Title: From a Business Idea to a Business Case: a Short Footpath

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1 Summary

This document illustrates the typical steps required to go from the identification of a possible business opportunity to its translation into the required engineering solutions and, finally, into a feasible business plan.
The immediate motivation for writing this document has been to provide support to students of capstone project disciplines such as *Projecto em Engenharia Electrotécnica, MIEET, UA*, https://www.ua.pt/pt/uc/2787 [2019-20].

2 Business Idea

For the purpose of this study, a business idea was imagined. It is, certainly, naïve, but provides a narrative (a "story") around which the basic concepts can be presented[1]. It is as follows:

Concept:

Imagine that a customer wants to buy a certain item, for example a jacket. The customer sees that jacket either at a shop or at an ecommerce web site and is inclined to buy it… but is not sure if the color and shape of the coat do combine well with some of the other clothes that the customer already has.
A group of young engineers thought that this situation could represent a business opportunity for a tool that would enable a customer to create animated visualizations of combinations of the item that raised his/her attention with other pieces of clothing. In this way it would be possible to preview how other items would match with the item of interest, enabling the customer to evaluate different visual effects and choose the one that is most within the dominant fashion standards or that most pleases his/her preferences.

Target Market:

The market (direct customers) to which this business idea is targeted is primarily formed by retail chains in the clothing, footwear and fashion accessories sectors. Some local independent retail stores of might also be part of the target market,
Europe will be the initial focus but later the company intends to operate worldwide.

To exploit this business opportunity, the above mentioned group of young engineers decided to create a company, ***Nice_Fit***, that will develop and commercialize a product with the characteristics presented above. This product will be named ***Dress_me_Up***.

[1] When reading this document, it is also recommended to look at the additional materials contained in Moodle relative to business modelling:
https://elearning.ua.pt/mod/resource/view.php?id=610185 (PEE- Moodle 2019-20)
https://elearning.ua.pt/mod/folder/view.php?id=504505 (PEE- Moodle 2019-20)

3 Characterization of the company to be created

3.1 Profile

Nice_Fit is a company whose main activity is the development and marketing of *Dress_me_Up*, a product supported by a set of technological solutions combining the following ingredients:

- Identification technologies such as RFID, bar codes and QR codes.
- Information systems integrating databases and video animations.
- Design of fashion, fashion forecasting and international trends identification.

The company seeks to maintain a relationship with their customers (from small retailers to big retail chains) over the complete life cycle of *Dress_me_Up*: sale, customization, configuration, deployment, maintenance, upgrading and updating).

Nice_Fit is located in Aveiro and has been formed by a group of young engineers that latter aggregated some additional elements from the areas of design and management. All come from the local University.

3.2 Vision and Values

Nice_Fit aims at having its products present in most fashion stores (clothing, footwear, accessories, etc), both at their physical locations and ecommerce platforms.

Nice_Fit main values are:

- To please both their direct clients (retailers) and the public at large.
- To contribute to the personal development of its employees through regular training and motivation benefits.

3.3 Mission

Nice_Fit mission is to contribute towards a more pleasant but also more responsible buying attitude, providing buyers with as much information as possible about the products of their interest.

Increased buyer satisfaction and more sustainable commerce are the key aspects of this mission.

3.4 Objectives

Nice_Fit central objectives are:

- To establish of a solid presence in the market of technological solutions for the support of the fashion retail sector.
- To build a relationship of trust with customers.

4 Business Model

4.1 Product and Value Proposition

The product delivered by *Nice_Fit*, named *Dress_me_Up* consists of a software application supported by a web based information system that enables customers in the clothing, footwear and fashion accessories sectors to create animated visualizations of the items in which they are interested, combined with other pieces of clothing. These previewing capabilities will enhance the satisfaction of both buyers and sellers, making the visit to a shop (physical or virtual) a pleasant experience and reducing the risk of post purchase frustrations and product returns.

4.2 Key Activities and Key Resources

4.2.1 Information System Component

The information system component of the product to be develop and marketed, *Dress_me_Up*, results from the combination of labeling and identification processes based on RFID, barcodes and QR codes with video and data bases. The resulting system enables a customer interested in a certain item to view different combinations of that item with others, corresponding, for example, to clothing or accessories that the user is not wearing that day, but with which he would eventually like to combine the item of potential interest. In this way the client can evaluate different visual effects and choose the one that most appeals to him/her or that is most within the dominant fashion standards. The customer can also discover visual effects that, otherwise, would escape his/her view.

4.2.2 Service Support Component

In addition to the *Information System Component*, *Dress_me_Up* also contains a *Support Service Component* which gives rise to a *Maintenance Contract*, an additional source of revenues for the company. This component of the business model corresponds to the provision of regular maintenance, updating and upgrading services, guaranteeing that installed systems run smoothly and are regularly feed with new items (articles clothing, footwear and fashion accessories).

Service support also includes hosting.

4.3 Interface with Customers

4.3.1 Target Customers

Nice_Fit has two main types of customers:

- Direct Customers:
  Direct customers are the retailers and retail chains that take the initiative of installing *Dress_me_Up* in their shops or in their ecommerce platforms.
- Indirect Customers:
  Indirect customers are the persons that buy articles in retailers shops or their ecommerce platforms.

4.3.2 Advertisement, Delivery and Customer Interaction Channels

The main advertisement, delivery and customer interaction channels will be the following:

- Live demonstrations on the premises of selected direct users (retailers).
- Live demonstrations in major fashion fairs.
- Live demonstrations in the public circulation spaces in major shopping centers.
- Web site.
- Publication of advertisements in some fashion magazines (under consideration).

Delivery channels will be built in partnership with local support companies (e.g. information systems installers, shopping systems installers, etc).

The product launch will be made in partnership with several brands of fashion products.

Direct customers (retail chains dealing with clothing, footwear and fashion accessories) in addition to the installation also receive training relative to the use of the system.

An 8h-to-20h call center will be available to provide assistance and support to direct users.

4.4 Company Build Up Strategy

4.4.1 Team

One of the priorities of the company will be to build a team of competent human resources, capable of transforming customer needs into competitive solutions.

Continuous personal development through training and production incentives will be promoted.

4.4.2 Key Competencies

The team will have the following main areas of competence:
• Information and identification systems (RFID, bar codes and QR)
• Fashion design
• Management (economics, finance, logistics, human resources)

4.4.3 Partnerships

Nice_Fit will be responsible for all software development and for the development and integration of technological solutions. However, several partnerships will be necessary in order to maximize the likelihood of success:

Strategic Partnerships:

A selected set of initial “seed” customers will be formed, which will receive pilot installations free of charge during their first year of utilization, so that they can familiarize themselves with the product and assess the possibility of adapting it to its needs in good conditions. It is expected that these “seed” customers will act as "spreaders" of the product, influencing other potential customers.

