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Dynamic Relationship of Foreign Direct Investment and Manufacturing Industrial Agglomeration

¹Yu Shihai and ²Song Fen
¹Economics School, Wuhan University of Technology, Wuhan City, 430070, People's Republic of China
²Department of Economics and Trade, Guilin University of Aerospace Technology,
Guilin City, 541004, People's Republic of China

Abstract: Since the late 20th century, as the economic globalization, foreign direct investment poured into China and produced the great influence on domestic industrial structure and layout, industrial competitiveness and industrial agglomeration. Industrial agglomeration is a world phenomenon in the economic life. The software industry of Silicon Valley of the United States and Bangalore of India and ceramic industry of Italy are famous cases; many areas rely on industrial agglomeration on the southeastern coast of China have also made significant economic benefits. Taking transportation equipment manufacturing industry of Hubei province in China for example, this study aims to analyze the dynamic relation between foreign direct investment and industrial agglomeration and important effects on the industrial agglomeration from FDI. The empirical result shows that FDI and the development of a regional industrial agglomeration have a positive correlation and at the same time the regional industrial concentration would attract FDI entry. Finally, put forward the corresponding reasonable policy recommendations so as to promote the efficient use of foreign capital and the better development of industrial clusters.

Key words: Foreign direct investment (FDI), industrial agglomeration, co-integration, granger causality test

INTRODUCTION

Since, China's reform and opening up, especially entry into the World Trade Organization, as a great potential market, China has been a hot land for international capital. The domestic large-scale foreign direct investment has a huge impact on China's industrial structure and competitiveness and promotes the formation and development of industrial agglomeration. So-called industry agglomeration refers to a specific field (usually with a dominant industry is given priority to), is closely related to a large number of industry enterprises and related supporting institutions on the space agglomeration and form a strong and sustainable competitive advantage phenomenon. Such as including spare parts, machinery and services specialized suppliers and professional infrastructure providers. The regional agglomeration of an industry and the capital flow are closely linked. Industrial agglomeration development theory and foreign investment location choice theory are the hot topic of academic circles.

In China, the regional industrial agglomeration and FDI whether there is a certain relationship? If so, then each region can make full use of FDI to promote economic development and industrial upgrading of this region; on the other hand, the development of the regional industry agglomeration could also attract more FDI. This study with industry agglomeration phenomenon resulting from FDI of Hubei province as an example analyzes the dynamic relationship between FDI and industry agglomeration and gives the corresponding policy recommendations.

Theoretical background: As early as in the classical political economics, Smith (1976) put forward that industrial agglomeration is joint groups of the enterprise with characteristics of labor division in order to complete the production of a product. Hereafter Marshall (1891) in his book "The principles of economics" proposed the industrial gathering, internal gathering and external economy concept. And the main three reasons of industry agglomeration under the condition of external economy and scale economy were expounded. The first reason is that the agglomeration could the service development and specialized inputs. The second reason is that the agglomeration of the enterprise in a specific space could attract sufficient labors with specific skills to ensure the lower probability of unemployment and reduce the labor

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Corresponding Author: Song Fen, Department of Economics and Trade, Guilin University of Aerospace Technology,
Guilin City, 541004, People's Republic of China

shortages. The third reason is that the industry agglomeration would produce spillover effects including overflow technology, information, etc. and get the better production function in the group than the single enterprise's.

