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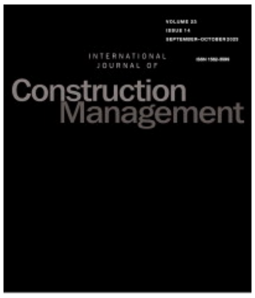

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Understanding the competitiveness factors of Korean contractors in the international construction market

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ABSTRACT
The international construction markets (ICM) are constantly changing with new pressures creating opportunities and threats., Enterprises from advanced major advanced economies have been successful in venturing overseas and winning projects by exploiting their design, engineering, technological, and managerial competencies. Construction markets have changed with Chinese, Japanese, Korean, and Turkish construction enterprises securing more projects overseas. Understanding and exploiting the competitive advantage possessed by enterprises from major advanced economies is being challenged by enterprises from newly industrialised economies. This study investigates the competitiveness factors of the Korean construction (KOC) enterprises to understand how they have been successful in exploiting their competitive advantages. The competitiveness evaluation model (CEM) is developed using system dynamics which compares the project performances between the models generated by general and Korea-featured competitiveness factors in winning work in the ICM. The findings reveal that ownership of the enterprise, government strategy and support for the construction industry enterprises, strong leadership, technology-intensive, and special characteristics of large Korean enterprises (Chaebol system) could be critical factors for creating competitive advantage.

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KEYWORDS
Competitiveness evaluation model; contractor competitiveness; international construction; system dynamics

Introduction

International construction is a convenient term for carrying out of any building, civil engineering, or engineering work in overseas markets, using extraction, manufacturing, and services. The scope includes project creation, feasibility, procurement, design, engineering, extraction, manufacturing, site production, maintaining, and renewal within a regulatory and governance system that includes statutory requirements, laws, regulations, codes, and standards in countries and regions around the world. International can refer to countries, enterprises, and markets. Construction and engineering have influenced the migration of capital, products, and people across political and geographical boundaries. The paradox of international construction is that projects are required to meet local conditions and local regulatory requirements; the site is fixed, whilst products, design services, construction services, and a mobile labour force are not. The growth in international construction has resulted from the mobility of capital and labour across boundaries.

ICM can be divided into countries, trading blocs, regions, and industry sectors, including buildings, power, transportation, etc. Players in the international construction markets include enterprises focused upon design and knowledge-intensive professional services, classified as knowledge-intensive business services (KIBS)[1]. Construction and site production is also classified as services, but not under KIBS. An estimate of the global construction output of design and construction services in 2021 based upon construction work put in place at current prices is in the region of US$10.49 trillion, equating to around 12% of the 2021 global domestic product of US$84 trillion (Oxford Economics 2021).

Annual output in the ICM has grown significantly over the past decade with a focus on investment in infrastructure and mega projects. Innovative technologies, digital transformation, new procurement methods, innovative project financing, and Public Private Partnerships (PPP) have all influenced the size and shape of international projects (World Economic Forum 2016). New challenges have emerged, with requirements for sustainable and environmentally responsible projects, social and ethical procurement, and pressure for increased local content requirements in low income developing[2] countries[3]. What characterises ICM is that they are complex, fast-moving, dynamic, influenced by regional and local issues, and increasingly driven by geopolitics.

Competitiveness

The market for goods and services is changing constantly with the creation of competitive advantage through such drivers as: being the cheapest, providing the best value for money, delivering the best quality, fastest delivery, being the most innovative and technologically advanced, the most politically acceptable, having the highest safety standards, and providing the most attractive financial arrangements for the transaction, or even government to government loans at attractive interest rates. Competitiveness is at the core of seeking growth at the country and enterprise levels. National competitiveness is a country's ability to create, produce,

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distribute and/or service products in international trade while earning rising returns on its resources. The drivers shaping competitiveness are creating issues for all enterprises; standing still is not an option. Competition in the marketplace is constantly changing in response to competitive pressures.

Competitiveness is not a zero-sum game. One country does not improve its competitiveness at the expense of other countries. The industry challenge is to create the conditions for resilient and sustained productivity growth that will shift a comparative advantage when an enterprise can produce goods at a lower opportunity cost than its competitors, to a competitive advantage (more efficient processes that exploit innovation and technology and create an environment for success).

Enterprises seek growth overseas because they may have outgrown their domestic market or see opportunities in overseas countries. Going overseas provides an opportunity to have the resilience to cyclability and avoid over-reliance upon a single market. A shift is happening with more projects being undertaken in emerging and developing countries. Engineering News Record (Engineering News-Record (ENR) 2021) states that since 2000, over 60% of major international construction projects have been undertaken in emerging or developing countries. This should not be confused with a domestic market increase. For example, the annual 2020 construction output of work put in place for Korea was US$189 billion, which ranks it in the top 10 countries in the world by size of output. Engineering News-Record (ENR) (2020) undertakes an annual survey to produce a table of the top 250 enterprises in contracting, and KIBS, for both domestic and international work. Enterprises are classified by the annual revenue (domestic and international), number of staff, and the sector markets where they operate.

There is a strong correlation between the size of the domestic market where an enterprise is registered and its position in the ENR international contractors ranking. China, the USA, Japan, and some European enterprises have a strong international presence. Korean[4] enterprises do not have a huge domestic construction market. The country does not have an abundance of natural resources; it is reliant upon technology, manufacturing innovative products and exporting goods and services where technological advantage can be exploited, such as the design and installation of oil and gas plants, industrial engineering, and super high-rise structures (Lee et al. 2011; Suh and Kim 2014; Lee and Jeon 2018). Korean construction enterprises have been active in international construction since the 1970s, working in the Middle East and North Africa (MENA) market to exploit the opportunities in hydrocarbons, water, and power transmission. The Great Man-Made River project in Libya was the world's largest irrigation construction project utilising a pipeline system that pumps water from the Nubian Sandstone Aquifer in the desert into Libyan towns and cities (Fookes et al. 1993). Korean enterprises at that time created a competitive advantage based upon exploiting advanced technology, using a flexible Korean labour force that was mobile and efficient, being prepared to take financial risks many contractors were reluctant to consider, and having a politically non-aligned government.

