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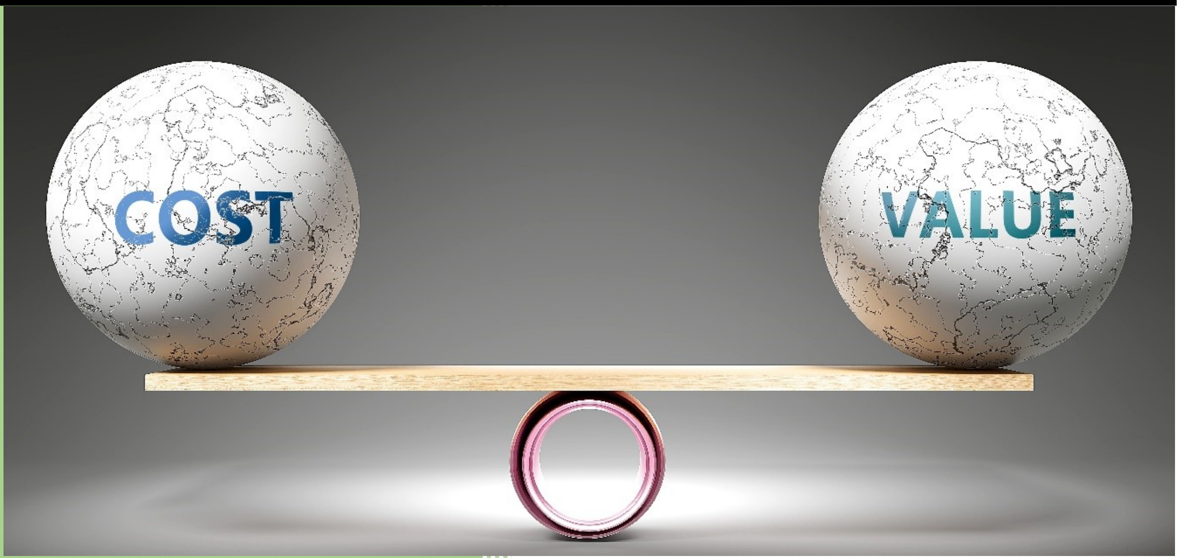
D 6.3

PRO-RES

Risks (image, market opportunity losses, financing and financial losses) related to non-ethical implementation of research results as well as the benefit of honest, by the book, deployment).



Main Author : Caroline Gans-Combe, INSEEC

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I – Contextual approach

The last phase of our approach constitutes a tool for economic evaluation of the potential cost of a lack of trust in a research process. It consists in comparing, from a loss of value point of view, the risks (image, market opportunity losses, financing and financial losses) related to non-ethical implementation of research results as well as the benefit of honest, by the book, deployment.

Originally, and at the request of the stakeholders interviewed in the framework of D6.2, D 6.3 was to evolve into a tool for recommending the best ethical approach relative to the nature of a given research project, in proportion to each organization and its specificities. As this was a request from the stakeholders, work has been done in this direction. It is detailed below, notwithstanding the fact that this evolution, which required a contractual modification, was not ultimately retained by REA, which favored the completion of the financial approach initially planned.

a) Turning from a document-based approach to a technical analysis one: building ethical documents pertinence indicator & recommender. What D 6.3 could have been.

During D6.2 survey phase, Question 8 (Table 1 Below) was dedicated to tools that could be used in order to better trust in KI players. We had foreseen in our deliverables to provide "A financial document assessing the impact on the accounts/finances of a player in the knowledge-based economy of problems related to research and innovation". However, this appeared in the end to be a request validated by only a minority (15%) of our stakeholders.

Indeed:

1 - The proposed format (a financial document) only came third (out of 5) when asking the question of what element would be pertinent to better trust in the KI, and under which format.

2 - Out of 1479 respondents, only 229 thought that the document-based approach was of interest and could indeed better things. (15,4%) whereas the technical analysis approach (recommendation + indicator) was considered pertinent by 859 respondents (58%). A vision that is much more in line with the logic of current citizen involvement.

Of note: We consider the two approaches together because indicators can only be derived from (live) data collection processes. The existence of separate questions arises from our desire to have a better granularity in the understanding of information collection methodologies.

Q8 : For you, a tool to rebuild trust would be effective if it was (multiple answers possible):	Answers
An indicator with precise and transparent criteria,	567
A recommendation/rating system with precise and transparent criteria,	292
An annual report in an accurate and transparent form,	229
A financial document assessing the impact on the accounts/finances of a player in the knowledge-based economy of problems related to research and innovation,	118
An impact document in a precise and transparent form.	94

Table 1 : Answers to Question 8

Thus, stakeholders, in a quintuple helix logic, viewed the tools to be developed more as being able to give funders visibility on the risks relating to the R&I project's ecosystem, than on the project risks as such, which, according to them, were already well identified (Confirmed by Table 2 Q 10 results below).

Q 10 : For you this type of tool would be effective if (multiple answers possible):	Numerical value
It was used in the evaluation of projects,	639
It was used in project funding decisions: institutional decisions at the policy or corporate strategy levels for example,	414
It was used in the financial analysis of companies,	149
It was serving in judicial processes,	43
It was used in the evaluation of insurance premiums.	55

Table 2 Q 10 results

They thus expressed a need for transparency on the actual implementation process of building an ethical environment (ecosystem) for research and innovation, rather than on the financial impacts of poorly designed processes. Moreover, they considered that the economic modelling should be established ex post and not ex ante, in contrast to what we had hypothesized. In short, stakeholders are saying: "show me the process & the documentary sources you have used are trusted/corresponding to your needs, so that I can get an idea of how much trust I can give to your R&I process".

This approach is original in the sense that it submits to collaborative analysis constructs that are supposed to be the basis for building trust, a way of doing things that has already proven its effectiveness, especially in the field of innovation financing (Walthoff-Borm, Vanacker & Collewaert, 2018).

However, to build indicators, live, ongoing data is required, which is exactly the material on which are built recommendation systems. Indeed, technical indicators are signals produced from the patterns observed in the movements of recommendation on a given subject. It could be adhesion or not to a given pathway, the Accord, or to a set of documents, experts or recommendations. These signals are in turn used to predict the future adhesion movements. Analysts look for indicators in the historical data and use them to implement several endpoints (for example, an ethical policy for a given innovation).

Hence, the idea was thus to switch from a document-based approach to a more end-users involvement approach by building a recommender that would in the end deliver a trust indicator in each ethical pathway.

As such we had pre-designed tools to:

1 => provide recommendation to R&I projects in need of knowing what the elements are pertinent for their need (or even experts for what it takes) => a given user look at a document/a set of documents => the most similar documents are provided to her/him (and the pertinence of the given document as per her/his problems is ranked => it's an iterative process)

2 => provide ranking per transactions (most & less used documents per users typologies') => a given user has used a given documents/sets of documents (transaction analysis) => the same set of documents is suggested to an user with the same typology. (and the pertinence of the suggested information as per her/his problems is ranked => it's an iterative process)

In the end we had two recommendations approaches and an indicator of coherence provided by end-users (sentiment analysis) => could be perform out of the project tweeter account, ect...

We could also extract indicators of:

- The typologies of end-users looking at a type of document.
- The typologies of documents most looked at/downloaded (transaction types)

All this was to be adapted to the project IT framework and datasets et delivered running on Jupyter. However, in the end, the original assessment was preferred by the EU to the predictor, the needed scripts, tests, and deployments were not finalised, and the team went back to the original deliverable.

b) Reverting to the original design.

This being established, Deliverable 6.3, which we had hoped to modify to be more in line with stakeholders' expectations as obtained in Deliverable D 6.2, finally reverts to its original design.

The aim of the present report is thus to propose a tool for the economic evaluation of the potential cost of a lack of trust in a research process.

This evaluation raises two questions:

[1] What would be the modalities for constructing the value (the price) of these risks? In other words, what are the targeted risks?
[2] How to calculate the two values, one free of risk and one intrinsically carrying a risk, that of the lack of trust in a process.

