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Research and Application of Coupling System Model in China's Financial Eco-system Analysis

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ABSTRACT

The frequent outbreak of the financial crises, not only let the governments pay more attention to the financial security issue, but also make scholars realize the importance of coordinated development of finance. But how to quantify the degree of coordinated development has always been a difficulty in their search of financial development. Referred by coupled coordination concept in physics and we build new perspective by combining principal component analysis and coupling system model. This could be a scientific measurement of development state of financial eco-system in China. According to 29 provincial statistical data from 1996 to 2010, a comprehensive development index of China's financial eco-system is designed by means of principal component analysis. This is the first time using coupling system model to calculate the coordinated development status of financial eco-system in China. The results indicates that the coordination of financial eco-system in China overall is in good condition, but the province coordination imbalance has already been obvious, showing significant "east outperformed west" situation. Through comparing coordination trend of various provinces and cities, we found the pattern which is the coordination level slightly decreased as well as the one increased first and then decreased is the most common form during the study. The policy implications could be that well-coordinated provinces should pay more attention to enhance the quality of financial assets and optimize resource allocations. Barely coordinated provinces should base on the development of number and scale of the financial ecological principal parts, and serious imbalanced provinces should initially develop and manage the financial eco-environment.

Keywords: Coupling system model, Financial eco-system, Coordinated development.

1. INTRODUCTION

The concept of financial ecology was first proposed by British Economist Alfred Marshall (1890) in his famous book “Principles of Economics”. He made a plea for the use of some kind of biological analogy in economics. But until the1990s, the frequently occurring financial crises made scholars pay more attention to this theory and currently it is still on the cutting edge of research. Patrick (1966) analyzed financial developments and economic growth in under developed areas and first describes the caution of financial developments and its position in economic growth. This could be regarded as the basis of this field for further research. After that, a number of scholars studied the development and stabilization of the financial system as well as the ecological evolution aspects (Merton, 1995; Demirguc-Kunt, 1998; Edwards, 2000; Qian, 2007; Houston, 2010). Although the idea of financial ecology is rooted in worldwide literature, we believe the clear concept of financial ecology was first concluded by a group of Chinese scholars. Bai (2001) first suggested the term of financial eco-environment. After that Zhou (2004) first analyzed issues which could affect financial ecology. Existing theory supports that financial system cannot create financial products and financial services by itself; the operation of financial system connects with local political structure, economic status, culture, legal system, etc. Moreover, principle parts in such environments and their behavior alienations could also affect financial systems (Xu, 2005). From the empirical evidences, the construction of an evaluation index system is the focus and principal problem as well. Xu (2005) built a regional financial eco-environment evaluation index system by adopting key figures such as capital return rate, the average bank loan return rate and weighted risk degree and so on. Besides, Duan, Li and Wu (2011) carried out researches on developed economic regions, Shanghai, Beijing and Chongqing are their targets. Sun (2013) and Jin and Xie (2014) took China as a whole or at provincial level. They adopted DEA, principal component analysis and grey correlation analysis in studies and calculated the development level and efficiency level of financial eco-systems.

We could conclude from above that existing research take consider of the regional financial eco-environment’s evaluation. The internal logic of principal parts in regional financial

eco-environment and the way of measurement is still a knowledge gap. To make up for defects of existing researches, coupling coordination degree as a concept is adopted to analyze the type, trend and degree of coordination in China regional financial eco-system. By computing and comparing coupling coordination degree of regional financial eco-system for 29 cities from east, middle and west China, we could define the type of each regional financial eco-system and their developing trends.

2. ESTIMATION METHODS and DATA DESCRIPTION

2.1 Estimation methods

First, taking st andardization of raw data matrix:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j^2} \tag{1}$$

Among them, x_{ij} represents i_{th} province and j_{th} index value, is average value of j_{th} for 29 provinces. s_j is st andard deviation of j_{th} index, Z_{ij} is i_{th} province and j_{th} index value after St andardization covariance matrix is not affected by dimension and order of magnitude.

Second, build a st andardized correlation coefficient matrix as below:

$$R = \begin{bmatrix} r_{11}\ r_{12} \cdots r_{ij} \\ r_{21}\ r_{22} \cdots r_{2j} \\ \cdots \\ r_{i1}\ r_{i2} \cdots r_{ij} \end{bmatrix} \tag{2}$$

Here r_{ij} is the correlation coefficient between primitive variable x_i and x_j.

