CONSTRUCTION INDUSTRY AND (DIS)ECONOMIES OF SCOPE

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This paper explores the presence, causes and effects of the economies of scope in the construction industry. From the cost efficiency viewpoint, the bid and win rates are regressed by factors, including the number segments in a public procurement, in which a construction business operates, using the public procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. We found that the bid rates of diversified firms are higher than those of specialized firms. Therefore, the winning probability of a firm decreases as their number of operational segments increases.

Keywords: competitiveness, modelling, procurement

INTRODUCTION

The construction industry is well known to benefit from the economies of scope and scale. Some government levels offer preferential treatment in procurement auctions to balance monopolization. Take for example California's small business preference program, which provides small firms with a 5% bid discount. The effect of these bid preferences on auction outcomes was analysed by Krasnokutskaya and Seim (2011). Nakabayashi (2013) also examined the extent to which small business allocations increase government procurement costs (e.g. lack-of-competition cost exceeding the production inefficiency cost). These studies elucidated the issue of preferential treatment of small businesses in the construction industry. However, they have not addressed the cause of disparity.

The economies of scope, which are similar to the economies of scale, are efficiencies gained from variety rather than volume (Panzar and Willig, 1977, 1981). In some economies of scope, combining two or more product lines in one firm is less costly than separately producing them. The concepts of the economies of scope (and scale) are very popular and serve as powerful explanations in the modern strategy of businesses and management (Goldhar and Jelinek, 1983; Porter, 1985; Chandler, 1990; Besanko et al., 2009; Organization for Economic Cooperation and Development, 2011).

The present study considered a range of businesses offered by a construction firm based on the public procurement data of the Hokkaido Regional Development Bureau from 2006 to 2012. This study also explored the presence, causes, and effects of the

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economies of scope in the firm's business range. Against intuition, the result is that the construction firm in question does not have any economies of scope in the aspects of cost and success probability. Instead, they have the diseconomies of scope in the given situation.

We draw on the situation of the diseconomies of scope in the construction industry up to the abovementioned section. A firm generally decides to set a segment of the construction industry, and then determines whether or not to participate in a bid within the resource. Multiple licenses are affordable, but they only generate sufficient revenue to employ human resources in each segment. In view of the technical and financial limitation, a firm cannot easily transition from one specialised segment to another, but it can in the medium to long term. Therefore, we consider the causal relationship based on the reason of the diseconomies of scope or segment concentration efficiency and the explanation of the existence of a multiple-segment firm even though the correlative relationship between the estimated cost and the number of segments is shown. This is related to the academic debates of the economies of scope in the construction industry. Japan has 483,639 construction firms. Many of these are small and medium firms, which face scale and scope issues that are difficult to solve; hence, the need for a solution. This serves as the background of this paper.

The remainder of this paper is structured as follows: Section 2 reviews the economies of scope and the lack of previous construction management studies considering this viewpoint. Section 3 explains the (dis)economies of scope according to empirical estimation. Section 4 describes in detail the actual situation of the relevant market. Section 5 investigates the origins and consequences. Section 6 provides the conclusions.

PREVIOUS STUDIES

The economies of scope are defined by Panzar and Willig (1981) as follows:

> Let $T = \{T_1, \dots, T_l\}$ denote a nontrivial partition of $S \subseteq N$. That is, $\cup_i T_i = S$, $T_i \cap T_j = \emptyset$ for $i \neq j$, $T_i \neq \emptyset$, and $l > 1$. There are *economies of scope* at y_S and at factor prices w with respect to the partition T if $\sum_{i=1}^{l} C(y_{T_i}, w) > C(y_S, w)$.

The *diseconomies of scope* are obtained if the inequality is reversed. This concept is clear, and the definition leads to the cost subadditivity that, $C(Y_1, Y_2) < C(Y_1, 0) + C(0, Y_2)$ where $c(\cdot)$ is the cost of a firm, and Y_1 and Y_2 are the inputs (i.e. the existence of quasi-public, sharable inputs for the economies of scope). Some of the particular key strategies for the economies of scope are vertical integration and self-production of shared-input services. The diseconomies of scope can be motivated by technological and managerial constraints (e.g. large multi-product production that requires a costly oversight).

