Spillovers of Environmental Performance among Mexican Industrial Facilities: The Case of Greenhouse Gases

Although environmental performance explanations in management include a geographical dimension (Buysse & Verbeke, 2003; Hart, 1995; Joy & Bansal, 2003; Sharma & Henriques, 2005; Shrivastava, 1995), this dimension has been underdeveloped in management research. In this paper, we use the theoretical background of agglomeration economies to explain how a facility's location influences spillovers of environmental performance to nearby facilities. In order to do so, geographically weighted regressions were used to study spillovers at the facility level within two different spatial scales (intra-urban and metropolitan spatial scales). Even though several theories can help to explain spillovers, agglomeration economies supply some of the precise mechanisms through which such spillovers occur at different spatial scales. Evidence suggests that spillovers of environmental performance can be found in Mexican facilities at both spatial scales when environmental performance is measured as greenhouse gases.

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The environmental performance of firms has typically been understood as a function of legislative and social pressures, economic opportunities, and ethical motives, among other factors (Buysse & Verbeke, 2003; Hart, 1995; Joy & Bansal, 2003; Sharma & Henriques, 2005; Shrivastava, 1995). Although these explanations include a geographical dimension, this dimension has been underdeveloped in management research. In this paper, we use the theoretical background of agglomeration economies to explain how a facility's location influences spillovers of environmental performance to nearby facilities. For this reason, the main objective of this study is to assess if the environmental performance, specifically greenhouse gas emissions, from neighboring facilities influence a focal facility's environmental performance. In order to do so, geographically weighted regressions were used to study spillovers at the facility level within different spatial scales.

Environmental performance has been conceptualized in different ways, either as a consequence of environmental management or as sets of ideas, beliefs or values; programs, rewards or punishments; resource intensity and amounts of emissions (Trumpp, Endrikat & Zopf, 2015). As different definitions of environmental performance have emerged, so have varying explanations. Some of the most widely used theories are institutional theory, the resource-based view, resource dependence, and stakeholder perspectives (Buysse & Verbeke, 2003; Hart, 1995; Joy & Bansal, 2003; Sharma & Henriques, 2005; Shrivastava, 1995). Although these explanations might include an indirect geographical dimension, they have ignored that geographical context entails more than just institutional factors (Bathelt & Glückler, 2003) when explaining spillovers of environmental performance from neighboring facilities. Even though some management studies have furthered the discussion by including variables and geographical methods that can explain such spillovers, economic geography remains one of the least explored streams in the management literature (Sorenson & Baum, 2003).

In this paper, we use this theoretical background to explain how the environmental performance of neighboring facilities influences a focal facility's environmental performance, which we call an environmental performance spillover. Even though several theories can help to explain spillovers, agglomeration economies supply some of the precise mechanisms through which such spillovers occur at different spatial scales. Briefly, agglomeration economies refer to the cost advantages that accrue to firms that are located in the same geographic area. Although previous studies have relied on agglomeration economies and spillovers between regions, we examine spillovers in terms of greenhouse gas emissions among facilities within a given region.

Literature Review

The environmental performance of facilities refers to the amount of emissions and hazardous substances generated by the facility's operations through any implemented action. Klassen and McLaughin (1996) spoke of environmental performance as a consequence of environmental management. In their proposed model, environmental management affects both choices of product and process, as well as management systems. Although Avram and Kühne (2008) broadened the concept of environmental performance by speaking of responsible business behavior, which concerns ethical and responsible business issues, their approach can still be linked to a firm's impact. Similarly, Uhlaner, Berent-Braun, Jeurissen, and Wit (2012) defined environmental management practices as actions implemented to reduce the environmental impact of a firm's operations. Here, we focus on environmental performance as the amount of greenhouse gases emitted regardless of whether it is due to process efficiency, newer technologies, or better managerial systems.

A spillover of environmental performance is the influence of the environmental performance from a proximate facility on a focal facility over a specific spatial scale – that is, within a specific distance or within a specific area. The concept of environmental spillover relates to the concept of knowledge spillovers (Doytch & Uctum, 2012; Henriques, Husted & Montiel, 2012; Nilsson, Bergquist & Schultz, 2017; Ning & Wang, 2017). According to Jaffe, Trajtenberg, and Fogarty (2000) knowledge spillovers are created when a firm invests in knowledge creation and produces external benefits for other firms (Feldman & Audretsch, 1999). In this case, we apply the same logic and posit that, when a facility engages in any action in order to improve its environmental performance, externalities for other facilities are generated – either among nearby firms or for firms within the same metropolitan area.

