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FINANCIAL RISK MANAGEMENT – CASH FLOW FORECASTING IN CONSTRUCTION PROJECTS – A CASE STUDY

ΔΙΑΧΕΙΡΙΣΗ ΧΡΗΜΑΤΟΟΙΚΟΝΟΜΙΚΟΥ ΚΙΝΔΥΝΟΥ – ΠΡΟΒΛΕΨΗ ΤΑΜΕΙΑΚΩΝ ΡΟΩΝ ΣΕ ΤΕΧΝΙΚΑ ΕΡΓΑ – ΜΕΛΕΤΗ ΠΕΡΙΠΤΩΣΗΣ

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To my wife and three daughters who with

their unrestricted patience paved the way for the destination.

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ABSTRACT

This paper, based on the literature of construction cash flow forecasting, develops a model which produces cash flow estimates using cost budget data and the work schedule. The forecasting method used is named as the “simpler method” with weighted means delay, where cost items are grouped into cost categories regarding each activity’s (cost) cash profile. Inadequate cash flow forecasting is among the most common reasons for contractors’ failures, and one of the main causes that insolvencies are higher than in any other industry. The model attempts to offer small construction companies in Greece with limited resources a simple model, developed fully in Microsoft Excel, that incorporates the relevant cash flow forecasting literature. Cash flow estimates from seven projects are compared with actual values but are not validated statistically, due to various risk factors occurrence. Sensitivity analysis showed that there exists a greater dependency of factors such as project duration and cost categories composition on cash flow. However, the model can serve as a useful project selection tool that shows sensitivity of credit policy and contractual payment terms to cash flow, assisting decision-making to firms.

Keywords: Projects cash flow forecasting, Cash flow model, Cost profile categories, Sensitivity analysis, Contract payment terms

Περίληψη

Στην παρούσα έρευνα, η οποία βασίζεται στην βιβλιογραφία των προβλέψεων ταμειακών ροών για κατασκευαστικά έργα, αναπτύσσεται ένα μοντέλο που παράγει προβλέψεις ταμειακών ροών χρησιμοποιώντας δεδομένα προϋπολογιστικού κόστους και προγραμματισμού εργασιών. Η μέθοδος πρόβλεψης που χρησιμοποιείται ονομάζεται η «απλούστερη μέθοδος» με την οποία εφαρμόζεται η σταθμισμένη μέση καθυστέρηση, όπου τα στοιχεία κόστους ομαδοποιούνται σε κατηγορίες σχετικές με το ταμειακό προφίλ της κάθε δραστηριότητας. Η ανεπαρκής πρόβλεψη ταμειακών ροών είναι ένας από τους πιο συνηθισμένους λόγους χρεωκοπίας των εργολάβων και μία από τις κύριες αιτίες ότι οι αφερεγγυότητες είναι υψηλότερες από ότι σε άλλες βιομηχανίες. Το παρόν μοντέλο επιχειρεί να προσφέρει σε μικρές τεχνικές εταιρείες στην Ελλάδα, με περιορισμένους πόρους ένα απλό μοντέλο, ανεπτυγμένο ολόκληρο στο Microsoft Excel, το οποίο ενσωματώνει την βιβλιογραφία πρόβλεψης ταμειακών ροών. Οι εκτιμήσεις ταμειακών ροών από επτά έργα συγκρίνονται με τις πραγματοποιθείσες αξίες ταμειακών ροών, δεν επαληθεύονται στατιστικά, κυρίως λόγω εμφάνισης διαφόρων παραγόντων κινδύνου. Η ανάλυση ευαισθησίας έδειξε ότι υπάρχει μία μεγαλύτερη εξάρτηση των παραγόντων διάρκεια του έργου και σύνθεση των κατηγοριών κόστους με τις ταμειακές ροές. Ωστόσο, το μοντέλο μπορεί να χρησιμεύσει σαν ένα χρήσιμο εργαλείο επιλογής έργου που δείχνει ευαισθησία της πιστωτικής πολιτικής και των συμβατικών όρων πληρωμής στις ταμειακές ροές, βοηθώντας τη λήψη αποφάσεων στις επιχειρήσεις.

CHAPTER 1: INTRODUCTION

1.1. Cash flow forecasting in construction projects

The present paper is an attempt to investigate cash flow forecasting in construction projects and its implications in companies' success in Greece. The industry worldwide has specific features which shape companies' economic behaviour, nonetheless in Greece where, during the last decade its financial crisis secured a huge setback, from large infrastructure projects to private homes. Both revenue and profit deteriorated sharply, while increased competition further prolonged the spiral. Low profit and levels of capital employed, the increased competition created by low entry barriers, and increased assets used as collateral which increased lending, were some of the industry characteristics, which can in certain circumstances cause increased bankruptcies, unemployment, and a decline in supply-chains prospect. Part of the problem caused during the crisis, deteriorated by the inadequate cash flow forecasting which torments companies institutionally in construction. The cash flow problem in construction consists of the inability of companies to alleviate the impact that industry-specific terms have on a project's cash flow, threatening its self-financing. Several risk factors influence project execution and cost, which along with certain contractual payment terms can produce a series of negative cash flows. Adequate cash flow forecasting can in the tender stage assist the company to select the projects with the most acceptable cash flow cycle and in the execution stage, how it can contribute to appropriate decision making when project risk factors occur and affect cash flow.

1.2. Research objectives and questions

The objective of this paper is to attempt an answer to the cash flow problem that construction companies confront during project execution i.e., when cash flow from invoiced works is less than cash flow needed for expenditure. The model employs the relevant research and develops a cash flow model that produces adequate cash flow results. The model should be easy to use, and yield appropriate cash flow reporting, without employing complex financial software. Validation of results relative to the actual cash flow values will be pursued and a sensitivity analysis will follow attempting to convey the variables that might have a large dependency on results. The three research questions are stated more analytically as follows:

a) employ the relevant academic literature to produce a model with the application of cost profile categories, time lags, cost weights and automatically produce cash flow forecast,

b) validate the results of the model with actual data of projects executed,

c) conduct a sensitivity analysis for factors that affect results presented and how a project's net present value may be affected by payment terms that often arise in projects.

1.3. Methodology of research

The research will begin with a step-by-step assembly of the model for the reader to comprehend the mechanisms that exist and operate in construction projects. Industry-specific contract terms and features have an important weight on the project cash flow cycle and they will be well explained during the detailed development of the model. Cash flow estimates of seven projects executed by one subcontractor of large project contracts in Greece will be compared with their actual cash flow values of these projects. Their deviations will be distinguished and will be tested for their validity using standard deviation as a measure. A sensitivity analysis will follow examining the relative dependency that certain factors have on the model.

1.4. Structure

In Chapter 2 after the appropriate meaning and terminology explanations that are essential for the reader to comprehend the mechanisms underlying construction projects, the three of the most prominent cash flow forecasting research methods will be presented (literature review). This will assist the reader to comprehend the basic points of other approaches and how the research has evolved for nearly six decades, attempting to present a model that produces adequate results. Chapter 3 describes the company that operates as a subcontractor of large projects in Greece during the last decade. In chapter 4 the reader goes through a step-by-step process of building a Microsoft Excel spreadsheet that produces cash flow forecasting values for a single project. In the next chapter cash flow estimates of seven projects produced from the spreadsheet, are compared with the actual cash flow values that the projects' execution has created. A sensitivity analysis will follow testing whether some variables have a greater dependency on the results. The chapter will end by summarizing the research findings. In chapter 6 a discussion will follow focusing on the basic findings, the practical implications, research limitations, and possible proposals for future research on the subject. The paper will end with a bibliography presented in chapter 7.

CHAPTER 2: LITERATURE REVIEW

2.1. Cash flow forecasting- Meaning and terminology

Companies use traditional resources of capital and labour to succeed in their goals of market share and growth. Cash, in addition, is a vital factor that in case of shortage may trigger company survival issues, even for profitable companies. A company can live without profit (for a while), but not without cash (Tangsucheeva and Prabhu, 2014). Researchers and entrepreneurs consider cash as an important factor and dispute profitability as an effective index to forecast company success, compared to cash. One of the reasons for this is that profitability may also be reflected by accounting rules and decisions (inventory valuation and depreciation), while cash flow can be a better indicator of companies' short-term success, (Pate-cornell, Tagaras and Eisenhardt, 1990).

Cash flow is the amount of cash flowing in or out of the company/project. The cash that flows in the project is called cash flow in (equity, debt, and receipts), while cash that flows out as expenditure is called cash flow out. The difference between receipts and disbursements within a certain period is called net cash flow. If positive, the contractor runs a self-financing project, however, if negative the contractor will require funding by borrowing or use of the company's equity. It is important to observe that in financial planning the crucial factor is time. Contractors are barely interested in what the accruals of inflows and outflows of the project are at its completion date, but how these progress through time. If for example, a contractor has agreed to a significant lump sum payment near the end of the project, thus turning accumulated net cash flow positive at that significant point of time, such a contract clause will do little to relieve the burden of borrowing cost, which has already been accrued during the project life.

Among the most useful tools for evaluating the future of a company's financial position in the market is cash flow forecasting. Cash flow forecasting in construction refers to the methods used to predict cash flow in various stages of the project, used when in tender or execution phases. In the tender stage, cash flow forecasting offers information regarding the amount of cash needed to execute the project, the interest rate costs that will be incurred, and appropriate decision-making concerning the bid strategies the company may follow, (Kaka, 1996). In the execution stages, cash flow predictions may prove most valuable for both the survival of the project and the longevity of the construction firm. Nowadays construction industry worldwide is characterized by very tight profit margins, minimum markup, and a high-risk environment, entailing accurate cash flow predictions mostly valuable, (Mahamid, 2012). Failure of construction firms has been found to relate to budgetary issues (low profit, lack of capital, increase operating expenditure, and debt) in 67% to total failures during 1989-93 (Arditi, Koksal and Kale, 2000). In such an environment firms operate in search of positive cash flow, carefully considering the contracts that will produce positive cash flows. The Red Book of International Federation of Consulting Engineers, clearly states that contractors consider positive cash flow when they prepare bids, (FIDIC, 2017, p. 37).

2.1.1. Company or Project level cash flow

Construction companies implement cash flow forecasting both at company and at project level. Day-to-day operations, especially in large projects must be followed closely to secure the viability of projects. At company level, the cash inflows and outflows of all projects are aggregated to display the company's position in the market and its ability to finance future projects in the tender stage. On the other hand at the project level, cash flow forecasting offers the prospect to the engineers to select the contracts that can be financed with existing resources (Kaka and Price, 1991) and present projects' potential to banks when additional funding is needed, (Navon, 1995).

Another reason for implementing cash flow forecasting at the project level is the complexity that surrounds construction projects, where many factors may affect their outcome. Numerous studies have been conducted regarding the factors with the most significant impact on cash flow. Some of these factors include changes in the initial design, production target slippage, inclement weather (Odeyinka, Lowe and Kaka, 2008) and inadequate budgetary control (Omopariola *et al.*, 2019). Zayed and Liu, (2014) conducted a survey evaluating forty-three different factors grouped into seven categories that affect cash flow. The factors with the highest impact on cash flow consisted of two groups i) those grouped as "financial" i.e., progress payment alterations (type and duration), advance payment, retention percentage, delays in retention discharge and ii) "during construction" factors such as mistakes in works execution and large changes in projects' duration. A carefully constructed forecast that takes into consideration risk factors and produces various future project scenarios, can be valuable to companies as it offers "food for thought", as also the opportunity to value risk in the model. In this paper, our focus will be cash flow forecasting at the project level.

2.1.2. Cash in

In construction projects, **cash in** is defined as the payments the contractor receives for compensation of works executed. Cash in comes in the form of monthly payments, retention releases, and advance payments (Odeyinka, Lowe and Kaka, 2008), but it may also have the form of borrowing (issuing debt). Besides borrowing, all forms of cash in are clearly described in contracts. Cash in differs from the earned value of the project, due to payment factors described in contracts: the time lag of payment received and retention held, (Ock and Park, 2016).

2.1.2.1. Monthly payments certificate

The contractual terms agreed describe among other issues the measuring method of works executed. According to FIDIC - Conditions of Contract for Construction - the contractor prepares a monthly progress report, which is submitted for approval to the independent engineer, (FIDIC, 2017, p. 35). Upon endorsement, the engineer issues a payment certificate which is transferred to the client/employer of the project. After approval of the payment certificate, the employer pays the contractor in cash. Monthly progress payments are the most usual form of project payment in comparison with other forms, i.e. specific project milestones, (Shash and Qarra, 2018). Kenley, (2005, p. 260), remarks that contractors prefer and find satisfying periodic instalments as a type of payment, which also reduces their financial cost, (Odeyinka and Kaka, 2012).

2.1.2.2. Advance payment

In projects where significant spending is necessary for machinery investment or for installation and materials expenditure necessitous to begin works, contract clauses may include a payment that occurs in advance of works commencement. Advance payment regime has been found that greatly assists contractors to manage projects prudently, thus enabling on-time project completion, (Aje, Olatunji and Olalusi, 2017) and avoid cost overruns, (Aje and Adedokun, 2018). Advance payment is usually calculated as a percentage of the contract amount which is received before delivering the product to the employer, and its reimbursement is retained as a fraction from works completed, (Ock and Park, 2016), (FIDIC, 2017, p. 70). The formula of advance payment usually takes the form of:

$A\ = P\ x\ CV\ Formula\ (1)$, (Ock and Park, 2016)

A = Advance Payment

P = Percentage of Advance Payment

CV = Contract Value

The reimbursement of advance payment may be calculated by multiplying the ratio of work completed (MV) to contract value multiplied with advance payment received (AV), i.e.

$$RAP = \frac{MV}{CV}\ x\ AV, Formula\ (2)$$

The above calculation facilitates contractors repaying advance payment with a standard percentage of works completed to total works, spreading the repayment through the duration of the project. However, advance repayment may also take the form of standard partial payments not connected to the monthly works completed.

Advance payment regime is of significant importance since it offers contractors flexibility in their cash flow management (Kenley, 2005, p. 260) and may inflict better project involvement by members, leading to increased project-goal awareness (Motawa and Kaka, 2009). Additionally, advance and progress payment postponement may have very harsh effects on cash flow (Shash and Qarra, 2018). Conversely, in markets where advance payment regime is not prevalent, findings showed that mediation effect of cash flow on project performance is non-significant, (Omopariola and Windapo, 2019).

2.1.2.3. Retention Money and Releases

In the execution stage, the employer usually agrees on some form of retention applied to contract value as works progress i.e., performance retention, as a security against future project quality deterioration. The monthly payment certificate has a retention which is deducted from payment, usually calculated as a percentage of works completed. Accumulated retentions are reimbursed to the contractor typically after the engineer issues a completion certificate (Shash and Qarra, 2018), or a Defects Liability Certificate (International Federation of Consulting Engineers - FIDIC, 2017). The equation for retention calculation is:

$$GP = \frac{MV}{CV}, Formula\ (3)$$

GP = Good performance retention

MV = Monthly Works Value

CV = Contract Value

The accruals of retention money, either in the form of good performance or advance payment, stiffens companies’ cash flow programs and may result in negative cash flows until the very end of construction (Park, Han and Russell, 2005). Many construction firms in quest of easing cash flows, replace retentions with bond financing which in some circumstances reaches 20% of construction companies' lending, (Shash and Qarra, 2018). Bond financing of retentions – especially advance payment - is widely used in the construction industry as employers demand security in case contractors default, (Kim, 2019).

2.1.3. Cash out

Cash out or cash outflow consists of the total expenditure a contractor accumulates to produce value/income. It may consist of both direct and indirect costs. Direct costs are the most significant portion of total costs and consist of labour, materials, machinery, sub-contractor services, and overheads. Indirect costs comprise of expenses that may be used in other projects and are usually company-related, for instance, financial costs based on company assets (Jiang, Issa and Malek, 2011).

2.1.3.1. Labour

Labour consists of the sum of all wages paid to personnel including social security contributions, paid leaves, health insurance, etc. Wages are usually paid within the first days of the next month which they are borne, and in many models have the shortest time lag.

2.1.3.2. Subcontractors - outsourcing

There has been a shift by contractors from more traditional methods of hiring labour to outsourcing, which has approached to range from 50% to 70% of the total cost. The main causes for this change are because contractors: a) lack specialized expertise needed, (Navon, 1995), b) decrease management costs associated with labour hiring, (Navon, 1995), c) alleviate labour cost associated with long service, holidays and termination (Kenley, 2005, p. 256) and d) shift finance load of the project to others (Kenley, 2005, p. 256). This last motive relieves everyday work of cash flow modellers since by allocating activities to subcontractors, with which they agree on a certain payment (one for all usually), they achieve more control in payment conditions, adding a level of certainty in cash flow planning, (Park, Han and Russell, 2005). A model has been developed that demonstrates the impact on project cash profile when subcontracting a portion of the whole project, (Elazouni and Metwally, 2000).