Differently Porter (1996) studied the industry agglomeration phenomenon from the angle of enterprise competitive advantage. And the industry agglomeration phenomenon of many countries was analyzed and industrial clusters concept was presented. At the same time "Diamond Model" was used to research on the industry agglomeration and industrial clusters. A region was able to attract a large number of foreign capitals. The reason is that developed infrastructure, a specific service equipment, skilled labor, good regional image and industrial agglomeration, etc. Markusen (1995) argue that foreign investment enterprises, especially multinational companies could be a leader in industrial agglomeration. Head *et al.* (1995, 1999) found that the Japanese manufacturing investment in the United States appeared obvious cluster effect and under the other same condition the Japanese investor preferred for those states which already has been more investors. Barry *et al.* (2003) research has shown that technology spillover effect, industry demonstration effect and productivity improvements resulting from industrial agglomeration attract the FDI into Ireland successfully. Hilber and Voicu (2010) studied the impact factors of location choice of FDI in Romania in the transition economies, the results found that gathering of the service sector is the main factor influencing location choice of FDI. As a result, a lot of empirical evidence shows that both developed and less developed economy, agglomeration economy are closely linked with FDI.

In recent years, domestic scholars pay more and more attention to research on the relationship between FDI and industrial agglomeration. Gai and Wang (1999) empirical research proves that the development of IT industry cluster in Zhong Guan Cun area multinational companies such as Intel, Microsoft play an important role. Xu and Chen (2003) pointed out that FDI play a very key role in the process of the formation of the domestic industry cluster; the empirical study from Kunshan, Jurong City of Jiangsu province show that many industrial clusters in the Yangtze River delta region belong to capital migration patterns. In such kind of industrial cluster "clustering life" of the foreign capital enterprise lead to the emergence of the industrial agglomeration and specialized labor division of labor is very fine. So the conclusion is that FDI could obtain greater benefits than the original market by use of industrial agglomeration, industry agglomeration is also

a good carrier of FDI. Zhao and Zhang (2007) analyzed the relationship between FDI penetration and the manufacturing industry agglomeration by means of the new economic geography model and the data from 20 manufacturing industry segments; the results show that the enhancement of FDI penetration could promote the agglomeration level of high agglomeration industry further. Empirical research indicate that FDI is the short-term reasons for the agglomeration formation of the agricultural product processing industry and is also the long-term factors affecting the development of agricultural product processing industry agglomeration (Su and Zang, 2010). But the industrial agglomeration is not the reason why FDI enter into the agricultural product processing industry. Bi and Sun (2012) found that both FDI and industrial agglomeration could promote each other by location entropy index.

METHODS

Theoretical assumption: Location entropy, also called specialization rate, is first put forward and used in location analysis it is used for measurement of the elements space distribution in a field and it could reflect the specialization degree of a certain sector. And so is the industry agglomeration. Location entropy is a very meaningful indicator and could analyze the status of regional dominant industries for research on the industrial structure.

Location entropy refers to the ratio of the proportion of the output value of the specific department in the gross industrial output value in a region and the proportion of national output value in the same department in the gross industrial output value. Location entropy is greater than 1, this industry could be a specialized department; the location entropy, the greater the specialization level is higher; if less than or equal to 1 location entropy, this industry could be a subsistence sector.

Location entropy mathematical expression is:

$$\beta_{ij} = \frac{q_{ij} / q_j}{q_i / q}$$

in which q_{ij} said industry i output value of region j, q_j said the total industrial output value of region j, q_i said the national output value of industry i, q said the gross industrial output value. The numerator of β_{ij} is the proportion of the industrial output value of industry i region j accounted for j region's, the denominator of β_{ij} is the proportion of the industrial output value of industry i accounted for the nation's; β_{ij} could estimate

the difference between the national average level and the region industry structure so as to evaluate the specialization level of a region. Higher β_{ij} index, higher the degree of agglomeration industry in a region. As the location quotient index β_{ij} is more than 1, industrial agglomeration status of industry i in the region j is higher than the national average level; as β_{ij} is less than 1, industrial agglomeration status of industry i in the region j is below the national average level.

