Scientific Review – Engineering and Environmental Sciences (2019), 28 (2), 183–191
Sci. Rev. Eng. Env. Sci. (2019), 28 (2)
Przegląd Naukowy – Inżynieria i Kształtowanie Środowiska (2019), 28 (2), 183–191
Prz. Nauk. Inż. Kszt. Środ. (2019), 28 (2)
http://iks.pn.sggw.pl
DOI 10.22630/PNIKS.2019.28.2.17

Hubert ANYSZ, Wojciech ROGALA

Faculty of Civil Engineering, Warsaw University of Technology

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.

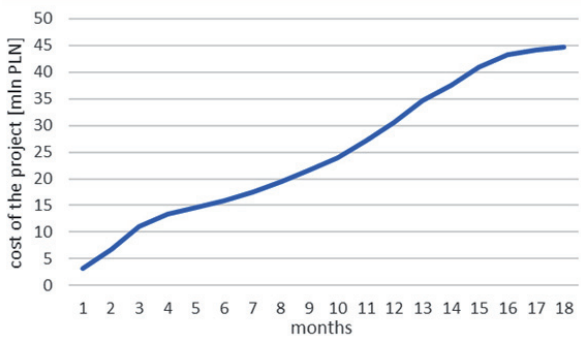

FIGURE 1. The cumulative cost of the project spent over the time by a general contractor

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.

TABLE. Settlement date of analysed costs and incomes

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

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.

$$\frac{1}{(1+i)^1} = \frac{1}{(1+i_d)^{360}} \tag{1}$$

The same NPV of the same single value paid in 360 days (calculated on daily and yearly basis) can be achieved only if

$$i_d = \sqrt[360]{1+i} - 1 \tag{2}$$

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.

$$NPV = \sum_{n=1}^{1,665} \frac{NV_n}{(1+i_d)^n} \tag{3}$$

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

$$\max C_d = \min \sum_{m=1}^{n} NV_n \quad \text{for } 1 \le n \le 540 \tag{4}$$

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

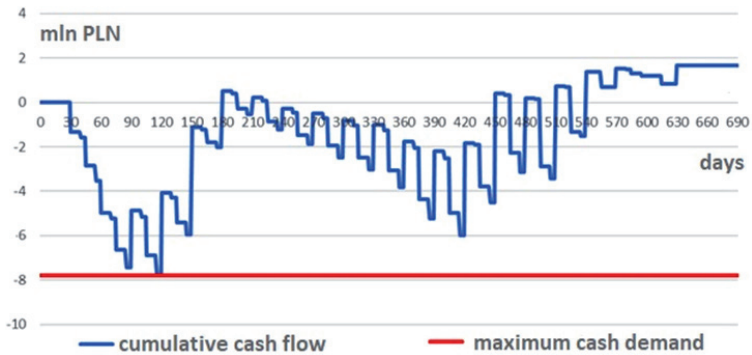

FIGURE 2. Maximum demand for cash (for K = 30 days, L = 45 days, M = 8%)

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 maxC_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

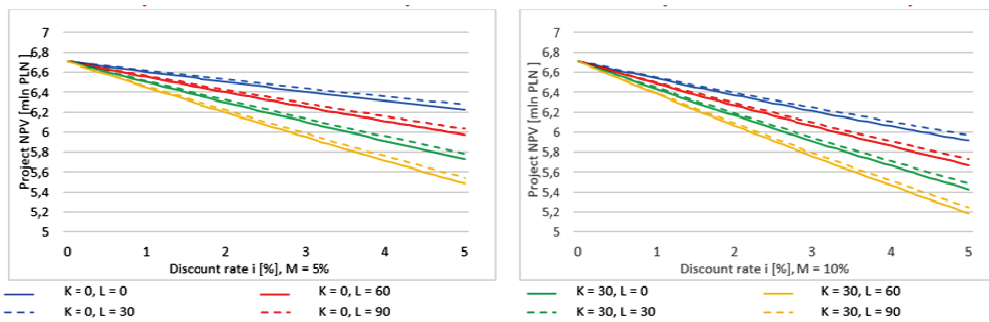

FIGURE 3. The *NPV* on the discount rate dependence

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).

