Examining the Determinants of China's Inward FDI Using Grey Matrix Relational Analysis Model

Hang JIANG[1]
Jan-Yan LIN[2]
Yi-Chung HU[3]

ABSTRACT
Grey relational analysis (GRA) model is an important part of grey system theory, which is used to ascertain the relational grade between an influential factor and the major behavior factor. Most of GRA models are mainly applied to the field in which the behavior factor and influential factor are the cross-sectional or time series data in a given system. However, owing to the panel data contains plenty information including individual and time characteristics, the traditional GRA model cannot be applied to panel data analysis. To overcome this drawback, the grey matrix relational analysis model is applied to measure the similarity of panel data from two dimensions of individual and time on the basis of the definition of the matrix sequence of a discrete data sequence. This paper examines the determinants of inward foreign direct investment (IFDI) in China using grey matrix relational analysis model. The study finds that the GDP per capita, enrollment of regular institutions of higher education, and internal expenditure on R&D are the key factors of IFDI.

KEYWORDS: *grey matrix relational analysis model, grey relational analysis, panel data, inward foreign direct investment*

JEL CLASSIFICATION: *F210, R110, C60*

1. INTRODUCTION

Since the 1980s, globalization has led to a rapid increase in the growth of foreign direct investment (FDI) all over the world. China, the World's largest developing country in terms of gross domestic output, has become one of the largest recipients of FDI in the world, and the inward FDI (IFDI) have been increasing continually in recent years (Figure 1). According to the United Nations Conference on Trade and Development (UNCTAD), the FDI flows and stocks of China were 133.7 billion and 1354.4 billion US dollar in 2016, which represent global shares of 7.66% and 5.07%, respectively (UNCTAD, 2016). Due to the great contribution of IFDI to economic growth, most of provinces or cities in China make great

[1] Jimei University (School of Business Administration), China; Chung Yuan Christian University (Ph.D. Program in Business), Taiwan, jianghang_xm@hotmail.com, corresponding author
[2] Chung Yuan Christian University (Department of Business Administration), Taiwan, rock@cycu.edu.tw
[3] Chung Yuan Christian University (Department of Business Administration), Taiwan, ychu@cycu.edu.tw

efforts to improve their business environments, liberalize policy regimes, and offer incentive packages to foreign investors in order to attract IFDI (Meng, 2012; Zhong & Chen, 2012). However, IFDI in China is also unevenly distributed with only a few provinces or cities receiving significant volumes of the total FDI inflows, such as Jiangsu Province, Guangdong Province, and Shanghai City. Because the performance of IFDI determinants, such as economic aggregate, market environment, and opening are multifarious in different regions, the attraction of IFDI for different regions are various. Therefore, one of the aims of this paper is to investigate the determinants contribute to the attraction of IFDI in several province and cities of China.

