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Searching for niche market for engineering consultants

Case of regional supervision systems in China

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Abstract

Purpose – A growing number of foreign consulting firms have been engaged in the Chinese construction market where the supervision system, as a kind of engineering consultant service has been widely implemented. However, the performance of supervision system varies significantly across regions. Therefore, foreign consulting firms are in desperate need of related performance benchmarking statistics to determine the niche market. A major issue is lack of a quantitative method to objectively evaluate regional supervision systems' performance. The paper aims to discuss these issues.

Design/methodology/approach – A new regional construction supervision system benchmarking model was developed via the principal component analysis method. This model is based on key performance indicators drawn from annual official statistics. This list of key indicators was refined by means of a focus group with selected experts. Consequently the performances of all 31 regional supervision systems were calculated and ranked.

Findings – Results indicate a general gap between coastal and inland regions. The various development trends of top 10 regions are analyzed and the underlying reasons are explored. Furthermore, the regions deserving more attention or currently lacking in development are identified. The supervision industry in China is shifting from a labor-intensive industry to a knowledge-intensive industry.

Originality/value – The proposed model provides a single quantitative parameter to conveniently benchmark the performance of various regions. The findings are vital for the benchmarking and clarification of future endeavor of the regional supervision systems and for foreign enterprises that are planning to enter the real-estate market in China.

Keywords China, Benchmark, Principal component analysis, Focus group, Niche market, Supervision system

Paper type Research paper

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Introduction

There is growing concern from both public and government on the construction quality and safety in China. In 1980s, construction supervision system was introduced to China to assure these issues are properly dealt with and this system develops at a high speed ever since (Wang *et al.*, 2009a). As a reform in the Chinese construction sector, the construction supervision system aims to shift the paradigm of construction management and to enable professional supervision companies assisting investors to manage construction projects in terms of construction quality, safety and cost (MOHURD, 2007).

According to the official statistics, China has the largest new-built floor areas under construction, i.e. 2 billion m^2 each year. Correspondingly, there were more than 6,000 supervision companies and 760,000 supervision engineers in 2011 (Wang *et al.*, 2012) to satisfy the huge demand of supervision services. Nowadays the supervision services have been applied widely in the construction projects at different regions of China. For example, it is compulsory to engage supervision engineers in most construction projects and their roles have been legally defined (MOHURD, 2001). In addition, the massive Chinese real-estate market is more open than ever before and much more attractive to the global competitors (Zhao *et al.*, 2011). Foreign consulting firms are in desperate need of the performance benchmarking statistics related to the regional supervision system to determine the niche market. Indeed, benchmarking initiatives have been fostered and promoted by Constructing Excellence as a response to the industry for efficiency and productivity improvement (Pan, 2010; Nasir *et al.*, 2012). As a systematic process of comparing performance amongst similar organizations in key business activities, benchmarking offers critical inputs for defining improvement targets as well as promoting changes (Costa *et al.*, 2006). Due to the unbalanced economic development in different regions of China, the supervision systems around the country perform at different levels (Wang *et al.*, 2011). Yet there are no theoretical models available to rank the performance of supervision systems at the regional level. This makes it difficult to benchmark the supervision systems in different regions. Consequently, it is hard for foreign consulting firms to make strategic decisions about which local market is the best pinpoint target. On the other hand, the last decade has witnessed the gradually opening Chinese construction industry. A growing number of architectural, engineering and construction (AEC) firms have participated in high-profile projects in China such as the 2008 Beijing Olympic Games Venues. To bridge the gap, a model based on the principal component analysis (PCA) is proposed in this study to rank the performance of regional supervision systems. This model provides government and industry practitioners with useful inputs for both policy making and the sustainable development of regional supervision systems. The research findings also serve as a critical reference for foreign consulting enterprises that are interested in entering the real-estate market in China so that appropriate decisions can be made.

Construction supervision system

There is generally lack of empirical research on construction supervision in China (Yung and Lai, 2008). Pioneering research on the Chinese supervision industry focused on the qualitative introduction of the supervision system. For instance, Wang *et al.* (2007, 2009a, b) explored the risk and insurance issues in the national supervision system. Furthermore, Deng and Shi (2009) compared the differences between Chinese and the international engineering supervision so as to propose a risk-oriented innovation mechanism for the supervision industry. However, these studies predominantly focused on the supervision system at the national level. By contrast, regional supervision systems (meso-level) were largely overlooked.

Tools have also been used by the construction industry, especially from risk assessment and project management perspectives. Use of advanced simulation-based techniques can support the decision making in project risk management process (Hazır, 2015; Maghrebi *et al.*, 2015). For instance, Kang *et al.* (2015) developed a hybrid project management approach for informed decision making. This approach combines experiment method and discrete event simulation to understand complex issues within the project context so that business process can be improved. Inspired by previous research, this paper applies advanced statistical method to provide a benchmark tool for decision making.