Spatial scale refers to the area within which a spillover operates. Whether among neighboring facilities or facilities within the same city, spillovers tend to be spatially bound to the place in which they are created (Feldman & Audretsch, 1999). The few studies that have researched the spillovers of environmental performance while considering the issue of spatial scale were conducted at the regional level (Constantini et al., 2010; Ning & Wang, 2017), thus leaving aside the influences that could be found among proximate facilities (an intra-urban scale) and within metropolitan areas. Although the metropolitan area might be an adequate spatial scale to study environmental performance spillovers between facilities because access to information or endowments is usually available throughout these areas (Harrison et al., 1996; Jacobs, 1969; Parr, 2001), evidence for spillovers being sensitive to distance has been found (Figueiredo, Guimarães & Woodward, 2015). At these different levels of analysis, we find that there are spillovers among neighboring facilities via localization economies and spillovers among facilities within the same metropolitan area via urbanization economies. We now explain each type of spillover.

Environmental Performance at an Intra-Urban Spatial Scale through Localization Economies

Localization economies refer to the cost advantages that firms or facilities in the same industry that are located near each other (Parr, 2001). These economies of scale are produced for co-located facilities due to the emergence of skilled labor, lower costs for inputs through industry linkages, and access to specialized knowledge pools (McCann & Folta, 2008; Parr, 2001). In order to benefit from these scale economies, facilities often decide to locate in a given spatial region in order to exploit these cost advantages (Knoben, 2009). In addition, localization economies also accrue to the ease of accessing information from facilities that are co-located due to distance decay effects (Parr, 2001). Such effects imply that the influence of a facility on another decreases with distance. Proximity provides focal facilities with easy access to information about their neighbors, either through access to the same pools of information resources or through commercial relations among nearby firms, which permits casual encounters and exchange of information.

Localization economies explain the spillovers of environmental performance between facilities because the inputs, such as technologies, knowledge, or labor needed to increase environmental performance, might be easily acquired since the cost of accessing them would be less. Consequently, the location of a facility in a place where other facilities with strong environmental performance exist can improve the focal facility's environmental performance by allowing cost-effective access to the same endowments that a neighboring firm might have. This, in turn, not only allows access to information about changes regarding environmental performance, but also to the same suppliers and labor pools that might be able to implement the changes needed. Therefore, we hypothesize:

> *Hypothesis 1. The greater the environmental performance of neighboring facilities, the greater the environmental performance of the focal facility.*

Spillovers of Environmental Performance at the Metropolitan-Area Spatial Scale

Defining urbanization economies as "the cost savings due to the scope economies that arise from industrial diversity" (McCann & Folta, 2008; Parr, 2001) suggests that there are advantages from industrial diversification that influence facilities within a geographical area (Van der Panne, 2004). As Parr (2004) mentioned, these advantages arise in the form of cost savings by an input that is shared across different industries in the same geographical area. Some examples include infrastructure, specialized business services, universities, laboratories, trade associations, and other institutions (Harrison, Kelley, & Gant, 1996; Parr, 2004). The previous argument implies that the existence of industries outside manufacturing firms in the same metropolitan area allows for innovations and improves the opportunity to interact with others (Jacobs, 1967). We suggest that it is through co-location of these diversified industries that urbanization economies both influence a facility's environmental performance and its spillovers.

The theoretical lens of urbanization economies brings a twofold explanation of the influence that environmental performance spillovers from facilities within a metropolitan area might have on a focal facility's environmental performance. We follow the National Institute of Statistics and Geography (INEGI) (2012) by defining a metropolitan area as an urban area whose functions and activities exceed the limit of two or more municipalities[1] that maintain a high degree of socio-economic integration. Given this definition, scope economies enable access to a set of advantages associated with being located in a metropolitan area that increase the opportunity to communicate within facilities (Dubé et al., 2016; Harrison et al., 1996; Parr, 2001). In addition, the industrial diversity in the same area allows employees at a facility to be exposed to different ideas and innovate (Jacobs, 1967).

These two mechanisms are intertwined because interaction within firms can also enable cross-industry fertilization of ideas. So, in a metropolitan context, opportunities for interaction with other actors in the same and different industries are improved (Glaeser et al., 1992; Harrison et al., 1996; Jacobs, 1967). According to Harrison, Kelley, and Gant (1996), industrial diversity in a metropolitan area "improves the opportunity to interact with others in the same or different industries, making it easier to copy a practice being used by industry peers and to modify a practice from an outside industry" (p. 236). The way in which urbanization economies might improve those opportunities for interaction is through enabling access to a set of advantages within the same metropolitan area, such as sharing infrastructure, institutions, trade associations, housing, universities, business services, and transportation services, among other possibilities (Dubé et al., 2016; Harrison et al., 1996; Parr, 2001). It would be

1 A municipality in México is defined as the vicinity association recognized by the state on the basis of political and managerial organization (Rendón, 1995).

expected that interaction among facilities located in the same metropolitan area might explain spillovers of environmental performance. Consequently, we present the following hypothesis:

> *Hypothesis 2. The greater the environmental performance of facilities located within the same metropolitan area, the greater the environmental performance of the focal firm..*

