Discussion Papers In Economics And Business

Quantifying the effects of Special Economic Zones using spatial econometric models

Zhaoying Lu

Discussion Paper 21-01

April 2021

Graduate School of Economics
Osaka University, Toyonaka, Osaka 560-0043, JAPAN

Quantifying the effects of Special Economic Zones using spatial econometric models

Zhaoying Lu[†]

March 31, 2021

Abstract

This paper evaluates the effects of a place-based program in China—Special Economic Zone (SEZ) program. It adds to the existing literature by introducing spatial proximity to understand the effects of SEZs on the local economy. Using a panel data set over the period from 2004 to 2007, the empirical results find that SEZs have positive spillover effects on regional productivity, most of which are from the neighborhood. Meanwhile, there exists a positive interdependence between local firms on regional productivity. The magnitude of spillover effects of SEZs is robust to changes in sample data, weight matrices selection, and alternative explanatory variables.

Keywords: Special Economic Zone, Place-based Policy, Spatial Analysis, Productivity, Spillovers.
JEL classification: C21, C23, R10, O21

[†]Graduate School of Economics, Osaka University, 1-7, Machikaneyama-cho, Toyonaka, Osaka, 560-0043 , JAPAN. E-mail: u571686b@econ.osaka-u.ac.jp

1 Introduction

“Place-based” policies refer to government efforts to achieve the goals of providing benefits to geographically targeted areas (Kline and Moretti, 2014). Generally, preferential benefits such as tax deduction, land use discount are provided to attract investment from other locations to targeted areas. A growing number of place-based programs are implemented in developed countries, for instance, Enterprise Zone programs in the US and Europe; and in developing countries such as Special Economic Zone programs. Some literature supports place-based policies for generating agglomeration effects and facilitating knowledge spillovers (Moretti, 2010; Neumark and Simpson, 2015). On the other hand, such policies are thrown into doubt that interventions by the government would lead to large distortions in the allocation of capital and labor whereas they have been implemented as a development strategy for policymakers worldwide (Greenbaum and Engberg, 2004; Glaeser and Gottlieb, 2008).

Since the operation of place-based programs needs to invest large government expenditure, the effectiveness of the programs becomes vital, especially for developing counties that have constraint resources to allocate. Although the existing literature studies the place-based programs of the United States or Europe in both theoretical and empirical view (see Neumark and Simpson, 2015), few attempts were made to investigate many questions in developing countries. One of the issues arises whether the rationals of the programs in developed countries still hold for developing countries. Also, the issue of whether the place-based program contributes to the local economy is crucial for policymakers to implement the cost-benefit analysis.

This paper aims to address the second issue: the spillover effects of the place-based program on the local economy. Among developing countries, this paper investigates a place-based program in China—Special Economic Zone (SEZ) program. China has been implemented SEZ program as a critical part of Chinese economic reforms since 1978. In the last decades, the government has cost a huge amount of money and allocated millions of acres to set up SEZs for regional developments[1]. Empirical literature finds that imple-

[1]As of 2006, there were 1,568 SEZs in more than 270 cities that cover 9,949 square kilometers in total (Zheng et al, 2017).

menting the policies has positive impacts on the firms located within SEZs or the cities hosting the SEZ program (Wang, 2013; Alder et al, 2016; Lu et al, 2019).

This paper considers the externalities from the targeted areas on the local economy, instead of focusing on the firms located within SEZs. Our analysis builds on the literature that the place-based program has impacts on the firms located nearby the targeted areas (Rosenthal and Strange, 2003; Zheng et al, 2017; Ciżkowicz et al, 2017). The implementation of SEZs has exerted influences not only on the targeted areas but also on local firms. The government subsidizes SEZs in many ways such as reducing taxes or constructing infrastructure. However, it may put local firms at a competitive disadvantage which might outweigh any good the place-based policies do to the firms within the targeted areas (Greenbaum and Engberg, 2004). On the other hand, bringing additional people or firms to SEZs is likely to improve the productivity of local firms. For example, firms in SEZs that have advanced techniques can benefit the local economy by vertical and horizontal linkages. Specifically, SEZs benefit local suppliers and customers through technical assistance, provision of information, and improved performances of the local firms may benefit SEZs in turn.

This paper answers two important questions on the spillover effects of SEZs. First, do SEZs have positive spillovers to the local firms in the same region? Second, do local firms benefit from SEZs of the neighboring regions? To evaluate the spillover effects of SEZs, we add to the existing literature considering geographical proximity. Using a panel data set over the period from 2004 to 2007, this paper quantifies the spillover effects on regional productivity for the firms outside zones in Eastern China. In contrast to previous studies that focus on intra-regional analysis, this paper considers inter-regional, as well as intra-regional spillovers arise from SEZs.

This paper finds that the presence of SEZs has positive spillover effects on the regional productivity of local firms. The spillover effects are not only confined to own counties but also the neighboring ones. Indeed, the neighboring counties contribute more to the regional productivity than the hosting county itself. In addition, the empirical result demonstrates that the regional productivity is contagious, that is, a region's productivity also affected by its geographic neighborhoods. Main results are unaffected by changes in sample data, weight matrices, and explanatory variables.

The first contribution of this paper is taking into account spatial dependence which allows us to examine the presence of interactions between adjacent regions. This kind of approach that adopts spatial lags to the dependent and independent variables has been widely used in the economic and geographic literature where there is an intuitive motivation that the observations will be influenced by the activities of neighbors. In the context of the SEZ program, it is plausible to think that observations are contagious and the externalities arising from a region have impacts on its neighbors.

The second contribution is that the spillover effects of SEZs can be distinguished by three different channels. Specifically, an increase in the presence of a SEZ will affect the own region itself (direct effect) and probably affects the neighboring regions (indirect effect). Moreover, spatial regression exploits impact passing through the neighboring regions and back to the region itself (feedback effect). These channels make us capture both inter- and intra-regional spillovers from SEZs to the local economy. However, to the best of the author's knowledge, existing literature focuses on the impacts of SEZs in an intra-region dimension that SEZs exert influences on the hosting regions in China. To fill this gap, the paper introduces spatial dependence to properly treat influences from neighbors and to assess the spillover effects of SEZs not only from the hosting regions but also from the further scope.

