Monte Carlo simulation as a modern instrument for liquidity planning

By Luiza Arcab

Actually, the members of the ICV International Working Group in 2020 had planned to,

PS fashion, a fashion company from Serbia with ideas, tips, etc. But Covid19 did not allow that. What to do?
After a survey among all working group members, the leadership team decided to work on self-imposed topic areas via internet, i.e. with teams, Zoom or Skype. The following four topics were selected in a doodle poll:

1. Monte Carlo simulation as a modern instrument for liquidity planning

2. changes in the business model in the near future

3. what kind of new technologies will be used in management / controlling in a few years?

4. how to make social responsibility (CSR) measurable in order to use CSR as part of the business model of companies.

Here is the report of the Monte Carlo Group, consisting of Luiza Arcab, Mariusz Rzeźnikiewicz and Jörn Ney; Luiza Arcab wrote the article [1]:

As the last few months have shown, running a business in an economy affected by lock-down means making decisions in a highly uncertain environment, often based on a lack of data on the business environment and constantly changing assumptions. The dynamic nature of the external environment makes it necessary for the company to plan, analyse and simulate numerous scenarios of the market situation and the company's response to it. Frequent, elaborate analyses and simulations of countless complex scenarios can be a time-consuming task for controllers. Common methods of descriptive risk analysis, such as sensitivity analysis and scenario analysis, which use the basic functions of a spreadsheet programme (such as MS Excel), offer only limited and inaccurate insight into a company's future situation because they focus only on a subjectively selected small number of scenarios - out of thousands of possible ones. The difficulty lies in choosing the right scenario (and the combination of values of the individual parameters) that offers the highest certainty of achieving the expected results.

Planners, controllers or managers make little use of knowledge of quantitative methods in business management. This is probably related to difficulties in correctly interpreting the obtained simulation results, concerns about sufficient knowledge of statistics and its ease of application in business practice. There are a number of analytical tools (software) on the market that are an extension of spreadsheets (such as MS Excel) and support the work of controllers in data analysis and are becoming increasingly common. Based on historical data and corporate planning, it is possible with their help to draw conclusions and take important measures to reduce risks.

[1] The "official language" in the ICV international working group is English; insofar the illustrations are written in English.

Quantitative methods in planning

One of the methods that can handle both sensitivity and scenario analysis is Monte Carlo simulation. It is a very effective and useful tool to support financial planning. One of the most important objectives in financial liquidity planning is to reduce liquidity risk (in the near or distant future) and to effectively manage working capital (e.g. payment targets). The simulation model quantifies the impact of all risks identified in the model and their influence on the cash flow for the period. Taking into account the extent of their volatility and the probability of occurrence, it is possible to give concrete figures. Among other things, it is possible to find out to what extent working capital can be influenced to minimise liquidity risk to an acceptable level in the coming months or years, or how a decline in the turnover rate of receivables, payables or inventories will affect the cash balance on a given day.

This article presents a precise and comprehensive approach to quantifying and aggregating various risk factors using Monte Carlo simulation. Effects of sample risks and volatility of external factors (such as sales revenue or ratios measuring working capital) on the company's liquidity are analysed and simulated in detail.

Application of Monte Carlo simulation (example)

The example shown below was developed on the basis of real data from a company operating on the European market. Based on the data for the last financial year 2020, the DSO (Days Sales Outstanding = period until money is received after revenue recognition) averaged 84 days, with actual payments being approximately 30 days shorter and longer (range of variation +/-30 days, range of values from 54 to 114 days). In the planned annual financial statements for 2021, including the balance sheet, income statement and cash flow statement, the same values were applied for this key figure, assuming that the current policy regarding payment periods for receivables can be continued.

With the help of a Monte Carlo simulation, we can check the probability of the loss of liquidity on the balance sheet date and the achievement of the planned cash balance. This is the starting point for a sensitivity analysis (simulating the behaviour of cash balances depending on changes in parameters that have a direct and indirect impact) and thousands of different decision scenarios (possible future variants based on different values of the parameters within their acceptable range of variability).