Huovinen and Kiiras (1994) referred to 'an extremely hard wall' of the ICM, which makes competing overseas in the construction industry more difficult to enter than walls surrounding many other industries. This reflects trade facilitation and the barriers to entry, which may be physical/geographical, political, technical, financial, or cultural. Some barriers are transparent, whilst others are opaque (non-transparent practices), even when the countries are part of a trading bloc. Governments can apply non-tariff trade policy measures such as technical standards, trade remedies, and quotas, all considered trade barriers. Enterprises from developing countries often have a small domestic market by output value. They have more difficulty because of the challenges in international environments, such as severe competition, local industry protection, and regional economic-bloc policies.

International construction entails risks and requires competitive abilities to handle physical, technological, financial, legal, sociocultural, and political issues (Ofori 2003). Being able to compete on low price can work in some developing countries, but there is pressure on delivering on good quality, on time, and meeting stringent safety standards. Increasingly environmental, social and governance issues (ESG) with stringent requirements to be met. Construction services and products are different to KIBS where design and consultancy services are influenced by technical competencies and client relationships.

Korea was an underdeveloped country in the 1960s, with no Asian construction enterprises seen as being successful in ICMs. Korea has a deep root of multilateral cultural, moral, and religious traditions. It is a country with limited natural resources and needs enterprises to operate internationally because construction is a key economic driver and source of foreign currency and invisible-export earnings. Korean enterprises' competitive advantage must be based upon a clear strategy that exploits the comparative advantage. This research aims to consider the factors that influence the competitiveness of Korean construction enterprises when they operate in the ICM. It considers the underlying theory of competitiveness and uses system dynamics to consider the crucial factors of competitiveness of Korean enterprises.

New competitiveness paradigm for construction

Competitiveness has been researched at various levels: nation, industry, and enterprise (Ofori 2003; Flanagan et al. 2007). The underlying theory of competitiveness remains ambiguous. At the nation level of competitiveness, the World Economic Forum (World Economic Forum 2016) evaluates annually the competitiveness of 133 countries focusing upon 12 pillars: Institutions; Infrastructure; ICT adoption; Macroeconomic stability; Health; Skills; Product market; Labour market; Financial system; Market size; Business dynamism; and Innovation capability. This gives a macroeconomic view of country competitiveness. It is difficult to evaluate the construction sector or enterprise competitiveness since each enterprise must compete on their innovative ideas, scale, financial capital, ability to exploit technology, management efficiency, human resources, and productivity and competency. Porter (1980, 1990) focused on the industry level to determine the factors of competitiveness with the Diamond framework. It considered what factors provide an industry with comparative and competitive advantages, like access to natural resources, skilled labour and capital, clusters of supporting industries, and the sophistication of business strategies.

A characteristic of ICMs is the unique nature of the country and sector markets. KIBS and construction services are not like manufactured goods. Traditional competitiveness is based on the industrial development status that depends on an effective supply of project resources at low prices, including labour, skills, and capital (Porter 1990; Green et al. 2008). Competitiveness in construction has been defined by the characteristics of scale, cost/-price, speed of delivery, management capability, technology, productivity, and entrepreneurial skills. However, the new competitiveness paradigm has shifted from conventional competition to a more complex framework where non-price factors are equally critical (Flanagan et al. 2005). Additional factors are becoming important to create competitive advantage, such as sustainable and renewable energy, environmental protection to conform with the UN Sustainable Development Goals, social requirements, resilience, appetite for risk, management of quality, and safety and health standards (Han et al. 2015; Hanafi and Nawi 2016). The ability to ability to provide project finance solutions, home government support, and geopolitical influence are uppermost in supporting competitiveness. The business boundary has been diminishing between nation and firm, and the role of nation-level has not received adequate attention because of the multinational enterprises and global alliances.

Porter's Diamond framework provides a basis to analyse competitiveness, even though it was founded upon a manufacturing perspective rather than services. The discussion of the justification of the new approach supports the suggestion from the literature, such as Ofori (2003) and Momaya (2004), that the diamond framework should be extended to reflect the new factors. New approaches to the diamond framework (multiple linked diamond and double diamond framework) were proposed by Cartwright (1993) and Moon et al. (1998). Flanagan et al. (2005) developed the hexagon framework to apply in the international construction industry where the boundary of nation, industry, and firm level is blurred. He propounded that competitiveness is multi-defined, multi-measured, multi-layered, dependent, relative, dynamic, and process/project related. The main suggestion is that Porter's framework should be extended to account for the international and complex dimensions. Their research assumes that a contractor's competitiveness is affected by six areas: factor conditions, demand conditions, government, industry characteristics, firm strategy and management, and human resources, which are organised in a hexagonal model. The hexagonal model can be used to analyse a contractor's competitiveness with the ability to satisfy stakeholders, shareholders, employees, clients, and overall society.

Dunning (1993) propounded other theories of competitiveness, with the eclectic paradigm that used the OLI approach that said ownership, location, and internalisation factors created competitive advantage. Ownership of the enterprise is important, but rarely considered. Barney's (1991) resource-based view developed the VRIO approach that defined resources as the critical factor. They should be valuable, rare, costly to imitate, and organised. The supporters (Dunning and Lundan 2008; Czajkowska and Kadlubek 2015; Ishkov et al. 2016) of this view argue that organisations should look inside the enterprise to find the sources of competitive advantage instead of looking at the competitive environment.

Government's role in enhancing competitive advantage

Park et al. (2015), highlighted the importance of government support which plays an important role in increasing the enterprise' and industries' competitiveness. Korean government offers support through soliciting projects by politicians; tied or targeted aid; market development grants, tax concessions; suppliers' credits, and insurance support (Lee and Jeon 2018). Korean enterprises enhanced the price competitiveness in infrastructure projects with close partnerships between the Korean government and the Middle East and Southeast Asian countries.