II. Identifying the “decision making” risks.

Before tackling any analytical approach, it is necessary to verify that both questions are answerable and more importantly that such an answer is paramount to our research. In other words, and in this case, to tackle the following issues: is it possible and needed to put a price on trust? is there a way to determine what the absence of trust costs? that is, to verify that trust (and its absence) are risks, prior to solving the pricing aspect. In other words, when we talk about putting a price on a risk in our context, what risk are we talking about? Or again, what risk will be the reference for arbitration, for decision-making by economic agents in our context.

a) Linking trust and risks

These questions about the links between trust and risk were brilliantly elucidated in the 1990s by Williamson - for the part that calculates the correlation or otherwise between risk and trust within the framework of so-called transactional approaches: Saussois, J.M. ed. (2016) - and more recently by Solhaug, Elgesem & Stølen. They are based on different views to the notion that have already been discussed in depth in Deliverable 6.1. We will therefore abstain to repeat here these different readings, for which the trade-offs have been widely described. On the other hand, this lengthy analysis allows us to highlight that the transactional approach proposes an interesting critical path in relation to the economic and valuation problems that concern us in this study.

For Williamson, the objectivity of the notion of risk implies that the latter is better identified by an approach based on the usual cost/benefit trade-off, and thus that, if the link between trust and risk is proven, the value of the former can be measured. He thus highlights the fact that the density of an agent's approach to a risk will be based on numerous costs - costs linked to the search for information, to "market failures", to the prevention of opportunism on the part of other agents, etc. - other than the costs intrinsic to the risk itself, and that it is ***these additional costs*** (all others being equal) that will be at the heart of the decision-making process.

We know that certain transactions taking place in the market may generate very large transaction costs. Consequently, economic agents may be led to seek alternative institutional arrangements that make it possible to minimize these costs, by arbitrating between the establishment of good practices prior to the transaction in confidence and the costs of these arbitrations, which Williamson calls the hierarchy.

We place ourselves here in the context of Coase's theorem, the application of which in our "trust transaction" is essential.

- Efficiency thesis: if transaction costs are nil and agents’ rights (aka property) are well defined, individuals involved in an externality will negotiate in such a way as to obtain an efficient allocation of resources;

- The invariance thesis: the allocation of resources will be identical regardless of the distribution of agents' (aka property) rights.

Solhaug, Elgesem & Stølen, 2007 give an interesting reading of the valuation of this risk. But they do have a very rough reading of arbitrage, i.e. the identification of the share of redhibitory risk in the costs that will change the attitude of agents.

For the authors, in a context where risk is defined by the probability and consequence of an incident (they therefore take an ex-post reading), the value of risk is given by a function

$$r : P \times C + RV,$$

where P is the set of probability values, C is the set of consequence values and RV is the set of risk values. In a trust relationship where **p** is the trust value, the subjective probability for deception is 1 - p. They also assume a t value of trust.

Moreover, they start from the assumption that in an economic exchange, the quality of the product/service exchanged cannot be known beforehand. However, this is seldom in fact the case as this assertion ignores the statistical practices of quality control (SQC), which responds precisely to the challenge of identifying the quality of industrial or non-industrial productions (Das, 2013). More precisely, it dismisses an essential point which is the subject of ***trust sourcing***, a critical point for stakeholders as seen in Deliverable 6.2.

This being said, the authors make the hypothesis that it is trust that underlies the act of exchange. The higher the trust, the lower the risk. Moreover, they indicate that the risk is also low if the consequences are minimized, the consequences being explained as the impact following the act of purchase.

In this context, and if $p > t$. What about the economic act? Should it flourish or not? The answer to that depends on the risk the agent is willing to take. The authors assume that if the maximum accepted risk is of value R and that the offered transaction is priced at c, the transaction will happen if $R < r(l - p, c)$. "*Clearly, if p is close to 1, i.e. trust is very high; the risk is low. But the risk is low also if the consequence value c closes to 0. The trust level is hence but one of two factors that must be present in order to calculate the risk. Generally, the risk value of such a transaction is given by applying the risk function: r(1-trust value, stake)*"

In any case, what this approach, however incomplete, confirms is that there is a tenuous link between risk and trust. It does not, however, identify precisely what we will call the economics of trust risk. To do this, we will continue to use the principles of transaction economics.

b) Using the transaction theory to tackle the economics of trust risk

In an economic reading of transactions, each actor can decide on the modalities of his transactions with any third party, i.e. decide to what extent each operator engaged in an interrelation, that is, to quote Williamson again:

"*(a) are aware of the range of possible outcomes and their associated probabilities, (b) take cost-effective actions to mitigate hazards and enhance benefits, (c) proceed with the transaction only if net gains can be projected, and, (d) if a given actor X can complete a transaction with any of the actors Y, the transaction will go to the one of the Ys for whom the largest gain can be projected.*"

The theory of transaction costs postulates that agents are endowed with only limited rationality in the probabilistic sense (Simon, 1990) while behaving opportunistically. The choice to implement a good practice would therefore not be so much a question of trust as of the ***cost of trust***?

And further still - since in the transactional approach - trust can only be established by recognizing/valuing the costs of establishing trust, it is clearly the latter that will guide future trade-offs in setting up or not setting up virtuous practices.

Indeed, for a given value (ν), a rational agent will choose any alternative Δ for which there is no alternative Δ' such that $\nu(\Delta') > V(\Delta)$. More simply, a rational agent will always choose the most efficient alternative in the absence of any other. Nevertheless, Simon's observation shows that this is in fact rarely the case since opportunism is a barrier to rationality. This is the starting point of the transactional approach, which postulates that any economic transaction generates costs prior to its realization. From the point of view of the economic approach, this indicates that it is not the best solution that will be chosen but the best solution in a given cost context. In this case, trust implies the costs of establishing trust, i.e. what we are dealing with: the implementation of good practices. There will therefore be a decision whose rationality will be constrained by the cost trade-off.

In this way, it is no longer the question of putting a price on trust that concerns us, but the costs of implementing good practices as decision-making tools, which greatly simplifies the problem.

We have a body of theory aimed at explaining and predicting the choices of agents satisfying certain conditions of rationality in contexts characterized by various degrees of uncertainty: the decision theory. This theory is constituted by a "Bayesian" approach implying that the choices of rational agents - even and including if their rationality is impaired, and we shall see below that this is the case - must respond to the laws of probability, concerning the way in which the probabilities of occurrence of a given event (their preferences) must consider new information.

In this framework, the preferences of an agent on a set of alternatives being chosen will depend on two elements: their evaluation of the desirability of the consequences that the alternatives may have and their evaluation of the probability of these consequences given the chosen alternative.

c) A cost base decision model: choosing or not to implement best practices?

i. About costs.

This third part implies some definitions as the notion of costs is far from being simple, and is a known issue for decision models (Giard, 2019).
If the global definition of a cost may seem simple: A cost is a sum of real or additional or substitution or subscriber charges concerning an operating means or a product (good or service) or a stage of product development... Because it is an accumulation of charges, ***a cost is always quite specific to the organization that determines it***. It is for this last reason that we have purposely not overloaded this report with calculations. These would have been too specific for each case examined. On the other hand, we have chosen to provide the methods and means of calculation to allow each organization to compute its individual risk in the perspective of a decision.

Its operational implementation is complex. Indeed, there are at least five methods of calculating costs: Full costing method, Variable cost method, Specific cost method, Marginal cost method and Activity-based costing (or ABC).

The ***Full costing*** (Fc) method is the most traditional approach to cost accounting attempts to evaluate different intermediate costs: Purchase costs, Production costs, Distribution costs to derive to the cost price. This method proceeds to the reclassification of the expenses according to whether they are: direct - directly attributable to the product such as raw materials, dedicated production tools, etc. indirect - cost elements common to several observed elements: support functions (HR, marketing, etc.), building costs, etc.
Indirect costs are broken down by analysis center to determine the portion attributable to each cost. In the end, the cost formula is the following: $Fc = \sum_{n}^{1}(Dc + Ic)$
That is the sum for all n operations implemented by the organization of the direct and indirect costs.
This method takes all costs into account but has a limitation, the allocation of indirect costs is a matter of arbitrary decisions and can thus be challenged.

The ***Variable cost*** (VC) method, also called direct costing (but not to be confused with the direct cost method), is based on the distinction between variable costs Vc (materials consumed, etc.) and fixed costs f (rent, personnel costs, etc.). The formula is the following: $\varphi_{vc} = \sum_{n}^{1}(Vc + f)$, That is the sum for all n operations implemented by the organization of the variable and fixed costs.
The objective is to calculate a margin on variable cost to analyze the profitability of a product and its capacity to cover the fixed charges. As such, the calculations here a made ex-post and require a turnover, which may not be observable in all organizations, the formula being:
Turnover (T) - Variable costs (VC) = Margin on Variable Cost (MCV) - Fixed costs (FC), the variable part takes into account both direct and indirect costs. This delivers thus a relevant indicator to compare several products or services, and the first step in the calculation of the break-even point but does not seem adequate for our purposes.

