Journal of Scientific Research and Development 3 (5): 157-163, 2016
Available online at www.jsrad.org
ISSN 1115-7569
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A Review of risk management and different resources in scheduling problems for mega projects

M. K. A Ariffin *, Bader, A. Sobhi

Department of Mechanical and Manufacturing Engineering, Fac. of Engineering, Universiti Putra Malaysia, 43400 Serdang, Malaysia

Abstract: Risk can affect both the cost-benefit analysis during the whole process of a project, or the demand, production costs, execution time, and financial variables. A number of mega-projects have had to deal with the impacts of the global financial crisis. As widely known, a large amount of investment is needed in implementing mega projects. In view of that, if any sort of wastage occurs, it would lead to the huge monetary problems. Hence, this paper reviews financial risk management pertinent for mega projects during financial global crisis and the impacts of resources in scheduling problems. An identification of risks and risk assessment techniques in planning the projects or during implementing project are also included. This paper also discusses on the appropriate solving method that could be developed using machine codes for solving and analyzing the problems in the project resources scheduling programs. The review resulted that an efficient and powerful resources scheduling software with a high ability of modeling and analyzing risks of the projects will be developed for industrial application too. Afterward, the method will be ready to use by the industrial practitioners, for the successful completion of their projects.

Key words: Risk management; Project methodology; Software; Assessment

1. Introduction

Nowadays at the production rivalry world, it is obvious that each country has its own local economy that is developed according to so many internal and external factors like industries, production, technology, foreign relationship, and import and export opportunities. It is also clear that an economical model of a country is affected by interrelation of commonwealth countries, as well as internal and external factors. Henceforth, various countries can be affected during worldwide crisis, and each country is involved with a vast range of opportunities and threats during the moment. Sometime they may become an enormous disaster called crisis. There are several natural causes e.g. earthquake, flood, drought etc., and some unnatural causes like oil, gold, and exchange market condition can setup a global crisis base. As widely known, worldwide crisis could damage a country's economy and even destroy it. In facts, world has experienced a widespread slump since 2007. This kind of crisis can affect wide areas in economy such as technology, industries, tourism, etc.

Mega projects are extreme cases of projects dominated by complexity and dynamic instabilities which originated from the internal and external environment, possible intangible benefits and attractive long term outcomes. Mega projects are extremely large-scale investment projects or top critical projects for a country, which require sophisticated technologies, involve a variety of systems/multiple parties. They include bridges, tunnels, highways, railways, airports, seaports, power plants, dams, wastewater projects, coastal flood protection schemes, oil and natural gas extraction projects, public buildings, information technology systems and aerospace projects. Mega projects can be seen as "temporary organization" because they are established as an autonomous organization during the existence of the project (Sato and Chagas Jr, 2014). The first and foremost problem in implementing mega projects is finance. Modern projects management started with high-technology mega projects (Flyvbjerg et al., 2003), that usually required an investment of more than US$1 billion.

Some project managers suppose that as soon as the unstable conditions happen to projects in each area, they should cease the project execution since it may become a global crisis. Many project managers rottenly do not pay enough attention to circumstance alarms and though they will pay much loss. Such attitude often leads to failure in project success and as a result, in some cases the company may come to bankruptcy. On the other hand, lack of a methodology to control risks during implementing project and making different but not sufficient decisions in these conditions, nothing obtained except wasting a lot of money and energy, firing personnel, getting loans or bankruptcy.

In project management studies there are various kinds of resources which obviously affect the

* Corresponding Author.

projects whether ordinary projects or mega projects. It should not be forgotten that each resource has its own properties, conditions and preparedness rules. Modern theories not only consider an asset's riskiness, but also its contribution to the overall riskiness of the portfolio to which it is added. Therefore, resources can be considered as one of the main aspects that can effectively influence the advantages of mega projects. A number of risk management models typically focused on possible risks between firms, projects, industrial organizations and government have been introduced. The limitations of such models, is a lack of concentration of the impact of different resources on the projects risk planning and controlling during financial global crisis. A comprehensive conceptual model is then required, to be able to assess and select the most appropriate method in risk management of projects.

