

## **Research on the risks and opportunities of international railway projects based on FIDIC-EPC contract<sup>1, 2</sup>**

**By Shangxin Yang**

### **ABSTRACT**

The globalization encourages the rise of international construction project. The risk which can be positive or, in most case negative, is no doubt one of the most important parts to control in the project. This article is based on international railway projects under FIDIC-EPC contract, trying to explore the risk factors and the opportunity factors which are less considered in the project, using Multi-attribute decision-making (MADM) method to choose best solution for responding to risks or opportunities and finally give relevant recommendations. This might help owners and contractors to understand and choose optimal risk response solutions to improve their risk management. It is concluded that there are five main risk factors: external, operational, project management, engineering and financial, and four main opportunity factors: scope, technology, working process and external. The best risk response solution is to mitigate while the best opportunity response is to share. Focusing on risk prevention and projection, also exploring the opportunities and sharing them can lead to more competitive advantages in the project.

**Key words:** International railway projects; EPC; International contract; Risk analysis; Decision making

### **INTRODUCTION**

Globalization and urbanization are becoming a trend in the world. The railway transport is booming following the city growth. Just in China 2017, the government has invested 100 billion euro on railway construction and about 30 billion euro on oversea railway construction [11]. International railway projects have both opportunities and risks. Generally, they use the FIDIC-

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EPC contract, on the condition of which risks balanced mechanism was changed. The owner pays a higher price at the same time the contractors are supposed to get a lot of extra additional risks, such as accidents, unforeseen difficulties and quality requirements [3].

It is well known that railway construction projects are always being a large-scale projects with high investment (For example, Shanghai metro line 2, construction cost is up to 10 million dollars per kilometer); taking a long time from construction to final operation phase will need 5-6 years in general and high risk. As a result, international railway projects face various risks which may diminish project profitability or even cause a project to fail. In 2004, a railway construction accident of Shanghai line 14 has caused hundreds injured and 150 million yuan lost, which was caused by the changed construction method with bad control of quality.

People began to study risk management after World War II [6]. In the 1950s, researchers undertook fundamental studies of risk management. Until now, In PMBOK (2000), it expands the risk management part from 4 aspects to 6 aspects [6]. It's becoming more and more important so that lots of international researchers are focused on this subject. It is found that there is a strong relationship between the amount of risk management efforts undertaken in a project and the level of the project success [3].

This paper will focus on international railway projects in terms of EPC contract and go into the different aspects of risks including external risk, financial risk, project management risk, engineering risk and operational risk. We will answer two questions:

- What are the main risk factors or opportunities that owners and design-builders must consider when selecting the railway project under EPC contract type? Because only when we fully understand the risk factors during the railway construction projects can we take effective measures to make sure the project is accomplished well.
- Which risk response strategies are better in dealing with the risk and opportunities?