The ***Specific cost method*** includes in its calculation all direct, variable, or fixed costs. It does not consider indirect elements, which are included in the structural costs. The objective is to show a margin on specific costs. This is a very operational indicator to judge the profitability of a product by evaluating the value created. It is thus possible to decide whether to continue marketing it. However, some products may have a low margin on specific costs, but contribute to covering structural costs, and they may also be of strategic interest. We have here the same issues than above as per the observability of data, the calculation being : Turnover (CA) - Variable costs (VC) = Margin on Variable Costs (MCV)
- Specific fixed costs (SCM) = Specific Cost Margin (SCM) - Common Fixed Cost (CFC) = Result

The ***Marginal cost method*** does not attempt to calculate the cost of a product, but to estimate the cost of the last unit produced. It should be noted that some variable costs do not remain strictly proportional (upwards or downwards) with the volume of activity because of threshold effects. The methods allow to measure the economic impact of activity fluctuations such as the taking of a new order and is thus not convenient in our case.

The final, for now, approach is the ***Activity-based costing (or ABC) method***. It differs from traditional approaches as it evaluates the costs of activities that contribute to the creation of a product or service. It is based on the distribution of indirect costs according to drivers (Zelinschi, 2009). The objective of the ABC method is to reconstruct a picture of the functioning of the organization, which is exactly our goal. Based on a modeling of the studied processes, the approach leads to the evaluation of the cost of the associated activities. An activity is a set of linked tasks that contribute to provide a product or a service. A process is a sequence of activities that are transversal to the classic functions of the organization, with a product or service as output. Products consume activities, activities consume resources. In this context, we will be looking to cost drivers (which replace the work unit found in traditional cost accounting). The cost driver is the unit that best represents the consumption of resources by the corresponding activity. We also speak of an activity driver (even if in theory there is a difference between the two). The formula is the following. Cost of the driver = total resources consumed (overheads) / volume of the driver. The cost of an activity = cost of the driver x number of drivers. In the end, for P the Cost of production of all n activities of an organisation, Dc the direct costs and Ci the cost of activities (involved in the development of the product or service analyzed): $P = \sum_{n}^{1}(Dc + Ci)$

Beyond the arbitrary aspects of the choice of drivers, this method really takes into account the functioning of the organizations, and gives the means to identify the activities enduring a cost risks (e.g.: profitable or not activities) which is a valuable sources of progress to improve overall performance. It is thus this process we've been using

This is why, while collecting data for our pricing tool, we have made the use of the ABC approach, the risk being based on an activity, the implementation or not of best practices.

ii. A model

Let I be an institution that we will call the agent who wishes to arbitrate between implementations of good practices in a cost context, and Ψ a set of propositions (X) on which the agent's visions (choice of implementing or not implementing good practices with respect to costs) focus. $\chi \in \Psi$ is a subset of propositions about the agent's choices. The reality of how these propositions are perceived is entirely in the hands of the agent (which will involve testing this data in t).

In this context, the value associated with any proposition X, denoted ν (X), is determined by the following expression:

$$\nu(X) = \sum_i o(N_i \,\&\, \chi \,|X).d(N_i \,\&\, \chi), \text{ avec } \Delta \in \chi \text{ et } \forall i \text{ } \textit{(for any i index)}: N_i \in \Psi.$$

With
Δ : the decision
o : measure of the probability of occurrence of the conjunction N_i & χ given X
d: desirability of convergence or conjunction of Δ and a state of nature N_i, (the agent's wish and the consideration of additional non-redhibitory factors)
N*i : state of nature, i.e. the various superfluous factors unknown in a number of cases but nevertheless with multiple occurrences and included in the scope of the proposals*
i : identification index of the information chain

This first expression puts into perspective the desirability of an action and its probability, i.e. what could be done and what would be desirable given X (implementation of good practices relative to costs). It is also interesting to note that the conjunction of the data collected in D 6.2 and this expression could already make it possible to measure the desirability for the actors concerned to implement or not to implement the ACCORD as defined in the ProRes framework.

This being said, if $X = \Delta$ (i.e. the agent knows with certainty that Δ is true) then the above mentioned expression becomes:

$$\nu(\Delta) = \sum_i o(N_i| \Delta).d(N_i \;\&\; \Delta), \text{ with } \Delta \in \chi \text{ and } \forall i : N_i \in \Psi.$$

In this context, we assume that the agent is aware of the information related to the implementation of good practices in a context of prior costs (X) (the volumetry of costs up or down depending on the implementation or not of good practices). How should the agent take this information into account in order to reassess the value of the different alternatives at his disposal (establishing good practices, partially establishing good practices, not establishing them at all), given his original information and objectives? In other words, how is the expression $\nu(\Delta|X)$ defined?

In a classical framework, the Bayesian rule could be applied, i.e., the information X would be taken into account by the rational agent, who is actually less rational since he is already influenced by an exogenous contingency not known to the other agents... i.e., additional costs. Here we find the original bias at the basis of the concept of irrationality, which is rather based on the measurement of a difference in information.

If we set $o(N_i^{\Delta}) = o(N_i|\Delta)$, in this case the actualized knowledge $o^*(N_i^{\Delta})$ of our agent, once the new information X is assimilated will be:

$$o^*(N_i^{\Delta}) = o(N_i^{\Delta}|X) = o(N_i^{\Delta} \,\&\, X)/o(X).$$

The information X must also be integrated into the evaluation of the desirability of the Δ action. The new evaluation thus becomes :

$$\nu^*(\Delta) = \sum_i o^*(N_i^{\Delta}).d(N_i \,\&\, \Delta \,\&\, X) = \sum_i o(N_i^{\Delta}|X).d(N_i \,\&\, \Delta \,\&\, X).$$

Let’s consider another organization that we will name institution II. Concretely, the information X that institution I has implemented the ACCORD at a given cost should allow institution II to revise its belief, for example, that it will obtain more, or less, public funding. The revision of its beliefs will then in turn lead to a revision of its preferences concerning the different objects contained in the set χ. In practice, institution II will amend its reading according not to its own approach, but to a competitive vision of the impact of a third party's action (the deployment of the ACCORD by institution I) on its own future. It could thus agree to implement the ACCORD and thus itself impact other third parties in turn.

However, this approach suffers from several difficulties. The main problem is that we assume that the information *X*. is known to both organizations in such a way that institution II assigns it a probability of 1, which allows it to apply Bayes' rule. However, the choice of institution I can mean different things, for example, the nature of the expectations of economic agents, the fear to be sanctioned if the given best practices are not in place, the existence of an institution request from let say the European Union or financiers, etc. In other words, rather than a single piece of information $\boldsymbol{X}$, the choice of organization I conveys a partition of information $\boldsymbol{X} = \{X_j\}$.

It is then possible that the same event (the choice to apply good practices) can be interpreted in different ways. Formally, this translates into a change in the probabilities that the institution I assigns to each element of the partition $\boldsymbol{X}$. These new probabilities then weight the Bayesian update, which gives:

> $o^*(N_i^{\Delta}) = \sum_j o^*(N_j^{\Delta}|X_j)\ o^*(X_j)$, with $o^*(X_j)$ the new adherence of Institution I to the proposal X_j.

We then talk about Jeffrey's conditions which are based on the fact that the agents' perceptions are not fixed but can evolve in an indeterminate way according to the successive iterations.

In fine, the delta value will be the concatenation of all the successive values. In addition to the fact that it allows to consider the fact that an information can convey a complex message, this method accounts in a more tangible way for unexpected events in a given temporality (time test t).

If it is the costs that constitute the basis of the probabilistic value of arbitration for the implementation of good practices, how can we put a price on these costs? This is the most difficult part of the analysis for the non-economist: the distinction between costs and prices, knowing that their expression is identical: in both cases there will be a monetary result. In economics, "price" is commonly understood to mean the estimate of any Ω item (object, service, etc.) as it is sold or bought, whereas "cost" is what this Ω item costs, its production price. In this context, it is impossible to put a value on an action not yet realized. In the same way, and notwithstanding the fact that by analogy, it is possible to propose evaluations, putting a price on the future remains a challenge (Gollier, 2011) since, no more than the cost, we do not know what Ω will be worth when it is exchanged.

When we place ourselves in the context of decision-making, which is our case, we nevertheless need figures to establish a diagnosis and a strategy. Analysts work on both sides of the equation: they establish prices for transactions with and without risks, whose figures are based on approaches and on actual past situations. They give a price to costs.

