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Project characteristics enabling the success of megaprojects: an empirical investigation in the energy sector

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Abstract

Megaprojects are extremely large-scale investment projects typically costing more than EUR 0.5 billion. They include power plants, infrastructural projects and even cultural events. Historical data show very poor performance for megaprojects. In particular they are often over-budget and/or behind schedule and, once finished, they deliver less benefits than planned. Despite the existing research in megaprojects, it is still unclear which project characteristics promote the delivery of successful megaprojects. This paper starts to tackle this issue focusing on energy projects and performing a cross-case analysis assessing how project characteristics are correlated with performance. The database is composed of 11 projects described by 50 characteristics categorised in 9 groups. The analysis assesses the correlation of the independent variables with the dependent performance variables expressed as spend against budget, delay in the planning phase of the project and delay in the execution phase of the project. The correlation is tested using the Fisher Exact test. The results show that there are few independent variables strongly correlated to the dependent variables. On the other hand several independent variables do not seem correlated to project performance. In the conclusions, the paper provides a rich research agenda for further investigations.

Keywords: Megaprojects, Energy, Quantitative Analysis.

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1. Introduction

Megaprojects (sometimes known as 'major projects' or 'complex projects and services') are extremely large-scale investment projects typically costing more than EUR 0.5 billion. Megaprojects include power plants (conventional, nuclear or renewable), oil and gas extraction and processing, highways, tunnels, bridges, railways, seaports and even cultural events such as the Olympics. What megaprojects have in common is their requirement for the co-ordination and control of a vast and complex array of social and technical resources.

They have a pivotal role in European Union implementation of both energy and transport policy. Unfortunately, and despite their criticality, megaprojects are associated with extremely poor design and delivery performance (Cantarelli, Flyvbjerg, & Buhl, 2012). Megaprojects are also renowned for failing to respond to the original societal or commercial need that instigated them and for providing functionality that does not meet their stakeholders' requirements and by an high risk of poor financial performance (Locatelli & Mancini, 2010).

Given the societal criticality of megaprojects, a European "COST Action" has been created to investigate how megaprojects can be designed and delivered more effectively to ensure their effective commissioning within Europe. Effective design and delivery means not only insuring that the megaproject is delivered on-time and to budget but that it satisfies the societal and commercial needs that motivated its creation and that it continues to do so throughout its entire life-cycle. This paper presents the preliminary findings from this COST Action in relation to megaprojects in the energy sector, in particular large power plants were chosen for the investigation.

This paper is organized as following: section 2 sets the background of the investigation i.e. the current understanding about project success; section 3 presents the method adopted in this research; section 4 shows the details of the database analyzed; section 5 presents and discusses the result and finally section 6 presents the conclusions and a rich research agenda.

2. Background to the investigation

Project failure is perceived as a widespread and substantive phenomenon. (Project Management Solutions, 2011) states that 37% of projects fail. Other researchers regard project failure rates as being even higher (Morris, 2008). Morris (2008) shows that between 60% and 82% of projects fail. Regarding megaprojects (Cantarelli, Flyvbjerg, & Buhl, 2012) analyzed a database composed by 806 projects (energy project, transportation projects etc.) delivered worldwide and found an average cost overrun of 35.5% with very heterogeneous performance (standard deviation 56.3). Moreover, once completed, the projects usually provide less benefit than expected. On the other hand, there are some examples of successful megaprojects. One of the better documented examples is the Beneluxlijn extension of the Rotterdam metro network (Mendel, 2012) which was finished just a few months after the original schedule and under budget. Projects like this demonstrate that it is possible to deliver megaprojects on time, budget and scope. But still the preconditions, enabling factors and barriers to deliver megaprojects on time and on budget are unclear.

Using this perspective there are at least two areas deserving attention: firstly, what can be considered as "project success", and secondly, which factors foster that project success.