The rest of this paper is organized as follows. Section 2 presents related literature that mainly focuses on developing countries. Section 3 introduces the background of SEZ policies released in China. Section 4 describes the data and calculates spatial autocorrelation. Section 5 and Section 6 present estimation models and empirical results. The conclusion is summarized in the last section.

2 Related Literature

Place-based policies in developed countries differ from those in developing countries on both policy goals and implement measures. To contrast evidence for similar types, this paper directly relates to place-based policies operating in developing countries.

Many studies find evidence that place-based programs have positive effects on the firms located within SEZs. In China, operating SEZs has been regarded as an engine for economic development (Zeng, 2011). Lu et al. (2019) find empirical evidence that implementing SEZ policies benefits firms in SEZs on industrial output, capital investment, and employment. Johansson and Nilsson (1997) find that SEZs have positive effects on exports in Hong Kong, Malaysia, Singapore, and Sri Lanka. In particular, they highlight the performances of SEZs in Malaysia for attracting foreign investors who transfer knowledge to domestic firms. In other studies, by contrast, fail to find positive evidence within the scope of zones. For instance, in Africa, many countries except a few with better performance such as Kenya and Ghana, SEZs have failed to stimulate capital investment or job creation (Zeng, 2017). In India, SEZs have been unsuccessful to bring about positive outcomes to meet zone expectations, instead, fierce competition to the bottom is triggered (Alkon, 2018).

In developing countries, implementing place-based policies is a way to stimulate the local economy, as well as to promote development within the zones. Wang (2013) and Alder et al. (2013) find that SEZs exert positive influences on the local economy with respect to employment, export, and foreign direct investment in China. Since using macro-level data, they evaluate the influences on the cities hosting the SEZ program, do not separate firms in zones with those outside zones in a region. Zheng et al. (2017) and Lu et al. (2019) distinguish firms located within SEZs and those outside zones by using geocoded firm-level data. Zheng et al. (2017) find that in several major cities of China SEZs have positive spillovers with respect to wage, employment, and productivity for non-SEZ firms located nearby SEZs. Ciżkowicz et al. (2017) also find that implementing place-based policies creates jobs for firms outside zones in Poland.

With regards to research methods, existing literature studying place-based policies can be divided into two types. One is literature that summarizes experiences of implementing place-based policies based on case studies and interviews. Zeng (2011) describes experiences in China and discusses keys of success and faced opportunities. Farole (2011) introduces experiences in Africa and possible reasons for those outcomes. The other one is literature that employs econometric models to estimate the effects of place-based policies. Many empirical studies evaluate the impacts of place-based policies by a quasi-experimental approach such as the difference-in-difference method (Wang, 2013; Alder et al, 2013; Zheng et al, 2017; Lu et al, 2019). These studies that allow for comparisons of treatment groups and appropriate control groups make valid identification of causal effects. The quasi-experimental approach is broadly applied to investigate the impacts of place-based policies in both developing and developed countries. Except for this kind of approach, spatial econometric models are used to assess the spillover effects of place-based policies by taking into account the geographical proximity of the observations (Ciżkowicz et al., 2017).

3 Background

This section introduces the background of SEZ programs implemented in China. SEZs are geographically designated areas by the government that is aimed to stimulate economic growth. They are subject to different regulations relative to other areas within the same country. Generally, the term "SEZ" is a zone that includes some common characteristics such as—it is located in geographically designated areas; it offers benefit to investors within the zone; it has separate customs areas; it has single administrations (World Bank, 2009).

The SEZ program has been implemented over the last 40 years as a crucial part of Chinese economic reforms since 1978. Before the reforms, China was an isolated socialist state dominated by central planning. Instead of carrying on previous policies, the creation of SEZs in the initial stage was an experiment to test for the market-oriented economy. By 1980, the first four SEZs were approved to set up in Shenzhen, Zhuhai, Shantou, and Xiamen. Since these regions were eastern coastal areas near Hong Kong, Macao, and Taiwan, the designation at that time took into account both economic and political factors. As the success of these regions, additional 14 coastal regions were designated as SEZs in 1984 to gain further access to foreign markets and investment. The next wave of SEZs in the 1990s gradually began to extend from eastern coastlines towards inland regions, especially after Deng Xiaoping's southern tour to SEZs in 1992. By 2001, SEZs were established one after another covering all provinces across China. As of 2006, SEZs account for 1,568 occupying 9,949 square kilometers of land in total.

By administrative levels, SEZs are divided into two categories: national-level and provincial-level. The former one is conducted by the central government and the latter one is directed by the provincial governments. National-level SEZs grant more autonomy and enjoy more privileges than provincial-level SEZs. Only authorized by the central government or the governments which have provincial administrative level are legal SEZs in China[2]. Although there are some differences between specific privileges of national- and provincial-level, SEZs are all granted market-oriented freedom and preferential benefits. The SEZ program is given greater autonomy to adjust related regulations along the basic lines of national ones by removing some constraints within the scope of the zones. Also, the government provides a series of preferential policy packages for foreign and domestic investors which enter the zones as the following[3]:

1. *Tax deduction.* In General, the policy deducts corporate income tax rate to 15-24% for firms in SEZs relative to 33% for ordinary domestic firms outside SEZs. Also, customs duty is exempted and duty-free allowances of intermediate inputs are offered for the firms located in SEZs.

2. *Land use discount.* The land is owned by the government and the land use right is strictly regulated in China. Different from many countries, officials can allocate land on large scale and convert agricultural land for industrial purposes when necessary. Land use rights for industrial purposes are granted for domestic and foreign investors which enter the SEZs. Besides land use rights, land use fees are discounted for entrants relative to the firms outside zones.

3. *Special treatment for a loan.* The state-owned bank looses lending policies and gives priority to the firms in SEZs to apply for a loan.

4. *Procedure simplification.* For potential investors who enter the zones, procedures are simplified and approved for high-speed.

5. *Property protection.* The government commits to the investors who enter the zones that all of their private properties are under-protected.

Besides these preferential policies, the government also makes a great effort to improve infrastructures of zones such as roads, ports, electricity, gas, water, telecommunications, and other service facilities. Furthermore, to attract skilled human capital, SEZs offer an

[2]The others that were not approved by the central or provincial governments violated related laws and regulations were abolished in 2006.

[3]See Wang (2013), Alder et al. (2016), Zheng et al. (2017), and respective provincial government websites for details.

extra personal income tax deduction, allowances, and Hukou registration priority benefit to a highly qualified individual[4].

