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ORIGINAL PAPER

Spatial linkages and third-region effects: evidence from manufacturing FDI in Mexico

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Abstract
We analyze the main characteristics that help explain the regional distribution of manufacturing foreign direct investment (FDI) in Mexico. Our main findings indicate the presence of a positive spatial relationship among states' FDI which, combined with the zero effect found for the market potential variable, points to the presence of complex vertical FDI. We consider that this is consistent with the fact that just over a third of manufacturing FDI in the country is located in the automotive sector. Moreover, we find positive direct and indirect effects of human capital, agglomeration, and states' fiscal margins. Based on the results of this research, attraction of FDI should be considered in a regional context and not only from a local perspective.

JEL Classification C21 · C23 · R12

1 Introduction

Which characteristics drive foreign direct investments (FDI) into a particular region? Do regions compete to obtain these investments? Or does a particular FDI helps to increase the amount of investment in neighboring states? These questions are of particular importance in a developing economy like Mexico because FDI helps to improve the economic conditions of the recipient region and its surroundings (Coughlin and Segev 2000).

Among other things, FDI gives developing countries the opportunity to facilitate access to developed countries' markets and global production systems through technology, production supply chains, and other intangible assets unavailable at

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accessible prices in the local economy (UNCTAD 2006). For example, from 1999 to 2015, FDI accounted for, on average, 12.6% of Mexico's total gross capital formation and 2.7% of its total GDP. Also, the literature has identified FDI as an important vehicle for technology and knowledge transfer through spillover effects.[1]

Since FDI is an important source of financial resources that help to improve a region's economic activity, states can offer investors favorable conditions to acquire FDI's benefits and to enhance job creation and economic growth. That is why a better understanding of the determinants of FDI attraction helps to shape future public policy strategies toward regional development (Jordaan 2008). Using an up-to-date database on the distribution of FDI at the state level, and using spatial econometric techniques that allow us to test our hypothesis about the presence of spatial effects (the so-called third-country/region effect; see Blonigen et al. 2007 and Regelink and Elhorst, 2015), we analyze regional patterns of FDI inflows in the manufacturing industry in Mexico from 1999 to 2015. We focus on this sector because it accounts for about 50% of the total inward FDI during this time period.

By applying a panel data Spatial Durbin Model (SDM), our main result indicates that manufacturing FDI is consistent with the case of *complex vertical specialization* (Bloningen et al. 2007; Baltagi et al. 2007) in which firms tend to offshore parts of their production chains to various regions to benefit from cost differences. We believe this is the case in part because the main source of manufacturing FDI in Mexico (just over a third of manufacturing FDI) is in the automotive industry, which is characterized by a high level of integration among its production chains: the car manufacturers and their suppliers (Sturgeon and Van Biesebrock 2010). Across states, we find a positive spillover effect on the process of attracting manufacturing FDI. The estimated spatial effect indicates that with a 10% increase in manufacturing FDI in a state's neighbors, the state's FDI manufacturing flows will increase on average between 3.7 and 4.3%.

Moreover, we obtain other results of the estimations with respect to control variables that are considered standard in the literature: (1) Variables such as agglomeration[2] and schooling show a positive and significant impact as factors of manufacturing FDI attraction, while higher wages have a negative and weak effect; (2) infrastructure and homicide rate have the expected effects, although without statistical significance; (3) from a methodological point of view—and in the spirit of LeSage and Pace (2009)—the interpretation of the estimated parameters is based on the decomposition of the impact effects, both direct and indirect, which enables us to get a richer interpretation of the variable impacts not only of a state's own characteristics but also of its neighbors'; and finally, (4) we include an indicator of fiscal incentives (fiscal margin) that is novel for the Mexican case and that helps us examine how subnational governments in the country compete for FDI projects in the manufacturing sector.

[1] See, for example, Borensztein et al. (1998), Durham (2004) and Li and Liu (2005).

[2] Following Glaeser (2010, p. 1), and broadly speaking, throughout the document we refer to the concept of agglomeration as "the benefits that come when firms and people locate near one another together in cities and industrial clusters."

With these results, we infer that manufacturing FDI is attracted to states with better-educated populations and with higher ratios of workers employed in the manufacturing sector (our proxy of agglomeration). Along with the indirect impacts found on the same variables, this implies that in general, the manufacturing FDI flows to a state depend not only on its own characteristics but also on those of the neighboring states, thus generating a clustering-type dynamic (Porter 2003).

Our novel findings regarding the fiscal margin variable (both direct and indirect) support this argument. Given that this variable is the most widely used and immediately available tool for state governments to attract FDI projects in the manufacturing sector, we discuss in detail its possible public policy implications. Finally, we consider that the design of public policy aimed to increase FDI flows into regions should be analyzed in a regional context and not only from a local perspective.

This article is organized as follows: Sect. 2 contains a literature review; Sects. 3 and 4 include data and descriptive analysis and the econometric model specification, respectively; Sect. 5 shows the results; and Sect. 6 concludes.

2 Literature review

Studies both at the international level and of the Mexican economy have estimated the determinants of attracting FDI following one of two strategies (Jordaan 2008). First, some studies use the number of new foreign-owned firms (total or manufacturing) in the host economy as a dependent variable by estimating conditional logit-type models. Second, other studies take the flows or the stock of FDI in monetary units as a dependent variable against a set of regional characteristics using a variety of econometric models, mainly panel type (fixed, random, dynamic, etc.). As Jordaan (2008, p. 396) pointed out: "…we can infer that those regional characteristics that are significantly associated with the regional distribution of FDI must play a role in the location process of new FDI."

