Sensitivity analysis of the contractor’s financial effects achieved on a single building site

**Key words:** sensitivity analysis, financial effects, construction site, NPV, cash flow, terms of payment, profit

**Introduction**

The contractor’s decision about placing a bid in a tender procedure and further construction project execution is usually based on predicted financial and economic effects of the decision and on the certainty of their occurrence. Sales and costs are estimated in advance, as well as, incomes and expenditures. Based on that net present value (NPV) and the required level of liquidity which is necessary to complete the project in the assumed period are calculated. The paper presents the influence of selected parameters arising from the contract between the client and the general contractor, from the subcontracts, from the contracts with suppliers and employees – on the financial result of a single construction project. The time schedule of erecting multi-story apartment building, the direct and indirect costs are the base for modelling cash flow and profitability of the project. Following variables are assumed: discount rate, terms of payments in the contracts signed by a general contractor with a client and suppliers and the level of retention money kept by a client till the completion stage of the project. The sensitivity analysis is prepared in order to find how the aforementioned variables influence profitability, NPV and the required level of a contractor’s liquidity. This kind of analysis is one of the basis allowing for evaluation of the risk of possibly wrong decision, i.e. accepting the project for execution but leading to losing the contractor’s liquidity and further to financial loss.

**The model**

As every construction project is unique, the time schedule and monthly costs of erecting it are unique too. Therefore, for the purpose of the paper, the ex-
emplary project is analysed. Described in BCO 4 (2018) 14-story building with an underground parking is chosen (design labelled 1122-404 there). Based on BCO 4 (2018) the time schedule is prepared. The total cost of construction works stated in the catalogue BCO 4 (2018) is 44.7 million PLN. As the catalogue provides information about the cost of the different type of works, based on that and the prepared time schedule, it is possible to calculate the costs spent in each of 18 months. The cumulative cost spent over time by the contractor is shown in Figure 1.

It is assumed that all systems in the building are built by subcontractors but the rest of the works are executed by a general contractor’s forces. Based on the catalogue BCO 4 (2018) and IRS 4 (2018), as well as on previous analysis (Anysz, 2017, 2018), it was possible to divide costs of the scheduled tasks executed by the general contractor’s forces into following parts: labour cost, machinery cost, cost of construction materials, overall cost of the construction site. As the catalogue gives the average cost of the building, it is assumed that the monthly sales of the general contractor are 15% higher than the cost in a given month. Then, inspired by Mangiero and Kraten (2017) and Zawistowski and Kulejewski (2018), the spreadsheet for $NPV$ calculation (ACCA Textbooks, 1998; Estrada, 2011) could be prepared on settlement dates described in the table.

Sensitivity analysis is made including assumptions:
- half of the retention money is paid back together with the last payment for work executed,
- the second half is paid back after 3 years warranty period,
- there are no schedule delays,
- there is no cost increase,
- income tax is omitted in the analysis: as it is influenced by overall headquarter cost and other contracts managed by the general contractor; income tax is lowered by the depreciation too (Act of 29 September 1994 on accounting; Biernacki, 2015),
- depreciation and financial cost are excluded (as they concern mainly the whole company, not the certain construction site),
- the discounting rate for $NPV$ calculation should be higher than 0.

FIGURE 1. The cumulative cost of the project spent over the time by a general contractor
Then, net value ($NV_n$) – i.e. daily cash flow could be calculated for each day $n$ of work execution (as a difference between inflow and outflow of cash), as well as the maximum demand for cash (Fig. 2). Calculating $NPV$ requires the use of discounting rate on daily basis depreciation and financial cost are excluded (as they concern mainly the whole company, not the certain construction site).

The daily discount rate ($i_d$) is calculated the discount rate for $NPV$ calculation should be higher than 0 ($i_d$). It is calculated based on yearly discount rate $i$ and the equation (1) assuming 360 days in a year.

$$i_d = \frac{360}{\sqrt{1+i} - 1}$$

As the warranty period was assumed to be 3 years, the last part of the retention money will is given back on the 1,665th day from the start of the work.

$$NPV = \sum_{n=1}^{1,665} \frac{NV_n}{(1+i_d)^n}$$

where:

- $n$ – number of days from the start of the construction work execution.

