Applying Spatial Durbin Panel Model on US Exports to Improve the Trade Deficit

Yi-Cheng Liu*

Department of International Business, Tamkang University

151 Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan, R.O.C.

E-mail: 122478@mail.tku.edu.tw

Wen Yang

Department of Statistics, Tamkang University

151 Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan, R.O.C.

E-mail: 071972@mail.tku.edu.tw

Corresponding Author: Yi-cheng Liu

Department of International Business, Tamkang University

151 Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan, R.O.C.

* E-mail: 122478@mail.tku.edu.tw

Applying Spatial Durbin Panel Model on US Exports to Improve the Trade Deficit

Wen Yang[1], *Yi-Cheng Liu*[2] *and Chao-Cheng Mai*[3]

Abstract

This paper aims to explain the US exports behavior, and empirical results provide valuable insights for improving persistent US trade-deficit issues. The main US export destinations are West-European countries of the European Union and Japan. The determinants of the US exports were highly related to countries with outward-foreign-direct investment from the US corporations and were highly open for international trade. Also, these countries tended to have a higher GDP *per capita* and have regional-economic-integration agreements according to evidences of the Spatial Durbin Panel Model. We suggest that the US increases exports to different regions and hence, improve US trade deficits.

JEL Codes: C33, C51, F18, P45, R12.
Keywords: Spatial Durbin Panel Model, US exports, US trade deficit, Exports Determinants, Spatial Patterns.

[1] Department of Statistics, Tamkang University 151 Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan, R.O.C., E-mail: 071972@mail.tku.edu.tw
2 Department of International Business, Tamkang University 151 Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan, R.O.C., E-mail: 122478@mail.tku.edu.tw
3 Department of Industrial Economics, Tamkang University and Research Center for Humanities and Social Sciences, Academia Sinica
Corresponding Author: Chao-Cheng Mai, Research Center for Humanities and Social Sciences, Academia Sinica, 128 Sec. 2, Academia Rd., Nankang, Taipei 11529, Taiwan, R.O.C.
Tel: 886-2-2782-1693 ext 130, Fax:886-2-2785-4160, E-mail: ccmai@gate.sinica.edu.tw

1. Introduction

The US exports ranked the second largest next to China's exports in terms of the total volume in the world for years. Meanwhile, it has accumulated massive trade deficits for decades. In light of the case of China, China continuously accumulates trade surpluses, its geospatial distribution has also been diversified distinctively since the beginning of the 1990s to the 2010s (Chou *et al.* 2009). This motivates us to investigate how the US export destinations have evolved and what determinants impacted its export destinations from the spatial econometric perspective.

Prior literature (Krugman *et al.* 1987 and Morrison 2011, etc) mostly focused on the trade deficit of the US, because it generates great concern and attention due to its magnitude. Some researched *issues* on imports of the US such as: Trefler 1993 and Piece and Schott 2016.

There was also research on the US exports respectively. This research included the US exports on certain products such as agricultural goods (Konandreas *et al.* 1978 and Bernard *et al.* 1997). Some studied the US exports evolution and competitiveness (Bernard and Jensen 2004a, Bernard and Jensen 2004b, Harrigan *et al.* 2015). They found that the manufactured goods of the US exports started declining in the 1960s and 1970s (Bowen and Pelzman 1984). The US exports from highly productive and skill-intensive firms charged higher prices. Its exports charged substantially higher prices to markets other than Canada and Mexico (Bernard and Jensen 2004a).

Though prior literature studied and analyzed how and why the US exports evolved over the past decades and its huge trade deficits accumulated so far. There is a lack of literature specifically applying the spatial econometric method to investigate these issues. Thus, the goal of this study is to scrutinize the geospatial distribution of the US exports and what decisive factors influence its exports destinations, which is one of the major attributes to its enormous deficits without improvement.

The paper is organized as follows. The importance of the spatial econometrics in studying international trade is illustrated in the second section. The third section explains variables and conducts spatial econometric models configuration. Empirical findings are presented and analyzed in the fourth section. The fifth section concludes this paper.

2. The Importance of using Spatial Models

Theoretical and measurement issues underlying export performances and development were evaluated and examined systematically in previous studies. In this paper, attention is paid to major exporting considerations contingent to spatial patterns, thus providing a rationale for investigating and explaining exports behavior of the US.