2.1.4. Project Duration

Project duration is an important factor that affects cash flow, especially in large projects. Large projects have higher amounts of average transactions and a duration change will have a greater impact on IRR, than a similar change in a smaller project, (Hwee and Tiong, 2002). Furthermore, duration greatly affects project cost by indirectly influencing payment terms described i.e., progress payments, retention releases, etc.

2.1.5. Time lag – payments delay

Time lag is an important factor that affects the viability of the project, by shaping both cash inflow and outflow, (Ock and Park, 2016). Time lag consists of the time between actual cash inflow and billing date as we mentioned earlier, (Purnus and Bodea, 2016), while the time lag between receiving materials/services and disbursing them may stretch to an even longer time, depending on payment agreements. The reason that payment occurring in a different period than actual cost affects cash flow, is fundamental to finance discipline since to evaluate a project we calculate its present value, which is also called discounting, (Bodie and Merton, 1998). Discount rate values the risk that the investor is willing to undertake to proceed in financing the project. If an investor finds two investment projects that return an equal value with different associated risk, she will select the one with the reduced risk. Increased discount rate has a greater effect project's net cash flow thus greater impact on the project's net present value.

2.1.6. Cash flow diagrams

Contractors construct cash flow diagrams to demonstrate the cash flow in/out of the project, facilitating this way comprehension of the project's financial situation. Engineers are familiar with other project management diagrams which they use to monitor project's growth, the S-curves, (Mavrotas, Caloghirou and Koune, 2005). S-curve in project management is built simply by projecting time-schedule cost activities cumulatively, as a function of project's duration, (figure 1). For cash flow forecasting purposes this project management tool can be transformed into a cash flow S-curve. Cost activities are broken into categories depending on their cash profile i.e., labour, materials, sub-contractor, and overheads, figure 2. Firms usually agree payment terms according to each activities' cash profile, for example, labour is paid on the same cost period that is generated, while sub-contractors' cost is applied a two-month time lag, including retentions held. Thus, cost activities curves are transformed to separate cash flow S-curves, (Kaka, 1996). Total cash out expenditure is generated by adding the separate cash flow S-curves producing a cash out S-curve.

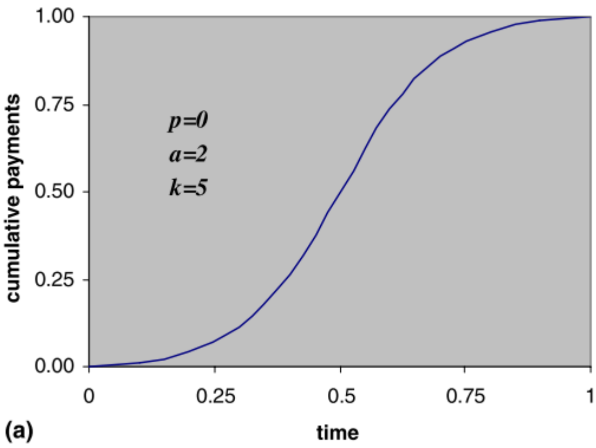

Figure 1 (Mavrotas, Caloghirou and Koune, 2005)

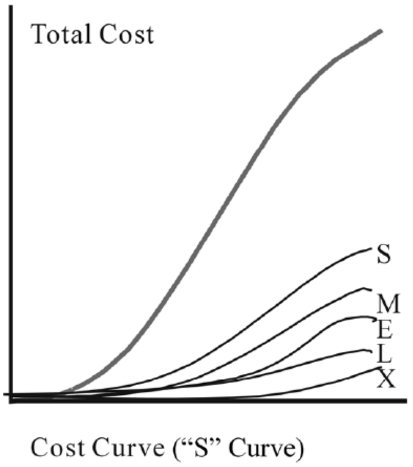

Figure 2, Cost curves (Park, 2004)

Cumulative cash in curve is generated similarly by integrating the earned value curve – the curve that reflects billed works – with appropriate time lag and retention applied, (Ock and Park, 2016). When these cumulative cash flow in and cash flow out curves are plotted together the area between them represents net cash flow (figure 3).

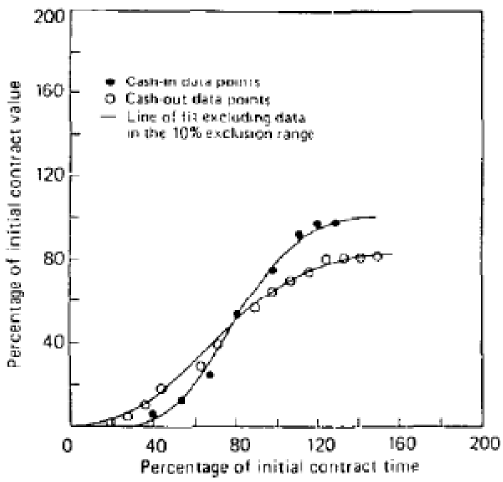

Figure 3 Typical component cash flows (Kenley and Wilson, 1989)

2.1.7. Project financing

To comprehend how cash is flowing within the context of a project it will be helpful to describe a few steps of the procedure starting from project commencement. When a company is awarded a project, it has agreed with the employer certain contract terms, which describe the payment procedure to the contractor. Initially, companies use their equity or debt to finance spending for tools, overheads, materials, and labour needed to begin works. According to the contract, there are agreed points of time that the contractor may measure the work completed, which points usually occur at the end of the calendar month. The contractor submits appropriate documentation for assessment to the employer and awaits to receive the respective compensation. The employer evaluates the work with the agreed measure and compensates the contractor, who uses this compensation for further financing the works needed to complete the project. Cash payments are thus converted to product, which appropriately priced return as income to the contractor. This is known as the cash flow cycle of the project and is diagrammatically presented in figure 4, (Shash and Qarra, 2018).

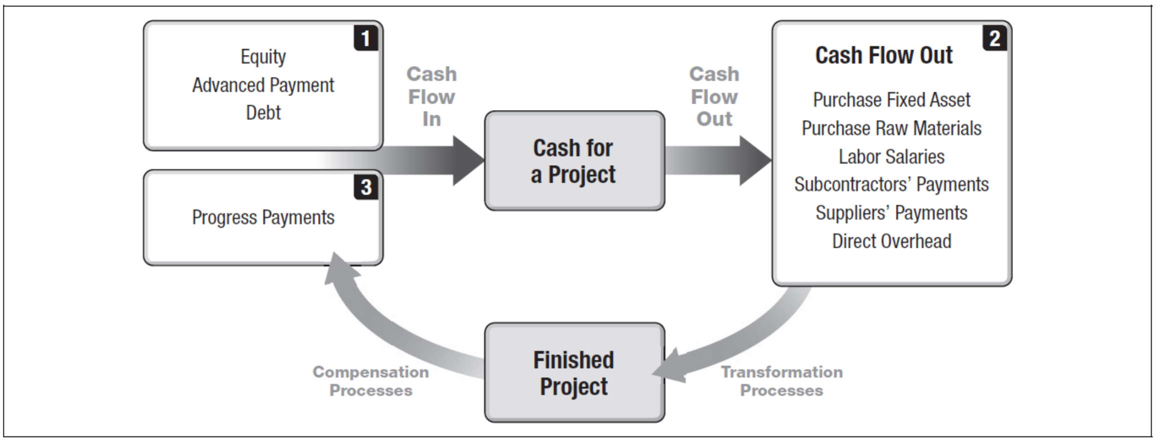

Figure 4 Cash flow cycle (Shash and Qarra, 2018)

As we mentioned earlier, there are also additional payment terms included in contracts that affect the cash flow cycle, the most ordinary being advance payments and retentions. In a later section, we will observe how agreements on payment terms can turn a series of positive to negative cash flows until the very end of the project, putting pressure on company's cash reserves (Zayed and Liu, 2014).

2.1.8. What can Contractors do to reduce the cash flow burden?

In addition to the situation described in the previous section, the contractor may need up to 90 days to receive cash for expenditure committed. According to payment clauses used in contracts, the contractor may submit a works certificate at the end of the month, while the Engineer issues a payment Certificate to the Employer after 28 days. The employer will then compensate the contractor after 56 days (Purnus and Bodea, 2016). Appropriate cash flow management should take into consideration the described time periods, contract terms agreed and design a cash flow cycle that will self-finance the project or achieve minimum negative cash flows. What contractors can do to reduce negative cash flow is to improve the ratio of the compensated amount to the amount paid for expenditure. This ratio is *"… a function of contractor's efficiency and the agreed upon percentage of retention"* (Shash and Qarra, 2018). The higher the contractor's claims from receipts are in respect to their expenditure, the less they will need to borrow. Retention held will be paid back sooner and the project will be financed properly.

2.1.9. What is the cash flow problem - Results inadequate forecasting?

What happens though when things go wrong and cash flow planning proves inadequate? There is increasing evidence that poor financial planning is among the most significant factors that cause insolvencies to contractors, (Economics Reference Committee, 2015), (Holt, 2013). Construction is the hardest hit industry with insolvencies representing 17% in 2018, (3001 out of 17.454) in the UK. This trend continued in 2019 with 18,7% (3.237 out of 17.259) and 16,27% in 2020 (2060 out of 12.663), (GOV.UK, 2021).

According to Barnes, (1972), construction companies are inherently characterized by low levels of capital employed which is partly due to the low-entry barriers needed. Low levels of capital do not hinder companies, though from sustaining significantly low levels of profit. Such a combination, however, leads companies to be significantly vulnerable to cash flow fluctuations. A relatively small delay on client's receipt or a mismeasure of quantities that will be corrected at the end of the project, may constitute a large proportion of company's working capital and profit. Although the ratio of profit to revenue may not be affected at all, cash flow reduction may lead to unpleasant results, as described in the next few lines. Inadequate cash flow may result in a contractor failing to meet agreed payment terms, resulting in labour and material shortages, reducing performance, and weakening its position. If the situation is not reversed it may get worse: the contractor's employer gets upset by the project's low performance, which fuels a generic breakdown by financial institutions, distressed sub-contractors and suppliers, leading to insolvency, (Kenley, 2005, p. xvii).

Contractors' inadequate financing does not only affect them as "victims" since it raises their insolvency-related risk but may have a "leading role" by creating a large burden on companies of the same supply chain, (Ross, Dalton and Sertyesilisik, 2013). Contractors may sign contracts with relatively low mark-up, (Mahamid, 2012) meaning that a significant part of their income belongs to their suppliers, subcontractors and their suppliers, etc. Managing cash carefully will assist supply chain survival.

Misplanning has also been attributed as a reason that prompts contractors to request loans. The employer pays the agreed value of works executed but cash flow in is short of expenditure, because of specific contract terms (percentage retention held for example) and the contractor turns to bank loans. However, borrowing money is not a solution to negative cash flows, because borrowing should be prudently based on plans that incorporate the needs and anticipate future gains for contractors, thus prolonging the existence of the company (Russell, 1991). For a company to achieve its goals, management should be able to prepare for the upcoming. Contractors can implement appropriate forecasting techniques to improve their financial position and avoid insolvency, which is a significant threat for many construction firms, (Kaka, 1990).

2.1.10. Background - The case in Greece

The construction industry in Greece has been severely hit recently, deteriorating the cash flow problem for construction companies in the industry in general. A climate of low capital and profit has also been the case in Greece, which has grown in intensity in the years following the property market collapse of 2008. For public contractors everywhere, their biggest client is the government. The number of available projects for tender has fallen sharply after 2014. Public contract bids have been increasing from 223 bids per year in 2009 to 377 in 2013 following a huge drop in 2014 to 190 with an average of 264 bids per year. The number of bids has further declined in the following three years with the average bids per year landing at 107.

Year	2009	2010	2011	2012	2013	2014	Avg
Number of public contracts bids	223	192	254	351	377	190	264,5
Average percentage bided by contractor	40,70%	41,10%	40,30%	36,40%	40,00%	41,50%	39,80%

Table 1. No of bids for Public contracts 2009-2014 (Association of Greek Contracting Companies SATE, 2018)

Year	2015	2016	2017	Avg
Number of public contracts bids	82	86	153	107
Average percentage bided by contractor	50,40%	58,60%	57,70%	56,00%

Table 2 No of bids for Public contracts 2009-2014 (Association of Greek Contracting Companies SATE, 2018)

However, such a decline of public projects bids did not come alone. A sharp decrease in the supply of projects – which represents a decline in the available revenue opportunities – was complemented with an increase in the average percentage bided. Companies struggling for survival were willing to undertake projects even below cost threatening their survival. The average public projects bid increased by more than 40% to account for 57% % in 2017 compared to 2009 (tables 1 and 2). The result of this situation, which is more thoroughly described in F.E.I.R. (2015), further decreased the average revenue of public contractors with income diminishing by 55% and net profits (EBITDA) by 79%, (Table 3).

in millions of €	2008	2009	2010	2011	2012	2013	Change 2008-2013
Net Profit before Tax	279.70	175.40	-168.70	-426.60	-200.20	-296.90	-206%
NetProfit EBITDA	1,315.20	1,197.30	555.40	443.80	357.30	273.60	-79%
Revenue	7,208.10	6,413.20	5,336.80	4,425.90	3,478.40	3,252.30	-55%

Table 3 – Profit of Construction Companies (F.E.I.R., 2015)

In addition to public contracts, many contractors have pursued in parallel other activities in the private market, which have also been hit by the property market crash. In 2013 construction companies have constructed 1.127 new private homes which represents a 95% decrease of the 21.868 new houses made in 2006, (Table 4), (ICAP Group, 2017).

Gross investment on capital assets in Greece (2006-2016)											
Current prices	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Private homes	21.868	25.203	19.63	15.538	11.205	9.567	5.903	4.02	1.815	1.31	1.127

Table 4 – Gross investment on capital assets in Greece (2006-2016) (ICAP Group, 2017)

Another characteristic of the Greek construction industry and the industry, in general, is its fragmentation in multiple small-sized companies. According to a survey of the Foundation of Economic & Industry Research, construction companies with less than 10 employees constitute 98,1% of the total compared with EU28 of 94,2%. (F.E.I.R., 2019). Such a feature creates hurdles in developing managing skills needed for employees that are usually pursued by larger companies and attracts personnel without adequate experience to ensure success.

The above context portrayed has certainly its roots in the specific institutional context occurring in Greece at the time, created mainly from the inability of the Greek government to increase spending and its failure to fund its external debt. The most significant factors that may be blamed at the time for the deterioration of market conditions, according to F.E.I.R., (2015) were:

- government spending decrease,
- the drastic decrease of demand along with the oversupply of houses which fueled the subsequent decrease in prices,
- assets used as collateral for lending which led to bank failures and contractors' failures to borrow,

- bureaucratic issues with buying and selling houses,
- fluctuations in the market tax system,
- worsening funding conditions of companies
- and market fragmentation.

Nonetheless, many of the above factors characterize not only the Greek market but the construction industry in general, such as fluctuations in government spending and available income, tax receipts, interest rates, and unemployment variations are unique features that have created a great number of construction company closures. (Kaka, 1990). Cash flow prediction models are not a panacea for the whole industry both in Greece and worldwide though. We will observe in chapter 4, when developing the cash flow model, how adequate planning and forecasting may offer useful information for companies to change strategies and avoid selecting projects that threaten their sustainability. To alleviate the negative consequences of inadequate cash flow forecasting, predictions models have focused on producing consistent results, (Chen, O'Brien and Herbsman, 2005). In the next section, we will review the most prominent cash flow forecasting approaches that researchers have developed to help companies alleviate cash flow-related challenges.

2.2. Literature review

2.2.1. S-curve forecasting - Ideal curves

A large part of cash flow forecasting has been built around project management's S-curve theory of cost estimation, (Mavrotas, Caloghirou and Koune, 2005). To accomplish a cost control method project managers employed two simple indices: a) the percentage of executed works plotted against the percentage of project time lapsed (figure 4) and b) the total sum spent against the sum forecasted to be paid when the contract is completed. If these two indicators are monthly followed, managers may have a good idea of the problem areas of the project, (Kaka, 1999). Such a process though is most accurately applied by integrating the schedule works program with the actual executed works measurement, thus calculating the monthly cumulative project cost to time. However, such a detailed method requires extra work added to the work already performed by project managers (schedule and measuring work executed, etc.), depicting the use of past projects' data to predict project execution behavior of current and future contracts as an answer to the problem, (Kaka, 1999).