Regarding the definition of project success (Ika 2009) review several of them and elaborating the idea of (Shenhar & Dvir 1996) writes *"In our journey toward a comprehensive understanding of project success, one should not confuse any more between project management success and project success. Semantically, project management success refers to efficiency, an internal concern to the project team, and project success embraces concerns for efficiency and effectiveness—in other words, all concerns, whether internal or external, short-term or long-term"*. Looking only at time and budget (the only performance dimensions analyzed in this paper) is therefore a very narrow definition of project success. On the other hand several projects analyzed are still under execution or stacked between the commissioning and the operation. Therefore, project performance measures that are possible to operationalise unambiguously tend to be associated with delivery on time and to budget. Assessing further dimensions is a future development of the work of this paper.

Given that project failure is seen as endemic, much attention has been given to identifying characteristics of projects that are associated with failure or with its potential inverse, success' (Pinto & Prescott, 1988), (Kog &

Loh, 2011). (Belassi & Tukel, 1996) is one of the first substantive investigations of critical success factors. The authors propose a theoretical framework, validated with a survey, concluding that "*The survey results demonstrate that project managers' managerial skills, team members' commitment and their technical background, project attributes and environmental factors are as viable and can be as critical as the organizational factors, although the criticality of these factors varies between industries.".* (Cooke-Davies, 2002) stresses the difference between success criteria (the measures by which success or failure of a project or business will be judged) and success factors (those inputs to the management system that lead directly or indirectly to the success of the project or business). He aims to answer to three research questions (i) What factors are critical to project management success?, (ii) What factors are critical to success on an individual project?, (iii) What factors lead to consistently successful projects? It is an empirical work, based on 136 projects, which provides valuable insights, however, given the scope of the analysis, there are two limitations: the projects are relatively small ($2 million budget and 18 months schedule) and the data quite old (1994 – 2000), so not exactly the focus of this research.

More recently (Tabish & Jha, 2011) conducted a survey with factor analysis and identified from 36 attributes that there are four success factors for public construction projects in India, including (i) awareness of and compliance with rules and regulations; (ii) pre-project planning and clarity in scope; (iii) effective partnering among project participants; and (iv) external monitoring and control. Finally (Ika, Diallo, & Thuillier, 2012) present another survey related to World Bank project success factors and in particular the relationship between critical success factors and project success. The exploratory factor analysis shows the five factors (monitoring, coordination, design, training, and institutional environment) are correlated to project success.

In conclusion few studies have actually tried to establish empirical correlations between 'success factors' and project success rather they mainly survey practitioner perceptions. This study reported in this paper aimed to empirically relate the identification of a characteristic of a megaproject with whether or not that megaproject was successful. Because of the (1) competences and the backgrounds of the authors and (2) the relevance of the field, the investigation is focused on Energy Megaprojects

3. Method

The methodology adopted in the research is based on the following steps. About 20 researchers where involved in the process.

Step 1 – Case collection

Each researcher (or group of researchers) were asked to prepare from 1 to 3 case studies. Each case study is a megaproject delivered in the EU, the list of all the case studies is given in Table 1. The information was systematically collected using a common template. This phase has two goals: firstly collect information about the specific case study, secondly to gain a preliminary qualitative knowledge of the factors leading to respect project budget/delivery date.

Step 2 – brainstorming

Once the case studies where finished the researcher involved met to brainstorm the project characteristics that influenced the projects' performance. The project characteristics are therefore based on the knowledge acquired in the case studies elaboration as well as from the researchers' previous knowledge and the wider literature.

Step 3 – systematistation

A sub group of researchers met to analyse the data further following the brainstorming. The "cleaning-up" allowed defining 50 project characteristics (being First Of A Kind - FOAK, Turnkey contract between Client and EPC, etc…) clustered in 9 groups.

Step 4 – definitions and binary attribution

For each project characteristics the researchers derived a definitions to assign unambiguously the value 0 (not present), 1(present) or N/A for not available / not applicable. The same applied to the "dependent variables", i.e.

the project performance measuress. The projects were analyzed using three performance indicators: over-budget, delay during the construction phase, and delay during the planning phase. Using these definitions and the data from the case studies templates the researchers derived a matrix with the 11 projects and for each project the 50 project characteristics, and the 3 project performance.

