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CONFERENCE PAPER

Identification of key supply chain elements for megaprojects success

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Synopsis

Each megaproject influences life on the society level, so megaproject success or failure has another level dimension. In the past, the research community recognized the vital importance of megaprojects for development of a country on the one hand. On the other hand, researched identified strong negative impact that schedule, time and cost overrun (not even mentioning deceptions of public) of megaprojects might have for the development of a country. Recent studies in project management bring up supply chain conception as fertile component for megaproject management development.

Relevance for practice/education

Identification of supply chain elements could have impact on the performance of megaprojects in terms of delay reduction.

Research design

Quantitative methodology was the research design used for this study.

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Main findings

Econometric analysis confirmed a strong relation between dependent variable "delay" on the one side and construction.

Research implications

Our idea was to screen the area and problems to indicate the direction for future research. For more exact relationships and insight, a much wider sample (more than 200 infrastructure megaprojects) should be considered.

Keywords

Supply Chain Management, Megaprojects Success, Supply Chain Elements

Abstract

The objective of the paper is to explore elements of supply chain management within megaprojects and identify the ones that have significant influence on the megaproject performance, thereby providing an idea of the possible influence on megaproject success in general.

Within the theoretical framework, supply chain elements are identified for the megaproject management research field. Based on the chosen megaproject sample and econometric analysis, the presence and the level of identified supply chain elements were tested in the management of megaprojects. Variable construction signifies time needed to build an infrastructure (without planning). Delay is a common problem in infrastructure megaprojects and is often for the reason higher costs are incurred for the project in total. Variable delay in this paper indicates the time needed for the project to be completed. Econometric analysis showed that two variables, delay and construction, are significant for megaproject performance. The discussion of the conducted screening is contained herein so that recommendations can be made for steps for further in-depth research. Authors would like to acknowledge that rigorous mathematical modelling could give important value in better understanding the aspects of delay problem in megaproject management.

Introduction

Today we live in a world of projects, driven by needs, problems or ideas. The concept of project management is trying to respond to all those challenges by directing change from an unsatisfactory pre-project situation for the better one after the project. The state after the project must be aligned with success criteria. A creative and inspiring part of project management responds to the numerous challenges that may affect the success or failure of each project, including at the megaproject level. For decades, one of the essential problems of the project management aspect has been represented by the time and cost overruns. Supply chain management significantly contributes in minimizing the cost and time, with the aim of ensuring delivery of the expected value for the user. Therefore, supply chain could be considered a ground for planning megaprojects with success. The objective of this paper is to identify the main elements of the supply chain in megaproject outcomes. The research question is: to what extent are elements of supply chain related to megaproject success? After the following literature review, the authors describe the method of project selection and its main characteristics. Then an econometric analysis is carried out by applying selected statistical methods. In the conclusion, the authors state that the most challenging problems that occur in megaprojects relate to delay and construction.

Literature review

The definition of a megaproject is one where spending is over US$1 billion or €0.5 billion. However, small and medium-sized countries have a gross domestic product (GDP) much lower than that of developed countries, so costs for a megaproject could range from €250–300 million. One of the important characteristics of these countries is a great need for developments (infrastructures, energy, public sectors reform, etc.), where megaprojects can have a strong impact on society (Mišić & Radujković 2015). Megaprojects are increasingly used as the preferred delivery model for goods and services across a range of businesses and sectors, including infrastructure, water and energy, information technology, industrial processing plants, mining, supply chains, enterprise systems, strategic corporate initiatives and change programs, mergers and acquisitions, government administrative systems, banking, defence, intelligence, air and space exploration, big science, urban regeneration and major events (Flyvbjerg 2014). Nowadays, most megaprojects operate in an environment with high uncertainty, such as widespread economic fluctuation, population growth, and increasing pressure arising from environmental and resource limitations (Shehu & Akintoye 2010).

During the 1990s, many organizations, both public and private, embraced the discipline of supply chain management (SCM). These organizations adopted several SCM-related concepts, techniques and strategies such as efficient consumer response, continuous replenishment, cycle time reduction, vendor-managed inventory system and so on, to help them a gain a significant competitive advantage in the marketplace. Companies that have effectively managed their total supply chain, as opposed to their individual firm, have experienced substantial reductions in inventory- and logistics-related costs, shorter cycle times and improvements in customer service (Morris & Pinto 2004).