Each SEZ has its administrative committee which performs management functions within its geographical scope. Administrative committees are directly controlled by the state or the provincial governments. They direct and administer affairs of SEZs on the behalf of the government such as project approval, local taxation, land management, public facilities planning, financial revenue, personnel, environment protection, and so on. For example, administrative committees take responsibility to attract investors from domestic or abroad that meet the standards of local development. Each administrative committee has the right to decide which investors could enter the zone. In particular, they offer a bundle of preferential policies and negotiate with potential entrants for details.

4 Data and Spatial Data Analysis

4.1 Data

The main data is firm-level data from the Annual Survey of Industrial Firms (ASIF) conducted by the National Bureau of Statistics of China (NBS) over the period from 2004 to 2007. The ASIF data covers all state-owned firms and non-state-owned firms with an annual turnover exceeding five million yuan (approximately $700,000). Those firms occupy over 90% of the total industrial outputs of China from 2004 to 2007. The data contains more than 100 variables, providing information on industrial output, intermediate input, total employment, industry affiliation, and geographic location. Geographic location is a 12-digit geographic code, which provides location information at the most disaggregated level. It consists of district (or county), jiedao (streets or avenues), and juweihui (communities or villages). Following Zheng et al., (2017), each firm's geographic location code and the exact geographic boundaries of SEZs can be used to identify whether a firm is located in SEZs or not[5].

[4] In China, each citizen is categorized by location of origin and further classified in a rural or urban Hukou.

[5] The geographic boundary of SEZs which covers detail information about villages, roads or coasts is released by the Ministry of Land and Resources of China.

Since the ASIF data is reported annually, it needs to be matched to construct panel data. Following Brandt et al., (2012), firms are linked over time using their ID number, firm name, legal person's name, address, and phone number. Firms with missing or negative values on industrial output, capital stock, intermediate input, and paid-up-capital are dropped from the sample (1.4%), and observations with employment below 8 workers are also dropped (0.1%) because they do not meet the current accounting standards.

This paper focuses on manufacturing industries in Eastern China: Beijing, Tianjin, Shanghai Cities, and Hebei, Shandong, Jiangsu, Zhejiang, Guangdong, Fujian Provinces[6]. Eastern China contributes at least half of GDP in China over the period from 2004 to 2007. The cities of Eastern China have some similar characteristics, for instance, they are located near eastern coastal regions and are more economically developed than the other regions in China. In addition, SEZ programs launched in Eastern China, and more than 30% of SEZs have been implemented in Eastern China until 2006. For these reasons, Eastern China is ideal to analyze the effects of SEZs on the local economy.

To investigate intra- and inter-regional spillovers from SEZs, we define *region* as a county in this paper. All variables are aggregated at the county-level by using firm-level data information. In particular, we calculate regional productivity (y_{it}) in two steps. We estimate total factor productivity (TFP) of the firms outside zones, and then compute regional productivity by averaging these firms' TFP in region *i* at year *t*[7]. We construct regional productivity as a function of three parts of explanatory variables. First, we assume that the presence of SEZs (sez_{it}) depends on the size of the economy in SEZs which is measured by aggregating the value-added of firms located in SEZs in a county *i* at year *t*[8]. Second, we employ a couple of variables as production factors describing regional productivity function: density of labor per square kilometer (emp_{it}) and capital stock per capita (cap_{it}) of the firms outside zones. Third, we consider spillovers of foreign firms

[6]Based on a notice released by the National Bureau of Statistics of China in 2011, China can be economically divided into four regions: Eastern, Central, Western and Northeastern. In this paper, Hong Kong and Macau are not included in Eastern China for the reason that they are special administrative regions, many characteristics of them are not comparable with Eastern China. Hainan Province is also not included, because it is an island geographically separated by the Qiongzhou Strait.

[7]See Brandt et al (2012).

[8]Instead of using the share of firms in SEZs relative to all firms in a county, it is believed that the present measure is more appropriate to capture the magnitude of spillovers from SEZs.

(fdi_{it}) and state-owned firms (soe_{it}). The former one is defined as the share of employment of foreign-affiliated firms relative to all the firms outside zones of a county. The latter one is defined as the share of the industrial output of state-owned firms relative to all the firms outside zones of a county.

Note that not all counties are implementing SEZ policy in China. In order to evaluate intra- and inter-regional spillover effects of SEZs on the local economy, we consider only counties that have had SEZs over the period 2004-2007. It turns out that above 40% of the counties have been operating SEZs programs in the sample period. The descriptive statistics for the variables are reported in Table 1.

[Insert Table 1 here]

4.2 Spatial Data Analysis

Spatial autocorrelation accounts for the coincidence of value similarity with locational similarity (Anselin, 2001). Positive spatial autocorrelation indicates that high (or low) values tend to cluster together in space, and negative spatial autocorrelation implies that high (or low) values are surrounded by low (or high) values. If high or low values are randomly distributed, then no spatial autocorrelations exist. To illustrate the degree of spatial autocorrelation, we calculate global Moran's I statistic and draw Moran scatter plot on regional productivity. As a standard measure for spatial autocorrelation, global Moran's I is defined as follows,

$$I_t = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(y_{it} - \mu_t)(y_{jt} - \mu_t)}{\sum_{i=1}^{n} (y_{it} - \mu_t)^2} \tag{1}$$

y_{it} denotes the variable of interest (regional productivity) for county i at year t; μ_t is the mean of the variable x at year t; n is the number of counties; w_{ij} is an element of spatial weight matrix between i and j; S_0 is the sum of all the weights w_{ij}. Alternatively, w_{ij} can be denoted as an element of row-standardized weight matrix, and then S_0 equals the number of observations. The equation (1) can be simplified as the following,

$$I_t = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(y_{it} - \mu_t)(y_{jt} - \mu_t)}{\sum_{i=1}^{n} (y_{it} - \mu_t)^2}. \tag{2}$$

The Moran scatter plot, first outlined in Anselin (1996), illustrates the relations between the spatially lagged variable on the vertical axis and the original variable on the horizontal axis. There are four quadrants divided by dashed lines that respect the relations of a county and its neighbors.