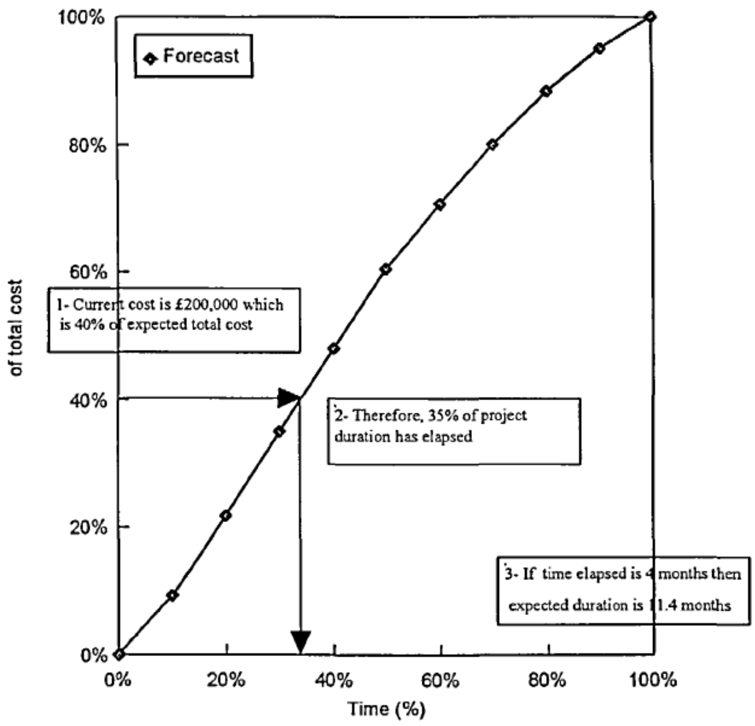

Figure 4 The Use of S-curves to calculate the expected duration of a current period, (Kaka, 1999)

Plotting cumulative project cost versus project duration has been statistically found to form a sigmoid shape. The explanation of the curve shape lies on construction execution behavior, as projects usually commence with works concentrating on gathering resources, then they pick up speed with a lot of activities running in parallel, increasing the growth of spending. Following this phase, sub-projects begin to complete, activities decrease in numbers, thus reducing works and expenditure, (Cristóbal *et al.*, 2015). The classic S-curve shape of cumulative project cost versus time is 25% of cost completed in 1/3 of project time, 75% works completed on the next 1/3 of the project, and 25% of cost executed on the final 1/3, (Park, 2004).

2.2.2. The wholly nomothetic model

Having in mind such a project behaviour, researchers contemplated whether they should use an S-curve projection to predict future cash flows. One of the first researchers was Hardy, (1970) who, using data from 25 building projects, demonstrated that there exists a common S-curve geometry in specific activities of a project when cumulative values are plotted against time. Grouping those sub-projects together produces average - or ideal - curves that can be used in forecasting cash flows for other similar projects. This concept was named “the wholly nomothetic model”, displaying its generic purpose. Hudson, (1978) developed a similar statistical approach model that with the use of multiple regression analysis forecasted cash flow for the Department of Health and Social Security projects in the UK. Data values were expressed as a proportion of contract value and time elapsed as a proportion of total duration. The data was categorised in sets depending on their cost categories, for which an average line was produced. Hudson's study generated a lot of research, which attempted to certify its predictive powers and improve its results, but has also attracted a lot of criticism, (Odeyinka, Lowe and Kaka, 2012).

2.2.3. The idiographic approach

Kenley and Wilson, (1986) have criticized this approach on its theoretical basis and argued that such a generic approach is not coherent with construction as a discipline. They stated DeGroot's argument that construction management is synthesized from both cultural sciences (as history for example) and natural sciences (as mathematics) and attempting to use methods belonging solely to the latter will produce inconsistent results. Projects are unique, "idiographic", as there exist several different factors that may affect their outcome: *"Individual variation between projects is caused by a multiplicity of factors, the great majority of which can neither be isolated in sample data, nor predicted in future projects"*, (Kenley and Wilson, 1986). Their research used data from seventy-two projects in two groups, constructing individual S-curves as well as two group average curves. The systematic error found in average curves was significantly higher than the individual curves, concluding that the construction of the ideal curves proposed by the wholly nomothetic model lacks consistency.

2.2.4. Value curves vs cost commitment curves

Evans and Kaka, (1998) tested the hypotheses whether value curves based on historical data are possible to generate accurate standard S-curves. They used data from twenty superstore projects, creating a value curve for each project, which was then subjected to logit transformation, - the same procedure performed by Kenley and Wilson, (1986). The transformed data were then used in a regression analysis which calculated alpha and beta coefficients to generate a Standard S-curve. S-curves produced were compared to the actual values and showed a higher error concluding standard S-curves cannot be created by value curves.

To further test the idiographic approach Kaka and Price, (1993) suggested a different process to create a standard S-curve model. They stated that mismeasuring work and different contract payments produce different value curves even for the same project, thus variating the accuracy of the standard curves. They collected data from 150 projects which they grouped according to the type and the duration of the project. They used the same procedure of logit transformation and regression analysis as the previous two models and generated S-curves that were found to be more accurate on cash flow forecasting than the model of Kenley and Wilson, (1986).

2.2.5. The Simpler method – weighted means delay

Researchers besides building models based exclusively on S-curves theory that utilise historical data to produce current trends, they have developed other models with reduced employment of S-curves. One such model is Cash Flow Forecasting System (CAFFS) which is aimed at improving the financial pre-hand estimate position, (Hwee and Tiong, 2002). Contractual data such as cost, payment agreements, and retentions are fed into an excel sheet generating a cumulative cash flow S-curve. To produce the cash outflow curve, the program utilises the method of cost categories, where cost is broken into categories with different cash profiles; for example, labour and materials belong in a different category since companies usually agree a credit period for materials, whereas labour is usually paid within the month executed. After commencement, the user inputs data of works measurement, income, and cost, producing the actual cash flow so far and, in case of discrepancies, re-adjusting S-curve that yields the net cash flow forecast for future periods. Such a method has a two-fold target: a) offer a cash flow estimate before project begins and b) construct a project management tool that displays basic project information, for example, work executed and cost incurred, further assisting engineers to readjust schedule and works which additionally improve cash flow.

The basic idea of the simpler method lies in the allocation of budget items to certain operation activities, (Henderickson and Au, 2000). A field engineer constructs a budget that includes cost items such as labour, materials, sub-contractors, and overheads. Subsequently, these costs are allocated as proportions of appropriate project subdivision expenditures. Following this process, Park, (2004) has introduced a model not grounded on standard value (income) S-curves but instead, on the construction of the cash-out curve. Since costs in projects have different time lags, which are usually described in contracts or by company policies, he grouped costs as a percentage of total cost, a characteristic that has already been introduced by Ashley and Teicholz, (1977). Cost categories that have already been identified and allocated to certain activities are applied a time lag to generate a cash out flow. Because each period works constitutes different proportions of these cost categories, weights have also been applied to the model. For example, earthworks usually executed by sub-contractors, have a different cash profile from concrete works where greater amounts of materials and labour are used. Weights of cost categories explain the non-linearity of cash curves depicted diagrammatically in figure 1, earlier in this section, (Park, 2004).

Using weights in constructing cash flows has been pursued by other researchers to incorporate risk factors during construction phase (Ock and Park, 2016), (Park, Han and

Russell, 2005). When risk factors that affect a project arise, i.e., change of plans, bad weather conditions, delays, etc., weights on cost categories alter to deliver the equivalent variations in future cash flow creating a dynamic system (the system is called moving weights), (Kenley, 1999). This method primarily aims to predict cash flow for construction projects using simple and fast methods, fulfilling the need of many companies in the bidding phase (Kaka, 1996).

2.2.6. The Cost-Schedule Integration method

The previous two methods described, besides aiming at an accurate cash flow prediction, they have been constructed to avoid time-consuming practices. S-curve theory models utilize data from similar previous projects, where using simple regression modelling may forecast cash flows for current projects. Similarly, grouping costs into categories according to their cash profile is utilized by simple models that can predict cash flows and even incorporate risk factors that impact results. The calculation of cash flow for a contract is usually a procedure that involves a complex pattern of linking resources with contract amounts, periods, measurement, and retentions that demand a lot of manhours (Kaka, 1990). Field engineers are discouraged from using such methods due to the manual work demanded time unavailability, or even lack of knowledge (Navon, 1995). One very detailed effort to produce a cash flow forecast was developed by Sears, (1981) who developed a Cost-Schedule Integration (CSI) model, that generated cash flow as a function of work schedule, however including a lot of manual integration between resources (costs) and scheduled activities. Navon, (1995), tried to solve this “compatibility problem” by constructing a computer software program allowing only minimal intervention.

2.3. Empirical review

Ock and Park, (2016) have developed a model (the simpler method) to facilitate decision-making in the pre-construction stage, by considering the criticalness of time-lags in cost categories. They constructed an algorithm, including all the factors needed in the cash flow cycle of the project (advance payment, work measurement, earned value, retentions, etc.), producing a cash flow forecast. They suggested that time lags are a critical variable of cash since they can highly impact on the results and accuracy of the model. However, this model accepts cost categories as different cost profile items but leaves the “inconvenient procedure” of linking budget items to schedule and then to cost profile categories. Such a process is described as incumbent and demanding considerable working hours, in a lot of cash flow forecasting attempts (Kaka, 1990; Navon, 1995), thus promoting companies to look for other forecasting methods.

As mentioned in previous section, Navon, (1995) developed a computer software model that facilitated automatic cash flow forecasting. (the CSI model). The users had to input a lot of detailed information such as the cost items of Bill of Quantities (BOQ) and the different project activities that form the budget, all in a specific coding system. Activities and BOQ items were linked to specific resources (for example labour, materials, and equipment), thus when a cost item was used, resources consumed produced the applicable cost. For example, when the activity: "slab and beam formwork erection" was executed, the software was programed to link with the cost items "15 cm slabs", which were associated with resources: labour, ready-mixed concrete, formwork, and equipment concrete pump). In the next step BOQ items, depending on their coding system, were allocated a date, and positioned in the work schedule, which facilitated the next step of cash flow calculation. This last step was fully automatic since the users had already input time lags, project calendars, payment terms, etc.

Such a detailed system requires elaborate software that will assist contractors in managing project costs and cash flow even with very large projects. However, it is highly unlikely that construction companies in Greece with 98% of them employing less than 10 employees – in the EU less than 94.1% - (F.E.I.R., 2019), will aim at hiring labour with such specialized knowledge to assist in cash flow forecasting activities. It is more likely for larger companies in Greece and around the world to be willing to invest in such intelligent software that will undertake complex calculations and assist engineers and financiers with information mostly useful in decision-making. Additionally, having in mind the complexity of construction projects and the various methods applied when constructing a project (precast works, bridges, buildings, road networks, electromechanical works, etc.) it is highly unlikely that investment in such ait is likely that only very expensive software will be capable of delivering value to the company. The author does not suggest that large or small companies should not invest in high-tech software, in contrast, this is what companies should do in order to grow, execute higher quality projects, hire more qualified scientists that will further boost the level of project execution, invest and develop new software and so on. On the other hand, since the statistics show that a very large sum of construction companies employ a low number of people, this carries a lower probability to invest in software. This paper, by introducing a model that calculates projects' cash flow forecasting, is trying to motivate companies and employees to use cash flow software which is very essential in decision making in both tender and construction stage, even from a low-profile software built-in Microsoft Excel. By employing academic literature highly flexible software such as Microsoft Excel may offer a very good level of report functionality that will assist decision-making for both small or large-sized companies.

2.4. Literature review conclusions

There has been a significant amount of study undertaken in the field of project cash flow forecasting, with researchers being intrigued by the very special characteristics the construction industry bears institutionally (high bankruptcy rate, low entry barriers, etc.). Researchers pursued different paths and implemented different disciplines when developing models, from complex mathematical functions to regression statistics and to simpler cost accounting methods. This paper is not trying to investigate which method has been proven to better predict project cash flow, but it is attempting to find a model that will better suit the highly fragmented construction sector in Greece, which has taken a huge setback at the beginning of the last decade. Complex math and statistical models do not suit small-sized construction companies in Greece, which do not afford to maintain specialized departments solely to assist forecasting. Additionally, the current situation in Greece where government policy failed to sustain the supply of projects, increased competition of projects and shrunk both company revenue and profits, has raised a question on how certain factors such as contract payments can affect cash flow. A lot of research has been undertaken to identify the risk factors that affect cash flow, for example, changes in the initial design, production target slippage, inclement weather, and inadequate budgetary control, however, it will be beneficial to observe the severity of certain factors and whether their impact is similar in projects carrying different characteristics.

CHAPTER 3: SCOPE OF RESEARCH

3.1. Scope of research

The scope of this research is undertaken in a construction company that mainly works as a subcontractor in large public infrastructure projects. The company belongs to a manufacturing firm that specialises in the making of precast cement products for clients operating in infrastructure, buildings, and large drainage projects. In the early 2000s the parent manufacturing company operating for at least fifteen years as a significant "ring" in the supply chain of large construction projects, executed a verticalization strategy intending to gain share in a largely decreasing – as was later unveiled – construction market. The construction company's creation although it coincided with the post-Olympics era in Greece and the subsequent financial crisis which caused a significant setback on the market, has resulted in the adoption and execution of significant small-scale projects that were part of larger infrastructure programs undertaken with state and EU funding. Some significant projects were:

- more than 100 small precast pre-secondary school units built in smaller rural areas in Greece,

- precast buildings constructed in isolated rural areas as part of large highways projects (police station, WC, toll office buildings in highways),
- precast buildings stationing electromechanical equipment located in far isolated energy projects.

Because of the parent's company specialization, the projects are undertaken usually involved precast construction work, which made up usually 30% to 40% of the total works of the project (when buildings were the main part of projects). The other project activities such as earthworks, roof, insulation, and electromechanical works were usually subcontracted, apart from some expensive electromechanical materials and the procurement of cement which were acquired by the company. Labour was used in the making of foundation, painting, and surveying which was performed by the company's engineers. This type of construction project has two significant characteristics that are worth mentioning since it has an impact on the cash flow analysis that we will analyse: a) significant amount of works is subcontracted and b) small duration of projects.

The company favors the approach of subcontracting the greatest part of the works, which usually account for up to 60% to 70% of the total cost, as it reduces management costs related to labor-hiring and also relieves the company the burden of financing skilled and specialized activities (Navon, 1995; Kenley, 2005, p. 256). In addition, projects that involve precast works in a manufacturing company, usually have a smaller duration than conventional projects, since the procedure of manufacturing, transporting, and installing precast products is not as lengthy as the conventional methods of building. Conventional building methods that are performed in the project field, are characterized by unpredictable weather conditions, less capital employed, require increased labour which conclude in increased project duration. Increased duration can lead to higher costs acquired and longer retention date releases since employers issue the defects liability certificate at the completion date.

3.2. Objectives and research questions

In this paper the author is researching the field of project cash flow forecasting and how to employ academic literature to **produce a simple cash flow forecasting model** built in Microsoft Excel, which can be used by engineers and financiers working in construction companies. The techniques used are not highly sophisticated with complex financial mathematics, but rather require entry-level of finance that employees in projects encounter quite often. The **reliability of the forecast will be tested** by comparing cash flow forecast from projects budget data and post-execution with actual data being fed into the model.

Finally, besides building a model, producing and validating its results, it is very essential to stretch the **impact that some factors have on cash flow relative to others**. A sensitivity analysis will be conducted following the results of the test, in an attempt to discriminate the factors that impact more than others in the model, thus conveying a greater dependency. The analysis will be extended to the sensitivity certain project factors, such as contract payments and credit policy, have on net present value as a measure of project selection, which may cause certain strategy changes i.e., a decrease/increase of subcontracting works to third parties, verticalization, change of credit, etc.

To summarize this paper will try to study the following three research questions:

a) employ the relevant academic literature to produce a model with the application of cost profile categories, time lags, cost weights and automatically produce cash flow forecast,

b) validate the results of the model with actual data of projects executed,

c) conduct a sensitivity analysis for factors that affect results presented and how a project's net present value may be affected by payment terms that often arise in projects.

CHAPTER 4: RESEARCH METHOD – MODEL DESCRIPTION

To challenge the research questions stated above, we will go through the steps of the model to comprehend how to employ the project data and deliver the cash flow forecast.

4.1. Step 1 – Budget and Schedule data

In **Step 1** (picture 4.1) we have a table of the project budget cost split into different activities, along with dates of the beginning and end of each of the activities. These are the most common project data that engineers use to assist them in different cost and project management reports. The level of analysis of activities depends on how much depth we demand for our model. Budget data can be several pages long with specific materials and activities being described in detail. However, the author has made effort to simplify this long list of project articles into general categories, called activities, since they put an extra burden in the model, deal with a lot of data, but have a decreased marginal result in comprehension.