Risk management remains as one of the least developed research topics even though it has high relevance with the success of mega projects. Delivering successful mega projects is difficult in a stable economic environment; nonetheless, in an unstable economic environment such as global financial crisis, successful achievement of mega-project goals becomes even more difficult and unlikely. For that reason, it is important to establish a method and system to manage risk factors effectively in advance. Additionally, it is also necessary to reduce the probability of such risk factors causing failures in the project by implementing scheduling software to control risk factors during executing stage. Therefore, the purpose of this paper is to review the financial risk factors in the perspectives of risk management for mega projects based on the previous works. A discussion on risks identification especially on their methodology and risk assessment techniques before and during implementing of projects also will be done. Besides, the effectiveness of resources influence projects in planning the projects or during implementing project is also presented; focused on resource-constrained project scheduling problems. Consequently, a suggestion on simulation software proposed both for modeling and analyzing risks of the projects; and monitoring and controlling risk factors through the execution of the projects, which can be used in the industrial applications is included in this review.

2. Literature review

A project is viewed as "a temporary endeavor to create a unique product, service or result" (PMBok, 2013). The temporary nature of projects indicates that a project has a definite beginning and a definite end (PMBok, 2008) but this is impractical for mega projects as the definition fails to capture the longer term effects that mega projects usually produce. Mega projects can directly give effects to the economy of a country and in fact annual budgets of country are planned based on mega projects. Since megaprojects involve substantial financial investments and commitment, an appropriate risk management strategies in place taken at early project development stage are of great importance, which consequently can avoid projects failure due to multiple, risk-prone events.

The purpose of project risk management is to minimize the risks of not achieving the objectives of the project and the stakeholders with an interest in it, and to identify and take advantage of opportunities. Specifically, risk management assists project managers in setting priorities, allocating resources and implementing actions and processes that reduce the risk of the project not achieving its objectives. It can be applied usefully at all stages of a project or procurement, from the earliest assessments of strategy to the supply, operation, maintenance and disposal of individual items, facilities or assets. It has many applications, such as the evaluation of alternative activities for budgets and business plans, the management of cost overruns and delays in projects. Risk management will also provide benefits in better accountability and justification of decisions, by providing a consistent and robust process that supports decision-making.

2.1. Project risk management

No project is risk free. Project risk is inherent in the project. The chances of a risk event occurring are greatest in the concept, planning, and at the beginning stage of project start-up phase and it reduced as project completion. As the risk event occurring is getting higher, the cost to fix the risk is getting higher too. Risk management is the important matter and must be well-versed to the project owner. They must be implemented before and during the start-up the project. Risk management is an activity which the integration of risk, risk assessment, developing strategies to manage the risk, and mitigation of risk using appropriate tools and method (PMBok, 2008). Project involves many factors, identifying, analyzing cause and effects, and the risk's dependencies and correlation is a difficult task to be conducted; as risk will affect the cost, time and the quality and outcomes of the projects. Therefore the risk assessment is the important issue to be addressed during the earlier stage of the project (Gary and Larson, 2008)

Mega projects have been shown to be particularly risky in terms of finance, safety, logistics and social and environmental impacts. Risk management is therefore particularly pertinent for mega projects and special methods and special education have been developed for such risk management. It is obvious that there is a direct relationship between logistics and resource preparedness, which considered as fuel of execution engine of mega projects and it is obvious that the sensation of financial crisis on the resources supply chain can directly affect the mega projects progress. Cost and

time escalations, poor outcome quality, shortfall benefits could be happen due to poor project management performance. Megaprojects poor performance are due their intrinsic characteristics uncertainty, high complexity, high risk, huge project size, large variety and number of people involved, political influence, etc. There are a growing number of mega projects have had to deal with the impacts of the global economic crisis. Depending on the stage of development at which a mega project rests, the issues of greatest concern appear to be:
(1) Securing financing and investment,
(2)Managing enterprise risk in an unstable economic environment,
(3) Planning and execution risk profile changes due to an unstable economic environment,
(4) Strategic execution adjustments, and
(5) Project life cycle changes resulting from unstable economic environment.

For a more desirable management of risks during future global crisis, an expanded image and a perspective of future horizon must be achieved. Nowadays, the process of risk management is followed systematically as national necessity in many countries. Risk identification is an integral part of overall risk management framework of projects. The risks associated with projects and their response planning differs according to the country and the sector specific environment in which they are being implemented.

2.2. Risk management

Risk management is one of the eight main areas of "A Guide to the Project Management Body of Knowledge" (PMBOK Guide), and is included in most training programs for project managers. Within the current view of project management as a life cycle process, project risk management (PRM) is also seen as a process that accompanies the project from its definition through its planning, execution and control phases up to its completion and closure. In the other words, risk management is simply a practice of systematically selecting cost effective approaches for minimizing the effect of threat realization to the organization.