Let us assume that our task is to optimise working capital. For simplicity, let's assume that we continue with our current policy on other elements of working capital management. We can simulate the effect of a possible change in the payment terms of trade receivables on our liquidity position at the balance sheet date. We can examine what result would be achieved by shortening or extending the payment terms by, for example, 10, 20 or 30 days. This will give us answers to the following questions, among others:

1) What is the probability of insolvency if payment terms are extended by an average of about 30 days?

2) What would be the expected average payment target at which we reduce the risk of insolvency to 3% (in other words, we are 97% sure that we will have positive cash on the balance sheet date)?

3) By how many days on average can we extend the payment terms for our customers in order to be 90% sure that we will have positive cash on the balance sheet date? (in other words, with an acceptable risk of non-payment of 10%).

Answering these and many other questions related to working capital or liquidity literally takes a few minutes, just as long as running the simulation and analysing its results.

However, before presenting answers to the above questions, we will go into what such a simulation model can look like and how to interpret the results of the simulation and make recommendations for management based on them.

Simulation model

The simulation model for liquidity planning is based on the following data:

1. integrated business planning (balance sheet, income statement, finance plan).

2. key figures on working capital (turnover rate of receivables, payables and inventories).

3. specified expected market risks and their potential impact on the parameters of the financial statements together with the probability of their occurrence.

There are three key input variables in the model (called input variables or assumptions):

- Revenue from the sale of products and services,

- working capital ratios, concerning receivables (DSO), payables (DPO) and inventories (DIO), and

- expected potential market risks, such as the occurrence of a pandemic or a supply chain disruption affecting sales revenues (in the following example, a limitation to two risks has been made to simplify the model, but their number can be much larger and they can be combined and grouped into a matrix of risks of different types with a certain probability of occurrence and impact on different elements of the financial statements).

For each input variable, parameters describing probability distributions based on historical data have been defined, such as: Median, minimum and maximum number of turnover days and turnover values, and in the case of risks, the probability of their occurrence and their impact on turnover (Figure 1).

The output variables (so-called forecast output or outcome) are the value of cash and cash equivalents in the cash flow statement as of the balance sheet date 2021.

Forecasting Possible Cash Outcomes
Using Monte Carlo Simulation within Oracle Crystal Ball software

Parameters FY2021

Input variables / Assumptions	Simulated		Min	Max	Mean	Std.Dev
Days Sales Outstanding (DSO)	84	Range Between 24 and 84 [days]	24	84	54	10
Days Payables Outstanding (DPO)	21	Range Between 20 and 40 [days]	20	40	21	3
Days Inventory Outstanding (DIO)	78	Range Between 60 and 90 [days]	60	90	78	5
Revenues	28.7	Min, Max, Most Likely Value [T€]	23	26	25	
Risk of Pandemic						
Pandemic Likelihood	0.1					
Impact Pandemic on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10	
Risk of Supply Chain shortage						
S.C. shortage Likelihood	0.3					
Impact S.C. shortage on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10	

Output / Forecast		
Pre-Mitigated Risk impact on Revenues	4.0	[T€]
Simulated Cash at the end of FY2021	4.2	[T€]

Figure 1: Input and output variables of the liquidity model
Source: Own representation

The liquidity model is constructed in such a way that it is possible to recalculate all items of the planned financial statements on the basis of the randomly taken values of the input variables and to determine the result of the output variables (in this case the cash balance on the balance sheet date). In a single simulation, each drawing of input variable values is automatically repeated for a certain, selected number of iterations (called trials). In the model discussed, a simulation was started with the number of iterations (repetitions) equal to 1000. The resulting 1000 values of the output variables of the simulation forecast are aggregated and plotted on graphs in the form of a histogram (so-called frequency chart) and the cumulative frequency chart distributions - Figure 2. This histogram represents the probability of occurrence of each NPV at the end of the financial year in a range of specified values. In the model discussed, the probability of obtaining the cash balance in the range of 4-4.25T€ (x-axis) is in the order of 0.06 (y-axis). The distribution, on the other hand, indicates the probability that the cash received is less than or equal to a certain value. There is a 23% probability that the cash balance is less than or equal to zero (i.e. the risk of insolvency).