Start Here **Step 1**

Purpose The purpose of this workbook is
to demonstrate one method for allocating project resources to time intervals to produce a cash flow model
Allocating resources to cost categories
Applying time lags to cost categories and project income
Calculating cash flow in/out and net cash flow of project

Settings	**Allocation table start date**		23/3/2021
	No of activities	**10**	
	No of periods	**16**	

Activity code	Activity name	Cost	Alloc Start	Alloc End	Cum sum	Diff column
1	Earthworks	30.000,00	23/3/2021	13/4/2021	30.000,00	510.000,00
2	Foundation	80.000,00	13/4/2021	7/5/2021	110.000,00	430.000,00
3	EM1	10.000,00	5/5/2021	11/5/2021	120.000,00	420.000,00
4	Precast 1	100.000,00	12/5/2021	18/5/2021	220.000,00	320.000,00
5	Floors (precast-1	50.000,00	18/5/2021	20/7/2021	270.000,00	270.000,00
6	Precast 2	100.000,00	23/5/2021	27/5/2021	370.000,00	170.000,00
7	Frames	80.000,00	27/5/2021	2/9/2021	450.000,00	90.000,00
8	EM2	40.000,00	31/5/2021	6/9/2021	490.000,00	50.000,00
9	Paintings	40.000,00	20/7/2021	24/8/2021	530.000,00	10.000,00
10	Quality controls	10.000,00	2/9/2021	9/9/2021	540.000,00	0,00
		540.000,00				

Picture 4.1 Bugdet & Schedule data

4.2. Step 2 – Cost allocation to periods

Next, once the user inputs, the activities, their assigned budget cost, beginning and ending dates we can proceed to **Step 2** "Allocation" (picture 4.2 & 4.3), where budget cost activities are automatically allocated to periods as these periods were assigned in step 1, cell named: "No of periods". The model uses monthly periods, but with a simple change in excel formulas could easily switch time periods to weeks. In this step, the model deals with the "compatibility problem", i.e. the attempt to link budget resources with schedule dates, that Navon (1995) tried to solve with computer software. An excel formula automatically allocates activity costs to periods based on the assumption that each working day's works proceed equally. Of course, this is not always the case since there are certain activities that cost is not carried equally through the working days, for example, formwork. Building foundation is comprised largely of formwork activities that amount to a significant amount of labour time, but only when concrete, is injected as a material, cost accumulates. When such an activity spans through the date of works measurement (in our project the end of the month), we must proceed to alterations in our model since the client will demand to complete a significant amount of the activity for it to be measured. In our model cost is divided by days, and its division produces a daily amount of work value, which is subsequently allocated to periods, according to commencement and ending dates of the specific activity.

Allocation **Step 2**

Go to prev Step
Go to next Step

Purpose To allocate the amount of each item based on a daily amount and the number of dates in each column.

Allocation
Activities, cost are allocated automatically to months/periods with excel formulas

"Sequenc	"Ifserror"	"Ifserror"	"Ifserror"	"Ifserror"	"Calc"	"Calc"			0	1	2	3	4	5	6	
Activity	**Activity name**	**Cost**	**Alloc Start**	**Alloc End**	**Days**	**DailyAmt**	**Total**	**Diff**	**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/20**
1	Earthworks	30.000,00 €	23/3/2021	13/4/2021	22	1.363,64 €	30.000,00 €	0,00 €	12.272,73 €	17.727,27 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,0
2	Foundation	80.000,00 €	13/4/2021	7/5/2021	25	3.200,00 €	80.000,00 €	0,00 €	0,00 €	57.600,00 €	22.400,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,0
3	EM1	10.000,00 €	5/5/2021	11/5/2021	7	1.428,57 €	10.000,00 €	0,00 €	0,00 €	0,00 €	10.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,0
4	Precast 1	100.000,00 €	12/5/2021	18/5/2021	7	14.285,71 €	100.000,00 €	0,00 €	0,00 €	0,00 €	100.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,0
5	Floors (precast-	50.000,00 €	18/5/2021	20/7/2021	64	781,25 €	50.000,00 €	0,00 €	0,00 €	0,00 €	10.937,50 €	23.437,50 €	15.625,00 €	0,00 €	0,00 €	0,0
6	Precast 2	100.000,00 €	23/5/2021	30/6/2021	39	2.564,10 €	100.000,00 €	0,00 €	0,00 €	0,00 €	23.076,92 €	76.923,08 €	0,00 €	0,00 €	0,00 €	0,0
7	Frames	80.000,00 €	27/5/2021	2/9/2021	99	808,08 €	80.000,00 €	0,00 €	0,00 €	0,00 €	4.040,40 €	24.242,42 €	25.050,51 €	25.050,51 €	1.616,16 €	0,0
8	EM2	40.000,00 €	31/5/2021	6/9/2021	99	404,04 €	40.000,00 €	0,00 €	0,00 €	0,00 €	404,04 €	12.121,21 €	12.525,25 €	12.525,25 €	2.424,24 €	0,0
9	Paintings	40.000,00 €	20/7/2021	24/8/2021	36	1.111,11 €	40.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	13.333,33 €	26.666,67 €	0,00 €	0,0
10	Quality controls	10.000,00 €	2/9/2021	9/9/2021	8	1.250,00 €	10.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	10.000,00 €	0,0

Picture 4.2

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
31/3/2021	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**	**31/12/2021**	**31/1/2022**	**28/2/2022**	**31/3/2022**	**30/4/2022**	**31/5/2022**	**30/6/2022**
12.272,73 €	17.727,27 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	57.600,00 €	22.400,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	10.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	100.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	10.937,50 €	23.437,50 €	15.625,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	23.076,92 €	76.923,08 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	4.040,40 €	24.242,42 €	25.050,51 €	25.050,51 €	1.616,16 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	404,04 €	12.121,21 €	12.525,25 €	12.525,25 €	2.424,24 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	0,00 €	0,00 €	13.333,33 €	26.666,67 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	10.000,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €

Picture 4.3

4.3. Step 3 – Cost categories

In this stage, the user must decide and characterise how to categorise activity costs according to their cash profile. Based on the academic literature already presented, we use three different cash profiles: Labour, Materials, and Subcontractors (picture 4.4), which the company considers when implementing its payment policy. The user allocates a percentage to each activity's cost according to their weight in this category, for example, foundation works are comprised of 20% labour, 40% material and 40% subcontractors. According to such classification, the model produces cost categories' values for every activity, for example, foundation work include 16.000,00€ of labour cost, 32.000,00€ for materials, and 32.000,00€ for subcontractors.

	A	B	C	D	E	F	G	H
1	**Cost Categories**			**Step 3**				
2	Go to prev Step							
3	Go to next Step							
4								
5	**Purpose**							
6		Period allocated cost is further distributed to categories according to their "cash profile"						
7		Cost categories	3					
8	90	Labour						
9	91	Materials						
10	92	Subcontractors						
11								
12								
13		"Ifserror"	"Ifserror"	90	91	92		
14	**Activity**	**Activity name**	**Cost**	**Labour**	**Materials**	**Subcontractors**		**Sum**
15	1	Earthworks	30.000,00 €	0%	10%	90%		100,00%
16	2	Foundation	80.000,00 €	20%	40%	40%		100,00%
17	3	EM1	10.000,00 €	0%	70%	30%		100,00%
18	4	Precast 1	100.000,00 €	0%	20%	80%		100,00%
19	5	Floors (precast-ti	50.000,00 €	0%	20%	80%		100,00%
20	6	Precast 2	100.000,00 €	0%	20%	80%		100,00%
21	7	Frames	80.000,00 €	0%	60%	40%		100,00%
22	8	EM2	40.000,00 €	0%	0%	100%		100,00%
23	9	Paintings	40.000,00 €	0%	40%	60%		100,00%
24	10	Quality controls	10.000,00 €	100%	0%	0%		100,00%
25								
26								
27	**Table ...**	**Cost Categories**						
28	**Activity**	**Activity name**	**Cost**	**Labour**	**Materials**	**Subcontractors**		**Sum**
29	1	Earthworks	30.000,00 €	0,00	3.000,00	27.000,00		30.000,00
30	2	Foundation	80.000,00 €	16.000,00	32.000,00	32.000,00		80.000,00
31	3	EM1	10.000,00 €	0,00	7.000,00	3.000,00		10.000,00
32	4	Precast 1	100.000,00 €	0,00	20.000,00	80.000,00		100.000,00
33	5	Floors (precast-ti	50.000,00 €	0,00	10.000,00	40.000,00		50.000,00
34	6	Precast 2	100.000,00 €	0,00	20.000,00	80.000,00		100.000,00
35	7	Frames	80.000,00 €	0,00	48.000,00	32.000,00		80.000,00
36	8	EM2	40.000,00 €	0,00	0,00	40.000,00		40.000,00
37	9	Paintings	40.000,00 €	0,00	16.000,00	24.000,00		40.000,00
38	10	Quality controls	10.000,00 €	10.000,00	0,00	0,00		10.000,00
39								
40				26.000,00	156.000,00	358.000,00	0,00	540.000,00
41								
42								
43								

Picture 4.4

4.4. Step 4 – Allocating cost categories to periods

The model has so far allocated cost to periods and assigned values to cost categories. In Step 4 the user allocates this assigned cost to periods. With simple excel formulas, the model calculates what type of cost will the project bear through its duration. For example, labour will only be needed in three periods: 2,3, and 7 (period 0 is the first period, so period 1 in cell E21 represents 2nd period), only for activities: foundation and quality controls. Materials amount for 156.000€ and subcontractors for 358.000€ which accounts for the largest cost of category. The cost allocation in this step uses the same dates of commencement and ending of activities that were input in Step 1.

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Cost of Period**			**Step 4**								
2	Go to prev Step											
3	Go to next Step											
4												
5	Purpose											
6		Allocate cost categories amount to periods										
20												
21				0	1	2	3	4	5	6	7	8
22				**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**
23	**1**	**Earthworks**	30.000,00	12.272,73	17.727,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00
24	**2**	**Foundation**	80.000,00	0,00	57.600,00	22.400,00	0,00	0,00	0,00	0,00	0,00	0,00
25	**3**	**EM1**	10.000,00	0,00	0,00	10.000,00	0,00	0,00	0,00	0,00	0,00	0,00
26	**4**	**Precast 1**	100.000,00	0,00	0,00	100.000,00	0,00	0,00	0,00	0,00	0,00	0,00
27	**5**	**Floors (preca**	50.000,00	0,00	0,00	10.937,50	23.437,50	15.625,00	0,00	0,00	0,00	0,00
28	**6**	**Precast 2**	100.000,00	0,00	0,00	23.076,92	76.923,08	0,00	0,00	0,00	0,00	0,00
29	**7**	**Frames**	80.000,00	0,00	0,00	4.040,40	24.242,42	25.050,51	25.050,51	1.616,16	0,00	0,00
30	**8**	**EM2**	40.000,00	0,00	0,00	404,04	12.121,21	12.525,25	12.525,25	2.424,24	0,00	0,00
31	**9**	**Paintings**	40.000,00	0,00	0,00	0,00	0,00	13.333,33	26.666,67	0,00	0,00	0,00
32	**10**	**Quality contr**	10.000,00	0,00	0,00	0,00	0,00	0,00	0,00	10.000,00	0,00	0,00
33												
34												
35	Sum		540.000,00	12.272,73	75.327,27	170.858,87	136.724,21	66.534,09	64.242,42	14.040,40	0,00	0,00
36	**90**											
37				**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**
38	**1**	Earthworks	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
39	**2**	Foundation	16.000,00	0,00	11.520,00	4.480,00	0,00	0,00	0,00	0,00	0,00	0,00
40	**3**	EM1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
41	**4**	Precast 1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
42	**5**	Floors (precas	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
43	**6**	Precast 2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
44	**7**	Frames	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
45	**8**	EM2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
46	**9**	Paintings	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
47	**10**	Quality contr	10.000,00	0,00	0,00	0,00	0,00	0,00	0,00	10.000,00	0,00	0,00
48												
49	**Labour**	26.000,00		0,00	11.520,00	4.480,00	0,00	0,00	0,00	10.000,00	0,00	0,00
50												
51												
52	**91**											
53				**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**
54	**1**	Earthworks	3.000,00	1.227,27	1.772,73	0,00	0,00	0,00	0,00	0,00	0,00	0,00
55	**2**	Foundation	32.000,00	0,00	23.040,00	8.960,00	0,00	0,00	0,00	0,00	0,00	0,00
56	**3**	EM1	7.000,00	0,00	0,00	7.000,00	0,00	0,00	0,00	0,00	0,00	0,00
57	**4**	Precast 1	20.000,00	0,00	0,00	20.000,00	0,00	0,00	0,00	0,00	0,00	0,00
58	**5**	Floors (precas	10.000,00	0,00	0,00	2.187,50	4.687,50	3.125,00	0,00	0,00	0,00	0,00
59	**6**	Precast 2	20.000,00	0,00	0,00	4.615,38	15.384,62	0,00	0,00	0,00	0,00	0,00
60	**7**	Frames	48.000,00	0,00	0,00	2.424,24	14.545,45	15.030,30	15.030,30	969,70	0,00	0,00
61	**8**	EM2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
62	**9**	Paintings	16.000,00	0,00	0,00	0,00	0,00	5.333,33	10.666,67	0,00	0,00	0,00
63	**10**	Quality contr	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
64												
65												
66	**Materials**	156.000,00		1.227,27	24.812,73	45.187,13	34.617,57	23.488,64	25.696,97	969,70	0,00	0,00
67	**92**											
68				**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**
69	**1**	Earthworks	27.000,00	11.045,45	15.954,55	0,00	0,00	0,00	0,00	0,00	0,00	0,00
70	**2**	Foundation	32.000,00	0,00	23.040,00	8.960,00	0,00	0,00	0,00	0,00	0,00	0,00
71	**3**	EM1	3.000,00	0,00	0,00	3.000,00	0,00	0,00	0,00	0,00	0,00	0,00
72	**4**	Precast 1	80.000,00	0,00	0,00	80.000,00	0,00	0,00	0,00	0,00	0,00	0,00
73	**5**	Floors (precas	40.000,00	0,00	0,00	8.750,00	18.750,00	12.500,00	0,00	0,00	0,00	0,00
74	**6**	Precast 2	80.000,00	0,00	0,00	18.461,54	61.538,46	0,00	0,00	0,00	0,00	0,00
75	**7**	Frames	32.000,00	0,00	0,00	1.616,16	9.696,97	10.020,20	10.020,20	646,46	0,00	0,00
76	**8**	EM2	40.000,00	0,00	0,00	404,04	12.121,21	12.525,25	12.525,25	2.424,24	0,00	0,00
77	**9**	Paintings	24.000,00	0,00	0,00	0,00	0,00	8.000,00	16.000,00	0,00	0,00	0,00
78	**10**	Quality contr	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
79												
80												
81	**Subcontract**	358.000,00		11.045,45	38.994,55	121.191,74	102.106,64	43.045,45	38.545,45	3.070,71	0,00	0,00
82												
83			0,00	12.272,73	75.327,27	170.858,87	136.724,21	66.534,09	64.242,42	14.040,40	0,00	0,00
84		0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Start Here | Allocation | Cost Categories | Materials | **Cost of Period**

Picture 4.5

4.5. Step 5 – Cash flow out

With cost allocated to periods according to cost categories, the user has the information needed to apply company's credit policy and calculate the cash flow out curve. The company has agreed to apply four months of credit to suppliers of materials, while subcontractors are paid in the second period after cost is certified and labourers are paid in the same month labour is performed (picture 4.6).

	A	B	C	D	E	F	G	H
1	**Cash flow out**			**Step 5**				
2	Go to prev Step							
3	Go to next Step							
4								
5	Purpose							
6		Input time lags and retention and calculate cash flow out						
7								
8					90	91	92	
9		Payments (Cash out)			Labour	Materials	Subcontractors	
10		Cost categories	Time lag		0	0,1	0,9	
11		Labour	0		0,2	0,4	0,4	
12		Materials	4		0	0,7	0,3	
13		Subcontractors	2		0	0,2	0,8	
14					0	0,2	0,8	
15					0	0,2	0,8	
16					0	0,6	0,4	
17					0	0	1	
18					0	0,4	0,6	

Picture 4.6

The user simply inputs the payment policy described and excel formulas "move" cost categories' values to the appropriate periods that payment is scheduled to fulfill. Foundation materials bought in the second period valued at 23.040,00€ (picture 4.5), are applied a time lag of four (4) months (picture 4.6) and are paid in the sixth period (picture 4.7). Excel formulas contribute to the automatic fill-out of the appropriate periods, according to the time lag input, which offers a sense of power to the program. Users can "play" with the time lags and manipulate cash flow results as we will realise in the next steps.

