The Integrated Financial Model and the use of Growth Patterns in Monte Carlo simulation Risk Analysis

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ABSTRACT

Through this paper the author highlights the importance of constructing an integrated financial model and in using growth patterns in projecting the key parameter projections to generate consistent and meaningful scenarios during a Monte Carlo simulation risk analysis application and to avoid and contain the correlation problem. The Integrated Financial Model© by Savvakis C. Savvides was created and tested after many years of expertise of the author in corporate lending and project finance as well as from teaching investment appraisal and risk analysis and the development of several related software. It is argued that to apply Monte Carlo Simulation Risk Analysis in a meaningful manner and to enhance the decision-making process the methodology should not be used "as a toy" but rather in a thoughtful manner that takes into consideration all aspects of a prudently constructed business plan and as this is manifested through an integrated financial model. The use of growth pattern functions for the key risk variables is essential so as to contain the correlation problem and for the simulation to be based on consistent and realistic scenarios.

Keywords: Market analysis, quantity demanded, elasticity of demand, project evaluation, market segmentation, market penetration.

JEL Classification: D11, D61, H43, L21, M31

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Introduction

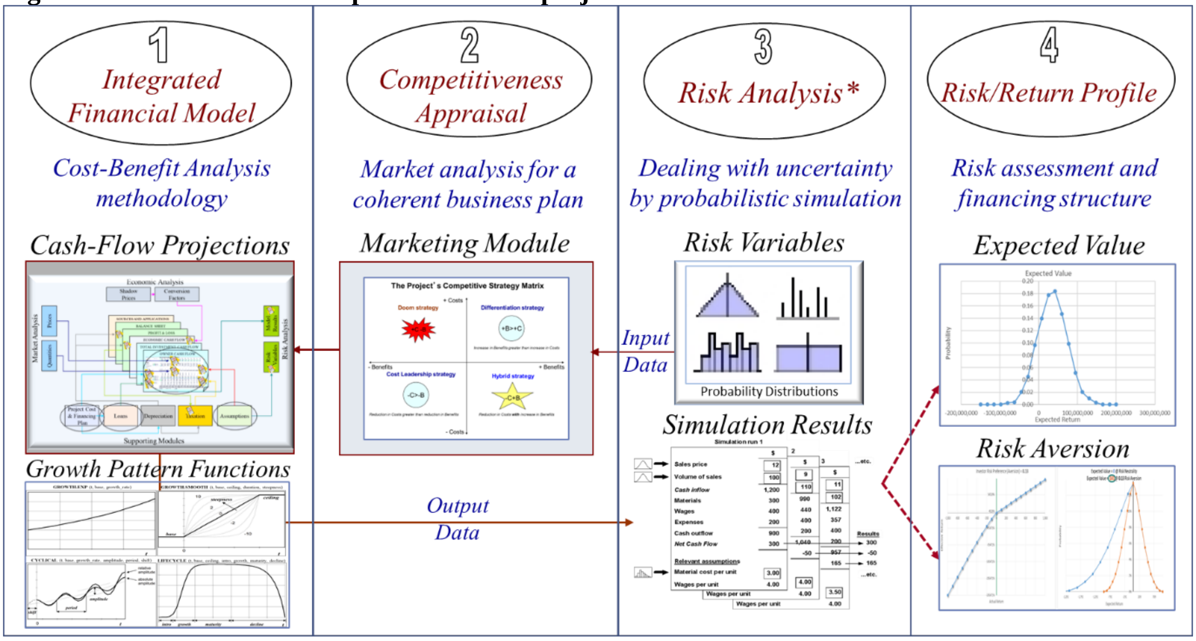
If there is one thing we know for certain, this is that there is nothing certain regarding the future. We simply cannot foresee the future. There is no crystal ball that can show us even a mere glimpse of what will take place at some time in the future. But what we do however does affect what and how the future develops for us and others that are affected by our plans. And we can learn from the past to gain a good idea of what under normal circumstances we may expect to happen if we repeat such actions at future time. But in an ever-changing world, even that is not a certainty. And yet, when we project our assumptions as they may affect a given business plan as if we expect them to take place with absolute certainty and that the outcome will be as we expect and calculate in our projections. In effect, whether we realise this or not, we attach to each input projected in a given, financial or other, model to a single-value probability distribution. In other words, we presume that all we project will happen with 100% probability and with no possible deviation. This is why the outcomes projected are also deterministic and presented as certainties. In effect this means that if we were to use Monte Carlo simulation methodology to run probabilistic scenarios using this certainty equivalent single-value probability distributions for each variable the scenarios that we will be generating will all be identical and the same.

We can obviously improve our understanding of risk and what may happen in the future of any such financial model of a projected business plan by varying our assumptions through relaxing the single-value probability for those parameters we consider to be risk variables. Indeed, many applications using a Monte Carlo risk analysis software are used in this manner. The result is of course that we end up with multi-value probability distributions for the selected outcomes of interest in the projected model.

A Monte Carlo simulation app can and sadly is sometimes used as a toy or in a manner so as to gain a better understanding of a given project venture. One that merely gazes at the results arrived at from any of the two approaches possible will hardly be able from these alone to tell the difference. This is about how to use Monte Carlo Simulation risk analysis so as to enhance one's understanding of the project and make better and wiser capital investment decisions.

The assessment of risk and return in capital investment entails more than just the projection of single-value expected revenues and costs. One needs to be applying the correct Cost-Benefit Analysis methodology but also to be employing an integrated financial model ([1] in Figure 1) where the details take second place to the competitive strategy of the project in its defined relevant market and targeted customers. This is done through a coherent Competitiveness Appraisal ([2] in Figure 1). The integrated financial model is also a necessary condition for projecting and maintaining consistency in one's assumptions when switching from the deterministic base value case to the probabilistic multi-value risk variables in the context of a Monte Carlo simulation process ([3] in Figure 1). Finally, one needs to assess risk in the correct context of Expected value [4] rather than in the historical volatility measures that are typically gathered and viewed from the floor of a stock exchange. A prudent risk assessment will also form the basis for arriving to an appropriate financing structure for a viable capital investment project.

Figure 1 - The evaluation of capital investment projects and the assessment of risk



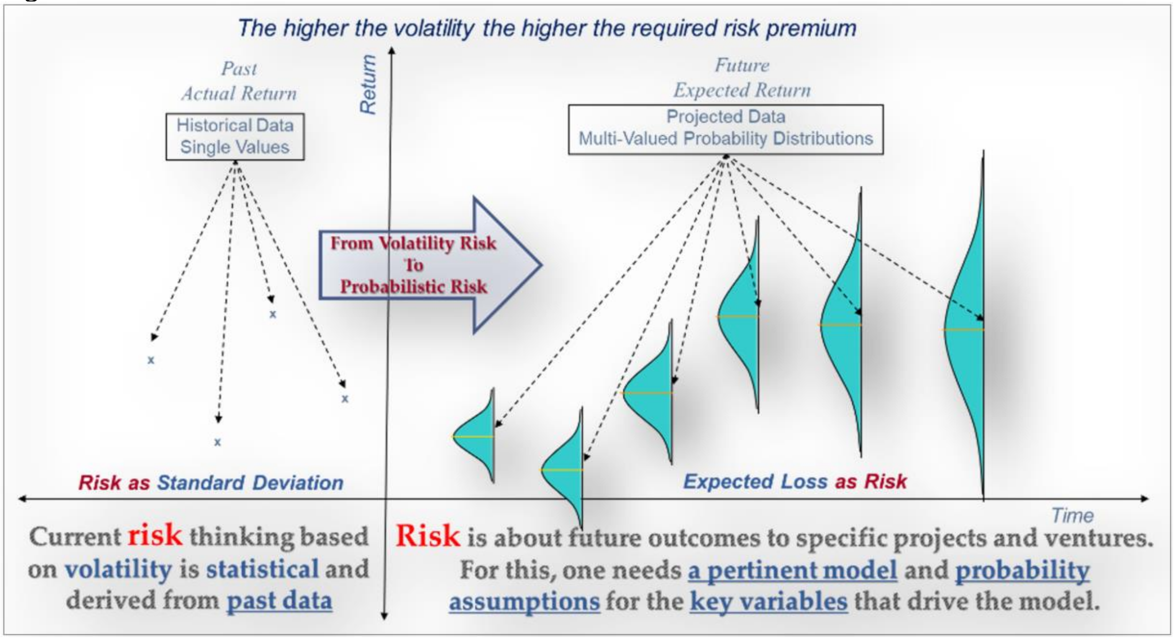
What is project risk and how to measure it

What is *really risk* and how it may be measured and be applied in capital investment and project finance decisions. Many project finance professionals are not at ease in accepting that "*volatility*" is a good or even an adequate description of what is capital investment risk. It is proposed that the use of Expected Value and more specifically *Expected Loss* as a *measure of risk* and as outlined in my published paper on Risk Analysis be applied through pertinent probabilistic appraisal using software such as *RiskEase*[1]. Through this methodology it is also possible to undertake Risk Aversion analysis and consider the capacity of a given project to meet and satisfy investor risk preferences.