III – Implementation decisions using pricing models

To price our best practice implementation problem to make it intelligible as an arbitrage approach, we will therefore: (a) Choose a pricing methodology establishing the importance of each parameters in the ACCORD implementation decision making process, (b) Establish the necessary costs by analogy (c) price the set of costs as per risk of non-implementation. We should thus have an operational model to measure the economic risks related to non-ethical implementation of the ACCORD's defined best practices.

To do this we will use known and proven financial analysis tools, on the one hand real options (ref) and on the other hand the concept of net present value and value at risk (ref). But instead of working on futures and portfolio valuations with given values, we will focus on costs. We will work in this way with the variables of the real options (6 in the classical model but which we will extend according to the elements detailed below).

The reference data will therefore be the costs related to the research projects.

We propose to use the cost parameters as listed and validated in the DEFORM project, in this case, the 8 cost typologies and the 74 critical paths of the risks of inadequate practices. The approach will therefore be parametric, which allows each user of the tool to work on constructed data rather than on collected data.

To put it simply, we will propose a methodology for evaluating the costs of a project produced without risk and the effect on costs of a problematic practice.

It will be up to the users to start from their own data whose parameters - the architecture - will have been defined in the project.

This should result in a fine set of percentage increases or decreases in said costs allowing stakeholders to measure the potential impact on their budgets of non-compliant practices.

Operationally, we proceeded in three distinct steps. First, we had to evaluate the underlying of our options. Indeed, to make a decision, we need to know what we are talking about economically. Starting from the assumption that we had to make comparisons, a common unit of understanding was necessary, hence the use of a monetary referent understandable by all, and consequently an evaluation. In this step, we tested two robust approaches: the Capital Asset Pricing Model (CAPM), which remains the most widely used, despite its highly debated empirical relevance, and multifactor models.

In a second step, we proceeded to model the valuation of each identified cost and then to concatenate them according to the approaches described above. This was done in order to freeze what is called the value at risk (cost of a project without risk & with risk).

Finally, in a third step, we applied the real options for the strategic choices (because it can be chosen to postpone the investment to manage the risk rather than to lose everything, in a logic of decision support).

a. Selecting a pricing methodology: Capital Asset Pricing Model (CAPM), or multifactor models.

1 – Discussing the valuation of project assets: a cost model

This step is fundamental as the first problem encountered by our approach is that the underlying asset considered is not a financial asset but a potential cost, which seriously complicates its valuation.

In this respect, the real options technique, which, it should be remembered, allows a strategic investment decision to be taken in relation to a non-financial underlying asset, seems particularly appropriate. Indeed, in this model, which appeared more than 30 years ago (Brach, 2003), the underlying asset can be anything: a project or a real asset (economic activities whatever their phase - start-up, acceleration, growth, etc.), patents or any other intellectual property, intangible assets, software, capital goods, production units, projects of any kind, including of course research, etc.). In addition, this method makes it possible to highlight the value of the asset with and without risk, which gives a timely vision of the strategy to follow. Our first line of work was therefore to establish the parameters of this underlying asset.

Theoretically the valuation parameters are similar to the valuation parameters of financial options. The fundamental difference lies in the fact that the underlying asset of the Real Option is none other than the investment project itself. This raises the question of how to model it. In an entrepreneurial logic, the present value of the asset is represented by the current value of the cash flows incurred. However, in a research project, the value is not limited to these flows, as they are extremely complex to identify.

This required us to look for an efficient approach to capturing the value of our assets, prior to defining their scope (what they are about). In other words, to define our approach to value before considering the parameters of that value.

For this we considered - as mentioned above - two methodologies: the Capital Asset Pricing Model (CAPM), and the multifactor models.

i. The Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) is the most famous and widely used valuation model despite the fact that its empirical relevance is highly debated: it was even announced as "dead" some years ago (Lai & Stohs, 2015).

Based on the "modern portfolio theory" as modelled by Markowitz in the middle of the last century (Aftalion, Poncet & Portait, 1998), it owes its wide dissemination to Sharpe, Lintner and Mossin (Miller, 1999) in the 1960s to its description of the relationship between the risk of a financial asset and its expected return.

The general idea on which the CAPM is built is the following: investors are remunerated by the time value of money (T) and by the risk (R). The time value of money is represented by the risk-free rate, which generally corresponds to the lowest but least risky investment rate, for example government bonds. The risk is represented by the Beta, the historical ratio between the volatility of the asset and the market, where the volatility indicates how much the price of that security or fund may vary, up or down, from its average price over a given period. The more volatile the market prices are, the higher the volatility of an asset. Volatility is a very important dimension of risk: the greater the volatility of a product, the greater the risk associated with that product will be. This is to be expected if the price of a product fluctuates a lot. Indeed, in such a context, one cannot be sure of being able to sell it at a profit or even without a loss. Depending on the asset class and the reference period, volatility is more or less significant. The CAPM formula is thus the following, with (actif) the asset to be valuated:

$$E_{ractif} = R_f + \beta_{actif}(E_{rm} - r_f)$$

With :

E_{ractif} : expected return on the financial asset
R_f : risk-free interest rate
β_{actif}: Beta of the financial asset or asset-specific interest rate.
$E_{rm} - r_f$: expected market return
E_{rm} : gross market return

Thus, the CAPM describes the return on the asset as the return on the risk-free asset plus a market risk premium (market return minus return on the risk-free asset) weighted by the asset's beta (β). Below is the detailed calculation that is to be used if implementing the process.

The risk-free rate represents the lowest but least risky investment rate, such as state bonds. There is no need to calculate them, they are known market data. In Europe, these are called the euro short-term rate (€STR) as adopted by the working group on euro risk-free rates on the 13th of September 2018. The current rate is -0.571 implying that non risk assets loose value daily on the market (rates are negative). Official current European rates can be consulted at this address. The expected market return corresponds to the historical return of the reference market (assets class) over a certain period (2 years, 5 years, 10 years, etc.).
The Beta (β)of the financial asset is defined as the ratio of the covariance (σ) of the asset's return with that of the market to the variance of the market's return. The formula is thus the following:

$$\beta = \frac{\sigma_{ractif,rm}}{V_{rm}}$$

The simplest way to calculate a Beta is the historical method. Thus, "ractif" will be the historical return on the asset, just as "rm" will be the historical return on the market. In practice, the closer the Beta is to 1, the more the asset will follow the market. To determine whether an asset offers an investment opportunity, the expected return calculated with the CAPM needs to be compared to the expected return on the non-risked asset, calculated for example in a fundamental way from the PER (price earnings rate) or other valuation techniques. In this way it can be determined whether the current price of the asset is low or high. To be efficient, CAPM must follow some very specific rules. The following are the different basic assumptions, mainly taken from Markowitz' work on modern portfolio theory (Buttell, 2010), and it is precisely because of these ten preconditions that the CAPM approach has been and remains so controversial (Table 3 : Capital Asset Pricing Model, critics & validation).

CAPM preconditions	Critics and validation
The ecosystem is neutral or needs to be neutralized (they are no transaction costs or taxes, which is of course not the case)	It is impossible to accurately calculate the expected market return, which distorts the final result.
Shorting or buying a security has no impact on its price	Interactions is one of the known effects on markets (Duffie, Garleanu, & Pedersen, 2002).
Investors are risk averse and rational	True, most investors seeking adequate return are not prepared to full risk
All investors have the same investment horizon	If there is anything variable in finance, it is investment horizons and their maturity (Gunthorpe & Levy, 1994), which is intimately linked to the nature of the investors on the one hand and to portfolio arbitrage on the other. This is one of the most problematic prerequisites of the CAPM model, which implies de facto splitting the market into actors with the same approach to maturities.
investors control their portfolio risk through diversification	True, this is a recommended practice.
The market is completely unregulated, and all assets can be traded.	This is the case for some markets, not for all, and something that systemically varies (e.g.: after the 2008 crisis, some regulation was passed again which was overturn in 2016 by a change of administration)
Investors can borrow and lend unlimited amounts at risk-free rates	Again, this in not systematically the case and can easily be overturn (c.f.: the reasons of the Evergrande crisis is mostly due to a change in regulation that highly impacts the company's financing model)..
All market information is equally available to all investors	No, this is not the case. Even more, some information can be distorted by markets structures or approach per se : e.g, the size effect or PER is not taken into account in the model. Indeed, it has been shown that small cap and/or low P/E stocks have higher returns than large cap and/or high P/E stocks.
Competition in the markets is perfect and undistorted	This is clearly not the case (Zheng, 2010).
all financial assets can be divided into smaller assets	This happens but noy systematically (Malevergne & Sornette, 2003).