From a management perspective, this may not be an expected satisfactory outcome. Therefore, knowing the outcome of the forecast based on assumptions of the current budget, we can perform further simulations and consider different variants of the value of working capital ratios, projected sales proceeds or the probability of occurrence of risks and their impact on the elements of the financial statements to find an acceptable value of the cash forecast at the end of the period.

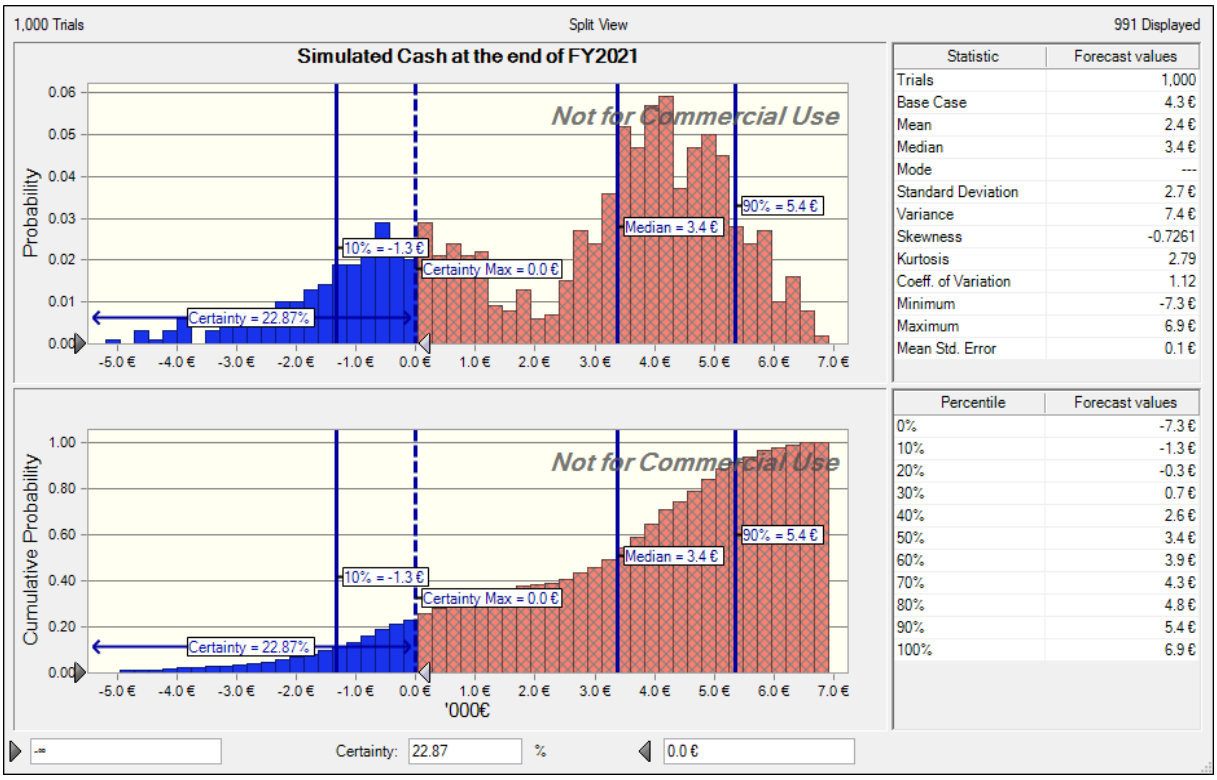

Figure 2: Output variable histogram - simulated present value as of the 2021 balance sheet date.
Source: Crystal Ball [Oracle software].

So let's check: "What is the probability of the company's insolvency if payment terms (settlement of receivables by customers) are extended by an average of 30 days? In the model we increase the parameter range of the input variable of the receivables turnover rate (DSO) by 30 days (Figure 3).