When we describe the past, the more detail we provide the more accurate we become. When we try to predict the future however, the more detail we attempt to carry forward from the past the less likely we will be to capture the essence of what may happen and to properly assess the risks. The future is uncertain. And no matter what people may claim, no one can predict the future. The best we can do is to assess in probabilistic terms on what we may expect to happen with respect to a given business plan we may have in mind to implement. Moreover, the longer into the future we look the wider the margins of uncertainty become and the probability distribution of the outcome we try to gauge and measure (Figure 2).

[1] Using *RiskEase*© software, by RiskEase Ltd (www.riskease.com).

Figure 2 - The Future is Uncertain and the Assessment of Risk is Probabilistic



Probabilistic analysis using Monte Carlo simulation is a necessary but not sufficient condition to properly assess a capital investment. To analyse and assess project risk one needs to have:

A simple, coherent, and fully **integrated financial model** which:

- applies the correct **cost-benefit analysis** methodology
- accommodates a **competitiveness appraisal**
- reliably **facilitates probabilistic risk analysis** (remains consistent and maintains its predictive ability in a Monte Carlo Simulation test).

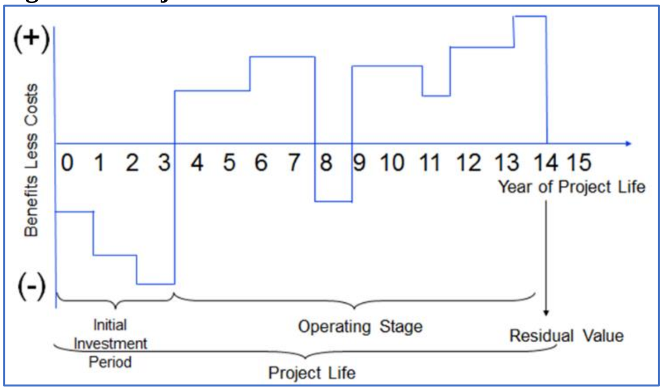
Therefore, before applying a sound and all-encompassing Monte Carlo simulation risk analysis, it is imperative that one employs an adaptable but fully *integrated financial model*. There are three essential requirements for this to happen which will be presented and discussed below:

1. It should apply the correct ***cost-benefit analysis** methodology and*
2. *Be **complete** covering all constituent parts of a comprehensive appraisal but remain simple and easily driven within an **integrated financial model***.
3. It must be modelled in a manner so that coherent and consistent scenarios will be generated during a simulation. To achieve this one needs to employ ***growth patterns** and **correlation settings** for the key risk variables*.

Cost-Benefit Analysis

The project net cash flow (benefits – costs) typically shows negative net cash flow for the initial years (as it is mostly the cost of the capital investment) and positive ones following the operational years as is resembled in the example in Figure 3. There is also a residual value collection at the assumed end of the life of the project.

Figure 3 - Project Net Cash Flow Profile



The Cash Flow projections can be drafted from different perspectives as they affect various stakeholders in a capital investment.

Project Stakeholders and Alternative Points of View

In a capital investment project, there are often more than one stakeholder involved. Particularly in capital investments for the public sector or in Public Private Partnerships (PPPs) one must evaluate the return and risks that may arise to different parties. It is therefore imperative to distinguish this and evaluate the cost and benefits of a planned investment that may accrue to the main stakeholders. The most common cash flow perspectives are:

a. Point of view of **Owner** (includes loans and repayments in the cash flow)
b. Point of view of **Total investment** (or *Banker's point of view*) which assumes that capital investment is financed completely through equity.
c. Point of view of **Economy**

Other examples of project perspectives that one may construct cash flows for are the government budget view, suppliers of inputs view and downstream processor's view. A well-balanced stakeholders' analysis of the different perspectives will highlight where and to whom the benefits and costs may accrue to. It can also form the basis on which the risks may be allocated to those parties involved in the project that are best fit to manage them.

Figure 4 - Analysis of Investment from Different Viewpoints

Analysis →	Financial				Economic	
Viewpoints:	Total Investment (Project) (A)		Owner (B)		Country (C)	
Year:	0	1	0	1	0	1
Receipts		400		400		440
Operating Cost		-140		-140		-150
Equipment	-1000	950	-1000	950	-1100	1045
Operating Subsidy		50		50		
Taxes		-100		-100		
Loan			500	-500		
Interest				-50		
Environ. Externality						-190
Opp. Cost of Land	-30	-30	-30	-30	-30	-30
Net Resource Flow	-1030	1130	-530	580	-1130	1115

More specifically the following will be referred to as they relate to the Cash Flow projections:

Residual Values (Cash Inflows)

- Buildings, Electromechanical, Furniture and Fittings, etc.
- Land

Assets Values (Cash Outflows)

- Buildings, Electromechanical, Furniture and Fittings, etc.
- Interest During Construction
- Land

Adjustments for **Working Capital**

- Accounts Receivable
- Accounts Payable
- Cash at hand

Outcomes (*Model Results*) of Financial Model

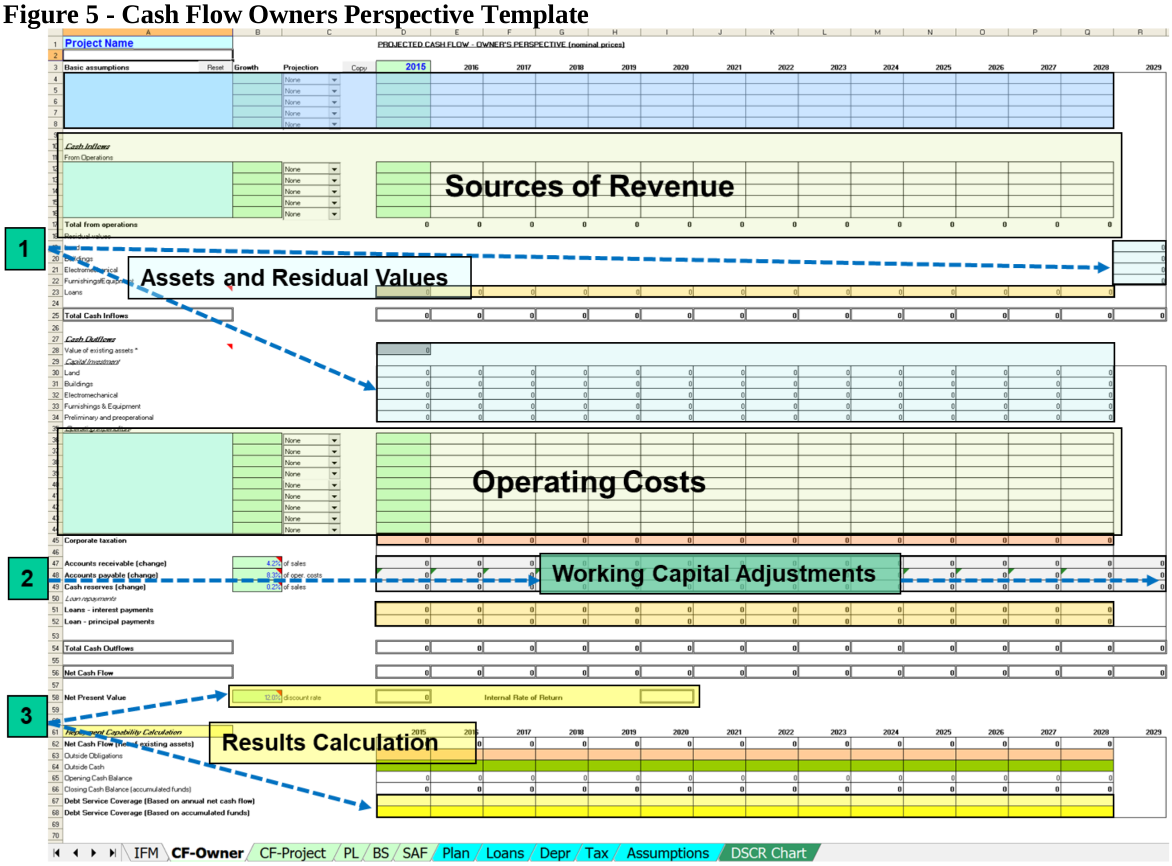
- Net Cash Flow
- Discounting Cash Flow: NPV and IRR
- Debt Service Coverage Ratios (Annual)
- Debt Service Coverage Ratios (Accumulated)