Figure 1 reports global Moran's I statistic and Moran scatter plot for regional productivity of each year. Moran's I is positive and gradually increase over the period from 2004 to 2007. It indicates that there is a positive spatial correlation on regional productivity allows for further analysis relying on spatial regression models. The presence of positive spatial autocorrelation is also confirmed by quadrants of the Moran scatter plot that upper right and lower left have a large number of observations.

[Insert Figure 1 here]

Counties that have high productivity tend to cluster together and counties with low productivity are tend to surround by counties with low. To assess the situation about spatial clustering, we calculate the local Getis-Ord (local G) statistic which is defined as below,

$$G_{it} = \frac{\sum_{j \neq i}^{n} w_{ij} y_{jt}}{\sum_{j \neq i}^{n} y_{jt}}. \tag{3}$$

The local G statistic is a share of the weighted average of observations in neighbor counties relative to the sum of all observations. It indicates that a value larger than the mean is a High-High cluster, a value smaller than the mean denotes a Low-Low cluster[9]. Figure 2(b) depicts the magnitude of local G distributed for the SEZ-hosting counties in the base map, which makes clusters of counties clear[10]. From Figure 2(b) we can see that counties in the close distance have higher similarity in regional productivity. In particular, we find that the clustering of the counties with above-average regional productivity where

[9]Since the randomization hypothesis of the exact distribution of the global Moran's I or the local G statistic is unknown, we use random permutation approach proposed by Anselin (1995) to test the significance. The randomization test was performed using 9,999 permutations and we obtained pseudo significance levels from the 2.5% and 97.5% quantile points of this simulated distribution.

[10]China's county-level GIS map is obtained from GADM database of global administrative areas. http://www.gadm.org (version: 3.6).

their neighboring counties also have above-average levels. Similarly, counties with below-average regional productivity are surrounded by counties with below-average levels.

[Insert Figure 2 here]

5 Model Specification

Many studies on the impacts of SEZs employ quasi-experimental approaches to make clear that SEZ programs do work and have heterogeneous characteristics in China. Although substantial empirical results relate to the impacts of SEZs can be known from previous studies, they focus on the impacts to the firms located within SEZs or to its own hosting region. In this paper, we evaluate the effects of SEZs not only from intra- but also from inter-regional dimensions. Instead of using quasi-experimental approaches such as difference-in-difference methods, we introduce spatial dependence to analyze the impacts of SEZs from their neighbor counties as well as from their own counties.

There are two advantages to employ spatial regressions. First, spatial regressions can take into account spatial lag of dependent variable and independent variables to describe the outcome of interest. The introduction of spatial dependence allows observations to have associations with each other and to explore the relationship between a county and the neighboring counties. However, neglecting spatial dependence would lead to biased estimation results due to omitted problems. Second, spatial regression captures spillover effects through three channels. An increase in SEZs will affect the SEZ-hosting county itself (direct effect) and possibly affect the neighboring counties (indirect effect). Furthermore, spatial regression exploits impact passing through the neighboring counties and back to the counties themselves (feedback effect). The inclusion of spatial information makes it possible to assess the impact of SEZ policy more comprehensively through multiple channels.

In the context of the SEZ program, mutual interactions between the observations in close proximity may happen. For example, a positive shock on productivity in a county could also be transferred to nearby counties through interactions of individuals; a technological growth in a given SEZ can benefit nearby counties through horizontal and vertical spillovers. Hence, spatial dependence should be considered when studying mutual interactions with neighboring counties on regional productivity. Furthermore, externalities arising from neighbor characteristics could also play a role in determining the dependent variable. Taking into account spatial dependence, we estimate the spillover effects of SEZs on the local economy via a Spatial Durbin Model (SDM) as follows,

$$y_{it} = \beta sez_{it} + \boldsymbol{Z}_{it}\boldsymbol{\lambda} + \delta \sum_{j=1}^{N} w_{ij} y_{jt} + \gamma \sum_{j=1}^{N} w_{ij} sez_{jt} + \sum_{j=1}^{N} w_{ij} \boldsymbol{Z}_{jt}\boldsymbol{\theta} + \alpha_i + \alpha_t + \varepsilon_{it} \quad (4)$$

where y_{it} denotes regional productivity of the firms outside zones for county i and year t; sez_{it} is the presence of firms in SEZs for county i and year t; $\boldsymbol{Z}_{it}$ contains a set of variables which could describe regional productivity; w_{ij} is row normalized inverse distance within 150 kilometer, otherwise zero; ε_{it} is the error term, normally distributed by (0, σ^2). County and year fixed effects are included to control for unobserved heterogeneity.

The estimated coefficient β describes the spillover effects from SEZs to the local economy on productivity. If β is significantly positive, which means that a 1% increase in the presence of SEZs stimulates regional productivity for the firms outside zones. Moreover, If the spatially lagged coefficient δ is statistically significant, it implies that a spatial autocorrelation exists and employing spatially lagged dependent variable is meaningful. Furthermore, if the coefficient γ is significantly positive, it implies that the presence of SEZs in a county is similar to the ones in neighboring counties at close distance.

With respect to the selection of models, we compare SDM models with other spatial regression models. As noted by LeSage and Pace (2009), SDM models nest most of the other specifications like Spatial Error Model (SEM) and Spatial Autoregressive Model (SAR). Hence, we estimate the SDM models and then compare them with SEM or SAR models by the Likelihood Ratio (LR) test. The estimation results obtained from these models can be used to test the hypothesis:

$$H_0 : \gamma = 0,\ \boldsymbol{\theta} = \boldsymbol{0},$$

$$H_0 : \gamma + \delta\beta = 0,\ \boldsymbol{\theta} + \delta\boldsymbol{\lambda} = \boldsymbol{0}.$$

The former hypothesis examines whether the SDM model can be simplified to forms of the SAR model. If the null hypothesis is rejected, it demonstrates that the SDM model better describes the data. The other hypothesis is used to examine between SDM and SEM model. If the null hypothesis is rejected, it means that the SDM model cannot be simplified to the SEM model. Since the SDM model is a generated form nesting the other two models, it is better favored than the two models in the case that either of the two hypotheses is rejected.

