A STUDY ON THE APPLICATION OF ECONOMIES OF SCALE IN THE CONSTRUCTION INDUSTRY: THE SRI LANKAN PERSPECTIVE

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ABSTRACT

The application of economic concepts acts as a catalyst to enhance the productivity and quality in the industries such as automotive, transportation and tourism. Economies of Scale (EOS) is such a concept, which could be applied to address the above concern. This research therefore explored the application of EOS to the construction industry. The study adopted a qualitative approach by conducting structured interviews among 14 participants representing consultants and contractors in the construction industry. Subsequently, a content analysis was performed to analyse the data collected, with the aid of NVivo 11. Considering the views of experts, the application of EOS concept is limited to pre-cast elements in both building and civil engineering projects in the construction industry. Majority of the experts opined that application of EOS concept is limited in the construction industry mainly due to unawareness on applicability of EOS (71%) and unique nature of the construction industry (43%). Further, it was identified that uncertainties in the construction industry act as the major barrier to the application of EOS. Confirmation of drawings at the initial stage, conducting training sessions and researches are strategies to promote the use of EOS in the construction industry, which in turn would enable direct economic growth via price efficiencies.

Keywords: *Construction Industry; Economies of Scale; Pre-cast Elements; Sri Lanka.*

1. INTRODUCTION

Needs are based on physiological, personal, or socio-economic requirements necessary for functioning of human life. On the other hand, wants are a means to fulfilling those needs. Usage of limited resources, which have unlimited commitments is a significant concern to individuals and societies. The term 'Economics' is, therefore defined as the studies carried out to explore the methods of how societies use limited resources to fulfil unlimited human wants (Samuelson and Nordhaus, 2005). It would no longer exist, if resources are adequate to fulfil all human wants (Manser, 2005).

Construction is an industry where several resources are being manipulated. Nagaraju *et al.* (2012) opined that money, men, material, machinery and other resources are manipulated within construction projects. Enhanced productivity, quality, efficiency and high-class workmanship are required for the success of construction projects (i.e. completed within cost and time stipulated). Waris *et al.* (2014) are of the view that economic concepts enable a careful management of resources to avoid unnecessary resource consumption or wastage. Thus, the application of economic concepts could act as a catalyst to speed up the construction projects without compromising the quality (Waris *et al.*, 2014). With that note, it is important to identify the applicability of economic concepts to construction projects.

Anecdotal evidences suggest that the micro economic concepts of EOS can be applied in the construction industry. The EOS could be used as a tool, for winning construction projects as it provides competitive advantages for the industry. However, far too little attention has been paid to apply EOS concept to the construction industry. This research therefore explores the application of EOS to the construction industry in Sri Lanka.

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2. LITERATURE SYNTHESIS

The concept of EOS originates from macroeconomics (Finkel, 1997). The term EOS is referring to the increase in productivity or decreases in average costs of production that arise from increasing all the factors of production in the same proportion (Samuelson and Nordhaus, 2005). Similarly, Sloman (2007) defines EOS as the concept where lower cost per unit output achieved through increasing the scale of production.

Literature revealed set of contributory factors as they are the tools of understanding EOS concept as listed below. The fundamental focus of contributory factor is clarity.

- Specialization and division of labour

Anecdotal evidences proved that large firms use division of labour to enhance their productivity (Sloman, 2007). As a result, those become specialized in their particular tasks. Higher performance could be achieved since the tasks are handled by the expertise (Husan, 1997). For example, in construction sites bar bending and bar cutting is done by special skilled labours and sophisticated equipment are operated by specialized operators.

- Container principle

This is linked to the cubic law, where doubling the height and width of a building leads to a more than proportionate increase in cubic capacity. To increase the capacity by eight-fold, the surface area needs to be increased by only four-fold (Sloman, 2007). Similarly, Husan (1997) mentioned that economies of increased dimension occur where cost increment is less rapid than capacity. Further, costs increase with surface area, while output increases with volume (or capacity) of additional units of plant and equipment.

- By-products

Sometimes by-products are generated in larger firms (Sloman, 2007). They can be sold or converted into another usable product.

