constructed using road distance between state pairs. Without controlling for fixed effects (column 5), the spatial lagged FDI coefficient is similar to those found using weighting matrix W_1 and W_2 , but this variable is not significant at the 5% level. When controlling for fixed effects, the coefficient's value and significance are very similar to those found with other weighting matrices. Finally, a common result to those found previously is the importance of years of schooling and low delinquency rates in attracting FDI.

6 Conclusions

Mexico is a country that is characterized by strong regional differences for attracting FDI. This paper studies the link between Mexican states' characteristics and inbound FDI. Spatial econometric techniques are employed to test the existence of spatial dependence for attracting FDI, as well as to identify FDI motivations. Results suggest the existence of complementarity between

the FDI received and FDI invested in neighboring states. This result, in addition to the positive influence of the proximity to foreign markets, suggests that agglomeration externalities extend between MNEs and international firms. This conclusion supports the idea that most inbound FDI in Mexican states is from a complex vertical type of FDI. Indeed, as Waldkirch (2003) noticed, MNEs seem to be more interested in creating vertical production networks than in exploiting Mexico's comparative advantage.

Estimates differ depending on whether fixed effects are controlled for. Without controlling for fixed effects, results suggest that market-related variables (GDP per capita, population, proximity to the US and Mexico City), endowment-related variables (years of schooling, wages, infrastructure), delinquency rates and the spatially lagged dependent variable are significant determinants to attract FDI. From these variables, only years of schooling, low delinquency rates and FDI in neighboring regions are still significant when state fixed effects are included. However, all estimates should be considered for policy implications. Indeed, without controlling for fixed effects, estimators tend to give long-run estimates, whereas models using fixed effects tend to give short-run estimates (Baltagi 2005).

These results have different policy implications for the short-run and the long-run. For the short-run, states have different options to attract FDI. First, improving the education level and social stability would increase a state's location advantage. Second, given the positive spatial dependence between Mexico's states, states' governments have an interest in cooperating to develop strategies to attract FDI together rather than to compete. For the long-run, in addition to the education level and social stability improvements, investments in infrastructure would increase the likelihood of attracting more FDI. However, proximity to the US is a location advantage for northern states attracting FDI,

which could lead to a bigger concentration of FDI in these states in the following years.

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Figure 1: Spatial distribution of accumulated FDI inflows (1994-2004). *Source:*
Elaborated by the author with data from the Mexican Ministry of Economy

Table 1: Theoretical hypothesis

Explanatory variable	Motivation for FDI			
	Pure Horizontal	Pure Vertical	Export Platform	Vertical Specialization
GDP per capita	+	- / +	- / +	- / +
Population	+	+	+	+
Years of Schooling	+	+	+	+
Wages	- / +	-	-	-
Industrial agglomeration	- / +	- / +	- / +	- / +
Infrastructure	- / +	+	+	+
Delinquency	-	-	-	-
Distance to Mexico City	-	0	0	-
Distance to the US	0	0	-	-
W FDI	-	-	-	+

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FDI	352	18.915	2.199	11.595	24.688
GDP per capita	352	-5.457	0.434	-6.238	-4.344
Population	352	14.634	0.800	12.809	16.486
Years of Schooling	352	1.981	0.137	1.540	2.303
Wages	352	2.444	0.172	2.026	3.101
Industrial agglomeration	352	-2.734	1.197	-5.160	1.113
Infrastructure	352	2.261	0.521	0.935	3.687
Delinquency	352	0.713	0.427	-0.245	1.595
Distance to Mexico City	352	5.950	1.162	2.812	7.716
Distance to the US	352	6.633	0.941	3.041	7.675

Notes. All variables are in logs unless indicated otherwise (see Appendix A for a detailed description and for the sources of the dataset).