Step 5 – statistical analysis – definitions & research questions

A statistical analysis was employed to identify correlations between independent and dependent variables that will deserve further investigation. The project characteristics are the “independent variables”, while the “dependent variables” are the project performance measures. The analysis aims to assess if there is a statistical correlation between independent and dependent variables, in other words aims to test questions like “is being a FOAK project correlated to being over-budget?”

Step 6 – statistical analysis - test

To test the correlation of this kind of database there are a limited number of suitable statistical tests: in particular, the chi squared and Fisher exact test (or Barnard's test). With large samples, a chi-squared test is usually employed. However, the significance value it provides is only an approximation, because the sampling distribution of the test statistic that is calculated is only approximately equal to the theoretical chi-squared distribution. The approximation is inadequate when sample sizes are small. The usual heuristic rule for deciding whether the chi-squared approximation is good enough is that the chi-squared test is not suitable when the expected values in any of the cells of a contingency table are below 5, or below 10, when there is only one degree of freedom. In contrast the Fisher exact test is, as its name states, exact. Chi squared is more suitable when independent variables are not binary (yes/no) but categorical (coal power plant/ Nuclear Power plant/solar power plant etc.) (Leach, 1979). Given the small sample in the statistical test the Fisher exact test is selected therefore. Considering the issue of one-side or two-sides researchers who choose one-tailed tests should be trusted to use it correctly, in this case it is very speculative to say if there is a direct or indirect correlation between the independent and dependent variable. So, it is more conservative and appropriate utilize the two-sides approach.

Step 6 – screening of the results

In order to screen the results from the Fisher exact test, only variables with a p-value lower than 20% are further investigated as possible correlation. It is worth to remember that the Fisher test does not test causation, but correlation. Therefore the 20% level, quite high for this type of research, has been chosen as first sieve, other analysis (qualitative and quantitative) are request to investigate the correlations.

4. Dataset

The database analysed is composed by the 11 energy projects in Table 1. This section provides a brief presentation of each of them.

Table 1 Projects considered in the analysis (NPP = Nuclear Power Plant; OWF = Offshore Wind Farm; CPP = Coal Power Plant; SPP = Solar Power Plant; OSG = Off shore gas storage; -- = non information or not applicable; Ope = Operation; Cons = construction; Pla = Planning)

Project Name	Moorburg	Lunen	Datteln	Adriatic LNG	Andasol	Olkiluoto 3	Flamanville 3	Hinkley	Mochovce	Greater Gabbard	Anholt Offshore
Phase	Cons	Cons	Con	Ope	Ope	Cons	Cons	Pla	Cons	Ope	Cons
Type	CPP	CPP	CPP	OSG	SPP	NPP	NPP	NPP	NPP	OWF	OWF
Country	Germany	Germany	Germany	Italy	Spain	Finland	France	U.K.	Slovak Rep	U.K.	Denmark
Over budget	Yes	No	No	No	No	Yes	Yes	--	Yes	Yes	No
Delay in construction	Yes	Yes	Yes	No	No	Yes	Yes	--	Yes	Yes	No
Delay in planning	Yes	No	Yes	Yes	Yes	No	No	Yes	--	No	--

Moorburg Power Plant

The Kraftwerk Moorburg is a 1.640 MW coal power plant close to the City of Hamburg, Germany. This project is built to ensure electrical supply for the city of Hamburg and the surrounding region. The original budget of 1.4 Bn EUR escalated to currently 3.0 Bn. EUR, and the project accumulated 2 years of delay.

Lünen Power Plant

The Kraftwerk Lünen is a coal power plant with an output of 750 MW electrical power, close to the City of Lünen, in Western Germany. This power plant is built to deliver electrical power and to ensure electrical supply for the city of Lünen and the surrounding cities in the future. This project is delayed about eight months. The budget of 1.4 Bn. EUR will not be exceeded thanks to the fixed-price contract the owner has agreed on with the consortium.