The economies of scope in the construction industry were referred to by Gann (1996) in terms of a comparative study of the manufacturing processes between industrialised housing and car production in Japan. The study stated that that the Japanese industrialised housing producers have analytically learned from other manufacturing processes (e.g. auto manufacture), particularly in delivering a wider range of choices for their customers. However, the study also noted the limitation and necessity of further research in the relationship between the standardization of parts and flexibility in the final production. Furthermore, this future study would require a deeper analysis based on the performance data.

The network effects in the construction industry are unique because of the independence of each project and the competitive tendering procedures used (Dubois and Gadde, 2000). The efficiencies arising from the customer–supplier collaboration are not similar to the economies of scope. However, the cause of the mechanism, which is being linked to the multi-sector business offered by construction firms, is similar. These findings require additional quantitative exploration from a reversed perspective.

Gibb (2001) surveyed and reported real case studies to discuss standardization and pre-assembly. His study claimed that the "success or failure of standardization and pre-assembly will depend on the pragmatic response of industry to an urgent need—and industry's ability to predict what the developing needs be". From the viewpoint of the economies of scope, the effect is not automatically achievable. Therefore, this issue must be empirically researched.

Other studies have also focused on the impacts of information technology (Brochner, 2006). However, very few studies have estimated and considered the effects of the economies of scope in the actual construction business. The economies of scope/scale on the professional construction service firms are analysed by using qualitative data from interviews obtained in a subjective perspective (Jewel et al., 2014). However, the real market output results from the conduct of the construction firm with the (dis)economies of scope in terms of the revealed preference (objective perspectives) are required. Therefore, this study seeks to contribute to the discussion on the economies of scope in the construction business from the viewpoint of real public procurement data.

Similar to the prior research situations in construction management, we first explored the existence and extent of the (dis)economies of scope in the construction industry based on the empirical study of real-world data. We then explained in detail the actual situation of the (dis)economies of scope. Our strategy comprised data extraction, estimation modelling, results and interpretation.

DATA AND ANALYSIS

Bidding and win rate

Estimating the cost function of each firm to compare the segregated cost with the integrated cost was impossible because of the limitations of our data structure. However, rich and unique public procurement data were available for use in each specific project segment. We considered a field of construction business of these segments in terms of the economies of scope.

We explored whether or not economies of scope exist for public procurement participants that bid across various construction divisions based on the results of the actual public procurement data shown as a revealed preference analysis. We estimate the effect of the number of construction segments on the successful bid situation and the bid and win rates by using the procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. Table 1 shows the data statistics.

The statistics of the Hokkaido Regional Development Bureau procurement data was presented in a predetermined price (i.e. upper price limit). This price was precalculated for public procurement requests for construction bids based on work and design specifications and construction drawings (Article 29-6, Public Accounting Act).

Table 1: Descriptive statistics

	RATE	WINRATE	KUBUNSU	NOOFPARTICIPANTS	PREDETERMINED		Number
Mean	0.9454	0.9152	2.1372	9.0259	1.54E+08	Y2006	18322
Median	0.9613	0.9347	2	8	97800000	Y2007	13337
Maximum	3.0556	1.0857	6	43	8.39E+09	Y2008	8776
Minimum	0.1033	0.4654	1	1	2400000	Y2009	7605
Std. Dev.	0.0854	0.0634	1.0694	5.1557	2.37E+08	Y2010	11348
Skewness	2.7906	−1.2308	0.9568	1.1039	11.2018	Y2011	9005
Kurtosis	50.2686	6.1759	3.7513	5.4097	221.6269	Y2012	6783
Sum	71068.99	11827.4	160665	678528	1.16E+13		
Observations	75176	12924	75176	75176	75176		

Firms must also have licenses to do construction business, guarantee construction quality and technology, and maintain the loan redemption credibility in Japan. Licenses are divided into 28 segments to promulgate the specialised construction technology. The segmentation is based on the construction technology, application and facilities. The licenses are affordable, but they only generate sufficient revenue to employ human resources in each segment. Firms cannot easily transition from one specialised segment to another because of these technical and financial limitations.

First, we formulated the relationship between the number of construction segments and the impact of the cost of a successful bid by defining a simple linear cost function with the dummy variable for the successful bidder among the participants (the winning bidder = 1; otherwise = 0). We then simply considered some rates of the project's predetermined price as the project cost (i.e. cost = rate × predetermined).