Cash Flow Statement Structure and Derivation

The Cost Benefit Analysis methodology is well-documented and is being applied for over 60 years effectively worldwide to identify viable capital investment projects. The Cash Flow from Owner's perspective is the fundamental core view as it gathers all inputs in a financial model and forms the basis from which to generate the cash flow for the "Total Investment" or "Economy's" perspectives. The Total Investment view is essentially the Owner's perspective cash flow without the loans as inflows and the repayment in terms of interest and principal as outflows as it is assumed that the investment is wholly equity financed. The Total investment perspective cash flow projections can then subsequently used as a basis to construct the Economy's Cash Flow which entails the calculation of Economic shadow prices [1].

The Cash Flow Owner's perspective (CF-Owner) integrates the inputs of a Financial Model. As such it will be discussed and used to demonstrate the *Integrated Financial Model* (IFM). It connects and links to all other inputs and supporting modules. More specifically the settings for the following items in the derivation of a Cash Flow Statement will be referred to discussed (Figure 5).

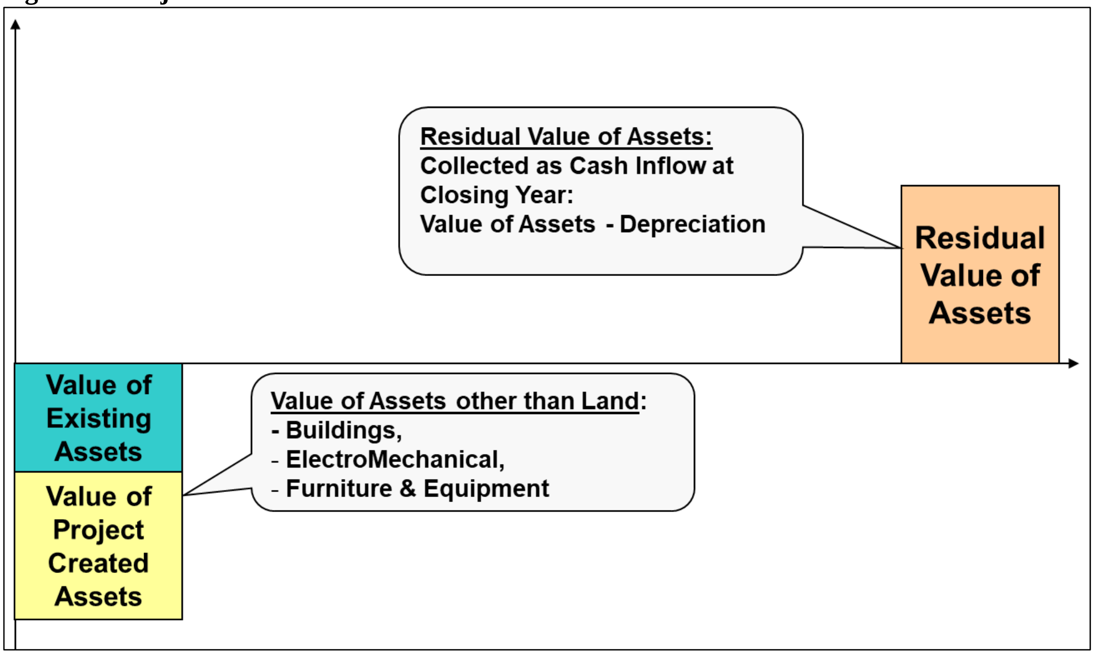
Figure 5 - Cash Flow Owners Perspective Template



1. Assets and Residual Values

- Buildings, Electromechanical, Furniture and Fittings, etc.
- Land

Figure 6 - Project Assets and Residual Values

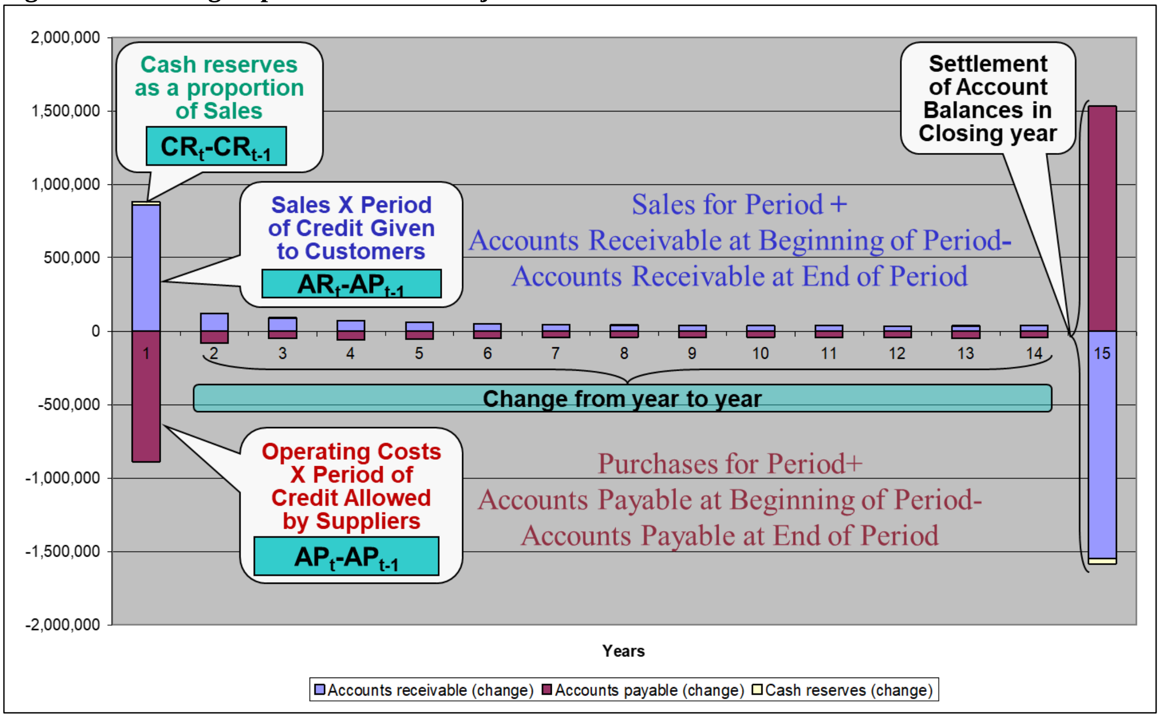


The Value of the Land must be "collected" as residual value at the end of the projection period at the same real cost it went into the cash flows as cost at the beginning of the period. In nominal terms, adjusted for inflation only.