- Multi stage production

Several economies can be attained through merging the activities when the production is carried out in different stages (Sloman, 2007). EOS occurs due to the higher levels of production yield proportional savings in stocks (Husan, 1997).

- Learning by doing (experience curve theory)

Unit costs decrease with increasing experience as they cut waste and find the most productive means of producing output (Chiang *et al*., 2008). The idealized pattern describing this kind of technological progress in a regular fashion is referred to as a learning curve, progress curve, experience curve, or learning by doing (Chiang *et al*., 2008).

Literature further elaborates the application of EOS in tourism, transportation and manufacturing industries. For example, Shi and Smyth (2012) analysed the change of long-run cost with output by estimating EOS at the industry level in transport, retail trade and accommodation recreational services, which closely aligned to tourism and proved that returns of the tourism industry can be maximized through specialization and EOS. Similarly, Sheu and Chen (2014) explained that when quantity becomes large, EOS usually facilitates the significant reduction of cost in transportation networks. Further, Worthington and Higgs (2014) highlighted that efficient production would be attained by adjusting the scale of production to most appropriate size for outputs produced in Australian urban water utilities. Moreover, Husan (1997) examined the importance of EOS in the automotive industry. By assessing the components which influence the cost of a communal rainwater harvesting system, Gurung and Sharma (2014) suggested that cost of communal rainwater harvesting system varies with the number of households.

In terms of EOS application in the construction industry, Ahadzie *et al.* (2008) found that Mass House Building Projects (MHBP) have applied EOS significantly and it became one of the critical success criteria for winning a competitive tendering. Parker (1997) indicated that large building units consist of greater EOS, while the small and medium sized units are more likely to reveal decreasing returns to scale. A common expectation is that EOS in road construction could lower the unit cost of constructing along with the length of the road (Atsushi, 2007). Road construction must exhibit EOS, meaning that the average construction cost decreases with the length of road contracted due to flexible allocation of labour and equipment and necessary overhead

costs (Atsushi, 2007). Manser (2005) emphasized that, when cost and time become crucial, construction moves from off-site to use of prefabrication techniques, where the space for technical EOS is much greater. In a similar way, Chiang *et al.* (2008) enlightened that prefabrication was adopted not because of client requirement, but as it enabled EOS, enhanced productivity and managerial efficiency. On other hand, some of the researchers are of the view that application of EOS in the construction industry is at a minimal level due to several reasons. For example, Sobol (2007) and Dunning (2014) indicated that less adoptability to new technology and lack of willingness to change limit the application of EOS. Meduri and Annamalai (2013) explained that financial difficulties faced by small contractors in handling several projects simultaneously are another barrier for the use of EOS in construction projects.

3. RESEARCH METHODOLOGY

As per the nature of the subject area, in construction industry, the application of EOS concept is very limited. It was very rare to find a case, which applies EOS within the construction industry; therefore, this study employed a qualitative approach conducting structured interviews to investigate the applicability of EOS within the construction industry in Sri Lanka. The unit of analysis for this research was the experts who have knowledge on application of economic concepts in the industry. Experts interviewed were selected with due considerations to their backgrounds, field of involvement and exposure to subject matter of the current research. Accordingly, altogether, fourteen (14) participants representing consultants and contractors were interviewed until the data get saturated. Here, the sample was selected using the convenient sampling method, which can be used when focusing on a limited number of informants where the in-depth information provides optimal insight on issue which is little known. Most of the interviewees occupied managerial positions and involved in project management, cost management and cost control activities. A summary profile of participants is presented in Table 1.

Table 1: Profile of the Participants

Representative Sector	**Number of Participants**		**Work Experience**	**Number of Participants**	
	No.	Percentage		No.	Percentage
Contractor	09	64%	Less than 10 years	03	22%
Consultant	05	36%	10-20 years	09	64%
			Above 20 years	02	14%
Total	14	100%	Total	14	100%

As observed from Table 1, majority of the experts (64%) belonging to the contractor organisations whose designations are: Quantity Surveyors, Managing Directors, Project Managers, Structural Engineers, General Manager Estimation and Contracts, and Contracts Manager. Rest of the experts belong to the consultancy organisations and include Directors, Quantity Surveyors and Architects. Almost all the interviewees are in the category of more than 5 years of experience in their field of work in the construction industry. Further, 78% of the experts have more than 10 years of experience while 14% of the experts have more than 20 years of experience. Accordingly, experts' views are collected to explore the current status of application of EOS concept, to identify the reasons and barriers for limited applicability of EOS, and proposed strategies to overcome those barriers. Subsequently, a content analysis was carried out to analyse the collected data with the aid of NVivo 11.