As the supervision system develops, an increasing number of supervision firms enter the market. Management issues associated with supervision firms have attracted the attention from scholars, e.g. knowledge management (Wu, 2010); the sustainable development of supervision firms (Wang and Ren, 2007). Moreover, the last decade saw research methods shifting from qualitative discussion to quantitative analysis. However, vast majority of these studies were conducted at the firm level.

Empirical evidences were provided in some previous studies on the construction supervision system. Wang and Zou (2009) stated that the supervision services were mostly labor intensive. For instance, vast majority of the supervision firms provided quality and safety supervision at the construction stage. By contrast, the high-end supervision services such as project management service, cost consultation service were rarely provided.

Similarly, the regional hierarchical structures of companies varied significantly. There are different levels of hierarchical qualification are certified by Ministry of Housing and Urban-Rural Development (MOHURD) for supervision companies. Table I shows the requirements for companies of different classes. The first-class supervision companies are qualified to supervise larger and more complex projects compared to the second- and third-class supervision companies (MOHURD, 2007). Wang *et al.* (2010) suggested the quantity of first-class supervision companies in Beijing is much larger than that of the second- and third-class companies. By contrast, the quantity of second-class supervision companies is much larger than that of the other two kinds of companies in Chongqing (Wang *et al.*, 2010). The uneven distribution of the hierarchical structure leads to the head-on competitions in the local market. In addition, Wang *et al.* (2011) delineated the distribution of supervision professionals in different regions. Senior professionals refer to the senior supervision engineers who have senior titles in their supervision companies. The proportion of senior professionals in the industry is much lower than that of junior professionals, which hinders the provision of high-end supervision services.

If these problems are analyzed from a competition perspective, building blocks could be provided for the performance ranking model. This is because the regions with

Table I. Supervision company qualification standards

Class	Assets (RMB)	Technology director working experience (years)	Number of certified engineers	Safety and quality records	Others
First	⩾3 million	> 15	⩾25	0 safety and quality accident in the past 1 year	Availability of facility
Second	⩾1 million	> 10	⩾15	0 safety and quality accident in the past 1 year	Availability of facility
Third	⩾0.5 million	> 8	⩾5	N/A	Availability of facility

fewer problems may be more competitive. Therefore, the variables such as the number of first-class supervision companies, number of high-end service companies and number of senior professionals are included in the PCA model.

However, the issues of supervision system performance as an outcome of the aforementioned managerial efforts were not explored in literature. Vast majority of the existing studies focused either on the national level, e.g. the strategic, risk issues in particular, of the Chinese supervision system, or firm level, e.g. knowledge management and sustainable development issues. There is lack of performance analysis such as performance ranking of regional supervision systems. This meso-level knowledge gap hinders the sustainable development of regional supervision system. This is because the meso-level knowledge is useful for decision maker to identify the short-term and long-term objectives for improvement. Moreover, the meso-level knowledge is critical for foreign consulting enterprises to make strategic decisions about which local market as a pinpoint to enter.

There are 22 provinces, four municipalities directly under the administration of the central government and five autonomous regions in China (see Table V). Due to the unbalanced economic development across these regions, regional supervision systems develop at different levels. For example, the supervision system in Guangdong is implemented earlier than other regions (Wang *et al.*, 2010). As a result, the system in Guangdong is more sophisticated than those of other regions. In general, coastal regions are better developed than inland regions in terms of economic scale which is connected somehow with their local construction industry. Therefore, there is geographical niche issue that foreign engineering consulting firms should be aware of when making decisions to entry among different provinces in China. However, no theoretical models are available to clearly benchmark the performance of construction supervision systems in various regions.

Research method

Data collection

The only possible source of statistical data for regional supervision systems in China is the MOHURD of the People's Republic of China. The other possible approach is to survey individual supervision firms across the nation. However, it is practically impossible to collect the statistics of all regional supervision systems by individual surveys, considering the scale of the sector. The quantitative data of each regional supervision system are collected by MOHURD on an annual basis. The information MOHURD collects annually include: the total number of supervision firms; the amount of high-end supervision firms; the number of first-class supervision companies; business type of supervision companies (e.g. state-owned, public listed, joint venture, etc.); number of senior professionals; amount of supervision income; number of supervision workers; amount of profit; amount of revenue; amount of fixed asset; income from overseas operation; and the qualification of other consulting activities (e.g. tendering and bidding agent, quantity surveying, engineering design). The meso-level data of regional supervision systems from year 2005 to 2011 consist of economic data as well as human resource statistics for each region. These data are used for subsequent PCA.