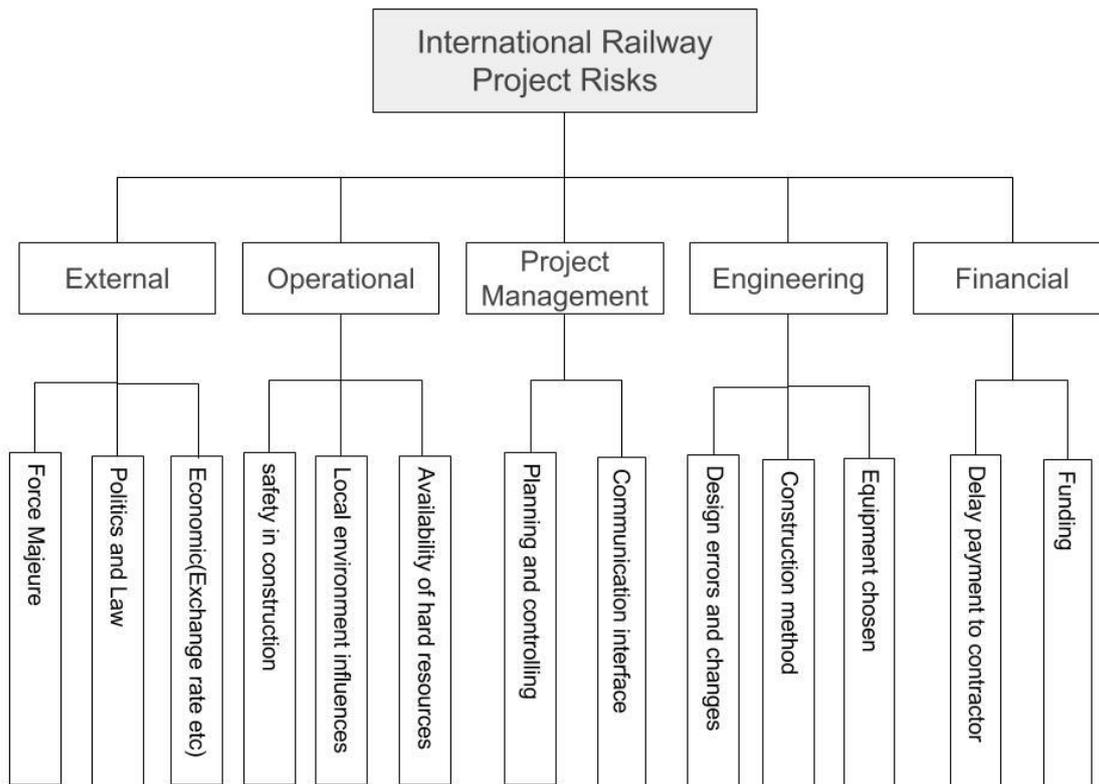
The findings will be able to help stakeholders make better decisions or considerations for controlling or reducing risks.

## **METHODOLOGY**

### **1. Identification of risks and opportunities in International Railway Project (EPC)**

In the international EPC project, contractor is made responsible for all the project phases to the End-User or Owner[12]. In addition to delivering a complete facility, the contractor should deliver the facility for a guaranteed price by a guaranteed date and it must perform to the specified level. Thus, during the bidding of international railway projects, contractors should predict risks fully, identify risks and take appropriate actions to transfer or reduce the losses of risks [10].

Through research and interview with experts who worked on the international railway projects. The risks are mainly categorized in 5 aspects: external, operational, project management, engineering and financial. All the risk factors are summarized in a Risk Breakdown Structure (In figure1) which is inspired by the PEJMAN REZAKHANI, classification of key risks [9].



*Figure 1 Risk category of international railway construction project*

- The external risks are those that have a liaison with the social context; they are influenced by many external factors and exceed the project inherent risks scope. Especially for the financial market risks, we need to take consideration of the real passenger flow vs expected, the occupation and use of urban land, the exchange rate.
- The operational risks are raised during the operation phase of the railway project. They are mainly about if resources providing are reliable, if there's a reasonable ticket price system, if site working in safety, and if the project affects natural environment in the tolerance.
- The project management risks are about the completion of project, communication and change management.
- The engineering risks relate to the technical and method aspects in which design is one of the most important risk factors.

- The financial risks mainly relate to payment of contractors and funding.

The risks responses are aimed at minimizing threats and maximizing opportunities. While we are talking about the risk, it's indispensable to take consideration of the opportunities that facilitate a positive or beneficial effect on the project. Although, the opportunities are less studied, it is as important as risk management and indispensable to the project success. For projects; there are at least three "types" of opportunity.

- First, related to project scoping and specifications
- Second, related to planning decisions for the work and process
- Third, the external environment including political and financial market environment
- Finally, the technology



Figure 2 Risk management illustrate

## 2. Multi-attribute decision-making (MADM) methods

A cost-benefit analysis approach is a useful tool for investment decision-making from a financial perspective. When the decision involves conflicting goals, the MADM method is more powerful. In this paper, we will use MADM compensatory Non-Dimensional Scaling Technique method to find the optimized risk response to minimize the threat and maximize opportunities in the international railway project.

### 2.1 Feasible alternatives

When the risk is a threat to the project, we propose four solutions to MINIMIZE THE RISK which are risk avoid, risk transfer, risk accept, risk mitigate.

- **Risk Avoid:** The risk is avoided by changing the project in some way or give up the project. This happens usually when the probability and gravity of risk are too severe. For example, the political risks adverse public opinion, the legal and regulatory risks regulatory controls etc.