Third, finding eigenvalue and eigenvector by solving characteristic equation:

$$|\lambda_i - R| = 0 \tag{3}$$

Using Jacobi approach find eigenvalue and put them in order of size, such as $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_i \geq 0$. Eigenvalue could be regarded as an impact strength index for principal components.

Fourth, variance contribution rate and accumulated variance contribution rate are computed. Contribution rate of principal component F_i is:

$$\frac{\lambda_k}{\sum_{i=1}^{p} \lambda_i} \tag{4}$$

Variance contribution rate represents the weight of principal component F_i's variance in all variances. The bigger the value, the better principal component F_i synthesizes information from Accumulated variance contribution rate is: $x_1, x_2, \cdots, x_p$

$$\sum_{k=1}^{m} \lambda_k \Big/ \sum_{i=1}^{p} \lambda_i \tag{5}$$

Accumulated variance contribution rate st ands for how much information the former k principal components from $x_1, x_2, \cdots, x_p$. In general, if the contribution rate of k principal components reaches 85%～95%, we believe these principal components of number k could include comparable amount of information from all indices. This mathematical adjustment reduces the number of variables and provides a more convenience way for analyzing. For this reason the eigenvalue is set at 85% being explained. The higher variance contribution rate means better explaining capacity of principal components and gives a better result.

Fifth, writing down principal components and compute principal component values of each sample. Principal are expressed by primitive variables $x_1, x_2, \cdots, x_p$ as below:

$$F_i = a_{1i}x_1 + a_{2i}x_2 + \cdots + a_{ni}x_n, i = 1, 2, ..., k \tag{6}$$

After computing the individual value of principal the comprehensive development level of financial ecological principal parts is the weighted average of individual principal components' variance contribution rate.

2.2 Model of coupling coordination degree

Commonly used coordination degrees refer to distance coordination degrees. It estimates the coordination relationship by computing the distance between static systems. Functions $f(x,t)$ and $g(x,t)$ are adopted to represent the comprehensive development level of financial eco-environment sub-systems and financial ecological principal parts sub-systems. Coordination measurement C_v is defined as the relative deviation coefficient of $f(x,t)$ and $g(x,t)$, the lower the better. Then we have:

$$C_v = \frac{2|f(x,t) - g(x,t)|}{f(x,t) + g(x,t)} \tag{7}$$

After deformation:

$$C_v = 2\sqrt{1 - \frac{|f(x,t) \times g(x,t)|}{\left|\frac{f(x,t) + g(x,t)}{2}\right|^2}} \tag{8}$$

Because $f(x,t) \times g(x,t) \leq \left|\frac{f(x,t) + g(x,t)}{2}\right|^2$,

when $f(x,t) \times g(x,t) \Big/ \left|\frac{f(x,t) + g(x,t)}{2}\right|^2$ has a larger

value, C_v has a smaller value, $f(x,t)$ and $g(x,t)$ have a better degree of coordination.

Define $cl = f(x,t) \times g(x,t) \Big/ \left| \frac{f(x,t) + g(x,t)}{2} \right|^2$, obviously, cl has its value between 0 and 1.

When $f(x,t) = g(x,t)$, when cl has the biggest value, C_v equals zero and that means smallest deviation. Then $f(x,t)$ and $g(x,t)$ are in the best coordinated development condition. Thus cl could at some degree reflects the degree of coordination of $f(x,t)$ and $g(x,t)$. By using above functions, define regional financial eco-systems' coordination degree as below:

$$C = \left\{ f(x,t) \times g(x,t) \Big/ \left| \frac{f(x,t) + g(x,t)}{2} \right|^2 \right\}^k \quad (9)$$

Here C is the coordination degree (or coordination K is adjustment coefficient. When K equals 2, C is the square of cl, or modified value of cl. If the value of cl is between 0 and 1, after taking square, C value will be smaller than cl. A smaller C value suggests a more inharmonious relationship. Lager C value is a symbol of better coordination state of financial eco-systems. Further optimizing operations give quantitative indicators to measure coordinated development degree of regional financial eco-environment and financial ecological principal parts, it is named financial eco-system's coupling coordination degree:

$$\begin{aligned} U &= (C \times T)^{\theta} \\ T &= \alpha f(x,t) + \beta g(x,t) \end{aligned} \quad (10)$$

Here U is coupling coordination degree, C is coordination degree and T is the financial eco-system's evaluation index of the comprehensive development level, it represents overall effect and level of two financial ecological sub-systems, α, β, θ are undetermined coefficients, all set value 0.5.