The Korean government is supportive of export initiatives, f. or example, government to government loans for projects provide an opportunity for Korean companies to win the project delivery. Government bodies such as the KIND[5], support overseas PPP projects where Korean companies are involved. The International Contractors Association of Korea (ICAK) is a promotion agency for the Korean construction industry overseas, aimed at enabling working opportunities for Korean contractors in foreign countries. Other bodies such as the Korea Trade insurance Corporation, the export credit agency under the government, and the Export-Import Bank of Korea all provide support to help secure projects for Korean contractors. Korea's Eximbank provides financial support for export and import transactions and enhances economic cooperation with foreign countries.

A new paradigm is required that embodies the theories of competitiveness and is appropriate for international construction. Figure 1 shows the paradigm based on the principles embedded in the various competitiveness models. The important role of government in supporting enterprise when they venture overseas is reflected in the principles.

Competitiveness of korean enterprises in the international market

Korean construction industry output is cyclical, with slow growth since 2015, as Figure 2 shows. From 2010 to 2014, international construction activity showed growth, but since 2015 winning new international orders has been flat. The estimated annual construction output for 2021 is US$185 billion. The decline in winning overseas projects by Korean enterprises is partly attributable to an increased cost base, increased competition in ICMs, particularly from China and European competitors, and partly by the shift in the competitiveness paradigm with the link between project finance, project creation, and linking technologies to projects (Han et al. 2015; Lin et al. 2022), such as the Chinese exploitation of high-speed rail by linking manufacturing with design and site production, supported by attractive project financing and loan arrangements. Korean construction enterprises are in the top ten countries of revenue in international construction (Engineering News-Record (ENR) 2021). Nine Korean contractors are ranked in ENR's 2021 Top 100 Global Contractors, whereas in the 1990s, only two enterprises ranked in the Top 100 global contractors.

Korean enterprises entered the Middle East and North Africa market in the 1970s with a focus on having a highly efficient, hard-working labour force prepared to work overseas, and withstand difficult working conditions (Lee et al. 2011). As Korea industrialised, the cost base became an issue with Korean enterprises seeking innovative technology to provide project success. There was success in automotive and electronics manufacturing by exploiting innovation and digitalisation. In the past decade, Korean construction enterprises established ambitious plans for competitiveness in industrial plants, power plants, refinery, petrochemical plants, infrastructure, and complex high-rise building projects (Han et al. 2019). Linking projects that require project financing, and managerial and technical ability has been important in securing overseas work. The engineering and construction companies are creating new opportunities by exploiting advanced high-tech solutions on projects using engineer, procure and construct (EPC) approaches where they can exploit their technology and design skills. They are also engaging in more PPP projects where the barriers to entry are high.

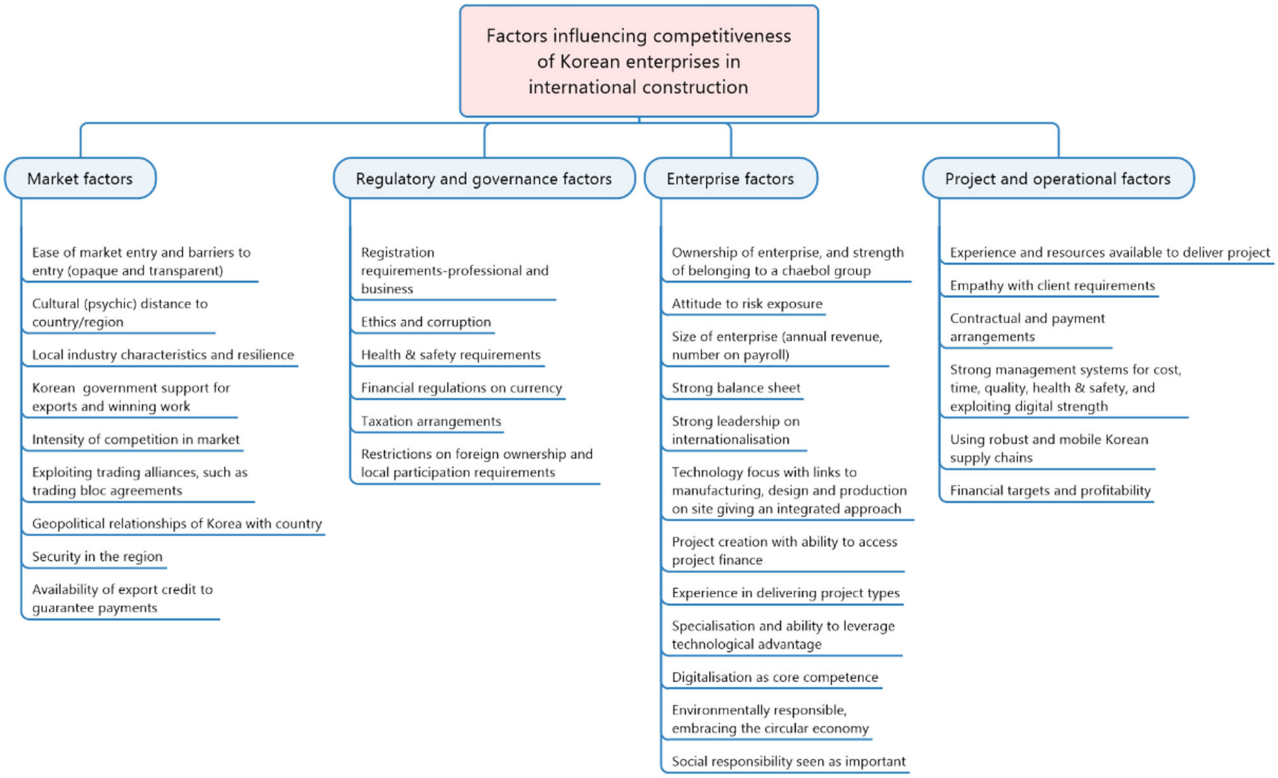

Figure 1. Factors influencing competitiveness-Korean enterprises.