PCA

PCA is utilized when the objective is to summarize as much original information as possible in a minimum number of components (Hair *et al.*, 2009; Phillips *et al.*, 2008; De Silva and Wimalaratne, 2012). It is a common practice to undertake PCA prior to cluster analysis so that dimensionality can be reduced (Jolliffe, 2002). Components are simply linear aggregates of correlated variables with a minimal loss of information. In technical terms, PCA takes into account the total variance instead of common variance as common factor analysis does. PCA has been commonly used in construction-related studies in order to draw the factor structure of a model (Phua and Rowlinson, 2004; Akintoye and Main, 2007; Leung *et al.*, 2014).

Suppose the sample covariance matrix denoted by **S** which is decomposed as following (Jolliffe, 2002):

$$\mathbf{S} = \sum_{i=1}^{p} \ell_i \mathbf{a}_i \mathbf{a}_i' = \mathbf{A}\mathbf{L}\mathbf{A}' \qquad (1)$$

where $\ell_1 > \ell_2 > \ldots > \ell_p \geqslant 0$ are the ordered eigenvalues of $\mathbf{S}$, $\mathbf{L} = diag\ (\ell_1, \ell_2, \ldots, \ell_p)$ and $\mathbf{a}_1, \ldots, \mathbf{a}_p$ are their corresponding normalized eigenvectors forming the column vectors of the orthogonal matrix $\mathbf{A} = (\mathbf{a}_1, \ldots, \mathbf{a}_p)$ and $\mathbf{A}'\mathbf{A} = \mathbf{I}_p =$ or $\mathbf{a}_i'\mathbf{a}_j = \begin{cases} 1 & \text{if} \quad i = j \\ 0 & \text{if} \quad i \neq j \end{cases}$.

The ith sample principal component (PC) is defined as Jolliffe (2002):

$$Y_i = \mathbf{a}_i'(\mathbf{x} - \overline{\mathbf{x}}) = a_{1i}(X_1 - \overline{x}_1) + a_{2i}(X_2 - \overline{x}_2) + \ldots + a_{pi}\left(X_p - \overline{x}_p\right) \qquad (2)$$

where $i = 1, \ldots, p$, $\boldsymbol{x}' = (X_1, X_2, \ldots, X_p)$, $\overline{\mathbf{x}}' = (\overline{x}_1, \overline{x}_2, \ldots, \overline{x}_p)$.

The first PC Y_1 has the largest variance among all possible linear aggregates; the second PC Y_2 has the largest variance among all possible linear aggregates that are uncorrelated with the first PC, and so on. The pth PC Y_p has the largest variance among all possible linear aggregates that are uncorrelated with all the preceding $(p-1)$ PCs (Jolliffe, 2002). Therefore, the first PC condenses the maximum information contained in the original variables. If the amount of information in the first PC is beyond a threshold value, it can be selected as a fairly good substitute of the original variables.

Data analysis

The regional supervision system data provided by MOHURD contain the indicators or independent variables for the PCA.

First, the provisional list of variables is prepared by the authors based on the statistics available from the MOHURD. A focus group was undertaken in order to finalize a list of indicators that are most appropriate to reflect the status of regional supervision system. As a type of group interview, the focus group is an effective approach to collect qualitative data from a group of experts with required knowledge and expertise (Morgan, 1988; Sim, 1998). The focus group approach has been applied in a number of construction-related studies (e.g. Love *et al.*, 2010; Ochieng *et al.*, 2013; Rogers *et al.*, 2015). Caution is required to determine the number of experts for the focus group to not only ensure diverse opinions but also allow the engagement of all participants (Zikmund *et al.*, 2010). Typical settings of focus group in construction-related studies are 10-15 experts each group with a duration of four to five hours (Singh and Holmström, 2015; Rogers *et al.*, 2015). Purposive sampling was employed to select experts that are qualified for participating in the focus group (Wong and Lin, 2014).

As a result, a total of 12 experts were invited and participated into this research. These experts have extensive experience of the supervision industry in China with qualification of registered supervision engineers. The participants of focus group were stratified according to various types of organizations related to the supervision industry covering academics (two), industry professionals (seven) and government officials who are managing the construction sector (three). The focus group session was facilitated by the research team aiming for in-depth discussion amongst experts. The foci of the discussion were: most appropriate indicators for the performance of regional supervision system; reliability of these statistics. The discussion flows across two days, average five hours per day. During the discussion, each expert must explain, from his or her own view, why one specific indicator is or is not a good indicator of regional supervision system performance. This is followed by the debate amongst experts who could comment and present their own opinions. Following an iterative process, consensus was reached about the most appropriate indicators to evaluate the performance of regional supervision system.

According to the outcome of focus group, the six variables were finally chosen to be the independent variables which can most likely reflect the competitiveness and performance of regional supervision systems, i.e. number of supervision companies (X1), number of first-class supervision companies (X2), number of high-end service companies (X3), number of senior professionals (X4), amount of supervision income (X5) and number of supervision workers (X6). The year 2005 to 2011 data are employed to build the PC model in the statistical analysis system (SAS) 9.2.