Spatial effects indicate that spatial dependence exists (caused by various degrees of spatial aggregation, spatial externalities, and spillover effects and spatial structure or heteroskedasticity (resulting from "heterogeneity inherent from the presence of spatial units and from the contextual variation over space") in the panel data utilized (Anselin 1988). The well-known first law of geography by Tobler (1970) proposed that "everything is related to everything else, but near things are more related than distant things." This law suggests that impacts become more significant if the distance between one region and the other region is closer. It advances to a turn in the empirical foundations of the policy decisions connected to international trade. Both Porojan (2001) and Flowerdew (1982) regarded that the obtained estimates which allow for the spatial autocorrelation and heterogeneity remain affected by the bias introduced via the logarithmic scale. That is to say; the conventional econometric model can no longer suffice in dealing with spatial dependence and spatial heterogeneity. On the other hand, spatial econometric techniques can eliminate the bias when spatial effects are neglected. Therefore, it is appropriate and necessary to apply the spatial methodology if the panel data is characterized with spatial effect.

Spatial econometrics enables testing for multiple sources of misspecification in spatial models and spatial dependence when other forms of misspecification occurs (Anselin, 1998). Thus, it can deal with the multidirectional nature of spatial dependence that often precludes the use of OLS.

3. Model Specification

3.1 Data and Variable Definitions

We reviewed previous papers and chose factors which are identified influencing export growth and geographic distribution of various economies from papers below.

The relationship between exports and GDP *per capita* of the trading partner was examined in early literature such as Schott, P. (2010). The empirical findings of Eichengreen *et al.* (2004) showed that GDP *per capita* of the importing country has a positive relationship with exports of the exporting country. Thus, we use GDP *per capita* instead of GDP as one of the explanatory variables.

In addition, following Head and Mayer (2014) and Thorbecke (2015), trade agreements (i.e. economic integration: *EI*) were selected to be one of the explanatory variables. On the other hand, Moser *et al.* (2008) and Morrow *et al.* (1998) interpreted the importance of political factors to the exports by employing gravity model.

The variable: Market Opportunity (*MO*) is measured by the ratio of host country j's GDP *per capita* to the US's GDP *per capita*. It represents the high- or low-income client markets to the US export activities. Thus, it is widely used as a gauge or signal of access to client markets (Eaton and Tamura 1994, Cheung and Qian 2009).

The variable: Openness (*OPEN*) represents the host country's openness to international trade. It is calculated by the country's total volume of international trade divided by its GDP (Wu *et al.* 2007). Openness to trade denotes to the degree of openness of international trade in the home country with the other countries in the world. This higher the value, the more open of the country economy and the greater the ease of entering the world market. The variable, Openness, has a positive effect on international trade development (Krueger 1974, and Rene and Mollick 2012).

Furthermore, Egger (2001) investigated the relationship between exports and outward foreign investment (*OFDI*) with the application of the gravity-model.

Overall, we chose six explanatory variables: the GDP *per capita*, the Market Opportunity, the Openness to International Trade, outward foreign direct investment from the US corporations to its export-partner nations (*OFDI*), the degree of the economic integration (free trade agreement), the political risk of the 30 largest exports partner countries of the US, and the outward foreign direct investment from the US to its 30 largest exports partner countries.[4]

In this paper, we adopted the spatial econometric models of Elhorst (2012) and in particular, Chou *et al.* (2015). Their models have been modified in a minor way to conform to the objectives of the present research.

A panel dataset was constructed for the estimation of the spatial econometric models by utilizing the above variables. Data for *GDPPC* and *EXPORT* were downloaded from the Datastream (the electronic data bank). The related data were downloaded from the World Bank website in calculating and compiling the data for Market Opportunity and Openness. The *OFDI* data is provided by the Organization for Economic Cooperation and Development (OECD) website. The *KOF* uses the *KOF* Index produced by the Swiss Federal Institute of Technology. It is the riskiest if *KOF*=1, and it is the least risky if *KOF*=100. *EXPORT* is the dependent variable and is the value of the US merchandise exports to a partner country. *EI*[5] represents the degree of bilateral economic integration between the US and its export partner country *j* in year *t*.

---

[4] Two reasons for selecting 30 largest destination countries of US exports: firstly, studying geographical distribution of US exports, we followed the Chou *et al.* (2015) and Thorbecke (2015) which selected the largest export partner countries of the country concerned. Secondly, the proportion of US exports to the 30 largest US export partner countries is 95.7%. Thus, it is logical that we focus on the 30 largest destination countries of US exports.

[5] With regards to the variables *EI*, it is presented as "1" to "4", with "1" representing that both countries did not participate in any economic agreements. A"2" signifies that both countries have joined in economic organizations or agreements like the World Trade Organization (WTO) or other regional trade agreement (RTA) or preferential trade arrangement (PTA). A "3" signifies that both countries have initiated or entered into negotiating procedure over an FTA. A "4" represents that both countries have signed the FTA. This variable is employed as the proxy to evaluate the degree of bilateral economic integration between the US and its export partner countries. The data source is from the WTO website which listed all member countries and countries with RTA or PTA.