2. Adjustments for Working Capital

- Accounts Receivable
- Accounts Payable
- Cash at hand

Figure 7 - Working Capital Cash Flow Adjustments



3. Outcomes (Model Results) of Financial Model

- Net Cash Flow
- Discounting Cash Flow: NPV and IRR
- Debt Service Coverage Ratios (Annual)
- Debt Service Coverage Ratios (Accumulated)

Figure 8 - CF-Owner Report Outputs (Model Results)

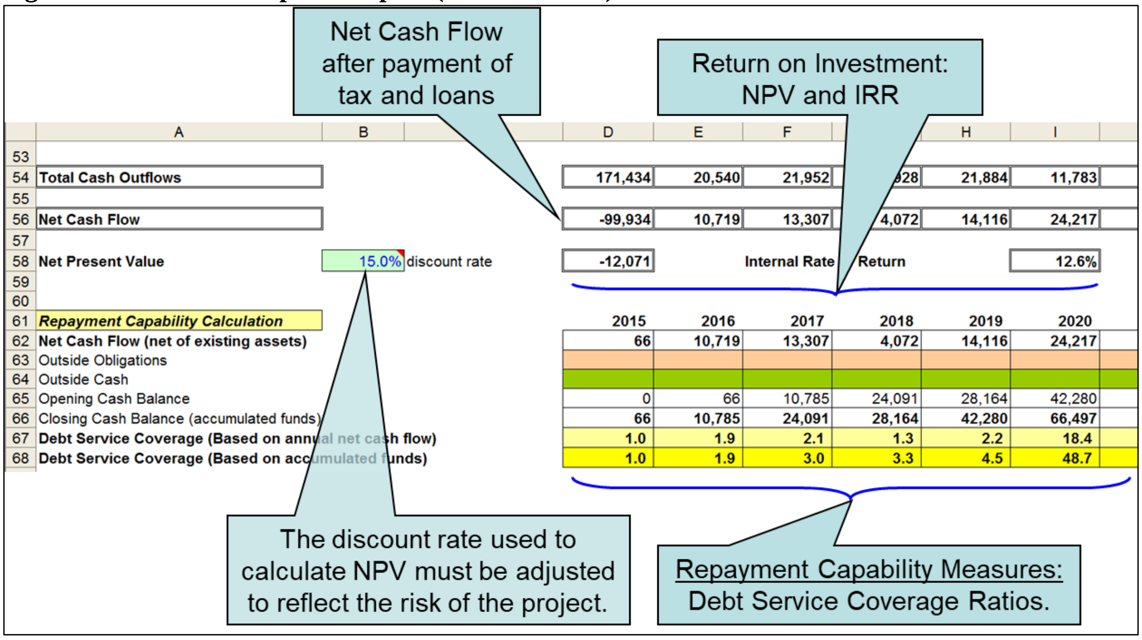


Figure 9 - Discounting and calculating NPV and IRR

Net Present Value (NPV)

$$\textbf{NPV} = \text{B-C} + \frac{\text{B-C}}{(1+r)^{\wedge}1} + \frac{\text{B-C}}{(1+r)^{\wedge}2} + \frac{\text{B-C}}{(1+r)^{\wedge}3} + \frac{\text{B-C}}{(1+r)^{\wedge}4}$$

Example of Discounting (10% Discount Rate)

Year	0	1	2	3	4
Net Cash Flow	-1000	200	300	350	1440

$$PV_{0.1}^{0} = -1000 + \frac{200}{1.1} + \frac{300}{(1.1)^2} + \frac{350}{(1.1)^3} + \frac{1440}{(1.1)^4}$$

NPV 676.25 = -1000.00 + 181.82 + 247.93 + 262.96 + 983.54

Internal Rate of Return (IRR)

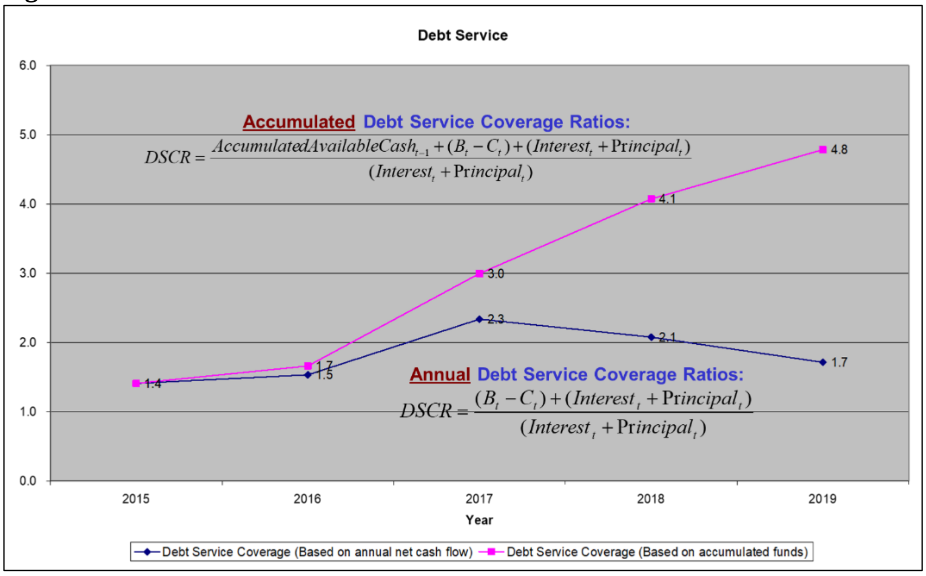
$$\textbf{IRR formula} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+K)^t} = 0$$

IRR is the discount rate (K) at which the present value of benefits are just equal to the present value of costs for the particular project.

Note: the IRR is a mathematical concept, not an economic or financial criterion

The Debt Service Coverage Ratios (DSCR) measure how well the project can cover its loan debt in paying interest and principal at the year it becomes due. The Annual DSCR in effect calculates how much cash-flows generated by project activities in the current period are higher than the debt service (interest including fees + scheduled principal) that is due in the same period. The Accumulated DSCR adds up the cumulative available net cash flows for the same period.

Figure 10 - Debt Service Ratios



Interest During Construction

Any interest that is paid during the construction phase of a project. Interest paid during construction period is often not deductible immediately as an expense. When is not immediately deductible as an expense it is added to the cost basis of the building instead and depreciable during operation of project for both taxation and financial reporting. For this reason, it is also known as capitalized interest.

The integrated Financial Model

The Integrated Financial Model (IFM) emerged from the need to have a coherent, manageable, and fully integrated financial model which can be used in risk analysis of capital investment projects and in credit risk assessment applications by means of software that employ the Monte Carlo Simulation methodology (such as *RiskEase*© by RiskEase Ltd). The biggest obstacle one faces when attempting to relax the deterministic assumption behind single-value forecasts included in a cash flow projection to assess risk, and in fact in any other type of deterministic model, is the problem of correlation and how to deal with it. This in effect means that the financial model one builds must be able to withstand the effects of changes in the driving input parameters arising from the multi-value probabilistic assumptions made while also maintaining its internal consistency generating realistic scenarios. A generation of scenarios during a simulation using a model that that does not provide for this and does not adapt to these changing values during a simulation process is likely to lose its forecasting ability. In fact, if not dealt with sufficiently well it is likely to introduce enough bias in generating unrealistic projections that would probably outweigh any benefits to be derived from a Monte Carlo type of probabilistic assessment of risk.