As suggested by LeSage and Pace (2009), we measure average direct and indirect effects to explain the marginal effects of the explanatory variable. Average direct effect, measured by taking an average of the own derivatives for the counties themselves, which captures the effects of SEZs to its own county. The average indirect effect is calculated by the average of derivatives with respect to neighboring counties, which measures the spillovers of SEZs to neighboring counties. In OLS regressions, the partial derivative of the dependent variable with respect to the explanatory variable equals the estimated coefficient. However, it is no longer the case in spatial regressions like SDM or SAR model because information from neighboring counties should also be included. To illustrate, we take the partial derivative of the dependent variable with respect to the presence of SEZs as follows,

$$\frac{\partial \boldsymbol{y}}{\partial \boldsymbol{sez}} = \boldsymbol{S_r}(\boldsymbol{W}) = (\boldsymbol{I_{NT}} - (\boldsymbol{I_T} \otimes \boldsymbol{W})\delta)^{-1} + (\boldsymbol{I_{NT}}\beta + (\boldsymbol{I_T} \otimes \boldsymbol{W})\gamma) \tag{5}$$

where $\boldsymbol{W}$ is $N \times N$ spatial weight matrix; $\boldsymbol{I_T}$ and $\boldsymbol{I_{NT}}$ are $T \times T$ and $NT \times NT$ idempotent matrices, respectively. From the equation (5), the partial derivative is not only depend on β, but also γ, δ and spatial weight matrix. By definition, average indirect effect is calculated by the average of diagonal elements of $\boldsymbol{S_r}(\boldsymbol{W})$ and average indirect effect is measured by the average of off-diagonal elements of $\boldsymbol{S_r}(\boldsymbol{W})$.

From the above equation, we can capture spillover effects through three channels. An increase in SEZs will affect the SEZ-hosting county itself (direct effect) and arouse spillovers passing through neighboring counties and back to the counties themselves (feedback effect). Furthermore, an increase in SEZs of county i affects the neighboring counties (indirect effect). Specifically, the indirect effect can also be interpreted from a different viewpoint: *impact to an observation*, which measures how changes in all neighboring counties influence a single county i[11]. In this paper, we consider the indirect effect by the viewpoint of *impact to an observation* to interpret estimation results.

6 Empirical results

6.1 Main results

[Insert Table 2 here]

The empirical results estimated by using the SDM model are shown in Table 2. In particular, the estimate β in (1) and (3) is significantly positive, respectively. In the third column, the estimate β amounts to 0.0507, which implies that a 1% increase in the presence of SEZs leads to a 0.0507% improvement in regional productivity for non-SEZ firms. In addition, the estimate δ from (1) to (3) is also statistically significant, which suggests the regional productivity in a county is explained by the ones in the neighboring counties. Furthermore, the estimate γ is significantly positive in (1) and (3), which implies that the presence of SEZs is similar to the one in the neighbor counties.

With respect to the comparison with other spatial regression models are proceeded by likelihood ratio tests. As presented in Table 2, the first hypothesis whether the SDM model can be simplified to the SAR model should be rejected at the 1% significance level; the second hypothesis whether the SDM model can be replaced by the SEM model also should be rejected. Thus, we conclude that the SDM model best describes the data. Moreover, introducing both individual and time-period fixed effects to the model is plausible, as the results indicate that the model with both individual and time-period effects in favor of the one with individual or time-period fixed effect respectively. Specifically, the hypothesis that the individual effects are jointly insignificant is rejected (1734.54, with 274 degrees of freedom, $p<0.01$), and the hypothesis that the time-period effects are jointly insignificant is rejected (12.02, with 4 degrees of freedom, $p<0.05$) by performing likelihood ratio tests. Thus, the remains of this paper employ the SDM model with individual and time-period fixed effects to calculate average direct, indirect effects and robustness checks.

[11] See LeSage and Pace (2009).

[Insert Table 3 here]

As noted above, one cannot interpret the estimate β or δ as a partial derivative or a relation with neighbors in the SDM model, one should present the estimates of direct, indirect, and total effects. In Table 3, we report direct, indirect, and total effects of the SDM model based on equation (5). In particular, the direct effect of the presence of SEZs on regional productivity is positive and similar to the estimate β. The feedback loops calculated by the difference between them are insignificantly different from zero, so that feedback loops can be neglected. The indirect effect from nearby counties is 0.3470, much more than the magnitude of the direct effect, suggesting that an increase in neighboring SEZs has a higher spillover effect relative to the hosting county itself. Consequently, the total effect indicates that a 10% increase in the presence of SEZs leads to a 4% increase in regional productivity for the firms outside zones. In other words, about 1/6 of this impact comes from the direct effect, and 5/6 from the indirect effect. It is not surprising because the indirect effects are cumulative impacts from all other neighboring counties and each non-SEZ is surrounded by several SEZs so that aggregating the indirect effects from the neighborhood would lead to a larger magnitude than the direct effect itself.

We divide two parts to explain the estimated results. Both of them beyond the scope of this paper should be carefully examined further. First, a possible explanation for spillovers from the hosting counties is that non-SEZ firms may benefit from SEZs by business linkages. Unlike a few multinational firms which have little connection with the local economy, the firms in SEZs establish strong linkages with the local firms (Zeng, 2017). These linkages promote local economic development and enhance the productivity of non-SEZ firms because they are backed by the firms in SEZs which generally have higher technology than themselves. Moreover, non-SEZ firms are surrounded by several SEZs which have their own competitive advantages and not doing repetitive production with SEZs in their neighboring counties in general.

6.2 Robustness Checks

In this section, we check the robustness of the results based on three approaches: alternative samples of the data, alternative spatial weight matrices, and alternative explanatory variables.

[Insert Table 4 here]

First, we consider the data which exclude first-tier and second-tier cities from the sample. First-tier and second-tier cities are the most developed, densely populated urban metropolises that have huge economic, cultural and political influence in China[12]. We drop them one by one from the sample to check whether our results are affected much by excluding a particular city. In Table 4 we present the partial derivative with respect to the variable sez as in equation (5). We find that the estimation results excluding first-tier and second-tier cities are similar to the result we obtain from Table 3.

[Insert Table 5 here]

Second, we examine the sensitivity of our estimates by alternative spatial weight matrices. Table 5 presents the derivative with respect to the variable sez by using alternative weight matrices. We employ another two weight matrices that based on a cut-off distance of 200 kilometers or 250 kilometers respectively to compare with the main results in Table 3 which used a cut-off distance of 150 kilometers. As shown in Table 5, the estimates of direct effect are not affected by different weight matrices. The indirect effect estimates are a little bigger but relatively constant with the cut-off distance of 150 kilometers.