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

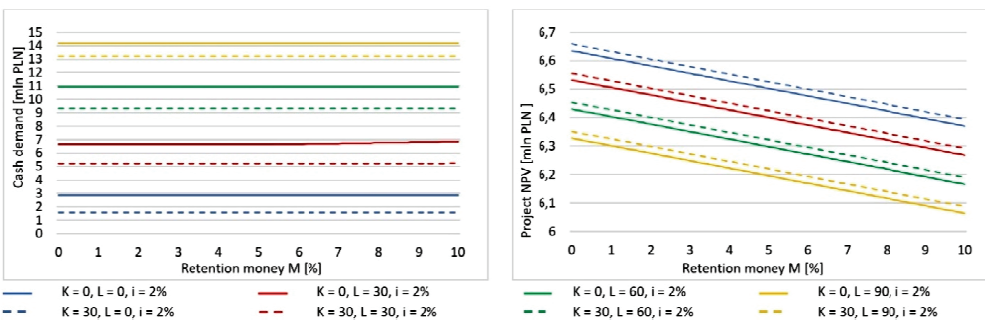

FIGURE 4. The influence of the retention money rate on cash demand and *NPV* values

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

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

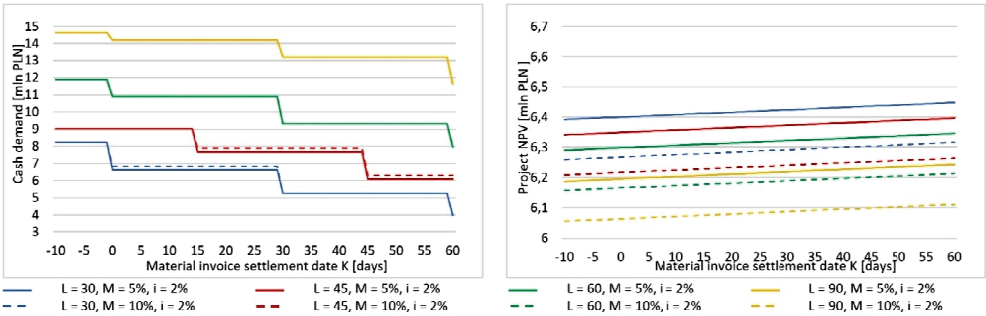

FIGURE 5. The influence of terms of payments to suppliers on cash demand and *NPV* values

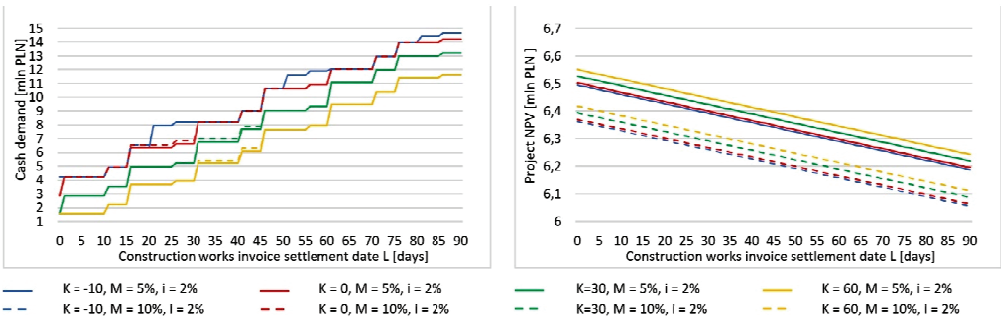

FIGURE 6. The influence of terms of payments from a client on cash demand and *NPV* values

the general contractor. 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.

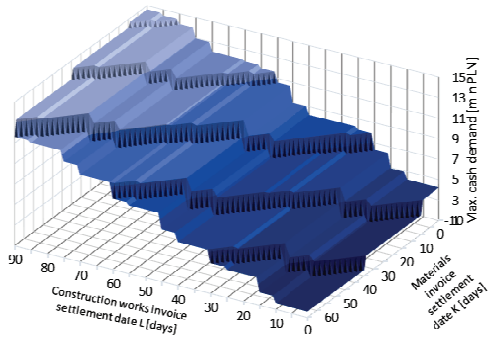

FIGURE 7. Maximum cash demand depending on settlement dates of construction works and invoices for construction materials (for $i = 2\%$, $M = 5\%$)

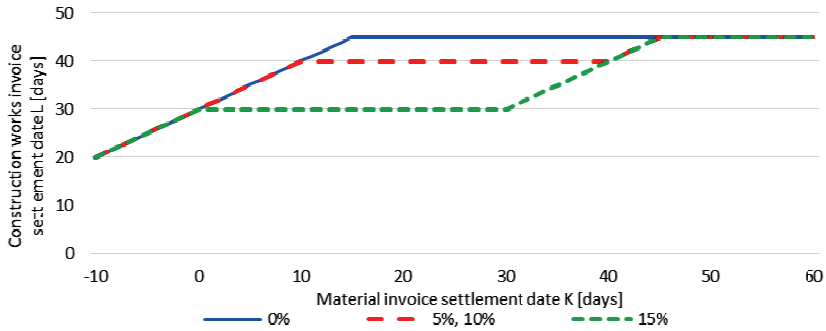

FIGURE 8. Acceptable contract terms (the area below the line) where 7.5 million PLN is not exceeded (for different retention money rates and $i = 2\%$)

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, Bałdys-Rembowski, Rogowski & Kaźmierczak, 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, contactor 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

ACCA Textbooks (1999). *Managerial Finance*. London: AT Foulks Lynch.