The empirical literature identifies the following variables as the main factors that influence the decision to bring FDI to a given location: regional demand, labor-related production costs, physical infrastructure, human capital, the presence of agglomeration economies, and public policies devoted to attracting or facilitating new FDI projects. Of these factors, those related to public policy incentives are the most difficult to incorporate due to the lack of data (Jordaan 2008).

A different branch of literature has pointed out that FDI could be spatially correlated, meaning that neighboring regions could affect one another, creating spillover effects or the so-called "third-country/region effect." Coughlin and Segev (2000), for example, pointed out that agglomeration economies and resource costs could be considered sources of this kind of effect. Agglomeration may lead to higher FDI in neighboring regions to the extent that its beneficial effects spill over to other provinces, transcending administrative boundaries. By raising resource costs in a region, FDI could make the cost structure in neighboring regions more attractive in relative terms.[3] In the following subsections, we describe prior studies' findings at the International level and for the Mexican economy, respectively.

2.1 International evidence

Several studies have addressed the determinants of FDI attraction at a regional level. For the case of advanced economies, by applying a conditional logit model at the state level for the United States from 1981 to 1983, Coughlin et al. (1991) found that on one hand agglomeration, road infrastructure, per capita income, and manufacturing density have a positive impact on FDI, as do higher unemployment rates and (surprisingly) unionization rates. On the other hand, wages have a negative impact, while incentive policies have two effects: high state tax rates impact FDI attraction negatively, while expenditures affect it positively. In another study of the United States from 1985 to 1999, Bobonis and Shatz (2007) employed dynamic panel techniques and found similar results for agglomeration (of foreign-owned property, plant, and equipment) and state policies, particularly targeted policies like unitary taxation and state foreign offices. Through the estimation of pooled OLS from 1980 to 1989, Hill and Munday (1992) found that in the United Kingdom, both financial incentives and access to markets are important determinants of the regional distribution of new FDI projects.

Crozet et al. (2004) analyzed the choice of location for firms' FDI in France from 1996 to 2005 using conditional logit models, finding a strong effect for agglomeration as a determinant of location, but little evidence in favor of public policy intervention through fiscal incentives. For European regions, Casi and Resmini's (2014) results for the 2005–2007 period, through the estimation of a cross-section spatial lag model, indicate that infrastructure, market accessibility, labor force quality, governance, and agglomeration exert a positive impact on attracting FDI. Moreover, they found a positive spatial effect. Jones and Wren (2016), in the case of Great Britain, found different FDI allocation patterns between sectors using a Markov transition matrix from 1996 to 2005. They found that the location of new FDI for services generally differed from the location of new FDI for manufacturing, including for services forward-linked to manufacturing industries.

For emerging economies, Coughlin and Segev (2000)[4] used a cross-section spatial error model (SEM) to analyze cumulative FDI distribution across Chinese provinces from 1990 to 1997 and found that the domestic market, productivity indicators, and location in coastal regions have a positive impact on FDI. Wages and illiteracy rates, in contrast, are negatively correlated with FDI, while the effect of infrastructure is ambiguous (not statistically significant). Concerning the spatial process, they

[3] In the context of a formal model, Hanson (1996) shows the effects of interactions between agglomerations and cost resources (wages) in the case of the garment industry in Mexico. Although the author does not consider FDI in his analysis, the model is useful to describe how external economies lead to agglomeration processes.

[4] According to Blonigen et al. (2007), this was the first study to use spatial econometric techniques to examine FDI behavior.

found that a region's FDI is positively associated with FDI in neighboring regions, through the error term. Also for Chinese regions, Cheng and Kwan (2000) found similar results for wages, regional GDP, and infrastructure in the period 1985–1995 with dynamic panel methodologies. Moreover, they found that policies designed to attract FDI (the number of special economic zones) have a positive impact, while there is no clear impact of the human capital variable.

For regions in Turkey, with a conditional logit model for a cross section with 1995 data, Deichmann et al. (2003) found that agglomeration, depth of local financial markets, human capital, and coastal access dominate FDI location decisions. They found no evidence that public investment is successful in attracting firms to particular regions. Ledyaeva (2009) analyzed the distribution across Russian regions of the cumulative FDI from 1995 to 2005 by applying a cross-section spatial autoregressive model and found evidence of a negative spatial association (suggesting regions compete with each other for FDI) and positive impacts of infrastructure (number of ports), access to fuel, and regional GDP. In this study, FDI was negatively correlated with political risks.

Employing cross-section logit and count-data models to India from 1991 to 2005, Mukim and Nunnenkamp (2012) found that economies of agglomeration (the presence of foreign firms of the same nationality) have a positive impact on FDI, as do education and infrastructure; the effects of wages are ambiguous. With the same logit-type methodology, Lee and Hwang (2014) established for the case of Korea the existence of a network of FDI firms and a backward linkage relationship with local upstream firms. Also, they found entirely different location patterns between high- and low-tech industry groups in the 1998–2005 period using nested logit models. Finally, for the Czech Republic, Schäffler et al. (2017) analyzed the distribution of 3984 German FDI projects across Czech regions using a Poisson count-data model and found market size (GDP), agglomerations, and distance to German headquarters to be the main determinants of attraction.