Methodology

While several prior studies have examined the effects of agglomeration economies on spillovers (Alkay & Hewings, 2012; Antonietti & Cainelli, 2009; Jaffe, Trajtenberg & Fogarty, 2000), some areas for further work have arisen due to the limitations in the methodology of those papers. To the best of our knowledge, few studies have explored environmental performance spillovers with the use of geographical methods (Constantini, Mazzanti & Montini, 2010; Ning & Wang, 2017). Hence, we aim to measure the extent to which environmental performance is dependent on proximity and location in a metropolitan area by exploring environmental performance spillovers among facilities through the lens of agglomeration economies at diverse spatial scales. We suggest that to assess the existence of environmental performance spillovers within neighboring facilities, a spatial panel analysis should be used; this methodology has generally been used to model geographic spillovers (Anselin & Varga, 1997; Constantin et al., 2010).

The contributions in this methodological approach arose first because, excluding a few papers, spillovers have seldomly been studied through the influence of neighboring facilities on a focal facility's environmental performance (Doytch & Uctum, 2012; Henriques, Husted & Montiel, 2012; Nilsson, Bergquist & Schultz, 2017). Second, geography has customarily been a proxy in the management literature rather than being tackled directly with geographical models (e.g., as a dummy variable for location at certain distance). In most cases in which geography has been used directly with the theoretical lens of agglomeration economies, it was considered only at the regional level by explaining spillovers between regions rather than delving deeper into an explanation of the spillovers among facilities within those regions (Constantini, Mazzanti & Montini, 2010; Ning & Wang, 2017).

Database description. We focus on environmental performance as the total amount of greenhouse gases weighted by their equivalent CO_2 quantity per facility. To obtain the data, we relied on the Emissions and Pollution Transfer Registry (RETC) published by the Secretariat for the Environment and Natural Resources (SEMARNAT). The RETC lists the emissions by facility that can be found either in water, air, or land during the production process of each plant. It contains the name of the establishment, the coordinates of the location, the industry, a description of the products, the county, the state, the address, and the amount emitted or transferred from a list of 104-174 substances. The database includes a total of 23,489 observations from 2004 to 2013.

Sample. We focused our coverage from the database on the last four years of yearly data because of inconsistencies and loss of information that occurred in order to create a balanced panel. So the initial sample included the total number of facilities in Mexico that were obligated to report their emissions annually to the RETC from 2010-2013. The main industries that report are petroleum, chemical, painting, metallurgy, automotive, paper and cellulose, cement, asbestos, glass, electric, waste treatment, food and beverage, plastic products, wood and products, health, textiles, drinks, and glass producers, among others. The sampling unit is the industrial facility, which is defined as the place where the productive activities are enacted. The final sample consists of a balanced panel of 805 facilities from 2010 to 2013 for a total of 3,200 observations of the greenhouse gases (GHGs) at the facility level.

Statistical method. One of the reasons for the growing interest in spatial specifications is the increasing tendency to acknowledge that people are not atomistic agents and that they interact through social norms, neighborhood effects, spillovers, and group effects (Anselin, 1999). This acknowledgement is important regarding spillovers, where the interest is mainly in studying the relationship between the environmental performance of neighboring facilities and their influence on a focal plant's environmental performance. One of the ways in which this can be tackled is through spatial econometrics, which, per Anselin et al. (2008), concerns problems of spatial autocorrelation and spatial heterogeneity in regression models. One of the ways in which spillovers have been previously operationalized is through spatially weighted regressions (Baltagi, 2012). Spatial effects can be measured directly through two main models: the spatial lag model and the spatial error model.

Spatial lag model. According to Anselin et al. (2008), in the spatial lag model, spatial dependence is incorporated through a spatially lagged operator used as a dependent variable that consists of a weight matrix **W** that expresses the interaction between two locations (equation 1). This method is appropriate when the research focuses on the strength of the spatial interaction. The estimation approaches for this model rely on maximum likelihood (ML) and the generalized method of moments (GMM). In the case of a cross-sectional design, the spatial lag is the specification of an interactive process in which the dependent variable is determined by the value of the dependent variable of the neighbors (Anselin et al., 2006). When extended to panel data, it means that the process is stable over time, although other specifications might suggest a more dynamic context (Anselin et al., 2008). Although the extension of this model can be straightforward when using panel data, there are also several specifications of the spatial lag dependence (Anselin, 1999).

Spatial error model. According to Anselin (1999), spatial dependence modeled through the spatial error model is referred to as nuisance dependence; here, the concern is on treating the biasing effects of spatial autocorrelation rather than understanding its explanatory power (equation 2). There are several possible ways to control for spatial error, because of the nature of this research, the most appropriate specification includes a spatial error process. Such models can also be extended to the spatial panel case and, sometimes, they can also be used simultaneously with the spatial lag model. According to Elhorst (2010), this model suggests that the dependent variable depends on local characteristics and that the error terms correlate across space.