The correlation coefficients in Table II shows that the six variables are highly correlated with a maximum value of 0.932 and a minimum value of 0.675.

Independent variables	Number of supervision companies	Number of first-class supervision companies	Number of high-end service companies	Number of senior professionals	Amount of supervision income	Number of supervision workers
Number of supervision companies	1.000	0.880	0.892	0.754	0.708	0.883
Number of first-class supervision companies	0.880	1.000	0.887	0.855	0.919	0.944
Number of high-end service companies	0.892	0.887	1.000	0.675	0.755	0.832
Number of senior professionals	0.754	0.855	0.675	1.000	0.907	0.921
Amount of supervision income	0.708	0.919	0.755	0.907	1.000	0.932
Number of supervision workers	0.883	0.944	0.832	0.921	0.932	1.000

Table II. Correlation coefficients between variables

Therefore it is likely that the information contained in the variables could be condensed into fewer PCs.

The data from 2005 to 2011 are used for PCA in the SAS 9.2. The eigenvalues and variances explained by the first PC are shown in Table III. It can be seen that all the eigenvalues are greater than the threshold value of 1 and the first PC explains at least 86 percent of the total variance in each year. The results indicate that the first PC is a good substitute of the original six variables.

The loadings of all variables in Table IV are very close to each other. This indicates that the first PC represents the overall performance of regional supervision systems. For example, the first PC equation of year 2011 is:

$$PC1 = 0.4 \times X1 + 0.43 \times X2 + 0.39 \times X3 + 0.4 \times X4 + 0.41 \times X5 + 0.43 \times X6 \quad (3)$$

where X1 is the number of supervision companies, X2 the number of first-class supervision companies, X3 the number of high-end service companies, X4 the number of senior professionals, X5 the amount of supervision income, X6 the number of supervision workers.

The development trends of top 10 regions ranked by the first PC from 2005 to 2011 are shown in Figure 1. Except Hubei province which only entered the top 10 list in 2005, all the ten regions, i.e. Jiangsu, Beijing, Guangdong, Shandong, Shanghai, Zhejiang, Sichuan, Henan, Hebei and Liaoning retain their top performances from year 2005 to 2011. However, the development trends vary significantly between regions as shown in Figure 1. For instance, some regions such as Beijing, Guangdong, Liaoning and Shanghai have an apparent downward trend while the regions such as Jiangsu and Sichuan have an upward trend. In particular, the supervision system development in

Table III. Eigenvalue and the proportion of variance explained by the first PC

Year	Eigenvalue	Proportion
2005	5.30	0.88
2006	5.14	0.86
2007	5.18	0.86
2008	5.27	0.88
2009	5.27	0.88
2010	5.27	0.88
2011	5.25	0.88

Table IV. Loadings of variables to compute principal components

Year	Number of supervision companies	Number of first-class supervision companies	Number of high-end service companies	Number of senior professionals	Amount of supervision income	Number of supervision workers
2005	0.42	0.42	0.37	0.41	0.42	0.40
2006	0.38	0.42	0.40	0.41	0.42	0.43
2007	0.38	0.41	0.40	0.40	0.42	0.43
2008	0.39	0.42	0.39	0.40	0.41	0.43
2009	0.39	0.43	0.39	0.40	0.41	0.43
2010	0.39	0.43	0.39	0.40	0.41	0.43
2011	0.40	0.43	0.39	0.40	0.41	0.43