As mentioned before, financial global crisis considered as the main crisis of this review. Therefore, financial risk management will be used as the management method of the paper. As a specialization of risk management, financial risk management focuses on when and how to get around using financial instruments to manage costly exposures to risk. It can be qualitative and quantitative. Since threats are available, risks can never be fully avoided or mitigated simply because of financial and practical limitations. Therefore all organizations have to accept some level of residual risks. There are 6 steps in risk management process:
(1) Risk Management Planning,
(2) Risk Identification,
(3) Qualitative Risk Analysis,
(4) Quantitative Risk Analysis,
(5) Risk Response Planning, and
(6) Risk Monitoring and Control.

This is possible when development is accompanied and reinforced by constant scientific and technological advancement. Despite this fact, most developing countries suffer from lack of strategies, immaturity of research and development activities, the limited exponent and disharmonic distribution and the weak information and knowledge flow of resource rules during global crisis. The rapid growth of global crisis around the world makes these countries less prepared. Hence, even though they might have some plans to manage the crisis effects in their countries, they cannot use them properly and timely. The evidence is reminiscent of this fact that economic power has belonged to the countries that have essential management and special ties to transform the scientific research into reality and then develop technologies according to their real experience because advanced technology is mentioned as the hope of developed countries in the next centuries. Management of Risks for many countries has become a critical issue to achieve competitive advantage.

Consequently, it seems to be necessary to develop a methodology to determine execution decisions of project according to long term policy of a country to reduce harms and loss of project before, during and after global crisis happen. The risk types according to their nature and examples include:
(1) Hazard risk (Liability torts, Property damage, Natural catastrophe),
(2) Financial risk (Pricing risk, Asset risk, Currency risk, Liquidity risk),
(3) Operational risk (Customer satisfaction, Product failure, Integrity, Reputational risk), and
4) Strategic risks (Competition, Social trend, Capital availability).

There are wide range of techniques for modeling and controlling the risk management that related to annual budgets of the country. These techniques are important to sustain inflow and outflow of country's income. Therefore, the mega projects that will be invested should be analyzed for the benefits of the economy in the long term. As one of the risk management aspects, risk modeling uses a variety of techniques including market risk, value at risk (VAR), historical simulation (HS), or extreme value theory (EVT) in order to analyze a portfolio and make forecasts of the likely losses that would be incurred for a variety of risks. Such risks are typically grouped into credit risk, liquidity risk, interest rate risk, and operational risk categories

It should be notice that for many years, the riskiness of an asset was assessed based only on the variability of its returns. In contrast, modern theories consider not only an asset's riskiness, but also its contribution to the overall riskiness of the portfolio to which it is added. Therefore, resources can be considered as one of the main aspects that can effectively influence the advantages of mega projects. A number of risk management models have typically focused on possible risks between firms,

projects, industrial organizations and government. The limitations of such models, is a lack of concentration of the impact of different resources on the projects risk planning and controlling during financial global crisis. Then, a comprehensive conceptual model is required to be able to assess and select the most appropriate method in risk management of projects regarding to the existing and even potentially effective but hidden agents in the process of risk management.

2.3. Resource scheduling

Resource-constrained Project Scheduling Problem (RCPSP) was firstly developed with the aim of reducing makespan of the project (Kelley, 1963). The RCPSP can be defined as a combinatorial optimization problem that means even a modest-size project network with only a few resource types might have several thousand feasible solutions. Informally, a resource-constrained project scheduling problem (RCPSP) considers scheduling project activities in order to complete a project in the minimum possible time under the presence of precedence and resource constraints. Precedence constraints are defined between activities (i.e., no activity can be started before finishing all its Predecessors) (Zare et al., 2012) The Multi-mode Resource Constraint Project Scheduling Problems (MRCPSP) are distinctive resource-constraint problems where each activity can be carried out via different modes (regarding to technologies or material etc.). As a consequence, the execution period (activity duration), resource requirement level and even the cash flow may be varying form a mode to another. The MPRCPSP was initially developed for minimizing the project makespan where the schedule is feasible with respect to the precedence and resource constraints, and also was proved to be a NP-hard problem. (Węglarz et al., 2011) provided a wide research on literature of the multimode project scheduling. One of the most important issues in MRCPSP studies is financial issues which can be considered in two ways of positive or negative cash flows. Positive cash flows are supposed to earn as scheduled milestones. Despite, negative cash flows are referred to those expenses which must be spent for making positive cash flows (as human resource salary, equipment and machinery purchasing and maintenance costs, raw material providing etc.). In such models, cash flow can be influenced by activity due date, duration, resource requirements and also payment method which will effect on activity execution mode as well.

