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CONTRACTOR'S CASH FLOW RISK QUANTIFICATION IN ROAD INFRASTRUCTURE PROJECT PORTFOLIO

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Abstract: *The extremely difficult problems faced by construction companies in the field of road infrastructure projects, especially of financial nature, have had and continue to have important effects on the projects implementation, manifested both by delays and cost overrun. With a continuous contraction of public infrastructure investments, the competition between construction companies increased. Due to the aggressive market, the construction companies participate in tenders with lower and lower prices, assuming risks beyond their power to mitigate. The paper presents a practical approach of the contractor's risk quantification of financial effort at the project portfolio level, taking into account the particularities of road infrastructure projects.*

Key words: *road infrastructure projects, project portfolio management, financial management, risk quantification.*

1. Introduction

The road infrastructure projects have a major impact on the economy strengthening and for this reason they became an important leverage of the economic strategy [1, 2]. Ensuring the financial resources represents a critical factor for a successful implementation of these projects, meaning the completion of construction works according to the contractual terms.

However, the construction companies often win the tenders at extremely low prices without taking into account the great risks that the lack of financing produces in finalizing the works in time, quality and profit.

In the last years, a significant number of contracts in road infrastructure projects have been terminated due to the contractor's insolvency [9-14].

The participation of a construction company to a tender related to road infrastructure projects must be preceded by a thorough analysis of the risks in case of wining the tender. Usually a construction company run several projects in the same time having different stages of development, with limited resources. In order to decide if to participate in a new tender, the top management must consider all the constraints of the ongoing projects and

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especially, the influence that a new project may have on the health status of company.

The paper presents a practical approach for the contractor's cash flow risk quantification in road infrastructure projects, at portfolio level.

2. The Road Infrastructure Projects in the Context of the Civil Engineering Trends

The downturn in activity for construction within the European Union (EU-28) lasted longer than in other economic sectors. Despite occasional short-lived periods of growth, the index of production for construction fell from a peak in February 2008 to a low in March 2013 [4]. In the first semester of 2017, the construction output remained relatively stable (Figure 1).

For the civil engineering, the trends are not clear cut: from February to December 2008, civil engineering output in the EU-28 fell. However, a substantial increase followed from January 2009, mainly due to a large expansion in civil engineering work in Spain. Civil engineering output then followed the broad downward path observed for construction as a whole, also reaching a low point in March 2013, having lost 22.9 % of its value compared with its peak in February 2008.The recovery in activity from this relative low was short-lived, as civil engineering output rose by 5.7 % between March and December 2013. During the first half of 2014 there was a dip in civil engineering activity (down 2.8 %), followed by a more substantial recovery (9.1 %). This in turn was followed by a further decline between March 2015 and January 2017 (the most recent period for which data are available), equal to 6.9 %, such that in January 2017 the level of civil engineering output in the EU-28 was just 4.3 % above its March 2013 low point.

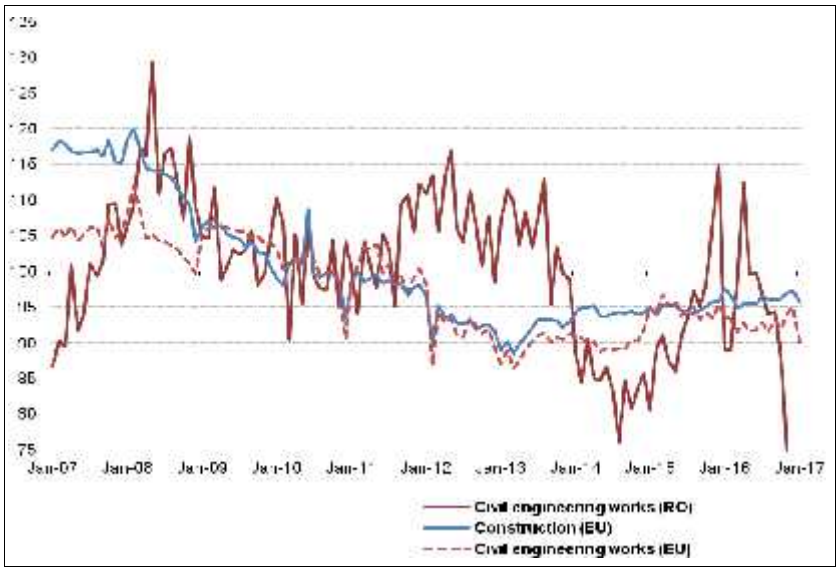

Fig. 1. *Production volume in civil engineering works, for Romania and EU28, in comparison with the construction sector (total), 2007–2017 (index data, 2010=100).* Source: Eurostat [9]

Regarding the Romanian civil engineering trends, it is even more difficult to analyze them. There were extreme high and low picks, which were not synchronized with the European evolutions. Due to these large variances, the civil engineering works in

Romania is unpredictable, which increase the risks of the infrastructure projects.