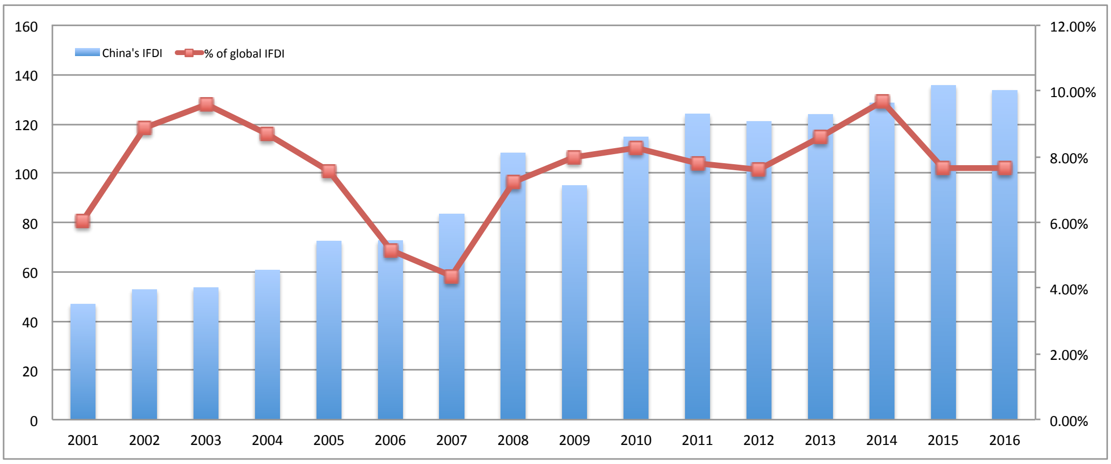

Figure 1. IFDI of China from 2001 to 2016 (unit: billion US dollar)

Source: UNCTAD stat.

Theoretically, the eclectic paradigm, as developed by Dunning (1988, 1995) provides a conceptual framework that can be used to explain FDI. The paradigm states that a country's propensity to attract FDI is a combined function of three broad variables, including the ownership advantages, location-specific advantages, and internalization advantages (Boateng et al., 2015). Additionally, Okafor et al. (2015) stated that the determinants of IFDI could be grouped into four main headings, theories assuming a perfect market, theories assuming imperfect markets, theories based on other factors, and other theories. All these headings have been summarized into the Dunning's organization, location and internalization (OLI) theory. According the OLI theory, there exist four locational motives of IFDI, which are resource seeking, market seeking, efficiency seeking and strategic asset seeking. All four locational motives are used to explain IFDI activities into China and determinants affect IFDI activities will be analyzed in this paper.

Many quantitative methods, including econometric methods (He & Sun, 2014; Anderson & Sutherland, 2015; Huang, et al., 2016; Salike, 2016), spatial econometric methods (Blanc-Brude， et al., 2014; Hsu & Jaw, 2015), and cluster analysis (Delis & Kyrkilis, 2016), have frequently been applied to analysis of China's IFDI determinants. Usually, the quantitative methods, especially econometric methods, not only require a long-term data set, require the data to conform to statistical assumption, such as having a normal distribution (Liu

& Lin, 2010). However, the data of China's IFDI and its determinants often do not conform to these usual statistical assumption, limiting the analysis capabilities of econometric methods. Therefore, to construct a model for China's IFDI determinants, a method is need that works well with small samples and without making any statistical assumptions.

Grey relational analysis (GRA) is a significant component of grey system, which is a mathematical model to analyze the relational grade between the internal factors of the system. The basic idea of GRA is to determine the relationship between different sequences according to the geometry of the data sequence curve (Deng, 2002). It is applicable no matter whether the sample size is large of small and no matter if the data satisfy a certain conventional distribution or not (Liu & Lin, 2010). GRA has been employed in various fields, where it has produced promising results, as it is not limited to data distribution and quantity (Jiang et al., 2016; Yin, 2013). In practice, a large number of practical problems analysis need to consider the characteristics of cross-sectional and time series at the same time (Liu et al., 2013). However, the traditional GRA is more suitable for relational analysis of cross-sectional data or time series data, rather than panel data (Cui & Liu, 2015). In order to extend the application field of GRA, some scholars introduced the basic concepts of the GRA into the similarity analysis of panel data, and construct the grey matrix relational analysis model (GMRA) of multi index panel data with spatio-temporal characteristics (Qian et al., 2013; Cui and Liu, 2015; Li et al., 2015). Compared to the traditional GRA, the GMRA analyze the similarity between reference matrix and comparative matrix, considering the characteristics of cross-sectional and time series simultaneously. Therefore, it is interesting to investigate the analyzing capacity of GMRA and apply GMRA to analyze China's IFDI determinants.

The remainder of this paper is structured as follows: Section 2 is a brief introduction of grey matrix relational analysis for panel data. Section 3 examines the validity of grey matrix relational analysis using real case of IFDI determinants of China. Section 4 discusses the outcomes and presents conclusions.