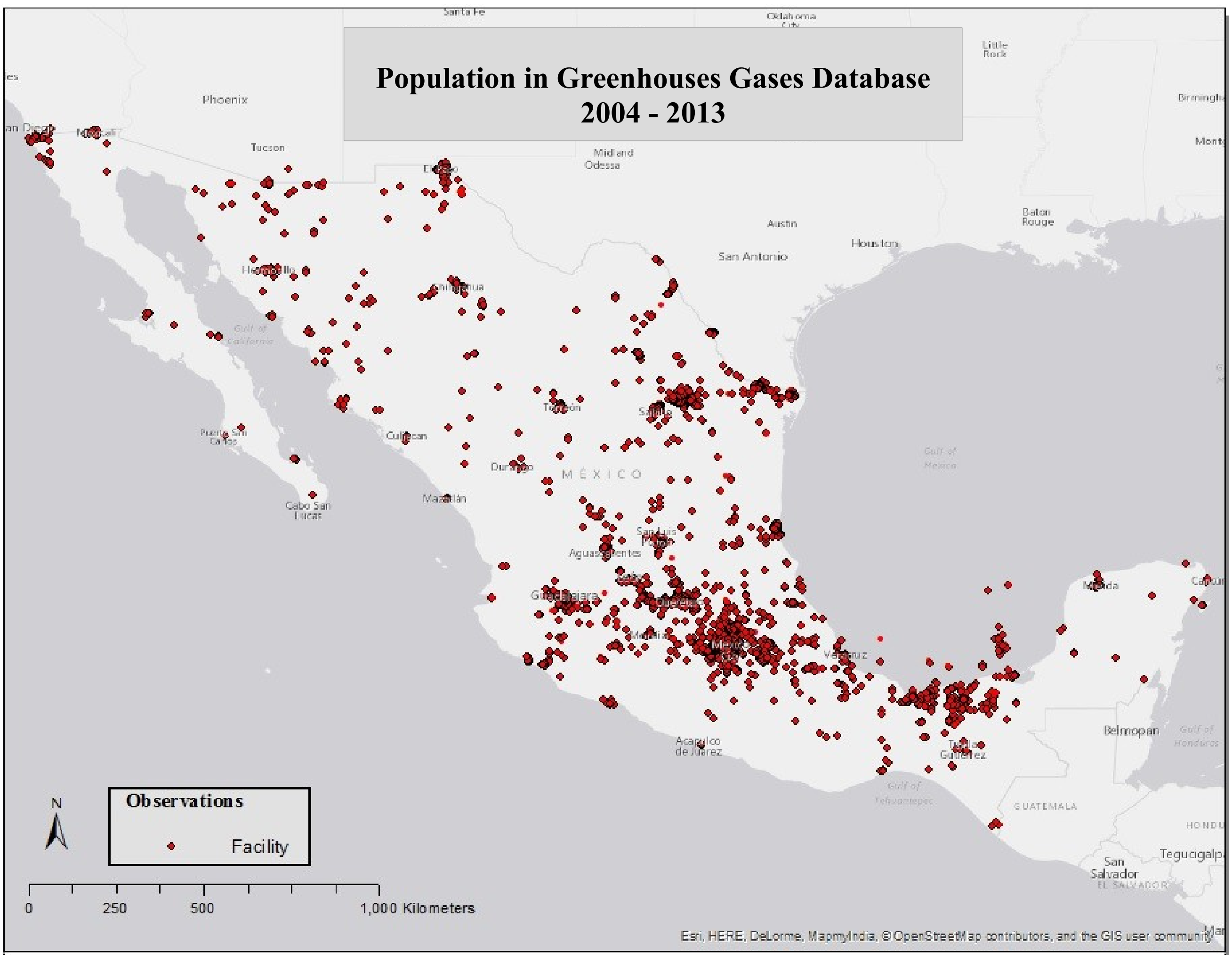

Figure 2. Map of the final sample for the greenhouse gases database for study

Main study model specification. To test for the existence of environmental performance spillovers (EPS) and control for spatial dynamics that occur locally in the locations of facilities, spatial panel was used to model the spatial lag and spatial error (equation 3). Two w_{ij} matrixes were used, the inverse distance matrix and the banded matrix. The first one considers a decay effect with increasing distances while the second matrix takes the value of 1 when the other facility is within the size of a metropolitan area and 0 otherwise. In the RETC, only information about environmental performance, location, and industries was available. For this reason, the spillover of environmental performance at a national level could not be controlled by other variables that might be relevant (such as production and industry intensity on the environment).