To give an example, suppose one builds a model to evaluate the investment return of a new business venture. In fact, what he is putting together on a spreadsheet is one out of countless possible scenarios, which may be described as the base case scenario. To measure risk, one needs to explore in a consistent and systematic manner what the model predicts if there is, as it is expected, some variability in the basic parameters driving the business model. This is why an integrated and simple financial model is necessary as a tool to assess risk. Consider a typical forecasting spreadsheet model of prices and quantities as shown in the table below:

Table 1: Projecting Cash Flows

Year	1	2	3	4	5
Number of widgets sold	100	120	130	140	150
Price	10	10	10	10	10
Revenue	1,000	1,200	1,300	1,400	1,500

The scenario shown in Table 1 above may be a reasonable one as a deterministic base case model. The analyst inputs some numbers in a spreadsheet as "best estimates" of quantities and prices to assess the amount of revenue he can expect from a business. Leaving aside for a while that sales depend on a host of other variables in the marketing mix of the company, such as the product features and its appeal to the targeted market, the advertising and promotion employed and the distribution channels available and even *how competitive* these products and prices are in the market (Savvides 2000), from a purely numerical point of view there is a real potential problem when one tries to replace deterministic with probabilistic values in the model. And that is that the inferred relationship in these parameters and values of a base case model will most likely be violated. The projection of sales of 120 units in year 2 in the above example is a reasonable one only if the attained sales in year 1 are 100 units (or thereabout). What happens however when we project that it is in fact possible that sales in year 1 can be as low as 50 units and as high as 150 units? Is the projection of 120 units in year 2 still pertinent if sales in year 1 are 70 units? Most probably not. There is an inferred relationship, or pattern if you prefer, that must be maintained when one relaxes the certainty equivalent assumptions for the purpose of assessing risk through simulation. The financial model should be capable to withstand such arduous tests. To take the above example one step further, are the prices which are assumed to be reasonable in the deterministic base case scenario still relevant when units sold in year 1 are way below expectations? Wouldn't a sounder and more coherent model adjust prices (and possibly other marketing mix variables – such as promotion) in year 2 and beyond to reflect the fact that sales are way below the viability threshold? Price in year 2 would most likely need to be reduced and promotion and distribution spending should increase (in a cost-effective manner) to generate a higher volume of sales in the future.

The point should be clear that the financial model must be maintaining its integrity and validity during the simulation process. To attain this, the model must be driven consistently through defining correlation settings but also realistic growth patterns and relationships between the key risk variables. Ergo, the need to put together an integrated financial model that applies the correct cost-benefit analysis methodology but also one that is also comprehensive in that it includes all modules and reports necessary in an appraisal of an investment. Moreover, it should be a financial model that uses *growth patterns* in the projection of key risk variables so as to generate consistent scenarios as these may arise from relaxing the deterministic assumptions and replacing them with multi-value probability distributions in the context of a Monte Carlo methodology. It should be a model that not only is *complete* and applying comprehensively the correct cost-benefit methodology but also *simple* and easily *adaptable* and ready to be re-employed as a front-end in many different types and sizes of capital investment projects[2].

[2] For an understanding of the framework for assessing credit risk in corporate lending read, [5] Savvides, Savvakis C. Corporate Lending and the Assessment of Credit Risk, Journal of Money, Investment and Banking, Issue 20, March 2011.

A complete, simple, and adaptable financial model

The Integrated Financial Model© (IFM) developed by RiskEase Ltd was prepared and tested in many projects, large and small and across many sectors, industrial, retail, infrastructure, small businesses. The philosophy of this approach is that, no matter how much detail and complexity there is in a spreadsheet (usually prepared by big house name consultants) the IFM can be attached over other more detailed workbooks and with the appropriate links in place put order on top of chaos. The complex detailed model will in effect become a feeder data sheet to the more familiar and fully integrated financial model that sits on top of it when the two workbooks are put together. Analysts can further enhance and develop their skills in this respect through studying several case studies and by actual fieldwork in project finance and credit risk assessments. An overview of the Integrated Financial Model (IFM) is illustrated in the Figure 11:

Figure 11 - The Integrated Financial Model (Design and Structure)

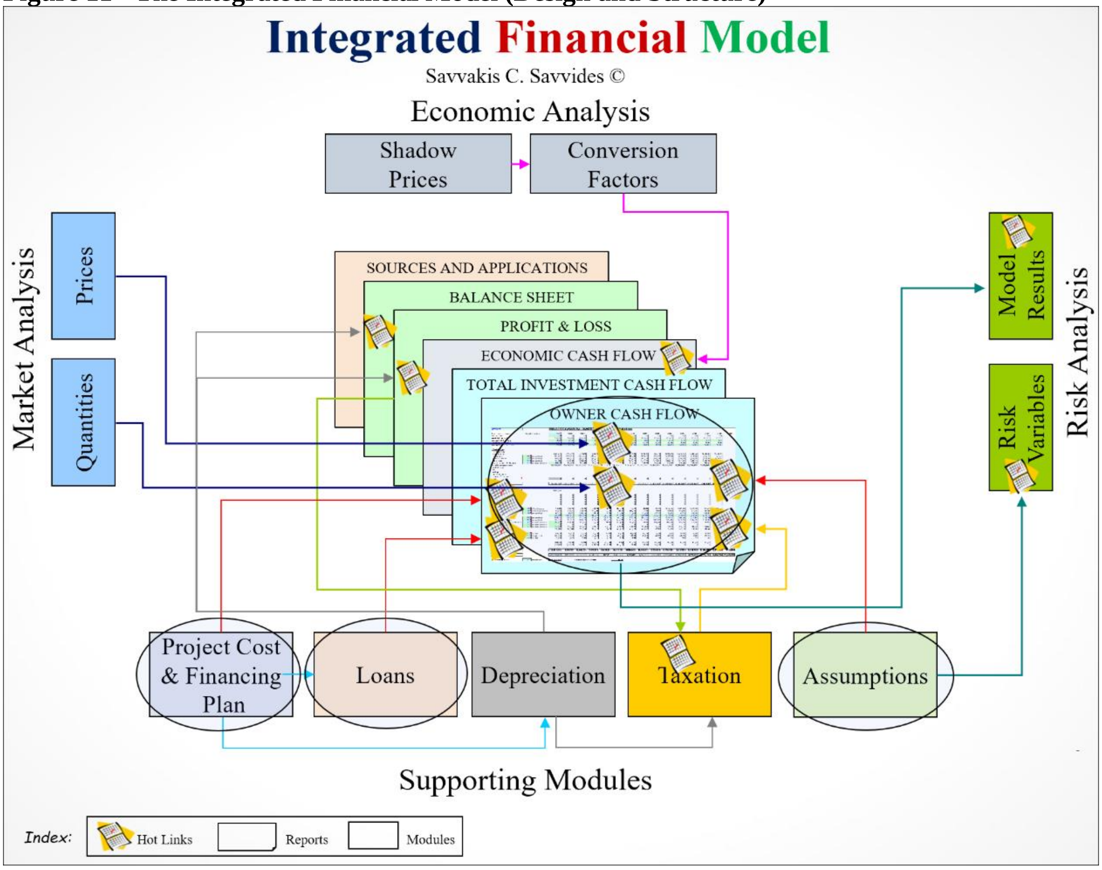
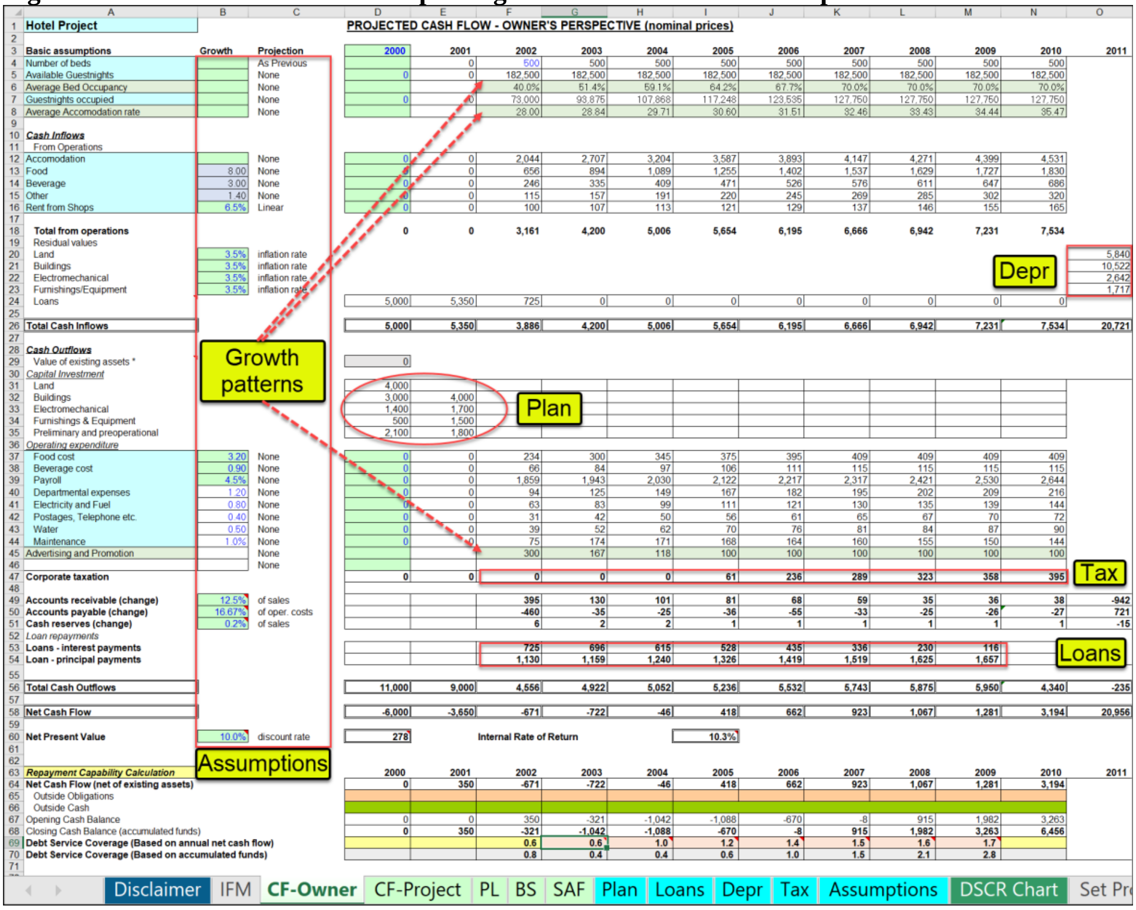