Table 3 Capital Asset Pricing Model, critics & validation

ii. Multifactor models

We are therefore aware that CAPMs are controversial, but in this case, they seem to take into account enough approaches to be valid for our purpose. Nevertheless, we also looked at the multifactor model (Djebali, 2011) for the analysis of the performance of an asset to check whether it could serve the project or not.

The idea of the model is simple. The idea is to decompose the residual risk contained in each asset into specific and common factors, to overcome the limitations of the arbitrage valuation model. These advances aim to further identify sources of return and portfolio construction techniques.

Multifactor models establish more sophisticated relationships between different assets in a portfolio, and therefore for us between different elements of a value. One of the main ideas is that for similar characteristics, assets should have similar returns and therefore similar prices. This makes it possible to give values by analogy in the absence of data on a specific asset. This degree of similarity between assets can be found at several levels. Specific or common return factors are weighted by their assumed importance. Specific risk factors are assumed to be decorrelated between assets in such a model.

Although attractive because they allow for a stronger decomposition of the sources of return or risk present within assets, multifactor models are not perfect. Several limitations remain. For example, they can only be based on permanent and not transitory factors, and cannot, in all cases, explain all the performance or risk of an asset. In any case, some uncertainty remains.

The other interesting aspect of the multi-factor approach is that it allows for the calculation of a return on a single security as well as on multiple securities, in other words, it allows for the highlighting of the different components of a "return", if any. In our case, the return is of course the observed benefit of implementing good practice.

If we relate this to our project, it allows us to consider the multiple factors that may or may not influence a decision to deploy good practice. The more excess return, the more valid the deployment will be.
The model can be expressed in this way for N factors and T parameters and considering the following elements.

- ⇨ Φ the sum of the parameters/assets used to make the decision whether or not to deploy the ACCORD (otherwise known as the portfolio); R_Φ the excess "return" of the portfolio, in other words the excess return if the good practices are deployed.
- ⇨ $X_{\iota,\kappa}$ the exposure of parameter i to risk k;
- ⇨ Ξ_I the weight of parameter i within the portfolio of parameters; R_k the return on factor k and
- ⇨ Δ_i, the specific influence of parameter i on decision making.

$$R_\Phi = \sum_{k=1}^{N} X_{\Phi,\kappa}\, R_k + \sum_{i=1}^{T} \Xi_i\, \Delta_i \text{ où } X_{\Phi,k} = \sum_{i=1}^{T} \Xi_i X_{i,k}$$

As the specific risks are assumed to be decorrelated, the decision-maker does not need to calculate the variances and covariances of each of the parameters, but only of the factors, in order to know the risk of implementation or not (the portfolio risk in finance).

In the end, what is a project if not a set of costs, and therefore in a way a portfolio of costs. In this second stage we will therefore define the contents of this portfolio. Once this has been established, we will have to value these different elements according to the models mentioned above to establish our risk scheme and enable each project leader to measure financially what the implementation of good practice could bring to his or her project, and conversely what non-implementation could generate. In other words, what joining or not joining the ACCORD could mean in economic terms.

b. Model the nature and scope of the relevant costs.

As we have seen above, the ABC method and the driver logic clearly meet our needs in analytical terms. Moreover, as we have said, the cost components affected by the problems of non-deployment of good practices have already been identified in the case of the DEFORM project, although the question of their evaluation cannot be fully resolved. This is one of the issues we will focus on here. These costs - for which there is now a relative consensus - include human values (direct costs of salaries, charges and training), indirect environmental costs (flows, legal ecosystem, etc.), communication costs, costs of access to finance (premium) and control costs. We will not repeat here the extent of the approaches that have enabled this identification, which is already amply detailed elsewhere (Gans Combe, Faucheux, Kuszla, Petousi & Garani, 2019), but we will detail how these costs are calculated according to established models and data. In this context, each type of cost is defined and modelled below.

i) Human value costs

Human value costs (H) have been largely documented (Roúca & Roúca, 2010) and include Social (s) and salary costs (S), recruitment and turnover costs (Rt) as well as Training costs (Tc).

$H = \sum_{n}^{1}(S + s + Rt) + \sum_{n}^{1} Tc$, n being the considered period of time.

Data exist as per the evaluation of the first three as these are expensed in the organisations' accounts, and therefore appear clearly in the accounting ledgers (sections 5 or 6, depending on the numbering standards). It will therefore be easy to define this first tranche of costs (α), on the basis of which the trade-offs will be established. However, the difficulty lies into the evaluation of the fourth component. Hence, to calculate the losses in training (Tc), we used the modelisations tested by Deloittle (Department of Innovation, Industry, Science and Research, 2011). In this approach, these costs are broken down between Direct costs: Costs uniquely associated with a Higher degree by research (HDR, we are after all talking about research organisations here) student during the course of his or her research training. These include computing equipment, field trip expenses, salary costs for supervisors, etc. and Indirect costs: Costs incurred by a university that are related to research training or an Higher degree by research student but which are also shared by faculties, staff or other students. These included counselling services, IT services, etc.

The point to emphasise here is that the more a structure put in place a rational planning of its research programmes (continuity, operational stability of support teams, stability of operational teams involved in research, etc.) the more it was able to achieve scale effects. This has already been observed in the manufacturing sector (Moussaoui, 2017) and is therefore also found in the research environment. According to Deloittle, *"the econometric equation for average cost of research training per Research Training Scheme Higher degree by research candidate is:*

$$Tc = \alpha + \sum \beta_i X_i + \varepsilon$$

[1] α: a constant standing for the costs shared by all research centres,
[2] A set of explanatory variables (Xi) including all the environment costs calculated in relation to location, type of organisation in which the training is implemented, type of contract, duration, students' enrolment, training scheme (if any), staff, internal, campus number,
[3] β a measure of how much Cost changes for a 1 unit change in each of the explanatory variables (i) and
[4] ε is an error term capturing the unexplained part of Costs if any."

Hence, $H = \sum_{n}^{1}(S + s + Rt) + \sum_{n}^{1}(\alpha + \sum \beta_i X_i + \varepsilon)$, n being the considered period of time.

The components of H being known, we will then compute H at t and t+1 weighted by inflation (*i*), and validate the significance of this calculation by an analysis of standard deviation, interquartile range1 in order to deal with the problem of extreme values and variance. If on this given D_h calculation, the above data are statistically significant we will use the value at t+1, otherwise we will apply to H a factor of one, implying that the crisis has had no impact on costs, an issue which is very unlikely to happen. Note that the weighting of inflation is important because it may have absorbed some of the cost growth.

$$D_h = \left(\frac{H_{t+1} - H}{100+i}\right)*100$$

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the same operation.

ii) Image costs and Brand rehabilitation

Brand rehab (Br) is not only communication but also includes higher pay and salaries as employees tend to refuse to work with structures having suffer image flaws due to fraud or malpractices. (Kahn, 2005). Brand rehab is based on two variations: the post and pre crisis of communication costs and the rise in pay and benefits as a variation of $\sum_n^1 (S + s + Rt)$ that we will call *H'*.

Br is therefore the expression of:

(1) A significant difference observed between pre- and post-crisis H'.
To do this we will calculate H' at t and t+1 weighted by inflation (*i*), then validate the significance of this calculation by an analysis of standard deviation, interquartile range1 in order to deal with the problem of extreme values and variance. If on this given calculation, the above data are statistically significant we will use the value at t+1, otherwise we will consider H' =1, implying that the crisis has had no impact on costs, an issue which is very unlikely to happen. Note that the weighting of inflation is important because it may have absorbed some of the cost growth.

We will designate this value as D_h with, for t=0 $D_h = \left(\frac{H'_{t+1} - H'_t}{100+i}\right) * 100$

As an exemple, if th H' cost at t is of 100 and 150 at t+1 with an annual inflation of 2%, the real cost of H' variation is not 50 but 49.01 that is ((150-100)/(100+2))*100.

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the same operation. This approach is particularly interesting if one wishes to validate the fact that a crisis may have impacted a structure over a given number of years.