2.2 The Mexican case

For the Mexican case, we found only four studies that have analyzed FDI determinants at a subnational level. Mollick et al. (2006), with panel econometrics techniques (both static and dynamic) from 1994 to 2001, found a significant impact of infrastructure and agglomeration (measured as the percentage of manufacturing GDP over total GDP) on total FDI. Jordaan (2008) found that agglomerations, wages, infrastructure, and human capital were all significant determinants of total FDI for the period 1989–2006 and that in the case of the maquiladora[5] sector (proxied by maquiladora employment, since FDI flows for this sector were unavailable), infrastructure has no impact, while agglomerations emerge as the main determinant of attraction.

[5] A maquiladora is a factory in Mexico that is run by a foreign company, which exports the products produced in the factory to its home country.

Jordaan (2012) applied a conditional logit to analyze spillover effects from agglomeration economies and state GDP on the location choice of new manufacturing firms between 1994 and 1999, finding a spatial effect only in the case of the agglomeration variable. Finally, by applying a spatial autoregressive model (SAR) to a panel of total FDI stocks from 1994 to 2004, Escobar Gamboa (2013) found the expected effects for regional GDP, human capital, and delinquency rate (negative) as determinants of attraction while observing an ambiguous effect of infrastructure. Furthermore, the spatial spillover is positive, significant, and robust to different spatial weight matrix specifications. However, his analysis does not separate direct and indirect effects, leading to an incomplete measure of variable impacts (LeSage and Pace, op. cit.).

It is worth mentioning that in methodological terms, Escobar Gamboa's paper is the most closely related to our study. The differences are that we rely on improved data on FDI, restrict our attention to the manufacturing sector, apply a broader discussion regarding employed spatial econometrics techniques, and report the impacts on their appropriate measures (direct and indirect effects).

3 Data and descriptive statistics

A recent change of methodology allows for improved precision in identifying where the quarterly flows (in millions of current dollars) of FDI go within the 32 Mexican states. In 2015, the Ministry of Economy in Mexico changed its criteria for identifying the geographic destination of an investment; businesses and the Ministry now have a closer relationship when defining the exact places where investment dollars are used. If a business cannot identify the specific place where its investment is going, the Ministry assigns a location based on data on that company's previous investments. The data improvement reflects the place where the investment is actually channeled, not just the office address of the recipient business (which is likely to be in Mexico City).[6] Using the new methodology, data have been revised back to 1999 to correct the placement of investments. This database is available at the state level by country of origin and economic sector according to the North American Industry Classification System (NAICS) on a quarterly basis.

According to this new information, between 1999 and 2015 on average, almost half of FDI flows went to the manufacturing sector (Fig. 1, panel a). Within that sector, transportation equipment absorbs, on average, one-quarter of the manufacturing FDI, followed by beverage and tobacco manufacturing (Fig. 1, panel b). Manufacturing FDI follows a similar pattern as total FDI. (The 2013 peak corresponds to an important acquisition in the beverage sector when Belgium group AB InBev acquired Grupo Modelo for $20 billion; Fig. 2.) The exception is the transportation

[6] See "Sintesis Metodológica Sobre la Contabilizacion de los Flujos de Inversion Extranjera Directa hacia México", Ministry of Economy http://www.gob.mx/cms/uploads/attachment/file/59194/Metodologia_para_la_elaboracion_de_las_cifras_sobre_los_flujos_de_IED.pdf.