Operational Partnerships:

Nice_Fit will have to resort to several operational partnerships related to the following aspects:

- Rental of space and respective condominium costs, water, electricity, etc.
- Computer equipment suppliers and installers
- Office, furniture suppliers and installers.
- Telecommunications services and Internet access providers and installers.
- Logistic operators, mainly, carriers.

4.5 Cost Benefit Analysis

In order to have an idea about the feasibility of the company it necessary to analyze the following aspects:

- What is the foreseeable market for the product? How could it evolve over time?
- What will be the foreseeable costs associated with the development, production, commercialization and further support of the product? How could they evolve over time?
- What will be the foreseeable revenues associated with the commercialization of the product? How could they evolve over time?

The combination and analysis of these questions can be done under several diferrent perspectives, namely the following:

- A project economics perspective:
  Under this perspective, the analysis is just concerned with the relation between what is expected to be necessary to spend to materialize the project (capital, consumables, labor, etc) and what is expected to have as revenues as a consequence of the project.
  Aspects such as how the project is financed (self-financing or loans, subsidies, taxes on profits, etc) are not taken into account.
  Basically, in this case the objective is to determine if the intrinsic nature of the project is feasible or not.

- A financial perspective:
  Under this perspective, all the aspects considered under the project economics perspective are also considered but, in addition other aspects are take into account such as the financing strategy (self-financing or loans and the corresponding cost of money), subsidies, taxes on profits, etc.

In the following sections the first approach will be used. It is commonly referred to as a **cost-benefit analysis** and adequate for an initial assessment of an engineering project, indicating if its intrinsic cost-revenue structure makes it feasible or not.

The second approach is usually favored by accountants and financial officers

4.5.1 Business Case Assumptions

4.5.1.1 General Economic and Financial Parameters

In order to construct our business case an Excel workbook was created:

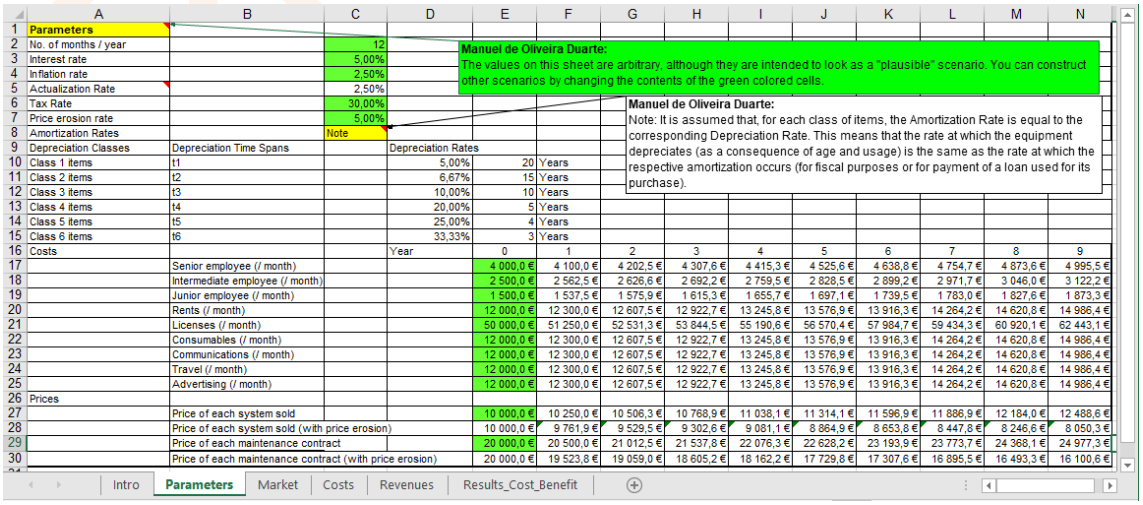
Cost_Benefit_Analysis_Nice_Fit_20200324-unprotected.xlsx

In this workbook a set of assumptions had to be made relating to several general economic and financial parameters as shown in the following table:

Table 1: General Economic and Financial Parameters

Parameters				
No. of months / year		12		
Interest rate		5,00%		
Inflation rate		2,50%		
Actualization Rate		2,50%		
Tax Rate		30,00%		
Price erosion rate		5,00%		
Amortization Rates		Note		
Depreciation Classes	Depreciation Time Spans		Depreciation Rates	
Class 1 items	t1	20	5,00%	
Class 2 items	t2	15	6,67%	
Class 3 items	t3	10	10,00%	
Class 4 items	t4	5	20,00%	
Class 5 items	t5	4	25,00%	
Class 6 items	t6	3	33,33%	
Costs			Year	0
	Senior employee (/ month)			4 000,0 €
	Intermediate employee (/ month)			2 500,0 €
	Junior employee (/ month)			1 500,0 €
	Rents (/ month)			12 000,0 €
	Licenses (/ month)			50 000,0 €
	Consumables (/ month)			12 000,0 €
	Communications (/ month)			12 000,0 €
	Travel (/ month)			12 000,0 €
	Advertising (/ month)			12 000,0 €
Prices				
	Price of each system sold			10 000,0 €
	Price of each system sold (with price erosion)			10 000,0 €
	Price of each maintenance contract			20 000,0 €
	Price of each maintenance contract (with price erosion)			20 000,0 €

The values in this table correspond to the "Parameter" sheet of the workbook *Cost_Benefit_Analysis_Nice_Fit_20200324-unprotected.xlsx*:



The values marked as green in this worksheet are arbitrary, although they are intended

to look as "plausible". They were set just for the purpose of constructing a possible scenario. Readers can (and are encouraged to) construct other scenarios by changing the contents of the green colored cells. However, this does not mean the non-colored cells are locked. The entire workbook is unlocked with the exception of its *Introduction sheet*. It was decided to have this workbook open so that students can adapt it as freely as they wish to their specific needs.

Please feel free to use the author's email (duarte@ua.pt) to pose any question or suggestion that may occur when using this document and associated workbook.

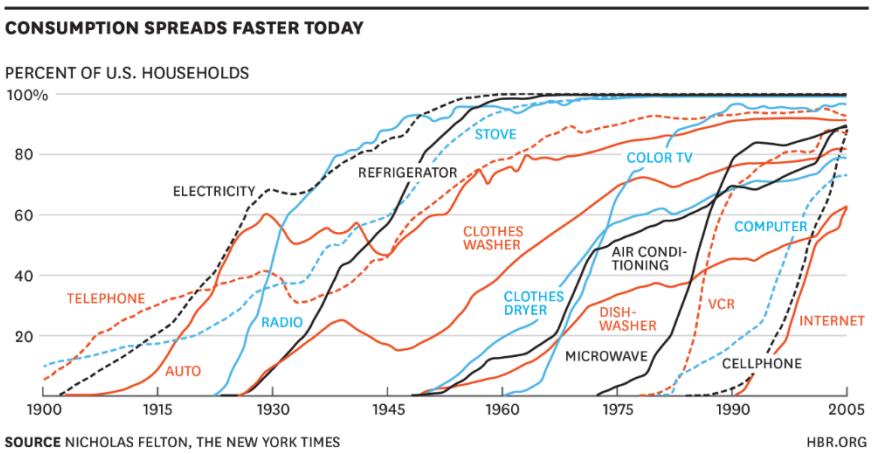
4.5.2 Market Perspectives

The introduction of something new in a market (a technology, a product or a service), being it in the form of a novelty or in the form of a replacement of something that already exists, is always an operation with a degree of uncertainty. Naturally, the actors involved in these processes try to deal with this uncertainty, so that its consequences are not a complete surprise. This is done, generally, by identifying the factors that influence the behavior of these processes and, thus, trying to get some idea in advance about their effects and the measures that can be taken to attract or avoid certain scenarios.