[Insert Table 6 here]

Third, instead of employing value-added as the presence of SEZs, we use industrial output and revenue of SEZs as alternative explanatory variables respectively. As presented in Table 6, we find that the estimates remain virtually unchanged relative to the ones in Table 3 using value-added as an explanatory variable.

[12]First-tier and second-tier are hierarchical classifications of Chinese cities. Cities in different tiers reflect differences in income level, population size, and business opportunity.

7 Conclusion

This paper evaluates the spillover effects of SEZs in Eastern China by considering geographical proximity. Using a panel data set over the period from 2004 to 2007, this paper quantifies the spillover effects on regional productivity for the firms outside zones. In contrast to previous studies that focus on intra-regional analysis, this paper considers inter- as well as intra-regional spillovers that arise from the presence of SEZs. The main result finds that SEZs have significantly positive effects on regional productivity for non-SEZ firms in the sample period. In addition, the spillover effects are not only limited to own counties but also neighboring counties. Indeed, SEZs in neighboring counties contribute much more to regional productivity relative to those in the hosting county itself.

This paper contributes to the debate that whether implementing SEZs has positive effects on the local economy. Most firms that enter SEZs are engaged in new productive activities rather than simply reallocating capital and labor from elsewhere. These firms bring vitality to the local economy through diffusing advanced technology and establishing strong business connections with local firms. Also, it is interesting to find that the effects of SEZs are not confined to the hosting county, instead, SEZs in neighboring counties benefit local firms much more than those in the hosting county. To understand the effects of SEZs on the local economy, it is also necessary to consider spatial dependence to evaluate the spillovers.

Although this paper sheds light on the spillover effects of SEZs on the local economy, we recognize there are limitations in this paper. For instance, we pool the sample data across industries to draw a global inference rather than attempt to examine each specific industry though there may be heterogeneous results for a specific industry. In addition, we only focus on the counties which have implemented place-based policies over the sample period, due to our model we employ limits our analysis to cover all the counties. Another limitation is that our model only focuses on spillover effects in a short period, does not consider dynamic influences over time. We leave the remaining issues for further research to evaluate whether the conclusion still holds.

References

Alder, S., Shao, L., Zilibotti, F. 2016. “Economic Reforms and Industrial Policy in a Panel of Chinese Cities,” *Journal of Economic Growth*, 21(4), 305-349.

Alkon, M. 2018. “Do Special Economic Zones Induce Developmental Spillovers?,” Evidence from India’s States. *World Development*, 107, 396-409.

Anselin, L. 1988. *Spatial Econometrics, Methods and Models*. Boston, U.S.: Kluwer Academic.

Anselin, L. 1996. “The Moran Scatterplot as an ESDA Tool to Assess Local Instability in Spatial Association,” *Spatial analytical*, 4, 121.

Anselin, L. 2001. “Spatial econometrics,” *A companion to theoretical econometrics*, 310-330.

Brandt, L., Van Biesebroeck, J., Zhang, Y. 2012. “Creative Accounting or Creative Destruction? Firm-level Productivity Growth in Chinese Manufacturing,” *Journal of Development Economics*, 97(2), 339-351.

Busso, M., Gregory, J., Kline, P. 2013. “Assessing the Incidence and Efficiency of a Prominent Place Based Policy,” *American Economic Review*, 103(2), 897-947.

Ciżkowicz, P., et al. 2017. “The Effects of Special Economic Zones on Employment and Investment: A Spatial Panel Modeling Perspective,” *Journal of Economic Geography*, 17(3), 571-605.

Cliff, A., Ord, J. 1973. “Spatial Autocorrelation,” London.: Pion.

Combes, P., Gobillon, L. 2015. “The Empirics of Agglomeration Economies,” In *Handbook of Regional and Urban Economics*, Vol. 5, pp. 247-348, Elsevier.

Elhorst, J. 2014. *Spatial Econometrics: from Cross-sectional Data to Spatial Panels*. Heidelberg, Germany.: Springer.

Farole, T. 2011. *Special Economic Zones in Africa: Comparing Performance and Learning from Global Experiences.* The World Bank.

Getis, A., Ord, J. 1992. “The Analysis of Spatial Association by Use of Distance Statistics,” *Geographical Analysis,* 24, 189–206.

Glaeser, E., Gottlieb, J. 2008. “The Economics of Place-Making Policies,” *Brookings Papers on Economic Activity*, 155-239.

Greenbaum, R., Engberg, J. 2004. "The Impact of State Enterprise Zones on Urban Manufacturing Establishments," *Journal of Policy Analysis and Management*, 23(2), 315-339.

Johansson, H., Nilsson, L. 1997. "Export Processing Zones as Catalysts," *World Development*, 25(12), 2115-2128.

Kline, P., Moretti, E. 2014. "People, Places, and Public Policy: Some Simple Welfare Economics of Local Economic Development Programs," *Annu. Rev. Econ.*, 6(1), 629-662.

LeSage, J., Pace, R. 2014. "The Biggest Myth in Spatial Econometrics," *Econometrics*, 2(4), 217-249.

LeSage, J., Pace, R. 2009. *Introduction to Spatial Econometrics*. Florida, U.S.: CRC Press.

Levinsohn, J., Petrin, A. 2003. "Estimating Production Functions Using Inputs to Control for Unobservables," *The Review of Economic Studies*, 70(2), 317-341.

Lu, Y., Wang, J., Zhu, L. 2019. "Place-Based Policies, Creation, and Agglomeration Economies: Evidence from China's Economic Zone Program," *American Economic Journal: Economic Policy*, 11(3), 325-60.

Moretti, E. 2010. "Local Labor Markets," *Handbook of Labor Economics*, vol. 4B. Elsevier, Amsterdam.

Neumark, D., Simpson, H. 2015. "Place-based Policies," *Handbook of Regional and Urban Economics*, 5, 1197-1287.

Rosenthal, S., Strange, W. 2003. "Geography, Industrial Organization, and Agglomeration," *Review of Economics and Statistics*, 85(2), 377-393.

Wang, J. 2013. "The Economic Impact of Special Economic Zones: Evidence from Chinese Municipalities," *Journal of Development Economics*, 101, 133-147.

World Bank. 2009."Clusters for Competitiveness: A Practical Guide and Policy Implications for Developing Cluster Initiatives." International Trade Department, PREM Network, Report, Washington, DC.

