論　　説

Empirical Analysis of Scope Economies Using Multi-product Composite Cost Function

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Abstract

This study employs a multi-product composite cost function to examine whether the major Japanese general contractors obtain scope economies by diversification. The analysis results indicate that contractors do not obtain scope economies by the sector and client diversification. This study considers that the unique characteristics of the construction industry and its delay of standardisation affect scope diseconomies.

1　Introduction

Contractors are categorised into 28 types of businesses in Japan. General civil engineering and general building are the primary types. Based on the overall planning, guidance and coordination, contractors who build civil engineering structures are classified into general civil engineering and those who build buildings are classified general buildings. Other contractors are classified into 26 specialised construction sectors.

In addition, two types of construction works exist: public construction and private construction works. Public construction works include the development of social projects, such as roads and bridges, and those where the clients are governments. Private construction works include building or development of houses and buildings and those where the clients are private firms or individuals. The contractor and price of public construction works are mainly determined by bidding, whereas those of private construction works are mainly determined by negotiated contracts. Construction work is build-to-order manufacturing. In other words, contractors start client work after receiving an order. The clients influence the construction work, because contractors erect the structure by setting up at the place specified by the client. This differs from shipbuilding and aircraft manufacturing, which are build-to-order industries where production equipment is set at a fixed place.

Therefore, the construction industry is diversified. Contractors must plan the management strategy

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by considering the different types of businesses and clients. Accordingly, this study examines whether contractors obtain benefits from diversification, from the perspective of scope economies. Moreover, it analyses concretely whether major Japanese general contractors obtain scope economies by diversifying types of businesses and clients.

General contractors in Japan directly contract for general civil engineering and general building construction projects from design to construction. They coordinate the entire construction work. In particular, they manage the professional contractors and materials manufacturers and complete the construction. Therefore, Japan's general contractors have comprehensive technical capabilities related to construction, and they work on a large scale. In contrast, in Europe and the United States, general contractors are relatively small, with design and construction clearly separated in large construction projects.

This study employs actual data, statistical method and economics model and focuses on diversification by types of businesses and clients in the construction industry. Few studies employ multi-product composite cost functions to analyse the scope economies in the construction industry. Therefore, it is possible to suggest for the management strategies in the construction industry from both sides of the empirical and theoretical studies.

2 Literature

2.1 Performance of diversification

Diversification is a primary focus in designing management strategy. In the construction industry, many contractors try to diversify into several fields strategically (Cho (2003) and Cheah, Kang and Chew (2007)). Diversification is performed by extending business and sales areas and by dealing with goods, services and human resources within the company. The process of diversification includes various processes, including expansion and development within existing companies, as well as a change in company form from through acquisitions and mergers.

Ramanujam and Varadarajan (1989) define diversification as the entry of a firm or business unit into new lines of activity, either by processes of internal business development or acquisition, which entail changes in administrative structure, systems and other management processes. For the construction industry, Hillebrandt (1989) defines diversification as the process by which firms extend the range of their business operations in which they are currently engaged.

Existing studies on the relation between diversification and companies analyse corporate performance, such as profitability, sales and bankruptcies. Many studies on diversification and corporate performance indicate that diversified firms have low profitability and growth potential than non-diversified firms (studies on construction industry include those by Ofori and Chan (2000), Choi and Russell (2005), Ibrahim and Kaka (2007) and Ibrahim, Ibrahim and Kabir (2009); studies on other industries include those by Berger and Ofek (1995) and Chen and Chu (2010)). Berger and Ofek (1995) analyse the impact of diversification on corporate value and demonstrate that diversified firms outperform single-line businesses. Furthermore, Berger and Ofek (1995) find that diversified firms have a lower operating rate of return than single-line businesses.

Comparing diversified and non-diversified firms, these studies indicate that the relation between performance and risk is a trade-off because diversified companies have lower performance and risk than single-line businesses (construction industry study includes that by Kim and Reinschmidt (2011); other industry study includes that by Lubatkin and Chatterjee (1994)). Kim and Reinschmidt (2011) find that the relation between the reduction of risk and the growth potential of firms is a trade-off in the American construction industry and that developing a business portfolio of contractors is important.