In this study at the plant level, the following equations were assessed:

Spatial Lag Model:

$$EP_{it} = \beta_0 + SEP_{it}\lambda + Ind_{ki}\beta_k + u_i + \varepsilon_{it} \quad (1)$$

Spatial Error Model:

$$EP_{it} = \beta_0 + Ind_{ki}\beta_k + u_i + \phi_{it} \quad (2)$$

$$\phi_{it} = \rho \sum_{j=1} w_{ij}\phi_{it} + \varepsilon_{it}$$

Spatial Lag and Spatial Error Model:

$$EP_{it} = \beta_0 + SEP_{it}\lambda + Ind_{ki}\beta_k + u_i + \phi_{it} \quad (3)$$

$$\phi_{it} = \rho \sum_{j=1}^{N} w_{ij}\phi_{it} + \varepsilon_{it}$$

where,

$i = 1, \ldots N$

$t = 1, \ldots T$

EP_{it} = environmental performance for observation i in time t[2],

β_0 = intercept term,

SEP_{it} = spatially weighted environmental performance of neighbors for observation i in time t,

λ = spatial autoregressive parameter,

Ind_{ki} = dummy variable that equals 1 if the observation i is in industry k and 0 otherwise[3],

β_k = parameter associated with the independent variable,

u_i = random effects for observation i,

ε_{it} = random error term,

ϕ_{it} = spatial auto-correlated error for observation i in time t,

ρ = spatially auto-correlated error parameter, and

2 The number of studied years is the same for all geographical regressions t= 1,…4.

3 The number of industries considered varies according to the study and measurement used. The maximum number of industries is k = 1,….13.

w_{ij} = element from matrix **W** that represents spatial relationship between observation *i* and *j*;

Greenhouse gases (GHGs). We chose to focus on greenhouse gases in Mexico, rather than toxic emissions tracked by RETC, because GHGs are only reported, but not regulated. Consequently, GHG emission data should be indifferent to local variations in environmental enforcement and corruption. This operationalization of environmental performance is the sum of the greenhouse gases emitted weighted by its equivalent in carbon dioxide (equation 4). The amount of emissions has been widely used as both dependent and independent variables in academic papers. As a dependent variable, the amount of emissions into the environment has been used to represent the degree of commitment in voluntary environmental programs (Delmas & Montes-Sancho, 2010), and to represent the construct of environmental performance (Doshi, Dowell & Toffel, 2013). For our work, we consider the following:

$$(4) \qquad GWP_i = \sum_{z=1}^{7} R_{iz} * E_z$$

where

$GWP_i =$ Greenhouse gas emissions for facility *i*,

$R_{iz} =$ kilos released of greenhouse gas *z* by facility *i*; *z* = 1, …7, and

$E_z =$ CO_2 equivalent quantity for greenhouse gas *z*.

Our objective in using this variable is to measure the extent to which environmental performance is dependent on proximity. One of the interesting points about the use of emissions or chemicals is that it can help to verify if firms have appropriated substantive environmental actions by watching the change of emissions over time, and it also helps to understand if those behaviors are diffused among the firms by watching the changes in emissions in a geographical space. The use of these variables as proxies for these constructs can be found in the literature (Delmas & Montes-Sancho, 2010; Doshi, Dowell & Toffel, 2013).

Independent variables. The set of variables is operationalized at the facility level, as is the dependent variable of environmental performance. This level is important for assessing the importance of distance through the spatial lag operator, which is an explanatory variable that measures the effect of neighbors. In this specification, dummy variables for industry are included because emissions vary by industry.

Environmental performance spillover (EPS). This variable is operationalized with the use of a spatial lag. According to Anselin, Le Gallo, and Jayet (2008), the spatial lag operator consists of a weight matrix **W** which is N x N that expresses the interaction between location *i* and location *j*. The spatially lagged operator expresses the existence and strength of a link between the observed locations in a network. It is usually a standardized binary matrix with $w_{ij} = 1$ when *i* and *j* are neighbors and $w_{ij} = 0$ when they are not within a specified distance. It can also be used as a distance matrix between *i* and *j*. We use both approaches in order to tackle hypotheses 1 and 2 because an inverse distance matrix can help model the relationship between neighboring facilities (hypothesis 1), and a binary matrix can help elucidate any metropolitan area effects (hypothesis 2). This idea is consistent with what Lesage (2008) asserted, such that inverse distance matrices help model the connectivity of an individual. The spatial lag operator is usually used in cross-sectional analyses, but its use in a panel can be extended by assuming the spatial lags are mostly constant over time and multiplied by a scalar parameter that can vary according to changes in the interaction structure. Building on Elhorst (2010), the variable is expressed as follows:

$$EPS_{it} = \sum_{j=1}^{N} w_{ij} EP_{jt} \quad (5)$$

where

SEP_{it} = spatially weighted environmental performance of neighbors for observation *i* in time *t*,

w_{ij} = element from matrix **W** that represents spatial relationship between observation i and *j*,[4] and

EP_{jt} = environmental performance of observation *j* in time *t*.

Industry. We used a dummy variable based on the industrial classification assigned by the INEGI to distinguish between industries in order to control for industry effects.