(2) A significant difference observed between pre- and post-crisis communication costs that we will call C'.
The growth in communication costs comes essentially from actions taken over time to counter the effects of a crisis (Farvaque, Refait-Alexandre & Saïdane, 2011). It is therefore necessary to consider a cost C which is the sum of the budgets allocated to corporate communication excluding product/service launches and outliers events, over a period of time t, and then to take into consideration the growth of these costs in relation to the time of their decrease until they reach the original level C. The period t should therefore be filled in by eliminating the phases of abnormality so as not to include black swans which could necessarily bias the assumptions. In addition, the growth in communication costs also includes a human resources function. To avoid redundancy, we will only consider the variations in exogenous costs accounted for in pure non-HR expenses, as these are already included in H' above. These data are also detailed in the ledgers and are therefore easily accessible to the financial departments of the concerned organisations.

The components of C being known, we will then compute C at t and t+1 weighted by inflation (*i*), then again validate the significance of this calculation by an analysis of standard deviation, interquartile range1 in order to deal with the problem of extreme values and variance. If on this given D_c calculation, the above data are statistically significant we will use the value at t+1, otherwise we will apply to C a factor of one, implying that the crisis has had no impact on costs, an issue which is very unlikely to happen. Note that the weighting of inflation is important because it may have absorbed some of the cost growth.

$D_c = \left(\frac{C_{t+1}-C_t}{100+i}\right)$*100

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the above described operation.

This being said, for t=0 the cost of brand rehab can be expressed as such.

$$B_r = \left(\frac{(H'_{t+1} - H'_t) + (C_{t+1} - C_t)}{100 + i}\right)$$

Table 4 Brand Rehab exemple

Variables	Values
H'_{t+1}	300
H'_t	150
C_{t+1}	600
C_t	800
i	2.2

As an example, we suppose that the crisis is starting and that we are at t+1. In the accounts we have the following elements, the inflation being of 2.2%. If we apply the above formula, the real cost of B_r is (150+200/102.2)*100 = 342.46 and not 350. Inflation tends to minimize the financial impact of a crisis. Again, if the cost is considered with t=n, the formula becomes the sum of all n iterations of the same operation.

iii) Ecosystem value: value for the shareholders, ect…

It might seem that this variable does not apply to all organisations. Nonetheless, it needs to be analysed if there is involvement of third-party funders at the top end of the balance sheet (capital holdings) but also because some data exist to be use for a-priori not concerned structures. When a crisis occurs, the loss of value for this type of actor can be extreme due to the intrinsic volatility of the markets. This was demonstrated during the 2008 financial crisis (Blot & Timbeau, 2009). To calculate the impact of this loss of value, it is necessary to calculate the time taken to return to the original value, the time taken to erase the loss. This will give a multiplier factor that makes it possible to measure the financial impact of a loss more simply than by successive concatenations of data sequences that can be complex to implement. If the organisation does not have capital funding, the market indices of the relevant sector can be used to calculate the factor in question.

The calculation to be implemented is as follows. Consider the value s of the share at t and t+1. The two values are subtracted and weighted by inflation to obtain V_s . The result is a crisis cost amplification factor Ψ that must be applied to the monetary sums calculated and that represents in a way the ecosystemic impact of the loss of confidence, the shock wave of the loss of confidence, which has been observed for several recent crisis (Colvin, 2020).

$$V_s = \left(\frac{s_{,t=1} - s_{,t}}{100+i}\right) \text{ with } \quad \Psi = 1 - V_s$$

iv) Access to finance

Access to finance is another barrier to identifying the costs of not implementing good practice. Apart from the fact that any organisation considered "at risk" will - if it borrows - have to pay a higher premium, i.e. a higher interest rate, the question does not necessarily arise in these terms for an unconcerned actor, such as research centres dependent on public money and grants. It is clear that a break in the liquidity chain has a significant cost for any economic actor, but assessing this cost is complex. On the other hand, it has been observed that the shorter the time to return to access to funding, the faster the value of the structure is recovered (Kahle & Stulz, 2013). We therefore propose here the empirical implementation of a second factor (μ) giving a relative weight to access to finance. The cost of risk would be multiplied by *X* for a structure banned from all financing until it is only *X*=1 for a structure retaining full access to its original financing, i.e., unaffected, knowing of course that the original situation must be taken into account. To calculate this starting point, we will use the ratings of the structures established by the central financial bodies (for example, the rating of the Banque de France: https://www.fiben.fr/modules-0) which rates the economic actors according to their capacity to honour their commitments. (μ) will be calculated by the ratio between the old Banque de France ratio (R_t) and the worst possible one if the structure is excluded from any access (R=9).

$$(\mu) = \frac{R_t}{R_{t+1}}$$

As soon as $R_t = R_{t+1}$ the ratio will be neutralized, implying the structure is back to normal as per its financing capacity.

v) Enhanced audit practices

Auditing is now part of the routine analytical monitoring actions implemented by economic actors. There are therefore observable audit costs through the deployment of management control and the use of monitoring service providers. It has been observed that this type of cost tends to increase sharply in the event of organisational problems observed in economic structures and is therefore part of both the overall costs to be included in pricing and the costs impacted by shocks within the considered projects (Fairchild, Gwilliam & Marnet, 2019). We will call A the audit costs observed at the original time t of our approach.

The components of A being known, we will then compute A at t and t+1 weighted by inflation (*i*). Of course, further to this calculation, we will validate the significance of this calculation by an analysis of standard deviation, interquartile range in order to deal with the problem of extreme values, and variance. If on this given D_a calculation, the above data are statistically significant we will use the value at t+1, otherwise we will apply to A, a factor of one, implying that the crisis has had no impact on costs, an issue which is very unlikely to happen. Note that the weighting of inflation is important because it may have absorbed some of the cost growth.

$$D_a = \left(\frac{A_{t+1} - A_t}{100 + i}\right) * 100$$

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the above described operation.

In conclusion, this approach allows us to:

[1] Calculate the value of the project at t (this is the basis for the decision-making final analysis below) => (=> $(H + C + A)\ R_t$
[2] Calculate the impact value of a crisis (increase in costs observed at t+1)
[3] Calculate the impact value of avoiding a crisis (decrease in costs observed at t+1)

Both being modelled in the same way, i.e.: (H+C+A) + ((Br+ Dh + Da) (μ+Ψ))

We have assumed that we are interested in the evaluation of a project cost before the implementation of good practices and in cost evaluations in the context of a positive or negative evolution of the situation.

We have emphasised the negative here to highlight the risk, but a decrease in costs observed at t+1 can happen. This does not change the model per-se but will show an increased value of the project and not a loss of value. A good way to assess the substantial financial gains that the deployment of ACCORD could generate.

c - Deciding whether to implement best practice: using real options.

- Real options in a nutshell

The real options method bridges the gap between financial options and investment projects, including and especially what we are dealing with here, i.e. research projects. Broadly speaking, it should be noted that it superimposes the financial notions of time and volatility on the project mode, whether it is entrepreneurial or not.

Real options complement the analysis provided by the net present value (NPV), which does not take sufficient account of the flexibility of projects and situations of uncertainty. Indeed, the evaluation of a project is often carried out using the IRR (Internal Rate of Return) method and the Net Present Value (NPV). To calculate the NPV (net present value) of a project, the value of the net cash flows created during its lifetime is calculated. All cash inflows and outflows of the project are valued in advance. In general, if the resultant value is greater than 0, then the project is likely to increase in value.

However, the NPV method can still be improved because it is too deterministic. It has difficulty in integrating certain unexpected events. Indeed, what about when there is no cash flow (no sales for example). One can certainly focus only on costs. This is feasible given the study above. But what if something unexpected happens (e.g. the implementation or non-implementation of good practices)? To answer this question, other evaluation methods have been developed, including the real options approach. This approach assesses the value creation (or not) attached to the project, taking into account the changes that may accompany its implementation, for example if the economic situation changes.

The real options method is therefore an approach whereby the consequences of an uncertain situation can be superimposed on the financing process.

The present value of the asset is represented by the present value of the most likely cash flows of the project. If the cash flows are only outgoing, one can focus on them without marking them down.

The strike price is the amount(s) to be invested to exercise the option in the case of an asset purchase (equivalent to a call) or the amount received in the case of an asset sale (equivalent to a put), i.e. simply the investment before the asset is realised/the research project is completed.

It also allows a value to be established at time t, i.e., to determine a residual value if the project is suspended. This is a very useful tool for a funder who can determine what is left over at a given time in the event of a shock to the project.

Volatility represents the level of uncertainty in the project, measured by the dispersion of the value of the underlying asset over time. Two different approaches are used to estimate volatility:

- A market-oriented approach is based on the volatility of the stock of the company holding the project or the implied volatility of the option on the stock, if it exists. This approach requires a company listing (or the existence of derivatives), which is clearly not the case here, or,
- An approach centered on the project consists in estimating its own volatility: the simulation of the distribution of the values of the project (at maturity or at an intermediate term, according to the authors) is carried out by the Monte Carlo Method, the standard deviation obtained is retained as an estimator of the volatility.