2. METHODOLOGY

2.1. Matrix sequence of panel data

A panel data set, while having both a cross-sectional and a time series dimension, differs in some important respects from an independently pooled cross section (Wooldridge, 2015). In other word, a panel of data consists of a group of cross-sectional units who are observed over time. From the perspective of cross-section, the index reflects the sectional development level of different individuals at the same period, whereas under the perspective of longitudinal section, each index represents the dynamic development level at the different period. Therefore, the observed value of each individual at different period can be corresponding to the different points in the matrix.

The value of indicator j $(j=1,2,\ldots,m)$ for individual i $(i=1,2,\ldots,n)$ at time t $(t=1,2,\ldots,T)$ is a_{ij}^{t}. Then, the matrix of panel data containing the time t and individual i for indicator j is presented as follow:

$$a_j = \begin{bmatrix} a_{1j}^{1} & a_{1j}^{2} & \cdots & a_{1j}^{T} \\ a_{2j}^{1} & a_{2j}^{2} & \cdots & a_{2j}^{T} \\ \vdots & \vdots & \ddots & \vdots \\ a_{nj}^{1} & a_{nj}^{2} & \cdots & a_{nj}^{T} \end{bmatrix} \quad (1)$$

2.2. Characteristics of cross-sectional and time series dimensions

Each matrix of panel data represents the individual behavior, aiming to accurately describe the characteristics of cross-sectional and time dimensions of the panel data. The column of the matrix describes the cross-sectional characteristics of each individual in a given period of time, while the row of the matrix reflects the temporal characteristics of the individual. In this paper, the degree of dissimilarity is used to counter measure the similarity between individuals, specifically, the smaller the degree of dissimilarity, the greater the similarity between individuals, and vice versa (Zhang, 2013). In addition, from the perspective of cross-sectional, the relative growth rate is used to express the difference of the development speed between individuals; from the perspective of time-series, the dynamic growth rate is used to measure the growth rate difference for same index at different periods.

Different indicators are measured using different units, so the impacts of some indicators may be neglected. Before calculating the relations, the original data should be normalized to avoid data distortion.

$$x_{ij}^{t} = \frac{a_{ij}^{t}}{a_{ij}^{t_0}} \quad (2)$$

Relative development rate for individuals α and β at same time period is

$$r_j^{t} = \frac{x_{\alpha j}^{t} - x_{\beta j}^{t}}{x_{\alpha j}^{t}} \quad (3)$$

where d_j^{1} represents the difference of relative development rate between two individuals.

Dynamic growth rate for individuals α and β at different time period, d_j^{2} is

$$d_j^{t} = \frac{x_{\alpha j}^{t} - x_{\alpha j}^{t-1}}{x_{\alpha j}^{t-1}} - \frac{x_{\beta j}^{t} - x_{\beta j}^{t-1}}{x_{\beta j}^{t-1}} \quad (4)$$

where $t = 2, 3, \ldots, T$.

$x_{\alpha j}^{t}-x_{\alpha j}^{t-1}$ and $x_{\beta j}^{t}-x_{\beta j}^{t-1}$ represent the indicators dynamic change of two adjacent time period, respectively. If the indicators change with the time in the same direction, the degree of dissimilarity will be small, which indicates the higher similarity between individuals.

2.3. Grey matrix relational analysis for panel data

Before the grey relational coefficient and grey relational grade calculation, firstly, the reference sequence and comparative sequence need to be set. Similarly, in the grey matrix relational analysis for panel data, it is necessary to set the reference matrix sequence and comparison matrix sequence before computation. X_0 and $X_1, X_2, \ldots, X_m$ are assumed as the reference matrix (behavior factor) and the comparative matrix (influential factors), respectively.