The results of diversification differ depending on circumstances, such as a firm's efforts to diversify (studies on various industries include those by Bishop (1995), Chakrabarti, Singh and Mahmood (2007) and Hall Jr. and Lee (2002); study on the construction industry includes Akintoye and Skitmore (1991)). These studies analyse business diversification and the correlation between businesses (construction industry study includes that by Kangari and Riggs (1988) and Giachetti (2012); study on other industries include that by Lubatkin and Chatterjee (1994), Mishra and Akbar (2007) and Adusei (2015)). Lubatkin and Chatterjee (1994) analyse firms listed on the New York and American Stock Exchanges, finding that the relation between stock returns and risk for a firm's diversification is the U-shaped. Moreover, they state that an important way to minimise a firm's risk is to diversify similar businesses.

Unlike these studies on diversified firm's performance, this study analyses whether contractors obtain scope economies by varying types of businesses and clients.

2.2 Scope Economies

Scope economies means that companies can be the more efficient by engaging in the multiple business activities. If companies can use common equipment in these multiple businesses, they can reduce costs. In other words, scope economies say that firms reduce their costs by diversifying multiple business lines (Baumol (1977), Teece (1980), Panzar and Willig (1981) and Bailey and Friedlaender (1982)).

Panzar and Willig (1981) define scope economies as cost savings that result from the scope (rather than the scale) of an enterprise. They also mention that scope economies exist when it is less costly to combine two or more product lines in one firm rather than producing them separately. In general, it is likely the diversified companies obtain scope economies, because these companies have multiple business lines. In particular, in the construction industry, the various types of business exist and contractors obtain order from various clients. Thereby, it is likely that contractors diversify and generate scope economies. Accordingly, this study employs the multi-product composite cost function from the study by Pulley and Braunstein (1992) to analyse whether major Japanese general contractors obtain scope economies.

Existing studies employ a multi-product composite cost function to analyse various industries. In the banking industry, these studies analyse whether banks obtain scope economies by diversifying business lines and business areas (Berger, Humphrey and Pulley (1996), McKillop, Glass and Morikawa (1996), Glass, McKillop and Morikawa (1998), Berger, Cummins, Weiss and Zi (2000) and Berger, Hasan and Zhou (2010)). Glass et al. (1998) examine whether Japanese banks obtain scope economies. They find that Japanese banks obtain scope economies by business area diversification but not by the product diversification.

For utility industries such as gas, water and power, studies employ a multi-product composite cost function to analyse whether the companies obtain scope economies (Piacenza and Vannoni (2004), Fraquelli, Piacenza and Vannoni (2004), Fraquelli, Piacenza and Vannoni (2005) and Bottasso, Conti, Piacenz and Vannoni (2011)). Fraquelli et al. (2004) find that Italian utilities obtain scope economies and note that relatively small professional companies obtain cost reductions by diversifying utility sectors that operate similar network services (gas, water and power). Ottoz and Giacomo (2012) analyse whether Italian transport companies obtain scope economies by comparing public and private companies. They find that public companies tend to diversify non-transport business-related sec- tors, whereas private companies tend to diversify transport business-related sectors. Moreover, Ottoz and Giacomo (2012) indicate that companies diversifying in transport business-related sectors obtain more scope economies.

No studies on the construction industry employ a multi-product composite cost function. However, Jewell, Flanagan and Lu (2014) employ interviews, company annual reports and published analyst reports to examine the scope economies of large contractors. With this qualitative and quantitative data, they find that construction companies obtain scope economies. Gann (1996) compares the Japanese automobile industry with the industrial housing industry and insists that the industrial housing industry must essentially standardise parts, such as the automobile industry, to obtain scope economies.

This study employs a multi-product composite cost function to analyse whether major Japanese general contractors obtain scope economies. Because few studies exist on scope economies in the construction industry and no study employs a multi-product composite cost function, this study can provide valuable suggestions for scope economies.

3 Analytical method

3.1 Multi-product composite cost function

This study uses multi-product composite cost function which is first developed by Pulley and Braunstein (1992) to examine whether major Japanese general contractors obtain scope economies by diversifying types of businesses or clients.