According to [3], at the end of 2015, the Romanian civil engineering works was still below pre-crisis levels, with 2,941 operating companies, compared to 4,133 companies in 2008, meaning that almost a quarter of the operational companies in 2008 disappeared in the following years. Among the main players there are both local and foreign companies. The most important 8.4% of the companies provided 80% of the turnover in 2015, the concentration of sales in this sector being above the average in the economy. It should be noted that "top 10" companies reached 19.4% of the sector's turnover, the highest level of concentration during the analyzed period.

The cumulative turnaround of the operating companies has drastically reduced in two stages: 27% decrease in 2008-2010, from € 6.6 billion to € 4.8 billion; 26% reduction in 2011-2014, from € 5.2 billion to € 3.8 billion (the minimum of the sub-sector over the last eight years). Regarding the number of employees in civil engineering works, there is a similar dynamics to the turnover: 26% decrease in 2008-2010 when the civil engineering lost about 31 thousand employees, from 118 thousand to 87.5 thousand people; and 23% reduction in 2011-2014, when another 21 thousand employees were lost, from 92 thousand to 70 thousand people.

In such unpredictable economic environment a deterministic approach of construction companies' financial management is not able to ensure their success on market. Therefore, a probabilistic approach of the financial support needed to complete the projects at the company level become more reasonable.

3. Cash Flow Risk Quantification Model: a Case Study

The most important causes of the projects failure is the lack of liquidity at the construction company level and the lack of cash flow forecast [8]. Many companies' takes their decisions mostly on intuition and experience rather than an objective and detailed analysis based on risk quantification.

The proposed method of contractor's financial risk quantification at the portfolio level involves the following steps:

1. Development of the most probable preliminary schedule and estimate the costs for each new project;
2. Analyse the contractual clauses and develop the contractor cash flow, considering the most probable schedule of payment;
3. Identify the risks and develop the optimistic and pessimistic cash flow scenarios;
4. Develop the schedule of financing and return of financing and create the combined cash flow – financing, incomes, costs and return of financing for all the scenarios: optimistic, most probable and pessimistic [6];
5. Include the new project scenario into the corresponding portfolio scenario and generate the portfolio cash flow and combined cash flow;
6. Quantify the reasonable probability for a certain target amount of financing by performing The Three Scenario Method or Monte Carlo Method [7];
7. Analyse the influence of the new project into the project portfolio and decide if the company is able to obtain the required financing.
8. Monitor the probability trend of financing during projects execution

The risk quantification of contractor's financial effort was made on a project portfolio consisted on three road infrastructure projects based on FIDIC Yellow Book Contract

General Clauses (Conditions of Contract for Plant and Design-Build for Electrical and Mechanical Plant and for Buildings and Engineering Works Designed by the Contractor) [5]. The first project is the construction of a section of highway length 20.850 km, the second is the rehabilitation of a national road of 88.460 km and the third is the construction of a section of highway length 19.650 km.

In the cash flow analysis several hypothesis were considered for all three projects:

- Construction project duration is 24 months, from which the first 6 months are designated for the design
- The payments will be made considering only the General Conditions of Contract;
- The amount of performance security is 10% and the advance payment is 15% of the Contract Price
- The retention money is 10% from each Interim Payment Certificate and minimum amount of Interim Payment Certificates is 5% of the Contract Price

The contract price for the first project (section of highway) is 116,250,677.18 Euro, for the second project (rehabilitation of a national road) is 92,679,839.00 Euro, while for the third project (section of highway) is 107,742,100.71 Euro, resulting a total amount of 316,672,616.89 Euro at the portfolio level (Figure 2).