Results

We measured the environmental performance of facilities to assess if there is an influence of spillovers of neighboring facilities on a focal facility's environmental performance through time. The independent variables related to industry were included in all models. The inverse distance matrix, allowed us to test if there is a spillover

4 The spatial relationship between neighbors(w_{ij}) is fixed through time. The maximum number of $t = 1,\ldots.4$ while for $j = 1,\ldots 1025$.

effect between facilities at an intra-urban spatial scale among proximate facilities (hypothesis 1). While the banded matrix allowed for the assessment of whether spillovers of environmental performance exist among facilities in the same metropolitan area (hypothesis 2). In table 1, there are 8 different industries represented in the hazardous substances database.

Table 1. Relative Frequencies of *Facilities per Industrial Sector*

Greenhouse Gases (GHGs)			
Sector		**Observations**	**Percent**
21	Mining	52	6.46
22	Electric Energy	67	8.32
31	Food	32	3.98
32	Drinks	322	40.00
33	Textiles	232	28.82
43	Commerce	1	0.12
48	Transport	88	10.93
56	Business Support Services	11	1.37
Total		**805**	**100.00**

This measurement is the sum of the equivalent greenhouse gases per facility. Table 2 presents the results of the spatial panel regressions used to test hypotheses 1 and 2. Hypothesis 1 asserts that the environmental performance spillovers occur between neighboring facilities while hypothesis 2 argues that there is a spillover of environmental performance between facilities located in the same metropolitan area. In this model, the dependent variable is the emission of greenhouse gases per facility, and the main independent variable are the greenhouse gases of the neighboring facilities (either proximate or within the same metropolitan area). The spatial autoregressive term (lambda) is significant for both the proximity and the metropolitan scale models across every model ($p < 0.001$), which implies that such spillover exists within Mexican facilities.

Hypothesis 1 is thus sustained by both the spatial lag and the spatial joint effects regressions of the proximity models. To test this last hypothesis, an inverse distance matrix was used. Under this hypothesis, focal facilities tend to have more similar greenhouse gas emissions with neighboring facilities rather than facilities located farther away. The same phenomenon occurs as predicted in hypothesis 2 in both the proximity and the metropolitan scale models that consider the banded matrix, which means that a spillover can be found within the spatial scale of an average-sized metropolitan area. A positive EPS's lambda coefficient indicates that there is a direct proportional relationship between neighboring facilities, such that the levels of facilities' greenhouse gas emissions within the same metropolitan area influence the value of the focal facility in the same direction. This means that, as was suggested in hypothesis 1, facilities tend to change their greenhouse gas emissions based on the levels of other nearby facilities' greenhouse gases.

In Table 2, we assess how belonging to a certain industry can have an influence on greenhouse gas emissions in contrast to other industrial sectors. When both spatial effects are considered in model 3, sector 21 (mining) and sector 22 (electric energy) have higher amounts of emissions in comparison with sector 56 (support services). Sector 21 has a coefficient of 8.68 with ($p < 0.01$), sector 22 has a coefficient of 12.55 at ($p < 0.001$), and sector 56 has a coefficient of 6.31 at ($p < 0.001$). Accordingly, sector 48 (transport), with a coefficient of 4.08 and a significance value of ($p < 0.05$), has a lower level of emissions in comparison to sector 56. In terms of the impact on greenhouse emissions, this means that sector 21 pollutes more than sector 56 by 969% in kilometric equivalent CO_2 tons, which contrasts with sector 48, as it pollutes 11.8% less than the base sector. This comparison implies that, in general, both the spillover from neighboring facilities as well as belonging to certain industrial sectors can explain the amount of greenhouse gas emissions for Mexican facilities when a distance decay effect is modeled through the inverse distance matrix.

Table 2. *Environmental Performance Spillovers Regression – Greenhouse Gases*

	Proximity Models (Inverse Distance Matrix)			**Metropolitan Scale Models** (Banded Matrix)		
Environmental Performance (Focal Plant)	**1. Spatial Lag Random**	**2. Spatial Error Random**	**3. Spatial Joint Effects Random**	**1. Spatial Lag Random**	**2. Spatial Error Random**	**3. Spatial Joint Effects Random**
GHG Spillover (λ)	**1.56e-04*****	------	**6.01e-05*****	**1.25e-03*****	------	**1.24e-03*****
	(9.26e-06)	------	**(6.04e-06)**	**(1.01e-05)**	------	**(7.48e-06)**
Intercept	**4.2183*****	**7.2986*****	**6.3179*****	0.3007	**8.129*****	0.3264
	(0.5711)	**(0.9883)**	**(0.8215)**	(0.2715)	**(1.0048)**	(0.3484)
Mining	**4.1205*****	**1.8376.**	**2.3751****	-0.4356	-0.0086	-0.2715
	(0.6302)	**(1.0864)**	**(0.9047)**	(0.2986)	(1.1125)	(0.3969)
Electric Energy	**6.8375*****	**5.6945*****	**6.2423*****	-0.2102	**3.5144****	-0.1518
	(0.6203)	**(1.0781)**	**(0.8966)**	(0.2977)	**(1.0962)**	(0.3848)
Food	**4.376*****	0.1918	**1.6689.**	-0.4456	-1.5491	-0.2490
	(0.6623)	(1.1420)	**(0.9484)**	(0.3151)	(1.1653)	(0.4041)
Drinks	**2.8583*****	0.2614	0.8709	-0.3676	-0.7876	-0.3634
	(0.5816)	(1.0133)	(0.8418)	(0.2740)	(0.4446)	(0.3649)
Textiles	**1.747****	0.0568	0.4392	-0.2943	-0.6262	-0.2683