This subsection briefly explains the multi-product composite cost function. Following Berger et al. (2000) and Berger et al. (2010), this study uses the following multi-product composite cost function.

$$\frac{C_t}{z_t r_{Mt}} = \left(\alpha_0 + \sum_{t=2}^{T} \gamma_t D_t + \sum_{i=1}^{N} \alpha_i \frac{q_{it}}{z_t} + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \alpha_{ij} \frac{q_{it}}{z_t}\frac{q_{jt}}{z_t} + \sum_{i=1}^{N}\sum_{k=1}^{M-1} \delta_{ik} \frac{q_{it}}{z_t} \ln\left(\frac{r_{kt}}{r_{Mt}}\right)\right)$$
$$\times \exp\left(\sum_{k=1}^{M} \beta_k \ln\left(\frac{r_{kt}}{r_{Mt}}\right) + \frac{1}{2}\sum_{k=1}^{M-1}\sum_{l=1}^{M-1} \beta_{kl} \ln\left(\frac{r_{kt}}{r_{Mt}}\right) \ln\left(\frac{r_{lt}}{r_{Mt}}\right)\right) + \varepsilon_t \qquad (1)$$

where C_t, $t = 1, 2, \ldots, T$ denotes total cost at time t, q_{it}, $i = 1, 2, \ldots, N$, $t = 1, 2, \ldots, T$ denotes amount of ith output at time t, r_{kt}, $k = 1, 2, \ldots, M-1$, $t = 1, 2, \ldots, T$ denotes the amount of kth input price at time t, z_t, $t = 1, 2, \ldots, T$ denotes total asset at time t, D_t, $t = 2, 3, \ldots, T$ denotes the year dummy and ε_t denotes the disturbance term.

Total cost and input prices are divided into the Mth input price in Eq.(1). This normalisation imposes linear homogeneity in the input prices, a necessary condition for the cost function in the studies by Abrate, Erbetta, Fraquelli and Vannoni (2014), Berger et al. (2000) and Berger et al. (2010). The normalisation by equity capital z_t in the studies by Berger et al. (2000) and Berger et al. (2010) is designed to help control for heteroskedasticity and help reduce scale biases in estimation.

The multi-product composite cost function that has been developed admits zero values for outputs but does not impose separability between outputs and input prices. Moreover, according to Fraquelli et al. (2004), the multi-product composite cost function is more suitable to actual data than the translog cost function. Therefore, this study adopts the the multi-product composite cost function.

3.2 Measurement of scope economies

This study uses the SCOPE which is the indicator of scope economies proposed by Berger et al. (2010).

For $t = 1, 2, \ldots, T$, this study assumes that the amount of output of a hypothetical company, focusing on each output at t is as follows.

$$
\begin{aligned}
\hat{q}_{1t} &= (q_{1t} + q_{2t} + \cdots + q_{Nt}, 0, 0, \ldots, 0) \\
\hat{q}_{2t} &= (0, q_{1t} + q_{2t} + \cdots + q_{Nt}, 0, \ldots, 0) \\
&\vdots \\
\hat{q}_{Nt} &= (0, 0, 0, \ldots, q_{1t} + q_{2t} + \cdots + q_{Nt})
\end{aligned}
\tag{2}
$$

For $i = 1, 2, \ldots, N$, $t = 1, 2, \ldots, T$, the SCOPE, by focusing on ith output at time t is defined as follows.

$$
\mathrm{SCOPE}_{it} = \frac{C(\hat{\boldsymbol{q}}_{it}, \boldsymbol{r}_t, z_t, \boldsymbol{D}) - C(\boldsymbol{q}_t, \boldsymbol{r}_t, z_t, \boldsymbol{D})}{C(\boldsymbol{q}_t, \boldsymbol{r}_t, z_t, \boldsymbol{D})} \tag{3}
$$

where $\boldsymbol{q}_t = (q_{1t}, q_{2t}, \ldots, q_{Nt})$ denotes the real amount of output vector, $\boldsymbol{r}_t = (r_{1t}, r_{2t}, \ldots, r_{Mt})$ denotes the input price vector, $\boldsymbol{D} = (D_1, D_2, \ldots, D_T)$ denotes the year dummy vector, $C(\boldsymbol{q}_t, \boldsymbol{r}_t, z_t, \boldsymbol{D})$ denotes the predicted cost of real company by estimation results and $C(\hat{\boldsymbol{q}}_{it}, \boldsymbol{r}_t, z_t, \boldsymbol{D})$ denotes the predicted cost of a hypothetical focused company, using estimation results. If $\mathrm{SCOPE}_{it} > 0$, it suggests economies of scope; If $\mathrm{SCOPE}_{it} < 0$, it suggests diseconomies of scope.