4. DATA ANALYSIS AND FINDINGS

Since literature is not evident on proper investigations carried out on application of EOS in Sri Lankan construction industry, this study explores the current status of application of EOS concept, reasons and barriers for limited applicability of EOS and suggest strategies to overcome those barriers. Accordingly, structured interviews were conducted with the intention of collecting experts' views on aforementioned aspects. Later, opinions of interviewees were analysed using NVivo 11 and the results of the analysis are presented in subsequent sections.

4.1. MOSTLY APPLICABLE AREA OF ECONOMIES OF SCALE WITHIN THE CONSTRUCTION INDUSTRY

This section summarizes the views of the experts regarding the application of EOS concept in construction projects. Initially, participants were questioned on their experience on application of EOS under the major types of construction projects and sub projects which comes under each type of construction. Results are presented in Table 2.

Table 2: Application of EOS within Building Construction and Civil Engineering Construction

	No. of Responses	**Percentage**	**Type of Project**	**No. of Responses**	**Percentage**
Building	03	22%	Apartment complexes	03	21%
			Hotel buildings	02	14%
Civil Engineering	03	22%	Highway construction projects	02	14%
			Road construction projects	01	7%
Building and Civil Engineering	08	56%	Road, bridge, culvert construction and dam construction	06	43%
			Apartments complexes	05	36%
			Other residential building construction projects	02	14%
			Hotel projects	02	14%
			Highway construction projects	01	07%
			Hydro power and power plants	01	07%
			Water supply projects	01	07%
			Ports	01	07%
Total	14	100%			

Amongst all interviewees, 56% of the experts have applied the EOS concept in both building and civil engineering construction projects. Under building construction projects, majority (21%) of the experts have practiced it for apartment complexes while 14% in hotel construction projects. Besides, 14% of the experts have applied EOS in highway construction projects under civil engineering construction. Relating to building and civil engineering, majority of the experts (43%) have applied EOS in road, bridge, culvert, and dam construction projects. Further, EOS concept is applied by 36% experts under apartment projects while only 14% experts have applied it on other residential building construction projects and hotel projects. Overall, in Sri Lanka, the EOS concept has significantly applied in building construction projects, especially in apartment complexes, hotel projects, road and highway construction projects.

Subsequently, experts were asked to comment on key areas, where EOS is applied within identified types. As per the data collected through interviews, four areas were identified where EOS concept is applied under the construction projects, whereas three areas under the civil engineering projects. Table 3 presents the results derived from the analysis.

As per Table 3, majority (91%) of the interviewees who applied EOS concept in civil engineering projects, stressed that it is mostly applied in pre-cast concrete elements. Contraly, 64% of the experts who applied EOS concept in building construction projects, emphasized that it is mostly applied in both pre-cast and pre-fab elements. Further, 46% among the interviewees who applied EOS concept in building construction projects, mentioned that this concept can be applied in formwork systems. One of the contract administration experts has specified the nature of formwork as steel, where this can be highly applied more efficiently. However, 36% indicated the possibility of applying the concept for aluminum components. In addition, 27% of the experts mentioned the applicability of EOS concept within laying asphalt and 18% of the experts agreed to the use of the concept in laying Aggregate Base Course (ABC), since significant quantities are available in those items in road and highway construction projects. Considering the views of the experts it was identified that EOS concept is highly applied in pre-cast elements both in building construction and civil engineering construction projects, even though there is a possibility of applying the EOS concept for steel pre-fab elements under building construction rather than pre-cast concrete elements.