3.2 Spatial Durbin Panel Model

When the performance of one area would affect that of the other area. It's called spatial autocorrelation existing in neighboring areas. This is the so-called neighboring effects. The definition of the common indicator for Moran's I is：

$$I = \frac{n}{\sum_i \sum_j W_{ij}} \times \frac{\sum_i \sum_j W_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2} \tag{1}$$

where n is the number of observed areas, y_i denotes the observed response value (i.e. *lnEXPORT* variable in our case) at the i^{th} area, $\bar{y}$ is the general mean value of dependent variables for all the observed areas, W_{ij} depends on whether the i^{th} area and the j^{th} area are in geographical neighborhoods. It is displayed below.

$$W_{ij} = \begin{cases} 1 & , \text{ the distance between i and j is smaller than } d \\ 0 & , \text{ other} \end{cases}$$

where d is the threshold distance and is determined by coordinating the latitude and longitude. We obtain d with the average of the shortest distance between two regions.

Anselin (1995) proposed that spatial clustering exists in the neighborhood if the test result indicates a positive spatial autocorrelation. It is called the hot spot (written as "High-High") if the reaction values in neighboring areas are high. It is called the cold spot (written as "Low-Low") if both the reaction values in the areas concerned are low. It indicates that spatial outliers exist if the test results show a negative spatial autocorrelation. It is denoted as "High-Low" if the reaction value for a particular area is high while that of the nearby area is low. It is denoted as "Low-High" if an observed area has the low reaction value while that of the neighboring area is high.

I
t T
h
e
m

Spatial dependence can be found in both dependent and independent variables as well as in model residuals (Anselin 2008). In spatial modeling, there has been a surge of methods capable of handling these dependency issues individually or simultaneously. Examples include the spatial lag model incorporating a spatial lag effect of the outcome, the spatial error model assuming autocorrelated error, and Spatial Durbin Model capturing dependencies in both response and independent variables. Of particular interest to us is the Spatial Durbin Panel Model, commonly employed in the spatial literature. We present it below.

Let Y_{it} be the response observation for i^{th} location (i=1,…,n) in year t (t=1,..,T) and X_{it} the corresponding row vector of independent variables as follow.

$$X_{it} = [\ln GDPPC_{it}, MO_{it}, OPEN_{it}, KOF_{it}, EI_{it}]$$

The Spatial Durbin Panel Model considered in this study is

$$Y_{it} = \alpha + \rho \sum_{j=1}^{n} W_{ij} Y_{jt} + X_{it}\boldsymbol{\beta} + \sum_{j=1}^{n} W_{ij} X_{jt}\boldsymbol{\gamma} + \mu_i + \nu_t + \varepsilon_{it} \tag{2}$$

w
h
e
r
e

Similarly to (non-spatial) panel models, a Hausman's specification test in spatial panel context can

t
h
e

The Spatial Durbin Panel Model of equation (2) can be regarded as a unified class of several spatial econometrics models, with inclusions of the effects μ_i and ν_t. If γ = 0 model (2) reduces to a spatial lag

be used to test the random effects model against the fixed effects model (LeSage and Pace 2009, and