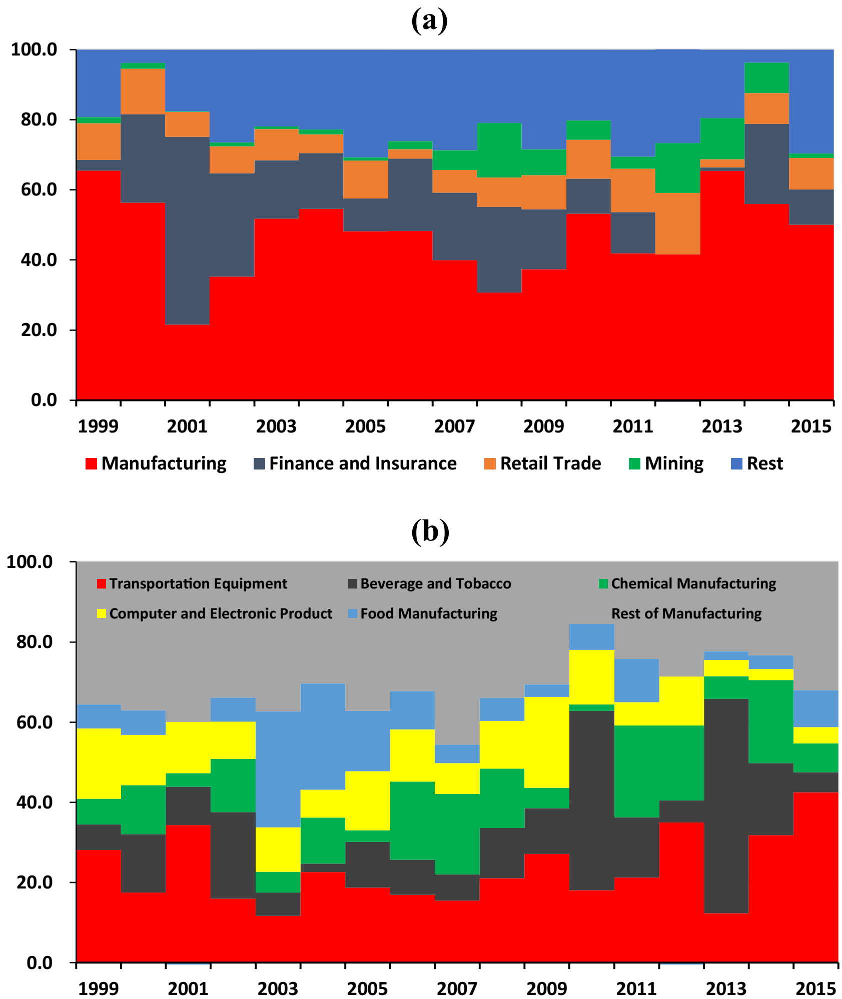


Fig. 1 Evolution of manufacturing and non-manufacturing FDI by subsector (NAICS), 1999–2015, percentages. *Source*: Own calculations based on Ministry of Economy information

equipment sector (mainly automobile investments), which tripled its FDI flows from 2011 to 2015 (Fig. 2).

To show the evolution of the regional distribution of manufacturing FDI during the period, Fig. 3 (panel a) considers the regional classification employed by the Mexican Central Bank (*Banco de México*) in its quarterly regional report (*Reporte Sobre las Economías Regionales*); the classification is illustrated in panel b. Figure 3 shows that the Central and Northern regions are the main destinations of manufacturing FDI with about 75% of the total, on average, during the whole period; they are followed by the North-Central region and then the South. It is worth mentioning that at the end of our study period (from 2011 onward), these latter two regions

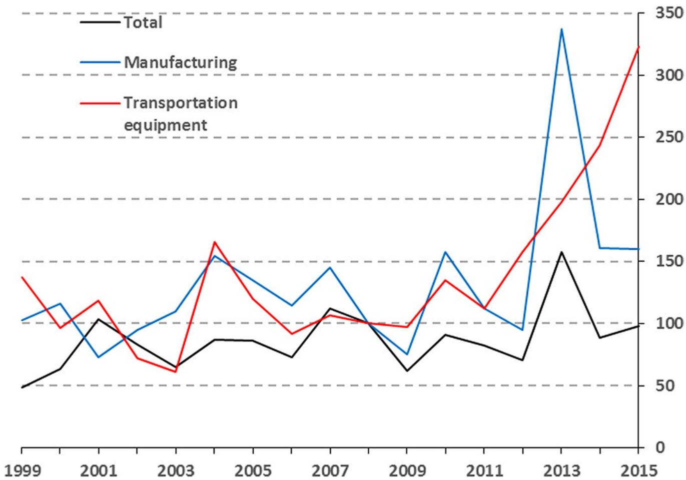


Fig. 2 Evolution of total, manufacturing, and transport equipment FDI: 1999–2015 (Index 2008 = 100). *Source*: Own calculations based on Ministry of Economy information

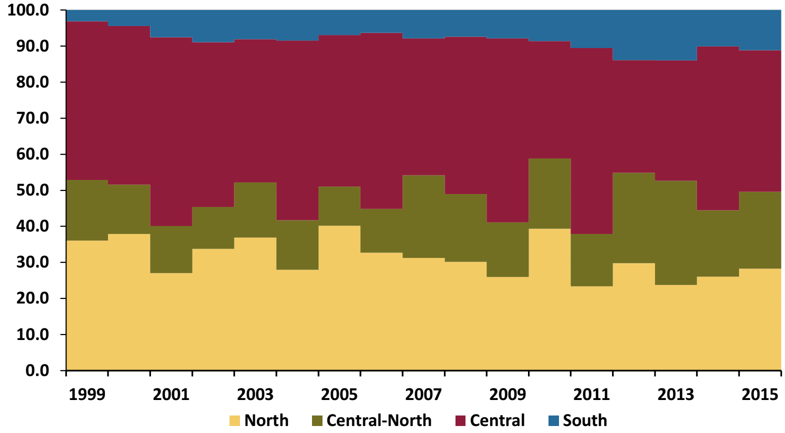
increased in relative participation, due mainly to new investments in chemical manufacturing in the South (particularly in the state of Veracruz) and to transportation equipment investments (in manufacturing of motor vehicle bodies and parts) in the North-Central region in the states of San Luis Potosi, Aguascalientes, and Jalisco.

3.1 Variables

Based on the prior studies noted in the literature review, we selected the following control variables:

- Total GDP as a measurement of the size of the host market. This variable was measured in constant millions of pesos (2008 base) excluding oil-related activities in natural logarithms.
- Average years of schooling among the population 15 years or older as a measurement of human capital, in logs.
- The ratio of formal workers in the manufacturing sector to the total as a measure of agglomeration economies.
- Fiscal margin, measured as a percentage of a state's unconditional revenues (federal transfers to the state plus the state's own revenue, such as taxes and rights). This is a measurement of the state's budget capacity to give fiscal preferences to potential future investments. It is expected that a state with less fiscal capacity

(a) Evolution of Regional Distribution of Manufacturing FDI 1999–2015, percentages



(b) Regionalization

Fig. 3 *Source*: Own calculations based on Ministry of Economy information. *Source*: Own elaboration based on Banco de México

cannot divert as much revenue to fiscal incentives to try to attract new investments.[7]

- Crime, measured as intentional homicides per 10,000 inhabitants, in logs.
- Infrastructure, measured by the telephone density for every 100 inhabitants, in logs.