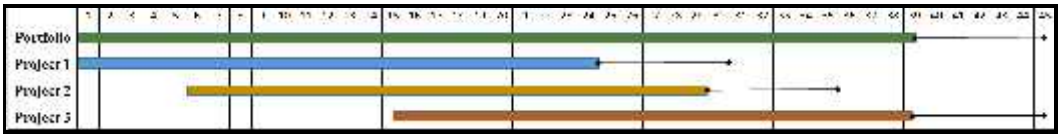

Fig. 2. *Project Portfolio Gantt Chart*

For each project included in the project portfolio, three schedules and cost estimation were performed, considering the specific risk events and uncertainties. The optimistic scenario considered that the statement of work and supporting documents are issued in 10 days after the reporting period and the payment is done in 30 days after the invoice date. The statement of work and supporting documents for the most probable scenario are issued in 30 days after reporting period and the payment is done in 30 days after the invoice date. For the pessimistic scenario it was considered that the statement of work and supporting documents are issued in 30 days after reporting period and the payment is done in 60 days after the invoice date. Among technical risks included in all three scenarios, the risk of delaying the payment affects significantly the financial effort of the construction company.

The project's cash flow consists of the following categories of contractor costs: costs of labour, materials, equipment and transport, other direct costs, overheads, profit and incomes. By aggregating each project scenario into the corresponding project portfolio, we will obtain the portfolio cash flow which reveals the company financial effort to finalize the works in time, quality and profit (Figure 3).

For each project scenario was developed an optimized financing and return of financing schedule in order to get a combined cash flow always positive. This is intended to establish both the time and the amount of funding for covering the projects implementation in each time period and respectively the time and the amount of return of funding (Figure 4). The corresponding portfolio total peak of cash flow and financing are presented (Table 1).

The combination of the project portfolio cash flow together with the optimum financing

and return of financing schedule lead to the real decision tool for construction companies, the combined cash flow (Figure 5).

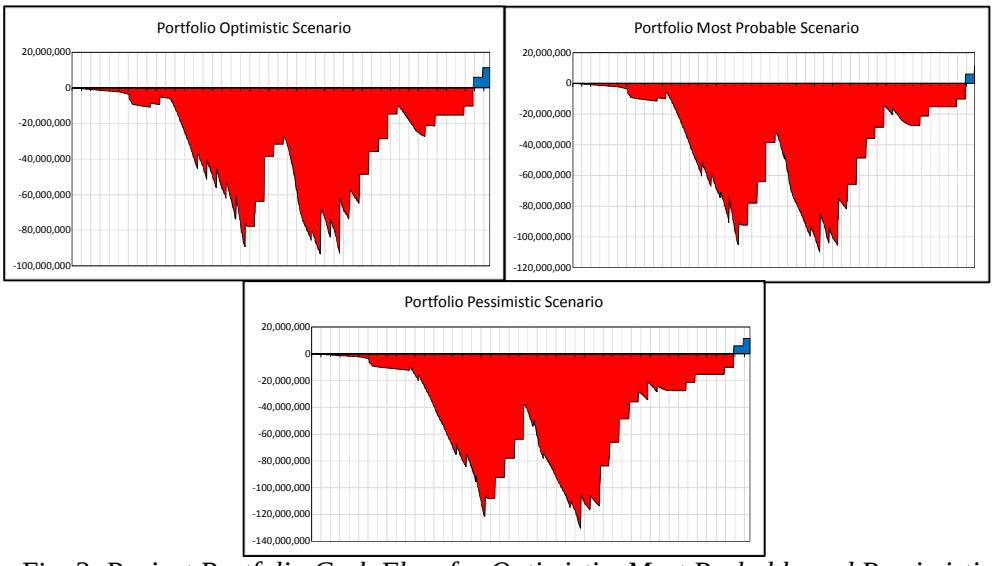

Fig. 3. *Project Portfolio Cash Flow for Optimistic, Most Probable and Pessimistic Scenario*