	A	B	C	D	E	F	G	H	I	J	K	L	M
21			31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/2021	31/12/2021	31/1/2022
22		**Cumulative cash out**	**0,00**	**11.520,00**	**27.045,45**	**66.040,00**	**188.459,01**	**315.378,38**	**413.610,97**	**486.773,99**	**513.333,33**	**539.030,30**	**540.000,00**
23													
24	90		0	1	2	3	4	5	6	7	8	9	10
25			31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/2021	31/12/2021	31/1/2022
26	1	Earthworks	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
27	2	Foundation	0,00	11.520,00	4.480,00	0,00	0,00	0,00	0,00	0,00	0,00		
28	3	EM1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
29	4	Precast 1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
30	5	Floors (precas	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
31	6	Precast 2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
32	7	Frames	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
33	8	EM2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
34	9	Paintings	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
35	10	Quality contro	0,00	0,00	0,00	0,00	0,00	0,00	10.000,00	0,00	0,00		
36													
37	**Labour**	26.000,00	0,00	11.520,00	4.480,00	0,00	0,00	0,00	10.000,00	0,00	0,00	0,00	0,00
38													
39													
40	91												
41			31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/2021	31/12/2021	31/1/2022
42	1	Earthworks					1.227,27	1.772,73	0,00	0,00	0,00	0,00	0,00
43	2	Foundation					0,00	23.040,00	8.960,00	0,00	0,00	0,00	0,00
44	3	EM1					0,00	0,00	7.000,00	0,00	0,00	0,00	0,00
45	4	Precast 1					0,00	0,00	20.000,00	0,00	0,00	0,00	0,00
46	5	Floors (precas					0,00	0,00	2.187,50	4.687,50	3.125,00	0,00	0,00
47	6	Precast 2					0,00	0,00	4.615,38	15.384,62	0,00	0,00	0,00
48	7	Frames					0,00	0,00	2.424,24	14.545,45	15.030,30	15.030,30	969,70
49	8	EM2					0,00	0,00	0,00	0,00	0,00	0,00	0,00
50	9	Paintings					0,00	0,00	0,00	0,00	5.333,33	10.666,67	0,00
51	10	Quality contro					0,00	0,00	0,00	0,00	0,00	0,00	0,00
52													
53	**Materials**	156.000,00	0,00	0,00	0,00	0,00	1.227,27	24.812,73	45.187,13	34.617,57	23.488,64	25.696,97	969,70
54													
55													
56	92												
57			31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/2021	31/12/2021	31/1/2022
58	1	Earthworks			11.045,45	15.954,55	0,00	0,00	0,00	0,00	0,00	0,00	0,00
59	2	Foundation			0,00	23.040,00	8.960,00	0,00	0,00	0,00	0,00	0,00	0,00
60	3	EM1			0,00	0,00	3.000,00	0,00	0,00	0,00	0,00	0,00	0,00
61	4	Precast 1			0,00	0,00	80.000,00	0,00	0,00	0,00	0,00	0,00	0,00
62	5	Floors (precas			0,00	0,00	8.750,00	18.750,00	12.500,00	0,00	0,00	0,00	0,00
63	6	Precast 2			0,00	0,00	18.461,54	61.538,46	0,00	0,00	0,00	0,00	0,00
64	7	Frames			0,00	0,00	1.616,16	9.696,97	10.020,20	10.020,20	646,46	0,00	0,00
65	8	EM2			0,00	0,00	404,04	12.121,21	12.525,25	12.525,25	2.424,24	0,00	0,00
66	9	Paintings			0,00	0,00	0,00	0,00	8.000,00	16.000,00	0,00	0,00	0,00
67	10	Quality contro			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
68													
69													
70	**Subcontracto**	358.000,00	0,00	0,00	11.045,45	38.994,55	121.191,74	102.106,64	43.045,45	38.545,45	3.070,71	0,00	0,00
71													
72			31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/2021	31/12/2021	31/1/2022
73	**Cumulative cash out**		0,00	11.520,00	27.045,45	66.040,00	188.459,01	315.378,38	413.610,97	486.773,99	513.333,33	539.030,30	540.000,00
74													

... Allocation | Cost Categories | Materials | Cost of Period | Cum Cost | **Cash out** | Value of works

Picture 4.7

Overall, cash profile categories of labour, materials, and subcontractors have led to the construction of the actual cumulative cash curve, shown in chart 4.1, which as stated in the academic literature in previous chapters, resembles an S-curve shape.

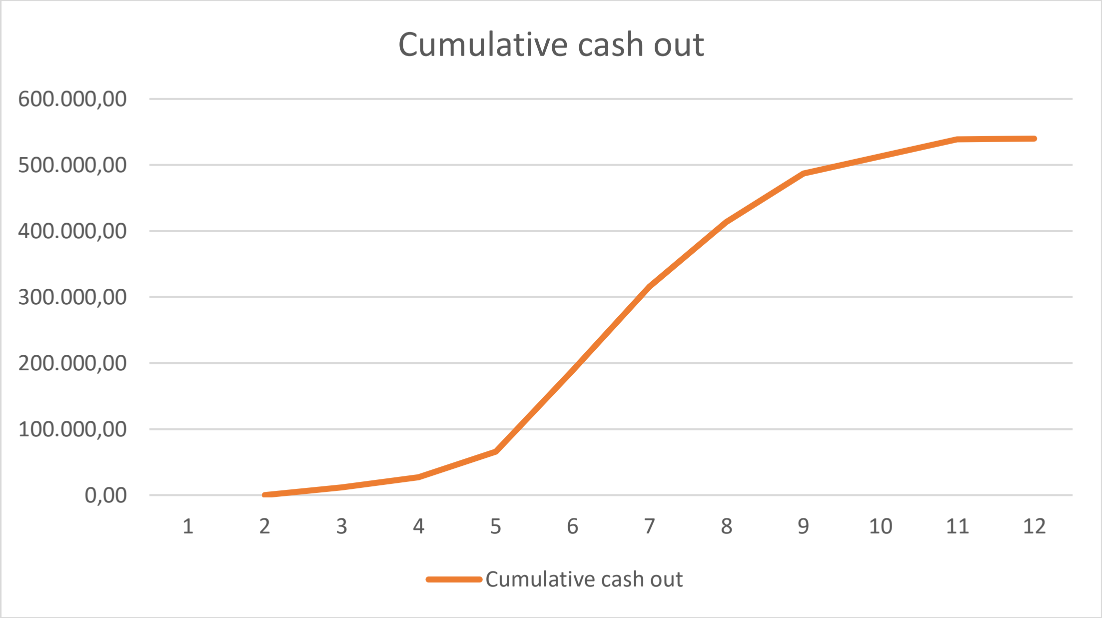

Chart 4.1 Cumulative cash out curve

4.6. Step 6 – Cash flow in

The construction of the cash out model is the key to complete cash flow forecasting and this has been accomplished with the assistance of time lags and cost, (Park, 2004). Since completing cash flow out in step 5, we can proceed to step 6 and build the cash flow in curve which is relatively a more straightforward process.

The contract value is offered to the contractors from the date projects are available for bidding. Since the cost budget has been built in previous steps, the user must only apply the markup price to the cost to obtain contract value. In the model the actual activity values (AV) are calculated by multiplying cost (AC) with markup (M) percentage:

AV = AC * M (%)

As shown in picture 4.8 after calculating activities values using markup, they are allocated to their periods of completion, which is the schedule period from step 1. The model assumes that whatever cost is applied in one period, is valued to the client at the same period too, which might not always be the case. For example, materials are often ordered and delivered to the project, but cannot be directly installed due to other works due. The cost of these materials has already been applied to the project but cannot be valued to the client.

In picture 4.8 invoiced work values are calculated, applied a time lag (Table 4.2) which produce cash in of invoiced work.

Receivables - Cash in	
Advance payment	10%
Retention	10%
Retention repaid	30/6/2022
Time lag cash in	3

Table 4.2

Cash flow in, however, as we have described in chapter 2, is not comprised solely by the monthly payment receipts to the contractor, but also includes advance payment, advance payment releases, good performance retention, and retention release. Of course, other contract payment terms may also affect cash flow in, but the author has focused on the most typical that are usually found in most contracts. Advance payment is 10% of the project value, while advance payment retention is calculated as in formula (2) in ch.2.

$$RAP = \frac{MV}{CV} \; x \; AV$$

21						0	1	2	3	4	5	6	7	8
22	Activity	Activity name	Cost	Markup	Value	31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021	30/11/202
23	1	Earthworks	30.000,00	5,00%	31.500,00	12.886,36	18.613,64	0,00	0,00	0,00	0,00	0,00	0,00	0,0
24	2	Foundation	80.000,00	7,00%	85.600,00	0,00	61.632,00	23.968,00	0,00	0,00	0,00	0,00	0,00	0,0
25	3	EM1	10.000,00	3,00%	10.300,00	0,00	0,00	10.300,00	0,00	0,00	0,00	0,00	0,00	0,0
26	4	Precast 1	100.000,00	5,00%	105.000,00	0,00	0,00	105.000,00	0,00	0,00	0,00	0,00	0,00	0,0
27	5	Floors (precast-tiles-plumbing)	50.000,00	3,00%	51.500,00	0,00	0,00	11.265,63	24.140,63	16.093,75	0,00	0,00	0,00	0,0
28	6	Precast 2	100.000,00	3,00%	103.000,00	0,00	0,00	23.769,23	79.230,77	0,00	0,00	0,00	0,00	0,0
29	7	Frames	80.000,00	8,00%	86.400,00	0,00	0,00	4.363,64	26.181,82	27.054,55	27.054,55	1.745,45	0,00	0,0
30	8	EM2	40.000,00	9,00%	43.600,00	0,00	0,00	440,40	13.212,12	13.652,53	13.652,53	2.642,42	0,00	0,0
31	9	Paintings	40.000,00	10,00%	44.000,00	0,00	0,00	0,00	0,00	14.666,67	29.333,33	0,00	0,00	0,0
32	10	Quality controls	10.000,00	20,00%	12.000,00	0,00	0,00	0,00	0,00	0,00	0,00	12.000,00	0,00	0,0
33														
34	a	**Invoiced work progress**			**572.900,00**	**12.886,36**	**80.245,64**	**179.106,90**	**142.765,33**	**71.467,49**	**70.040,40**	**16.387,88**	**0,00**	**0,0**
35														
37	e	**Cash in of invoiced works(time lag)**							12.886,36	80.245,64	179.106,90	142.765,33	71.467,49	70.040,4
38	b	**Advance payment retention**	**10%**						-1.288,64	-8.024,56	-17.910,69	-14.276,53	-7.146,75	-7.004,0
39	c	**Retention**	**10%**						-1.288,64	-8.024,56	-17.910,69	-14.276,53	-7.146,75	-7.004,0
40	g	**Advance payment**	**10%**		57.290,00	57.290,00								
41	f	**Retention repaid**	**30/6/2022**		57.290,00									
42														
43	**h**	**Final monthly cash flow in**				**57.290,00**	**0,00**	**0,00**	**10.309,09**	**64.196,51**	**143.285,52**	**114.212,27**	**57.173,99**	**56.032,3**
44						**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/202**
45	i	**Cumulative monthly cash flows in**				57.290,00	57.290,00	57.290,00	67.599,09	131.795,60	275.081,12	389.293,38	446.467,37	502.499,7
46														
47														

Picture 4.8 – Cash flow in

Formula 2 is reassuring the contractor that advance payment will be reimbursed with steady payments during the whole project duration, as opposed to calculation with two or three lump-sum payments. Retention money is retained with similar calculation to advance reimbursements i.e., steady payments to the client as a percentage of the invoiced works. The contract usually describes the retention release date which in our example occurs, picture 4.9, sixteen periods after project commencement.

						12	13	14	15
22	Activity	Activity name	Cost	Markup	Value	31/3/2022	30/4/2022	31/5/2022	30/6/2022
23	1	Earthworks	30.000,00	5,00%	31.500,00	0,00	0,00	0,00	0,00
24	2	Foundation	80.000,00	7,00%	85.600,00	0,00	0,00	0,00	0,00
25	3	EM1	10.000,00	3,00%	10.300,00	0,00	0,00	0,00	0,00
26	4	Precast 1	100.000,00	5,00%	105.000,00	0,00	0,00	0,00	0,00
27	5	Floors (precast-tiles-plumbing)	50.000,00	3,00%	51.500,00	0,00	0,00	0,00	0,00
28	6	Precast 2	100.000,00	3,00%	103.000,00	0,00	0,00	0,00	0,00
29	7	Frames	80.000,00	8,00%	86.400,00	0,00	0,00	0,00	0,00
30	8	EM2	40.000,00	9,00%	43.600,00	0,00	0,00	0,00	0,00
31	9	Paintings	40.000,00	10,00%	44.000,00	0,00	0,00	0,00	0,00
32	10	Quality controls	10.000,00	20,00%	12.000,00	0,00	0,00	0,00	0,00
33									
34	a	**Invoiced work progress**			**572.900,00**	**0,00**	**0,00**	**0,00**	**0,00**
35									
37	e	**Cash in of invoiced works(time lag)**				0,00	0,00	0,00	0,00
38	b	**Advance payment retention**	**10%**						
39	c	**Retention**	**10%**						
40	g	**Advance payment**	**10%**		57.290,00				
41	f	**Retention repaid**	**30/6/2022**		57.290,00				57.290,00
42									
43	h	**Final monthly cash flow in**				**0,00**	**0,00**	**0,00**	**57.290,00**
44						**31/3/2022**	**30/4/2022**	**31/5/2022**	**30/6/2022**
45	i	**Cumulative monthly cash flows in**				515.610,00	515.610,00	515.610,00	572.900,00
46									
47									

Picture 4.9 – Retention released

4.7. Step 7 – Cash flow forecasting

The product of all the calculations of steps 1 – 6 is demonstrated in picture 4.10, as the final cash flow report. Cash flow in is transferred from the previous step in the first rows of the table and cash flow out is displayed few lines underneath. Net cash flow is calculated at the bottom of the table, showing the periods that cash flow is negative or positive. Net present value of each period's cash flow is calculated as the product of net cash flow multiplied by $(1+\varepsilon\rho)^t$, where $\varepsilon\rho$ is the period's real interest rate and t is period. Cumulative net cash flow is calculated at the bottom of the table revealing the period or periods that net cash flow turns negative or positive.

				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
20		**Periods**		**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**	**31/12/2021**	**31/1/2022**	**28/2/2022**	**31/3/2022**	**30/4/2022**	**31/5/2022**	**30/6/2022**
21		**Cash flow in**		**57.290,00**	**0,00**	**0,00**	**10.309,09**	**64.196,51**	**143.285,52**	**114.212,27**	**57.173,99**	**56.032,32**	**13.110,30**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**57.290,00**
22	e	Cash in of invoiced works(time l	572.900,00				12.886,36	80.245,64	179.106,90	142.765,33	71.467,49	70.040,40	16.387,88	0,00	0,00	0,00	0,00	0,00	0,00
23	b	Advance payment retention	-57.290,00				-1.288,64	-8.024,56	-17.910,69	-14.276,53	-7.146,75	-7.004,04	-1.638,79						
24	c	Retention	-57.290,00				-1.288,64	-8.024,56	-17.910,69	-14.276,53	-7.146,75	-7.004,04	-1.638,79						
25	g	Advance payment	57.290,00	57.290,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
26	f	Retention repaid	57.290,00																57.290,00
27																			
28																			
30																			
31		**Cash flow out**		**0,00**	**11.520,00**	**15.525,45**	**38.994,55**	**122.419,01**	**126.919,37**	**98.232,58**	**73.163,02**	**26.559,34**	**25.696,97**	**969,70**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
32	90	Labour	26.000,00	0,00	11.520,00	4.480,00	0,00	0,00	0,00	10.000,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
33	91	Materials	156.000,00	0,00	0,00	0,00	0,00	1.227,27	24.812,73	45.187,13	34.617,57	23.488,64	25.696,97	969,70	0,00	0,00	0,00	0,00	0,00
34	92	Subcontractors	358.000,00	0,00	0,00	11.045,45	38.994,55	121.191,74	102.106,64	43.045,45	38.545,45	3.070,71	0,00	0,00	0,00	0,00	0,00	0,00	0,00
36																			
37		**Net cash flow**		**57.290,00**	**-11.520,00**	**-15.525,45**	**-28.685,45**	**-58.222,50**	**16.366,15**	**15.979,69**	**-15.989,03**	**29.472,98**	**-12.586,67**	**-969,70**	**0,00**	**0,00**	**0,00**	**0,00**	**57.290,00**
38		**Net Present Values of CF**		**57.290,00**	**-11.472,20**	**-15.396,88**	**-28.329,85**	**-57.262,15**	**16.029,41**	**15.585,95**	**-15.530,36**	**28.508,71**	**-12.124,35**	**-930,20**	**0,00**	**0,00**	**0,00**	**0,00**	**53.825,96**
39		**Cumulative net cash flow**		**57.290,00**	**45.770,00**	**30.244,55**	**1.559,09**	-56.663,41	-40.297,27	-24.317,58	-40.306,62	-10.833,64	-23.420,30	-24.390,00	-24.390,00	-24.390,00	-24.390,00	-24.390,00	**32.900,00**
40																			
41				NPV	30.194,03														
42	εp	0,05																	
43	ρ	12																	
44	εp/ρ	0,00417																	
45																			

Picture 4.10 – Cash flow forecasting

CHAPTER 5: RESULTS

5.1. Validation of results

The research will be undertaken with data from seven construction projects which the construction company has acted as a subcontractor and were completed in the last decade. Contract values ranged from half a million euros to approximately five million, however only one project exceeded significantly over one and a half million (table 5.1).