It goes without saying that in the absence of shares when talking about a research project, the second approach is preferred.

The expiry date marks the end of the life of the option, i.e. the date by which management no longer has the option to choose between action or no action. In other words, the project date must be delivered.

The risk-free rate valid for the entire life of the option, that is the rate of a risk-free asset whose issuer is characterised by a higher level of solvency. Treasury bonds do correspond to such requirements.

Optional dividends that could be generated by the underlying asset. In the context of a project, the dividend is equivalent to any income that could be derived from the actual asset and paid to the owner. They reduce the appreciation of the asset, in other words future income if it exists.

- Applicability to our approach

Abel, Dixit, Eberly, & Pindyck (1996) early on suggested that an organisation with an investment opportunity 'held' something akin to a financial call option, i.e. *'the right, not the obligation, to acquire an asset that corresponds to the right of access to the profit stream generated by a project at a time of its choosing in the future'*. The realisation of the investment then corresponded to the exercise of the call option. We assume that the research project resembles an investment opportunity that will or will not be realised not according to market criteria but according to value creation criteria. To do this, we will use the approach of Blais (2005) which postulates the existence of a correspondence table between the parameters of real options (assimilated to investment options) and those of financial options which we will transform by a new translation towards realisation parameters. The calculation will make the link between the expected value of the action, i.e. the impact on the value of a research project of the implementation or not of good practices. In a way, we will have the vision of a sensitivity to the risk of implementing or not implementing good practice in a project:

Real option to realise	Variable	Real option to invest	Variable	Financial call option
Total project cost	S	Present value of assets to be acquired to complete a project.	S	Price of underlying asset
Investment to be made to complete the project	E	Investment to be made to complete the project	E	Exercise price of the option
Period during which the action can be delayed.	τ	Period during which the action can be delayed.	τ	Time remaining until the option expires.
Time value of money	r	Time value of money	r	Risk-free rate
Risk measure of non-performance on the value of assets.	α	Risk measure of project assets	α	Volatility

Table 5 correspondence between the parameters of real options and projects' implementations choices (Adapted from Blais).

Needless to say, that the calculation of the discount rate is paramount to determine the appropriateness of investments by comparing different cash flows over different time periods. To calculate the present value of a sum to be received in the future, a discounting operation is carried out on the financial flows. The formula for discounting a flow is as follows: $V(0) = V(n) / (1 + i)^n$ Where: - V(0) is the present value of the flow - V(n) is the value of the flow in year n - i is the annual interest rate on risk-free investments - n is the number of years between now and the payment of the flow. To calculate the present value of an investment, all the flows (year 1, year 2, .., year n) generated by the investment must be added together. This is particularly the case for bond investments that pay interest every year and then repay the principal at maturity.

With these prerequisites in place, the decision cycle for research actors in their choice of whether or not to implement the ACCORD from a strictly financial point of view would go through the stages detailed in Figure 1 below. In this respect, it should be recalled once again that we are not talking here about other "motivators" in the decision-making process, such as peer pressure, media pressure, whistleblower announcements, etc., but only about economic stress, economic logic, in other words the impact of value pressure on a research project.

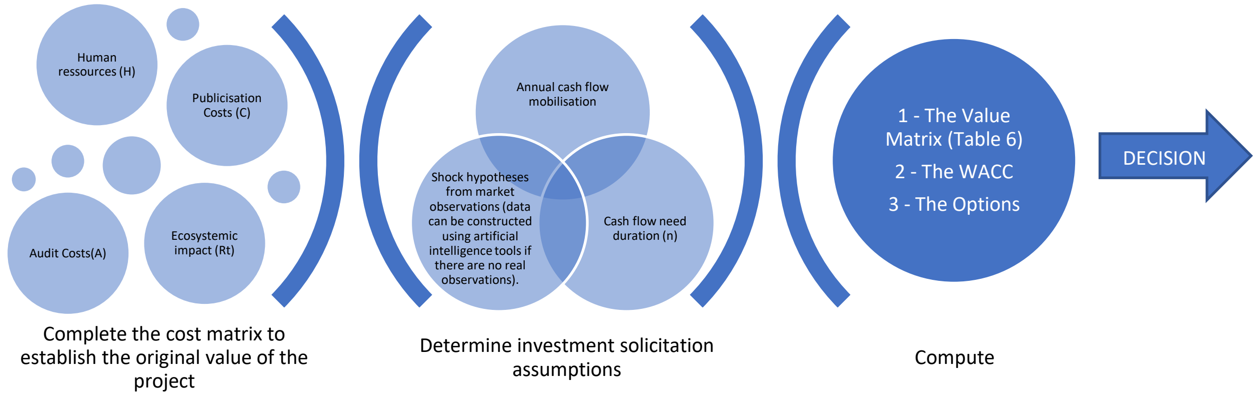

Figure 1 Stages needed towards the implementation of a decision making model of whether or not deploy the ACCORD.

All other things being equal, i.e., there is a constant representing fixed costs which exist but are not directly related to the project. These costs can be calculated but are not directly impacted by the future of the project (a research center will not close because a project is stopped). On the other hand, the project represents a relative weight for the ecosystem which must be factored and considered (Rt).

➢ Numerical example

Suppose there is a research project with a cost of 12 million Euros (original value). This project is to be carried out over 10 years and therefore requires an investment of 1 200 000 Euros each year. It is known that on this project there is a 45% chance that a shock will occur, i.e. that it will fail due to the non-implementation of good practices in general (França & Haddad, 2018). Recent studies also indicate that 14% of projects fail due to poor ethical practices, including Fraud (Fazekas, Ugale & Zhao, 2019). We do not know whether these statistics are cumulative, so we will consider an average in our calculations to avoid statistical over- or under-representation of the risk.

- ✓ The risk of ethical shock, i.e., the failure of good practice in the field, is therefore 32.1%.
- ✓ The neutral risk is therefore 12.9%.
- ✓ The risk of no shock is therefore 55%.

For the last 2 evaluations, we make this distinction for reasons of granularity. But for the decision study, we will keep the total of 67.9%.

We also know how to calculate the loss of value due to the shock (see above) either directly from the ledgers or predictively using the domain cost analogies (Button & Gee, 2013). It is known that losses due to fraud vary between 5 and 15% of total company revenues. (Cohn, 2020). For the benefit of this example, we will calculate the loss in value (P) from the ACFE valuation as reported by Cohn weighted by the proposals of Böhme & Moore (2009) and Fazekas, Ugale & Zhao (2019). Our average theoretical loss in value (Δ) in the event of a shock is therefore 10% excluding inflation.
We therefore have the following figures:
Total value (T) of the project= 12 000 000
Expected investment period n = 10
Theoretical annual value of the investment = T/n = 1,200,000
This gives us, as a synthesis of hypotheses, the table below (table 6: the value Matrix).

Values	Amounts in €	Amounts in € at t+1	Likelihood of occurrence	Models
Total Project value (T)	12 000 000			
Theoretical annual Project Value (Λ).	1 200 000			
Shock Value (P) – current time t	1 200 000	1 080 000		$= P_t - \Delta P_t$
Annual value – no shock (V_{ns})	1 200 000	1 200 000	67.9%	
Annual value – incl. shock (V_s)	1 080 000	972 000	32.1%	$\Lambda_t = \text{P} - (P_t - \Delta P_t)$

In order to calculate our option value, i.e. what impact the shock will have on the value of the project, we now have an important variable called the discount rate. The discount rate is used to assess the profitability of an investment project.

The discount rate or cost of capital is a rate that corresponds to the profitability expected by all the providers of funds (institutional financiers, shareholders, creditors) of an economic actor, it is also called weighted average cost of capital. In other words, it indicates to a third party the potential cost of financing, because financing has a cost. Incidentally, calculating this amount could be useful for the EU to make visible the real market cost of the institution's research funding.

In terms of investment, the discount rate is one of the key parameters for calculating the NPV. It allows the potential cash flows to be generated by an investment project to be discounted in order to assess its profitability while taking into account the value of money over time. It also allows arbitration between different potential investment projects for an economic actor. In this case, the EU could add an objective economic indicator to the subjective perception of scientific experts in order to provide input for research funding decisions other than by a simple personal reading of actors, however competent they may be, but necessarily biased by their professional background and perimeter.