Datteln IV Power Plant

Datteln IV is a coal power plant which was started 2007 by E.ON-Kraftwerke GmbH. The power plant is designed to deliver 1,100 MW and is located in Datteln, in Western Germany. Because of the lawsuit of a close-by farmer, the regional court decided in 2009 that the approval of the whole project is contrary to law and stopped issuing permissions for following approvals. On-going lawsuits prevent to finish execution works and taking the plant into operation. According to the initial plan the power plant should start operations at the end of 2011. Currently it is not possible to say when the plant will start operations. The investment for this project was planned to be about 1.2 Bn. EUR which cannot be confirmed to be reached anymore.

Adriatic LNG

The Adriatic LNG terminal is placed at 15 Km far from the coast of Porto Viro, in the province of Rovigo, in the Adriatic Sea. The regasification capacity is 8 billion m^3 per years which corresponds more or less at the 10% of the Italian gas consumption. When required the gas flows into the pipeline system, long about 120 Km. The LNG Terminal of Rovigo and the section of pipeline Terminal-Cavarzere are owned and managed by Adriatic LNG a joint venture between ExxonMobil, Qatar Petroleum and Edison. The section of pipeline Cavarzere-Minerbio is owned and managed by Edison Stoccaggio, a subsidiary of Edison.

Andasol Solar

The Andasol solar power station is located in Andalusia, in the southern of Spain. It is the first European parabolic trough solar power plant and is composed of two sub-power plants: Andasol 1 and 2. Each plant has a gross electricity output of 50 MWe and produces around 175 GWh per year. The project of the Andasol CSP plant was supported by the European Commission because it is FOAK and a utility-scale demonstration for technical and economic developments of the solar thermal technology (parabolic trough of the type EuroTrough and thermal storage).

Olkiluoto 3 & Flamanville 3

Olkiluoto 3 & Flamanville 3 are two projects aiming to build the EPR nuclear reactors. Olkiluoto 3 is the fifth nuclear power plant built in Finland. TVO, the Finnish utility owner has selected AREVA NP & SIEMENS consortium to deliver the entire power plant on a lump-sum turnkey delivery basis. As architect engineering (A/E) and main contractor AREVA NP is responsible for organizing both the engineering and the construction of the entire plant. AREVA-SIEMENS: Is the A/E, reactors vendor and main contractor. AREVA is mostly owned by the French State.

In mid-2004 the board of EdF decided in principle to build the first demonstration unit (Flamanville 3) of an expected series of Areva EPRs. This decision was confirmed by the EdF board in May 2006, after a public debate, when it approved construction of the EPR unit at Flamanville, Normandy, alongside two existing 1300 MWe units. The decision was seen as an essential step in replacing aging EDF's reactors. The construction of Flamanville 3 is the first NPP built in France since the N4 program. FL3 is a “made in France” reactor in which the French State is the main player since it controls the project delivery chain: directly through the regulatory authority (ASN), through its ownership of the client (EDF), and through its ownership of the prime contractor (AREVA SA/NP). Both are over-budget and late (Locatelli & Mancini, 2012).

Hinkley Point

In UK there is a plans are for four EPR nuclear reactors to be built by EDF Energy at Sizewell in Suffolk and Hinkley Point in Somerset. EDF applied for consent to construct and operate the first two (3260 MWe) at Hinkley Point in October 2011, though the Generic Design Assessment (GDA) process on reactor designs was not concluded (see section above on Generic Design Assessment). EDF plans to start up the first of these new reactors by the end of 2017 and have it grid-connected early in 2018. By mid of September 2010 EDF Energy had let £50 million in contracts for site works at Hinkley Point, and by February 2013 pre-development costs there had reached almost £1 billion. In May 2012 EDF Energy said that it "remain[s] committed" to building the Hinkley Point reactors and was working toward a final investment decision by the end of the year, which would depend on having "the correct market framework [to] allow an appropriate return on the massive investment required." A £1.2 billion civil engineering contract was deferred. In March 2013 environmental permits were granted for the plant operation, and planning permission was received.