[7] In Mexico, states' public finances are highly dependent on federal transfers (Hernandez-Trillo and Jarillo-Rabling, 2008). According to INEGI, on average, states' own revenue accounts for only about 10 percent of their total revenue.

Table 1 Descriptive statistics of explanatory variables. *Source*: Own elaboration with data from INEGI, Ministry of Economy, Ministry of Finance, and Ministry of Labor

	Mean	SD
log(GDP)		
Central	12.66	1.04
North-Central	11.91	0.72
North	12.85	0.35
South	12.13	0.45
Log(Education)		
Central	2.12	0.12
North-Central	2.10	0.1
North	2.19	0.06
South	2.01	0.13
log(Telephone density)		
Central	2.69	0.51
North-Central	2.65	0.30
North	2.92	0.23
South	2.14	0.39
Agglomeration		
Central	0.35	0.12
North-Central	0.21	0.11
North	0.41	0.07
South	0.11	0.05
Fiscal margin		
Central	0.46	0.14
North-Central	0.38	0.05
North	0.44	0.06
South	0.39	0.11
Log(Crime)		
Central	−1.58	0.8
North-Central	−0.43	0.93
North	−0.80	0.88
South	−1.10	0.94
Wages		
Central	21.37	42.18
North-Central	−16.10	19.88
North	14.19	20.98
South	−11.89	30.28

- Wages of each state relative to the national average measured as the deviation of the daily wage reported to the Social Security Institute in pesos (real terms).[8]

[8] The wage for the manufacturing sector exclusively at the state level was not available.

- The real exchange rate in Mexican pesos per dollar, to capture external time shocks that are common to all states, in logs.

Except for crime and wages, we expect these variables to have a positive impact on FDI, the dependent variable. We used INEGI—the Mexican official statistics agency, which publishes the *Statistical and Geographical Yearbook by State* (*Anuario Estadístico y Geográfico por Entidad Federativa*)—as the source for all independent variables except fiscal margin and wages, which were obtained from the Mexican Ministry of Finance (*Secretaría de Hacienda y Crédito Público*) and Ministry of Labor (*Secretaría del Trabajo y Previsión Social*), both at the state level.

Table 1 shows the descriptive statistics at the regional level of the explanatory variables. As expected, the North and Central regions—which have the highest flow of manufacturing FDI, as shown earlier in Sect. 3—have the highest infrastructure endowments (telephone density), education, agglomeration, and fiscal margin. Wages (in relation to the national average) are lower in the South and the North-Central regions, which receive the lowest amounts of manufacturing FDI. For the crime variable, the pattern of regional distribution is not clear, as the highest incidence is registered in the northern part of the country (North and North-Central).

4 Model specification and theoretical hypothesis

To estimate the impact of states' characteristics on FDI flows during the period 1999–2015 for the 32 Mexican states, we use a panel data approximation, following the baseline econometric Spatial Durbin Model (SDM) in the applied literature on FDI determinants (Regelink and Elhorst 2015):

$$\ln\left(\mathrm{FDI}_{i,t}\right) = \mu_i + \lambda_t + \rho W \ln\left(\mathrm{FDI}_{i,t}\right) + \beta X_{i,t} + \theta W \ln\left(\mathrm{GDP}_{i,t}\right) + \varepsilon_{i,t} \tag{1}$$

where $\ln\left(\mathrm{FDI}_{i,t}\right)$ are the flows of manufacturing foreign direct investment across each state i in millions of constant 2008 pesos at year t.[9] $X_{i,t}$ is a matrix of control variables described in the previous section, which takes into account cost-oriented and performance-oriented variables. The model also takes into account the spatially lagged dependent variable $W\ln\left(\mathrm{FDI}_{i,t}\right)$ and the spatially lagged GDP (market potential). W is a panel, row-standardized contiguity neighbor weight matrix, while ρ is the spatial autoregressive coefficient that measures the spatial relationship of the FDI of neighboring states.[10] β and θ are parameters to be estimated that measure the impact of the economic variables; $\varepsilon_{i,t}$ represents the error term with the following

[9] The data from the Ministry of Economy (*Secretaría de Economía*) are expressed in millions of current dollars. For the conversion, we use the nominal peso/dollar exchange rate (*fix*), and the GDP deflator (2008 base) to convert the data in millions of constant pesos. We also considered this variable in millions of constant dollars, which did not change the results obtained below.

[10] In the present case, we use the "queen contiguity" principle: one entity is considered to be neighboring another only if they share a common border. The matrix W is binary and takes the value of 1 if the entities share a border and zero otherwise. Additionally, the elements of the main diagonal of W are equal to zero per construction.

Table 2 Summary of hypothesized spatial lag coefficient and market potential effect for various forms of FDI. *Source*: Blonigen et al. (2007, p. 1308)

FDI motivation	Sign of the spatial lag	Sign of market potential variable
Pure horizontal	0	0
Pure vertical	−	0
Export-platform	−	+
Complex vertical specialization	+	0

characteristics: $\varepsilon_{i,t} \sim N(0, \sigma^2 I_n)$; and μ_i and λ_t are state-specific fixed effects and a variable that captures macroeconomic shocks common to all states, respectively. It is worth mentioning that these last two elements are "optional" to include in the model (Regelink and Elhorst 2015, p. 3). However, as we do not have a random population, but a whole set of spatial units or states within a country, we have to include fixed effects in the estimations (Elhorst 2012). Moreover, we also include real exchange rate (Mexican peso/U.S. dollar, in logs) to control for the common macroeconomic shocks that could affect the amounts of FDI received by the states (Arellano and Bover 1990).