Table 5.1

Project name	Contract Values
P1	572.900,00
P2	944.505,00
P3	5.321.850,00
P4	991.100,00
P5	1.090.000,00
P6	481.240,00
P7	1.503.110,00

The projects studied will be evaluated concerning whether their real-time cash flows deviated significantly from their forecast. A cash flow estimate has been prepared with reference to the project's budget as a continuous process. Engineers prepare an estimate before the start of the project but revaluate when various factors impact on project execution. The numerous causes that impact on the project make forecasting highly complex and uncertain (Odeyinka, Lowe and Kaka, 2008), applying additional problems to validating results. As stated by Hong-Long Chen and Chen, (2000): *"to create a successful automatic cash flow forecasting is highly difficult due to the compatibility of different factors in a project as well the dynamic process caused by deviations in the progress of a project underway…"*. Small deviations from the budget may impact highly on cash flow, since variated cost, refers to cost categories with different cash profile, thus affecting more than one cash flow periods.

Not significant deviations of actual cash flow from budget planned values may mean more than just a "good" model though. It may also reveal that risk factors, such as weather conditions, change of plans, and delays have not occurred during construction. Thus, budget data prepared before the start of the project are readjusted after period works completion, to avoid significant discrepancies caused by various risk factors occurring during construction. Indeed, this is what occurs in real life since readjusting is accepted even from clients, when significant factors arise. It will be of no significant use to compare planned building works with their respective actual values if for example, due to insulation materials supply shortage, building works are delayed six months. Before the shortage was known forecasted cash flow values would deviate significantly from actual. Readjustment of the model presented, serves also as a project management tool, to facilitate engineers to achieve works completion as closer to schedule as possible. Park, (2004) uses automatic readjustment of schedule when deviations occur, however, we will proceed manually to such alterations.

To evaluate the estimates of the model Standard Deviation (SDY) of Y estimate has been selected as a measure, (Kaka and Price, 1991), which measures the variance of actual values from the mean, (measure of dispersion).

$$SDY = \sqrt{\frac{\sum(Y-YE)^2}{N}}$$

Y is the actual value at any period

YE is the estimated value at any period

N is the number of periods

In picture 5.1 we can see the variability of the actual cash flows compared with budget data and their deviations from the mean value of each project. Although expressing the deviations in euros is not a comparable measure, however, when deviations are compared to period net cash flow, we can easily observe when forecasts have succeeded or not. For example, in project 1, period 4 we observe a deviation of 14.457,90€, (budget forecast is -47.782,72€ and the actual value is -33.324,12€), which compared to budget forecast is a 30% variation, which constitutes a significant deviation. Moreover, we observe that the mean of deviations is 5.360€ and with a variance around the mean – that is standard deviation – of 9.549,60€. In other words, the model in this project has forecasted that net cash flow will deviate by approximately 15.000,00€ at most, in each of the periods of project 1.

Project	0	Periods	0	1	2	3	4	5
Project 1	**Budget**	Budget Net cash flow	57.290,00	-3.529,16	69.465,26	112.408,75	-47.782,02	-46.360,72
Project 1_a	**Project**	Project Net cash flow	57.290,00	-3.529,16	67.577,11	107.839,01	-33.324,12	-54.144,93
	Budget - Project		0,00	0,00	1.888,16	4.569,74	14.457,90	7.784,21
	Mean	**5.360,8887**						
	Excel STDEV	**9.549,60**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 2	**Budget**	Budget Net cash flow	95.407,50	8.221,44	16.589,44	5.118,23	-1.844,04	-4.142,95
Project 2_a	**Project**	Project Net cash flow	95.407,50	7.288,52	19.231,47	7.561,47	-1.054,43	-1.792,95
	Budget - Proj		0,00	932,91	2642,03	2443,24	789,61	2350,00
	Mean (m)	**3.484,98**						
	Excel STDEV	**11.219,12**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 3	**Budget**	Budget Net cash flow	532.185,00	82.237,64	94.615,39	96.876,00	46.475,47	238.311,75
Project 3_a	**Project**	Project Net cash flow	521.692,50	81.103,50	94.981,24	92.978,43	42.541,32	231.365,41
	Budget - Proj		10492,50	1134,15	365,85	3897,56	3934,15	6946,34
	Mean (m)	**3.635,7138**						
	Excel STDEV	**5.863,3095**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 4	**Budget**	Budget Net cash flow	99.110,00	37.065,22	-2.826,63	93.472,88	28.703,68	57.775,01
Project 4_a	**Project**	Project Net cash flow	99.110,00	36.472,17	-3.038,80	94.603,02	27.796,77	59.654,83
	Budget - Proj		0,00	593,04	212,17	1130,14	906,92	1879,82
	Mean (m)	**8.794,1100**	0	0	0	0	0	0
	Excel STDEV	**23.843,8816**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 5	**Budget**	Budget Net cash flow	119.900,00	44.775,33	10.651,10	42.199,88	40.412,97	-17.524,78
Project 5_a	**Project**	Project Net cash flow	119.900,00	32.063,09	7.627,13	19.367,74	25.020,86	22.670,67
	Budget - Proj		0,00	12712,24	3023,97	22832,14	15392,11	40195,45
	Mean (m)	**9.289,5231**						
	Excel STDEV	**11.549,4842**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 6	**Budget**	Budget Net cash flow	0,00	0,00	5.905,50	12.175,15	5.077,04	-5.874,73
Project 6_a	**Project**	Project Net cash flow	0,00	0,00	5.905,50	11.921,15	5.331,04	-5.574,73
	Budget - Proj		0,00	0,00	0,00	254,00	254,00	300,00
	Mean (m)	**94,9714**						
	Excel STDEV	**242,2121**						
	0	**Periods**	**0**	**1**	**2**	**3**	**4**	**5**
Project 7	**Budget**	Budget Net cash flow	150.311,00	61.190,52	62.182,61	57.670,96	-45.175,25	-62.957,72
Project 7_1	**Project**	Project Net cash flow	150.311,00	48.639,43	57.383,40	52.929,60	-6.905,72	-93.187,93
	Budget - Project		0,00	12551,08	4799,21	4741,36	38269,53	30230,20
	Mean (m)	**9.341,5623**						
	Excel STDEV	**9.280,4641**						

Picture 5.1

In projects 2, 4, and 5 the model has calculated values with greater deviations than other projects, extending from 11.000 to 23.000 euros. Following value deviations from picture 5.1, charts 5.1 and 5.2 show schematically how actual cash flow is progressing during the project. In chart 5.1 actual values shift underneath budget value (planned) in period 6 and then overlap the budget in the next two periods. Decreased net cash flow in period 6 may have been produced by unpredicted delays in previous period works, which triggered a change in period's 6 cash flow, which the contractor tried to match by increasing the speed of works in the periods following the delay.

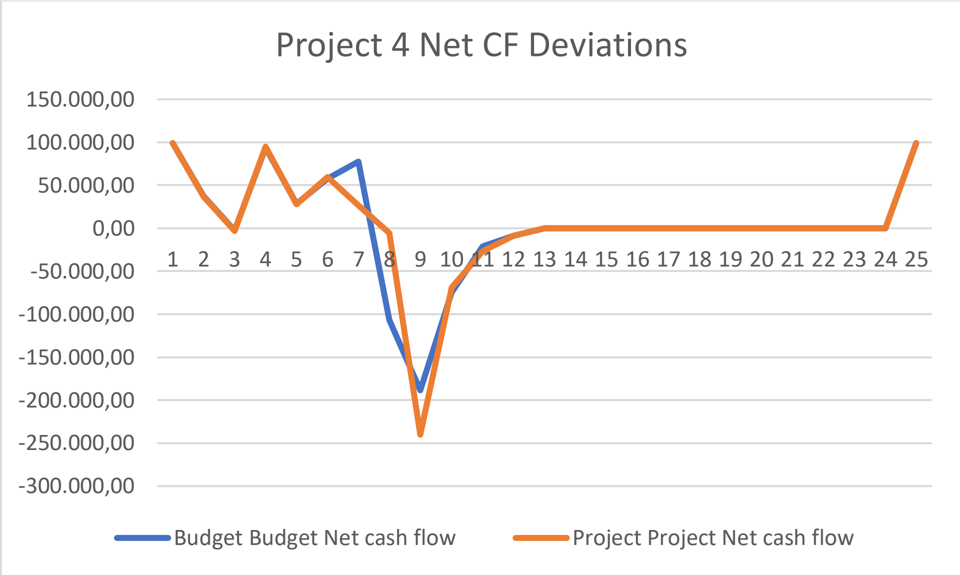

Chart 5.1 Net CF deviations P4

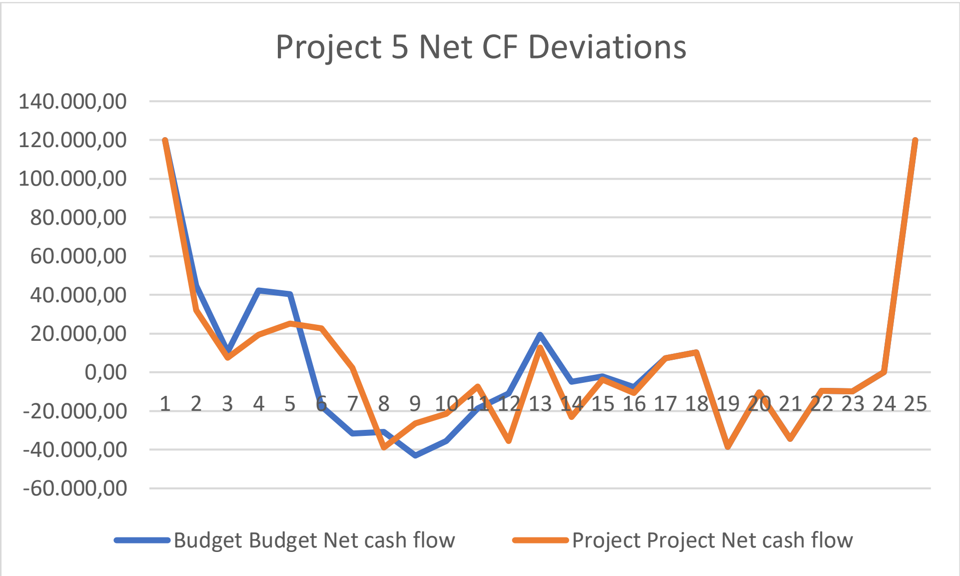

Chart 5.2 Net CF deviations P5

	Cost of Period		0	1	2	3	4	5	6
			31/10/2010	**30/11/2010**	**31/12/2010**	**31/1/2011**	**28/2/2011**	**31/3/2011**	**30/4/2011**
1	**Earthworks**	125.000,00	42.119,57	40.760,87	40.119,57	0,00	0,00	0,00	0,00
2	**Roads**	80.000,00	0,00	5.000,00	25.833,33	25.833,33	21.333,33	0,00	0,00
3	**Foundation**	202.000,00	0,00	0,00	45.375,00	63.937,50	57.750,00	30.937,50	0,00
4	**Precast Buildings**	255.000,00	0,00	0,00	0,00	0,00	0,00	129.590,16	125.409,84
5	**Steel Construction**	42.000,00	0,00	0,00	0,00	0,00	9.800,00	10.850,00	10.500,00
6	**EM**	205.000,00	0,00	0,00	52.520,66	52.520,66	47.438,02	52.520,66	0,00
Sum		909.000,00	42.119,57	45.760,87	163.848,56	142.291,49	136.321,35	223.898,33	135.909,84

Picture 5.2 Planned expenditure (P4)

	Cost of period		0	1	2	3	4	5	6
			31/10/2010	**30/11/2010**	**31/12/2010**	**31/1/2011**	**28/2/2011**	**31/3/2011**	**30/4/2011**
1	**Earthworks**	123.000,00	41.445,65	40.108,70	41.445,65	0,00	0,00	0,00	0,00
2	**Roads**	78.000,00	0,00	4.875,00	25.187,50	25.187,50	22.750,00	0,00	0,00
3	**Foundation**	198.000,00	0,00	0,00	45.375,00	63.937,50	57.750,00	30.937,50	0,00
4	**Precast Buildings**	255.000,00	0,00	0,00	0,00	0,00	0,00	72.857,14	182.142,86
5	**Steel Construction**	42.000,00	0,00	0,00	0,00	0,00	9.800,00	10.850,00	10.500,00
6	**EM**	205.000,00	0,00	0,00	52.520,66	52.520,66	47.438,02	52.520,66	0,00
Sum		901.000,00	41.445,65	44.983,70	164.528,81	141.645,66	137.738,02	167.165,30	192.642,86

Picture 5.3 Actual expenditure (P4)

In pictures 5.2 and 5.3 we can observe the differences in schedule and actual works for project P4. Works are scheduled to reach 223.898,33 and 135.909,84 euros (picture 5.2) in periods 5 and 6, whereas it reaches 167.165,30 and 192.642,86 euros respectively (picture 5.3). Consequently, since works are comprised of different cash profile categories (labour = 0, materials = 4, and subcontractors = 2) they affect cash flow in periods 5, 7, and 9. A similar process is undergone in project 5, (chart 5.2 & pictures 5.4 and 5.5), where works picked up on period 3 to account for the out-of-schedule works decrease in period 2.

	Cost of Period		0	1	2	3	4	5
			30/11/2012	**31/12/2012**	**31/1/2013**	**28/2/2013**	**31/3/2013**	**30/4/2013**
1	**Earthworks**	385.000,00	36.435,33	37.649,84	37.649,84	34.006,31	37.649,84	36.435,33
2	**Foundation**	155.000,00	0,00	0,00	37.200,00	86.800,00	31.000,00	0,00
3	**Building**	310.000,00	0,00	0,00	0,00	0,00	16.865,28	24.093,26
4	**EM**	145.000,00	0,00	0,00	0,00	0,00	0,00	0,00
5	**Surroundings**	95.000,00	0,00	0,00	0,00	0,00	0,00	0,00
Sum		1.090.000,00	36.435,33	37.649,84	74.849,84	120.806,31	85.515,13	60.528,60

Picture 5.4 Planned expenditure (P5)

	Cost of period		0	1	2	3	4	5
			30/11/2012	31/12/2012	31/1/2013	28/2/2013	31/3/2013	30/4/2013
1	Earthworks	385.000,00	36.435,33	37.649,84	37.649,84	34.006,31	37.649,84	36.435,33
2	Foundation	155.000,00	0,00	0,00	14.307,69	50.384,62	50.961,54	39.346,15
3	Building	310.000,00	0,00	0,00	0,00	0,00	16.865,28	24.093,26
4	EM	145.000,00	0,00	0,00	0,00	0,00	0,00	0,00
5	Surroundings	95.000,00	0,00	0,00	0,00	0,00	0,00	0,00
Sum		1.090.000,00	36.435,33	37.649,84	51.957,53	84.390,93	105.476,67	99.874,75

Picture 5.5 Actual expenditure (54)

The different cost flow factors that occur on a project and are difficult to predict can impact the dynamic process of cash flow and produce ambiguous results. Kaka, (1999) in an effort to construct a cash flow model based on historical trends, used several similar projects as benchmarks. However, he stated that only "successful" projects should be used, reflecting the ambiguous results that were created. In our case, a change in work schedule may affect differently cash flow, depending on the number of period payments it affects, or which cost categories and with what credit policy it influences. A delay in an activity that does not extend in many periods – and was not predicted - may impact on a certain period's cash flow more, than it would if the change occurred in a longer activity, thus having a smoother impact on cost.

In picture 5.6 we can observe the deviations of actual values as a percentage of estimates. Project 4 has a standard deviation of 0,25 where in the six first periods deviations are less than 0,08. Then as we mentioned in chart 5.1 work progress slowed compared to schedule, then picked up and in the following periods and created discrepancies in forecasting.

	0	Periods	0	1	2	3	4	5	6	7	8
Project 4	Budget	Budget Net cash flow	99.110,00	37.065,22	-2.826,63	93.472,88	28.703,68	57.775,01	77.511,22	-106.810,74	-188.581,99
Project 4_a	Project	Project Net cash flow	99.110,00	36.472,17	-3.038,80	94.603,02	27.796,77	59.654,83	26.596,67	-5.567,63	-240.208,38
Project 4	Budget - Proj		0,00	0,02	-0,08	0,01	0,03	0,03	0,66	-0,95	-0,27
	Mean (m)	-0,0358									
	Excel STDEV	0,25									

Picture 5.6 Deviations in percentages

Kaka and Price, (1991) note that a 3% variance of the estimate is *"considered well within acceptable limits and demonstrates the reliability of the model."* In the results presented we have obtained a best estimate of 0.23 in project 1, however, the author's point of view is that the presented cash flow model should not be held accountable for this. Model's validity greatly depends on how accurate the estimate is or how well risk factors are revaluated to produce the correct estimate, and more effort should be put into this. Construction is characterised by risk factors that highly affect the cost and if not timely incorporated in the model, cash flow estimates will not be valid. The cash flow model, however, solves the compatibility problem of activities and work schedule that engineers spend a lot of labour-hours to solve and offers a fast estimate on cash flow on the tender phase. It can also produce a forecast in the tender stage and as we will observe in the next paragraphs, it can portray the importance of credit policy on cash flow.