Mochovce

In 1982, construction on the first two units of the four-unit Mochovce nuclear power plant was commenced by Skoda, using VVER-440 V-213 reactor units. Work on units 3 & 4 was started in 1986 and halted in 1992. Construction of units 3 & 4 was reactivated in mid-2009 and the units were expected to commence operation in 2012 and 2013. €2775 million has been allocated to the completion project. In October 2004, the government approved Italian Enel's bid to acquire 66% of Slovenské Elektrárne (SE) for €840 million as part of its privatisation process. Enel's subsequent investment plan approved in 2005 involved €1.88 billion investment to increase generating capacity, including €1.6 billion for completion of Mochovce units 3 & 4. The estimated cost of this project has risen since then and is currently put at €2.775 billion.

Greater Gabbard

The Greater Gabbard Wind Farm project is a located offshore of Suffolk, UK and consists of 140 turbines with the planned capacity of 500MW and an expected output 1750 GWh/a. The turbines are 23 km from land in a depth of water of 2.4 – 10m. Fluor, the EPC contractor, has a fixed price $1.8bn EPC contract, which has changed significantly during the lifetime of the project. Original targets were for first power to be generated on Q4 2009, 42 turbines to be installed by Feb 2010 and a further 98 by March 2011 which would also see the completion of the project. Due to several reasons it has been completed on 7 September 2012. Surprisingly, external stakeholders had none too negative impact on project performance. The EPC-contractor, Fluor, had announced high 340 Million of Euros in losses due to the Greaterr Gabbard project.

Anholt Offshore

The Anholt Offshore Wind Farm is a Danish project located Between Djursland and Island of Anholt and consisting of 111 wind turbines. It will produce 4.5 % of Denmark's electrical power (400 MW or consumption of approx. 400.000 households). The total investment in preliminary investigations, design and construction of the offshore wind farm as well as an operation centre amounts to DKK 10 billion (1.32 Billion Euros) and life cycle costs for concession duration are about 2.3 Billion Euros. The wind farm is connected via a 25km-cable to the shore and is located where the sea-depth is about 15 to 19 meters. The Anholt Offshore Wind Farm is according to the original cost estimation still on budget, mainly, due to a fixed-price contract. The operational start date is set by the end of 2013. If this is not achieved, high penalties and reductions of subsidies will be the consequence. Up till now, the project is on time.

5. Result: Correlations among independent and dependent variables

This section summarizes the most interesting results obtained with the Fisher exact test (Leach, 1979). Table 2 shows the independent variables (among the 50 assessed) with a p-value lower than 20%. These independent variables come from four categories. The results are showing correlations between the independent and the dependent variables – not causations. Therefore, the impact of independent variables presented in Table 2 is not a final explanation for performance in megaprojects but a collection of potential explanations.

Table 2 Independent variables correlating with performance in energy megaprojects (p-value lower than 20%)

	Category	Independent Variables / Project characteristics	Correlating with	p-value
1.	Stakeholder	There is a presence of one major stakeholder	Delay in execution	5%
		More than 50% share of the client is under government control	No delay in planning	17%
2.	Project Environment	Project has been delayed by the authority	Over budget	20%
3.	Project Management	Client and Owner are different	not delay planning	20%
4.	Not classified	Financial Support from the European Union	No delay in execution	7%
		Tough physical or environmental conditions	not delay execution	18%
		The project is nuclear	Over-budget	17%

Delay planning

The statistical analysis shows two correlated independent variables relating to the delay in the planning phase of energy-megaprojects. The two variables are: (1) more than 50% share of the client is under government control (p-value 17%), and (2) the client and owner are different (p-value 5%), correlate with not delaying in planning phase.