The firms' bid rates will likely decrease if the economies of scope reduce the cost and the number of segments provide the economies of scope. We analyse this inference using the following formula:

$$Rate_i (or\ Win_i) = \alpha_{1,1} + \beta_{1,1} NOOFSEGMENTS_1 + \beta_{1,2} \log(BIDLAST_i) \\ + \beta_{1,3} NOOFPARTICIPANTS_i + \varepsilon_1 , \quad (1)$$

where, subscript *i* is the project number; Rate is set to the bid rate of the firm's project (i.e. the bid price divided by the predetermined price); *Win* is the winning rate (i.e. the winning price divided by the predetermined price); *NOOFSEGMENTS* is the number of segments in which a firm participates; *NOOFPARTICIPANTS* is the number of participants in the project; *BIDLAST* is the bid value of the firm (the last bid value is used if multiple bids are placed; and, ε_1 is an error term. The coefficients to be determined are $\alpha_{1,1}$, $\beta_{1,2}$, and $\beta_{1,3}$. Table 2 shows the results. We considered subsets of the coefficients in these tests. A variable is not considered in that model if its coefficient values are null (i.e. column).

Table 2: Estimation of the bid and win rates

Dependent Variable:	RATE		WINRATE	
Method: Least Squares	n=75176		n=12924	
	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)
C	0.9417 ***	1.2491 ***	0.9123 ***	0.8953 ***
	(0.0007)	(0.0063)	(0.0013)	(0.0111)
NOOFSEGMENTS	0.0017 ***	0.0017 ***	0.0013 ***	0.0008 *
	(0.0007)	(0.0003)	(0.0005)	(0.0005)
LOG(BIDLAST)		-0.0154 ***		0.0024 ***
		(0.0003)		(0.0006)
NOOFPARTICIPANTS		-0.0030 ***		-0.0044 ***
		(0.0001)		(0.0001)
R-squared	0.0005	0.0797	0.0005	0.0901
Adjusted R-squared	0.0005	0.0796	0.0004	0.0898
S.E. of regression	0.0854	0.082	0.0634	0.0605
Akaike info criterion	-2.0827	-2.1652	-2.6781	-2.7717

The results in Table 2 indicate that the coefficients of both the bid and win rates are positive and statistically significant, but the coefficients of the project size (i.e. the last bid price) and the number of participants are negative and statistically significant. These coefficients are not different with or without the other variables of the project size (LOG(*BIDLAST*)) and the competitive situation (*NOOFPARTICIPANTS*). Therefore, firms that engage in more public procurement construction segments generate higher last bid (i.e. the last bid divided by the predetermined price) and win (i.e. the win bid divided by the predetermined price) rates.

Win probability

Second, we formulated the relationship between the number of construction segments and the probability of a successful bid as a logit function with the dummy variable for the successful bidder among the participants. We then estimated the selection probability of a winning bid among the participants as follows:

$$y_i = \alpha_2 + \beta_{2,1} z_{1,i} + \beta_{2,2} z_{2,i} + \beta_{2,3} z_{3,i} + \beta_{2,4} z_{4,i} + \varepsilon_2 \ , \qquad (2)$$

where, y is equal to 1 in the case of a successful bid in the project, or 0 when firms participate in the bid but do not win; z_1 is the number of construction segments; z_2 is the project scale (i.e. logarithm of the last bid price of the participant for the project); z_3 is the number of participants; and z_4 is a dummy variable for the year (the dummy variable is 1, otherwise, 0, when the date of the bid is in a specific year). The correlation between the number of participants and the last bid price of the participant for the project may cause bias in the estimation. However, the correlation coefficient for these data is 0.1071, which is not sufficiently high to cause problems. The parameters to be determined are α_2, $\beta_{2,1}$, $\beta_{2,2}$, $\beta_{2,3}$ and $\beta_{2,4}$. Assuming that the ε variables in accordance with the extreme values of type *i* and using observation data based on the log-likelihood function, *P* is the odds rate and *z* is the collective term of the abovementioned variables, z_1 to z_4:

$$\log P = \sum \left[y_i \log\left(\frac{\exp(\alpha + \beta z)}{1 + \exp(\alpha + \beta z)}\right) + (1 - y_i) \log\left(\frac{1}{1 + \exp(\alpha + \beta z)}\right) \right]$$

It is possible to estimate the model parameters with the maximum likelihood. Table 3 presents the results. The results indicate that the coefficient for the number of construction segments (*NOOFSEGMENTS*) is negative and statistically significant in the first column. Therefore, this finding shows that the probability of success decreases with an increasing number of construction segments, which is in contrary to the definition of the economies of scope.