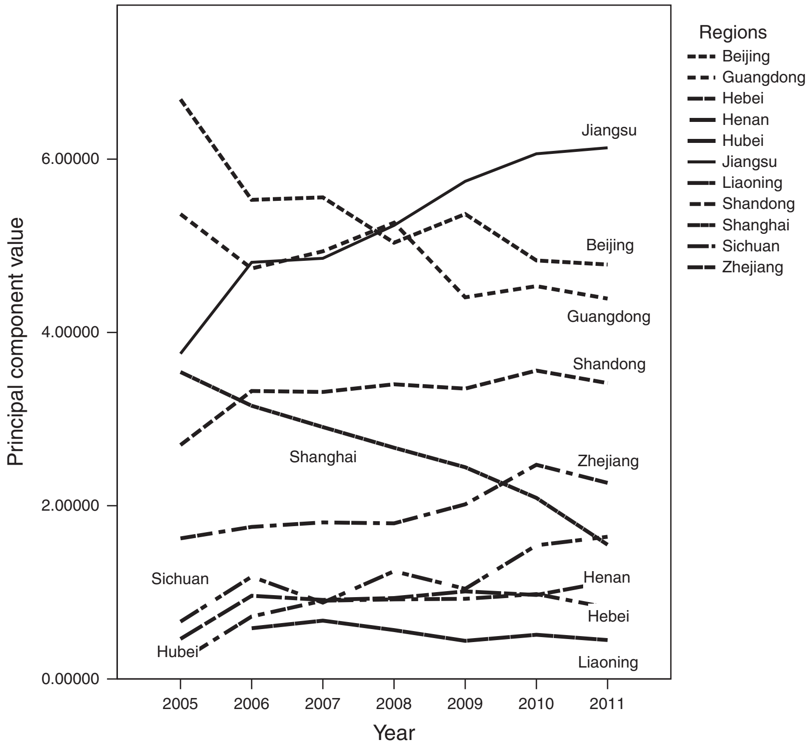


Figure 1. Top 10 regions of regional supervision systems from 2005 to 2011

Shanghai and Jiangsu provides a sharp contrast between downward and upward trends. The other regions develop in a zigzag manner.

The ascending trend of regional supervision system PC, to a certain degree, reflects the growing scale of construction locally and vice versa. For instance, the real-estate market of Jiangsu increased from RMB154.5 billion in 2005 to RMB429.9 billion in 2010 (Li, 2010). In particular, the real-estate market achieved a growth at an annual rate of approximately 30 percent on average in those six years. In 2011, there were more than 450 thousand units of indemnificatory apartments for the low-income people under construction. The large scale of constructions results in a great demand for supervision services which is aligned with the dramatic upward trend of Jiangsu in Figure 1. By contrast, the residential building investment growth rate reduced from 6 to 2 percent from 2004 to 2008 in Shanghai (Guo, 2010). The growth of the construction industry in Shanghai was slowing down which explained why the local supervision system has a dramatic descending trend.

Validation of the model

The 2011 statistics are analyzed for the purpose of validating the model. The number of PC is determined by Scree plot and variance explained (see Figure 2). Construct the so-called "Scree plot" of the eigenvalue ℓ_i on the vertical axis vs i on horizontal axis with equal intervals for $i = 1, \ldots, p$, and join the points into a decreasing polygon. To determine the appropriate number of components, the point at which the polygon levels off should be identified. The "Scree plot" on the left shows that the eigenvalue of the first component is approximately 5.3 and the eigenvalue of the second component is largely

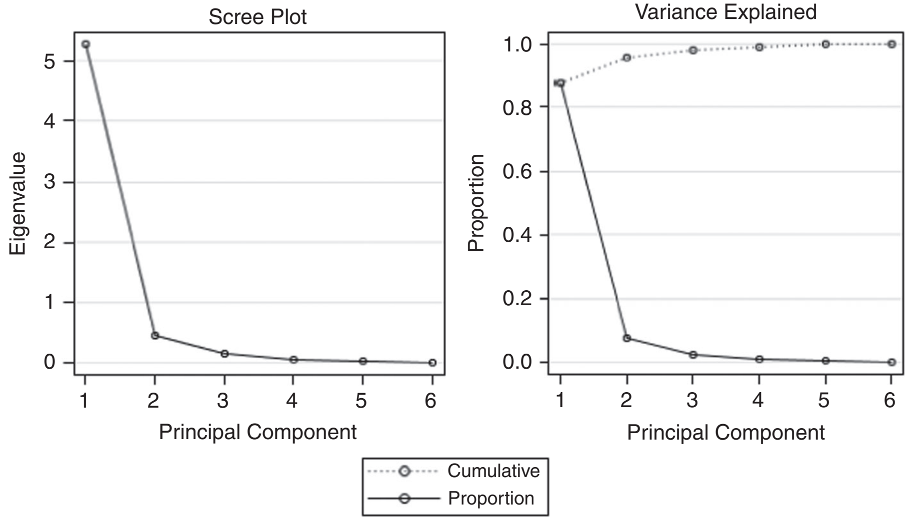


Figure 2.
Scree plot and variance explained

decreased to below 1.0. The elbow of the polygon suggests two PCs should be preserved. However, the "variance explained" plot on the right shows that more than 85 percent of total variance can be accounted with the first PC only. The second PC explains less than 8 percent of the total variance. Hence, the first PC is a good summary of the original information contained in the initial six variables. As a result, only the first PC is retained.