The supply-side component for an organization may be composed of suppliers of basic raw materials and components, along with transportation links and warehouses, and it ends with the internal operations of the company. The inbound component begins where the organization delivers its output to its immediate customer. This portion of the supply chain may include wholesalers, retailers, distribution centres and transportation companies, and it ends with the final consumer in the chain (Morris & Pinto 2004). Although the adoption and implementation of total SCM-related strategies is quite prevalent in the retail and manufacturing industries, and their benefits are well understood, project-based organizations have lagged behind in their acceptance and use of such strategies. For instance, the engineering and construction industry worldwide has been plagued by poor quality, low profit margins, and project cost and schedule overruns (Yeo & Ning 2002). It is estimated that in the construction industry about 40% of the work constitutes non-value-adding activities such as time spent on waiting for approval or for materials to arrive on the project site (Mohammed & Bashir 2015).

Megaprojects as a delivery model for public and private ventures have never been more in demand, and the size and frequency of megaprojects have never been greater. On the other side, performance in megaproject management is strikingly poor and has not improved for the 70-year period for which comparable data are available, at least not when measured in terms of cost overruns, schedule delays and benefit shortfalls (Flyvbjerg 2014). Following on that evidence, most research has focused on the link between SCI and performance; however, UTS ePRESS

recent literature reviews indicate that the results regarding the relationship between SCI and performance are mixed and not very convincing (Larsson et al. 2015).

From the literature review, project delay was identified as one of the most common problems in the construction industry worldwide. Despite more than 20 years of recent developments in the project management profession, we are still faced with the same challenges regarding cost and time overruns. Several studies investigating the causes of delay in projects in the construction industry have been conducted worldwide. Odeyinka and Yusif (1997) reported that 7 out of 10 projects surveyed in Nigeria suffered delays. According to Assaf and Al-Hejji (2006), 70% of the large construction projects studied in Saudi Arabia experienced average time overruns of between 10% and 30%.

Numerous other data provided by PricewaterhouseCoopers (PWC), World Bank, McKinsey, Standish, or other institution reports confirm this trend. The common methods – the ROF method and projects in construction supply chain performance – can be evaluated by six indicators. According to the analysis and characteristics of projects in the construction supply chain, the evaluation index of projects in supply chain performance are schedule, quality, cost, organizational flexibility, core enterprise satisfaction and partner closeness (Ke et al. 2015). But despite a rich literature in supply chain management domain, indicators to measure the effectiveness of supply chain strategies are rare (Zhao, Flynn & Roth 2006).

However, the simple copy and paste scenario is not valid because the construction business is project-oriented, and so are related megaprojects. Despite the many similarities which apply to all business, megaprojects have a specific context and framework. Each business is under the spiralling pressure of the “bigger-better-faster-cheaper” syndrome, and whatever one did yesterday, it is not enough for today or tomorrow. This dramatically applies to megaprojects, for which the trend has been increasing. Nevertheless, being private or public, each megaproject engages huge resources and high expectations. As the name itself implies, a megaproject is big game, and Merrow (2011) was right by naming them as “creators or destroyers of capital.” Therefore, a delay should be considered as one of the most important elements in megaproject management, and SCM influence is extremely interesting and important.

Classification of components in megaproject success

Another important perspective on megaprojects is evaluation of success. Numerous discussions and contributions have been done and published on that topic (Mišić & Radujković 2015). In the case of many megaprojects, the initial evaluation was revised, which implies that megaproject success evaluation is a complex assignment and that it needs a longer time span after delivery or start of usage before it can take place. Frankly, it is not possible to judge the success of a megaproject in a short time or only by basing it on costs alone, because the “megaproject success triangle” includes not only the business perspective but also societal and environmental perspectives (see Figure 1). In most cases, benefits for the particular community or society are a key element for judgement, whereas all types of megaprojects must be judged by their impact on the environment, which basically means analysing what leave to or take from future generations (Radujkovic 2014.).