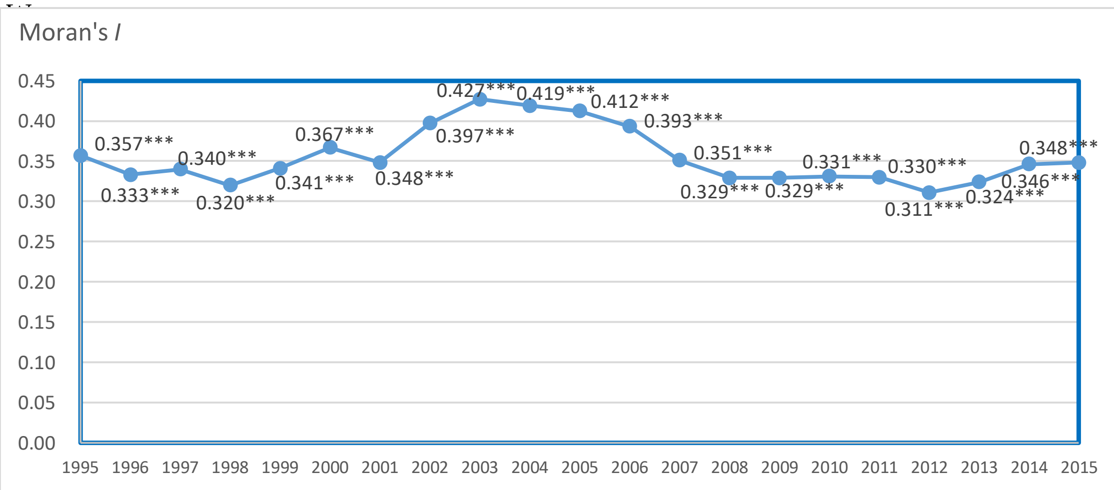
E
l
h
o
r

model (Anselin 2008), while the constraint of $\gamma+\rho\beta=0$ applies to the spatial error model (Burridge, 1981). Elhorst (2014) indicated that the Spatial Durbin Panel Model should be recommended when one believes both the spatial error model and the spatial lag model are inappropriate to describe the data. For this

4. Estimation Results

Significant spatial effects were examined and identified according to results of the Moran's *I* coefficient on exports. Average values of the Moran's *I* on US exports from 1995 to 2015 are all above 0.3 and are all statistically significant (P value<0.01) as shown in Figure 1. It indicates that the spatial correlations existed between the US exports and the US export-partner countries each year of this study. This also can be confirmed by the Moran's *I* Scatterplot which was drawn from the estimated coefficients of the Moran's *I* on export each year.

According to empirical findings of Moran's *I* (see Table 1), there is a clear tendency that the increasing proportion of the US exports to the West-European countries have been very significant during the period of this study. Germany, the UK, and their neighboring countries were consistently the most important export -partner countries each year of this study because these two countries were categorized at the High-High quadrant. It is noticeable that Japan is the only important export-partner country of the US in Asia every year throughout the period of this study. From the year 2006 onwards, Australia merged to become another important export -partner country of the US in Asia. Japan and Australia were the only two countries that appeared to be important to the US exports in Asia. The mainland China was never an important export -destination country of the US while imports from the mainland China to the US are one of the largest. Mainland China, as well as other East-Asian countries except for Japan, were not important export -partner countries of the US. This is a major cause of the US trade deficits.



Note. ***Significance at level 0.01

Figure 1. Moran's *I* for Spatial Correlation on the US Exports

Table 1. Country clusters of spatial autocorrelation (the US Exports 1995-2015)

Country	Quadrant			
	I (High-High)	II (Low-High)	III (Low-Low)	IV (High-Low)
Belgium	2004*-2015*	1995*-2003*		
France	1997*-2015*	1995*,1996*		
Germany	1995*-2015*			
Italy	2011*-2015*	1995*-2010*		

Switzerland	2007*-2015*	1995*-2006*		
UK	1995*-2015*			
India	2008-2015	1995-2003, 2004* 2005-2007		
Singapore	1996,1997 1999-2015	1995,1998		
Hongkong	2004-2015	1995-2003		
Taiwan	1995-2015			
Korea	1995-2015			
Canada	1995-2015			
Australia			1995*-2005*	2006*-2015*
Brazil			1995*,1996* 1998*-2000* 2002*-2005*	1997*,2001* 2006*-2015*
Saudi Arabia			1995*-2011*	2012*-2015*
UAE			1995*-2010*	2011*-2015*
Japan				1995*-2015*
Netherlands				1995*-2015*
Mexico				1995-2005,2006* 2007-2010 2011*,2012 2013*,2014,2015*
China			1995-1999	2000-2015
Spain		1995*-2015*		
Malaysia		1995-2015		
Argentina		1995-2015		
Chile			1995*-2011* 2015*	2012*-2014*
Colombia			1995*-2011* 2015*	2012*-2014*
Peru			1995*-2015	
Ireland			1995*,1996* 1997-1999,2000* 2001,2002,2003* 2004*,2005,2006* 2007-2012 2013*,2014,2015	
Israel			1995-2015	
Turkey			1995-2015	
Thailand			1995-2015	

Note. *significant at the level 0.1

Also interestingly, we noticed that Canada was not statistically significant to become the important export-partner country of the US. Mexico turned up to be statistically significant an important export -partner country of the US from 2006. Brazil became very significant to the US exports between 2006 and 2015.

Summarizing the above findings, several salient features are noticed. Firstly, the intensity of US exports in West-European countries and Japan was very apparent. Also, the country kept the focus on the West-European countries by extending its exports to other neighboring countries in the EU in later years of this study.

Secondly, some of the largest US trade -partner countries: Canada, Mexico, China and other East Asian (except Japan) countries were not important to the US exports. Mexico only became significant for a couple of years during the second half of this period. Australia was very insignificant in the first half of this period but became significant in the second half of this period.