The correlation pattern plot is used to examine the correlations between the PCs and the original variables (see Figure 3). As shown in Figure 3, the nearly horizontal profile

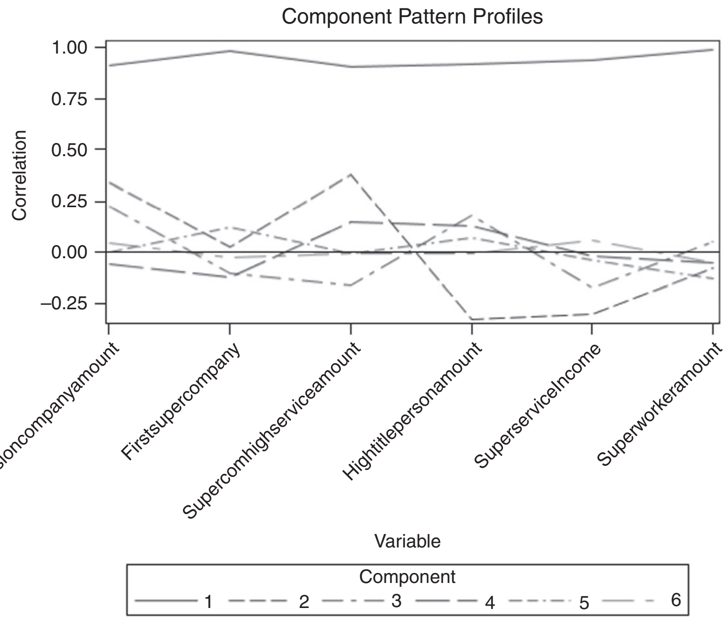


Figure 3.
The correlation pattern plot for year 2011

from the first component indicates that the first component is correlated evenly across all variables while the rest of PCs have no clear patterns. The nearly equivalent linear strength (all above 0.8) further confirms that the first PC is a good substitute of the original six variables.

The component pattern plots are shown in Figure 4. The pattern plot shows all variables positively and evenly correlate with the first PC. The amount of high-end service companies (X3) and amount of supervision companies (X1) correlate highly with the second component, and the amount of senior professionals (X4) and amount of supervision service income (X5) correlate highly but negatively with the second component. Therefore, X1 and X3 forms a contrast with X4 and X5 in the second PC. However, there is no definite conceptual interpretation of the second PC. Consequently, it is reasonable to discard the second PC and only the first PC is attended.

Table V depicts the ranking results classified by the first PC as well as the coast-inland and old east-central-west system for comparison. This shows that the results fit the coast-inland classification reasonably well, but with the notable exceptions of Sichuan, Henan, Guangxi and Tianjin.

The above ranking patterns of regional supervision systems are, to a certain extent, validated by the coast-inland as well as the old east-central-west inequality. In order to accelerate the development of Chinese economy, the central government implemented a coastal-oriented policy to enable the coastal regions to integrate with the world markets