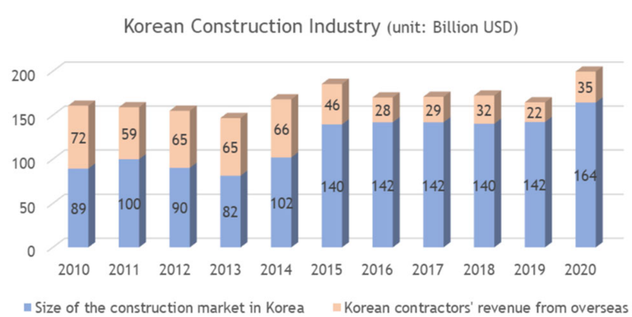

Figure 2. Korea's annual construction output. Source: Construction Association of Korea (CAK) and International Contractors Association of Korea (ICAK).

Chaebols[6]

Something special about the Korean economy that distinguishes it from other economies is the ownership of the enterprise and the influence of the Chaebols, an arrangement of the major enterprises unique to Korea, offering a special competitiveness characteristic (Byun et al. 2018). The Chaebol system has been credited for the country's economic development and for transforming the country from an exporter of cheap products to a major global player in high value products. Chaebol's first became prominent in South Korea in the early 1960s and 1970s. They create a competitive advantage through scale, exploitation of technology, and connectivity to diversified businesses (Park and Yuhn 2012). The Chaebol has a wide range of subsidiary companies in Korea and worldwide within a single corporation. Many large Korean contractors, such as Samsung, Hyundai, Daewoo, Lotte, SK Group, LG Group, and Daelim, belong to a Chaebol corporation. They have subsidiary companies worldwide that can provide support when the construction company bids for a project in a new country or market (Sial and Doucette 2020). For example, Hyundai Engineering & Construction obtained information on a new project from subsidiary firms such as Hyundai Motor Company and Hyundai Merchant Marine, spreading worldwide (Moskalev and Park 2010). Other associated subsidiary firms (Hyundai Engineering or Hyundai Architect & Engineer) help to bid and deliver the project successfully.

The development of Korean enterprises in the past three decades shows how Korea has improved competitiveness within a short period, with efforts from the national (government supported bodies), industry (Chaebol system), and enterprise (well-educated, hardworking, and dedicated people). In this research, the CEM is developed taking account of the Korean case, based on the competitiveness in the new competitiveness paradigm.

Research methodology

This research aims to understand the factors of competitiveness of Korean construction enterprises and evaluate its practical performance by the development of a Competitiveness Evaluation Model (CEM) that can be benchmarked to other developing or underdeveloped construction industries. The competitiveness factors of KOC and the CEM were verified using the system dynamics simulation where practical performance between general and Korean-featured competitiveness factors was compared. The research framework is structured into three parts: the competitiveness factor identification phase, the data collection phase, and the model development phase, as shown in Figure 3.

In the factor identification phase, the literature review identified 38 competitiveness factors. In the data collection phase, semi-structured interviews and questionnaire surveys were carried out to obtain quantitative data. Six professionals in the international construction industry conducted web-based and face-to-face interviews before setting the main questionnaire structure and determining the questions. The questionnaire was

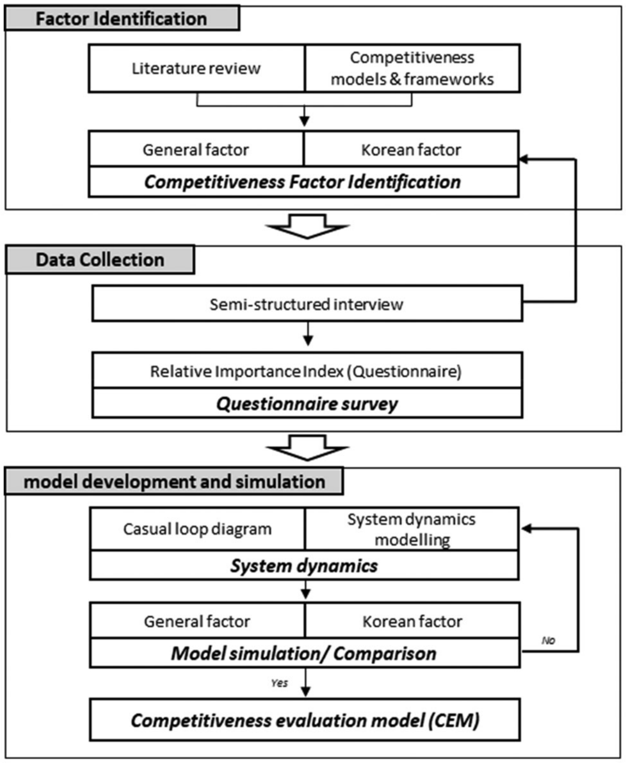

Figure 3. Research framework.

divided into two parts. Part 1 with five questions designed to acquire personal and general information regarding their organisation, projects, and role. In Part 2, the respondents were asked to rate the performance (importance) of the competitiveness factors and interrelationships using a Likert five-point scale. Values of 1–5 were assigned to the responses for the importance and interrelationship of the general and Korea-featured competitiveness factors, for instance, with 1 as 'lower importance', 2 as 'less important', 3 as 'neutral', 4 as 'more important', and 5 as 'very important'. The relative importance of all surveyed competitiveness factors was calculated using the Relative Importance Index (RII). In the model development phase, calculated RIIs were used to develop CEM using system dynamics. To verify the competitiveness of KOC and CEM, simulated project performances were compared using both general and Korea-featured competitiveness factors by system dynamics simulation.

Data collection

All interviewees who participated in semi-structured interviews are senior managers or directors in their organisations, with an average of over 21.3 years of working experience in ICM. Using empirical experience and expertise, they reviewed the nominated competitiveness factors to determine the influential ones. As part of the interview, comments and suggestions for the survey items, item wording, item sequence, and directions were also solicited. The total number of factors was adjusted through the semi-structured interview, where six factors were combined into general or Korean-featured factors. The formal survey questionnaire consists of 32 competitiveness factors.