Forecasting Possible Cash Outcomes
Using Monte Carlo Simulation within Oracle Crystal Ball software

Parameters FY2021

Input variables / Assumptions	Simulated		Min	Max	Mean	Std.Dev	Change in Days
Days Sales Outstanding (DSO)	84	Range Between 84 and 144 [days]	84	144	114	10	30
Days Payables Outstanding (DPO)	21	Range Between 20 and 40 [days]	20	40	21	3	
Days Inventory Outstanding (DIO)	78	Range Between 60 and 90 [days]	60	90	78	5	
Revenues	28.7	Min, Max, Most Likely Value [T€]	23	26	25		
Risk of Pandemic							
Pandemic Likelihood	0.1						
Impact Pandemic on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10		
Risk of Supply Chain shortage							
S.C. shortage Likelihood	0.3						
Impact S.C. shortage on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10		
Output / Forecast							
Pre-Mitigated Risk impact on Revenues	4.0	[T€]					
Simulated Cash at the end of FY2021	4.2	[T€]					

Figure 3: Change in the input variable of the liquidity model - DSO by 30 days
Source: Own representation

After starting the Monte Carlo simulation, we receive the result of the forecast within one minute in the form of a graph (Figure 4). From this we can see that an extension of the

payment terms by an average of 30 days increases the probability of insolvency (from 23% if the current payment policy is continued) to a value of about 36%.

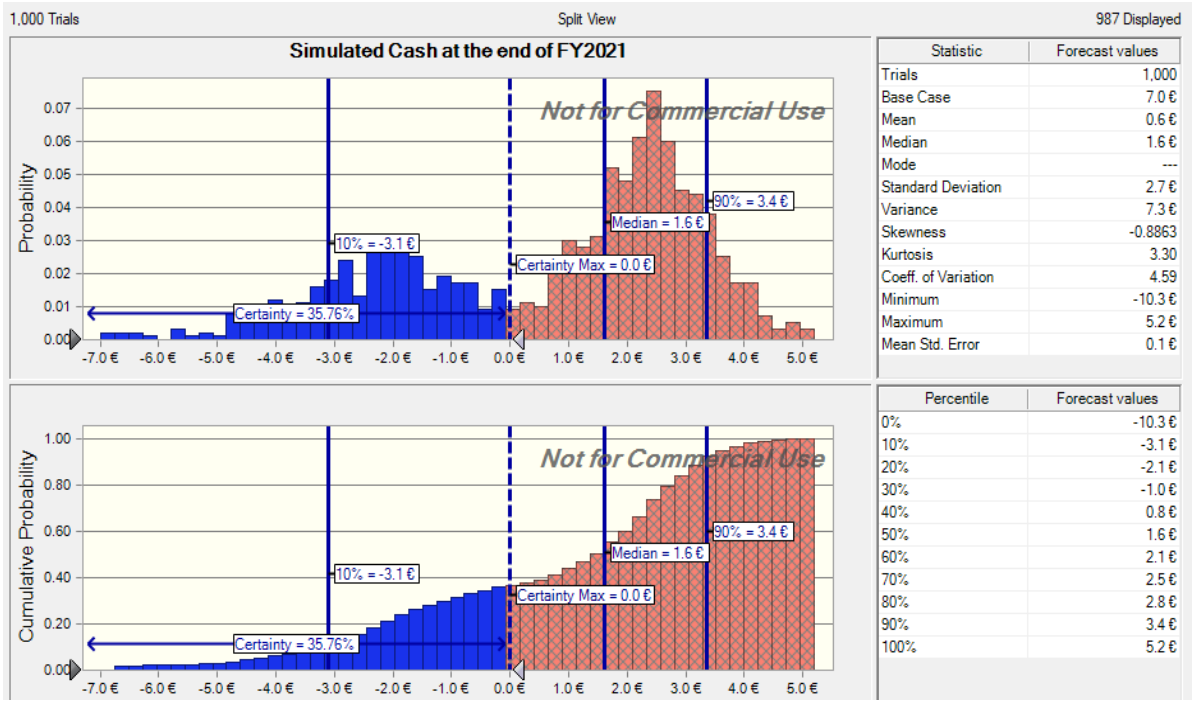

Figure 4: Histogram of the output variables - simulated value of cash and cash equivalents on the balance sheet date 2021 - payment term extended by 30 days.
Source: Crystal Ball [Oracle software].

And what is the outcome of the forecast if we negotiate with customers and shorten the payment terms by about 30 days? - Figures 5 and 6.