2.3 Index description and data sources

Regional financial eco-environment and financial ecological principal parts data for our analyses are public data from government's statistical departments. Among them Regional financial eco-environment data comes from China statistical yearbook (1997-2011). Financial ecological principal parts data is collected from China financial Yearbook (1997-2011), Chinese securities and futures statistical yearbook (1997-2011). Other reference resources are China compendium of statistics 1949-2009, China statistical yearbook for regional economy and related provincial statistical yearbook data to guarantee the reliability. These indexes are listed in Table 1.

Table 1. Index for regional financial eco-systems

Targets	Factors
Economic foundation	GDP per capita/Per capita gross industrial production/Tertiary Industry Proportion/Per capita total investment in fixed assets/Per capita investment in real estate development/ Per capita total retail sales of social consumer goods
Degree of economic openness	Total imports and exports/ Inbound tourism foreign exchange earnings/Foreign direct investment/ Total import goods of foreign-funded enterprises/At the end of the year the number of enterprises in the registration of foreign-funded enterprises
Enterprise financial integrity	Gross value of industrial output/Annual average balance of fixed assets/Annual average balance of circulating assets/Number of industrial enterprises/Total profit(Index for Industrial Enterprises above Designated Size only)
Local government services	Per capita income/Per capita expenditure/Tax revenue/State organ personnel accounted for
Residential living st anders	Per capita wages/Per capita disposable income/Per capita consumption expenditure/Volume of post /Number of local telephones/Power consumption
Humanistic environment	Per capita government education expenditure/Number of educational infrastructure/Number of full-time teachers in colleges and universities
Social security	Pension expenditure/the number participation of endowment insurance at the end of the year/The unemployment insurance fund expenditure/Number of urban community service facilities
Financial ecology principal parts	Deposits and loans of financial institutions/All financial institutions to loan to deposit ratio/ Premium income/Insurance density/The stock market turnover/The number of listing corporations/ The stock market value

3. EMPIRICAL RESULTS ANALYSES

3.1 Type comparison of coupling coordination degrees

The coupling coordination degree of regional financial eco-system refers to the coordinated development level of regional financial eco-system. It ranges from 0 to 1; closer to 1 represents a better condition in coordinated development. Target regional financial eco-systems are classified by grades of coupling coordination degrees. The time span is 1996 to 2010 and the research targets are 29 province level administrative regions. The results are listed in Table 2.

Table 2. Types of 29 provincial financial eco-systems' coupling coordination

States of Coupling Coordination	Types of Coupling Coordination	Provinces
Well coordinated development	Synchronous type financial eco-environment and financial ecological principal parts	Shanghai, Guangdong
	Financial eco-environment lag behind financial ecological principal parts	Beijing
Moderate coordinated development	Financial ecological principal parts lag behind financial eco-environment	Liaoning, Jiangsu, Zhejiang, Sh andong
	Financial eco-environment lag behind financial ecological principal parts	Sichuan
Basic coordination development	Financial ecological principal parts lag behind financial eco-environment	Tianjin, Heilongjiang, Hubei, Hunan, Shaanxi
	Synchronous type financial eco-environment and financial ecological principal parts	Hebei, Henan
	Financial eco-environment lag behind financial ecological principal parts	Fujian, Shanxi, Anhui
Moderate recession	Gain and loss type financial ecological principal parts	Jilin, Inner Mongolia
	Gain and loss type financial eco-environment	Jiangxi, Yunnan, Gansu, Xinjiang, Guangxi
Severe recession	Mutual loss type financial eco-environment and financial ecological principal parts	Qinghai
	Gain and loss type financial eco-environment	Hainan, Guizhou, Ningxia