Questionnaires were distributed to middle-level managers of KOC firms listed in ENR's Top Global 250 Contractors (Engineering News-Record (ENR) 2021). A brief description of the competitiveness factors and the CEM was provided with a cover letter. The confidentiality and anonymity of all responses were ensured at every stage of the research process. A total of 302 questionnaires were distributed by web-based or email, and 136 responses were received, a 45% response rate. Table 1 shows that 36 respondents (26.5%) were project managers, 38 (27.9%) site managers, 29 (21.4%) project engineers, 11 (8.1%) design managers, and 22 (16.1%) other consultants. They were all at the middle or higher management level.

The field survey asked KOC experts to rate the level of importance and interrelationships of general and Korean-featured competitive factors. The Relative importance index (RII) method was used to determine the relative importance and interrelationships of the competitiveness factors. RIIs are calculated for each factor as in Equation (1) (Dixit et al. 2019);

$$\mathrm{RII} = \frac{\Sigma W}{(A * N)} \quad (0 \le \mathrm{RII} \le 1) \tag{1}$$

where W = weighting given to each factor by respondents (ranging from 1 to 5); A = highest weight (i.e. 5 in this case); and N = total number of respondents. The RII value had a range of 0 to 1 (0 not inclusive); the higher the RII, the higher the importance factor compared with other factors.

The Bartlett test of sphericity for overall significance of correlations between parameters and the Kaiser-Meyer-Olkin (KMO) test were conducted before the RII calculation. KMO measures sampling adequacy is a test to assess the appropriateness of the data set (Norusis 2012). Table 2 shows the result of the Bartlett test was 703.118, and the associated significance level was 0.003. All variables had a significant correlation of at least 5%, which means that all competitive factors are suitable to be included in the RII calculation. In the KMO test, because the sampling adequacy is higher than 0.5 (0.695), the variables (competitiveness factors) can be recognised to meet the fundamental requirement. Finally, all 32 competitiveness factors are evaluated through the RII, and the results are shown in Table 3.

Using system dynamics simulation shows which competitiveness factors will positively affect whole project performance under limited resources. Therefore, the value of importance weight and interrelationship weight, which are relative values using the RII method rather than the mean value of the factor, were calculated and used for system dynamics. Interrelationship weights were used as the basic data set for interrelationship modelling between factors in causal loop diagrams, and importance weights were used as flow variables of each factor in system dynamics simulation.

Government support and Technology-oriented factors such as F04 (Korean government support for export and winning work), F07 (Geopolitical relationships of Korea with country), F21 (Technology focus with links to manufacturing, design and production on-site giving an integrated approach), or F25 (Digitalisation as core competence) that have been studied as a traditional strong point of KOC (Park et al. 2015) are ranked relatively high in Importance weight with 9th, 15th, 3rd, and 10th respectively. Government's support is the main competitive factor (Chen and Orr 2009; Blanco et al. 2017). Facilitating and helping to open international construction markets to Korean contractors and employing advanced construction technologies is essential (Taofeeq et al. 2020) for the KOC in the future. Korea successfully entered the international construction market focused upon high risk, labour-intensive projects such as The Great Man-Made River project in Libya do not provide competitive advantage in current markets. Korean engineering and construction enterprises have, has developed innovative and

Table 1. Survey respondents.

Experience(Years)	Project Managers	Site Managers	Project Engineering	Design Managers	Other roles	Total Responses
Less 10	8	5	5	7	10	35
11-15	13	9	12	2	4	40
16-20	9	16	9	1	7	42
21-30	5	5	3	1	–	14
Over 30	1	3	–	–	1	5
Total	36	38	29	11	22	136

Table 2. Result of bartlett's test and KMO measure.

Bartlett's test of sphericity	Approx. χ^2	703.118
	Sig	.003
	Df	110
KMO measure of sampling adequacy		.695

advanced construction technology, such as the design and installation of small module reactors for nuclear power plants, and the development of high strength concrete using hollow glass powder. Innovative financial engineering has become important to create and unlock projects.

A factor that receives insufficient attention is the ownership and organisation of the enterprise, and the impact of the Chaebol effect. F16 (Ownership of enterprise, and strength of belonging to a chaebol group), F18 (Size of the enterprise-annual revenue, number on payroll), or F20 (Strong leadership on internationalisation), are all highly ranked in importance weight with 6th, 11th, and 1st can be analysed as chaebol-related factors, particularly noticeable in KOC project implemented by chaebol contractors. The Chaebol effect, represented by fast decision-making, strong leadership, and the ability to exploit technology from other industries into construction has not received significant attention. Due to the increasingly large and complex projects and procurement, the Chaebol effect is becoming more influential. The Chaebol system typically provides synergic advantages to their subsidiary firms by supporting intelligence, acquaintance, financial guarantees, and administrative operations. For instance, when Samsung Construction Co bid for the Burj Khalifa project in Dubai, Samsung Electronics supported its subsidiary company by the financing guarantee using their acquaintance with the Dubai royal family (Seo 2010). Within the Chaebol system, the immediate decision-making regarding 'Go-or-No-Go' in projects or adventurous whole-hearted support can be made across organisational and regional boundaries, since whole corporations are owned and operated by a single founder family who has final authority all about business (Lee et al. 2011).

Development of competitiveness evaluation model (CEM)

Causalities of all competitiveness factors are expressed in a causal loop diagram, based on the survey results (Interrelationship weight) and discussions with international construction experts who participated in data collection (survey questions and questionnaire structure). The causal loop diagram is generated to recognise the structure of the whole system and causalities by formulating all interrelated system parameters (Whang and Flanagan 2015). The causal loop diagram is generated using different feedback loops of causalities among system parameters. Through the formulation of the various causal loop diagrams, the entire implementation strategy or mutual influences between different project elements can be understood comprehensively.