Table 3: Tests for spatial correlations of FDI using different weighting matrices

Weighting matrix	Moran's I	Z-scores	p-value	Geary's C	Z-scores	p-value
W_1	0.371	9.763	0.000	0.570	-9.932	0.000
W_2	0.275	10.945	0.000	0.696	-10.631	0.000
W_3	0.216	12.166	0.000	0.796	-8.926	0.000
W_4	0.205	11.834	0.000	0.819	-7.629	0.000

Table 4: Benchmark and spatial lag model estimates for the determinants of FDI

Dependent Variable: log of FDI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP per capita	0.902 (0.250)**	-1.084 (0.822)			0.822 (0.198)**	-1.086 (0.718)		
Population	0.779 (0.088)**	0.702 (1.470)	0.755 (0.091)**	0.803 (1.474)	0.819 (0.067)**	-0.150 (1.005)	0.788 (0.068)**	0.003 (1.010)
Years of Schooling	5.527 (0.859)**	9.783 (2.285)**	6.968 (0.842)**	9.786 (2.308)**	4.888 (0.621)**	4.513 (1.952)*	5.895 (0.795)**	4.192 (1.954)*
Wages	-2.893 (0.484)**	-1.639 (0.519)**	-2.260 (0.457)**	-1.901 (0.546)**	-2.683 (0.546)**	-0.409 (0.425)	-1.902 (0.431)**	-0.641 (0.447)
Industrial agglomeration	0.006 (0.064)	0.580 (0.660)	0.006 (0.063)	0.664 (0.669)	0.052 (0.054)	0.653 (0.491)	0.059 (0.049)	0.701 (0.515)
Infrastructure	1.936 (0.269)**	-1.667 (0.545)**	2.198 (0.251)**	-1.533 (0.547)**	1.968 (0.205)**	-0.883 (0.524)	2.200 (0.194)**	-0.730 (0.517)
Delinquency	-0.538 (0.195)**	-0.941 (0.267)**	-0.593 (0.198)**	-0.910 (0.271)**	-0.595 (0.141)**	-0.917 (0.221)**	-0.683 (0.129)**	-0.871 (0.219)**
Distance to Mexico City	-0.300 (0.075)**		-0.189 (0.068)**		-0.182 (0.083)*		-0.057 (0.067)	
Distance to the US	-0.448 (0.054)**		-0.410 (0.058)**		-0.373 (0.036)**		-0.326 (0.036)**	
$W \cdot FDI$					0.132 (0.067)*	0.562 (0.149)**	0.163 (0.070)*	0.576 (0.152)**
Observations	352	352	352	352	352	352	352	352
Adj. R^2	0.864	0.685	0.857	0.684	0.863	0.677	0.856	0.676
RMSE	0.812	0.566	0.831	0.567	0.799	0.565	0.821	0.566
State fixed effects	no	yes	no	yes	no	yes	no	yes

Notes. * significant at 5%; ** significant at 1%. Robust standard errors to both heteroskedasticity and autocorrelation are in parentheses under coefficient estimates. Each regression also includes a time trend variable and a constant. Columns (5) to (8) are estimated by two-step GMM using the first spatial lags of exogenous variables ($W \cdot X_i$) as excluded instruments for the spatially lagged dependent variable $W \cdot FDI$.

Table 5: Spatial lag model estimates for the determinants of FDI using alternative weighting matrices
Dependent Variable: log of FDI

	W_2		W_3		W_4	
	(1)	(2)	(3)	(4)	(5)	(6)
GDP per capita	0.896 (0.188)**	-0.329 (0.487)	0.565 (0.207)**	-1.366 (0.539)*	0.695 (0.189)**	-1.486 (0.724)*
Population	0.815 (0.051)**	0.743 (1.032)	0.666 (0.079)**	0.998 (0.958)	0.729 (0.083)**	0.992 (1.134)
Years of Schooling	5.301 (0.405)**	3.745 (1.465)*	3.786 (0.659)**	5.905 (1.474)**	4.744 (0.659)**	5.326 (2.056)**
Wages	-2.398 (0.450)**	-0.278 (0.428)	-1.621 (0.487)**	-0.128 (0.485)	-2.491 (0.483)**	-0.195 (0.542)
Industrial agglomeration	0.031 (0.043)	0.882 (0.498)	0.078 (0.059)	0.654 (0.459)	-0.009 (0.065)	0.850 (0.498)
Infrastructure	1.867 (0.174)**	-0.568 (0.434)	2.310 (0.224)**	-0.779 (0.387)*	2.256 (0.230)**	-0.655 (0.565)
Delinquency	-0.566 (0.090)**	-0.731 (0.206)**	-0.749 (0.134)**	-0.709 (0.225)**	-0.643 (0.134)**	-1.006 (0.243)**
Distance to Mexico City	-0.199 (0.056)**		-0.040 (0.082)		-0.233 (0.079)**	
Distance to the US	-0.329 (0.035)**		-0.372 (0.042)**		-0.430 (0.038)**	
$W \cdot FDI$	0.174 (0.051)**	0.682 (0.154)**	0.464 (0.127)**	0.731 (0.147)**	0.133 (0.096)	0.696 (0.195)**
Observations	352	352	352	352	352	352
Adj. R^2	0.864	0.681	0.861	0.687	0.862	0.685
RMSE	0.797	0.561	0.805	0.556	0.803	0.558
State fixed effects	no	yes	no	yes	no	yes