Anysz, H. (2017). The profit as in-company evaluation of the construction site effectiveness. *MATEC Web of Conferences*, *117*, 00009. DOI 10.1051/matecconf/201711700009

Anysz, H. (2018). Założenia systemu rozliczeń TKW + M (techniczny koszt wytworzenia plus marża [Assumptions of the TMC + M settlement system (total manufacturing cost + margin)]. *Przegląd Budowlany*, *89*(1), 48-53.

Anysz, H. & Zbiciak, A. (2013). Przyczyny powstawania opóźnień w realizacji kontraktów budowlanych: analiza wstępnych wyników badania ankietowego [The reasons of delays in building contracts execution: the preliminary analysis of the survey]. *Autobusy: technika, eksploatacja, systemy transportowe*, *14*(3), 963-972.

BCO 4 (2018). Biuletyn cen obiektów budowlanych BCO. Część I – obiekty kubaturowe. IV kwartał 2018 r. [Cost of erecting building objects BCO. Part I – volume building objects. 4Q 2018]. Sekocenbud, 69(1839).

Biernacki, K. (2015). Paradoks podatkowy w metodzie NPV [Tax paradox in NPV method]. *Zeszyty Naukowe Uniwersytetu Szczecińskiego. Finanse, Rynki Finansowe, Ubezpieczenia*, *74*, Vol. 1. *Rynek kapitałowy, wycena przedsiębiorstw, inwestycje*, 389-396. DOI 0.18276/frfu.2015.74/1-33

Coface (2018). *Badanie płatności w Polsce 2018: Opóźnienia płatnicze wzrosły pomimo solidnego wzrostu gospodarczego*. Notatka prasowa [*Payment survey in Poland: Payment delays increased despite solid economic growth.* Press release]. Retrieved from: http://www.coface.pl/Aktualnosci-i-media/Biuro-prasowe/Badanie-platnosci-w-Polsce-2018-Opoznienia-platnicze-wzrosly-pomimo-solidnego-wzrostu-gospodarczego [accessed: 07.04.2019].

Estrada, J. (2011). *The essential financial toolkit*. London: Palgrave Macmillan.

IRS 4 (2018). Informacja o stawkach robocizny kosztorysowej oraz cenach pracy sprzętu budowlanego IRS. IV kwartał 2018 r. [Information on labour cost estimate rates and

prices of construction equipment IRS. 4Q 2018]. *Sekocenbud*, *60*(1830).

Kochalska, H., Bałdys-Rembowski, R., Rogowski, W. & Kaźmierczak, D. (2018). *Sytuacja finansowa przedsiębiorstw budowlanych. Niestabilna kondycja branży na szczycie koniunktury – Ogólnopolski Raport BIG InfoMonitor o zadłużeniu firm z sektora budowlanego.* Wydanie drugie [*Financial position of construction enterprises. The unstable condition of the industry at the peak of the economic growth. National Report of InfoMonitor Economic Information Bureau on the debt of construction companies.* Second edition]. Warszawa: BIK Group.

Leśniak, A. (2012). Przyczyny opóźnień budowy w opiniach wykonawców [Causes of construction delays from the viewpoint of contractors]. *Technical Transactions. Civil Engineering*, *109*(1-B), 57-68.

Mangiero, G.A. & Kraten, M. (2017). NPV Sensitivity Analysis: A Dynamic Excel Approach. *American Journal of Business Education*, *10*(3), 113-126.

Ustawa z dnia 11 marca 2004 r. o podatku od towarów i usług. Dz.U. 2004 Nr 54, poz. 535 [Act of 11 March 2004 on tax on goods and services. Journal of Laws 2004 No 54, item 535].

Ustawa z dnia 13 października 1998 r. o systemie ubezpieczeń społecznych. Dz.U. 1998 Nr 137, poz. 887 [Act of 13 October 1998 on the social insurance system. Journal of Laws 1998 No 137, item 887].

Ustawa z dnia 29 września 1994 r. o rachunkowości. Dz.U. 1994 Nr 121, poz. 591 [Act of 29 September 1994 on accounting. Journal of Laws 1994 No 121, item 591].

Zawistowski, J. & Kulejewski, J. (2018). Influence of the contractor's payment method on the economic effectiveness of the construction project from the contractor's point of view. *Open Engineering*, *8*, 562-570. DOI 10.1515/eng-2018-0055

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.

Authors' address:
Wojciech Rogala
(https://orcid.org/0000-0001-7798-1191)
Hubert Anysz
(https://orcid.org/0000-0002-3804-5859)
Politechnika Warszawska
Wydział Inżynierii Lądowej
al. Armii Ludowej 16, 00-636 Warszawa
Poland
e-mail: w.rogala@il.pw.edu.pl
h.anysz@il.pw.edu.pl