The grey matrix similarity coefficient for X_0 and $X_1, X_2, \ldots, X_m$ can be calculated by equations as follows:

$$\gamma_j^1(t)=\frac{1}{1+\left|r_j^t\right|} \quad (5)$$

$$\gamma_j^2(t)=\frac{1}{1+\left|d_j^t\right|} \quad (6)$$

where $r_j^t=\dfrac{x_{ij}^t-x_{i0}^t}{x_{i0}^t}$, and $d_j^t=\dfrac{x_{ij}^t-x_{ij}^{t-1}}{x_{ij}^{t-1}}-\dfrac{x_{i0}^t-x_{i0}^{t-1}}{x_{i0}^{t-1}}$.

The relational grade of relative development rate and dynamic growth rate are as follows:

$$\gamma^1=\frac{1}{T}\sum_{t=1}^{T}\gamma_j^1(t) \quad (7)$$

$$\gamma^2=\frac{1}{T}\sum_{t=1}^{T}\gamma_j^2(t) \quad (8)$$

Finally, the grey matrix relational grade can be calculated by equation as follows:

$$\gamma_{j0}=w\gamma^1+(1-w)\gamma^2 \quad (9)$$

where $0<w<1$, and w is usually specified as 0.5 (Cui & Liu, 2015).

If $\gamma_{10}\geq\gamma_{20}$, we conclude that the relational grade between X_1 and X_0 is superior to the relational grade between X_2 and X_0, denoted as $X_1\succ X_2$.

3. EMPIRICAL STUDY

In this study, IFDI determinants of Jiangsu Province (JS), Guangdong Province (GD), Shanghai City (SH), Zhejiang Province (ZJ), and Tianjin City (TJ), the top 5 IFDI regions in China, are taken as an example to verify the validity and practicability of the grey matrix relational analysis model. These provinces or cities are not only the top 5 IFDI regions, but also the relatively developed regions in China, no matter measured by the economic aggregate, population, or the percentage from the whole economy.

3.1 Determinants of IFDI

The IFDI of different provinces and cities, as the reference matrix, are presented by total amount of FDI actually utilized. It captures the flow of investment made by foreign investors in a host country for the purposes of acquiring lasting management interests.

Any increase in the size of the local market is viewed by market seeking FDIs as an opportunity to enter host market (Asiedu, 2002). Both of Mottaleb and Kalirajan (2010) and Asiedu (2006) ascribed that the positive relationship between market size was positively related to FDI in different sample country. Therefore, FDI will be attracted to countries with higher GDP per capita as it demonstrates large market size. In this paper, GDP per capita is used to measure the size of the host country's domestic market.

Blonigen and Piger (2014) found the natural resources have positive impact on FDI. Kolstad and Wiig (2012) also found a positive significant relationship between Chinese outward FDI and natural resources. Bellak et al. (2008) used measures of information and communication infrastructure and found these determinants had positive influences on FDI. Kinda (2010) attributed the negative relationship between poor infrastructure and FDI to the increased transaction costs incurred as well as operational difficulties for foreign firms in the host country. Following the literatures, this study used two measures to capture the availability of resources, which are investment in infrastructure and primary energy output. Credible investment in infrastructure can stimulate FDI through its positive impact on the productivity of investment. The availability of natural resources output is an incentive for FDI especially in the case of developing countries. Hence, the region with higher investment in infrastructure and natural resources will attract FDI.

There are four variable to capture the regional efficiency. The return on capital, trade openness, and inflation are applied to capture macroeconomic factors while enrollment of regular institutions of higher education are used to capture the availability of human resources. Ivohasina and Hamori (2005) found a positive relationship between return on capital and FDI because sample countries have scarce available finance and the lowest capital-labour ratio, and hence the highest return on capital. In theory, FDI will go to countries that offer a higher return on capital. This study used the inverse of real GDP per capital to proxy the return on capital as in Asiedu (2002). Host countries with open economies will be attractive especially to export oriented FDIs because of transaction costs that result from market imperfections will be reduced (Anyanwu, 2012; Masuku and Dlamini, 2010). Based on the previous studies, trade openness was measured as the share of trade (imports and exports) in GDP. Study by Wadhwa and Reddy (2012) showed that inflation was negatively related with FDI due to macroeconomic instability and potential risk for foreign investors. This study measured inflation as the annual percentage change in the cost of acquiring goods and services in the host country. Quality of human capital and the raising of human capital through education and skill acquisition positively influence FDI. The enrollment of regular institutions of higher education is employed to capture the availability and quality of human capital in this study.