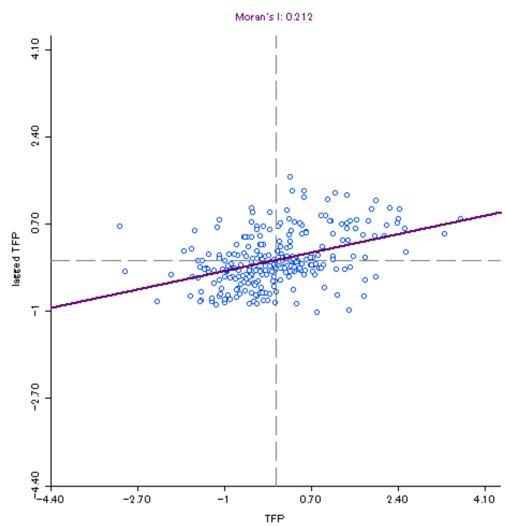
Zeng, D. 2011. *How Do Special Economic Zones and Industrial Clusters Drive China's Rapid Development?* The World Bank.

Zeng, D. 2016. "Special Economic Zones: Lessons from the Global Experience," *PEDL*

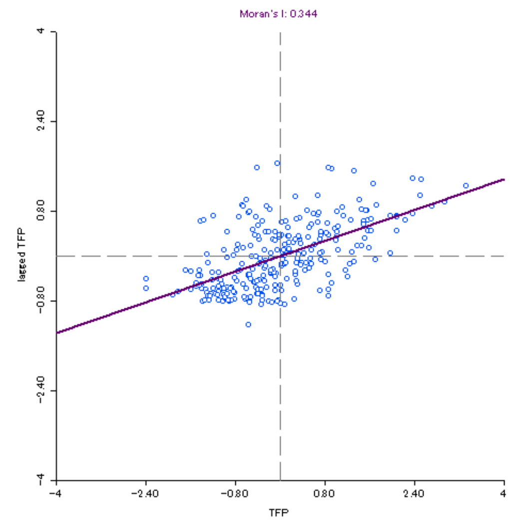
Synthesis Paper Series, 1, 1-9.

Zheng, S., et al. 2017. “The Birth of Edge Cities in China: Measuring the Effects of Industrial Parks Policy,” *Journal of Urban Economics*, 100, 80-103.

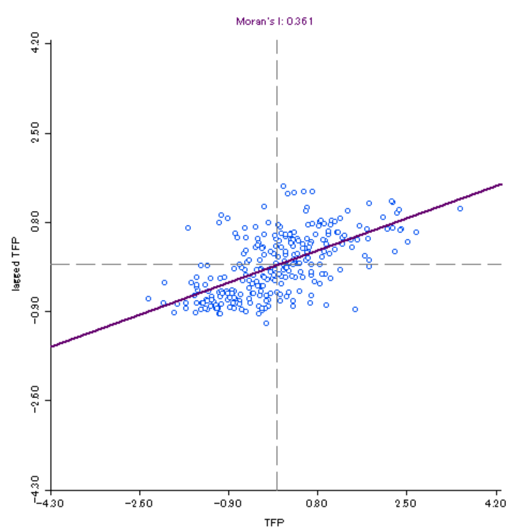
Figure 1: Moran Scatter Plot of Regional Productivity (TFP) over the period 2004-2007