Manufacturing attracts the most FDI in Hubei province, so this study selects several typical industries with higher industrial agglomeration and more FDI than others; meanwhile compares their location quotient. These selected industries are transportation equipment manufacturing industry, food processing industry, textiles industry and electronics, communication equipment manufacturing industry. Table 1 clearly reflects the variation trend of the agglomeration degree of the above industries. By 2010 the location entropy of the first three industries are more than 1. This result indicates that these three industries have certain specialization advantages in the region. Especially for transportation equipment manufacturing industry, its location entropy has grown steadily since 1999, in 2010 up to 3.67. The industrial agglomeration of the transportation equipment manufacturing industry especially auto manufacturing industry in Hubei province is quite higher than other industries in this region even national average level. By contrast, the location entropy of food processing and textile industry has been hovering in 1 and the reason is that the technology level of light industry is generally lower than other industries, so the agglomeration demand is not high. The location entropy of electronic, communication equipment manufacturing industry has been in 0.5; the reason is that on the one hand this industry of Hubei province started relatively late, the agglomeration level is not obvious; on the other hand the scale of this industry in Hubei province lost the attract to FDI compared to domestic other region's currently. Whether the agglomeration formation of transportation equipment manufacturing industry and foreign direct investment has direct connection? The following empirical analysis would utilize the relevant data from transportation equipment manufacturing industry and FDI to explain the dynamic relationship between them.

Modeling: The original data for this study are derived from China statistical yearbook (2000-2011) and statistical yearbook of Hubei province (2000-2011) (Li and Xu, 2011). According to the above related theory and analysis, FDI link with the industrial agglomeration directly or indirectly.

Therefore, establish the binary simple equation:

$$LNQ_t = \alpha + \beta\, LNFDI_t + \mu_t$$

Among them, α, β is to be estimated parameters, μ_t is the random disturbance term which represent other impact factors except FDI, Q_t said the location entropy, β_{ij} FDI said FDI over the years.

In order to further confirm the effect of FDI on the industrial agglomeration, this study selects the location entropy index of transportation equipment manufacturing industry of Hubei province (1999-2010) as the explained variable and selects the actual utilization values of foreign direct investment of Hubei province (1999-2010) as below Table 2 as the explanatory variable, while eliminates the influence of price factors.

Firstly, according to the average exchange rate of CNY (China Yuan) in the current year, the USD value of FDI is converted into CNY value (unite: hundred million). Then in order to eliminate the heteroscedasticity of the sample data, make logarithmic processing all the data; $LNFDI$, LNQ represent the logarithm value of FDI and the location entropy respectively and Δ represents the first order difference of the corresponding variables.

Unit root test: Regression analysis on the time series data is a prerequisite for time series stationarity, because non-

Table 1: The location entropy value of several industries (1999-2010)

| Year | Industry type | | | |
	Transportation equipment manufacturing industry	Food processing industry	Textiles industry	Electronics, communication equipment manufacturing industry
1999	2.3288	1.4396	1.2529	0.3407
2000	2.4841	1.2778	1.1735	0.2975
2001	2.5372	1.3383	1.1630	0.4337
2002	2.8640	1.1731	1.0728	0.3464
2003	3.2351	1.0927	1.0763	0.3027
2004	3.3822	0.8615	1.0086	0.2481
2005	3.4105	0.9102	0.9905	0.3525
2006	3.4272	1.0356	1.0334	0.4257
2007	3.4889	1.1391	1.0409	0.4087
2008	3.5513	1.1963	0.9815	0.4224
2009	3.5784	1.3688	1.0705	0.4917
2010	3.6713	1.4212	1.0725	0.3638

Source: Statistical Yearbook of Hubei Province (2000-2011) Li and Xu (2011), China Statistical Yearbook (2000-2011), Sheng (2011)

Table 2: The actual utilization values of foreign direct investment from Hubei Province

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FDI_t	91488	94368	120993	140151	155702	207126	218475	244853	276622	324481	365766	405015

(1999-2010) Unit: 10,000 USD Source: Statistical Yearbook of Hubei Province (2000-2011), Li and Xu (2011)