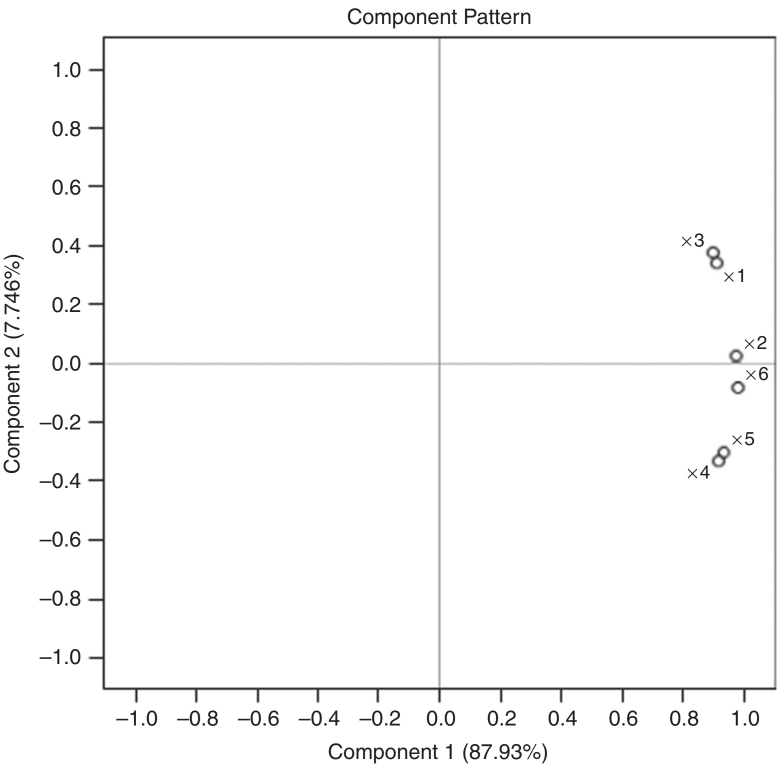


Figure 4. The component pattern plot

Table V.
Regional supervision system ranks

Regions	Principal component score	Regional supervision system rank	Region classification	Location	Regional R&D rank in 2001
Jiangsu	6.13	1	Coastal	Eastern	10
Beijing	4.78	2	Coastal	Eastern	3
Guangdong	4.39	3	Coastal	Eastern	4
Shandong	3.42	4	Coastal	Eastern	16
Zhejiang	2.26	5	Coastal	Eastern	19
Sichuan	1.64	6	Inland	Western	13
Shanghai	1.55	7	Coastal	Eastern	1
Henan	1.12	8	Inland	Central	25
Hebei	0.82	9	Coastal	Eastern	7
Liaoning	0.45	10	Coastal	Eastern	17
Shanxi	0.21	11	Inland	Central	8
Hubei	0.17	12	Inland	Central	18
Anhui	0.05	13	Inland	Central	26
Hunan	−0.2	14	Inland	Eastern	20
Heilongjiang	−0.39	15	Inland	Central	22
Fujian	−0.43	16	Coastal	Eastern	5
Shananxi	−0.56	17	Inland	Central	23
Jilin	−0.7	18	Inland	Central	6
Chongqing	−1.1	19	Inland	Western	14
Guangxi	−1.17	20	Coastal	Western	21
Yunnan	−1.28	21	Inland	Western	24
Gansu	−1.39	22	Inland	Western	27
Tianjin	−1.49	23	Coastal	Eastern	2
Jiangxi	−1.54	24	Inland	Central	29
Inner Mongolian	−1.62	25	Inland	Western	11
Xinjiang	−1.92	26	Inland	Western	15
Guizhou	−2.08	27	Inland	Western	28
Ningxia	−2.63	28	Inland	Western	12
Qinghai	−2.69	29	Inland	Western	9
Hainan	−2.73	30	Inland	Eastern	30
Tibetan	−3.11	31	Inland	Western	31

as soon as possible. For example, special economic zones were established and favorable tax policy was enforced in the coastal regions to attract both domestic and foreign investments. The above policies may, to a certain extent, widen the inland-coastal disparity (Kanbur and Zhang, 2005). These are corresponding to the better performance of coastal supervision systems than inland ones.

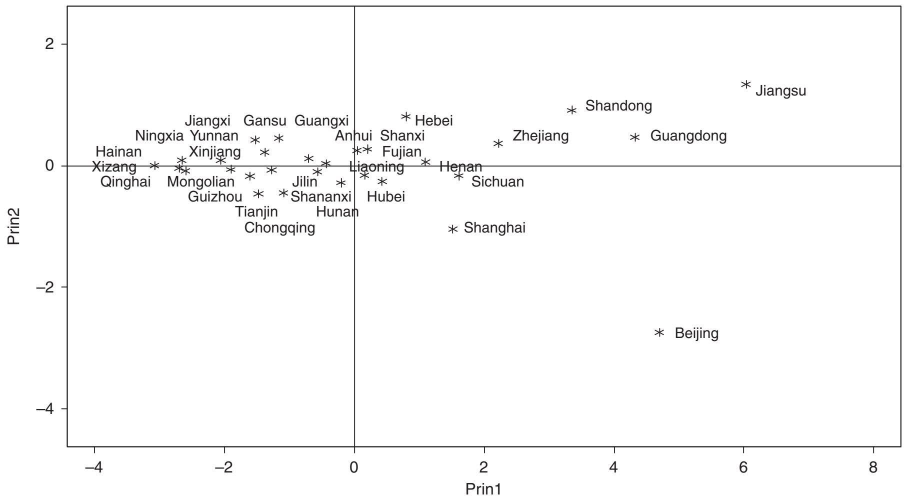
The exceptional performance of Sichuan may partly attribute to the Grand Western Development Program initiated since 2000 in China. The program covers the following regions: Sichuan, Chongqing, Shananxi, Gansu, Qinghai, Ningxia, Xingjiang, Inner Mongolian, Tibetan, Guangxi, Yunnan and Guizhou. The objective of the program is to reduce the economic gap between the eastern and western regions of China so as to achieve common prosperity nationwide. However, most regions covered in the program are still lower ranked in terms of the performance of regional supervision systems. It means that after more than a decade of development under the program, the supervision systems in the western regions are yet to be improved but some regions start catching on such as Sichuan. This is also evidenced by the increase of real-estate investment in Sichuan from RMB70.1 billion in 2005 to RMB219.5 billion in 2010 (Huang, 2010).

With respect to the statistics from 2005 to 2010 of Henan, the investment in real-estate market increased from RMB38.9 to RMB211.4 billion (Liu and Liu, 2010). By contrast, the real-estate investment in Guangxi increased from RMB28.7 billion in 2005 to RMB120.6 billion in 2010 (Qiu, 2010) which was much less than Henan. Hence, the Henan supervision industry outperforms some coastal regions such as Guangxi. The below average performance of Tianjin supervision system was closely related to the local real-estate investment. The real-estate investment in Tianjin increased from RMB32.8 billion in 2005 to RMB86.7 billion in 2010 (Du and Dong, 2010). Both the magnitude of increase and the total scale were much smaller than other coastal regions.