Since the interpretation of the parameters' estimates is different from non-spatial regression techniques, and using the correct measurements is not usual in the literature on FDI, we put emphasis on the estimations of direct and indirect effects (see LeSage and Pace 2009). To isolate these two effects—the impacts on the dependent variable for observation i given changes in X_{ik} (direct) and the impacts on the dependent variable for observation i given changes in X_{jk} (indirect)—we use the impact calculations of Piras (2013) based on Kelejian et al. (2006) and LeSage and Pace (2009). Moreover, the SDM of Eq. (1) is estimated by both the generalized method of moments (GMM) and maximum likelihood (ML), taking into account the nonlinearity of the equation.[11] The reason to employ ML in addition to GMM is that to the best of our knowledge decomposition between direct and indirect effects is not available for the GMM estimator. However, as we shall see below, both methods of estimation yield very similar results.

4.1 Spatial relationships in FDI: analytical considerations

Taking the theoretical contributions of Markusen (1984) and Helpman (1984)[12] about bilateral FDI investment decisions of multinational enterprises (MNE) as a point of departure, a number of recent papers have recognized that FDI decisions are multilateral in nature and therefore the so-called third-country effect needs to

[11] Folowing Anselin (1988), since we have a dependent variable in the right-hand part of the equation, re-expressing the model $y = \rho Wy + X\beta + \varepsilon$ as $Ay = X\beta + \varepsilon$, with $A = I - \rho W$, and the error term as $\varepsilon = \Omega^{\frac{1}{2}} v$, gives us $\Omega^{\frac{1}{2}}(Ay - X\beta) = v$, or $f(y, X, \theta) = v$, with θ as a vector of parameters, and f is not linear in y, X, and θ.

[12] Both cited in Blonigen et al. (2007, p. 1304).

Table 3 Estimation results, a-spatial fixed effects, SLX, and Durbin model. Dependent variable: log of manufacturing FDI in 2008 constant pesos

Variable	Panel	Panel	Panel SDM		Panel SDM	
			Coefficient estimates		Marginal effects (ML)	
	Fixed effects	SLX	ML FE	GMM FE	Direct effects	Indirect effects
ρ			0.376***	0.435***		
			(8.02)	(2.38)		
$\ln(GDP)$[1]	−0.252	−0.180	−0.206	−0.210	−0.256	−1.089
	(−0.34)	(−0.21)	(−0.26)	(−0.27)	(−0.34)	(−0.73)
Wages	−0.012*	−0.012*	−0.010*	−0.010	−0.011*	−0.006
	(−1.72)	(−1.67)	(−1.63)	(−1.59)	(−1.72)	(−1.61)
ln(Education)	5.775***	6.033***	5.804***	5.768***	5.941***	3.268**
	(3.17)	(2.61)	(2.72)	(2.68)	(2.70)	(2.41)
ln(Telephone density)	0.556	0.551	0.535	0.532	0.548	0.303
	(1.56)	(1.54)	(1.62)	(1.60)	(−1.59)	(1.49)
Agglomeration	9.433***	9.395***	7.724***	7.462***	7.933***	4.366***
	(4.20)	(4.16)	(3.68)	(3.32)	(3.62)	(2.94)
Fiscal Margin	1.879*	1.930*	1.991**	2.001**	2.092**	1.149**
	(1.86)	(1.84)	(2.05)	(2.05)	(2.08)	(1.95)
ln(Homicides)	−0.093	−0.090	−0.024	−0.014	−0.021	−0.012
	(−0.76)	(−0.73)	(−0.21)	(−0.12)	(−0.18)	(−0.18)
ln(Real Exchange Rate)	−1.056	−1.052	−0.700	−0.645	−0.717	−0.393
	(−1.17)	(−1.17)	(−0.84)	(−0.76)	(−0.83)	(−0.81)
Market Potential		−0.207	−0.684	−0.758	*See:*	
		(−0.18)	(−0.64)	(−0.70)	$\ln(GDP)$[1]	
R^2	0.063	0.064	0.729	0.734	*N/A*	
Log likelihood	*N/A*	*N/A*	−1720.1	*N/A*	*N/A*	
N	544	544	544	544	544	
T	17	17	17	17	17	

t values in parenthesis

***$p<0.01$; **$p<0.05$; *$p<0.1$

[1]GDP does not include oil-related activities; spatial matrix defined as "queen" contiguity

be taken into account; that is, FDI inflows in a given region may be affected by FDI inflows in other locations, especially in neighboring regions (Escobar 2013). Regelink and Elhorst (2015) pointed out that the popularity of the spatial econometric specification described in Eq. (1) is that it can be used to test which motive drives FDI. Table 2 summarizes these effects.

According to the literature (see Blonigen et al. 2007, Escobar 2013 and Regelink and Elhorst 2015, for example), in the first case, where $\rho = 0$ and $\theta_{\ln(\mathrm{GDP})} = 0$, we are in the presence of *horizontal FDI*, and the estimation of an a-spatial model will be enough to obtain unbiased and efficient estimators. Escobar (2013) described it as a “pure horizontal FDI” where “a parent firm decides to open a filial to supply the local market.” In this case, FDI follows its determinants for each of the regions independently, and it is competitive among states, i.e., more FDI in state i means less for state j. The second case, where $\rho < 0$ and $\theta_{\ln(\mathrm{GDP})} = 0$, represents *vertical FDI*: an investing foreign firm outsources part of its production to lower its costs. In this case, we face a competitive FDI among regions in order to obtain access to low-cost inputs. The third case, where $\rho < 0$ and $\theta_{\ln(\mathrm{GDP})} > 0$, is *export-platform* FDI: an investing foreign firm invests in the region to supply a third region. Finally, the case where $\rho > 0$ and $\theta_{\ln(\mathrm{GDP})} \geq 0$ is *complex vertical FDI*: a firm spreads its production chain among several neighboring regions in order to access cost-differential inputs.