In addition, (Kolisch and Drexl, 1997) found that MRCPSP is NP-hard if more than one resource is considered. To come up with such problem, many heuristics and metaheuristics approaches are applied so far. (Yan et al., 2009) applied some heuristics to solve project scheduling problem in order to provide a quick response structure while encountering with maritime disasters. (Laslo, 2010) presented an integrated method using simulation for resource planning and scheduling to minimize scheduling dependent expenses. But among all metaheuristic algorithms, Genetic algorithm (GA) and Simulated Annealing (SA) have been used more frequently to solve MRCPSP (Alcaraz et al., 2003; Hartmann, 2011; Lin and Gen, 2008; Lova et al., 2006; Mori and Tseng, 1997; Ozdamar, 1999). Kim et al. (2005) proposed a Hybrid GA and Fuzzy Logic Controller (FLC-HGA) to solve the Resource-Constrained Multiple Project Scheduling Problem (RC-MPSP). Their objectives were minimizing total project time and total tardiness penalty. (Ke and Liu, 2010) used hybrid fuzzy set and GA to minimize total cost with completion time limits (Chen and Askin, 2009; Hartmann and Briskorn, 2010) Jarboui et al. 2008) used Particle Swarm Optimization (PSO) to show the effectiveness of PSO for solving MRCPSPs.

Maximizing Net Present Value (NPV) of projects is considered as an important objective in financial studies of scheduling problems. The idea of maximizing NPV was first proposed by (Russell, 1970). The proposed model was nonlinear without taking limitations of resources. They assumed Activity on Art (AOA) to present network charts. Afterward, (Grinold, 1972) converted the model proposed by Russell into linear model and developed two optimal finder algorithms considering fixed and variable due date of project. (Elmaghraby and Herroelen, 1990) proposed an optimal-finder algorithm which includes resource constraints for maximizing NPV. (Etgar et al., 1997) showed that resources beyond time limit can have significant effect on makespan of project. Meanwhile, (De Reyck, 1998) offered an algorithm based on which both positive and negative cash flows had been considered. A lower and upper bound were considered for each activities where coupled with limited resources. (Icmeli et al., 1993) discussed that adding resources limitations caused turning model into a non-poly nominal model which cannot be solved easily by optimizing algorithms. Then, they considered discounted rate in the proposed a model a way that more cash flows will be earned in case of completing an activity in shorter period (RCPSPDCF). Later, many researchers tried their utmost effort with the aim of solving the problem of maximizing NPV while discount rate is taken into consideration. (Baroum and Patterson, 1999) solved a RCPSPDCF model with 50 variables where only positive cash flows were considered. After that, (Icmeli and Erenguc, 1994) used Tabu Search (TS) algorithm in solving RCPSPDCF problem. They set penalty for activities later than the due date. (Yang et al., 1993) developed statistical programming for solving RCPSPDCF problems while positive cash flows were taken into consideration. Moreover, (Zhu and Padman, 1999) used TS for solving RCPSPDCF problems. (Mika et al., 2005) presented a model with the aim of maximizing NPV of project with taking discounted rate and also both renewable/nonrenewable resources. They used hybrid of SA and TS to solve the problems.

Delgoshaei et al. (2014) used SA for maximizing NPV of the MRCPSP-DCF.

During the last decade, considering preemptive resource in scheduling problems have been more developed due to their impacts on making major delays through project lifecycle as well. Demeulemeester and Herroelen (1996) presented an optimal solution for RCPSP while they considered preemptive resources in their model. Buddhakulsomsiri and Kim (2006) discussed that considering pre-emption resources is vital while studying makespan of the project. Damay et al. (2007) applied linear programming algorithms for preemptive RCPSP studies while Ballestín et al. (2008) proposed heuristic for solving preemptive RCPSP. Peteghem and Vanhoucke (2010) used GA to minimize makespan of MRCPSP while they considered preemptive resources which allow activity splitting through their research.

2.4. Scheduling software

An appropriate solving method must be developed using machine codes to solve and analyze the problems. Simulation software can be used to control risk factors during executing a project. Vensim is industrial simulation software for modeling, connecting and analyzing data. It is an efficient algorithm for building accurate simulation models of dynamic feedback systems. Vensim can also be run over a network allowing multiple users to interact with a single model. A range of applications of Vensim are:

(1) Simulating for improving the performance of real systems,

(2) Developing, analyzing, and packaging dynamic feedback models especially:

(a) High quality, with dimensional consistency and Reality Check,

(b) Connections to data and sophisticated calibration methods,

(c) Instant output with continuous simulation,

(d) Flexible model publication,

(e) Model analysis, including optimization and Monte Carlo simulation.