- **Risk Transfer:** The contract could share risks between owner and contractor. Under the EPC contract, the owner takes no responsibilities of all the environment and project quantity change. Also, the most common way is the assurance. It could reduce the risk of arrearages and lost control of the project.
- **Risk Accept.** The risk may be accepted perhaps because there is a low impact or likelihood.
- **Risk Mitigate:** This strategy is to take preventive or protective action to face the risks. Some actions are taken to reduce either the risk occurring's probability or the gravity. For example, the performance failure, unclear expectations, poor leadership etc.

Otherwise, when the risk can provide the opportunities for the project, we develop four solutions to MAXIMIZE THE OPPORTUNITIES which explores, enhance, share and ignore.

- **Opportunity Explore:** The action will come into action when the risks really happen.
- **Opportunity Enhance:** This strategy tries to improve the probability of the event occurring and bring up the gravity of the opportunity if it happens.
- **Opportunity Share:** Both parties in the projects will share the gain benefits which were not planned. Such as the new technology.
- **Opportunity Ignore:** This is when we identify an opportunity but do nothing, similar strategy as the risk accept.

## 2.2 Development outcomes and cash flow of the Feasible Alternatives

Effective risk management practices and tools are necessary for companies to reduce risk, seize opportunities and gain a competitive advantage over companies that do not. [17] In the following, we analyze the outcomes and cash flow of each feasible alternative of risk and opportunities.

- **Risk Avoid:** The risk avoid strategy can totally avoid the risk but on the other hand, they lost the profit or maybe lose money.
- **Risk Transfer:** Some or all the risk is transferred to a third party for example insurance. For example, some environmental risks like natural disasters, storms may be insured against.
- **Risk Accept:** This strategy could be more economic.
- **Risk Mitigate:** people can plan to put in place to respond if the risk is realized. These preventive actions are more for economic, financial and political issues. If the preventive and protection actions have well done during the project lifecycle, it can reduce the loss of risk to the lowest without too much investigating.

- **Opportunity Explore:** The adjusted to take advantage will help stakeholders to gain more profits of the opportunity bring.
- **Opportunity Enhance:** Will have more probability to get the opportunity which can gain benefits. Although it increases the probability, there still the chance that gets nothing in feedback.
- **Opportunity Share:** The opportunity is shared with a partner or supplier and maximize the benefits through use of shared resource/technology
- **Opportunity Ignore:** It could cause people to lose focus on their main objective.

### 2.3 Selection of the Criteria

In this phrase, two matrix analyses will be created, one for risk while the other for opportunities. The paper chooses great, good, fair and poor four levels to assess if the response measures can efficiently respond to the criteria.

According to our previous analysis of risk and opportunities factors, we will select the following criteria for risks responses to risk:

- Cost
- Force majeure
- Politics and laws
- Exchange rate change
- Construction safety
- Delay
- Design error
- Construction method chosen wrong

Below Table 1 is the risk matrix analyses table:

Attribute	Risk Avoid	Risk Transfer	Risk Accept	Risk Mitigate
Cost	Poor	Faire	Great	Faire
Force majeure	Good	Faire	Poor	Good
Politics and laws	Good	Good	Poor	Faire
Exchange rate change	Poor	Good	Poor	Good
Construction safety	Safe	possible have a safety problem	Not in a safe environment	Low possible have safety problem
Delay	Poor	Faire	Poor	Great
Design error	Poor	Faire	Poor	Great
Construction method chosen wrong	Poor	Faire	Poor	Faire

*Table 1 Multi-attributes decision making matrix - Threat*

Similar, we select the following criteria for risks responses to opportunities:

- Technology
- Politics and laws
- Exchange rate change
- Change of scope
- Construction processes

Table 2 is the opportunity matrix analyses table:

Attribute	Opportunity Explore	Opportunity Enhance	Opportunity Share	Opportunity Ignore
Technology	Great	Faire	Good	Poor
Politics and laws	Good	Good	Great	Faire
Exchange rate change	Great	Good	Great	Faire
Change of scope	Faire	Faire	Good	Good
Construction processes	Great	Faire	Great	Poor

*Table 2 Multi-attributes decision making matrix - Opportunity*

## FINDINGS

### 1. Analysis and comparison of the alternatives

As we can know the different occurring probability and the impact gravity can give criteria different weight in the comparison. So, to produce more reasonable results, the paper use the Additive Weighting Technique produces a true RATIO SCALE analysis. First to apply the more sophisticated compensatory MADE methods, we set the criteria for 0-3 ranking.