The maximum demand for cash ($\max C_d$) during 540 days of the construction work execution can be found as

$$\max C_d = \min \sum_{m=1}^{n} NV_n \text{ for } 1 \leq n \leq 540$$

The model built has 4 variables: terms of payment for suppliers ($K$), terms

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**TABLE. Settlement date of analysed costs and incomes**

<table>
<thead>
<tr>
<th>Cost/Income type</th>
<th>Settlement date</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction materials ($K$)</td>
<td>15th day of the month</td>
<td>sensitivity analysis for $K$ form –10 to 60</td>
</tr>
<tr>
<td>Construction works ($L$)</td>
<td>end of each month</td>
<td>sensitivity analysis for $L$ from 0 to 90</td>
</tr>
<tr>
<td>Labour costs</td>
<td>end of each month</td>
<td>65.2% of labour cost as workers’ remuneration</td>
</tr>
<tr>
<td></td>
<td>10th day of consecutive month</td>
<td>34.8% of labour cost as social security (Act of 13 October 1998 on the social insurance system)</td>
</tr>
<tr>
<td>Machinery cost</td>
<td>end of each month</td>
<td>--</td>
</tr>
<tr>
<td>Overall construction site cost</td>
<td>end of each month</td>
<td>--</td>
</tr>
<tr>
<td>Subcontractors</td>
<td>end of each consecutive month</td>
<td>--</td>
</tr>
<tr>
<td>Value-added tax</td>
<td>25th day of the consecutive month</td>
<td>Act of 11 March 2004 on tax on goods and services</td>
</tr>
<tr>
<td>Retention money ($M$)</td>
<td>construction works invoice</td>
<td>Sensitivity analysis from $M = 0%$, VAT included</td>
</tr>
</tbody>
</table>

\[ NV_n = \text{Net value} \]
\[ NV = \text{Net value} \]
\[ C_d = \text{Cost} \]
\[ K = \text{Terms of payment for suppliers} \]
of payment from the client ($L$), the retention money rate ($M$) and the discount rate ($i$). The sensitivity analysis can be made for $NPV$ and $\max C_d$. It is to emphasize that none of the variables ($K$, $L$, $M$, $i$) affect the profit achieved on the construction site (calculated as a difference between sales and the cost).

**Sensitivity analysis**

The maximum demand for cash depends on three variables ($K$, $L$, $M$). It is independent from the discount rate $i$. The net present values depend on all of the above. How sensitive they are is shown in the figures below, separately for each variable. The Excel simulation allows to present the influence on the project $NPV$ and cash demand, depending on the settlement date of materials and construction works invoice, retention money on the guarantee account and the discount rate.

The analysed project is profitable independently on the contract terms. In each case $NPV$ of the project is positive, even if the worst case scenario is considered. Negotiating settlement date of delivered materials for 2 weeks will affect the project $NPV$ by approximately 11,000 PLN. Negotiating shorter term of payment for construction works is more important as every 2 weeks will increases the project $NPV$ by approximately 45,000–50,000 PLN. Each 1% of the retention money rate affects the project $NPV$ by approximately 25,000 PLN. Many contractors treat the part of retention money paying back after guarantee period as a loss and assume that suspended money are not going to be returned when guaranty expires. This makes the negotiations on the payment suspension rate affecting, the project profitability even more – equally as payments from a client.

The discount rate has the greatest impact on $NPV$, nevertheless it does not depend on contract terms negotiations, but on the market conditions. In short term contracts executed in countries with a stable economy, it should not influence the project much (Fig. 3).

The analysis shows, that the cash demand is much more susceptible to the impact of the negotiated contract terms. Extended payment for materials by two weeks can lower the cash demand by
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1.5 million PLN. The two weeks delay in payment for construction works can increase the maximum cash demand by 3.6 million PLN. Retention money as a guarantee of precise performance does not affect cash demand so vitally as well as the discount rate does (Fig. 4).