We estimated the win probability using not only the number of construction segments, but also the logarithm of the last bid price of the participant for the project and the number of participants (the second column) to verify this. We further refined the model by additionally considering the fiscal year (third column). The coefficients of the predetermined price, number of participants and number of construction segment were all negative and significant. In addition, the economies of scope were still unobservable even when the fiscal year was considered (third column). These results are consistent with those of the "Bidding and win rate" section in that firms engaging in multiple segments generate higher bid rates (and, therefore, win rates), resulting in a lower probability of winning bids.

Table 3: Logit estimation of the winning probability

Dependent Variable:	WINPROB					
Method: Least Squares	n=75176					
	Coefficient (Std.Error)		Coefficient (Std.Error)		Coefficient (Std.Error)	
C	-1.5230	***	1.4027	***	1.5374	***
	(0.0216)		(0.1711)		(0.1754)	
NOOFSEGMENTS	-0.0231	***	-0.0645	***	-0.0661	***
	(0.0091)		(0.0097)		(0.0097)	
LOG(BIDLAST)			-0.0656	***	-0.0683	***
			(0.0094)		(0.0095)	
NOOFPARTICIPANTS			-0.2197	***	-0.2182	***
			(0.0029)		(0.0030)	
Y2006					-0.1215	***
					(0.0383)	
Y2007					-0.1711	***
					(0.0394)	
Y2008					-0.1431	***
					(0.0423)	
Y2009					-0.0685	
					(0.00435)	
Y2010					-0.0052	
					(0.0415)	
Y2011					-0.0510	
					(0.0425)	
McFadded R-squared	0.0001		0.1144		0.1149	
S.E. of regression	0.3773		0.3516		0.3916	
Akaike info criterion	0.9178		0.813		0.8126	

MOTIVATION OF FIRM BEHAVIOUR

Source for the diseconomies of scope

The diseconomies of scope in the construction industry may occur because the specialization of the segmentation enhances the efficiency of doing business in the construction industry. Increasing the number of segments may force firms to make advancements in their respective segments. We estimated the regression between the average bid rate of each business and the bidding participation to check this assumption. We then used the following equation to test this hypothesis:

$$Rate_{Ave,k} = \alpha_4 + \beta_{4,1} NP_k \left(+\beta_{4,2} \frac{NP_k}{Segments_k}\right) + \varepsilon_4 , \quad (4)$$

where, variable *NP* is the number of bids in which a business participated. Segments is the number of segments, in which the firm operates. Table 4 shows the results.

Table 4: Relationship between each firm's rate and participation

Dependent Variable:	Firm's Avr.RATEi			
Method: Least Squares	n=3680			
	Coefficient (Std.Error)		Coefficient (Std.Error)	
C	0.9548	***	0.9558	***
	(0.0020)		(0.0020)	
NP	-9.69E-05	**		
	(4.46E-05)			
NP/Segments			-0.0002	***
			(0.0001)	
R-squared	0.0013		0.0025	
Adjusted R-squared	0.0010		0.0022	
S.E. of regression	0.1055		0.1054	
Akaike info criterion	-1.6600		-1.6612	

The results in Table 4 indicate that the coefficients for the *NP* and *NP/Segments* are both negative and significant. The magnitude of the latter was much larger than that of the former. Therefore, costs were reduced for jobs that receive many bids, especially from firms participating in few segments. The results were also correlated given that the variables were correlated. However, this finding still indicated the presence of the diseconomies of scope.

Reason for multiple segments

Firms may seek multiple segments despite the diseconomies of scope because of the risk of business fluctuation in the construction industry. Firms can stabilise the revenue flow by increasing the number segments, in which they participate in. We estimate the regression between the number of bids won by a firm and the number of segments, in which the firm operates, to check this assumption. We used the following equation to test this thinking:

$$WinNumber_k = \alpha_5 + \beta_{5,1}\, NP_k + \beta_{5,2}\, NOOFSEGMENTS_k + \varepsilon_5 , \qquad (5)$$

where, *WinNumber* is the number of bids won by the firm. Table 5 shows the results.