Opportunities offed for the exchange of localized tacit knowledge, ideas, interactive learning, and the need to harness such assets have become very important strategic motives for FDI (Dunning, 1988). Moreover, Pradhan (2010) showed that the desire to acquire strategic assets through the accumulation of new technology, marketing skills and operational capabilities has led Indian MNEs to move some of their activities across borders. The study used the internal expenditure on R&D and number of R&D personnel to capture the strategic asset seeking variable. Higher R&D expenditures and numerous R&D personnel will enable foreign firms to accumulate new technology, marketing skills, and operational capabilities in host country. As described above, all of the variable terms of FDI, market seeking variable, resource seeking variable, efficiency seeking variable, and strategic asset seeking variable are shown in table 1.

Table 1 Variable description

Aspect	Variable
FDI	I_0 Total amount of FDI actually utilized
Market seeking	I_1 GDP per capita
Resource seeking	I_2 Investment in infrastructure
	I_3 Primary energy output
Efficiency seeking	I_4 Return on capital
	I_5 Trade openness
	I_6 Inflation
	I_7 Enrollment of regular institutions of higher education
Strategic asset seeking	I_8 Internal expenditure on R&D
	I_9 Number of R&D personnel

Source: authors

3.2 Data collection

The paper uses grey relational matrix relational analysis on top 5 IFDI regions in China for period 2011 to 2015. All the data used in this paper are collected from, the China Statistic Yearbook (2012–2016), Statistic Yearbook (2012–2016) for different province and cities, and Economic and Social Development Statistics Bulletin (2011–2015) for different province and cities. Table 2 reports the summary statistics.

Table 2 Summary statistics

	Mean	Std. Dev.	Min	Max
IFDI (I_0)	1996166.76	784417.82	181660	3575956
GDP per capita (I_1)	78581	16853.88	107960	50842
Investment in infrastructure (I_2)	19017.01	11947.02	45905.17	5067.09
Primary energy output (I_3)	2987.99	2093.33	6862.51	57.66
Return on capital (I_4)	0.000013	0.000003	0.00002	0.00001
Trade openness (I_5)	0.16	0.17	0.88	0.03
Inflation (I_6)	102.86	1.27	105.40	101.40
Enrollment of regular institutions of higher education (I_7)	102.17	62.51	187.13	44.97
Internal expenditure on R&D (I_8)	976.61	456.45	1801.23	297.76
Number of R&D personnel (I_9)	3977.03	19655.43	98.23	115.00

Source: authors

3.3 Empirical results

According to the methodology aforementioned in the Section 2, the grey matrix relational model is used to calculate the relational grade between IFDI and market seeking variable, resource seeking variables, efficiency seeking variables, and strategic asset seeking variables of the top 5 IFDI regions in China. Table 3 shows the grey matrix relational grade between IFDI and its determinants.

As can be seen from Table 3, there exist higher relational grade between IFDI and the GDP per capita, Number of R&D personnel, enrollment of regular institutions of higher education, internal expenditure on R&D, and primary energy output, rather than the other determinants.