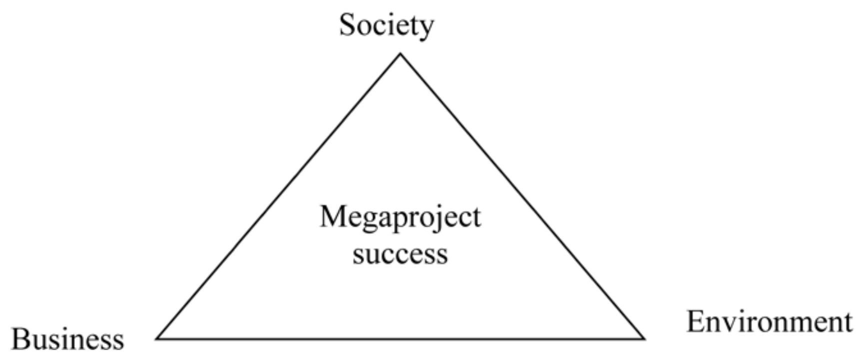

Figure 1 Framework for megaproject success analysis. **Source**: author

So regardless of the type of megaproject, certain community members, or even society itself, are key stakeholders. The management of a megaproject involves far more than "management-by-the-book criteria" or "simple client- or parent organization– oriented management." However, if we approach the problem from any of those angles, we would remove time as a key variable, supposing that delivery fully fits the needs. While analysing megaprojects at the first meeting of IPMA SIG (International Project Management Association, Specific Interest Group Megaproject 2015), it was argued that the inbound, or supply-side, component in a megaproject is longer than any of its separate phases and that it significantly influences timing of each phase, from concept to delivery.

THE CONTEXT OF RESEARCH DESIGN

The main objective of this paper was to identify key elements of supply chain management and to analyse the strength of those variables in megaproject management. Therefore, we conducted a literature review to identify the main elements of SCM and to observe their relation. We have gathered publications from ProQuest, Science Direct, EBSCO, SCOPUS, Emerald and Taylor & Francis. Our search was based on the following key words: "supply chain," "project management," "megaproject," "construction management" and "megaprojects success."

During our work, we had access to respected journals in the fields of operation management, project management and supply chain management. All the papers we selected reflect the current state of the art and profession. The intent of this paper was to screen the literature and to open discussion on supply chain management influence to some of the key supply chain elements while dealing with infrastructure megaprojects. In the paper, an analysis of the supply chain management framework is conducted as the analysis of SCM and selected supply chain elements.

THE CONTEXT OF RESEARCH DESIGN

The context for this research relies on megaprojects in the transport industry. Megaprojects are extremely large-scale investment projects typically costing more than €0.5 billion. Megaprojects include power plant (conventional, nuclear or renewable), oil and gas extraction and processing projects and transport projects such as highways and tunnels, bridges, railways, seaports and even cultural events such as the Olympics. Megaprojects are united by their extreme complexity (both in technical and human terms) and by a long record of poor delivery (Brooks 2015). The performance of megaprojects has long been seen as problematic in terms of overall on-time and to-budget delivery and in terms of the utility of the megaproject once in operation (i.e. the megaproject does produce the intended societal benefits). The proportion of megaproject delivery failure has been put as high as 66% (Magnusen & Samset 2005). Some of the key problems encountered in major projects are cost overruns, tactical budgeting, a narrow planning perspective, the wrong choice of concept and the adverse effect of uncertainties (Magnusenm & Samset 2005). It is estimated that in the construction industry, about 40% of the work constitutes non-value-adding activities such as time spent on waiting for approval or for materials to arrive on the project site (Mohammed & Bashir 2015). The infrastructure of megaprojects is not considered in this paper, so we are talking about construction here and how the supply chain might influence its success.

Based on literature review findings, as well as our own previous research (Mišić & Radujković 2015), we selected 11 variables for analysis. Those variables are considered to be basic and significant for megaprojects management as well as for construction management and supply chain management. These variables are predicted cost (in billion euros), actual cost (in billion euros), project completed (over or under budget), funding (private or public), months in planning, months in construction, project completed (in months), workforce price, approach to supply chain project logistics and procurement.

DATA COLLECTION

The screening and analysis are based on an example database of 29 case studies of megaprojects from OMEGA (OMEGA 2012). The case studies are mentioned in the Table 1. Data were averaged (cross-sectional data) and referred to the sample size of n = 29 (included observations).