All connections of the factors were converged into four project performance criteria (see Table 3: Market condition, Regulatory and governance, Enterprise competence, and Project and operational implementation), presented in red in Figure 4. On average, all factors interact with 3.74 other factors. The top five factors (F04, F15, F22, F31, and F32), which have high relationships with other competitiveness factors, show 28.28% in inter-relationship weight, and affect an average of 6.42 other factors in the causal loop diagram. Among them, [F04] and [F31], showing the unique characteristics of the Korean construction industry, are ranked 4th and 2nd in RII, respectively. However, despite relatively low RII, [F15], [F22], and [F32] have interrelationships with other competitiveness factors. Through the generation of a causal loop diagram, when trying to apply a specific factor to the project, it is possible to be aware of the effects on other factors and the side effect (indicated by (-) in the causal loop diagram). Moreover, this causal loop diagram is used as basic input data for system dynamics simulation to investigate project performance using competitiveness factors and to develop the CEM.

System dynamics

Modelling

System dynamics is used to achieve practical quantitative simulation data. Based on different factor interrelationships generated in the causal loop diagram, all equations and functions of the competitiveness factors are formulated as stock and flow diagrams for system dynamics modelling (Martinez-Moyano and Richardson 2013). Interrelationships between variables (i.e. general or Korea-featured competitiveness factors) are expressed as different formulations using simple arithmetic and complex calculations and function formulae.

Using the Vensim[7] program (DSS Version 4.0), dynamic model structures and elaborate formulas were established, modified, and simulated. The system dynamics model was generated through the integration of different stock and flow diagrams, as shown in Figure 5. Using the Check model and Sensitivity tests, structural and equational problems of the modelling were resolved, and the technical validity of the model and simulations have been found.

Overall, the modelling structure is generated based on a causal loop diagram and a specific degree of importance and interrelationships between variables (general and Korea-featured competitiveness factors) are referred from the questionnaire responses (see Table 3). Based on the 32 project competitiveness factors used as auxiliary variables and constant values, 5 stock variables (including Project performance) and 12 flow variables were formulated, as shown in Figure 5. Finally, the values of the four stock variables, which are also the category of competitiveness factors in Table 3 are incorporated as flow variables for the main stock variable (Project performance).

Simulation and Comparison

System dynamics was used to compare the differences in project performance according to the application of Korea-featured and

Table 3. RII and Ranking of Korean competitiveness factors.

Category	No.	Competitiveness factors	Rank	RII	Import-ance weight (%)	Interrela-tionship weight (%)
Market condition factors	F01	Ease to market entry and barriers to entry (opaque and transparent) (G)	23	0.566	2.801	4.48
	F02	Cultural (psychic) distance to country/ region (G)	16	0.648	3.206	3.39
	F03	Local industry characteristics and resilience (G)	26	0.534	2.642	3.14
	F04	Korean government support for export and winning work (K)	9	0.701	3.469	5.21
	F05	Intensity of competition in market (K)	28	0.498	2.464	3.62
	F06	Exploiting trading alliances (such as trading bloc agreement) (G)	31	0.366	1.811	1.60
	F07	Geopolitical relationships of Korea with country (K)	15	0.651	3.221	2.77
	F08	Security in the region (G)	18	0.617	3.051	1.89
	F09	Availability of export credit to guarantee payments (G)	19	0.603	2.984	2.21
Regulatory and governance factors	F10	Registration requirements-professional and business (G)	27	0.501	2.479	2.96
	F11	Ethics and corruption (G)	13	0.669	3.310	2.34
	F12	Health & safety requirement (G)	12	0.681	3.370	1.96
	F13	Financial regulations on currency (G)	30	0.431	2.133	2.03
	F14	Taxation arrangements (G)	32	0.353	1.747	2.27
	F15	Restrictions on foreign ownership and local participation requirements (G)	29	0.484	2.395	5.65
Enterprise competence factors	F16	Ownership of enterprise, and strength of belonging to a Chaebol group (K)	6	0.786	3.889	1.92
	F17	Attitude to risk exposure (K)	17	0.646	3.196	3.66
	F18	Size of enterprise (annual revenue, number on payroll (K)	11	0.686	3.394	3.81
	F19	Strong balance sheet (G)	24	0.557	2.756	4.24
	F20	Strong leadership on internationalization (K)	1	0.852	4.216	4.73
	F21	Technology focus with links to manufacturing, design and production on site giving an integrated approach (K)	3	0.833	4.123	2.36
	F22	Project creation with ability to access project finance (G)	14	0.657	3.251	5.56
	F23	Experience in delivering project types (G)	5	0.795	3.934	2.20
	F24	Specialisation and ability to leverage technological advantage (K)	7	0.783	3.876	1.85
	F25	Digitalisation as core competence (K)	10	0.689	3.409	2.44
	F26	Environmentally responsible, embracing the circular economy (G)	20	0.590	2.919	2.29
	F27	Social responsibility seen as important (G)	25	0.538	2.662	1.77
Project and operational factors	F28	Experience and resources available to deliver project (G)	4	0.801	3.963	2.83
	F29	Empathy with client requirements (G)	22	0.567	2.804	1.45
	F30	Strong management systems for cost, time, quality, health & safety, and exploiting digital strength (G)	8	0.703	3.478	1.51
	F31	Using robust and mobile Korean supply chains (K)	2	0.835	4.132	5.63
	F32	Financial targets and profitability (G)	21	0.589	2.914	6.23
					100	100

[a](G): General competitiveness factor/(K): Korea-featured competitiveness factor.

general factors. To that end, the system dynamics simulated the Project performance (main stock variable). Models were simulated using the Importance weights (see Table 3) of general and Korea-featured factors. Simulation results, as seen in Figure 6, were compared when increasing the constant value (Importance weight) of the general factors and decreasing the Korea-featured factors' (a), as opposed to the simulation graph (b). The Importance weight is a ratio; thus, the sum is always 100%. Therefore, when increasing the Importance weight of one factor in a simulation, it is necessary to lower the other factors and meet 100%. Since real projects are carried out with limited resources, system dynamics simulations continued to find out what project performance (graph pattern) would be shown by increasing or decreasing the constants (Importance weight) of various general or Korea-featured factors without increasing the sum of the total constants. Due to the page limitation, only final simulation results of Project performance are presented, and simulation results of the other four sub stock variables (Market condition, Enterprise competence, Regulatory and governance status, and Project and operational implementation) are not presented.