Criteria	
Poor	0
Faire	1
Good	2
Great	3

Construction safety	
Not in a safe environment	0
possible have a safety problem	1
Low possible have safe problem	2
Safe	3

Use formula Relative RANK (attribute value-worst case) / (Best Case- Worst case) to enable every value based on 1. Risk matrix analysis results are shown in table 3:

Attribute	Risk Avoid	Risk Transfer	Risk Accept	Risk Mitigate
Cost	0,00	0,33	1,00	0,33
Force majeure	0,67	0,33	0,00	0,67
Politics and laws	0,67	0,67	0,00	0,33
Exchange rate change	0,00	0,67	0,00	0,67
Construction safety	1,00	0,33	0,00	0,67
Delay	0,00	0,33	0,00	1,00
Design error	0,00	0,33	0,00	1,00
Construction method chosen wrong	0,00	0,33	0,00	0,33
<b>TOTALS</b>	<b>2,33</b>	<b>3,33</b>	<b>1,00</b>	<b>5,00</b>

Table 3 Risk alternatives analysis result

The relative ranks of risks are based on the research of Guanghong Ma and all 2016, shen 1977. The results in consideration of the weighting are shown in Table 4.

Attribute	Relative rank	Normalized Weight	(Alternative) X (Normalized Weight)			
			Risk Avoid	Risk Transfer	Risk Accept	Risk Mitigate
Cost	5	0,14	0,00	0,05	0,14	0,05
Force majeure	7	0,19	0,13	0,06	0,00	0,13
Politics and laws	6	0,17	0,11	0,11	0,00	0,06
Exchange rate change	8	0,22	0,00	0,15	0,00	0,15
Construction safety	4	0,11	0,11	0,04	0,00	0,07
Delay	3	0,08	0,00	0,03	0,00	0,08
Design error	2	0,06	0,00	0,02	0,00	0,06
Construction method chosen wrong	1	0,03	0,00	0,01	0,00	0,01
<b>TOTALS</b>	<b>36</b>	<b>1,00</b>	<b>0,35</b>	<b>0,46</b>	<b>0,14</b>	<b>0,60</b>

Table 4 Addictive weighting analysis - Risk

In the same logic, opportunity matrix analysis and comparison are shown in Table 5:

Attribute	Opportunity Explore	Opportunity Enhance	Opportunity Share	Opportunity Ignore
Technology	1,00	0,33	0,67	0,00
Politics and laws	0,67	0,67	1,00	0,33
Exchange rate change	1,00	0,67	1,00	0,33
Change of scope	0,33	0,33	0,67	0,67
Construction processes	1,00	0,33	1,00	0,00
<b>TOTALS</b>	<b>4,00</b>	<b>2,33</b>	<b>4,33</b>	<b>1,33</b>

Table 5 Opportunity alternatives analysis result

Additive weighting analysis:

Attribute	Relative rank	Normalized Weight	(Alternative) X (Normalized Weight)			
			Opportunity Explore	Opportunity Enhance	Opportunity Share	Opportunity Ignore
Technology	4	0,27	0,27	0,09	0,18	0,00
Politics and laws	5	0,33	0,22	0,22	0,33	0,11
Exchange rate change	3	0,20	0,20	0,13	0,20	0,07
Change of scope	1	0,07	0,02	0,02	0,04	0,04
Construction processes	2	0,13	0,13	0,04	0,13	0,00
<b>TOTALS</b>	15	1,00	<b>0,84</b>	<b>0,51</b>	<b>0,89</b>	<b>0,22</b>

*Table 6 Additive weighting analysis - Opportunity*

## 2. Selection of the preferred alternative and recommendation

First, concerning the negative risks occurred during the railway project. According to the previous analyses, **RISK MITIGATE (0.6)** would be the best choice as risk response measure. Risk accept is the worst choice, in the other words, too negative to respond to risk.