Table 2 exhibits that the Hausman-test statistic is -28.2908 (P value=0.0002), which is statistically very significant. Thus, the fixed effects model is more fitting for this study. Based on results of the tests shown above, these denote that the panel data utilized in this study has spatial characteristics and is more fitting with spatial and time-fixed effects. We, hence, conduct the model specification and it can be written as follows.

$$Y_{it} = \alpha + \sum_{i=1}^{n} X_{it}\beta_i + \mu_i + \nu_t + \varepsilon_{it} \tag{3}$$

The result of Table 2 exhibits the LR-test statistic of the LR-test joint significance spatial fixed effects is 1370.3234 (P vale=0.0000). It is statistically very significant. It signifies that spatial effects exist. In addition, the LR-test statistic of the LR-test joint significance time-period fixed effects is 183.2815(P value=0.0000), which is also statistically very significant (see Table 2). This denotes the existence of time effects. According to results of the above LR tests, it indicates that it is necessary to take both spatial and time effects into account in the model configuration.

Results of Table 2 also exhibit the LM test no spatial lag statistics is 62.1563 (P value=0.000) and the LM test no spatial error statistics is 48.4806 (P value=0.000). Both results of the LM tests are statistically very significant. They signify that the panel data utilized in this study are spatially lag and spatially error.

Furthermore, results of the robust LM test no spatial lag statistics is 13.7197 (P value=0.000). The robust LM test no spatial error statistics is 0.0433 (P value=0.835) according to Table 2. Of the two, only the robust LM test no spatial lag statistic is statistically significant. Consequently, it signifies that there exist spatial lag effects. Hence, Model (3) can be modified as follows.

$$Y_{it} = \alpha + \rho\sum_{j=1}^{n} W_{ij}Y_{jt} + \sum_{i=1}^{n} X_{it}\beta_i + \mu_i + \nu_t + \varepsilon_{it} \tag{4}$$

In addition, results of Table 3 show that the LR test spatial lag statistics is 124.5534 (P value=0.0000), while the Wald test spatial lag statistic is 116.9252 (P value=0.0000). Results of both tests are statistically very significant. Consequently, the SDM is superior to the SLM and the SEM in the case of this study. The model (4) can, therefore, modified as follows.

$$Y_{it} = \alpha + \rho\sum_{j=1}^{n} W_{ij}Y_{jt} + \sum_{i=1}^{n} X_{it}\beta_i + \gamma\sum_{j=1}^{n} W_{ij}X_{jt} + \mu_i + \nu_t + \varepsilon_{it} \tag{5}$$

Following LeSage and Pace (2009), direct and indirect effect were estimated to obtain an interpretation of the spatial spillover effects. Estimates of direct effects include the direct and feedback effects from its neighboring countries. Estimates of indirect effects include the spatial spillover effects. Total effects combine direct and indirect effects. The direct, indirect, and total effects of each explanatory variable are displayed in Table 3 (columns 2 to 4)

GDPPC stands for the GDP *per capita* of export-partner countries of the US. It had very significant positive direct, indirect, and total effects on the US exports (see Table 3). This indicates that countries with higher *GDPPC* significantly and positively demanded highly value-added goods that are produced more competitively in the US and exported from the US. This result matches findings of the Moran's *I* test: the long-run intensity of the US export destinations was the West-European countries and Japan with higher *GDPPC* pretty well. It also proves the findings of studies of Bernard and Jensen (2004a) and Bernard and Jensen (2004b) aforementioned.

The estimated coefficients of the *MO* (Market Opportunity: GDP *per capita i* / GDP *per capita j*) show that it had significantly negative direct, indirect, and total effects on the US exports. Though most US

Table 2. Results estimated without Spatial Interaction Effects on the US Exports

Determinants	No spatial & time-specific fixed effects	Spatial fixed effects	Time-period fixed effects	Spatial and Time-period fixed effects
$lnGDPPC_{i,t}$	0.2366***	0.6999***	02278***	0.4658***
	(0.0000)	(0.0000)	(0.000000)	(0.0000)