	(0.5846)	(1.018)	(0.8462)	(0.2741)	(1.0329)	(0.3609)
Commerce	1.5258	3.493	3.3939	0.8854	4.0008	0.9159
	(1.9741)	(3.4089)	(2.8476)	(0.9281)	(3.4284)	(1.2341)
Transport	**-1.0875.**	**-1.8593.**	**-2.1361***	-0.2691	-1.4161	-0.3762
	(0.6061)	**(1.0552)**	**(0.8749)**	(0.2825)	(1.0780)	(0.3730)

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; **.** $p < 0.1$
n = 3,220

In summary, evidence was found to support both hypotheses 1 and 2 regarding the spillovers of environmental performance in both the proximity and metropolitan scale models. Although GHGs Spillovers (λ) were found to be significant at ($p < 0.001$) levels, the spillover in hypothesis 1 was only limited to neighboring facilities. The same occurs when such spillover is modelled as through the use of a banded matrix, as an effect can be found if all facilities within the metropolitan area are considered.

***Model fit specification*.** According to Millo and Piras (2012), some of the most common procedures used to test spatially weighted regressions are the Lagrange multiplier tests for individual effects and spatial correlation. Such tests were introduced by Baltagi, Song, Jung, and Koh (2007), and they determine different model specifications, such as joint and random effects. The main alternative hypotheses under consideration in this paper are that 1) there are random effects present, 2) that spatial autocorrelation is different from zero, and 3) the alternative hypothesis that spatial autocorrelation is different from zero under random effects. Although the main objective of this paper is to explore whether there are spillovers in environmental performance, it is also important to assess the effects through the spatial error. Although a spatial lag might not be significant as an explanation, the geographical concentration of diverse firms in a certain area might convey an effect on the behavior of the facilities. By modeling the spatial error, it is possible to account for spatial effects that might bias the results of the regression.

As can be seen in Table 3, several tests were performed to assess the fit of the spatial lag and spatial error models and their appropriateness. A series of LaGrange multiplier tests derived by Baltagi et al. (2003), which test marginal and joint effects for combinations of random effects and spatial correlation, were used. For both sets of regressions, it was found that the null hypothesis of no random effects and no spatial autocorrelation under random effects was rejected at ($p < 0.001$), which makes the random effects models with spatial effects more appropriate under the alternative hypothesis; these are thus the models displayed. Also, in the case of the inverse distance matrix, the model with spatial autocorrelation seems to be more appropriate, while in the case of the banded matrix, it is a model that includes the spatial lag and random effects.

Regarding the post-estimation tests, the proper models are those that include a spatial autocorrelation parameter (lambda) under random effects; that is, models that include both spatial lag and spatial error parameters using either an inverse distance or banded matrix. In those models, lambda shows significance, which suggests that geography does matter and that emissions levels, either greenhouse gases or hazardous substances, are influenced by neighbors' emissions levels.

Discussion

The hypotheses regarding spillovers of environmental performance are framed within the logic of urbanization and localization economies. Such spillovers should be considered because their existence implies that the assumption that facilities act as independent entities does not hold true within all contexts. The logic of hypothesis 1 is that spillovers of environmental performance rely on proximity to other facilities. In this case, the advantages of localization economies are those that influence such spillovers. This happens because, to exploit the cost advantages of scale economies regarding specialized labor pools, industry linkages, and specialized knowledge pools, firms often decide to cluster within a specific location (Knoben, 2009). This finding is consistent with Parr (2001), who mentioned that it is easier to access information from facilities that are located nearby rather than far away. In contrast, hypothesis 2 posits that spillovers occur among facilities in the same metropolitan area. The main idea is that urbanization economies can explain such spillovers of environmental performance because the same agglomerative advantages exist within the same area. Some of the advantages are, for example, that location in the same urban area allows facilities to increase the opportunity to communicate and be exposed to different ideas or innovation (Dubé et al., 2016; Harrison et al. 1996; Jacobs, 1969; Parr, 2001).