Recommendation: The international railway project under EPC contract should focus on pre-evaluation, prevention and protection, in other words, risk mitigate. Give priority to prevention, take targeted preventive measures for high risks to reduce the occurrence probabilities or gravity [3]. Make action plan in the case when the risk occurred, appropriate protections measure can properly come into effect.

Then, for the positive risks, opportunities, in the railway project, we can see the result OPPORTUNITY SHARE (0.89) and OPPORTUNITY EXPLORE (0.84) nearly have the same score. Although the opportunity share could be the optimize option in some situation such as the financial or market positive change, explore would be a better choice.

Recommendation: Considering the risks includes the possibility of “upside risk” or “opportunity,” which could have a beneficial effect on achieving objectives. [17] Facing the opportunities, it’s better to share it with partners or in certain environment explore it which will get 100% the opportunity.

Of course, strengthen the study of FIDIC contract terms in the international railway project is always important, especially like the country as China who is less familiar with it.

### **3. Performance monitoring and post-evaluation**

The aim of risk management is quantification of the undesirable and the development of response actions minimizing damages [14].

#### **1) Performance monitoring**

For risks performance monitoring, one of the most important KPI could be the number of the risks occurring during the whole project. This could also be tracked in the risk register which reported and register all the risks and actions during the project. Maintaining the risk register to keep informer issues of uncertainty. Also monitoring against the cost, scope changes, and scheduling can help us to check if the response strategies do a favor to the project benefits. At last, it is recommended to take dynamic risk management approach during whole railway project's life cycle to monitor.

#### **2) Post-evaluation**

The post-evaluation of the efficiency of proposed solutions would mainly base on the risk register, risk log and other daily reports during the project. The important points to evaluate are:

- If the risks numbers reduced
- If the negative uncertainties have a big influence or damage on the project
- If the project performs well in the cost and time regardless of the uncertainty factors
- If the changes in project cause little impact on project, instead certain changes make the project get more benefits

## **CONCLUSIONS**

The capacity to see risks and opportunities, allows companies to develop flexible organizations that can manage value protection and value creation simultaneously[17]. The article based on the international EPC railway project, first identify the risk factors in the project and then develop the optimized the risk response action using the MADM method.

It answers the two questions:

#### **1) What are the main risk factors or opportunities that owners and design-builders must consider when selecting the railway project under EPC contract type?**

Based on the analyses and findings, we find out that in the international EPC railway project, there are **five** high-risk factors need to pay attention: external, operational, project management, engineering and financial. The opportunities are related to scoping, external, technology and the work planning.

## 2) Which risk response strategies is better in dealing with the risk and opportunities?

The better option in the given project environment is to MITIGATE risk and SHARE the opportunities. These actions can prevent a company from loss caused by exposure to risks such as accidents, delay of the project, damage to property or influence social image. In the meantime, by exploring and share the opportunities can help company the take advantage of these opportunities occurred in the project.

The MADM method supports the article in analyzing the different alternatives. In the multi-attributes, the paper gets a reasonable and reliable result which can be implied in the future international railway project.

### FOLLOW ON RESEARCH

This paper is only focused on the International Railway Project under EPC-FIDIC contract. To go further, future analysis can base on the other railway project type, for example, the local light railway project. It may come out different results, for example, the local project doesn't have international final market risk factors.

On the other hand, although the article based on plenty of pre-search on the international railway projects risks, the time is limited that it is failed to conduct a real project example and do the relevant analysis to make the result more reliable and reality. In the further research, we can interview some real project and make a comparison to the measure proposed by the article.

### BIBLIOGRAPHY

- [1]. Mingming, D. *Research on Contract Risk Management in International Contracting Project*. Ocean university of China, Beijing. (In Chinese)
- [2]. Wei.ZHANG(2012). *Risk Evaluation of Urban Rail Transit Project Based on PPP Mode*, Tianjin University institute of management, Tianjin. (In Chinese)
- [3]. Guanghong, M., Huimei, L. & Jianjun Z. (2016). Research on the Risks of International High-Speed Railway Projects Based on the FIDIC-EPC Total Price Contract. *ICCREM 2016*,1402-1411
- [4]. Tran, D. Q., & Molenaar, K. R. (2014). Impact of Risk on Design-Build Selection for Highway Design and Construction Projects. *Journal of Management in Engineering*, 30(2), 153-162.
- [5]. Dixuan, H(2008). *Research on the Method of Risks Evaluation on Urban Rail Transit*. Beijing Transport University, Beijing (In Chinese)
- [6]. Dionne, G. (2013). Gestion des Risques: Histoire, Définition et Critique (Risk Management: History, Definition and Criticism). *SSRN Electronic Journal*. doi:10.2139/ssrn.2198583Shen, L. (1997).