A possible explanation for a correlation of (1) a governmental shareholder (with more than 50% of share) in the megaproject and an on time-planning phase is that energy megaprojects have to pass many approval stages during the planning phase. If the main shareholder is the government itself, then its plans are very likely to meet requirements of local and regional authorities. This is true in the case of EDF in France for the Flamanville case. EDF is the biggest French utility and the French Government owns 85% of its shares. Second, if client and owner are different, there is a correlation to a not delaying-planning phase. It seems that both have an advantage if speeding up the project.

Delay in the execution

There is one factor correlated with delays during the execution phase of energy projects: the presence of one major stakeholder (p-value: 5%). A major stakeholder is operationalised as a definitive stakeholder, powerful, urgent and legitimate - using the stakeholder classification framework of (Mitchell, Bradley, & Donna, 1997) In energy projects main contractors typically fit into this category of being a definitive stakeholder. Stakeholders, especially major ones, play an important role in the context of evaluating a project's performance (Littau, Nirmala, & Adlbrecht, 2010). In the case of Flamanville 3, for instance, the main contractor, EDF is the client and main project owner, therefore a definitive stakeholder. Because EDF did not keep the requirements of the HSE (Health and Safety Executive) the authorities (other definitive stakeholder) stopped construction works for a month. Another example is provided by the case of Olkiluoto 3 (nuclear power plant). The turnkey contractor Areva-Siemens consortium was responsible for causing many problems – among others the choice of inexperienced subcontractors, poor communication, and not clarified changes to plans, etc. – that led to execution delays (Ruuska, Ahola, Artto, Locatelli, & Mancini, 2011). Although the correlation seems strong, the causation is still unclear.

Second, the statistical analysis shows that projects which are supported financially by the European Union are correlated to not delaying in execution phase (p-value 7%). One possible explanation could be the demanding approval process required by the European Union before funding an energy project. This could motivate the EPC-company to increase the quality of plans and cost estimations which could be the reason for no delays in the execution phase – as it was the case with the Andasol project and the Anholt Offshore project.

Third, tough physical environmental conditions are also correlated to not delaying the execution phase (p-value 18%). This correlation might be surprising on the one hand, as one could expect that tough environmental conditions could impact execution works negatively. On the other hand, tough physical environmental conditions are could promote a better planning.

Over-budget

In the sample there are five projects over-budget and five projects in budget. Being over-budget is correlated mainly to two independent variables: (1) Project has been delayed by the authority (p-value 20%), (2) the fact that the project is a nuclear power plant (p-value 17%). In the case of the Moorburg power plant project, problems with the environmental requirements, specifically the emission of warm water into the local river, caused massive discussions and disagreement in local politics which resulted in approval delays. Further, this requirement led to an execution of an additional cooling tower which caused a huge cost increase. In the Flamanville case, the Safety authority ASN required EDF to stop concrete pouring on May 26 (ban lifted June 17). Problems *'show insufficient discipline on the part of the licensee and insufficient project organization'*. Welding anomalies were also found in one of the four bottom pieces of the steel liner of the containment building.

The second correlated independent variable is "the project is a nuclear power plant". There is this strong correlation since all the 3 nuclear power plants in the sample are over-budget. According to (Locatelli & Mancini, 2012) there are two potential emergent groups of explanations for the poor performances of these projects: (1) FOAK issues in terms of both the capabilities of the architect-engineer and the supply chain (2) Poor forecasting leading to unrealistic targets (so that it is no surprise that the projects overran!)

Independent variables not correlated

Further, some more independent variables are presented which surprisingly do not correlate, even if existing literature stress their relevance.

First of a kind (FOAK)

In many cases, like nuclear power plants, FOAK-megaprojects are over-budget and delay (Akinci & Fischer, 1998). However the sample shows different results as summarised in Table 3. This table and the Fisher Exact test do not show a correlation between being a FOAK and being over-budget or delay. Looking at case by case is possible to find FOAK projects like Andasol and Adriatic LNG with good cost and time performance while NOAK (N - of a kind) project late and over-budget.