Certainly, raising the retention money rate increases cash demand (what is invisible in Fig. 4) but this influence can be almost neglected. The applied scale of the vertical axis allows for showing the level of cash demand while its increase is invisible. The scale is kept for Figures 3–6 for easier comparison of the influence of different variables. The analysis made above proves that NPV of the project analysed is stable. It can be improved by successful negotiations, but in each of the cases analysed it is positive. The most important factor, which influences the project success, is cash demand. The settlement invoice date for materials and construction works can influence the project success, as cash demand can differ from 1.6 million up to 14.2 million PLN. This may cause, despite that project NPV is attractive, that the contractor with low financial liquidity is unable to complete the project successfully. The two variables influencing cash demand the most are: terms of payments from a client and terms of payment to suppliers (Figs. 5, 6). Their influences are the opposite. Making extended settlements with suppliers, improve the liquidity of

FIGURE 3. The NPV on the discount rate dependence

FIGURE 4. The influence of the retention money rate on cash demand and NPV values
When the general contractor is paid later, the demand for cash rises. Their joint influence can be shown as a surface chart (Fig. 7). Maximum cash demand is shown on the vertical axis.

Such an approach can help the contractor to analyse, whether he is able to finish the project with success, depending on his financial condition. It can also give the contractor an answer, to what extent they can take part in negotiations. This approach also allows evaluating the material distributor offer. In many cases, it can turn out, that e.g. choosing the more expensive distributor, but offering better payment terms can lower the risk of the project. As much more depends on cash demand, the point is to find the contract terms, which allows maintaining the financial liquidity of the contractor. Making the horizontal section of the chart shown in Figure 7 at 7.5 million PLN – Figure 8 can be drawn. The extreme, but still acceptable contract terms for the contractor, who is able to invest up to 7.5 million PLN, are shown in Figure 8. Each contract terms below the particular line can be accepted. This figure shows that if 30 days payment time for materials and construction works are agreed, the payment delay of over 2 weeks is to cause the loss of contractor’s financial liquidity. In such case, despite the high $NPV$, the contractor will not be able to complete the project. It turns the profitable project into a very risky one.
The cash demand are the same for retention money – 5 and 10% in described case. Analysis of the influence of payment delays on basis of Figure 8 can contribute as well to finish project on time, as this delays of payments are the third reason of construction delays (Leśniak, 2012; Anysz & Zbiciak, 2013).

Taking into account, that total indebtedness of construction companies is over 4,700 million PLN (Coface, 2018) and small and medium construction companies suffer from 4 months delay in payments (Kochalska, Baldis-Rembowski, Rogowski & Kazmierczak, 2018), if there is any risk of construction works payment delay, the contractor should not accept this project or should secure the additional financial resources.

Conclusions
Within up-to-date construction market conditions, contractors can accept only secure contracts that guarantee the profit on a desirable level. However, the prospect of the profit may be only illusory one. Despite the high profit, contactors can easily go bankrupt if they do not calculate the cash flow and do not analyse the financial liquidity within particular contract terms.
The presented sensitivity analysis shows how the payment conditions influence the project NPV and cash demand. Cash demand strongly depends on the terms of the invoice payment. The influence for NPV is lower, nevertheless, in case of less profitable contracts, it can be important enough to make the proposed set of analysis before accepting the contract. What was surprising, the influence on the project NPV of the retention money rate is similar to the terms of the invoice payment. Despite NPV stability, in this particular project, negotiations of terms of payment (with the client and the suppliers) can influence a lot the financial liquidity of the contractor.

The reason for the most of construction companies bankruptcy is the loss of financial liquidity. The reasons for the lack of cash for running a business are delays in payments and overestimation of investment opportunities. In both cases, analysis, as presented in this paper, can protect the contractor from taking a wrong decision leading to the loss of financial liquidity. Simulating the cash flows and analysis of particular contract terms influence on NPV and cash demand, can contribute not only to productive negotiations but also to analysis how possible delays in payments can influence financial stability of the company.

The presented analysis proves that accepting the profitable contract is only a part of the project success. By negotiating the contract terms, contractor can substantially lower the cash demand and the risk of insolvency. The above can contribute as to easier surviving on the market as to earning a good reputation of a reliable company.

References


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Summary

Sensitivity analysis of the contractor’s financial effects achieved on a single building site. Based on catalogues, the time schedule of erecting multi-storey building has been prepared. Real current conditions and the average cost of the building allows for creating the model where four variables influence NPV and maximum cash demand of a contractor erecting the building. The simulation made in the spreadsheet is the base for calculating and presenting the sensitivity analysis of each variable separately, as well as, for creating the surface chart where the joint influence of terms of payments affects the maximum demand for cash. The way of using of this chart has been described aiming at the protection of the contractor from losing financial liquidity while the profitable project is executed.

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