$MO_{i,t}$	-0.0254*** (0.0003)	-0.0232*** (0.0093)	-0.0239*** (0.0006)	-0.0101 (0.1978)
$OPEN_{i,t}$	0.0710* (0.0545)	0.2094*** (0.0000)	0.0736** (0.0532)	0.1682*** (0.0000)
$KOF_{i,t}$	-0.0389*** (0.0000)	-0.0092** (0.0205)	-0.0379*** (0.0000)	0.0010 (0.7948)
$lnOFDI_{i,t}$	0.5968*** (0.0000)	0.3658*** (0.0000)	0.5883*** (0.0000)	0.2909*** (0.0000)
$EI_{i,t}$	0.2310*** (0.00000)	0.0889* (0.0000)	0.1935*** (0.0000)	-0.0167 (0.4287)
Log likelihood	-612.5305	-10.9391	-604.4600	80.7071
σ^2	0.4139	0.0612	0.4028	0.0458
R^2	0.6365	0.7242	0.5898	0.3169
LM test no spatial lag	87.8675*** (0.000)	177.8990*** (0.000)	80.8499** (0.000)	62.1563*** (0.000)
LM test no spatial error	48.8871*** (0.000)	131.7317*** (0.000)	40.1612*** (0.000)	48.4806*** (0.000)
robust LM test no spatial lag	39.8871*** (0.000)	57.4648*** (0.000)	41.4915*** (0.000)	13.7191*** (0.000)
robust LM test no spatial error	0.0530 (0.818)	11.2975*** (0.001)	0.8028 (0.370)	0.0433 (0.835)
Effects: Spatial fixed effect	***1370.3234****** ***(0.0000)***			
Effects: Time-period fixed effect	***183.2815****** ***(0.0000)***			
Hausman test	-28.2908*** (0.0002)			

Note. 1.Figures in parentheses are the p-value.
2.*Significance at level 0.1 **Significance at level 0.05 ***Significance at level 0.01

main export destinations are countries mostly with higher GDP *per capita*, the negative effects of *MO* on the US exports signify that the US exported more to countries with lower GDP *per capita* relative to the GDP *per capita* of the US. In other words, the demand of capital-intensive and high-end technology goods of the US was higher from countries with a GDP *per capita* relatively lower than the GDP *per capita* of the US.

The estimated coefficients of the *OPEN* of each country's market show that it had very significantly positive direct effect though it had significant indirect and insignificant total effects on the US exports. This implies that the US exports benefited from export-partner countries with an economic environment more open to international trade. However, there are negative spillover effects for US exports to the export-partner country's neighboring countries.

Table 3. Results estimated of SDM model with Spatial and Time-period fixed effects on the US Exports

Determinants	Spatial and Time-period fixed effects	Direct effect	Indirect effect	Total effect
$lnGDPPC_{i,t}$	0.5061*** (0.0000)	0.5443*** (0.0000)	0.7485*** (0.0000)	1.2928*** (0.0000)

$MO_{i,t}$	-0.0179**	-0.0327***	-0.2708***	-0.3036***
	(0.0156)	(0.0004)	(0.0000)	(0.0000)
$OPEN_{i,t}$	0.1428***	0.1328***	-0.1645*	-0.0318
	(0.0002)	(0.0021)	(0.0591)	(0.7589)
$KOF_{i,t}$	-0.0001	-0.0003	-0.0050	-0.0054
	(0.9793)	(0.9226)	(0.5641)	(0.5716)
$lnOFDI_{i,t}$	0.3000***	0.2983***	-0.0603	0.2379**
	(0.0000)	(0.0000)	(0.4705)	(0.0152)
$EI_{i,t}$	0.0226	0.0323	0.1748***	0.2071***
	(0.2489)	(0.1201)	(0.0029)	(0.0024)
$W{*}lnGDPPC_{i,t}$	0.4094***			
	(0.0003)			
$W{*}MO_{i,t}$	-0.1940***			
	(0.0000)			
$W{*}OPEN_{i,t}$	-0.1611***			
	(0.0057)			
$W{*}KOF_{i,t}$	-0.0039			
	(0.5573)			
$W{*}lnOFDI_{i,t}$	-0.1320**			
	(0.0286)			
$W{*}EI_{i,t}$	0.1226***			
	(0.0020)			
*W*dep.var.*	0.2935***			
	(0.0000)			
Log likelihood	173.1680			
σ^2	0.0359			
R^2	0.9706			
Wald test spatial lag	116.9252***			
	(0.0000)			
LR test spatial lag	124.5534***			
	(0.0000)			
Wald test spatial error	125.0903***			
	(0.0000)			
LR test spatial error	132.4055***			
	(0.0000)			

Note. 1.Figures in parentheses are the p-value.
2.*Significance at level 0.1 **Significance at level 0.05 ***Significance at level 0.01

The estimated coefficients of the US *OFDI* showed that direct and total effects had significant positive effects on the US exports while indirect effects had insignificant and negative impacts. Thus, a complementarity relationship between exports and the *OFDI* existed. Spatial properties were identified to have a significant impact on the decision between the US *OFDI* and exports. This suggests that there was a substitutive relationship between the US *OFDI* and exports. The US exported more goods to countries with the higher foreign direct investment from US corporations.