- [7]. Project risk management in Hong Kong. *International Journal of Project Management*, 15(2), 101-105. doi:10.1016/s0263-7863(96)00045-2
- [8]. Performance evaluation of major risk factors affecting construction projects. (2016). *Rev. Téc. Ing. Univ. Zulia*. doi:10.21311/001.39.1.11
- [9]. CLASSIFYING KEY RISK FACTORS IN CONSTRUCTION PROJECTS - TUIASI. (n.d.). Retrieved November 12, 2017, from [http://www.bing.com/cr?IG=E23AFFBA93914AF38057B44895C16790&CID=2F0634948D7B69540F093FAC8C7D6868&rd=1&h=kPjEF04i2cpZiQXtZrDyizWATlq-EHVTZX\\_Ei8QjwSw&v=1&r=http%3a%2f%2fwww.bipcons.ce.tuiasi.ro%2fArchive%2f292.pdf&p=DevEx,5067.1](http://www.bing.com/cr?IG=E23AFFBA93914AF38057B44895C16790&CID=2F0634948D7B69540F093FAC8C7D6868&rd=1&h=kPjEF04i2cpZiQXtZrDyizWATlq-EHVTZX_Ei8QjwSw&v=1&r=http%3a%2f%2fwww.bipcons.ce.tuiasi.ro%2fArchive%2f292.pdf&p=DevEx,5067.1)
- [10]. Sangsomboon-, P., & Yan, S. (2014 issn (2226-8235)). Analysis of Risk- Response based on Railroad Construction Project. *International Journal of Management Sciences and Business Research*, 3(12), 81-91. Retrieved from <http://www.ijmsbr.com/Volume%203%20Issue%2012%20Paper%2011.pdf>
- [11]. 2017年中国轨道交通行业投资情况分析【图】. (2017, September 11). Retrieved November 12, 2017, from <http://www.chyxx.com/industry/201709/560894.html> (In Chinese)
- [12]. Engineering, procurement, and construction. (2017, September 28). Retrieved November 12, 2017, from [https://en.wikipedia.org/wiki/Engineering,\\_procurement,\\_and\\_construction](https://en.wikipedia.org/wiki/Engineering,_procurement,_and_construction)
- [13]. Zavadskas, E., Lias, R., & Turskis, Z. (2008). *Multi-attribute decision-making methods for assessment of quality in bridges and road construction: State-of-the-art surveys* (Vol. 3). <https://doi.org/10.3846/1822-427X.2008.3.152-160>
- [14]. Dziadosz, A., & Rejment, M. (2015). Risk Analysis in Construction Project - Chosen Methods. *Procedia Engineering*, 122, 258-265. doi:10.1016/j.proeng.2015.10.034
- [15]. Planning Planet - Benefit Cost Analysis. (n.d.). Retrieved November 14, 2017, from <http://www.planningplanet.com/guild/gpccar/managing-change-the-owners-perspective>
- [16]. Kendrick, T. (2015). *Project opportunity: risk sink or risk source?* Paper presented at PMI® Global Congress 2015—North America, Orlando, FL. Newtown Square, PA: Project Management Institute.
- [17]. Tamara, B., Marc J., E., & Kristi, Y. (2008). *MANAGEMENT ACCOUNTING GUIDELINE*. The Society of Management Accountants of Canada (CMA Canada), the American Institute of Certified Public Accountants, Inc. (AICPA) and The Chartered Institute of Management Accountants (CIMA).
- [18]. Effective strategies for exploiting opportunities. (n.d.). Retrieved November 19, 2017, from <https://www.pmi.org/learning/library/effective-strategies-exploiting-opportunities-7947>
- [19]. Risk. (n.d.). Retrieved November 21, 2017, from <http://prince2.wiki/Risk>

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