The good coordination development class has a value of coupling coordination degree between 0.8 and 1, Shanghai (0.97), Guangdong (0.97) and Beijing (0.93) belong to this category. When referring to coordination type, Shanghai and Guangdong belong to synchronous type financial eco-environment and financial ecological principal parts while Beijing has financial eco-environment lag behind financial ecological principal parts. It indicates that these provinces not only have big coupling coordination degree values, but also achieve the best coordination developments. Judging from the developments of two financial ecological subsystems' comprehensive development levels, both financial eco-environment and financial ecological principal parts in these 3 provinces have the rank almost no lower than top 3. Coupling coordination degree between 0.6 and 0.8 belongs to Moderate coordinated development type, 5 target provinces are found in this group. Out of them Liaoning (0.62), Jiangsu (0.78), Zhejiang (0.71) and Sh andong (0.69) have financial ecological principal parts lag behind while Sichuan (0.65) has financial eco-environment lag behind. The above results indicate that about half of east provinces belong to moderate coordinated development and they all have financial ecological principal parts that lag behind. Coupling coordination degree between 0.4 and 0.6 is the range for basic coordination development type, 10 provinces belong to this group. Tianjin (0.5), Heilongjiang (0.49), Hubei (0.53), Hunan (0.47), Shaanxi (0.45) belong to the type financial ecological principal parts that lag behind, Henan (0.51), Hebei (0.55) are Synchronous type financial eco-environment and financial ecological principal parts, Fujian (0.52), Shanxi (0.42), Anhui (0.41) have financial eco-environment lag behind. We could find 6 provinces out of central China region which belong to this coordination development class and thus it is also the typical coordination development class of financial ecological subsystems in central China. Coupling coordination degree value between 0.2 and 0.4 is an indication of moderate recession and there are 7 provinces in this group. Jilin (0.37) and Inner Mongolia (0.33) have gain and loss type financial ecological principal parts while Jiangxi (0.34), Yunnan (0.34), Gansu (0.21), Xinjiang (0.38) and Guangxi (0.33) have gain and loss type financial eco-environment. It is not difficult to find provinces from the west China area that are main members in this coupling coordination type. Coupling coordination degree between 0.0 and 0.2 is defined as severe recession and 4 provinces are found in this group. Hainan (0.01) is the only east province and the other 3 provinces are from west China, namely Qinghai (0.0), Guizhou (0.16) and Ningxia (0.05). This coupling coordination type is the worst type of all. Hainan is the only one that could be regarded as a quasi-east province and the other 3 members are all from the west. We believe it has some relationship with their locations where regional economic environment developments are all lag behind. Disorderly developments in financial eco-system could have already hedged their two subsystems' coupling coordination developments.

3.2 Time comparison of coupling coordination degrees

It's also valuable to investigate the different coordination developments and trends of financial eco-system according to different time period, empirically for the 9th 5-Year plan, 10th 5-Year plan and 11th 5-Year plan periods. Similar techniques are adopted in this analysis and the whole time period is 1996-2010. The computing results are listed in table3. If we take East, Central and West China regions as the scale, they all performed an inverted U shape trend for the whole three periods. It could be regarded as a symbol that the 10th 5-Year plan period has the highest financial eco-system coupling coordination degrees for all three regions. But this result is not significant at provincial level in which we can't find a dominant pattern and four patterns are found at provincial level (Table 3).

Table 3. Evolution trends of financial eco-systems' coupling coordination degrees for 29 provinces

Provinces	Score of Coupling Coordination Degree			Trends
	9_{th} 5Y plan	10_{th} 5Y plan	11_{th} 5Y plan	
Beijing	0.81	0.90	0.94	↑
Tianjin	0.49	0.46	0.45	↓
Hebei	0.54	0.52	0.47	↓
Liaoning	0.67	0.62	0.55	↓
Shanghai	0.93	1.00	0.97	↑ and ↓
Jiangsu	0.74	0.77	0.76	↑ and ↓
Zhejiang	0.68	0.7	0.72	↑
Fujian	0.53	0.51	0.49	↓
Sh andong	0.68	0.68	0.66	↓
Guangdong	0.97	0.96	0.93	↓
Hainan	0.22	0.00	0.15	↓ and ↑
East China	0.74	0.75	0.73	↑ and ↓
Shanxi	0.37	0.40	0.36	↑ and ↓
Jilin	0.41	0.37	0.34	↓
Heilongjiang	0.52	0.49	0.38	↓
Anhui	0.37	0.41	0.35	↑ and ↓
Jiangxi	0.28	0.33	0.26	↑ and ↓
Henan	0.48	0.50	0.44	↑ and ↓
Hubei	0.53	0.53	0.46	↓
Hunan	0.44	0.46	0.40	↑ and ↓
Central China	0.4	0.41	0.34	↑ and ↓
Sichuan	0.59	0.62	0.58	↑ and ↓
Inner Mongolia	0.30	0.32	0.31	↑ and ↓
Guizhou	0.00	0.18	0.00	↑ and ↓
Yunnan	0.35	0.35	0.28	↓
Shaanxi	0.42	0.43	0.36	↑ and ↓
Gansu	0.19	0.25	0.04	↑ and ↓
Qinghai	0.00	0.00	0.00	→
Xinjiang	0.37	0.37	0.32	↓
Guangxi	0.29	0.32	0.22	↑ and ↓
Ningxia	0.03	0.14	0.13	↑ and ↓
West China	0.33	0.35	0.31	↑ and ↓
All	0.53	0.54	0.51	↑ and ↓

Note: 1. ↑ representing Increased consistently, ↓ representing Decreased consistently, ↑ and ↓ representing Increased first and decreased afterwards, ↓ and ↑ representing Decreased first and increased afterwards, → representing Remain unchanged. 2. Data source: Collected by writers and computed by SPSS19.0 software.