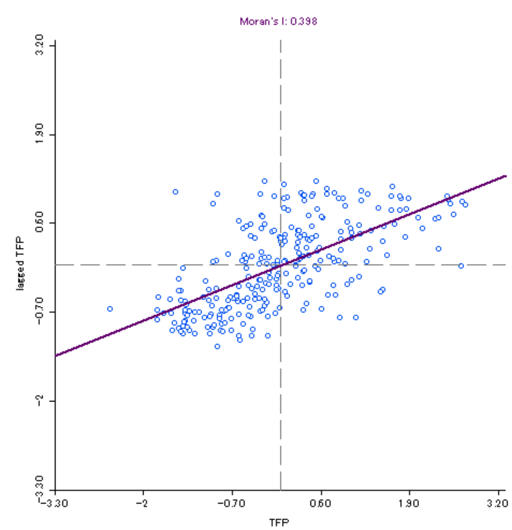
(a) TFP for non-SEZ firms in 2004



(b) TFP for non-SEZ firms in 2005

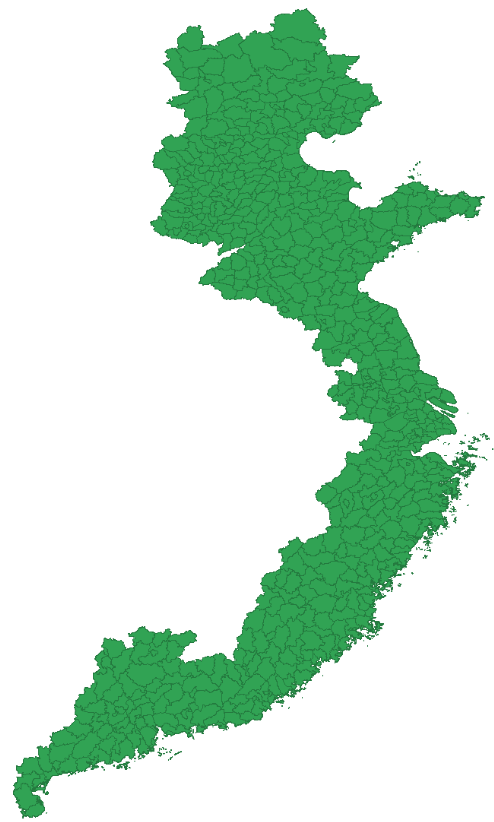


(c) TFP for non-SEZ firms in 2006

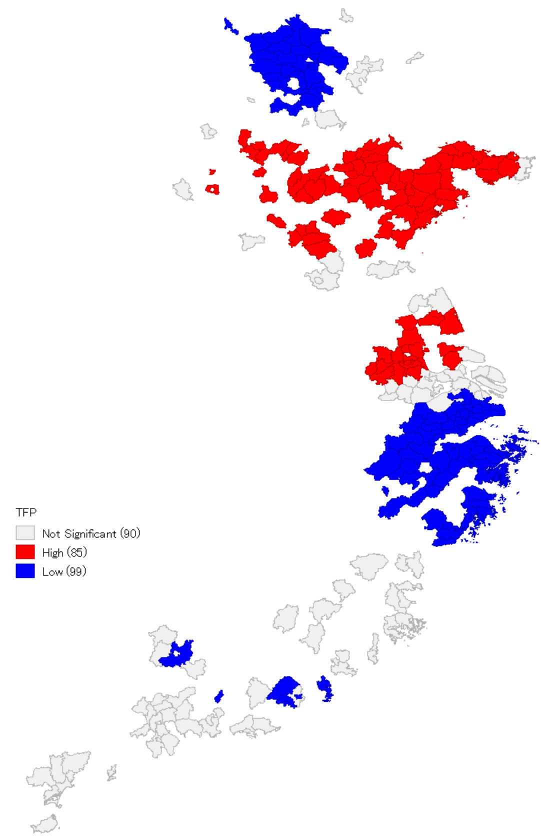


(d) TFP for non-SEZ firms in 2007

Figure 2: Map of Eastern China



(a) all counties in Eastern China



(b) Local G_i Cluster Map of Eastern China in 2007 for the counties which have had SEZs over the sample period

Table 1. Descriptive Statistics

Variable	Mean	Std.Dev	Min	Max	Obs
y (in logs)	5.6158	0.4080	4.4770	7.1418	1,096
sez (in logs)	13.3603	1.3483	7.5652	16.3967	1,096
emp (in logs)	3.4963	1.4679	-2.7914	6.7051	1,096
cap (in logs)	4.5145	0.4804	2.6194	6.0368	1,096
fdi (fraction)	0.1248	0.1105	0	0.6451	1,096
soe (fraction)	0.0641	0.0998	0	0.6932	1,096

Table 2. Main Estimation Results

	SDM		
	(1)	(2)	(3)
sez	0.0482	0.0134	0.0507
	(4.2842)	(1.5378)	(4.4681)
emp	0.0883	0.0230	0.0710
	(2.9483)	(2.6178)	(2.3212)
cap	-0.0660	0.1276	-0.0818
	(-2.0952)	(5.2171)	(-2.5469)
fdi	-0.1647	-0.3498	-0.2059
	(-1.3411)	(-3.2602)	(-1.6739)
soe	-0.1694	-0.5814	-0.1282
	(-1.5280)	(-5.2964)	(-1.1486)
W*sez	0.1609	0.0363	0.1906
	(5.2193)	(1.1795)	(5.4617)
W*emp	0.0108	-0.0426	-0.1101
	(0.1509)	(-2.1716)	(-1.3236)
W*cap	0.0698	-0.1316	-0.0309
	(0.9216)	(-2.6451)	(-0.3332)
W*fdi	-0.0719	0.5054	-0.5202
	(-0.2333)	(2.3726)	(-1.5546)
W*soe	0.1456	0.9089	0.6035
	(0.5438)	(2.9992)	(1.9900)
W*y	0.4609	0.7269	0.4079
	(9.5086)	(23.8487)	(7.8507)
Individual effect	Yes	No	Yes
Time-period effect	No	Yes	Yes
Number of observations	1,096	1,096	1,096
R-squared	0.8797	0.4437	0.8804
Log-likelihood	575.37	-290.39	581.38
Prob. of spatial lag (SAR vs SDM)	0.00	0.00	0.00
Prob. of spatial error (SEM vs SDM)	0.00	0.00	0.00

Note: t-statistics are reported in parentheses.

Table 3. Average Direct, Indirect, and Total Effects Estimates

	Direct	Indirect	Total
	(1)	(2)	(3)
sez	0.0606	0.3470	0.4076
	(5.3423)	(6.1864)	(6.9011)
emp	0.0679	-0.1238	-0.0559
	(2.2040)	(-0.9160)	(-0.3855)
cap	-0.0835	-0.0967	-0.1802
	(-2.6363)	(-0.6440)	(-1.1289)
fdi	-0.2305	-0.9880	-1.2185
	(-1.8729)	(-1.8230)	(-2.1559)
soe	-0.1046	0.8747	0.7701
	(-0.9330)	(1.8094)	(1.4883)

Note: t-statistics are reported in parentheses.

Table 4. Robustness checks with alternative sample data
the partial derivative with respect to sez

	Direct	Indirect	Total
	(1)	(2)	(3)
Beijing	0.0530	0.2800	0.3330
	(4.4658)	(5.1659)	(5.7641)
Shanghai	0.0597	0.3429	0.4026
	(5.1211)	(5.9230)	(6.5632)
Guangzhou	0.0615	0.3594	0.4210
	(5.5044)	(6.0359)	(6.6668)
Hangzhou	0.0594	0.3541	0.4136
	(5.1521)	(6.2541)	(6.9445)
Nanjing	0.0576	0.3381	0.3957
	(4.9785)	(6.5212)	(7.1723)
Tianjin	0.0687	0.3415	0.4103
	(5.8758)	(6.7759)	(7.6503)
Suzhou	0.0627	0.3510	0.4137
	(5.2672)	(6.0928)	(6.7469)
Dongwan	0.0600	0.3534	0.4135
	(5.1300)	(6.3599)	(7.0025)
Ningbo	0.0610	0.3397	0.4007
	(5.1694)	(6.0144)	(6.7674)

Note: t-statistics are reported in parentheses.

Table 5. Robustness checks with alternative spatial weight matrix
the partial derivative with respect to sez

	Direct	Indirect	Total
	(1)	(2)	(3)
150 kilometer	0.0606	0.3470	0.4076
	(5.3423)	(6.1864)	(6.9011)
200 kilometer	0.0586	0.4156	0.4742
	(5.0635)	(5.3032)	(5.8454)
250 kilometer	0.0600	0.5264	0.5865
	(5.1379)	(5.4261)	(5.8456)

Note: t-statistics are reported in parentheses.

Table 6. Robustness checks with alternative explanatory variables
the partial derivative with respect to sez

	Direct	Indirect	Total
	(1)	(2)	(3)
Value added	0.0606	0.3470	0.4076
	(5.3423)	(6.1864)	(6.9011)
Industrial output	0.0366	0.3474	0.3841
	(2.8530)	(5.0108)	(5.1944)
Revenue	0.0242	0.3683	0.3925
	(1.9367)	(5.4235)	(5.4755)

Note: t-statistics are reported in parentheses.