Table 5: Relationship between the number of bids won by each firm and the number of segments, in which they operate

Dependent Variable:	WinNumber		WinNumber
Method: Least Squares	n=3680		n=3680
	Coefficient (Std.Error)	Coefficient (Std.Error)	Coefficient (Std.Error)
C	0.5308 ***	-0.6013 ***	-15.6859 ***
	(0.0649)	(0.1589)	(0.8774)
NP	0.1459 ***	0.1357 ***	
	(0.0048)	(0.0055)	
NOOFSEGMENTS		0.9812 ***	14.0538 ***
		(0.1538)	(0.6918)
R-squared	0.7272	0.7345	Method:Two-Stage Least
Adjusted R-squared	0.7271	0.7344	Squares. Instrument
S.E. of regression	3.4826	3.4358	specification: Number
Akaike info criterion	5.3340	5.3072	Participation

The results in Table 5 show that the coefficient for *NP* is positive and significant, which is natural given that more participation should lead to more wins. Furthermore, the coefficient of *NOOFSEGMENTS* (the number of segments) is also positive and significant. Therefore, firms win more bids when they operate in more segments. However, there may be a correlation between *NOOFSEGMENTS* and *NP*. Therefore, we applied the two-stage least squares method with *NP* as the instrument variable. The third column is the result, in which the coefficient of *NOOFSEGMENTS* is positive and significant. Therefore, the decentralization of a segment's project generates the diversification of risk in the construction industry. The risk diversification explains why a firm seeks for multiple segments despite the diseconomies of scope.

DISCUSSION AND CONCLUSION

The construction industry has some features, such as local outdoor production, single-item–order production and labour-intensive production, which enhance the division of business. This industry also has other features, such as multiple building materials, complex process works and required schedule managing, which enhance the business integration. In light of these various factors, it is worth recognizing that the cost characteristics of the industry enhance efficiency from the viewpoint of both business and social welfare through optimal resource utilization.

This study considered the variety of construction segments of a firm in public procurement. We also explored the presence, causes and effects of the diseconomies of scope. From previous work regarding the network effect of the construction industry, there has been little presence of permanent networks. On the contrary, the temporary networks had substantial coordination because of project independency (Dubois and Gadde, 2000). We quantitatively verified the claim by using the procurement data of the Hokkaido Regional Development Bureau from fiscal years 2006 to 2012. The effect on the successful bid selection was regressed by the number of construction divisions and other control factors, such as the project size and the number of procurement participants. As a result, the bid and win rates of firms operating in multiple segments were higher than those operating in fewer segments. This result was verified through the probability of winning bids, as it decreased as the number of segments in which a firm participated increased.

The cause of the diseconomies of scope in the construction industry was also considered. One hypothesis was that the specialization of the segmentation enhanced efficacy in the construction industry. We performed a regression analysis between the average bid rate of each business and the number of bids, in which a firm participated to check this hypothesis. The results showed that the costs are reduced for jobs that received many bids, especially from firms participating in few segments.

This study has three main implications for construction management. First, the result of this study based on an empirical analysis indicates that the bid rates of the diversified firms are higher than those of the specialised firms. Therefore, the probability that a firm wins decreases as their number of operational segments increases. In line with this result, policy measures to enhance the industrial total productivity should include a plan to promote for specialised firms. Some government levels have preferential treatment programs in procurement auctions for small and medium firms, as had been mentioned in the first section. Furthermore, our result supports the type of policy program not only for the small and medium firms, but also skilled and sustainable firms in the construction industry.

We draw on the situation of the diseconomies of scope in the construction industry up to the abovementioned section. A firm generally decides to set a segment of the construction industry, then determines to participate in a bid within the resource. The correlative relationship between the estimated cost and the number of segments is shown. However, we consider the causal relationship based on the reason of the diseconomies of scope or segment concentration efficiency and the explanation of the existence of a multiple-segment firm because of two aspects. First, we researched on the origin of the diseconomies of scope from the viewpoint of the segment concentration efficiency. Second, we dealt with the reasoning of the existence of a multiple-segment firm.

Third, considering these findings, the factors of (dis)economies of scope and scale in terms of the business segment (e.g. managerial issues, climate conditions, and geographical situation) need to be investigated in detail. Extending this examination to other areas, to the country as a whole, and across other global regions is another challenge related this study. To consider the future research, data gathering is one of the key issues.

To further comprehend the cause of diseconomies of scope, for our next step, we will interview both diverse and specialised construction firms. Both statistical analysis and anecdotal evidence are useful for the development of construction management theory and empirical study. Additionally, if it is possible, we would like to try to conduct a social experiment to verify the diseconomies of scope in both the laboratory and the field. Whether or not the findings of the diseconomies of scope in the construction industry are applicable in the worldwide situation is a global issue that needs to be investigated. However, the mechanism used in this article can be applied to construction industries in all countries, and is worthy of future research.

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