To comprehend the mechanisms of cash flow construction and to understand the complexity that surrounds project cash flow models, it would be helpful to undergo a sensitivity analysis to further interpret the deviations that occurred. Also, we will observe the sensitivity that contract payments and credit policy have on cash flow.

5.2. Sensitivity analysis

We will now observe the impact of certain factors in cash flow, beginning with an increase in cost.

ettings	Allocation table start date				1/10/2010	
	No of activities	6				
	No of periods	32				

A 10% increase of cost in porecast activity

ctivity ode	Activity name	Cost	Alloc Start	Alloc End	Cum sum	Diff column
1	Earthworks	125.000,00	1/10/2010	31/12/2010	125.000,00	809.500,00
2	Roads	80.000,00	25/11/2010	28/2/2011	205.000,00	729.500,00
3	Foundation	202.000,00	10/12/2010	31/1/2011	407.000,00	527.500,00
4	Precast Building	280.500,00	1/3/2011	30/4/2011	687.500,00	247.000,00
5	Steel Constructi	42.000,00	1/2/2011	31/5/2011	729.500,00	205.000,00
6	EM	205.000,00	1/12/2010	31/3/2011	934.500,00	0,00
		934.500,00				

Picture 5.6.1

In picture 5.6.1 we have increased cost by 10% in a single activity, Precast. Precast cost, an activity that spans in a two-month period, increases to 280.500,00 from 255.000,00. As this activity is comprised of 10% materials and 90% of subcontractor works, cash flow in periods from May until August are affected by 0,08, 0,08, 0,02, and 0,06 respectively and a standard deviation of 0,02 is produced, (picture 5.6.2).

7	8	9	10
-144.760,15	-148.957,00	-53.151,41	-20.940,98
-156.423,26	-160.243,88	-54.447,31	-22.195,08
-0,08	-0,08	-0,02	-0,06

Picture 5.6.2

A slightly different case is described in picture 5.6.3 where this time precast's cash profile consists of 30% of materials and 70% of subcontractors. We observe in the picture the significantly higher cash flow deviation produced when the company proceeds in such a strategy change (picture 5.6.3). Because materials are paid in four months, the cost that would have been paid to subcontractors in the 7th and 8th periods is shifted to the 9th and 10th periods in material suppliers (credit for suppliers is four months). In this case deviations in the 7th and 8th periods double and increase dramatically in the following two periods – 9 and 10.

7	8	9	10
-144.760,15	-148.957,00	-53.151,41	-20.940,98
-118.842,11	-123.875,03	-79.069,45	-46.022,95
-0,18	-0,17	-0,49	-1,20

Picture 5.6.3

If, however, the cost increase did not occur, but the company experienced a delay in the same activity, cash flow would suffer a greater deviation. Periods from 6 until 11 would experience a greater impact of deviations where in the 11th period actual cash flow would deviate by almost 100% (picture 5.6.4). In this case, the standard deviation would shift to 0.52 which is almost twenty-five times increase, (pictures 5.6.4, 5.6.5, and 5.6.6).

6	7	8	9	10	11
21.554,38	-144.760,15	-148.957,00	-53.151,41	-20.940,98	-8.680,00
-16.871,92	-142.647,26	-35.312,06	-126.116,31	-16.715,22	-17.272,39
1,78	-0,01	-0,76	-1,37	-0,20	-0,99

Picture 5.6.4 A delay of one month in activity precast

			0	1	2	3	4	5	6	7	8	9	10	11
Periods			**31/10/2010**	**30/11/2010**	**31/12/2010**	**31/1/2011**	**28/2/2011**	**31/3/2011**	**30/4/2011**	**31/5/2011**	**30/6/2011**	**31/7/2011**	**31/8/2011**	**30/9/2011**
Cash flow in			**99.990,00**	**37.065,22**	**40.269,57**	**179.803,90**	**172.924,35**	**70.902,79**	**169.805,53**	**119.600,66**	**9.548,00**	**0,00**	**0,00**	**0,00**
Cash in of invoiced works(time	999.900,00			46.331,52	50.336,96	224.754,88	216.155,43	88.628,48	212.256,91	149.500,82	11.935,00	0,00	0,00	0,00
Advance payment retention	-99.990,00			-4.633,15	-5.033,70	-22.475,49	-21.615,54	-8.862,85	-21.225,69	-14.950,08	-1.193,50			
Retention	-99.990,00			-4.633,15	-5.033,70	-22.475,49	-21.615,54	-8.862,85	-21.225,69	-14.950,08	-1.193,50			
Advance payment	99.990,00		99.990,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Retention repaid	99.990,00													
Cash flow out			**0,00**	**0,00**	**54.638,41**	**66.977,89**	**80.587,83**	**52.906,53**	**148.251,15**	**238.442,77**	**133.423,03**	**79.069,45**	**46.022,95**	**8.680,00**
Labour	69.000,00		0,00	0,00	25.154,72	35.445,28	1.960,00	2.170,00	2.100,00	2.170,00	0,00	0,00	0,00	0,00
Materials	444.000,00		0,00	0,00	0,00	0,00	12.635,87	14.228,26	113.175,94	124.551,39	45.636,14	79.069,45	46.022,95	8.680,00
Subcontractors	396.000,00		0,00	0,00	29.483,70	31.532,61	65.991,96	36.508,26	32.975,21	111.721,38	87.786,89	0,00	0,00	0,00

Picture 5.6.5 Precast activity comprises 30% Materials & 30% Subconstractors

			0	1	2	3	4	5	6	7	8	9	10	11
Periods			**31/10/2010**	**30/11/2010**	**31/12/2010**	**31/1/2011**	**28/2/2011**	**31/3/2011**	**30/4/2011**	**31/5/2011**	**30/6/2011**	**31/7/2011**	**31/8/2011**	**30/9/2011**
Cash flow in			**99.990,00**	**37.065,22**	**40.269,57**	**179.803,90**	**172.924,35**	**70.902,79**	**169.805,53**	**119.600,66**	**9.548,00**	**0,00**	**0,00**	**0,00**
Cash in of invoiced works(time	999.900,00			46.331,52	50.336,96	224.754,88	216.155,43	88.628,48	212.256,91	149.500,82	11.935,00	0,00	0,00	0,00
Advance payment retention	-99.990,00			-4.633,15	-5.033,70	-22.475,49	-21.615,54	-8.862,85	-21.225,69	-14.950,08	-1.193,50			
Retention	-99.990,00			-4.633,15	-5.033,70	-22.475,49	-21.615,54	-8.862,85	-21.225,69	-14.950,08	-1.193,50			
Advance payment	99.990,00		99.990,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Retention repaid	99.990,00													
Cash flow out			**0,00**	**0,00**	**54.638,41**	**66.977,89**	**80.587,83**	**52.906,53**	**148.251,15**	**264.360,80**	**158.505,00**	**53.151,41**	**20.940,98**	**8.680,00**
Labour	69.000,00		0,00	0,00	25.154,72	35.445,28	1.960,00	2.170,00	2.100,00	2.170,00	0,00	0,00	0,00	0,00
Materials	393.000,00		0,00	0,00	0,00	0,00	12.635,87	14.228,26	113.175,94	124.551,39	45.636,14	53.151,41	20.940,98	8.680,00
Subcontractors	447.000,00		0,00	0,00	29.483,70	31.532,61	65.991,96	36.508,26	32.975,21	137.639,41	112.868,85	0,00	0,00	0,00

Picture 5.6.6 Precast activity comprises 10% Materials & 90% Subconstractors

In picture 5.6.7 we summarize the three cases that we have mentioned and their respective cash-flow deviations. We observe that cost changes do not produce as high deviations as a change in the duration of an activity. Change of strategies that shift costs from subcontractors to suppliers also creates deviations but almost half of what a duration change generates.

Type of change	Standard deviation
Increase in cost	0,02
Increase in duration	0,52
Change of cash profile	0,26

Picture 5.6.7

5.3. Sensitivity analysis in contract payments and credit policy

In picture 5.7 we observe the cash-flow table with no time lags on credit accounts – labour, materials, and subcontractors are paid on the same month works are executed – and no credit offered to the client. The client has agreed to compensate the contractor for works executed on the same period, also settling for no advance payment paid and no retention for good performance applied. In this "unreal situation" with a 0.05 yearly nominal interest rate as a discount (reflecting the opportunity cost of money), the contractor receives a net present value (NPV) of 37.708,06 euros, just below 38.138,00€ "profit" if discount rate is neglected.

Cash flow

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Payments (Cash out)	
Cost categories	**Time lag**
Labour	0
Materials	0
Subcontractors	0
Receivables - Cash in	
Advance payment	0%
Retention	0%
Retention repaid	30/6/2022
Time lag cash in	0

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Periods		**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**	**30/11/2021**	**31/12/2021**	**31/1/2022**	**28/2/2022**	**31/3/2022**	**30/4/2022**	**31/5/2022**	**30/6/2022**
	Cash flow in		**14.921,05**	**102.178,95**	**196.228,57**	**124.533,10**	**104.063,67**	**30.974,66**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
e	Cash in of invoiced works(time la	572.900,00	14.921,05	102.178,95	196.228,57	124.533,10	104.063,67	30.974,66	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
b	Advance payment retention	0,00	0,00	0,00	0,00	0,00	0,00	0,00										
c	Retention	0,00	0,00	0,00	0,00	0,00	0,00	0,00										
g	Advance payment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
f	Retention repaid	0,00																0,00
	Cash flow out		**13.642,11**	**92.487,89**	**188.242,86**	**120.518,31**	**94.690,80**	**25.180,03**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
90	Labour	24.366,00	0,00	15.466,00	0,00	0,00	0,00	8.900,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
91	Materials	152.374,80	1.364,21	32.447,79	42.198,57	32.254,45	37.008,34	7.101,44	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
92	Subcontractors	358.021,20	12.277,89	44.574,11	146.044,29	88.263,87	57.682,46	9.178,58	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Project Net cash flow		**1.278,95**	**9.691,05**	**7.985,71**	**4.014,78**	**9.372,87**	**5.794,64**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	Net Present Values of CF		**1.278,95**	**9.650,84**	**7.919,58**	**3.965,01**	**9.218,27**	**5.675,41**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
	Cumulative net cash flow		**1.278,95**	**10.970,00**	**18.955,71**	**22.970,50**	**32.343,36**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**	**38.138,00**

		NPV	37.708,06
εp	0,05		
p	12	**Profit**	38.138,00
εp/p	0,00417		

Picture 5.7

However, the client has proposed the following terms as a basis for an agreement which the contractor must decide to accept or not:

- the client will pay within 30 days of works executed
- advance payment will be paid within the first month of works commencement
- Advance payment will be repaid proportionally by 10% of works executed every month, starting from period 0.
- Good performance retention will deduct from payment proportionally 10% of works executed and will be reimbursed to the contractor on 30/06/2022.

In such a real-time situation the contractor must evaluate the above terms along with market conditions that the company faces (suppliers' credit, bank loans, etc.) and assess how the project's cash flow can be maximized. We will calculate Net Present Value' cash flow, as it is a relatively useful measure of project performance when comparing payments in different periods. Moreover, as we have mentioned earlier a positive cash flow does not show the whole picture, especially in construction projects. Retentions often deduct important resources when works are executed, and cumulative cash flow can turn negative for large periods until retention is refunded. Therefore, terms that turn positive cumulative cash flow will also be evaluated.

Cash flow

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Payments (Cash out)	
Cost categories	Time lag
Labour	0
Materials	4
Subcontractors	2

Receivables - Cash in	
Advance payment	10%
Retention	10%
Retention repaid	30/6/2022
Time lag cash in	1

			0	1	2	3	4	5	6	7
	Periods		**31/3/2021**	**30/4/2021**	**31/5/2021**	**30/6/2021**	**31/7/2021**	**31/8/2021**	**30/9/2021**	**31/10/2021**
	Cash flow in		**57.290,00**	**11.936,84**	**81.743,16**	**156.982,86**	**99.626,48**	**83.250,93**	**24.779,73**	**0,00**
e	Cash in of invoiced works(time la	572.900,00		14.921,05	102.178,95	196.228,57	124.533,10	104.063,67	30.974,66	0,00
b	Advance payment retention	-57.290,00		-1.492,11	-10.217,89	-19.622,86	-12.453,31	-10.406,37	-3.097,47	
c	Retention	-57.290,00		-1.492,11	-10.217,89	-19.622,86	-12.453,31	-10.406,37	-3.097,47	
g	Advance payment	57.290,00	57.290,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
f	Retention repaid	57.290,00								
	Cash flow out		**0,00**	**15.466,00**	**12.277,89**	**44.574,11**	**147.408,50**	**129.611,66**	**99.881,04**	**41.433,03**
90	Labour	24.366,00	0,00	15.466,00	0,00	0,00	0,00	8.900,00	0,00	0,00
91	Materials	152.374,80	0,00	0,00	0,00	0,00	1.364,21	32.447,79	42.198,57	32.254,45
92	Subcontractors	358.021,20	0,00	0,00	12.277,89	44.574,11	146.044,29	88.263,87	57.682,46	9.178,58
	Project Net cash flow		**57.290,00**	**-3.529,16**	**69.465,26**	**112.408,75**	**-47.782,02**	**-46.360,72**	**-75.101,31**	**-41.433,03**
	Net Present Values of CF		**57.290,00**	**-3.514,51**	**68.889,98**	**111.015,27**	**-46.993,88**	**-45.406,83**	**-73.250,85**	**-40.244,46**
	Cumulative net cash flow		**57.290,00**	**53.760,84**	**123.226,11**	**235.634,86**	**187.852,84**	**141.492,12**	**66.390,81**	**24.957,78**

		8	9	10	11	12	13	14	15
	Periods	**30/11/2021**	**31/12/2021**	**31/1/2022**	**28/2/2022**	**31/3/2022**	**30/4/2022**	**31/5/2022**	**30/6/2022**
	Cash flow in	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**57.290,00**
e	Cash in of invoiced works(time la	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
b	Advance payment retention								
c	Retention								
g	Advance payment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
f	Retention repaid								57.290,00
	Cash flow out	**37.008,34**	**7.101,44**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
90	Labour	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
91	Materials	37.008,34	7.101,44	0,00	0,00	0,00	0,00	0,00	0,00
92	Subcontractors	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Project Net cash flow	**-37.008,34**	**-7.101,44**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**57.290,00**
	Net Present Values of CF	**-35.797,54**	**-6.840,60**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**53.825,96**
	Cumulative net cash flow	**-12.050,56**	**-19.152,00**	**-19.152,00**	**-19.152,00**	**-19.152,00**	**-19.152,00**	**-19.152,00**	**38.138,00**

NPV	38.972,54
Profit	38.138,00

εp	0,05
ρ	12
εp/ρ	0,00417

Picture 5.8

In picture 5.8 the terms that the client has proposed are applied along with the addition of contractors' payment terms agreement with suppliers and subcontractors. Since subcontractors and materials procurement both account for almost 90% of the total project, their payment terms have an important weight on cash flow. Labour is paid on the same month that is executed, while material suppliers offer a credit of four months and subcontractors two months. With these payment terms, NPV is increased to 38.972,54 euros, however, cumulative cash flow turns negative on the 9th period until the 15th, and the contractor will require to withdraw 19.152.00 from its cash reserves to pay for liabilities that mature during these periods.

If suppliers and subcontractors do not agree to the former credit terms and demand payment one month earlier, NPV will decrease 5% to 36.890.44€. Each time the above group of creditors will require a change in payment terms by one month – increase or decrease – this will affect NPV by almost 5%, positive or negative. Of course, this proportion of change is not generic at all and only applies to the specific project circumstances: work schedule, project duration, cost categories, retention percentages, receipts, etc. Shifting labour liabilities by one month, when labour only accounts for 5% of the cost will have a much smaller impact on cash flow.