5 Results

In Table 3, we show the estimation results for Eq. (1). For comparative purposes, only we include two special cases of our reference model. The first column corresponds with the a-spatial fixed effects with robust standard errors (with $\rho = \theta = 0$); the second column is a spatial externalities SLX model (with $\rho = 0$ to account for a local spillover effect of the market potential). The last column presents the results of the full Spatial Durbin Model (SDM) with direct and indirect effects.

Lee-Yu corrected standard errors for ML models; for the estimation of the Durbin model, we used Millo and Piras’ (2012) *splm* package in R. The last two columns report the marginal effects coefficients.

We use fixed effects in all specifications given the nature of the data. (Units are not randomly selected from a population.) The first column shows the effects of the determinants using a spatially blind model, with a positive and statistically significant impact of education, agglomeration, and fiscal margin and a negative impact of wages. GDP (the size of the state’s economy) shows a negative impact but is not statistically different from zero.

With these results, we can infer that manufacturing FDI is attracted to states with a better-educated population and with a higher ratio of workers employed in the manufacturing sector, but the effect is negative for states with higher salaries (at only the 10% significance level). The average daily wage in the formal sector in Mexico is 294 pesos (around \$15 per day), and since the variable in the model is measured as a deviation from the national average, it means that an increase in one peso over the national average represents a reduction in 0.01% in FDI.

When we include the market potential (Table 3, second column, SLX model), the effect is not significant at the 10% level, meaning that FDI does not get attracted to internal markets (export-oriented industries). In contrast, the effect of the fiscal margin (the budget capacity of a state’s government plus unconditional federal transfers) is positive and statistically significant, meaning that states with higher budget independence (those that do not rely completely on federal transfers) get a higher manufacturing FDI. This budget independence provides each local government with a better condition to bargain with potential investors, for example.

With the spillover effects estimation (Table 3, third column, SDM model), we report direct and indirect effects of each variable and the spatial spillover coefficient ρ. It follows a similar direct effect compared with the a-spatial fixed effects model with a highly significant positive spillover effect between 0.376 (ML) and 0.435 (GMM). This means that an increase of 10% in the average FDI flows in the neighbors of state i will increase the FDI in that state, on average, between 3.76 and 4.35%.

With the indirect decomposition, we can measure the spillover effect for each of the determinants of FDI. We find a positive spillover effect for education, agglomeration, and fiscal margin, meaning that improving these conditions will benefit neighbors' capacity to attract FDI for the manufacturing sector. The market potential effect remains negative but not significant. This latter result, along with the positive spatial spillover effect referred to previously, implies that manufacturing FDI across Mexican states corresponds to the complex vertical case (Regelink and Elhorst, op. cit.).

One clear example of this involves investments in the automobile sector, which account for one-quarter of total FDI in manufacturing between 1999 and 2015 with the arrival of new assembly plants, suppliers located close to these places (in the same state or in neighboring ones),[13] creating productions chains that promote cost benefits for firms providing FDI. And given that roughly 80% of cars produced in Mexico are destined for foreign markets (*Secretaría de Economía* 2016); the relevant market for this industry (much like electric equipment and electronic components) is not the local or regional market.

On average, manufacturing FDI shows a positive spillover effect across Mexican states, implying a positive synergy of the investment in neighboring states. A potential cluster behavior may be happening, meaning that foreign manufacturing investment tends to concentrate around the same region, increasing the sharing of resources and lowering costs. Also, the fiscal margin is a key factor to attract investment, perhaps by lowering costs via lower local taxes and land-granting programs.

As a measure of human capital, education shows a positive relationship with FDI, direct and indirect, meaning that increasing the level of education raises foreign investment not only in that particular state but also in nearby regions. Specialization has a positive direct impact (a large pool of specialized workers is positively related to higher foreign investment) and has positive spillover effects among states' neighbors. Both the homicides variable and telephone density (our proxy of infrastructure) have the expected sign but are not statistically significant on any of the different specifications.

While the decision of neighborhood was arbitrary, since we selected a contiguity definition for W (i.e., states with common border are neighbors), there is a criticism that the results may be driven by a different definition of W.[14] We tested a different

[13] For example, according to INEGI, two of the Mexican states with the heaviest levels of production in the automobile sector, Coahuila and Guanajuato, increased the number of economic units dedicated to produce auto parts between 2008 and 2013 by 52.3% and 102.4%, respectively (from 88 to 124 and from 42 to 84).

[14] LeSage and Pace (2014) suggested that this criticism is misleading, since any W will capture the immediate and more important neighbor impacts.

neighbor matrix based on a state's three nearest neighbors (see Fig. 4 in the Appendix) instead of using border contiguity and re-estimated Eq. 1, and the results were practically the same.[15]

5.1 Comparison with other studies

According to the studies reviewed for the Mexican economy, our results are similar in the effects obtained for the variables of agglomeration and human capital. However, we did not find an effect of regional demand (GDP) in any of our estimates. This may be due to the fact that most of the studies of Mexico consider total FDI, with the exception of Jordaan (2008, 2012), who obtained a similar result when considering the FDI of the maquiladora and export sector (closely related to our variable of manufacturing FDI). Also, the manufacturing sector is heavily export-oriented, meaning that local demand has little effect on FDI flows.