Figure 6 shows the simulation results of the two models, showing different graph patterns. Even if they have the same equations and functions, a wide range of constant values and delay time can make project performance (graph pattern) different. Both simulation results look like an S-curve, a normal project progress pattern (Wang et al. 2016). It validates proper modelling and simulation as if they reflect the situation of the actual project. However, interestingly, the graph form of the Korea-featured factor simulation (Figure 6(b)) shows greater amplitude. After lower project performance in the initial project stage, the graph increases dramatically during the construction stage. It falls again in the closing stage.

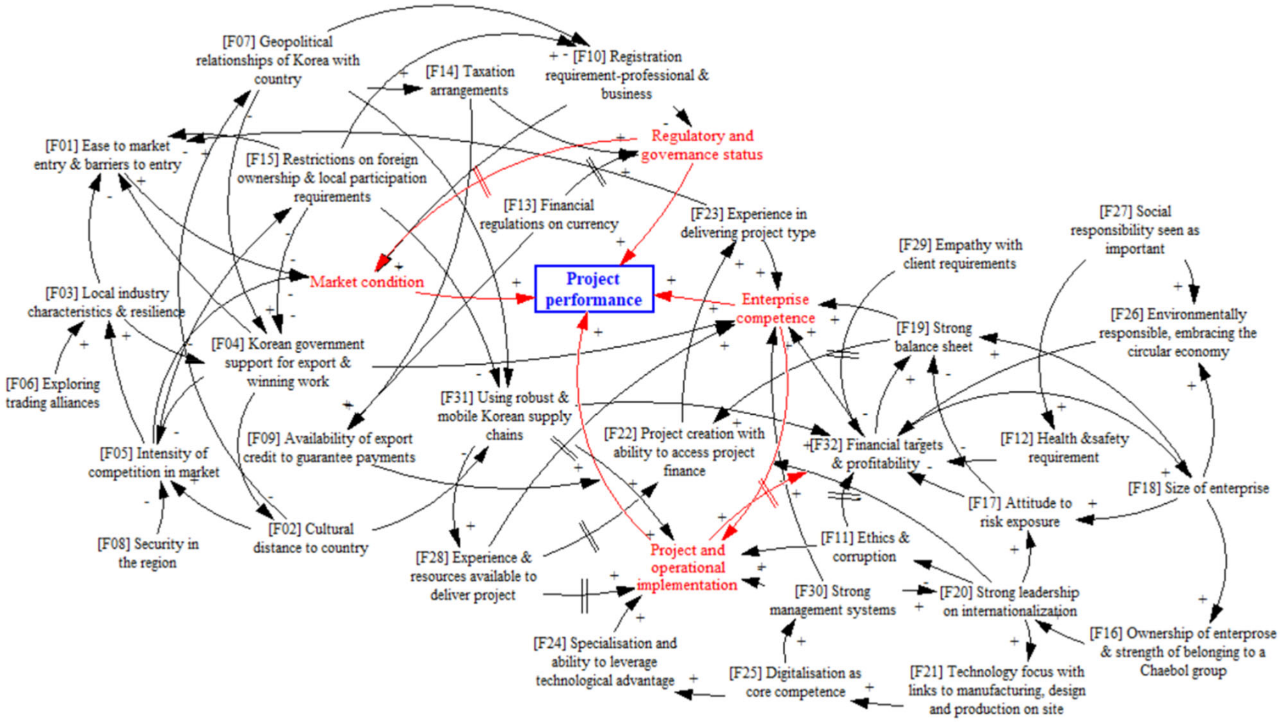

Figure 4. Causal loop diagram of project competitiveness factors.

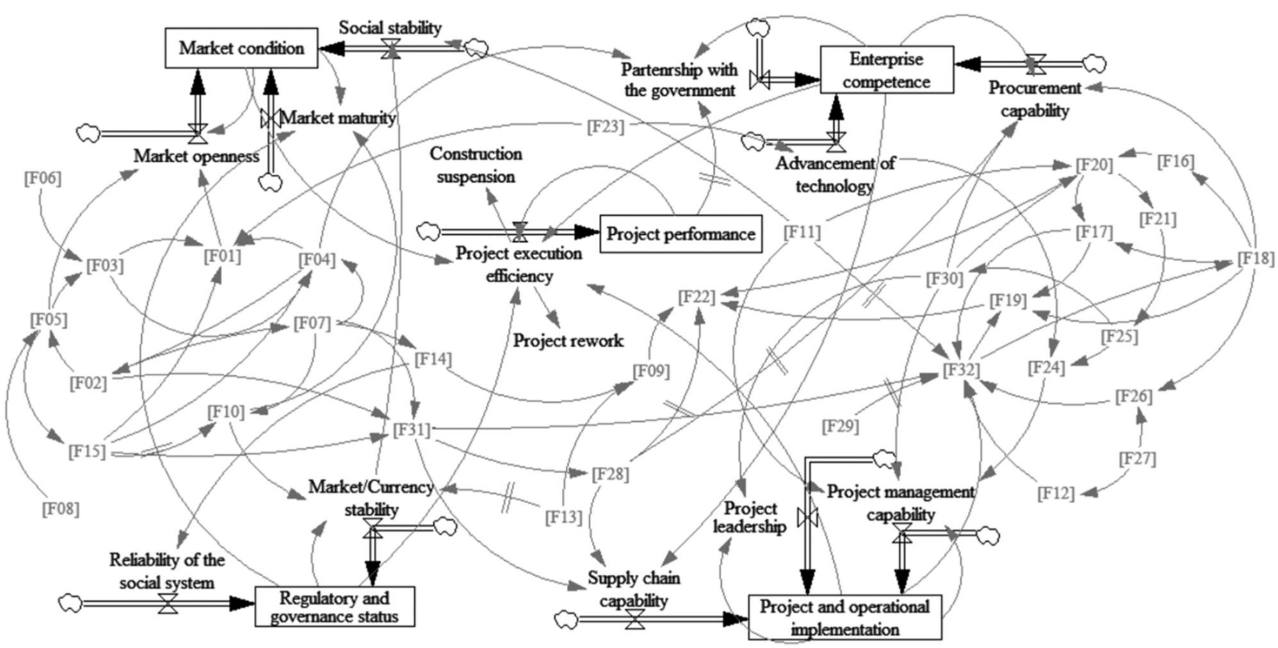

Figure 5. System dynamics modelling for project performance.