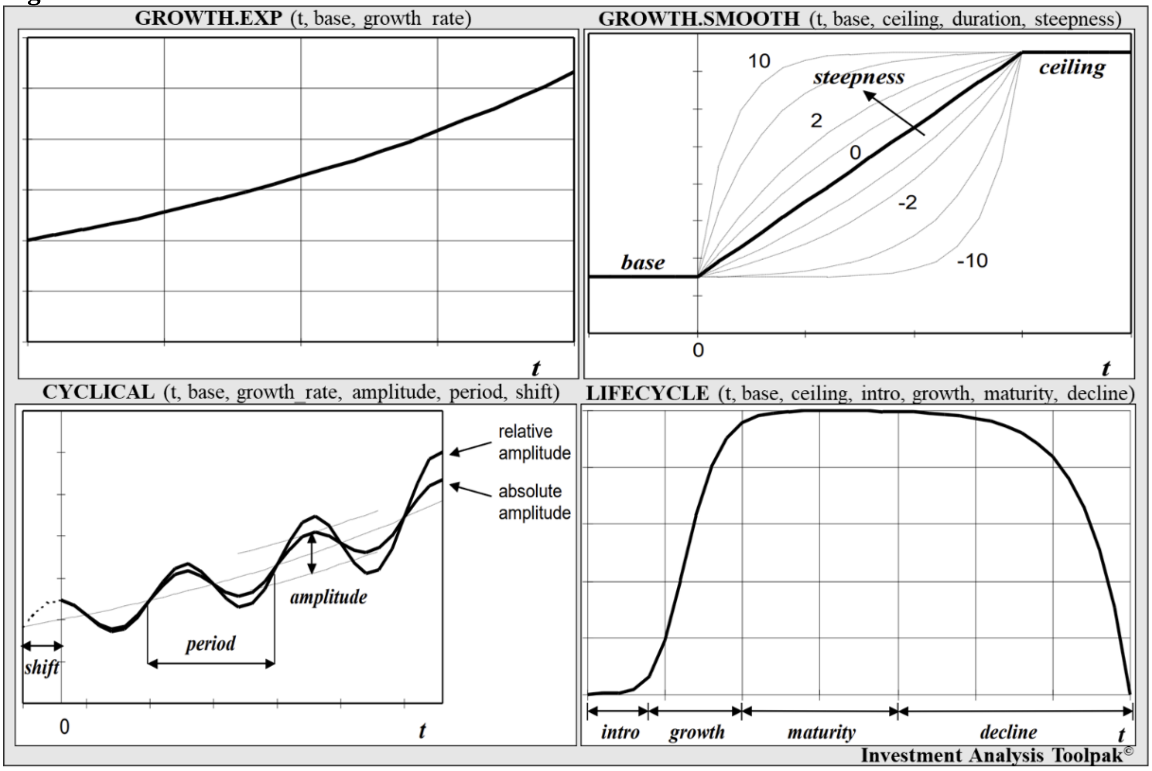
Figure 12 - Links to Source Sheets Updating the Cash Flow Owner Template



Growth patterns and correlations

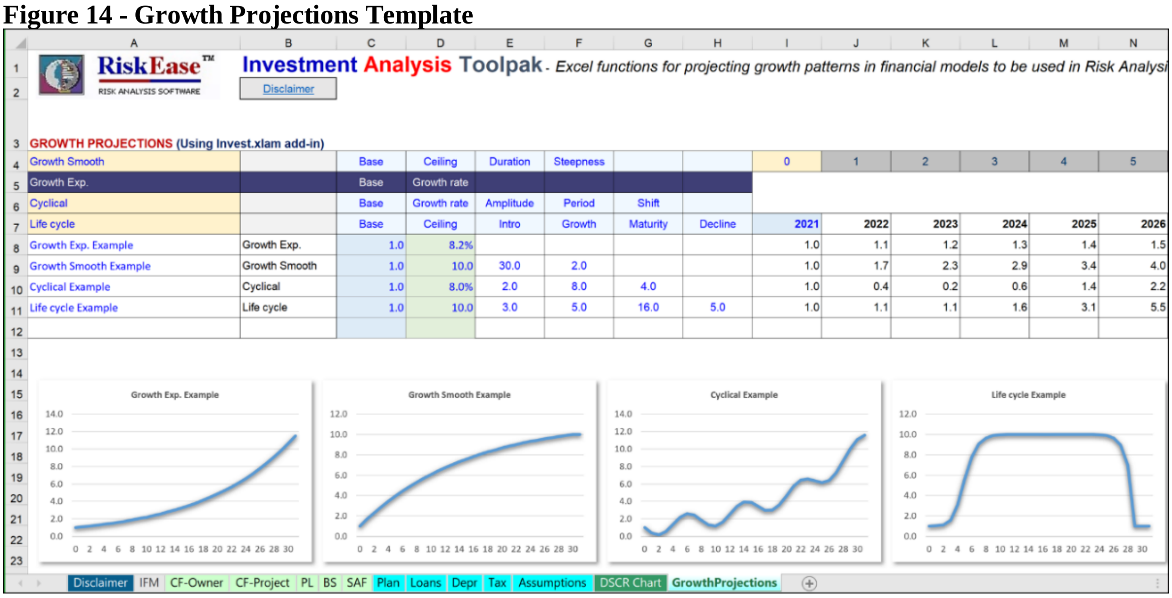
The Investment Analysis Toolpak© is a collection of freeware add-in functions that one can use to define and project growth patterns in a financial model. They are included with RiskEase© Monte Carlo Simulation software and can be freely passed on with any workbook that uses them. They can easily be defined using only a few parameters as shown in Figure 13. They can then be copied and applied over the extent of periods in the projected cash flows.

Figure 13 - Growth Pattern Functions



There is also a Template on which one simply selects the function and then enters the parameters that will define the growth pattern to be applied as shown in Figure 14.