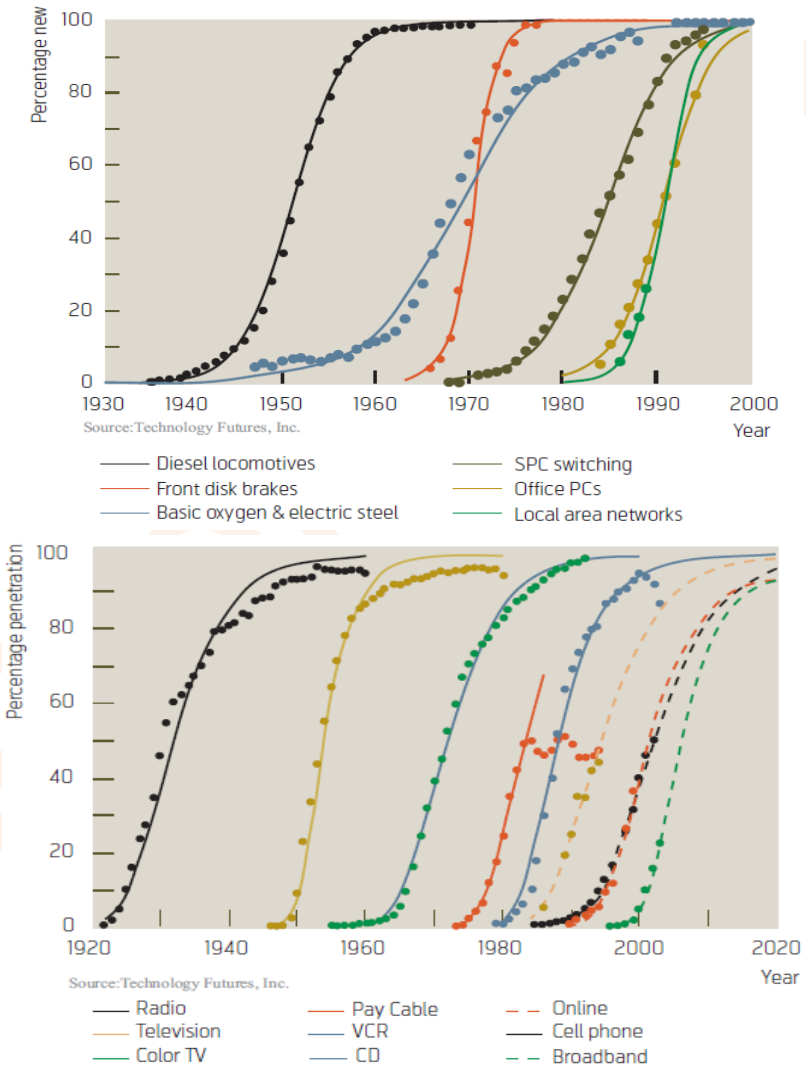
It is also of great importance to look at what has been the market behavior in the past, when confronted with the introduction with some degree of similarity with those they are now being planned to be introduced.

The following figures illustrate the adoption patterns of a diverse set of technologies, products and services throughout the 20th century in the United States of America [2]:

[2] Data from other countries with similar economic and social development levels are likely to have similar patterns. However, the practice of collecting statistical data in these countries started later and, therefore, such data are not available for the periods represented in the graphs.



(a) [2]



(b) [1]

Figure 1 - Patterns of adoption of various technologies, products and services throughout the 20th century in the USA

From the observation of the previous figures it is evident the recurrence of a pattern of temporal evolution approaching an S curve[3], although, in some cases, very asymmetric.

It is a case to ask: "What can explain that products, services and technologies as diverse as those to which the previous figures refer, have so similar adoption patterns?"

To help answering this question, the reader is referred to the following document: *"Modelos Matemáticos para os Processos de Adopção de Tecnologias, Produtos e Serviços: Breve Introdução"* [3].

For the purpose of this study the adoption model to be considered, expressed as the percentage of the target market that, a certain moment t, has already adopted the product under consideration, will be a logistic function $N(t)$ as depicted in Figure 1.

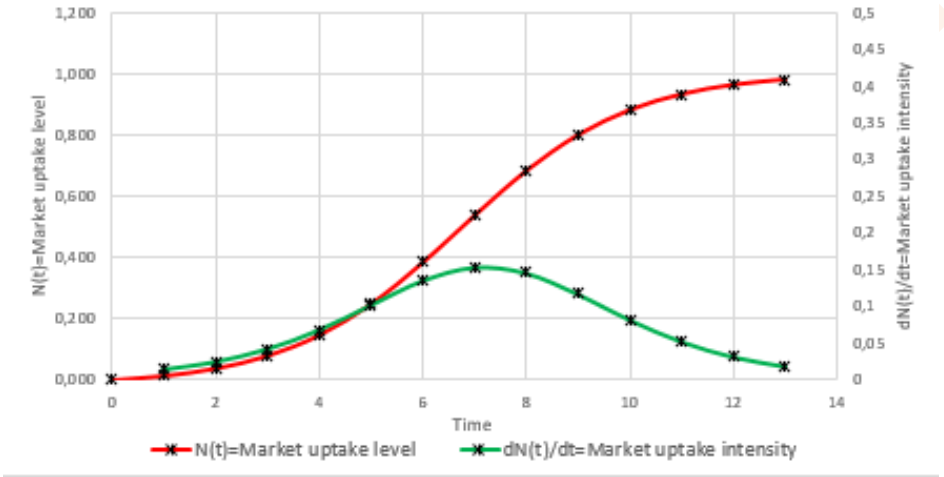


Figure 1: Logistic function

Its mathematical structure is the following:

$$N(t) = \frac{1}{1 + \alpha e^{-\beta t}} \qquad \textbf{1}$$

The symbols used in this expression have the following meaning:

- α:This value will determine how early or how late the market starts to grow;
- β:This value will determine how quickly/slowly the market will react once it takes off.