Table 3 Grey matrix relational grades between FDI and its determinants

	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9
JS	0.838	0.781	0.886	0.910	0.732	0.897	0.893	0.787	0.823
GD	0.976	0.883	0.944	0.861	0.893	0.914	0.980	0.885	0.943
SH	0.676	0.678	0.663	0.634	0.628	0.645	0.649	0.708	0.682
ZJ	0.960	0.891	0.886	0.832	0.648	0.876	0.915	0.948	0.954
TJ	0.925	0.980	0.871	0.815	0.827	0.855	0.895	0.950	0.953
Mean	0.875	0.842	0.850	0.810	0.746	0.837	0.866	0.855	0.871

Source: authors

Under the perspective of different provinces and cities, the rankings of the relational grade between FDI and its determinants are displayed in Table 3. Here the relational grade between FDI and its determinants in Jiangsu Province is taken as an example to explain the grey relational order. Thus, the descending order of relational grade between FDI and its determinants in Jiangsu Province is return on capital (I_4) $\succ$ inflation (I_6) $\succ$ enrollment of regular institutions of higher education (I_7) ≻ primary energy output (I_3) ≻ GDP per capita (I_1) ≻ number of R&D personnel (I_9) ≻ internal expenditure on R&D (I_8) ≻ investment in infrastructure (I_2) ≻ trade openness (I_5).

Table 4 Ranking of relational grades between FDI and its determinants

Variable	JS	GD	SH	ZJ	TJ
GDP per capita (I_1)	5	2	4	1	4
Investment in infrastructure (I_2)	8	8	3	5	1
Primary energy output (I_3)	4	3	5	6	6
Return on capital (I_4)	1	9	8	8	9
Trade openness (I_5)	9	6	9	9	9
Inflation (I_6)	2	5	7	7	7
Enrollment of regular institutions of higher education (I_7)	3	1	6	4	5
Internal expenditure on R&D (I_8)	7	7	1	3	3
Number of R&D personnel (I_9)	6	4	2	2	2

Source: authors

As can be found from Table 4, the motivations of foreign firm direct invest in sample regions are different. The IFDI in Jiangsu Province have been motivated by efficiency seeking variables. IFDI in Guangdong is mostly likely to be motivated by efficiency and market seeking variables while IFDI in Zhejiang is most likely to be influenced by market and strategic asset seeking variable. Recent IFDI activities in Shanghai are motivated by strategic asset seeking variables while IFDI in Tianjin is most likely to be motivated by resource and strategic asset seeking variables. Due to the difference in economic development situations of each province and city, the performances of IFDI determinants are various. The foreign investors can make a decision on the location for investment depending on the performance of IFDI determinants in different provinces and cities. For example, the foreign investors, with the motives of market seeking, can choose to invest in Zhejiang Province.

4. CONCLUSIONS

A grey matrix relational analysis model for panel data is developed and illustrated in this paper. The grey matrix relational analysis model use relative development rate and dynamic growth rate to present the cross-sectional and time-series characteristics of panel data. Therefore, the grey matrix relational analysis model makes up for the deficiency of traditional GRA model, which can only deal with cross-sectional or time-series data at a time, and considers cross-sectional and time-series characteristics simultaneously.

In this study, we take the FDI determinants of top 5 IFDI regions in China as an example to verify the validity and practicability of the grey matrix relational analysis model. The results indicate that GDP per capita, enrollment of regular institutions of higher education, and internal expenditure on R&D are the primary determinants of IFDI in sample provinces and cities, while the determinants of IFDI in different provinces and cities are various. Moreover, the results show that recent IFDI in China have been motivated by market seeking and efficiency seeking variables. Because of the different characteristics in different regions, the motives of FDI are various. The implication for policy makers is that in order to attract IFDI, governments need to pay more attention to their policies to advance the development of key determinants.

In this study, the weights of relative development rate and dynamic growth rate are equal, specified as 0.5, when calculating the grey matrix relational grade. However, equal weight for the importance of the relative development rate and dynamic growth rate cannot reflect the importance of these two rates. Therefore, future research will explore the optimal weight by using the sensitivity analysis or a certain optimal algorithm.

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