4 Empirical analysis

4.1 Data

Using real data, this section examines whether major Japanese general contractors obtain scope economies. The sample is a balanced panel that includes financial data of 19 major Japanese general contractors from fiscal 1994 to 2013, totaling 380 observations. The basic data source is the Nikkei NEEDS and the contractors' financial statements. To estimate the weighted average cost of capital (WACC), prices of Japanese government bonds are obtained from the Ministry of Finance and stock prices are obtained from Yahoo! JAPAN Finance.

4.2 Models

This study assumes following two models in Eq.(1).

・Model 1 (diversification of types of businesses): inputs of contractors are labour and capital (whose price is r_1, r_2 respectively) and the output is civil engineering works, construction works and other works (whose amount is q_1, q_2, q_3 respectively).

・Model 2 (client diversification): inputs of contractors are labour and capital (whose price is r_1, r_2 respectively) and the output is public works, private works and other works (whose amount is q_1, q_2, q_3 respectively).

This study uses the ratio of personnel expenses to total number of employees (PETE, the unit is a million yen) as a proxy variable of the price of labour and WACC as a proxy of the price of capital. Completed construction contracts (the unit is a million yen) is a proxy variable for each output. Furthermore, it uses a year dummy from fiscal 1994 (D_2) to fiscal 2013 (D_{20}). Table 1 presents the summary statistics of each variable.

4.3 Result

After logarithmic transformation of the left-hand side of Eq.(1), this study estimates each parameter by non-linear least squares regressions. Table 2 represents estimation results on Model 1, and Table 3 represents them on Model 2. Moreover, using estimated coefficients in the composite cost function, this study obtains the cost for both the observed diversified contractors and for the hypothetical focused contractors, assuming that both follow the same cost function. Finally, this study obtains the SCOPE. Table 4 represents the SCOPE in Model 1, and Table 5 represents it in Model 2.

The negative means of SCOPE suggest that focus is associated with lower cost. The −0.278 mean of SCOPE on types of business implies that diversified contractors could have saved about a quarter of their costs if they had focused on one type of business. The −0.184 mean of SCOPE on clients implies that diversified contractors could have saved about a fifth of their costs if they had focused on one client. This result means that major Japanese general contractors obtain scope diseconomies. In other words, the diversification of these contractors is inefficient.

5 Discussion and Conclusion

This study use a multi-product composite cost function to analyse whether major Japanese general contractors obtain scope economies by diversifying types of businesses and clients.

From the empirical results, contractors obtain scope diseconomies by diversifying business sectors and clients. Construction production activities have the characteristics of single-order production, and outdoor moving production (in other words, on-site production) is unlike the equipment industry (i.e., manufacturing). Contractors work according to the different and individual conditions of each business. Therefore, it is difficult for contractors to share the same equipment by running multiple business activities. In addition, Gann (1996) compares the industrial housing industry with the Japanese automobile industry and indicates that the construction industry, unlike the manufacturing industry, has not been standardised. The two principal reasons that contractors obtain scope diseconomies by diversification are the following:

・Condition is significantly differ for each construction project due to the unique characteristics of the construction industry.

・Standardisation of construction has been delayed in the Japanese construction industry.

This study uses actual data and economic models and focuses on diversification in the construction industry. No study employs a multi-product composite cost function to analyse scope economies in the construction industry. This study focuses on the difference between the types of businesses and clients in the construction industry. Therefore, this study contributes to a better understanding of management strategy in the construction industry.