Often, an actor present in a given market already has an established customer base and when launching a new product or service he is confident that he will be able to have guaranteed a percentage of the market, P_i (starting level), right from the moment that the product is launched. On the other hand, his knowledge of that market and of his purchasing power tells him that it will also not be expected to achieve the uptake of more

[3] It is also clear from the observation of the curves that the acceleration in the adoption of new technologies and products over the last century has increased considerably.

than a final percentage of P_f (saturation level). In these conditions, it is common to use the following modified version of the logistic curve that takes into account the initial and final uptake levels:

$$P(t) = P_i + (P_f - P_i)\frac{1}{1 + \alpha e^{-\beta t}} \qquad \textbf{2}$$

Figure 2 illustrates this Modified Logistic Function with different parameter values.

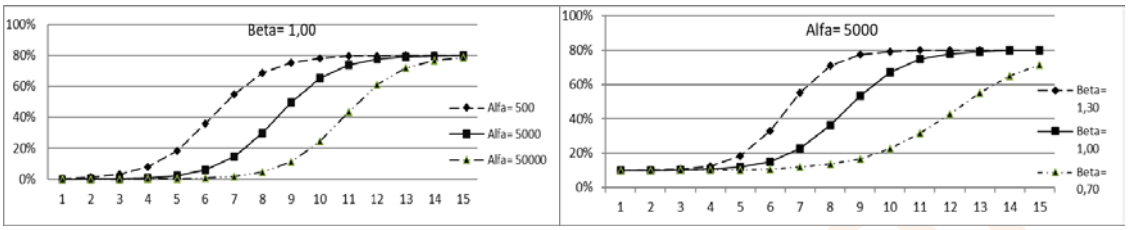


Figure 2: Modified Logistic Functions with different parameter values

This type of curve will be used to model the evolution of *Nice_Fit* market in our study.

With the help of a market prospection company *Nice_Fit* estimates that the maximum size of its target market, worldwide (retail chains in the clothing, footwear and fashion accessories sectors and some large independent retailers), is 2000. This value will be used as "Potential market size" in the *Market* worksheet of workbook *Cost_Benefit_Analysis_Nice_Fit_20200324-unprotected.xlsx.*

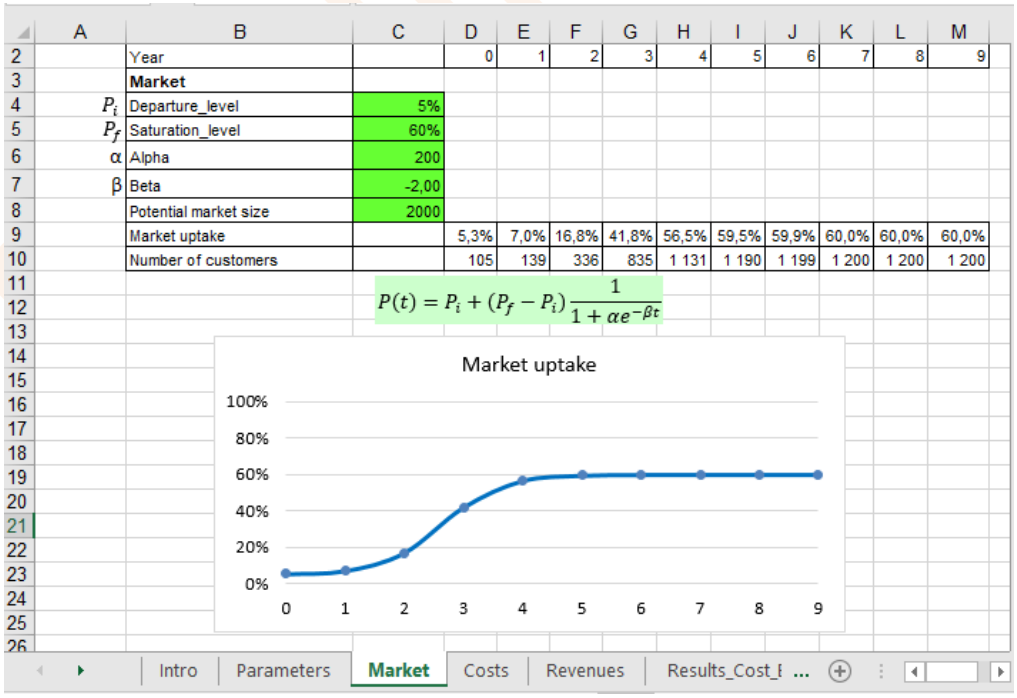


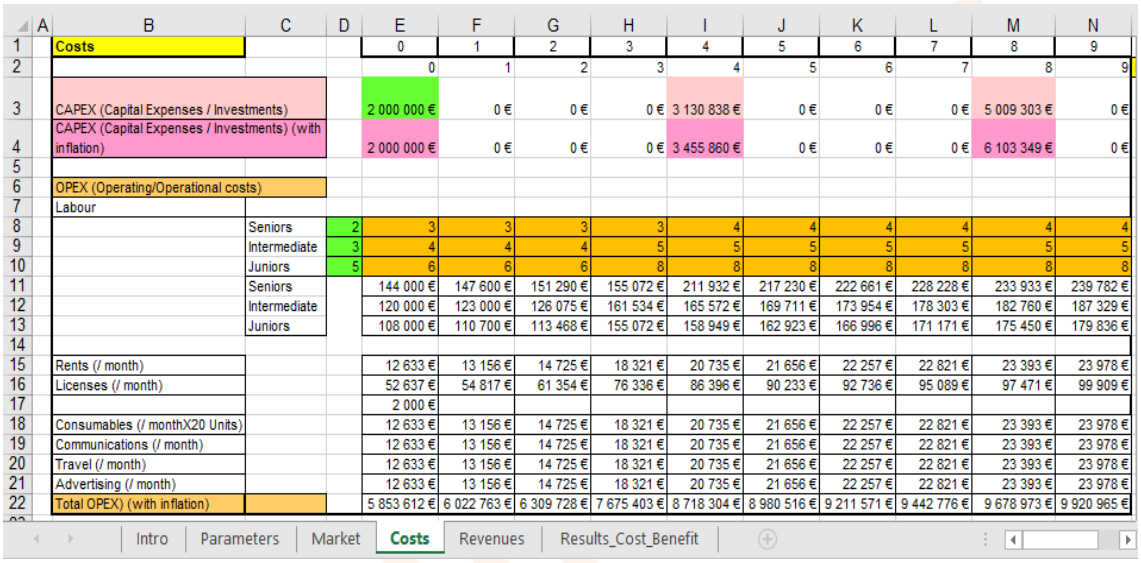
Figure 3: A possible scenario for Nice_Fit market evolution

Obviously, what is shown in Figure 3 is just a scenario. It will be used ahead in order to determine its economic consequences but other scenarios, with different values of α and β might (and should) be used.