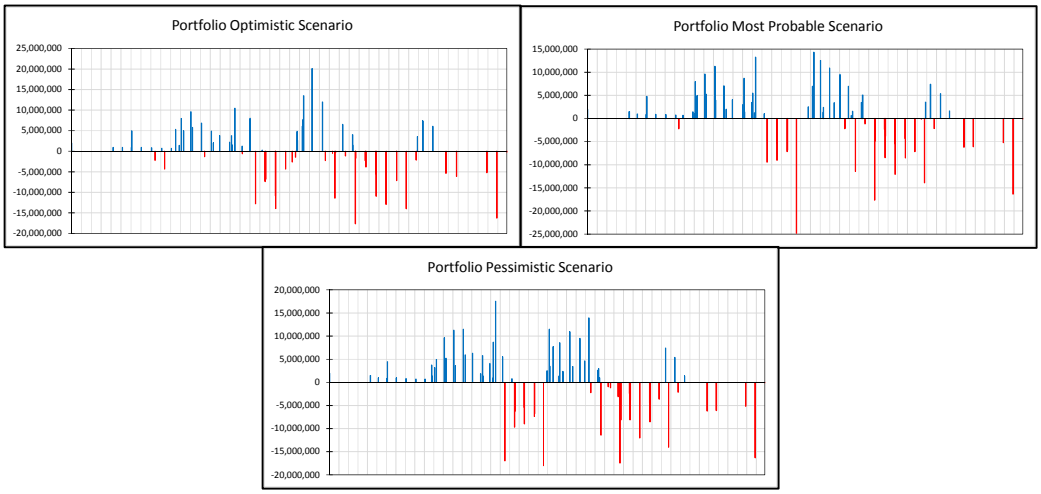

Fig. 4. *Project Portfolio financing (blue colour) and return of financing (red colour) for Optimistic, Most Probable and Pessimistic Scenario*

Projects and Portfolio Total Peak of Cash Flow Table 1

	Total Peak of Cash Flow		
	Optimistic	Most Probable	Pessimistic
Project 1	84,087,656	93,869,803	110,933,734
Project 2	67,225,952	76,865,094	80,510,749
Project 3	75,857,275	85,654,863	95,462,103
Portfolio	182,694,280	215,133,230	251,676,083

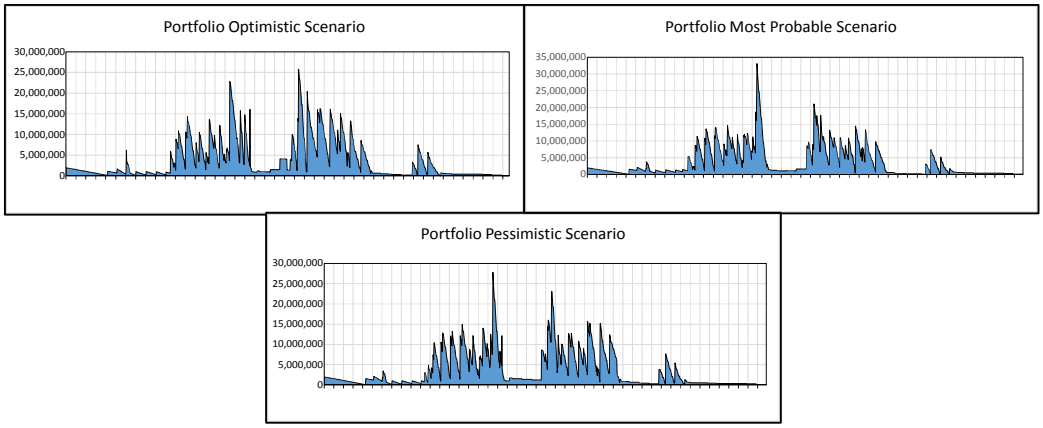

Fig. 5. *Project Portfolio Combined Cash Flow (incomes, costs, financing and return of financing) for Optimistic, Most Probable and Pessimistic Scenario*

Due to the sessional work of road infrastructure projects construction, the cumulative financing and return of financing can be divided for each year, providing the maximum amount of money for each season (Figure 6).