Table 3: Correlation of FOAK with cost and time performance

	Overbudget		Delay in planning		Delay in execution	
	YES	NO	YES	NO	YES	NO
FOAK	4	2	3	3	4	2
NOT FOAK	1	3	2	1	3	1

Mono cultural

Projects that are mono cultural – that is to say when nationalities of client and prime contractor (as a firm) and the nationality of client, owner and first-tier contractor are the same – are expected to perform better, than projects were the mentioned parties come from different countries and cultures, because of cultural barriers (Anbari, Khilkhanova, Romanova, & Umpleby, 2004). The analysed sample does not show relevant correlations to any of the dependent variables. Thus, mono cultural energy megaprojects are not performing better or worse than multi-cultural projects.

The project is modular

Planning and executing projects modularly is expected to reduce project complexity (especially in megaprojects) and thus increase project performance (Jameson, 2007). Whether the project is modular, or not, was considered as an independent variable. Thereby, modularity can mean, the project is composed by physical distinct modules that have been pulled together – as IKEA furniture or, the project is composed by single independent elements – as a solar power plant. According to the analysis no such expected correlation could be identified. This is suggesting, that modularity in megaprojects is might not be the key to improve project performance.

Local residents were involved in the project

As is the case with many energy megaprojects, local residents try to stop projects by demonstrating against them. Project stakeholder management promotes communication with critical stakeholders and the integration of them into the project and, finally, engagement with them in favour of the project's objective (Bourne & Walker, 2005). Surprisingly, there no correlation was established between the involvement of local residents and a positive project performance from the analysed sample. The cases analysed suggest that the involvement of local residents is not leading to better project performance.

6. Conclusions & Future research

This paper aimed to provide a preliminary understanding about how energy megaprojects can be designed and delivered more effectively. Despite the fact that media coverage is focused on projects that are over-budget and late, there are projects that are delivered on time and on budget even if the planning phase last longer than what was expected. The report shows that the statistical analysis of empirical data can be a valuable tool to enable researchers to focus on the most relevant dimensions. The statistical analysis shows which project characteristics are correlated to project performance and point out where to start to investigate for the causation. Using this approach, it appears that internal stakeholders (like an EPC Company) and external stakeholders (like a governmental authority) play a major role towards project success. As a consequence a proper designed project governance, and in general the entire "project delivery chain" is critical success factor that needs to be considered for future projects. This paper represents the first of its kind and paves the way to a research stream summarized in the following research agenda.

- This paper, focused on energy megaprojects, investigates the correlations between independent and dependent variables, but the correlation does not imply the causation. A first research stream aims to analyse more deeply the statistical correlated variable to investigate the causation.
- The statistical analysis presented in this paper is based on the Fisher Exact test. The test is useful for categorical data that result from classifying objects in two different ways; it is used to examine the significance of the association (contingency) between the two kinds of classification, in this case an independent variable and a dependent variable. However it could be interesting to test not binary variables, for instance categorical variable like the kind of technology (nuclear /coal /renewable). In this case it is more suitable to perform an analysis using the chi-squared test. The dependent variables tested in this statistical analysis are cost and time performance. Nevertheless it is self-evidential that megaprojects are not (or should not) built for the sake of the project itself, but to deliver benefit during their operation. A logical development is the enlargement of this analysis to the infrastructure life cycle with a particular focus on the benefit delivered.
- The projects included in the databases are European energy projects; a logical follow-up is to include other typologies. A first enlargement is the inclusions of other construction projects, like in the transportation field (bridges, high speed railways) and more in general the construction (big hospitals, research centres etc.). A second further enlargement is the inclusion of non-construction projects such as IT projects and R&D projects (like development of a new drug). A third one is the inclusion of not European projects. The analysis among the different typologies can point out the relevance of the type of technology on the project performance.
- There are several specific areas (like stakeholder management and project governance) deserving specific investigation. According to the results in this study, stakeholders might have high influence on time-related issues in megaprojects. To identify the mechanisms and reasons for this influence, a cross-case analysis on stakeholder issues should be conducted as a next step in the research agenda.

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