Table 1 List of megaprojects

No	Continent	Country	Name of the Project
1	Australia	Australia	CityLink Melbourne – providing supply
2	Australia	Australia	Cross City Tunnel parking supply
3	Australia	Australia	South West Railway supply
4	Europe	France	France Meteor
5	Europe	France	France Millau
6	Europe	France	France TGV
7	Europe	Germany	NBS_Cologne supply duty power
8	Europe	Germany	Tiergartentunnel
9	Europe	Germany	BAB20
10	Europe	Greece	Rionantrion
11	Europe	Greece	Athensmetro
12	Europe	Greece	Attiki Odos
13	Europe	Hong Kong	Airtrain
14	Europe	Hong Kong	West Harbour
15	Europe	Hong Kong	West Rail
16	Asia	Japan	Ōedo Line
17	Asia	Japan	Shinkansen
18	Asia	Japan	Shinjuku
19	Europe	Netherlands	HSL Zuid

Table 1 continued

20	Europe	Netherlands	Randstadrail
21	Europe	Netherlands	Beneluxlijn
22	Europe	Sweden	Arlanda Rail Link
23	Europe	Sweden	Oresund Link
24	Europe	Sweden	Sodralanken
25	Europe	UK	Channel Tunnel Rail
26	Europe	UK	Jubilee Line Extension
27	USA	New York	Airtrain
28	USA	California	Alameda Corridor
29	USA	Massachusetts	Central Artery

Source: OMEGA Centre, Megaprojects Executive Summary, University College London, UK, 2012

From the literature review, we identified the most important elements of the supply chain (Table 2).

Table 2 Elements of the supply chain

Author	Year	Variable of SC
Cooper & Ellram (1993)	1993	Inventory management approach, total cost approach, time horizon, amount of information sharing and monitoring, amount of coordination of multiple levels in the channel, joint planning, compatibility of corporate philosophies, breadth of supplier base, channel leadership, amount of sharing risks and rewards, speed of operations, information and inventory flows
Cooper, Lambert & Pagh (1997)	1997	Service, cost, productivity asset/utilization, time
McAdam & McCormack (2001)	2000	Delivery to original promise date, faultless installs, bid management cycle times, order fulfilment lead time, delivery to customer requested date, cash to cash cycle time, upside production flexibility, total supply chain management cost, bid management costs, inventory days of supply
Hong et al. (2011)	2011	Schedule, quality, cost
Hong et al. (2011) Cheng et al. (2010)	2011	Reliability, quick response, flexibility, cost, asset, utilization ratio
Hong et al. (2011)	2011	Satisfaction of core enterprise, affinity of partner
Goh & Eldridge (2015)	2015	Product type, product unit value, lifecycle, demand variability, fulfilment strategy, key supply chain metric, S&OP stage, enterprise resource planning and data warehousing system

Source: authors

The purpose of this study was to identify elements of supply chain that have impact on the performance of megaprojects. It was found that supply chain management is very well known in the manufacturing, oil and gas, and construction industries, but it is not so understood within megaprojects management. We did not delve deeply into the processes of supply chain activities; rather, we wanted to capture a general picture of the main elements of SCM in relation to megaproject success. Therefore, we see now that there is a call for further research of other, different elements within various processes of supply chain management activity.

In most of the models of estimated regression analysed in this paper, coefficients were not statistically significant because of the rather small sample (29 infrastructure megaprojects). Initial screening suggested the following variables for detailed statistical analysis: *delay* (in terms of months; can be negative if the item is before deadline or positive if the item is out of schedule); *under budget* (deviation of the budget as a percentage difference between actual and overlooked cost of megaproject), which can be negative if the actual cost is higher than forecasted, and vice versa; *private* (% of private funding); *planning* (time in months); and *construction duration* (time in months).

Data analysis and discussion

In the analysis that was done (based on the data set) the most significant model is shown in Table 3. This model was analysed with the dependent variable "Delay." This variable was marked as dependent because of the relevance dedicated to delay as a problematic element in infrastructure megaprojects in academic research done so far. In this sphere, first we estimated the model that contains only the constant member (it is a "variable C" in the EViews 8.0. software records). The method that was used to estimate the coefficients was ordinary least squares (OLS) method.