The degree of bilateral economic integration between the US and its export -partner countries (*EI*) was found to have an insignificant direct effect on the US exports. However, there were significantly positive indirect and total effects. This might be interpreted that neighboring countries of the US export-partner countries may have close economic integration agreements with each other and therefore reduce trade barriers and improve international trade through the export-partner countries of the US. This, in turn, may increase the US exports to these neighboring countries. This can be applied to the case of the US long-term major export-destination countries, those countries of the European Union (EU) in particular. The spatial characteristics were found to have a positive impact on the US exports, and thus the relationship between the US exports, and *EI* was determined by the spatial neighboring factor.

The political risk (*KOF*) is identified to have insignificant and very slightly negative direct (-0.0003), indirect (-0.0050), and total effects (-0.0054) on the US exports. Thus, the impact of the *KOF* was insignificant to the US exports during the period of this study.

In summation, the estimation results discern the decisive factors of the US exports are countries with higher GDP *per capita*, more open economic environment to international trade, bilateral or multilateral trade agreements with the US or neighboring countries, and with higher *OFDI* from the US corporations.

5. Concluding Remarks

This paper explored the spatial configuration of the US exports from 1995 to 2015. We identified the Spatial Durbin Model (SDM) as the much more appropriate model than others after applying a series of spatial statistical techniques including the LR test, the LM test, the Robust LM test, and the Walt test, among others.

Empirical findings of the Moran's *I* reveal, firstly, the intensity of US exports on West-European countries and Japan was very apparent. Also, it kept focusing on the West-European countries by extending its exports to other neighboring countries in the EU through the later years of this study.

Secondly, Canada, Mexico, mainland China, and countries in the East Asia were not important nations of the US exports except Japan and Australia (only in the second half of this period).

Thirdly, the US exports to most countries in the Americas were statistically insignificant. The US exports did not benefit from the geographic proximity, but reversely it imported more from countries in the Americas than it exported to these countries, which resulted in the other main cause of the US trade deficits.

Distinctive characteristics of the US exports were found by applying the spatial econometric model proposed in this paper. The estimations results discern the decisive factors of the US exports are countries with higher GDP *per capita*, more open economic environment to international trade, bilateral or multilateral trade agreements with the US or neighboring countries, and with higher *OFDI* from the US corporations.

The US exports apparently focused on West-European countries and Japan during the period of this study. It is suggested that the US can expand and diversify exports to countries in different regions and enhance US total exports volume, which would improve the US trade deficit.

References

Anselin L. (1988). *Spatial econometrics: methods and models* (1st ed.). Dordrecht: Kluwer Academic Publishers. http://dx.doi.org/10.1007/978-94-015-7799-1

Anselin, L. (1995). Local indicators of spatial association — LISA. *Geographical Analysis*, 27(2), 93-115. http://dx.doi.org/10.1111/j.1538-4632.1995.tb00338.x

Anselin, L., Bera, A., Florax, R., and Yoon, M. (1996). Simple Diagnostic Tests for Spatial Dependence. *Regional Science and Urban Economics*, 26, 77–104. http://dx.doi.org/10.1016/0166-0462(95)02111-6

Anselin, L. (1998). *Spatial Economics: Methods and Models*. Boston: Kluwer Academic Publisher, US.

Anselin L. (2008). *Spatial Panel Econometrics, [in:] Mátyás L., Sevestre P. (Editors), The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*. Verlag Berlin Heidelberg, Springer, Third Edition.

Bernard, K., Armah, Jr., and Epperson, J. (1997). Export Demand for US Orange Juice: Impact of US Export Promotion Programs. *Agribusiness*, 13(1), 1-10.

Bernard, A. and Jensen, B. (2004a). Why Some Firms Export. *Reivew of Economics and Statistics*, 86(2), 561-569. http://dx.doi.org/10.1162/003465304323031111

Bernard, A., and Jensen, J. (2004b). Entry, Expansion, and Intensity in the US Export Boom, 1987–1992. *Review of International Economics*, 12(4), 662-675.

Bowen, H. and Pelzman, J. (1984). US Export Competitiveness: 1962-1977. *Applied Economics*, 16,