(3) Vensim provides the ability of customizing multiple diagrams with different colors, fonts, symbols, arrows, and pipes. Moreover, an equation editor helps user builds the equations for a simulation model,

(4) Vensim can create and simulate models with hundreds of thousands of variables (Fig. 1).

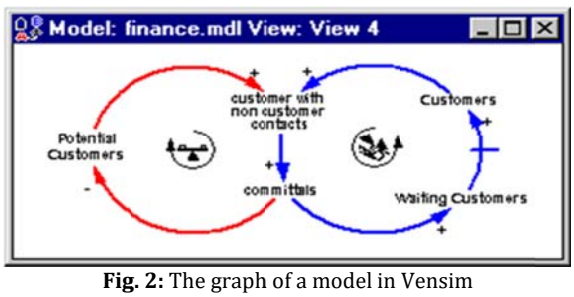

Fig. 2: The graph of a model in Vensim

Vensim contains a highly efficient simulation engine providing fast simulation times which allows storage of huge datasets (Fig. 2).

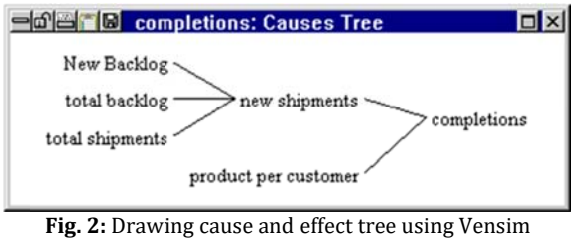

Fig. 2: Drawing cause and effect tree using Vensim

One important benefit of using software like Vensim is the ability of monitoring and controlling risk factors through the execution of a project. Causal Tracing is a powerful method of following the causes or uses of a variable (or its behavior) throughout a model. A dataset stores the dynamic behavior of all variables in the model for later viewing and analysis. Multiple simulations (experiments) can be performed and stored to allow comparison of behavior resulting from different conditions (Fig. 3).

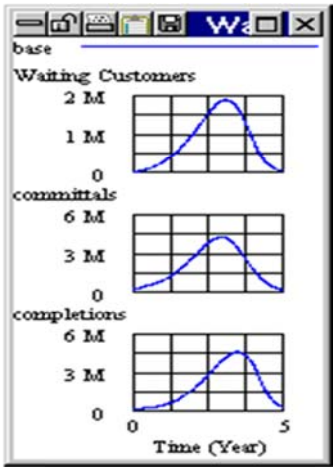

Fig. 3: Tracing the results by Vensim

Hence, it seems using Vensim abilities in the project scheduling programs like Microsoft Office Project (MSP) or Primavera can strengthen the power of modeling and analyzing the condition of risks. This scheduling software with a high ability of modeling and analyzing risks of the projects could be developed for industrial applications.

3. Summary and conclusion

A megaproject includes many risk factors that can cause delays or failures during the project life cycle. This paper discussed a review of literatures on project risk management for global economic crisis, and focused on financial risk management, risk assessment techniques and identification of the risks in mega projects. It also discusses the impact of different resources in scheduling problems on the projects risk planning and controlling. Consequently, simulation software proposed both for modeling and analyzing risks of the projects; and monitoring and

controlling risk factors through the execution of the projects, which can be used in the industrial applications is suggested. Effective risk management minimizes threats, maximizes opportunities and achievement of projects objectives. The literature survey revealed a large percentage of the project delays, difficulties and cost overruns are attributed to risks related to the absence of clear risk management strategies. Hence, to be successful, a risk management exercise on a mega project indicated that using Vensim as scheduling software with a high ability of modeling and analyzing risks of the projects could be developed to handle the risks identified. Many of the most common risks identification techniques focus on risks within the project, but are not generally used to consider sources of overall risks to the projects. This paper recommends that the risk management systems should have at their core a computer generated probabilistic program that can generate very sophisticated models of risk from both risk element probability of occurrence and impact perspectives. Finally, the software systems need to be extremely powerful and, can organize and generate valuable data which will aid in maximizing the effectiveness of the risk management program. Afterward, the method will be ready for the industrial applications that will contribute to the successful completion of their projects. In conclusion, by adopting a clear risk management approaches, the success rate and the productivity of mega projects can be enhanced.

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