Likewise, our results coincide with Jordaan's work on the importance of the agglomeration variable as a determinant of manufacturing FDI[16]; it has a higher impact than the wages variable, for which we obtain only weak statistical evidence (only 10% significance in some models). The latter would imply that the FDI of the manufacturing sector takes into account both the quantity (pooling) and the quality of human capital.

As noted, the effect of our proxy variable for the rule of law, homicides, has the expected sign but is not significant. Escobar (2013), in his estimates for total FDI, found that a measure different from ours (delinquency) has a negative and significant impact. Regarding the infrastructure variable, the studies reviewed have a positive impact on *total* FDI, particularly Mollick et al. (2006), since in Escobar (2013) the impact is conditional for the inclusion of fixed effects. However, in our case and similar to Jordaan (2008), infrastructure is not an important locational factor for export-oriented sectors, such as manufacturing.

Regarding the spatial effects, similar to Jordaan (2012)—although with a variation in the methodology since he uses an SLX model—we obtain spillover effects in the agglomeration variable, which as noted turns out to be one of the most significant factors in attracting manufacturing FDI. The positive spatial spillover effect (not its magnitude) is similar to Escobar (2013) in the Mexican case, although his estimations were carried out with a spatial autoregressive (SAR) model with no decomposition effects and for total FDI measured as stock.

Finally, our novel result is the one that considers the fiscal margin variable. As we pointed out in the literature review, this variable has not been considered in the previous studies for Mexico, and it is scarce in studies on emerging or developing economies. The most common tax incentives granted by state governments in Mexico

[15] Considering the possibility of the presence of multicollinearity between the independent variables, we use the variance inflation factor (VIF) test. According to the results, none of the variables was even close to the value of 4, which is used as a "rule of thumb" to identify potential muticollinearity problems.

[16] Although this result is in line with previous literature, we have to point out the potential presence of endogeneity with manufacturing FDI. A higher manufacturing FDI can lead to a higher proportion of workers in the manufacturing sector.

are tax cuts and exemptions, land grants, and other public perks such as construction of infrastructure in nearby industrial plants to facilitate their connectivity and operation. Exemptions on property tax are offered for long periods of time, from 10 to 20 years on average. State governments have economic promotion laws that regulate the amount of direct monetary support that can be granted.

Given that fiscal incentives are the tools most immediately available for state governments to attract FDI projects in the manufacturing sector, and according to the spatial effects found by the fiscal margin variable, we consider that the design of public policy aimed to increase FDI flows into regions should be considered in a regional context and not only from a local perspective. When competing on an individual basis for FDI projects, states can fall into a zero-sum game or "race to the bottom" via tax cuts and fiscal exemptions, which may compromise their ability to grant other public services (Gurtner and Christensen 2009) through discretionary arrangements. For example, in the case of the construction of a KIA automotive plant in the state of Nuevo Leon in 2016, the government exceeded the limits established in the local law of economic promotion, which indicates that incentives cannot exceed 5% of the total investment. According to press reports,[17] such grants totaled about 28% of the total investment of approximately $2.5 billion.

6 Conclusions

The results of this study show that FDI has complementarity effects—that is, if the FDI amounts attracted by neighboring entities increase, then the investment amounts captured by the reference entity also tend to go up. Thus, in addition to direct and indirect impacts of variables such as schooling and agglomeration on FDI, this suggests the presence of positive externalities in the processes of attracting FDI from the manufacturing sector. Our novel findings regarding the fiscal margin variable (both direct and indirect) support this argument. Regarding public policies aimed at increasing flows of this type of investment, estimates suggest that because of the positive pattern of spatial dependence in the FDI localization process the attraction of FDI should be considered in a regional context and not only from a local perspective.

Further research might distinguish between "new" and "total" FDI since total flows of FDI include reinvestments of existing foreign capital and firms. Also, future research can include other sectors in the analysis (e.g., export-oriented manufacturing).

Finally, in the case of the Southern region, public policies designed to attract more FDI flows in the manufacturing sector would have to be linked to the increase in what (Borensztein et al. 1998, p. 115) referred to as *absorptive capabilities*[18]

[17] See "Mexico's 'El Bronco' Jaime Rodríguez Bucks at Incentives for Car Plant," *Wall Street Journal*, May 16, 2016, https://www.wsj.com/articles/mexicos-el-bronco-jaime-rodriguez-bucks-at-incentives-for-car-plant-1463439790.

[18] "The higher productivity of FDI holds only when the host country (or region) has a minimum threshold stock of human capital. Thus, FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host economy (region)." Borenztein and De Gregorio (op. cit., p. 115).

through gradual improvements in human capital, for example. As Chiquiar (2005) pointed out for the Mexican case, the economic backwardness of this region (at least since the post-economic liberalization era in the mid-1980s) is explained not only by the geographical distance to the relevant market (the U.S. economy) but also by its low levels of physical and human capital.

Appendix

See Fig. 4.

Fig. 4 Two definitions of *W*: 3 nearest neighbors (above), Queen-contiguity neighbors (below). *Source*: Own elaboration with information from INEGI

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