461-473.
Burridge, P. (1981). Testing for a Common Factor in a Spatial Autoregression Model. *Environment and Planning A,* 13(7), 795–800. http://dx.doi.org/10.1068/a130795
Cheung, Y. and Qian, X. (2009). The Empirics of China's Outward Direct Investment. *Pacific Economic Review*, 14(3), 312-341.
Chou, K., Chen, C., and Mai, C. (2009). A Geospatial Analysis of China's Exports, 1991–2008, *Eurasian Geography and Economics*, 50(5), 532-546.
Chou, K. H., Chen, C. H. and Mai, C. C. (2015). Factors Influencing China's Exports with a Spatial Econometric Model. *The International Trade Journal*, 29 (3), 191-211.
Eaton, J. and Tamura, A. (1994). Bilateralism and Regionalism in Japanese and US Trade and Direct Foreign Investment Pattern. *Journal of the Japanese and International Economies*, 8(4), 478-510.
Egger, P. (2001). European exports and outward foreign direct investment: A dynamic panel data approach. *Review of World Economics*, 137(3), 427–449. http://dx.doi.org/10.1007/BF02707625
Eichengreen, B., Rhee, Y. and Tong, H. (2004). The Impacts of China on the Exports of Other Asian Countries. NBER Working Paper Series 10768, 1-36.
Elhorst, J. (2012). Matlab Software for Spatial Panels. *International Regional Science Review,* 37(3), 389-405. http://dx.doi.org/10.1177/0160017612452429
Elhorst, J. (2014). *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels* (1st ed.). Berlin, Heidelberg : Springer-Verlag Berlin Heidelberg. https://doi.org/ 10.1007/978-3-642-40340-8
Flowerdew, R., Aitkin, M., (1982). A Method of Fitting the Gravity Model Based on the Poisson Distribution. *Journal of Regional Science*, 22(2), 191-202. http://dx.doi.org/10.1111/j.1467-9787.1982.tb00744.x
Head, K., and T. Mayer, (2014). Gravity Equations: Workhorse, Toolkit, and Cookbook, chapter 3 in Gopinath, G, E. Helpman and K. Rogoff (eds), vol. 4 of the Handbook of International Economics, Elsevier, 131-195. http://dx.doi.org/10.1016/B978-0-444-54314-1.00003-3
Harrigan, J., Ma, X., and Shlychkov, V. (2015). Export Prices of U.S. Firms. *Journal of International Economics*, 97(1), 100-111. http://dx.doi.org/10.1016/j.jinteco.2015.04.007
Konandreas, P., Bushnell, P., and Green R. (1978). Estimation of Export Demand Functions for U.S. Wheat. *Western Journal of Agricultural Economics*, 3(1), 39-49.
Krueger, A. (1974). The Political Economy of the Rent-Seeking Society. *American Economic Review,* 64(3), 291-303.
Krugman, P. Baldwin, R., Bosworth, B., and Hooper, P. (1987). The Persistence of the U.S. Trade Deficit. *Brooking Paper on Economic Activity*, 1987(1), 1-55. http://dx.doi.org/10.2307/2534513
LeSage, J. and Pace, R., (2009). *Introduction to spatial econometrics*. Boca Raton, US: CRC Press Taylor & Francis Group. http://dx.doi.org/10.1201/9781420064254
Morrison, W. (2011). China-U.S. Trade Issues. *Current Politics and Economics of Northern and Wesetern Asia,* 20(3), 409-461.
Morrow, J. D., Siverson, R. M., and Tabares, T. E., (1998). The Political Determinants of International Trade: The Major Powers, 1907–1990. *American Political Science Review*, 92 (3), 649-661.
Moser, C., Nestmann, T., and Wedow, M. (2008). Political Risk and Export Promotion: Evidence from Germany. *World Economy*, 31 (6), 781–803. http://dx.doi.org/10.1111/j.1467-9701.2008.01102.x
Piece, J., Schott, P. (2016). The Surprisingly Swift Decline of US Manufacturing Employment. *The American Economic Review*, 106(7), 1632-1662,
Porojan, A., (2001). Trade Flows and Spatial Effects: The Gravity Model Revisited. *Open economies review,* 12, 265-280.
Rene, C., and Mollick, A. (2012). Convergence Rates to Output Growth in a Global World: The Roles of Openness and Government Size. *The International Trade Journal*, 26(3), 201-222.
Schott, P. (2010). U.S. Manufacturing Exports and Imports by SIC or NAICS Category and Partner Country, 1972 to 2005. Yale Scholl of Management & NBER, 1-4.
Thorbecke, W. (2015). Understanding the Evolution of Japan's Exports, RIETI Discussion Paper Series 15-E-131. *Research Institute of Economy*, Trade and Industry, Tokyo.
Tobler, W. (1970). A Computer Movie Simulating Urban Grown in the Detroit Region. *Economic Geography*, 46, 234–240.
Trefler D. (1993). Trade Liberalization and Theory of Endogenous Protection: An Econometric Study of U.S. Import Policy. *Journal of Political Economy*, 101(1), 138-160. http://dx.doi.org/10.1086/261869
Wu, H., Chen, C. and Chen, L. (2007). Foreign Trade in China's Electronics Industry. *Eurasian Geography and Economics*, 48 (5), 626-642.