Credit periods Mater & Sub	NPV	% change of NPV
5,3	41.046,01	5,32%
4,2	38.972,54	0,00%
3,1	36.890,44	-5,34%
2	34.799,65	-10,71%

Table 5.2

Cash flow

Go to prev Step
Go to next Step

Payments (Cash out)	
Cost categories	Time lag
Labour	0
Materials	4
Subcontractors	2

Receivables - Cash in	
Advance payment	10%
Retention	10%
Retention repaid	30/6/2022
Time lag cash in	1

			0	1	2	3	4	5	6	7
	Periods		31/3/2021	30/4/2021	31/5/2021	30/6/2021	31/7/2021	31/8/2021	30/9/2021	31/10/2021
	Cash flow in		57.290,00	11.936,84	81.743,16	156.982,86	99.626,48	83.250,93	24.779,73	28.645,00
e	Cash in of invoiced works(time la	572.900,00		14.921,05	102.178,95	196.228,57	124.533,10	104.063,67	30.974,66	0,00
b	Advance payment retention	-57.290,00		-1.492,11	-10.217,89	-19.622,86	-12.453,31	-10.406,37	-3.097,47	
c	Retention	-57.290,00		-1.492,11	-10.217,89	-19.622,86	-12.453,31	-10.406,37	-3.097,47	
g	Advance payment	57.290,00	57.290,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
f	Retention repaid	57.290,00								28.645,00
	Cash flow out		0,00	15.466,00	12.277,89	44.574,11	147.408,50	129.611,66	99.881,04	41.433,03
90	Labour	24.366,00	0,00	15.466,00	0,00	0,00	0,00	8.900,00	0,00	0,00
91	Materials	152.374,80	0,00	0,00	0,00	0,00	1.364,21	32.447,79	42.198,57	32.254,45
92	Subcontractors	358.021,20	0,00	0,00	12.277,89	44.574,11	146.044,29	88.263,87	57.682,46	9.178,58
	Project Net cash flow		57.290,00	-3.529,16	69.465,26	112.408,75	-47.782,02	-46.360,72	-75.101,31	-12.788,03
	Net Present Values of CF		57.290,00	-3.514,51	68.889,98	111.015,27	-46.993,88	-45.406,83	-73.250,85	-12.421,18
	Cumulative net cash flow		57.290,00	53.760,84	123.226,11	235.634,86	187.852,84	141.492,12	66.390,81	53.602,78

		8	9	10	11	12	13	14	15
	Periods	30/11/2021	31/12/2021	31/1/2022	28/2/2022	31/3/2022	30/4/2022	31/5/2022	30/6/202
	Cash flow in	0,00	0,00	0,00	0,00	0,00	0,00	0,00	28.645,0
e	Cash in of invoiced works(time la	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0
b	Advance payment retention								
c	Retention								
g	Advance payment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0
f	Retention repaid								28.645,0
	Cash flow out	37.008,34	7.101,44	0,00	0,00	0,00	0,00	0,00	0,0
90	Labour	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0
91	Materials	37.008,34	7.101,44	0,00	0,00	0,00	0,00	0,00	0,0
92	Subcontractors	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0
	Project Net cash flow	-37.008,34	-7.101,44	0,00	0,00	0,00	0,00	0,00	28.645,0
	Net Present Values of CF	-35.797,54	-6.840,60	0,00	0,00	0,00	0,00	0,00	26.912,9
	Cumulative net cash flow	16.594,44	9.493,00	9.493,00	9.493,00	9.493,00	9.493,00	9.493,00	38.138,0

NPV	39.882,83
Profit	38.138,00

εp	0,05
p	12
εp/p	0,00417

Cumulative cash flow idoes not turn negative

Picture 5.9

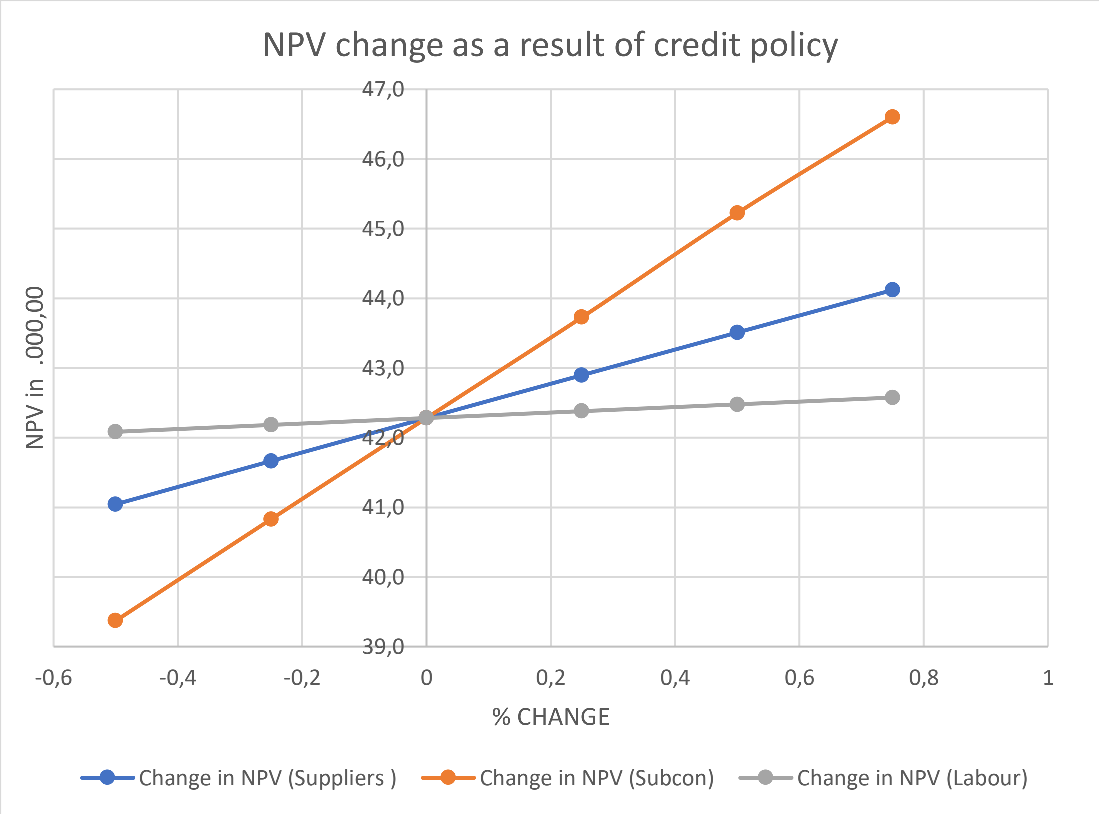

Chart 5.3

Percentage change in Credit	Change in NPV (Suppliers)	Change in NPV (Subcon)	Change in NPV (Labour)
-0,5	41,0	39,4	42,1
-0,25	41,7	40,8	42,2
0	42,3	42,3	42,3
0,25	42,9	43,7	42,4
0,5	43,5	45,2	42,5
0,75	44,1	46,6	42,6

Table 5.3

Chart 5.3 and Table 5.3 depict graphically the sensitivity the changes in credit policy of each cost category have on Net Present Value. A change in subcontractors' credit policy has greater influence than the other categories since it carries the greater amount of cost.

In picture 5.9 all terms applied have stayed the same as in picture 5.8 but retention is refunded in two equal instalments one in the period following works completion and the second installment on the 16th period as in the previous case. With this scenario, NPV has improved by 2,5%, but the more important impact is on cumulative cash flow that has turned positive through all project duration, which can be seen in figure 5.9. Even if the contractor can agree to increase credit to suppliers and subcontractors to five and three months respectively thus achieving a NPV 41.046,01€, it may appeal greater to the contractor to demand a retention refund earlier than that proposed from the client, or even replace the retention with a bond with an acceptable interest rate.

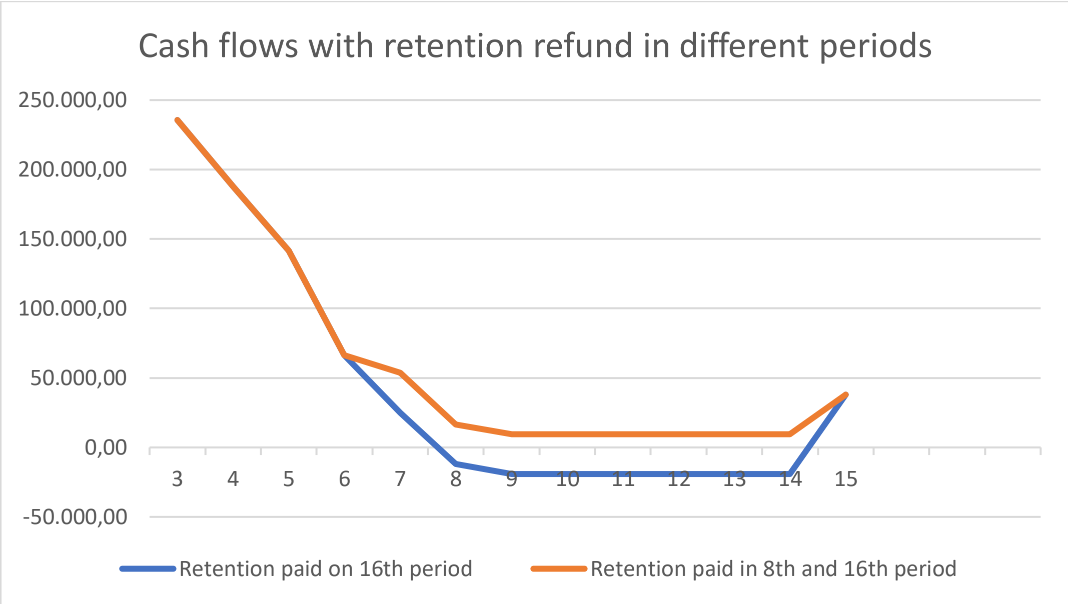

Figure 5.3

Refunding retention to the contractor usually includes a certain period after the project is completed where all quality and inspection operations have been concluded and the independent engineer issues the Defects Liability Certificate. In large projects that include a substantial amount of interconnected subprojects, a subcontractor may have to wait for the Certificate of the whole project, the period to receive the retention refund may even be longer than the duration of the subproject, thus making retention reimbursement a highly sensitive factor to cash flow.

In our sensitivity analysis, we observed in the first example that a credit increase by one month to suppliers and subcontractors affects NPV by 5%. This may seem not so much as significant to someone outside the construction industry, however, we have already mentioned that the industry is characterised by low markup, considerable competition and almost a decade with decreased revenue and profit. Company managers should well consider their policy against their creditors since it could be an opportunity that would greatly benefit their company. The managers should more carefully and with the help of a cash flow model, such as this presented, explore the different cash flow outcomes that contract payment deliver. A general rule is to prolong advance payment retention to the whole duration of the project and agree to receive good performance retention – at least a portion of it – as early as possible. Net present value is a good measure of project viability, but managers should also look for long periods of negative cash flow. We have observed in picture 5.9 that a partial refund of good performance retention, erased negative cash flow for the second half of the project.

5.4. Findings

This study has attempted to research project cash flow forecasting which has been unceasingly a major issue to companies that are active in the construction industry. Regarding the research questions, the findings of the study are mentioned below.

A) Employ the relevant academic literature to produce a model with the application of cost profile categories, time lags, cost weights and automatically produce cash flow forecast.

Among the different cash flow forecasting approaches, the study presented the three most researched methods: a) Ideal curves constructed from the S- curve theory and based on historical projects data, b) the Cost-Schedule integration method and c) the simpler method which the study employed. This method used a less time-consuming technique with budget cost categorised to broad cost categories concerning their cash profile, i.e. when the cost is actually paid depending on its characteristics and company credit policy. Research has shown that such categorisation offers increased financial control to modellers. Three categories identified: labour, materials (or suppliers), and subcontractors and weights were implemented to budget cost items, thus producing a final cash profile. Cost integration to schedule was solved using Microsoft excel formulas that allocated cost according to their working days schedule. Cash flow in was calculated and allocated to schedule according to the cost markup of work progress, retentions, and other payment practices, thus producing a final cash flow report.

B) Validate the results of the model with actual data of projects executed.

Seven projects were selected from a company that operates as a subcontractor of large public projects contractors. Actual values of cash flow were collected from ERP accounting software and were compared against planned budget values. Standard deviation was selected as a measure according to other similar research techniques and actual values were found to deviate significantly in all cases (0,23 was the lower SDY). However, concerning the construction industry characteristics with numerous uncontrolled risk factors occurring, deviations of more than 3% can be more than acceptable (Kaka and Price, 1991).

C) Conduct sensitivity analysis for factors that affect results presented and how a project's net present value may be affected by industry-specific terms.

A sensitivity analysis was implemented to convey the factors that have a greater dependency on the model. A 3% increase in cost – which occurred in only a specific activity – showed a little impact on cash flow, producing a deviation of 0,02.

On the other hand, the same increase in cost occurring in the certain activity, which had a different composition of cost categories – subcontracting was reduced, and works were shifted to materials – produced thirteen times more deviation i.e., 0,26. Finally, when the change of factors included only a delay in work progress by one period, this had a much higher impact on cash flow. Deviations were higher since the changes in cost affected more periods, i.e, work progress was not completed in the planned period, thus current period cost categories were affected, including those of the next, producing significant alterations in the actual values of four periods, yielding a standard deviation to 0,52. It is apparent that the dynamic process of work progress and cost in this model, are highly affected when an unplanned change occurs that affects a greater amount of cost attributed to cost categories. Both in the case of duration and cash profile change, more than one cost category was affected, which produced a series of alterations in the cash flow process. Thus, although the model works smoothly when significant changes do not occur, certain unplanned factors seem to create great disturbance in cash flow results.

Additionally, there is evidence that projects variating between them may be the cause of variation in results. It has been mentioned in literature review that project grouping is essential when testing the validity of cash flows since certain characteristics of projects (total cost and duration) are significant factors that influence results. A delay in a sub activity that will produce a total delay of one period impacts more on a twelve-month project that in a three-year project.

Finally, sensitivity analysis was extended to include the dependency credit policy and payment terms have on net present value as a measure of project selection. Again, cost categories as a percentage of total cost played an important role in net present value. A change in credit policy of subcontractors and materials, which consisted 90% of the total cost, shifted NPV by 5%, while receiving retention reimbursement in two installments compared to one at the very end of the project, transformed a series of negative cash flow periods to positive.

CHAPTER 6: DISCUSSION

6.1. Practical implications

This research has focused on delivering a practical and easy-to-use model that engineers and financial professionals of construction companies can comfortably implement in their work, during both tender and execution phases. Although comparison of actual cash flow deviated significantly from planned values highly due to industry-related risk factors, the model can produce statistically accepted results when factor changes have already been forecasted. Mechanisms that incorporate risk factors are absent in the model could offer better-accepted results if adopted in future attempts. However, the model can act as a strong project selection tool, since it realises an important amount of policy changes to deliver different screenshots of cash flow forecast: a) change of payment method to creditors, b) change of strategy concerning allocating works to subcontractors, c) change of contract terms related to payment (retentions, advance payments, etc.), d) project duration changes, e) time lags to clients, etc. Cash flow reporting is presented as a simple student textbook, incorporating all variables in a spreadsheet, with the user controlling those variables and influencing cash flow accordingly.

6.2. Research limitations

This research has focused on certain projects with relatively short duration where various cost changes may have inflicted a higher burden on limited period cash flow. Precast activities accumulate a great number of resources that otherwise would take longer periods to fulfil, thus reducing project's duration. The small sample size of projects which were constructed in the last decade may have also constituted a limitation on its own in this research. Moreover, to the small number of projects, projects in the sample were executed during a significant crisis in the industry, which may have influenced their cost and progress at the time. If a larger sample of projects existed that could be reduced to those fulfilled in the last five years, the results could have been different. Also, as it was presented earlier, projects that are considered unsuccessful should not be included in the sample and such a method of selection has not been implemented due to the small sample.

6.3. Basic Findings

The study has focused to develop a practical and useful model to assist with the difficult task of cash flow forecasting of construction projects. Among the various approaches existing in research, the author selected the method that enabled ease of use and simple but powerful cash flow reporting. Cash flow terminology was implemented in a user-friendly spreadsheet environment that facilitated comprehension with various charts and tables. Multiple industry-specific terms were presented and analysed, focusing on their impact on cash flow, without requesting previous financial knowledge. The development of the model has fulfilled the first of the basic research questions of this paper. The second research question was to test the validity of cash flow estimates that the model produced. Mainly due to the lack of a greater sample, its validity could not be evaluated statistically, although views that higher deviations can be accepted in the construction industry exist in literature. A sensitivity analysis showed that cash flow estimates have a greater dependency on duration and cash profile changes than cost alterations. Further analysis conveyed that industry-specific payment terms (advance payment, retention, credit policies to subcontractors) may significantly affect a project's cash flow cycle and should be taken into consideration before bidding.

6.4. Contribution

This research has contributed to the area of construction project cash flow forecasting, in an attempt to stress the importance of forecasting for companies operating in Greece. The local industry has received a huge blow in the last decade, with a multiplicity of factors occurring which in general deteriorated construction companies' business. Consistent cash flow forecasting executed either on the tender stage or during execution phases is highly critical to the success of the firm. Contractors, besides confronting industry's characteristics (low markup, low capital, increased risk factors, low entry barriers, increased competition), also have to overcome obstacles created by the industry's specific payment terms, which add extra complexity and hurdles in their effort to complete execution. A highly fragmented industry, with 98% of companies operating with less than 10 employees, does not facilitate the development of specific departments, with specialised financial knowledge to assist forecasting. The model developed can offer a beneficial tool in both forecasting and evaluating projects without the need of investing in more complex and expensive software.

6.5. Proposals for further research

The model presented has been found to significantly deviate from cash flow estimates due to the small size of projects included and to the lack of risk factors incorporated in the model. The projects in the present study had length of around one and a half year (18 periods) and it would be interesting to test cash flow for projects that have a larger duration. An increased project sample which will be selected and grouped according to specific project characteristics (e.g., duration) has been pursued in other studies and has offered more consistent findings. Additional calculations that would feature changes of cash flow in case risk factors occur could offer more consistent results.

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