Table 3: Mostly Applicable Areas of EOS within the Construction Industry

Applicable areas	Sources	References	Percentage
Mostly applicable area of EOS within the construction industry	14	32	
Under building construction projects	11	17	
Pre-cast concrete and pre-fabricated steel elements	07	07	64%
Formwork	05	05	46%
Aluminum components	04	04	36%
Concrete	01	01	09%
Under civil engineering projects	11	15	
Pre-cast concrete elements	10	10	91%
Laying Asphalt	03	03	27%
Laying ABC	02	02	18%

In another point of view, one of the large building design experts pointed out that EOS can be mostly applied within the design. He was of the opinion that EOS concept must be effectively applied in designing where it helps to economize the design. One of the budget estimating experts stated that EOS concept can be applied at the material procurement stage.

Majority of the experts were of the opinion that EOS concept can be applied even up to purchasing new plant and equipment as well. It is safe to say that EOS can be applied within various stages of a construction project such as design, procurement and construction by considering the opinions. At the construction stage, EOS can be applied even up to the installation of new plant and machinery.

4.2. CONTRIBUTORY FACTORS FOR ECONOMIES OF SCALE

The study identified contributory factors of EOS concept, which accelerate the cause of EOS within the construction industry. Results derived from the analysis of experts' opinions are shown in Table 4.

Table 4: Contributory Factors for EOS

Factors	Sources	References	Percentage
Contributory factors for EOS	14	30	
Division of labour	13	13	93%
Specialisation of labour	09	09	64%
Gained discount rates due to bulk purchasing	08	08	57%
Application of new technology or changes in methodology	05	05	36%
Shared fixed costs	04	04	29%
Operational efficiencies in machineries	04	04	29%
Learning by doing (experience curve theory)	04	04	29%
Generation of by-products	01	01	07%

According to Table 4, majority of the experts (93%) specified enhanced labour productivity due to the divisions of labour as a key contributor of EOS. Further, 64% of the experts were of the opinion of that specialization of labour accelerates the EOS. Additionally, 57% of the experts were of the opinion that discount rates obtained due to the bulk purchasing causes EOS. Moreover, application of new technology or changes in methodology is considered as a contributory factor by 36% of the experts. In addition, 29% of the experts were with the view of that shared fixed costs, operational efficiencies in machineries, and learning by doing (experience curve theory) cause EOS. According to one of the budget estimation experts, generation of by-products also can be a contributory factor of EOS.

4.3. REASONS AND BARRIERS FOR LIMITED APPLICATION OF EOS WITHIN THE CONSTRUCTION INDUSTRY

The review of literature survey identified that application of EOS concept is limited in the construction industry compared to other industries. Agreeing to that, 86% of the experts emphasized that other industries apply these concepts much more effectively when compared with the construction industry. According to the experts, this concept is mostly applied within manufacturing or production industries. One of the cost controlling experts explained the reason for the high applicability of the concept in aforementioned areas as follows: "*Most of the time manufacturing firms decide their cost at the end of the product. When it comes to the construction industry, cost is concerned at the beginning of the project at the tendering stage. The cost is estimated at the beginning even without knowing the product. In such situations, we just try to bid for the project and win it, we are not going to apply these concepts and reduce the cost*". Further, majority of the experts were of the opinion that repetitive nature of products in manufacturing industry requires the EOS concept as it can be easily practiced there. Overall, 93% of the experts were not satisfied with the current application of EOS within construction industry.

Therefore, this study identified the reasons for limited applicability of EOS concept within the construction industry in Sri Lanka and findings of the analysis are presents in Table 5.