4.5.3 Cost Structure

Nice_Fit cost structure is assumed to be the one shown in the "Costs" sheet of Excel workbook *Cost_Benefit_Analysis_Nice_Fit_20200324-unprotected.xlsx*:

Table 2: Nice_Fit cost structure



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Costs			0	1	2	3	4	5	6	7	8	9
2					0	1	2	3	4	5	6	7	8	9
3		CAPEX (Capital Expenses / Investments)			2 000 000 €	0 €	0 €	0 €	3 130 838 €	0 €	0 €	0 €	5 009 303 €	0 €
4		CAPEX (Capital Expenses / Investments) (with inflation)			2 000 000 €	0 €	0 €	0 €	3 455 860 €	0 €	0 €	0 €	6 103 349 €	0 €
5														
6		OPEX (Operating/Operational costs)												
7		Labour												
8			Seniors	2	3	3	3	3	4	4	4	4	4	4
9			Intermediate	3	4	4	4	5	5	5	5	5	5	5
10			Juniors	5	6	6	6	8	8	8	8	8	8	8
11			Seniors		144 000 €	147 600 €	151 290 €	155 072 €	211 932 €	217 230 €	222 661 €	228 228 €	233 933 €	239 782 €
12			Intermediate		120 000 €	123 000 €	126 075 €	161 534 €	165 572 €	169 711 €	173 954 €	178 303 €	182 760 €	187 329 €
13			Juniors		108 000 €	110 700 €	113 468 €	155 072 €	158 949 €	162 923 €	166 996 €	171 171 €	175 450 €	179 836 €
14														
15		Rents (/ month)			12 633 €	13 156 €	14 725 €	18 321 €	20 735 €	21 656 €	22 257 €	22 821 €	23 393 €	23 978 €
16		Licenses (/ month)			52 637 €	54 817 €	61 354 €	76 336 €	86 396 €	90 233 €	92 736 €	95 089 €	97 471 €	99 909 €
17					2 000 €									
18		Consumables (/ monthX20 Units)			12 633 €	13 156 €	14 725 €	18 321 €	20 735 €	21 656 €	22 257 €	22 821 €	23 393 €	23 978 €
19		Communications (/ month)			12 633 €	13 156 €	14 725 €	18 321 €	20 735 €	21 656 €	22 257 €	22 821 €	23 393 €	23 978 €
20		Travel (/ month)			12 633 €	13 156 €	14 725 €	18 321 €	20 735 €	21 656 €	22 257 €	22 821 €	23 393 €	23 978 €
21		Advertising (/ month)			12 633 €	13 156 €	14 725 €	18 321 €	20 735 €	21 656 €	22 257 €	22 821 €	23 393 €	23 978 €
22		Total OPEX) (with inflation)			5 853 612 €	6 022 763 €	6 309 728 €	7 675 403 €	8 718 304 €	8 980 516 €	9 211 571 €	9 442 776 €	9 678 973 €	9 920 965 €

Intro | Parameters | Market | Costs | Revenues | Results_Cost_Benefit

Figure 4: A possible scenario for Nice_Fit cost structure

In relation to CAPEX (Capital Expenditure) it is being assumed that all investments made by the company are in capital goods with a life span of 4 years, corresponding to depreciation and amortization rates of 25%. After every 4 years, the equipment has to be replaced and its capacity increased by a factor proportional to the market increment

In relation to every OPEX (Operating/Operational expenditure) cost item (Labour, Rents, Licenses, Consumables, Communications, Travel, Advertising, etc) its time evolution is a function of the initial assumed cost (green cells in the "Parameters" worksheet) affected by a factor proportional to the market increment ("Market worksheet).

4.5.4 Revenue Structure

Nice_Fit revenue structure is based on the business strategy options previously presented which are now recalled for convenience:

- Revenue streams come from 2 sources:
  - Sale of *Dress_me_Up* systems. Unit price: 10.000€.
  - Sale of maintenance contracts. Unit price: 20.000€/year.

- The sale of a *Dress_me_Up* system in year *k* implies, by contractual terms, the following:
    - *Nice_Fit* provides during year *k*, free of charge, the service associated with a maintenance contract.
    - At year *k+1* and following the *Dress_me_Up* buyer pays a maintenance contract.

With these assumptions the revenue stream for Nice_Fit as the following aspect (worksheet “Revenues” of Excel workbook *Cost_Benefit_Analysis_Nice_Fit_20200324-unprotected.xlsx*:

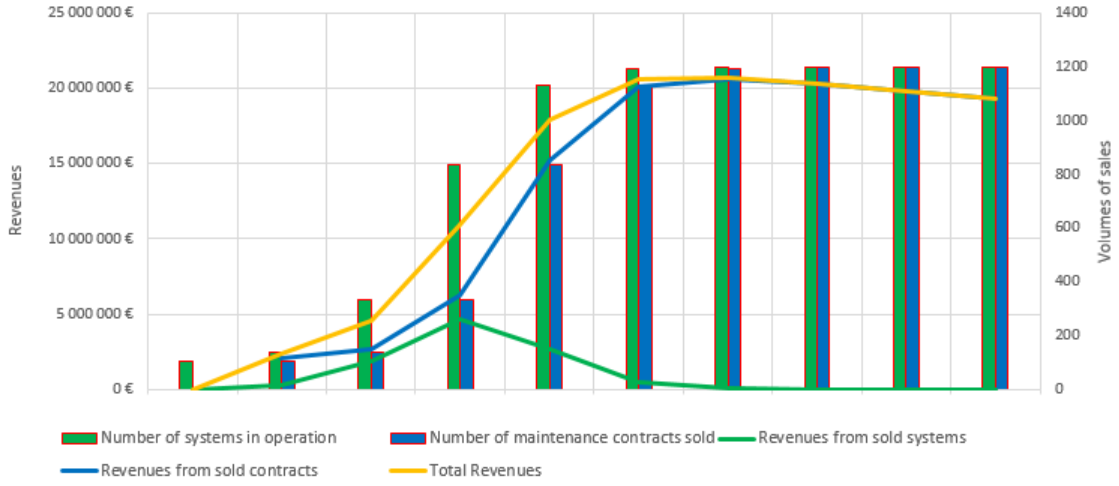


Figure 5: A possible scenario for Nice_Fit revenues

4.5.5 Results

Under the assumptions presented in previous sections, the analyzed scenario produces the following economic results for the project:

***Table 3: Nice_Fit* Resuls**

Resultados	Results										
Ano	**Year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Custos	Costs	-7 853 612 €	-6 022 763 €	-6 309 728 €	-7 675 403 €	-12 174 164 €	-8 980 516 €	-9 211 571 €	-9 442 776 €	-15 782 322 €	-9 920 965 €
Receitas	Revenues	0 €	2 388 391 €	4 527 313 €	10 896 212 €	17 855 753 €	20 574 856 €	20 671 806 €	20 261 692 €	19 790 200 €	19 320 451 €
Cash Flows	Cash Flows	-7 853 612 €	-3 634 372 €	-1 782 415 €	3 220 808 €	5 681 588 €	11 594 341 €	11 460 235 €	10 818 916 €	4 007 879 €	9 399 486 €
Cash-flow actualizado	Cash-flow (discounted)	-7 853 612 €	-3 545 729 €	-1 696 528 €	2 990 841 €	5 147 239 €	10 247 708 €	9 882 125 €	9 101 578 €	3 289 453 €	7 526 435 €
Cash-Balance	Cash-Balance	-7 853 612 €	-11 399 341 €	-13 095 869 €	-10 105 028 €	-4 957 789 €	5 289 918 €	15 172 043 €	24 273 621 €	27 563 074 €	35 089 509 €

Indicadores Económicos	Economic Indicators	Valor
Valor actual líquido	Net Present Value	35 089 509 €
Taxa interna de rentabilidade	Internal Rate of Return	30,76%
Período de recuperação	Payback Period	4
Cash Balance (último ano do projecto)	Cash Balance (project last year)	35 089 509 €
Valor residual	Residual Value	NA

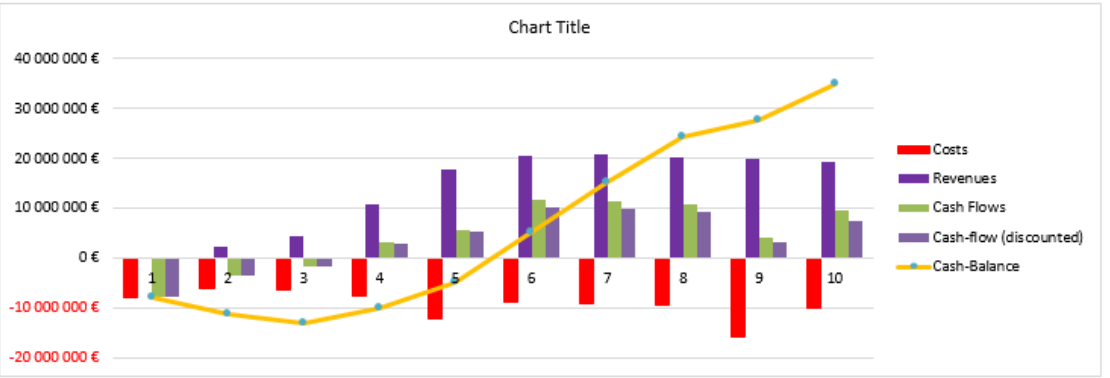


Figure 6: A possible scenario for Nice_Fit economic results

Observations:

1. The economic variables and indicators shown in the above table (Cash Flow, Cash-flow (discounted), Cash-Balance, Net Present Value, Internal Rate of Return, Payback Period) are explained in Section 6, Annex: Economic Analysis of Engineering Projects (A Summary)
2. As previously mentioned, what is shown as “Results” is just a possible scenario. With different market, costs and revenue assumptions other results would be obtained. The reader is encouraged to construct other alternative scenarios and try to figure out how different parameters influence the results.

5 Conclusions and Final Remarks

In general terms, the following can be said:

- The business model of the proposed idea seems to be feasible although it is necessary that investors are prepared to support a potentially long payback period. This may imply the need to finance the operation with equity or through loans. In this document, this hypothesis was not considered, and it would certainly imply additional costs (opportunity costs if own capital was used or interest costs if loans were used).

- The economic analysis carried out did not take into account the possibility of competition. If competition was present, it would be necessary to take into account the market share and the possible churn between *Nice_Fit* and competitors.

- It could also be an interesting exercise to make a sensitivity analyzes relative to some of the assumed parameters, costs and prices.

- As previously stated, the economic analyzes present in this document has a project economics perspective and is just concerned with the relation between what is expected to be necessary to spend to materialize the project (capital, consumables, labor, etc) and what is expected to have as revenues as a consequence of the project. Basically, the objective of this analysis has been to determine if the intrinsic nature of the project business model is feasible or not.
  Aspects such as the financing strategy (self-financing or loans and the corresponding cost of money, possible subsidies, taxes on profits, etc), are not taken into consideration as they would certainly be if an accountant or financial officer would take.

6 Annex: Economic Analysis of Engineering Projects (A Summary)

6.1 Variables and Indicators

The variables and indicators that are commonly used in the economic analysis of engineering project are listed bellow:

$CF = Cash\ Flow$
$CB = CashBalance$
$I = Investiment$
$Ca = CapEx = Capital\ expenditure$
$Op = OpEx = Operational$ expenditure
$R = Revenues\ /\ Receitas$
$T_d = Depreciation\ rate$
$T_a = Amortization\ rate$
$T_{tx} = Tax\ rate$
$T_i = Inflation\ rate$
$T_j = Interest\ rate$

6.2 Economic Analysis of Engineering Projects: Essential Factors

The economics of an engineering project involves some essential factors:

- Time:
  Every project as a time to start and a time to end.
  This implies the need for planning the expected flows of spending and revenues over time, as a function of expected activities.

- Capital expenditure ($CapEx$)
  This relates to all spending in capital goods
  (e.g.: buildings, durable equipment, basic infrastructures such as ducts and cables, tradable patents, etc).

- Operational expenditure ($OpEx$)
  This relates to all spending in the acquisition of consumables and services (e.g.: labor, communications, energy, etc).

- Revenues:
  This relates to all possible incomes that might be generated by the project (sales, royalties, etc)

6.3 Money Time Value:

Under a financial perspective, the value of money is not constant over time, being affected by several factors, namely interest rate, t_j and inflation rate, t_i.

Assuming that at $t = 0$ available capital is $C(0)$, then, at $t = 1$, isolated effects of *interest rate* and *inflation rate* are the following:

- Interest rate effect:

$$C(1) = C(0).\left(1 + T_j\right) \Rightarrow \textit{increase in value} \qquad \textbf{3}$$

- Inflation rate effect:

$$C(1) = \frac{C(0)}{(1+T_i)} \Rightarrow \textit{decrease in value} \qquad \textbf{4}$$

Considering now the combined effects of interest and inflation results in the following:

$$(1) = C(0).\frac{1+T_j}{1+T_i} = C(0).(1 + \frac{T_j - T_i}{1+T_i}) \qquad \textbf{5}$$

Usually, T_i is a small value and the above equation can be simplified to the following format:

$$C(1) \approx C(0).\left(1 + (T_j - T_i)\right) \qquad \textbf{6}$$

Defining $\left(T_j - T_i\right) = T_a$ as *discount rate* (also designated by *actualization rate*) then:

$$C(1) = C(0).\ (1 + T_a) \qquad \textbf{7}$$

6.4 Net Future Value (NFV) and Net Present Value (NPV)

Generalizing the above relations, Net Future Value (NFV) of capital $C(0)$ at time k subject to an actualization rate T_a is defined as by the following formula:

$$Net\ Future\ Value\ of\ C(0)\ at\ time\ K = C(k) = C(0).(1 + T_a)^k \qquad \textbf{8}$$