Finding and analysis

Through the system dynamics simulations, three distinct differences are found in the simulation pattern of the Korea-featured factors model. First, there has been slow performance progress in the initial part of phase A (See Figure 6(b)) since the project begins. It can be interpreted that Korean contractors sometimes make a highly competitive bid or win a project under unfavourable project conditions, or procurement according to the owner's decision or business strategy of a chaebol group. Thus, project performance in the initial stage could be lower than their international competitors, who focus more on general factors. During the construction stage (Phase B), the graph indicates higher progress, which can be analysed by using Korea-featured technology (such as digitalisation) or management (such as strong leadership and hard-working attitude), Korean contractors increase the project performance to the maximum during the construction stage (phase B). These characteristics make KOC competitive in ICM despite the lack of soft skills (Park and Kwon 2011). The last finding is the steep decline of project performance in the closing stage (Phase C). With the end of the construction stage and the beginning of the project closing stage, project progress has dropped.

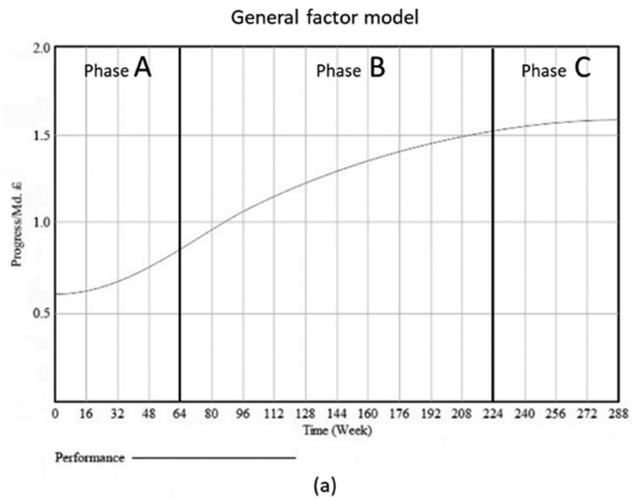

Figure 6. Comparison between general and Korea-featured factors model.

The higher fluctuation in the graph of the Korea-featured factor model in Figure 6(b) can be explained by characteristics of KOC; government support [F04], strong ownership and leadership by the chaebol group [F16, 20], and construction technology and digitalisation [F24, 25] as a competitive edge and side effect of intensity of competition [F05], strong coercive ownership [F16], risk-taking attitude [F17], or obsession with Korean supply chain [F31], which would be recognised as the chronic problem of KOC (Park et al. 2015: Lee and Jeon 2018). Other factors will have an influence, such as the culture and the focus on respect for relationships. Contractual claims always have the potential to occur, but Korean contractors are less focused on the claim mentality and more concerned with long-term relationships.

Conclusions

This study generates a CEM to investigate the competitive factor of Korean construction enterprises in the international construction market. To compare the characteristics and competitiveness of general and Korea-featured factors, the importance and interrelationships of factors were surveyed by Korean construction experts in ICM. Highest three factors among the top five important factors are all Korea-featured factors in order of [F20], [F31], and [F21], and two Korea-featured factors [F04 and F31] were also surveyed on the top five factors that were most related to other factors. The survey found that Korea-featured factors not only have an important effect on the project performance, but also influence other competitiveness factors. To evaluate the competitiveness of Korea-featured factors affecting the performance of international projects, system dynamics models, which are weighted on general factors and Korea-featured factors, were simulated. Unlike the simulation result of the general factor model, the Korea-featured factor model shows less performance in the initial stage (phase A), but very high performance in the construction stage (phase B) and a sudden drop in the final stage (phase C).

Based on the simulation result, flexible application of Korea-featured factors could be considered depending on the project situation (construction region, scale, and complexity), i.e. large-scale projects that cause incessant problems during the construction stage and result in poor performance. Since the Korea-featured factor model shows the highest performance in phase B, it could be suitable for projects with a difficult construction stage. In the ICM, enterprises should be aware of the intensive government support for project winning [F04] and focus on the methods of acquiring construction technology [F21, 25] as their strategy for international construction. Understanding the Korea experience to develop competitive advantage will bring benefits to understanding how to sustain competitive advantage.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. KIBS includes architectural and engineering services, and all technical consultancies.
2. Countries are classified by supra-organisations, such as World Bank, International Monetary Fund, World Economic Forum, into categories. For the purposes of this paper and to classify the categories for the construction sector; advanced industrialized, developed, emerging, and developing countries are used. Korea is considered an advanced industrialized country.
3. The International Monetary Fund (IMF) classify economies as:
- Advanced economies- which are sub-categorised into Euro Area, Major Advanced Economies (G7), Newly Industrialized Asian Economies (Singapore, Republic of Korea, Japan), and other Advanced Economies. In the advanced economy category are 31 countries. - Emerging and developing countries- with 81 countries, including China, India, Brazil, Mexico, Malaysia, UAE. - Low income developing countries- with 72 countries.
4. Korea is used to refer to the Republic of South Korea. It has a population of 51.79 million and is one of the most densely populated countries in the world.
5. KIND is the Korean Overseas Infrastructure and Urban Development Corporation. A government organization to support Korean companies for overseas Public-Private-Partnership (PPP) project in planning, feasibility studies, project loans, and investment.
6. Chaebol is a generic term referring to the large business groups in South Korea, such as Samsung, Hyundai, LG, and Lotte. Each consists of multiple firms, which, even though legally independent, are clustered and coordinated as a group and is owned and run by a family. Chaebols have the characteristics of: family ownership, control, and management; highly diversified big number of subsidiaries under the unified central command; multivariate cross shareholding, and mutual loan guarantees among subsidiaries
7. *Vensim is simulation software for improving the performance of real system. It emphasizes quality, connection to data, flexible distribution, and advanced algorithms.*

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