Table 3 Analysis with numerical variables

Dependent Variable: Delay				
Method: Least Squares				
Sample: 129				
Included observations: 29				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	−5.252805	11.30016	−0.464843	0.6462
Under Budget	−0.183842	0.123761	−1.485462	0.1504
Private	−0.019854	0.116027	−0.171114	0.8656
Construction	0.288506	0.085304	3.382072	0.0025
Planning	0.003081	0.044835	0.068721	0.9458
R-squared	0.539671	Mean dependent var		26.58621
Adjusted R-squared	0.462950	S.D. dependent var		30.20586
S.E. of regression	22.13598	Akaike info criterion		9.187871
Sum squared resid	11760.04	Schwarz criterion		9.423612
Log likelihood	−128.2241	Hannan-Quinn criter.		9.261702
F-statistic	7.034161	Durbin-Watson stat		1.844509
Prob (F-statistic)	0.000677			

In the final part of the econometric analysis, we set out with numerical variables.

Model can be written as:

$E(Y)$= -5,252805 - 0,183842X_1 - 0,019854X_2 + 0,288506X_3 + 0,003081X_4 where variable Y = Delay, Under Budget, X_2 = Private , X_3 =Construction and X_4 =Planning.

Here we were very careful because the estimated coefficients are interpreted differently when the numerical variables in relation to the first part of the analysis, where variables were "dummies." According to the above estimated model, for example, the greater the percentage of private funding, the less delay can be expected (for 1% of private funding delay is reduced by 0.019854 month). It can be seen that the construction time significantly affects the delay, that is, increase of construction time for one month will cause a delay completion of the megaproject for 0.2885 month (which is approximately nine days). Similarly, other estimated coefficients can be interpreted in the same way, with only one of them statistically significant (Construction), although it is now an R-squared value (i.e. coefficient of determination) and is slightly better than the previous models (model was interpreted 53.967% of total deviations). This is not a strong significance. Durbin-Watson is close to 2, which is good (DE = 1.8445), and the F-test is also good, because Prob(F-statistics) is close to zero.

The regression analysis on 29 megaprojects was used for screening this way: where to look when we talk about supply chain in infrastructure megaprojects. The sample used is fair for the screening purpose, but still not big enough for declaring the algorithm which reflects the general case. Our screening analysis showed several interesting findings. First, the expected findings that megaprojects are suffering by delays and SCM should be considered as one of the significant variables for megaproject management. The presence of the SCM in a megaproject management contributes to reducing delay time. By combining theories of SCM and procurement process, the positive effect will be even greater. The other point of the findings confirms that private funding also influences delay reductions, possibly by better use of SCM. It can be expected that the megaproject will be completed ahead of schedule, on average 6.5 months if the supply chain and procurement are present, irrespective of logistics. And finally, it is shown that construction time significantly affects the delay; that is, an increase in construction time for one month will cause a delay for completion of the megaproject for 0.2885 month (which is approximately nine days). Between limited rationality and self-interest, adaptable supply chain initiatives may give megaprojects performance strong criteria for superior performance, managing their construction activities and reducing delay as well as costs. The "doing more with less" or "better-bigger-faster-cheaper" syndrome becomes the mantra of organizations that seek to survive in a resource-constrained world. Eco-efficiency considerations will drive many supply chain decisions, as companies seek to reduce both their use of scarce resources and their costs (Christopher 2011). When dealing with megaprojects, this leads to another, human dimension, because such megaprojects influence the life of many people in a particular community. So, each scenario leading to a delay of megaproject delivery is a huge problem. Our screening research showed the direction for how SCM can make a positive effect to megaproject delivery and therefore to better community prosperity.

Conclusions

This paper offers screening of the important factors related to supply chain challenges in megaprojects. The analysis resulted in an indication that delay and construction are significant variables in relation to megaproject duration, and that supply chain is important for dealing with the topic of performance as regards infrastructure megaprojects. The objective of the paper was achieved: we found significant elements of supply chain and tested their relevance on the OMEGA database. The limitations of this paper are related to the number of megaprojects that were taken into the account: the analysis would be more rigorous if we had more than 200 megaprojects; and according to Flyvbjerg, Bruzelius and Rothengatte (2003), this should be taken into account in order to come to the proper conclusions. Our idea was screening the area and problems, with purpose of indicating the direction for future research. For more exact relationships and insight, a much wider sample (more than 200 infrastructure megaprojects) should be considered. However, our analysis confirmed the research observation mentioned in the literature. This paper shows promising initial results for the first level of the research, and we think there is reason to go further with this research. The research was conducted in order to identify key aspects of supply chain in megaprojects and to show the path for future research that will delve more deeply into this subject. The future results would be even more valuable if other types of megaprojects were analysed. It is possible to use the methodology employed to conduct this research for different types of megaprojects.

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