Table 5: Reasons for Limited Applicability of EOS

Reasons	Number of Experts	Percentage
Designers' unawareness on applicability of EOS concept	10	71%
Unique nature of the construction industry	06	43%
Changes in initial design	03	21%
Limited number of repetitive features within the designs	03	21%
High risks and uncertainties involved within the construction industry	03	21%
Lack of willingness to change	02	14%
New technology is not that much adopted	02	14%
Barriers in procuring raw material with discounts	02	14%
Lack of time between awarding and the commencement	02	14%
Difficulty in handling projects simultaneously	01	07%
Deficiency of analysed databases between per unit cost and number of items produce	01	07%
Price is determined before the production process begins	01	07%
Limited number of researches were conducted on these area	01	07%

As Table 5 presents, majority of the experts (71%) identified the reason for lower applicability as the designers' unawareness on applicability of EOS concept in the construction industry. Unique output has been identified as the second reason to limited applicability of EOS. One of the contract administration expert stated that "*construction is always associated with risk. Always the conditions are changing in the industry unlike in the manufacturing industry. It has repetitive elements, large quantities, high value items, low value items, public areas, accommodation and so many other things. It is an industry which is associated with lot of sub sections. Therefore, one construction product may not be similar to another*". On the other hand, uniqueness makes less number of repetitive elements.

Subsequently, experts were questioned on existing barriers for application of EOS within Sri Lankan construction industry, which are caused as results of over identified reasons. Identified barriers in applying EOS are presented in Table 6.

Table 6: Barriers in Applying EOS

Barriers	Sources	References	Percentage
Barriers in applying EOS within the identified areas	11	15	
Uncertainties in construction industry	05	05	36%
Lack of knowledge in economic concepts	04	04	29%
Occurrence of variations	02	02	14%
Limited storage facilities	02	02	14%
Improper distribution of tasks	01	01	7%

As per Table 6, 36% of the experts stated that uncertainties in construction industry act as a barrier when applying this concept within those particular areas. Adverse climatic or environmental conditions can be the reason for uncertainty. The experienced civil engineering expert was also of the same view that applicability of EOS is less in civil engineering projects due to the unforeseeable physical conditions encountered. Besides, lack of knowledge in economic concepts has been commented as a barrier to apply EOS by 29% of the experts. In addition to that, 14% of the experts mentioned occurrence of variations and limited storage facilitiesas barriers. One of the project control experts said that *"if there is a possibility of occurring variations, contractors are reluctant to purchase materials at once and they will not obtain the discount advantages"*. At last, improper distribution of tasks is opined by only one expert.

4.4. PROPOSED STRATEGIES TO OVERCOME THE BARRIERS

At the end of interviews, experts were asked to comment on the strategies in overcoming aforementioned barriers. Considering the experts' views, strategies shown in Table 7 were identified to overcome limited applicability of EOS in the construction industry.

Table 7: Proposed Strategies to Overcome the Barriers

Strategies	Sources	References	Percentage
Strategies to overcome barriers	09	09	
Confirmation of drawings at the initial stage	05	05	36%
Conducting training sessions	02	02	14%
Conducting researches	02	02	14%

Accordingly, 36% of the experts were of the opinion that the best way to overcome the aforementioned barriers is to confirm drawings and obtain detail drawings as early as possible. In addition, 14% of the experts were of the opinion that management of the organizations should conduct some training sessions in order to provide a good knowledge on applying economic concepts in construction projects. Another 14% of the experts stated that the best way to overcome barriers is conducting some researches on these economic concepts and providing the knowledge to the industry.

5. DISCUSSION AND CONCLUSIONS

Application of EOS is limited to certain areas such as mass house building projects, road projects and highways in construction industry compared to manufacturing, automobile and apparel industries. Although its application is limited, it is a known concept within the Sri Lankan construction industry and found mostly applied in pre-cast concrete element under the civil engineering projects while applying in both pre-cast concrete and pre-fabricated steel elements of building construction projects. This has been the situation in the international context (Manser, 2005 and Chiang *et al*. 2008). Further, it was identified that production of pre-cast / pre-fabricated elements has more opportunity to adhere with EOS as they cast within a factory under the controlled conditions of temperature. Further, formwork, aluminium components and concrete under building construction projects and laying asphalt and laying ABC under the civil engineering projects, were identified as the most applicable areas of EOS within the construction industry. Moreover, it can be applied within design stage, procurement stage, project execution stage and within the execution stage even up to purchasing of new plant and equipment.