Figure 14 - Growth Projections Template



A	B	C	D	E	F	G	H	I	J	K	L	M	N
Growth Smooth		Base	Ceiling	Duration	Steepness			0	1	2	3	4	5
Growth Exp.		Base	Growth rate										
Cyclical		Base	Growth rate	Amplitude	Period	Shift							
Life cycle		Base	Ceiling	Intro	Growth	Maturity	Decline	2021	2022	2023	2024	2025	2026
Growth Exp. Example	Growth Exp.	1.0	8.2%					1.0	1.1	1.2	1.3	1.4	1.5
Growth Smooth Example	Growth Smooth	1.0	10.0	30.0	2.0			1.0	1.7	2.3	2.9	3.4	4.0
Cyclical Example	Cyclical	1.0	8.0%	2.0	8.0	4.0		1.0	0.4	0.2	0.6	1.4	2.2
Life cycle Example	Life cycle	1.0	10.0	3.0	5.0	16.0	5.0	1.0	1.1	1.1	1.6	3.1	5.5

These patterns can then be applied to a cashflow projection as demonstrated in Figures 15 and 16.

Figure 15 - Projecting Growth

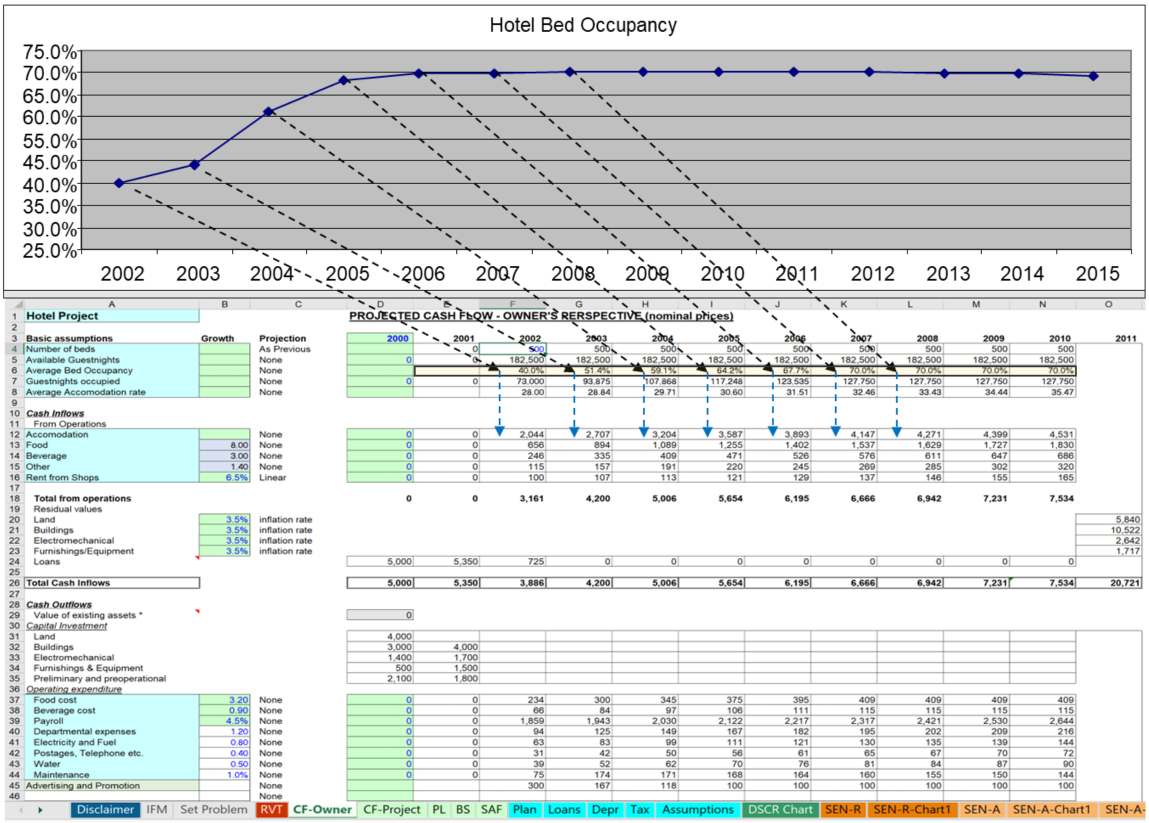
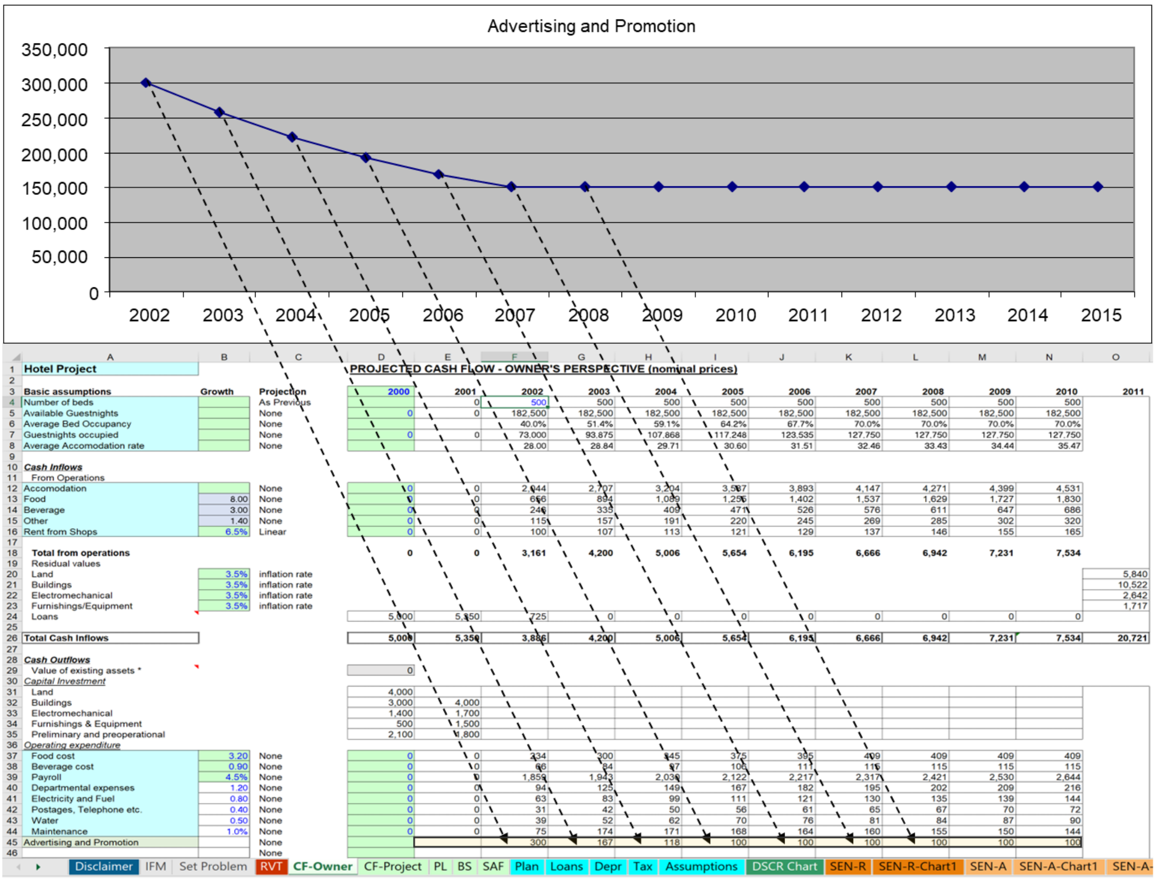


Figure 16 - Projecting Negative Growth



The growth patterns thus defined and which are driven by only a few key parameters that can then be defined as risk variables in a Monte Carlo simulation can also be correlated as such through the Risk Analysis software in use where an appropriate relationship between such variables is expected to exist (such the inverse correlation between Prince and Quantity of a product). As demonstrated in Figures 17 and 18, by inversely correlating "Accommodation rates" growth rate with "Occupancy rates" ceiling.