The probability of non-payment, has decreased significantly from the "starting point" 23% to 3%. By shortening the payment period by an average of about 30 days, the company can be 97% certain that at the end of the projected balance sheet year the cash balance will be greater than zero. In addition, it can be assumed with 50% certainty (median) that the cash balance in the financial plan will be less than or equal to T€ 6.5. The probability of achieving a balance less than or equal to 7.5 T€ is 90%.

By simulating the payment terms of the company's receivables, which are on average 10, 20 or 30 days shorter or longer, we can see how each change in value affects the projected cash position on the balance sheet date. As a result, we get the results shown in Figure 7. The insolvency probability refers to the value of the cash forecast results less than or equal to 0.

Forecasting Possible Cash Outcomes
Using Monte Carlo Simulation within Oracle Crystal Ball software

Parameters FY2021

Input variables / Assumptions	Simulated		Min	Max	Mean	Std.Dev	Change in Days
Days Sales Outstanding (DSO)	84	Range Between 24 and 84 [days]	24	84	54	10	-30
Days Payables Outstanding (DPO)	21	Range Between 20 and 40 [days]	20	40	21	3	
Days Inventory Outstanding (DIO)	78	Range Between 60 and 90 [days]	60	90	78	5	
Revenues	28.7	Min, Max, Most Likely Value [T€]	23	26	25		
Risk of Pandemic							
Pandemic Likelihood	0.1						
Impact Pandemic on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10		
Risk of Supply Chain shortage							
S.C. shortage Likelihood	0.3						
Impact S.C. shortage on Revenue	10	Min, Max, Most Likely Value [T€]	5	15	10		
Output / Forecast							
Pre-Mitigated Risk impact on Revenues	4.0	[T€]					
Simulated Cash at the end of FY2021	4.2	[T€]					

Figure 5: 30-day change in the input variables of the liquidity model - receivables turnover rate
Source: Own representation

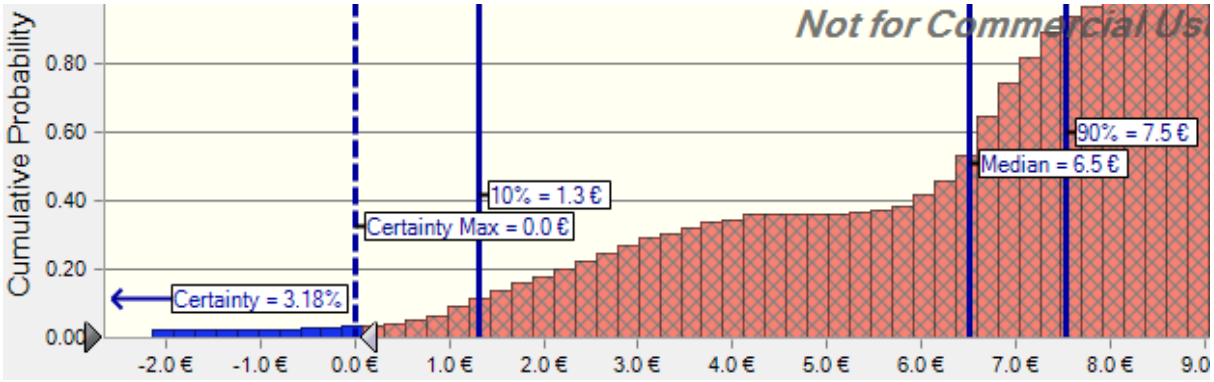

Figure 6: Output variable histogram - simulated present value as of the balance sheet date 2021 - payment target shortened by 30 days.
Source: Crystal Ball [Oracle software].

Working Capital Metric	Min	Max	Mean	Probability of insolvency	Probability of positive cash	Customer Payment Terms Policy
DSO	24	84	54	3%	97%	- 30 days
	34	94	64	5%	95%	- 20 days
	44	104	74	10%	90%	- 10 days
DSO	**54**	**114**	**84**	**23%**	**77%**	**- / + 0 days**
	64	124	94	25%	75%	+10 days
	74	134	104	29%	71%	+20 days
DSO	84	144	114	36%	64%	+30 days

Figure 7: Summary of the results of the simulation forecast for the extension and shortening of payment periods for receivables.
Source: Own representation

In the table with the results of the simulation forecast we find the answer to the question: "By how many days on average can we extend the payment terms of our customers in order to be

90% sure that we will have a positive cash balance on the balance sheet date? (in other words, with an acceptable insolvency risk of 10 %)". The answer is: 10 days.