Table 3. *Tests for Spatial Panel Regressions of Greenhouse Gases*

Greenhouse Gases (GHGs)

Database	**Ha**	**Score**
Inverse Distance Matrix	Random Effects	**51.647*** **
	Spatial Autocorrelation	**5.444*** **
	Random Effects SAR	**2697*** **
Banded Matrix	Random Effects	**51.647*** **
	Spatial Autocorrelation	-0.6058
	Random Effects SAR	**2667.4*** **

Previous calls for attention to the spatial scales of spillovers and their precise mechanisms have been made in different contexts (Trippl et al., 2009). Environmental performance spillovers have been studied with the nation, region, and city as units of analysis within the framework of agglomeration economies (Constantini et al., 2010; Grazi et al., 2016; Ning & Wang, 2017). The way in which this study has approached spillovers of environmental performance at both intra-urban (immediate vicinity) and metropolitan spatial scales is through geographically weighted regressions. Evidence supports the existence of environmental performance spillovers either from facilities within the same metropolitan area or neighboring facilities. Even though this is one of the few studies to empirically tackle spillovers of environmental performance at the facility level within a metropolitan spatial scale, previous studies with different units of analysis have found that environmental performance is also explained by location (Constantini et al., 2010; Ning & Wang, 2017). Some of the explanations offered by previous authors about why a geographical influence might appear are as follows: environmental performance is generally associated with specific industries that have high levels of pollution and might be bounded to geography (extractive industries); the abatement difficulty might depend on the kind of pollutants because regional infrastructure might be focused on abatement of certain kinds of pollution; and the institutional environment regarding the stringency of standards and sanctions across the different regions (Constantini et al., 2010; Henriques et al., 2012; Ning & Wang, 2017). Coefficients related to hypotheses 1 and 2 were not only found to be significant, but the sign of the relevant coefficient implies that spillovers exist among neighboring facilities and that there is a direct relationship between a neighbor's environmental performance and a focal facility's environmental performance between proximate facilities and facilities located within the same metropolitan area. The results found by Constantini et al. (2010) indicated that environmental performance spillovers from neighboring regions tend to increase the environmental performance in a focal region.

Conclusions

Although several explanations of environmental performance are found in different theoretical explanations such as stakeholder theory, resource-dependence, resource-based view, industrial organization and institutional theory among others (Buysse & Verbeke, 2003; Delmas & Toffel, 2008; Hart, 1995; Sharma & Henriques, 2005; Shrivastava, 1995; Whiteman & Cooper, 2000), spillovers of environmental practices, performance and ideas have seldom been studied (Henriques et al., 2012; Nilsson et al., 2016). Rather than being a theory that substitutes previous findings, agglomeration economies complement previous studies by looking at the mechanisms through which these spillovers happen at different spatial scales. Some of the less explored areas are related to how context and more specifically neighbors influence such environmental performance in facilities. It is interesting to explore this area because it implies that facilities do not act independently of their local context.

Although the RETC and INEGI are public databases, there are many limitations with respect to the available information. Regarding the RETC, there are gaps in certain time periods. One of the implications is that the spatial panel had to be restricted to fewer years (2010 – 2013) because, as the time period increased, fewer observations were available for a balanced panel. In the case of conceptual development, Eriksson (2011) mentions that there is a black box where relatedness within the firms is often overlooked. Although we tackle some of his critiques by studying spillovers within the geographical context and distance to other facilities, still some areas of opportunity remain regarding how factors within the firm influence such spillovers. Regarding the design, Van Oort et al. (2012) posit that agglomeration economies are best used for multilevel phenomena. Unfortunately, it is not yet possible to run a geographically-weighted multilevel panel regression. Also, when studying localization economies, a variable that measures diversification or concentration of industries within an area could have been useful in order to understand if proximity to "like" industries enhances such spillover. There also remains the question about what is causing spillovers of environmental performance: are they specific ideas, programs, technologies or processes?

Though environmental performance and its spillovers have been addressed in the literature (Buysse & Verbeke, 2003; Delmas & Toffel, 2008; Hart, 1995; Henriques et al., 2012; Nilsson et al., 2016; Sharma & Henriques, 2005; Shrivastava, 1995; Whiteman & Cooper, 2000) findings signal new directions for future research. As it was found, spillovers of environmental performance do exist and they can vary throughout at different spatial scales. Candau and Dienesch (2017) found that rule of law and industry structure might influence behavior towards pollution. Also, although Dasgupta, Laplante, Wang and Wheeler (2002) discussed how development influences pollution (the environmental Kuznets curve) and address how the effect might be decreasing, they still question its behavior regarding the kinds of pollutants that are measured. In short, when studying environmental performance spillovers, the location of study might be relevant, further models could consider a comparison of such spillovers within metropolitan areas from countries with different degrees of development or rule of law. In summary, agglomeration economies help explain environmental performance and its spillovers between facilities and the mechanisms through which they occur in local areas. The theory might be applied to other spatial scales such as integrated regions and industrial sectors within metropolitan areas. Although it has left out explanations regarding the internal aspects of firms, it can shed light on the mechanisms through which spillovers of environmental performance occur and the importance of context and proximate facilities.

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