The following picture illustrates the above effect:

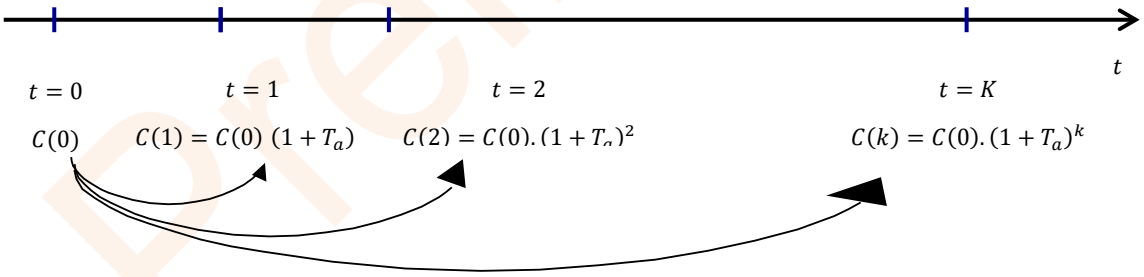


Figure 7: Net Future Value illustration

Inversely, assuming that at $t = K$, available capital is $C(k)$, then its Net Present Value (NPV) is defined as follows:

$$C(0) = \frac{C(K)}{(1+T_a)^k} = \text{Net Present Value of C(k) at time 0} \qquad \textbf{9}$$

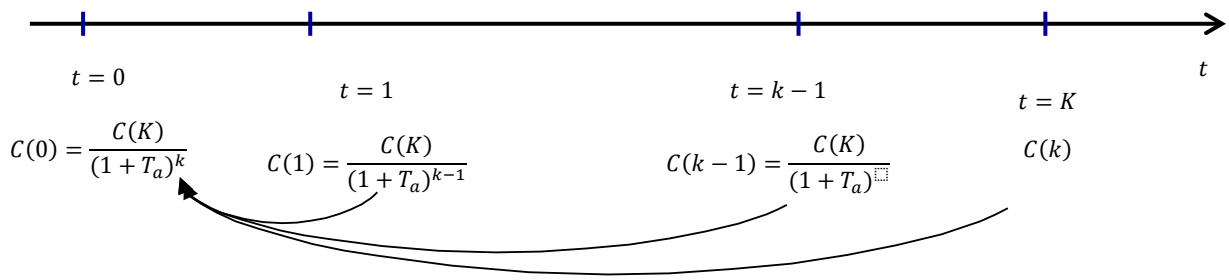


Figure 8: Net Present Value mechanics

If we have a series of financial flows in different instants of time, $F_i = R_i - E_i$, where R_i and E_i are, respectively, revenues and expenses at timet_i as illustrated in the following figure:

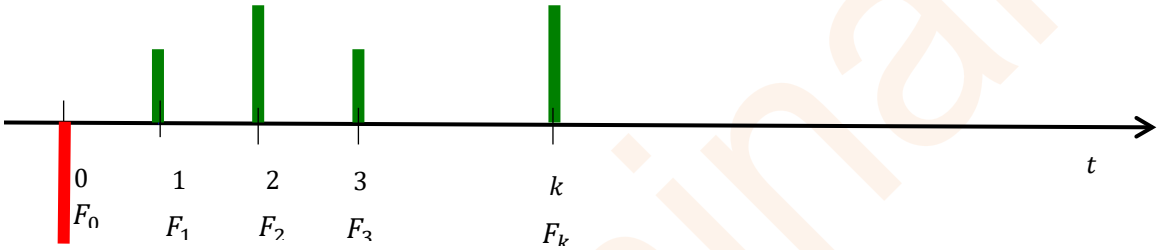


Figure 9: Net Present Value illustration

Each one of these flows $F_i = R_i - E_i$ is designated by a CashFlow.

The accumulated sum of a series of ***CashFlows*** is designated by ***CashBalance.***

For the case when the accumulated period goes from $t = 0$ to $t = k$ we have:

$$CashBalance\ at\ time\ k = CB_k = \sum_{j=0}^{K} CF_j. \qquad \textbf{10}$$

The Net Present Value of a series of CashFlows referred to t=0 is given by the following expression:

$$NPV[F(i), i = 1 \dots k] = \sum_{i=0}^{k} \frac{F_i}{(1+r_a)^k} = \sum_{i=0}^{k} \frac{R_i - E_i}{(1+r_a)^k}. \qquad \textbf{11}$$

Therefore, NPV is the accumulated sum of all CashFlows, each one of them referred to time $t = 0$ (or, in an alternative way of saying, “discounted to $t = 0$”) and corresponds to the final value of the project discounted (or actualized) CashBalance.

Net Present Value (NPV) is one of the most common profitability metrics for engineering projects.

Two other common profitability metrics for engineering projects to be addressed in these slides are:

- Internal Rate of Return (IIR)
- Payback Period (PBP)

6.5 Internal Rate of Return (IRR)

The Internal Rate of Return (IIR) of a project is the value that the actualization rate T_a should have to make the net present value (NPV) of the project equal to zero:

$$IRR:\ NPV[F_i|T_a = IRR] = \sum_{i=1}^{k} \frac{F_i}{(1+IRR)^i} = 0. \qquad \textbf{12}$$

When analyzing if a certain project should go ahead or not, IRR indicates the rate of return that will be earned on the overall project if all projected future cash flows (expenses and revenues) do occur at the initially expected actualization rate of T_a
If the IRR exceeds the rate of return that can be earned elsewhere (for example in a bank earnings deposit) the project should go ahead. Otherwise, it is better to use the investment elsewhere.

To illustrate the concept of IIR let us consider the following very simple project:

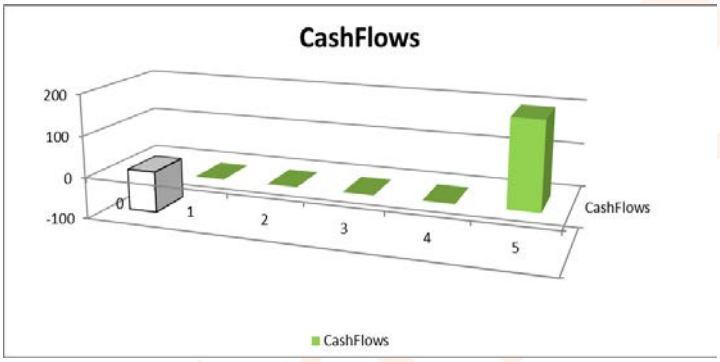


Figure 10: : A very simple investment project…

At a first glance, a project where an initial investment of 100 units of money is made and returns 200 units of money seems an “interesting” project… or seems not?