Dependent variable: LNQ
Method: least squares
Date: 05/03/12 Time:14:52
Sample;1999 2010
Included observation:12

Varible	Coefficient	Std.error	t-statistic	Prob.
C	-0.625287	0.156998	-3.982763	0.0026
LNFDI	0.350690	0.031076	11.28498	0.0000

R-squared	0.927194	Mean dependent var		1.140175
Adjusted R-squard	0.919913	S.D.dependent var		0.161413
S.E.of regression	0.045679	Akaike inof criterion		-3.183332
Sum squared resid	0.020866	Schwarz criterion		-3.102514
Log likelihood	21.09999	Hannan-Quinn criter.		-3.213254
F-statistic	127.3509	Durbin-watson stat		1.152974
Prob (F-statistic)	0.000001			

Fig. 1: Regression results of LNQ (the logarithm value of foreign direct investment) and LNFDI (the logarithm of location entropy) using least square method

Table 3: Results of augmented dickey fuller test of LNFDI and LNQ

Variable	ADF statistic	1 (%)[*]	5 (%)[*]	10 (%)[*]	Conclusion
LNQ	-1.0146	-4.4206	-3.2598	-2.7711	Non-stationary
ΔLNQ	-3.7608	-4.5826	-3.3210	-2.8014	Stationary
LNFDI	-1.1456	-4.2001	-3.1754	-2.7290	Non-stationary
ΔLNFDI	-3.8772	-4.2971	-3.2127	-2.7477	Stationary

1 (%)[*], 5 (%)[*], 10 (%)[*] said the critical value under the significance level 1 (%), 5 (%), 10 (%) respectively. LNFDI and LNQ represent the logarithm value of foreign direct investment and the location entropy respectively and Δrepresents the first order difference of the corresponding variables

stationarity could lead to spurious regression. So further unit root test has to be carried on, this study adopts the ADF (Augmented Dickey Fuller) test method shown in Table 3.

The ADF test results shown in Table 3 could be concluded that LNQ and LNFDI are non-stationary time series; after first order difference, under the 5% significant level these two time series are stationary, namely LNQ and LNFDI is integrated of order I (1).

Co-integration test: Co-integration test is the premise that there is the same order integrated with two variables. So these two variables exists a long-term and stable relationship. Conversely, no co-integration means that there is no the long-term and stable relationship. In line with the above test results LNQ and LNFDI are integrated of order; so the co-integration test could be carried on in order to confirm the long-term and stable relationship between FDI and transportation equipment manufacturing industrial agglomeration.

Utilize Eviews 6.0 software, regression results of the Ordinary Least Square (OLS) are as follows in Fig. 1.

The regression equation is as below Eq. 1:

$$LNQ = -0.6253+0.3507 \ LNFDI \ (-3.9828) \ (11.2850)$$
$$(-3.9828) \ (11.2850) \qquad (1)$$

$$R^2 = 0.9272 \ F = 127.3509 \ DW = 1.1530$$

In brackets the T-statistic is far greater than the absolute value of 2.5; obviously, the coefficients of the variables are very significant. The determination coefficient R^2 is greater than 0.9 and at the same time, F-statistic is greater than the critical value $F_{0.05}(10, 9) = 3.02$ on the 5% significance level. DW-statistic (DW = 1.15) is located in between the lower bound $d_L = 0.758$ and the upper bounds $d_U = 1.604$; so the existence of autocorrelation could be proved for the two variables. Thus, the explanatory variables and the dependent variables are highly correlated, so to a certain extent the selected model could explain the features of the dependent variable.

Time series E for the residual errors of the model, the results of ADF unit root test for time series E is as Fig. 2.

As could be seen from the above Fig. 2, the absolute value of ADF test statistic (-2.1973) is greater than the absolute value of the critical value (1.9777) under the 5% significant level, thus the residual error sequence is stationary. There is a long-term equilibrium relationship between dependent variable and independent variable. The regression equation shows that if FDI value grows 1%, the location entropy would increase by 0.35%; so foreign direct investment would promote the industrial agglomeration phenomenon.