First type, coupling coordination degree of regional financial eco-system increased consistently during the three economic periods. Two east provinces are in this group, Beijing (0.81-0.94) made the highest coupling coordination degree progress in 29 provinces, starting from the edge of moderate coordinated development to well-coordinated development. Zhejiang (0.68-0.72) has increased coupling coordination degree of regional financial eco-system at a moderate level; the score range is kept in moderate coordinated development level.

Type two, coupling coordination degree of regional financial eco-system remained unchanged. Qinghai from West China is the only one that belongs to this category. Throughout the research process, Qinghai didn't show solid evidences in the developments of financial eco-environment and financial ecological principal parts. Two reasons could lead to this result, first, these two sub-systems have already lain on the bottom of the 29 provinces. Second, these two sub-systems may not have enough mutual promotion effects; one could be a hedge for the other's temporary incensement. All the above factors kept Qinghai' coupling coordination degree at an extremely low level and has no sign of improvement.

Type three, coupling coordination degree of regional financial eco-system decreased consistently during the three research periods. 11 provinces in total, the eastern zone has 6, respectively is Tianjin, Hebei, Liaoning, Fujian, Sh andong and Guangdong. 3 in central China, they are Jilin, Heilongjiang and Hubei. Yunnan and Xinjiang are two west provinces in this group. On the individual level, Heilongjiang (0.52-0.38) kept the largest decline range while Sh andong (0.68-0.66) is the smallest one. Three provinces changed their coupling coordination type due to the change of coupling coordination degrees. Liaoning (0.67-0.55) degraded from moderate coordinated development type to basic

coordination development type. Jilin (0.41-0.34) degraded from basic coordination development type to moderate recession type. Heilongjiang (0.52-0.38) degraded from basic coordination development type to moderate recession type. The other provinces maintained their coupling coordination type for the whole research period.

Type four, coupling coordination degree of regional financial eco-system increased first and decreased afterwards. 14 provinces are put in this group. Shanghai and Jiangsu from East China, Shanxi, Anhui, Jiangxi, Henan and Hunan from central China, Sichuan, Inner Mongolia, Guizhou, Shaanxi, Gansu, Guangxi and Ningxia from west China. We could conclude from the above information that regional financial eco-system coordination developments have more fluctuations in central and west China, precisely more than 85%. Guizhou kept the largest fluctuation range from 0 in the 9th 5-Year Plan period to 0.18 in the 10th 5-Year Plan period and then back to 0 again in the 11th 5-Year Plan period. Gansu takes the 2nd place and its coupling coordination degree for the three research periods are 0.19, 0.25 and 0.04. Inner Mongolia has the smallest fluctuation range which is 0.03.

4. CONCLUSIONS

This research adopts 29 China provincial statistical data from 1996 to 2010 and empirically examined the coordinated developments of regional financial eco-environment and financial ecological principal parts. The main difficulty in this research is qualitative analyses are usually incomplete in feature, so it can't reflect the relationship between two sub-systems with accuracy. Moreover, the basic coordinated development condition of regional financial eco-environment is a concept of clear connotation but unclear denotation. Thus the concept of coupling coordination degree is selected for description and it is used as an evaluation index in empirical tests of coordinated development levels of financial eco-systems. Results indicate that most of the provinces are in good coordinated development condition, about 60% of the provinces are no worse than basic coordination development type. Only 4 provinces are in serious imbalance and most of them are from west China. But coordination development types in three major economic regions appear to be obviously imbalanced. The trend of financial eco-systems' coupling coordination curve from 1996 to 2010 suggests a ladder fall from east to west. The annual average coupling coordination degree values for east, central and west are 0.72, 0.42 and 0.36 respectively. For the three research periods, Beijing is the one that increased coordination development level consistently and made the biggest progress such as upgrade in development type. Heilongjiang is the one that made the largest decrease, starting from basic coordination development to moderate recession type. That may be due to significant decline in the competitiveness of financial eco-environment and financial ecological principal parts. Qinghai remained stable during the research period. The reason could be backward financial eco-environment and financial ecological principal parts interact with each other and lead to a long term imbalance status in financial eco-systems.

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