To answer this question next picture presents the value of the NPV associated with this “project” for different values of the actualization rate.

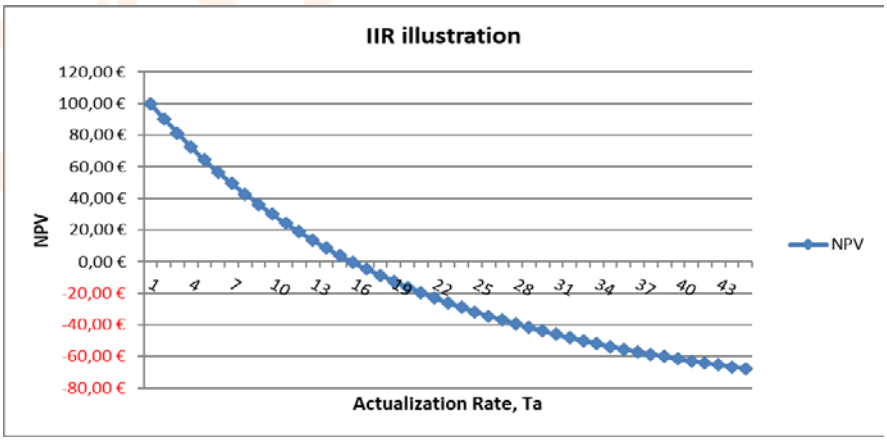


Figure 11: Internal Rate of Return illustration

As can be seen, when $\boldsymbol{T_a}$ increases the corresponding NPV decreases and there a value of $\boldsymbol{T_a}$ when NPV=0. This value of $\boldsymbol{T_a}$ corresponds to the IIR of this "project".

By visual inspection it can be conclude that for this case, IIR is around 15%.

In summary:

- When $T_a = IRR$, it means that the investor of the project is going to get from the project the same that he would get from putting the money in a bank at an actualization rate of T_a. In such case it would be indifferent to him to invest in the project or to invest in a bank.
-
- If $T_a < IRR$, then the investor gets more from the project than from somewhere else and the project should go ahead.

- If $T_a > IRR$, then for the promoter of the project it is better to invest putting the money in a bank at an actualization rate of T_a or more.

6.6 PayBack Period

The period of time taken by the project until the CashBalance changes from negative to positive is called *payback period:*

$$PBP = P, such\ that\ \{NPV[F(i), i = 1 \dots P] < 0\} \& \{NPV[F(i), i = 1 \dots P+1] > 0\}$$

or

$$\{\sum_{i=0}^{P} \frac{F_i}{(1+T_a)^P} < 0\} \ \&\ \{\sum_{i=0}^{P+1} \frac{F_i}{(1+T_a)^{P+1}} > 0\}. \qquad \textbf{13}$$

Its calculation is simple, but it does not take into account what happens after the recovery period nor does it allow to measure the profitability of the project.

6.7 A Simple Numerical Example

Let us consider a **hypothetical** project that generates expenses and revenues over a period of 10+1 years as shown in the following scenario:

Discount rate	5%										
Time=>	0	1	2	3	4	5	6	7	8	9	10
Capital Expenditure (CAPEX)	2 000 000 €										
Operational Expenditure (OPEX)	24 000 €	36 000	61 200	122 400	244 800	440 640	749 088	1 198 541	1 797 811	2 516 936	3 272 016
Revenues	0 €	48 000	192 000	576 000	1 152 000	1 728 000	2 073 600	2 488 320	2 737 152	2 874 010	3 017 710
Cash Flow	-2 024 000 €	12 000	130 800	453 600	907 200	1 287 360	1 324 512	1 289 779	939 341	357 074	-254 306
Accumulated CashFlow=CashBalance	-2 024 000 €	-2 012 000	-1 881 200	-1 427 600	-520 400	766 960	2 091 472	3 381 251	4 320 592	4 677 666	4 423 360
Discounted Cash Flow	-2 024 000 €	11 429	118 639	391 837	746 356	1 008 680	988 371	916 622	635 783	230 173	-156 122
Discounted Accumulated CashFlow=Discounted Cash	-2 024 000 €	-2 012 571	-1 893 932	-1 502 095	-755 740	252 941	1 241 312	2 157 934	2 793 717	3 023 890	2 867 768
NPV	2 867 768 €										
IIR	24%										
PBP	4										

Figure 12: A Simple Numerical Example

It is stressed that, in this table, the values for CAPEX, OPEX and revenues are merely hypothetic enabling us to construct a possible “narrative” an see its consequences in terms of some of project economic indicators such as NPV (Net Present Value), IIR (Internal Rate of Return) and PBP (Payback Period).

An Excel file is available, ***Simple_Financial_Analysis_MOD_20191028.xlsx***, that the reader can experiment with and create different scenarios, changing the values of CAPEX, OPEX and revenues, as well as its time evolution. Each imagined scenario is just a “possible narrative”. It is interesting to compare different scenarios and observe how they affect the corresponding economic indicators.

The following graphic compares the effects on CashBalance of taking or not taking into account the effects of time:

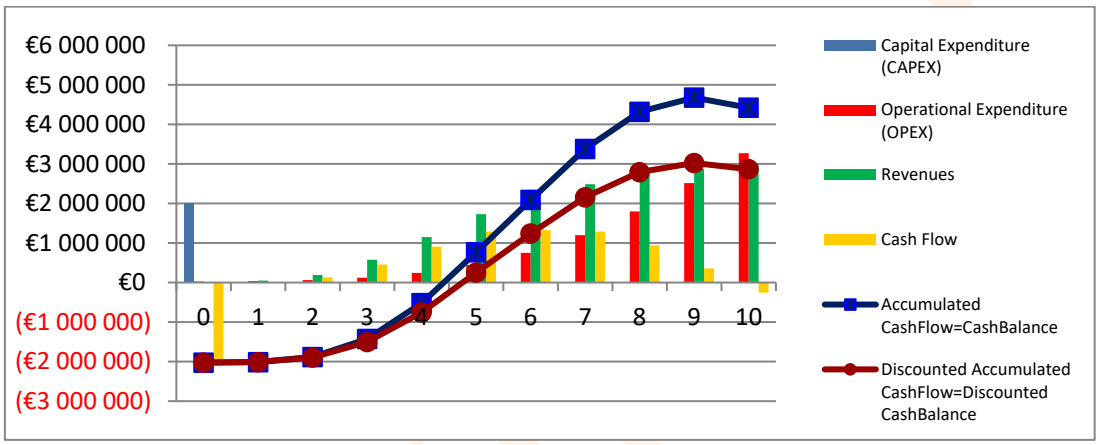


Figure 13: Net Future Value illustration

The curves "Accumulated CashFlow=CashBalance" and "Discounted Accumulated CashFlow=Discounted CashBalance“, refer, respectively, to not having or having taken into account the effects of time.

7 Bibliography and References

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