Granger causality test: Co-integration test reveals that there is the long term positive correlation relationship between foreign direct investment and industrial

Null hypothesis: E has a unit root
Exogenous: None
Lag length: 0 (Automatic based on SIC, MAXLAG=2)

		t-statistic	Prob.*
Augmented dickey -fuller test statistic		-2.197333	0.0327
Test critical values:	1 (%) leve	-2.792154	
	5 (%) leve	-1.977738	
	10 (%) leve	-1.602074	

*Mackinnon (1996) one-sided p-values.
warning: probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 11

Fig. 2: The results of augmented dickey-fuller test for time series E. (MacKinnon, 1996)

Table 4: The results of granger causality test for LNQ and LNFDI

Lag period	Null hypothesis	F-statistic	Probability	Conclusion
1	LNFDI does not granger cause LNQ	0.1734	0.6880	Accept
	LNQ does not granger cause LNFDI	3.4006	0.1024	Accept
2	LNFDI does not granger cause LNQ	3.6818	0.0912	Reject
	LNQ does not granger cause LNFDI	0.6570	0.5580	Accept
3	LNFDI does not granger cause LNQ	2.4134	0.3064	Accept
	LNQ does not GRANGER CAUSE LNFDI	62.3250	0.0158	Reject

agglomeration; but a causal relationship between them is not clear. So the Granger causality test would give the specific causality relationship between and as shown in Table 4.

The results of Granger causality test show that under the condition of the different lag period (1, 2, 3) the result is also consistent. This study selects the 1-3 lag periods and the 10% significance level to carry on the Granger causality test between LNQ and LNFDI. The above Table 4 indicates that as the lag period is 1 the null hypothesis is accepted, i.e., there is no causal relationship between LNQ and LNFDI; as the lag period is 2 LNFDI under the significance level 5% (Probability 9.12%) does Granger Cause and FDI could affect the formation of industrial agglomeration; as the lag period is 3 LNQ does Granger Cause LNFDI (Probability 1.58%), the industrial agglomeration would also affect FDI flow. To sum up LNQ and LNFDI influence, supplement each other.

RESULTS AND DISCUSSION

The results of empirical analysis show that FDI has a positive role in promoting transportation equipment manufacturing industry agglomeration in Hubei province. FDI expand the local enterprise communication with outer space; so directly promote the formation of local industrial agglomeration. In general FDI mainly make use of increasing the capital formation, expanding market demand, accelerating technological spillover so, as to make the local industrial clusters integrate into the global value chain, improve the competitiveness of industrial clusters. Meanwhile the industrial cluster has the advantage of attracting FDI; in a highly open economy environment, the free flow of production factors could make them enter into some areas and industrial clusters which are more efficient with higher returns. FDI and industrial agglomeration supplement each other and form a virtuous cycle.

In conclusion, the empirical results are consistent with Marshall's (1891) viewpoints. The certain advantages of industrial agglomeration could attract a large number of foreign direct investment access to these areas. Porter (1996), Head *et al.* (1995, 1999) and Barry *et al.* (2003) thought industrial agglomeration supplied the kinds of conveniences to development of foreign direct investment. This study draws the same conclusion. Xu and Chen (2003) and Zhao and Zhang (2007) hold this view foreign direct investment could improve the phenomenon of industrial agglomeration. The reason is that foreign direct investment could gain more market profits. The empirical research of this study also confirms this view. In a word, upon most cases industrial agglomeration and foreign direct investment have a mutual promotion relation.

As is well know, Hubei province is a thorough fare of nine provinces and the key development area in China. Specially the automobile manufacturing industry clusters has already formed and begun to take shape and produce a good industrial agglomeration effect. By contrast the concentration degree of electronic, communication

equipment manufacturing industry is not obvious. But at the same time optical fiber communication technology, biological technology, laser technology as the main industry of east-lake high-tech development zone are gradually growing, so these industry would achieve the agglomeration and cluster development and play a important role on the local economy.