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Table 1: Summary Statistics

	count	mean	sd	min	max
civil engineering works	380	144998.60	93828.80	870.00	416717.00
construction works	380	338018.68	334998.52	32426.00	1426369.00
public works	380	140470.91	95126.88	0.00	450062.00
private works	380	342546.37	336426.09	31173.00	1452169.00
other works	380	27010.67	43312.37	0.00	237484.00
WACC	380	0.02	0.01	0.01	0.09
PETE	380	11.65	5.69	4.14	29.63
total assets	380	651809.39	600174.75	64869.00	2583070.00
total cost	380	463961.18	388326.46	70689.00	1578793.00

Table 2: Estimation result on Model 1

	Coef.	Std. Err.	P-value
α_0	-0.189	0.077	0.015
α_1	0.035	0.028	0.214
α_2	0.155	0.093	0.096
α_3	0.283	0.196	0.150
γ_2	0.005	0.003	0.119
γ_3	0.012	0.005	0.026
γ_4	0.016	0.007	0.021
γ_5	0.020	0.009	0.018
γ_6	0.027	0.011	0.017
γ_7	0.025	0.011	0.018
γ_8	0.026	0.011	0.018
γ_9	0.026	0.011	0.019
γ_{10}	0.023	0.010	0.017
γ_{11}	0.019	0.008	0.018
γ_{12}	0.016	0.007	0.020
γ_{13}	0.021	0.009	0.016
γ_{14}	0.024	0.010	0.016
γ_{15}	0.027	0.011	0.016
γ_{16}	0.021	0.009	0.017
γ_{17}	0.025	0.010	0.016
γ_{18}	0.026	0.011	0.016
γ_{19}	0.025	0.010	0.016
γ_{20}	0.021	0.009	0.017
α_{11}	-0.066	0.032	0.040
α_{12}	-0.034	0.038	0.375
α_{13}	-0.356	0.200	0.075
α_{22}	-0.202	0.094	0.033
α_{23}	-0.207	0.160	0.198
α_{33}	-0.269	0.165	0.103
δ_{11}	-0.006	0.005	0.267
δ_{21}	-0.001	0.005	0.891
δ_{31}	0.018	0.024	0.454
β_1	-0.778	0.126	0.000
β_{11}	-0.086	0.020	0.000
N		380	
AIC		-180.108	

Table 3: Estimation result on Model 2

	Coef.	Std. Err.	P-value
α_0	-0.179	0.073	0.014
α_1	0.107	0.071	0.133
α_2	0.129	0.054	0.017
α_3	0.180	0.166	0.279
γ_2	0.006	0.004	0.093
γ_3	0.013	0.005	0.022
γ_4	0.017	0.007	0.017
γ_5	0.021	0.008	0.015
γ_6	0.028	0.011	0.014
γ_7	0.026	0.011	0.015
γ_8	0.027	0.011	0.015
γ_9	0.027	0.011	0.016
γ_{10}	0.023	0.010	0.015
γ_{11}	0.019	0.008	0.016
γ_{12}	0.017	0.007	0.018
γ_{13}	0.022	0.009	0.015
γ_{14}	0.026	0.010	0.014
γ_{15}	0.029	0.012	0.014
γ_{16}	0.023	0.009	0.015
γ_{17}	0.025	0.010	0.015
γ_{18}	0.026	0.011	0.015
γ_{19}	0.024	0.010	0.014
γ_{20}	0.020	0.008	0.015
α_{11}	-0.165	0.080	0.039
α_{12}	-0.101	0.051	0.051
α_{13}	-0.039	0.134	0.773
α_{22}	-0.079	0.035	0.024
α_{23}	-0.400	0.208	0.056
α_{33}	-0.190	0.147	0.197
δ_{11}	-0.006	0.005	0.201
δ_{21}	0.006	0.004	0.106
δ_{31}	0.005	0.021	0.802
β_1	-0.815	0.122	0.000
β_{11}	-0.092	0.019	0.000
N		380	
AIC		-93.740	

Table 4: SCOPE based on types of businesses

	count	mean	sd
civil engineering	380	-0.019	0.359
construction	380	-0.467	0.141
others	380	-0.346	0.334
average		-0.278	0.278

Table 5: SCOPE based on clients

	count	mean	sd
public	380	-0.019	0.329
private	380	-0.320	0.128
others	380	-0.213	0.268
average		-0.184	0.242