Zhang *et al.* (2010) ranked the research and development (R&D) activities in different regional construction industries of China with data collected in 2001 as shown in the last column of Table V. Due to the different timing and research objectives, their findings cannot be directly compared with finding of this study. However, the pattern of developed coastal regions compared to the developing central and western inland regions remains obvious and consistent, more or less, with the pattern classified by the first PC. It should be noted that R&D activities in Sichuan rank fourth among the western regions which may also contribute to the high performance of the local supervision system.

Figure 5 plots the distribution of regions vs the first two PCs. The first PC has a much larger variance than the second PC. Hence more information is covered in the first PC than the second one. Again the figure illustrates that the first PC is a better substitute of the original variables than the second PC. In addition, Jiangsu and Beijing are apparent outliers as they are the top two ranks in Table V. The two regions outperform the other regions with a large visual gap between.

In summary, Figures 2-5 visually illustrate the validity of the PCA-based model. The model validity is further verified by means of consistent pattern identified in previous studies and macro-policy effects.



Notes: Prin1, the first principal component; Prin2, the second principal component

Figure 5.
Plot of the first two principal components for all regions

Conclusions

Research on the performance of regional supervision systems in China is still in its infancy. However, this issue is increasingly important for the worldwide construction industry in a globalization context. The system complexity warrants a sophisticated and objective approach to rank its performance. Due to the scarcity of data, little research, quantitative in particular, has been undertaken to evaluate their performance in China. However, the identification of performance gap between different regional supervision systems is not only vital for them to benchmark with each other and clarify future endeavor but also critical for foreign consulting firms to make strategic decisions. Findings of this study are beneficial to both policy makers and industry practitioners considering the scale of the industry. Similarly, the gradually opening Chinese construction industry presents significant opportunities for foreign AEC firms. This is evidenced in the participation of foreign AEC firms in a number of high-profile projects such as 2008 Beijing Olympic Games venues. Indeed, the foreign AEC firms have a role to play during the rapid urbanization of China.

This paper aims to provide a useful approach for the characterization of the current supervision system in China and provides some hindsight to foreign companies about strategies to enter this emerging market. A number of indicators were used in previous studies to measure the performance of regional supervision system performances in China. This study proposed a PCA-based model to investigate the status quo of regional supervision system performances in China. The model provides a single quantitative parameter to conveniently benchmark the performance of various regions. This will streamline the process of performance evaluation of supervision system across regions. From PCA perspective, the first PC statistically captures as much information as possible covered in the model variables. The model involves six variables including number of supervision companies (X1), number of first-class supervision companies (X2), number of high-end service companies (X3), number of senior professionals (X4), amount of supervision income (X5) and number of supervision workers (X6). The first PC scores are then calculated for each region. The scores imply a general pattern of degrading performance from the coastal to inland regions or from the eastern via the central to the western regions.

From these six variables, it can be inferred that the supervision industry in China is shifting from a labor-intensive industry to a knowledge-intensive industry. As stated by Wang *et al.* (2010), the supervision engineers provide low-tech services for developers at the early stage of the industry but this will be changed sooner or later. The variables such as the amount of high-end service companies and senior professionals in the ranking model indicate that knowledge-intensive services become more and more important for the industry.

The research findings provide valuable information for both researchers and practitioners. For researchers, the model enables the meso-level (between firm-level and national-level) performance analysis of regional supervision systems. Moreover, a better appreciation of the current situation is achieved in a quantitative manner. The PCA ranking model of regional supervision system also provides potential framework for future quantitative research at the firm level. As the regional performance is an aggregation of the firm performances in the region, the PCA model can be applied to the supervision firm with certain modifications. This is an area for future research.

The findings provide useful reference to local professional entities of supervision system as well as related government departments to identify the performance gap between local system and the systems of other regions. A clear benchmark will motivate them to take measures to improve. The six variables in the model provide guidance for monitoring performance and further improvement. Hence the findings will be beneficial to the effective policy making. Supervision system is designed for improving the project performance such as cost, quality and safety. Therefore, the improvement of performance of regional supervision industry can make significant contribution to the practice and society.

For overseas consulting enterprises, the following recommendations could be derived according to the model. First, the inland or western markets are the best pinpoint candidates to enter since these markets are much less competitive than the coastal or eastern ones. Second, providing high-end supervision service may be a good choice for foreign companies to start their business in regional supervision industry. Since the supervision services are in the process of shifting to knowledge-intensive services, foreign consulting enterprises could seize the opportunity to gain competitive advantage by avoiding low-tech supervision services as most local firms did. Hence, head-on competitions could be avoided. Third, if the foreign consulting firms determine to compete in the coastal or eastern markets, make sure the scale of the firms, e.g. number of professionals, amount of investments, etc., are large enough to outperform the local firms.

It should be noted that the model is developed in the context of China. Therefore, contextual factors should be taken into consideration if this model is applied in other contexts. However, the benchmarking method based on PCA is likely to be applied in other contexts such as different industries in other countries.

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