Recommendations

Therefore, in order to fulfil the task of optimising working capital (here only in the area of payment of trade receivables), the analysed company should take measures to negotiate with its customers shorter payment terms of receivables by at least 10 days. Shortening the time of receipt of payment by an average of 10 days (to the maximum acceptable payment term of 104 days) improves liquidity and reduces the risk of insolvency from 23% to 10% (by 13%). The probability of becoming insolvent is 10%, i.e. 90% of certainty of having a positive cash balance (more than 0) in 2021.

If it becomes possible to shorten the payment period by an average of 20 days, then we reduce the risk of insolvency to 5%.

It is also possible to reduce the risk to 3%, but then the payment period would have to be shortened by an average of 30 days, which may prove difficult or even impossible under current market conditions.

On the other hand, if we grant our counterparties a deferral of payment of 30 days on average, our insolvency risk increases to a level of 36% (which only results in a probability of 64% that we remain liquid).

In order to optimise liquidity and working capital management, the parameters of the other ratios should also be reviewed to find optimal payment terms for trade payables and inventory turns that mitigate insolvency risk in the future to an acceptable and expected extent.

However, it may turn out that little can be done to optimise working capital, in which case it is very valuable to know what the probability of insolvency is and to take other measures in terms of liquidity management. If we know several months in advance that there is a significant risk of insolvency and we have a tool to quantify that risk, then it is realistic to apply for a loan or seek other sources of funding before the business runs into financial difficulties.

To simplify the above example of applying Monte Carlo simulation, we have assumed variability only in relation to the settlement of trade receivables and continuation of the existing policy in relation to other elements of working capital management.

In business practice, the liquidity model should be applied comprehensively. It is recommended to test the impact of changes in all input variables, both individually and collectively (i.e. working capital, sales revenue and market risk indices), on the cash balance at a given date, assuming stability or variability of individual parameters and quantities of the model input variables. It is possible to completely exclude input and output variables from the simulation if we assume that a change in these values will not significantly affect the forecast.

Wider use of Monte Carlo simulation

Quantitative risk management methods, one example of which is Monte Carlo simulation, can be used to create various predictive models (both simpler and more sophisticated) that will be a useful tool in your daily work.

The liquidity model as presented can be extended and modified for the needs of individual organisations. It is possible to introduce other important input variables into the model, such as risk matrix and its impact on the parameters of the financial statements or individual cost items of the operational activity.

The number of possible forecast output parameters can be greater than one, so that in addition to the forecast present value at the end of the balance sheet year, the result from operations (EBIT), net profit or other relevant key performance indicators (KPI) can also be simulated in one simulation run. Furthermore, the simulation can be extended in time, e.g. over several reporting periods.

Conclusions

The liquidity model is a tool that supports controllers and companies not only in liquidity management, but also in financial planning and optimisation of investment projects. Rebuilt and adapted to the individual needs of the organisation, it enables expected operating results or other measures of effectiveness to be achieved in a way that maximises the desired effects.

A planning model that includes all planning assumptions about sales, cost items, investments, working capital or possible risk effects can be easily revised using Monte Carlo simulations. Since the simulation takes only a few minutes, important input variables can be tested for sensitivity and quickly adjusted as much as possible in preparation for detailed planning. Controllers can simulate thousands of possible scenarios and select more realistic ones, knowing the degree of probability of occurrence.

With a tool to monitor the results of changes in working capital management policies (discussed in this article), it is possible to check the impact on the main balance sheet items in a very short time.

No statistical expertise is required to use this simulation method. Controllers have sufficient competence and knowledge resources to apply quantitative risk management methods in their daily work.

If you would like to expand your knowledge with the described financial planning model, build simulation models or apply quantitative methods in practice, please contact me:

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