DISCUSSION

Strengthen the construction of macro environment. The investment from the transnational corporation dose not leads to the industry accumulation but the correlation industry importantly. Only the local industries are related with each other largely, the geographical space agglomeration of transnational corporations would form the industry cluster and achieve the cluster development. In China, the export-oriented manufacturing industry cluster which attract much FDI have not mature and agglomeration advantages and the reasons is below, one is the lower participation level of local enterprises in the multinational industrial chain; the second is the less technology spillovers effect; the last is the lower regional innovation ability. So the external economy has not stimulated. Only the initial location advantage could attract the FDI from transnational companies but the current situation change gradually; transnational companies shift their investment to other areas. Therefore, only make full use of the impetus from the industrial agglomeration and form the regional innovation network, so more and more multinational companies would stay the local industry zone and form a virtuous cycle.

From the perspective of the government management and control, three aspects are extremely important. One enact the corresponding policies, laws and regulations, which could regulate the economic activities, protect the legitimate rights and interests of enterprises and ensure the formation of free competitive environment. In addition, strengthen the construction of urban public service system, so provide a good development space for FDI. Second, build the high-level universities and a variety of training institutions and enhance the communication and cooperation with the regional transnational companies and other enterprises so as to establish a set of effective industry-university-research cooperation system. Third is the construction of intermediary organizations. The government should actively contribute to a variety of chamber of commerce organizations to promote the various communications between multinationals and local companies. Once the cost and location advantage convert

into the flexibility network agglomeration advantage, the technology innovation and upgrading would promote the development of industry clusters towards a virtuous circle.

Selective introduction of FDI. On the one hand, fully pay attention to improving the quality and efficiency of foreign investment. Actively introduce foreign direct investment to transfer into the fund, the technology-intensive industry, especially the high-tech industry. The aim is to get advanced technology, modern management and special talents. On the other hand, attach great importance to the environment capacity. The environmental capacity has been a new production factor worldwide and a country with lower environmental standards has been regarded as the comparative advantage in pollutant products production. Therefore, pay special attention to preventing pollutant industries and resource-based industry turn into the ground; avoid becoming a "polluter paradise".

The demonstration effect of typical enterprises. Multinational companies in the host country would face more risk and uncertainty than domestic enterprises. Overseas funded companies often adopt the "follow up" strategy as choosing the investment location and object. Such as "Taiwan-investment highland" of Wuxi City in Jiangsu province, "Japan-investment highland" of Suzhou City, these two areas are specific demonstrative investment zone. Therefore, the typical demonstration effect from specific countries contributes to FDI introduction. The competition of intra-industry makes the technology transfer faster to the local enterprises, so the technology spillover effect is obvious and efficient. Any more, the competition could promote learning activities and innovation so as to reduce the technology gap with the foreign companies.

Strengthen the labor division based on specialization in the industry agglomeration zone. In the agglomeration area the specialized labor division and cooperation among the enterprises is the basis for the development of industrial agglomeration. In the era of knowledge economy, the specialized production level directly affects the normal operation and healthy development of industry clusters lead to by FDI. The advantages of foreign industry mainly are the technological innovation ability. Specialization is an indirect effect to promote technology progress, so the technical level and innovation ability of the enterprises in the industry agglomeration zone are improved gradually in order to enhance enterprise's competitive advantage.

Access to the international industry chains and technical spillovers, the best way for the domesticenterprises is the compatible production for foreign companies. For this goal on the one hand try to

reduce the technical gap with foreign companies; on the other hand seek the cooperation opportunity actively. In this process absorb and master the advanced technology from the foreign-owned companies, carry through the secondary innovation activity and the final aim is the formation of independent innovation ability.

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