Notes. * significant at 5%; ** significant at 1%. Robust standard errors to both heteroskedasticity and autocorrelation are in parentheses under coefficient estimates. Each regression also includes a time trend variable and a constant. Results are estimated by two-step GMM using the first spatial lags of exogenous variables ($W \cdot X_i$) as excluded instruments for the spatially lagged dependent variable $W \cdot FDI$. The weighting matrix W_2 in columns (1) and (2) is constructed using 883.42 kilometers as a threshold for neighboring relationships. In columns (3) to (6), the weighting matrix is defined as an inverse distance weight matrix, but the distance measure differs between the weighting matrix W_3 and the weighting matrix W_4 (see the text for details).

A Variables definition and data sources

Variable name	Description	Source
FDI	The FDI stock (FDI_t) for each year t is computed by applying the perpetual inventory method to annual FDI inflows (fdi_t). The applied formula is: $FDI_t = \sum_{j=0}^{j=d} fdi_{(t-j)} - \frac{1}{d} \sum_{k=1}^{k=d} fdi_{(t-k)}$, where d is the FDI average service life, which is supposed to be equal to 10 years. State level real GDP per capita in 2000 US dollars (USD)*. State's population. Average years of schooling of those over 15. Average daily wage reported to the social security in 2000 USD*. The ratio of the industrial sector's consumers of electricity in $t-1$ over the state's area.	Secretaría de Economía - Dirección General de Inversión Extranjera INEGI - Banco de Información Económica Consejo Nacional de Población (CONAPO) - México en cifras Secretaría de Educación Pública (SEP) - SisteSep Secretaría del Trabajo y Previsión Social (STPS) Consumers of electricity data from Comisión Federal de Electricidad (CFE); State's area from INEGI - Anuario Estadístico de los Estados Unidos Mexicanos Comisión Federal de Telecomunicaciones (COFETEL) - Estadísticas e Información de Mercados INEGI - Estadísticas Judiciales en Materia Penal Counties population data was obtained from INEGI - 1990 Censo General de Población y Vivienda; and counties' coordinates were obtained from world-gazetteer data set.
Infrastructure	Telephone line density for every hundred inhabitants.	
Delinquency Distance	Number of registered delinquents for every hundred inhabitants. The distance is measured using Head and Mayer's (2002) weighted CES distance formula: $distance_{i,j} = \left(\sum_{k \in i} \left(\frac{population_k}{population_i} \right) \sum_{l \in j} \left(\frac{population_l}{population_j} \right) distance_{k,l}^\theta \right)^{1/\theta}$, where k and l are all counties with more than one hundred thousand inhabitants in 1990 that belong to state- i and state- j , respectively; distance between counties is measured as the great circle distance from the biggest city in the county. A value of $\theta = -1$ is set because, as pointed out by Head and Mayer (2002), this value is frequently found in gravity equations literature. Road distance is the weighted road distance between states' most important urban agglomerations (those over 150,000 inhabitants).	
Road distance		Population data from INEGI - 1990 Censo General de Población y Vivienda; and road distance data from the Secretaría de Comunicaciones y Transportes (SCT) 'Rutas punto a punto' application.

Notes. *Data transformed to constant USD employing the real exchange rate Mexico Peso / US Dollar reported by the Centro de Estudios de las Finanzas Públicas de la H. Cámara de Diputados.