Figure 17 – Parameters of Projected Patterns

GROWTH PROJECTIONS (Using Invest.xlam add-in)

Growth smooth	*Growth projection*	*Base*	*Ceiling*	*Duration*	*Steepness*		
Growth Exp.	*Growth projection*	*Base*	*Growth rate*				
Cyclical	*Growth projection*	*Base*	*Growth rate*	*Amplitude*	*Period*	*Shift*	
Life cycle	*Growth projection*	*Base*	*Ceiling*	*Intro*	*Growth*	*Maturity*	*Decline*
Occupancy	Growth Smooth	40.0%	70.0%	5	2		
Accommodation Rates	Growth Exp.	28.00	3.0%				

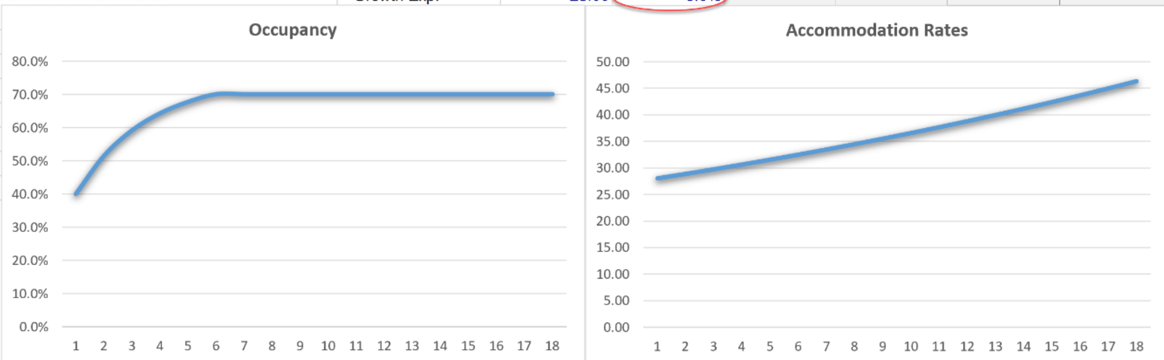
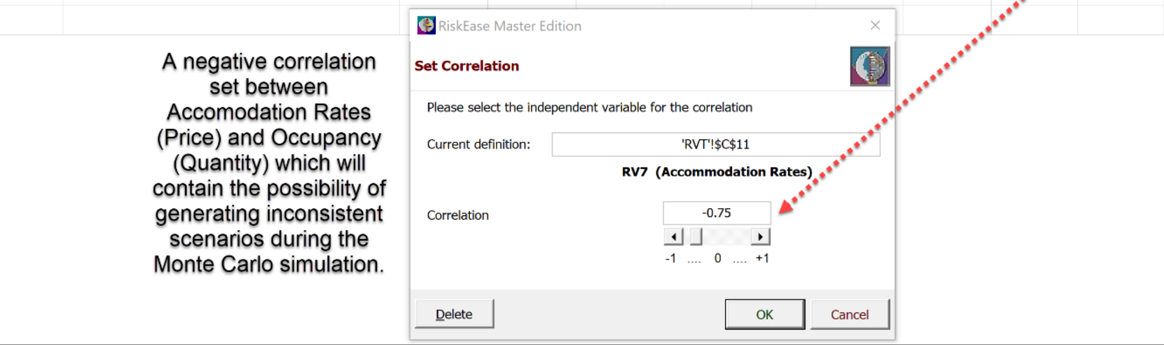


Figure 18 - Correlating driving parameters of growth patterns defined as risk variables

Risk Variables Table

RV No	Risk Variable Description	Base Value	Prob. Distr.	Range Min	Range Max	Para-meter	Truncation Min	Truncation Max	Correlations Ind. Var.	Correlations r [-1..1]
1	Growth factor - Labour Inflator	4.50%	UNIF	3.00%	6.00%	30/70				
2	Domestic Inflation	3.50%	STEP	1.00%	5.00%	4				
3	Food Revenue per guestnight	8.00	TRNGL	5.50	10.00	44%				
4	Beverage Revenue per guestnight	3.00	TRNGL	2.00	4.50	-33%				
5	Occupancy	70.0%	NORM	50.0%	85.0%	47%			RV7	-0.75
6	Occupancy - Steepness	5	NORM	3	6	47%				
7	Accommodation Rates	3.0%	NORM	0.5%	4.5%	36%				



As such, the scenarios created during the simulation process will remain consistent and coherent with what may be expected to be a realistic set of circumstances. If this is left unchecked and not catered and contained in this manner it is almost certain that the Monte Carlo Simulation will not generate realistic scenarios of what may happen if the modelled business plan reflected in the cashflow projections is applied in real life.

Conclusion

Monte Carlo simulation is the only way one can attempt to gain an understanding of what to expect from a given business plan. No one can predict the future as it is by definition uncertain. But it is possible with prudent and comprehensive analysis to take correct decisions as they relate to capital investment. Monte Carlo can be useful if employed correctly but it can also lead one to the wrong decisions if used as a toy.

One needs first and foremost to apply the correct *cost-benefit analysis methodology* in the framework of an *integrated financial model* that projects cashflows and calculates correctly the return and debt repayment capability of the project. Secondly, it is imperative to study the *market and competitive environment* that a given project will enter into. There is no substitute to real and diligent thinking that must go into the creation of a sound and valid business plan which is likely to create a sustainable competitive advantage for the intended capital investment. It is necessary but not sufficient to consider the competitive environment and identify a market performance gap that the project can exploit. It is also necessary to quantify the assumptions in the form of cashflow projections and within this framework to identify and define the *key risk variables* that drive the financial model. Hence, one should define the margins of uncertainty by setting probability distributions that capture the range and probabilities for the identified risk variables.

There is however one further issue that is often overlooked. And this pertains to how the scenarios generated during a simulation may remain realistic and relevant. Monte Carlo simulation is a mechanism that simply selects inputs from a range of multi-value probability distributions defined for the key risk variables in the financial model and records the outcome with respect to the model results that are defined (such as the return and debt service year be year). It does not automatically create consistent and realistic scenarios during a simulation. On the contrary, if left unchecked and uncatered for, it will almost certainly create inconsistent and unrealistic scenarios. The Monte Carlo software employed will still generate probability distributions of the recorded outcomes from any simulation. But it will not be apparent that these may have arisen from inconsistent simulation scenarios.

State of the art Monte Carlo simulation software allow the user to *set correlation conditions* between the defined risk variables. However, this is not enough for ensuring consistency in the projections during a simulation. To achieve this, it is vital to set growth patterns with only a few parameters defined and driving the projection for some of the key risk variables. A set of typical functions that project these patterns enable the projection of such growth patterns which can then be correlated through the software by simply adding correlation coefficients to the driving parameter(s) of the defined functions (such as the *ceiling* assumed or the *growth rate* or even the *duration*).

To summarise, for a thoughtful assessment of risk in capital investment decisions on needs:

1. To understand and apply in the form of an integrated financial model the correct Cost Benefit analysis methodology.
2. To analyse the market that the project will enter and compete in is and to prudently study it arriving at an appropriate business plan.
3. To identify the key risk variables in the model and define appropriate probability distributions capable of capturing the possible range and risk associated to each.
4. To cater for correlations that may exist in the financial model and among the defined risk variables. The correlations problem has often been cited as the Achilles' heel of Monte Carlo simulation. If not catered for, it is more than likely that inconsistent and

unrealistic scenarios will be arise during a probabilistic simulation. To manage and contain it, it is not enough to just correlate any two or more risk variables. It is imperative to ensure that a projected pattern remains intact and consistent during the Monte Carlo simulation process.

5. It is therefore necessary to use growth pattern functions that drive the projections with a only a few key parameters. These key parameters can then be correlated in a Monte Carlo simulation software to ensure that two correlated projected patterns in the cash flow remain consistent creating coherent and realistic scenarios during a simulation.

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