In terms of contributory factors of EOS, unlike previous studies, this study has revealed extensive set of factors including division of labour, specialisation of labour, gained discount rates due to bulk purchasing, application of new technology or changes in methodology, shared fixed costs, operational efficiencies in machineries, learning by doing, and generation by-products. This study confirms that application of EOS concept is limited in the local context for the similar reasons stated in the literature. However, this study further revealed eight reasons which reduce the application of EOS within the construction industry in Sri Lanka. They are: unique nature of the construction industry, initial design changes, limited number of repetitive features within the design, high risks and uncertainties involved, lack of time between awarding and the commencement, deficiency of analysed databases between per unit cost and number of items produce, pre-determined prices, and limited research and development. Consequently, uncertainties exist within the construction industry has been identified as the main barrier to the application of EOS in Sri Lankan construction industry as construction is always cope with the uncertainties since construction products expose to the external factors. Accordingly, it is recommended to confirm the detail drawings at the initial stage of constructions and to conduct regular training sessions and increase the number of researches carried out focusing the construction industry, in order to overcome existing barriers.

According to the finding of the study, there is a high possibility to apply EOS within apartment complex projects or road construction projects, which consist of more repetitive elements. If a firm runs at EOS, that firm has the opportunity to enhance the profit figures. In future, there would be more applications of EOS within the areas such as external cladding, curtain walls, electrical cables and layering PVC pipes. Finally, it is recommended for a construction firm to apply the EOS concept for their products and obtain price efficiencies and not to increase the quantity to a level at while where diseconomies of scale are applied and generate price deficiencies.

6. REFERENCES

Ahadzie, D., Proverbs, D. and Olomolaiye, P., 2008. Critical success criteria for mass house building projects in developing countries. *International Journal of Project Management,* 26(6), 675-687.

Atsushi, L., 2007. Aid and competition in procurement auctions: A case of highway projects. *Journal of International Development*, 19(7), 997-1015.

Chiang, Y., Tang, B. and Wong, F., 2008. Volume building as competitive strategy. *Construction Management and Economics,* 26(2), 161-176.

Dunning, J., 2014. *Economic analysis and multinational enterprise.* 3rd ed. Oxon: Routledge.

Finkel, G., 1997. *The economics of the construction industry*. Armonk, New York: M.E. Sharpe.

Gurung, T. and Sharma, A., 2014. Communal rainwater tank systems design and economies of scale. *Journal of Cleaner Production,* 67(1), 26-36.

Husan, R., 1997. The continuing importance of economies of scale in the automotive industry. *European Business Review,* 97(1), 38-42.

Manser, J., 2005. *Economics: A foundation course for built environment.* New York: Taylor & Francis.

Meduri, S. and Annamalai, T., 2013. Unit costs of public and PPP road projects: Evidence from India. *Journal of Construction Engineering and Management*, 139(1), 35-43.

Nagaraju, S., Reddy, B. and Chaudhuri, A., 2012. Resource management in construction projects. *Engineering Science and Technology,* 2(4), 660-665.

Parker, E., 1997. The effect of scale on the response to reform by Chinese state-owned construction units. *Journal of Development Economics,* 52(2), 331-353.

Ruddock, L., 2009. *Economics for the modern built environment.* 2nd ed. New York: Taylor & Francis.

Sabol, L., 2007. Technology, change, and the building industry. *Real Estate Review*, 36(3), 1-12.

Samuelson, P. and Nordhaus, W., 2005. *Economics.* 18th ed. New Delhi: Tata McGraw-Hill Edition.

Sheu, J. and Chen, Y., 2014. Transportation and economies of scale in recycling low-value materials. *Transportation Research Part B: Methodological,* 65, 65-76.

Shi, H. and Smyth, R., 2012. Economies of scale in the Australian tourism industry. *Applied Economics*, 44(33), 4355-4367.

Sloman, J., 2007. Essentials of economics. 4th ed. England: Prentice Hall.

Waris, M., Liew, M., Khamidi, M., and Idrus, A., 2014. Investigating the awareness of onsite mechanization in Malaysian construction industry. *Procedia Engineering*, 77, 205-212.

Worthington, A. and Higgs, H., 2014. Economies of scale and scope in Australian urban water utilities. *Utilities Policy*, 31(1), 52-62.