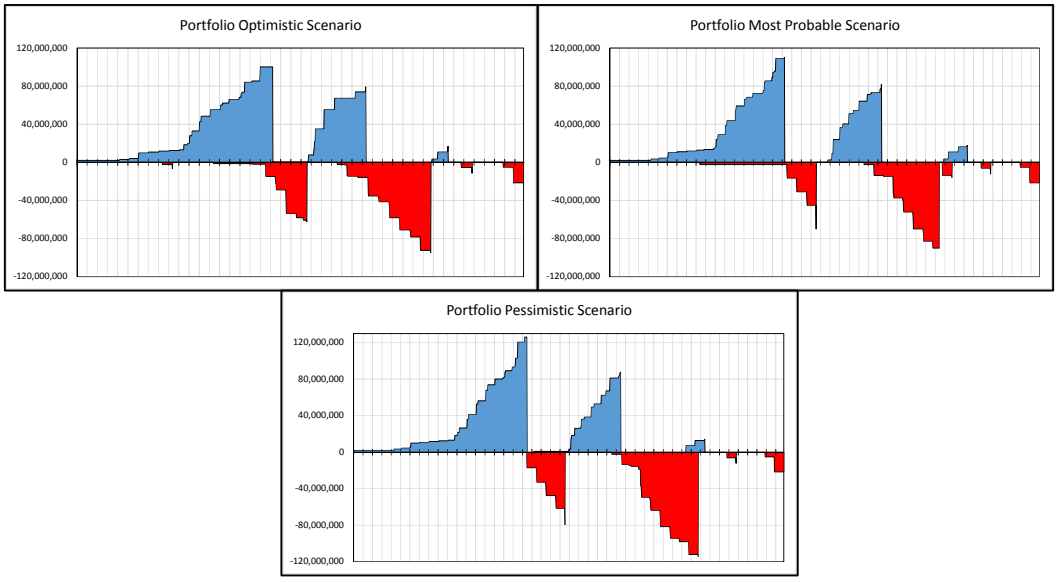

Fig. 6. *Project Portfolio Cumulative Financing (blue colour) and Return of Financing (red colour) considering the working seasons for Optimistic, Most Probable and Pessimistic Scenario*

In our particular case study there are three working seasons with three maximum amount of financing and return of financing. For each working season, we will use the Three Scenario Method or Monte Carlo Method (Figure 7) in order to identify the target amount of financing with a reasonable probability (Table 2).

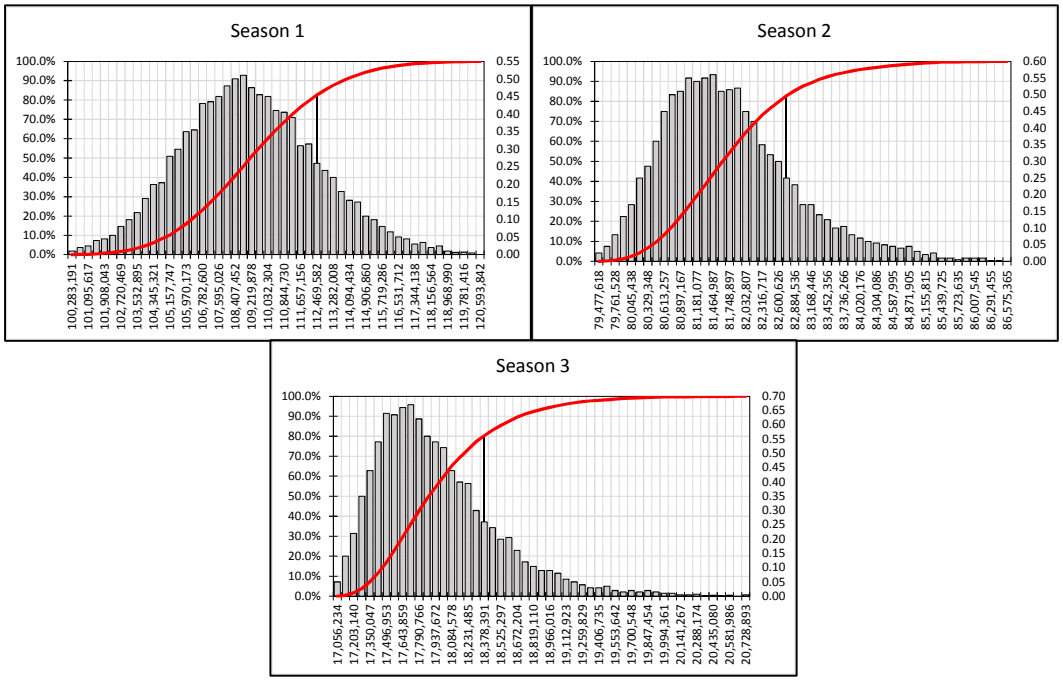

Fig. 7. *Cumulative Probability Curve of the Project Portfolio Financing for each working season using Monte Carlo Method*

Maximum amount of financing, target value and its probability Table 2

	Optimistic	Most Probable	Pessimistic	Target Financing	Probability
Season 1	100,188,131	110,128,232	120,624,645	112,470,000	82.70%
Season 2	79,470,899	82,054,114	86,607,039	82,800,000	82.80%
Season 3	17,051,498	18,027,054	20,831,315	18,450,000	80.30%

The probability to ensure the target amount of financing for each working season will be then monitor in order to take the best decisions by adding supplementary funds, or decrease them.

4. Conclusions

Due to the numerous risk events and uncertainties in implementing the road infrastructure projects, the construction companies face tremendous difficulties in supporting their projects with financial resources.

In unpredictable economic environment such as today, a deterministic approach of construction companies' financial management is not able to ensure their success on market. Therefore, a probabilistic approach of the financial support needed to complete the projects at the company level become more reasonable.

The paper presents a practical approach for the contractor's cash flow risk quantification in road infrastructure projects, at portfolio level. The proposed model allows construction companies to predict their financial effort and to quantify the cash

flow risk.

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