In any case, no investment should be retained if its profitability is lower than the minimum profitability requirements of all the funders, simply because if this is the case the project will not create value and will therefore not be effective for the institution.

The discount rate can be calculated by different methods (direct method, indirect method, actuarial method) and under different assumptions. Among the main classical methods for calculating the discount rate, we will apply the so-called indirect method, as it is the one most commonly used for deciding on investment choices, and therefore the one closest to our decision-making needs. This method is based on several assumptions:

- ✓ the investment project is financed in a continuous and identifiable manner throughout the duration of the project (no financing mix);
- ✓ the risk class of the organisation is stable and like that of the investment project.

From a mathematical point of view, the discount rate or cost of capital (WACC) for the company is an average profitability which, according to this model, corresponds to the market value of the overall weighted equity or equity allocated to the project, by the rate of return required by the financiers (if the organisation is listed), plus the market value of its net financial debts weighted by the cost of the debt (if the organisation is indebted).

The following formula is used: WACC = $(\mathrm{T}_r * (1-\Gamma)) + C_d\ (1-\mathrm{I})$

With:

- ➢ Financial leverage Γ = net financial debt / (equity + net financial debt)

- Company risk rate T_r = Risk free rate + Company risk premium
- Company risk premium ρ = Market risk premium x Company beta
- Company Beta β = Deleveraged Company Beta x (1+(1-TheIS) x (Net Financial Debt / Equity))
- Cost of debt C_d which is the market interest rate after tax (as the company saves tax on interest payments to its creditors).
- I = corporate tax.

The values of net debt and equity are market values. The cost of capital depends only on the risk of the economic asset and it pre-exists the financial structure. Indeed, it is according to the risk of this economic asset and the financial structure that creditors and shareholders will determine the rate of return they require on the company's debt and equity. The cost of debt is the after-tax market interest rate (because the company makes a tax saving on the interest payment to its creditors).

Important Notice: The reference to market values tells us that this type of calculation is dependent on local situations. It is therefore up to the users of this method to integrate the data specific to its geographical perimeter and the situation of its markets, all data being public and accessible on the websites of central banks or international financial organisations such as the ECB or the IMF.

Example of WACC calculation with current data:

Assumptions:

- 7-10 year government bond rate (risk-free rate): 0.5%.
- Market risk premium: 5.0
- Current corporate tax rate: 25%.
- Sector beta of comparable "deleveraged" organisations: 1.10. We consider that there is no debt attributable and charged to the project.
- There is no market capitalisation to take into account. We consider this to be a non-quoted institution.
- Project debt (DFN): €0
- Project Value (PV) of €12M.
- Normative cost of debt of 6.0%.

[1] Calculation of the organisation Beta:

Organisation Beta at zero debt = (Benchmark Beta)1.10 + no mark-up given due to structure's market capitalization; it is not listed. 0 = 1.1.

Hence, Organisation Beta β = 1.1

[2] Calculation of the organisation risk premium

Organisation risk premium = Market risk premium x Organisation beta = 5.0% x 1.1 = 5.5%.

Hence Organisation risk premium ρ = 5.5%.

[3] Calculation of the Company risk rate

Company risk rate T_r = Risk free rate + Company risk premium = 0.5% + 5.5% = 6%.

Hence Company risk rate T_r = 6%.

[4] Calculation of the financial leverage

There is no financial leverage Γ as there is no debt. We will thus consider that the leverage Γ is neutralized (Bancel, Lathuille & Lhuissier, 2014).

$$\text{WACC} = (T_r * (1-\Gamma)) + C_d \ (1-I)\ \Gamma$$

= (6%*1) + (6%* (1-25%) 1)
= 6% + 0.045

WACC = 6.045%

The project discount rate is the cornerstone for evaluating the profitability of an investment. The indirect method is one of the main methods used to determine it. However, it is conditioned by several assumptions, which explains its limitation. It is therefore interesting to adapt the discount rate calculation models on a case-by-case basis (depending on whether the company is indebted or not, listed or not, etc.), and to take into consideration the limits of each model to determine the most coherent discount rate for the investment project.

Figure 2 COFACE's sectoral risk analyses.

If the calculation is too complex, it is possible to use spot discount rates observed on the markets (https://www.spac-actuaires.fr/lexique/taux-dactualisation-historique/). They are so called because they provide a snapshot at a given time of market expectations according to the maturity date of the assets. Central banks also offer valuations of this type (https://www.banque-france.fr/statistiques/taux-et-cours/les-indices-obligataires). Finally, as these evaluations are very dependent on the countries considered, they should be factorized with the sectoral risk analyses proposed by the specialized organizations (Figure 2).

We therefore obtained a discount rate (θ) of 6.045% excluding inflation, or 8.245% based on the average inflation rate currently observed, freely available on the International Monetary Fund's website (Long & Ascent, 2020) or from Eurostat.

Let's go back to our illustrative scenario. A research center plans to set up a system for monitoring good research practices. This has a cost, and it needs to know when this implementation is the most optimal to preserve the value of its research projects and investments.

The company wants to know the optimal time to implement these practices, i.e. when the trade-off between operational costs and the impact on project value will be most beneficial, or when it will be possible to observe a financial increase in value from x to z, or a decrease in value from x to z. If the company has the possibility to postpone its investment by one year, it will know the real value of the invested flow with certainty, otherwise, it will have to be satisfied with the predictive.

The table below summarizes the calculations to be carried out and their results for the hypotheses outlined above.

	t	t+1	t+2	t+3	t+4
Annual value – no shock (V_{ns})	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €
Annual Value - incl. shock (V_s)	1 080 000,00 €	972 000,00 €	874 800,00 €	787 320,00 €	708 588,00 €
Project Net present value actualised – ns (V')	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €
Project Net present value actualised - s (V'')	13 098 847,79 €	11 788 963,01 €	10 610 066,71 €	9 549 060,04 €	8 594 154,03 €

Table 6 Valuation calculations - Shock/Crisis impact

It is recalled that, according to the data observed, the shock - i.e. an impacting crisis on our give project - affects the latter to the extent of 10% of its value excluding inflation (on average). To compare the present value of the project given its implementation. The two net present values V' and V" are compared, V' being V_{ns}/WACC and V" being $V_s/WACC$.

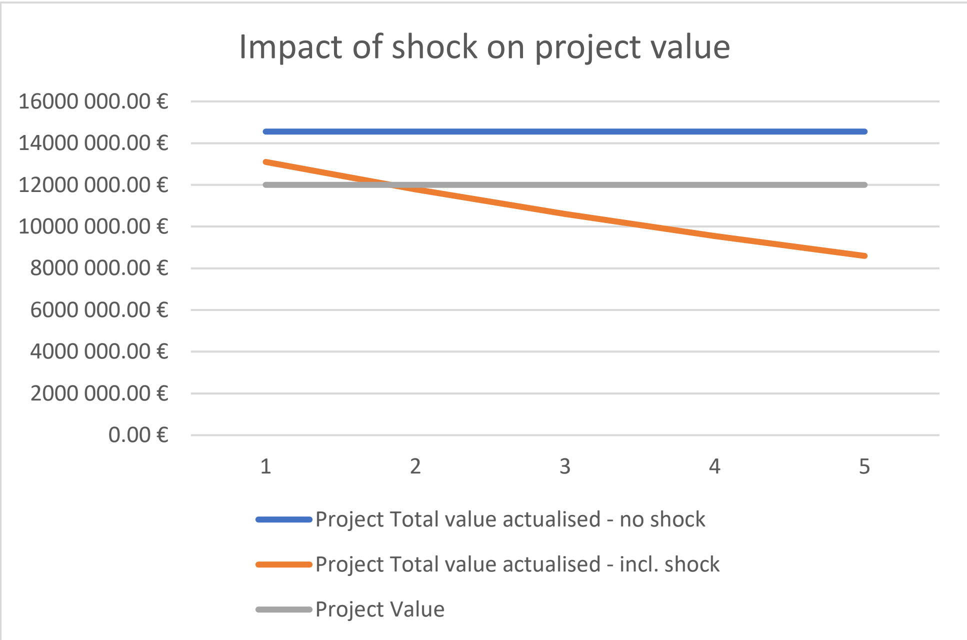

Figure 3 Impact of shock on project value

In year t, the project is certainly impacted by the shock but retains a slight surplus value. The promoters could therefore be lured by this figure and consider that the value of the project is not called into question by a potential credibility crisis, and that the risk/cost trade-off is not in favour of an institutional change.

The potential provided by the possibility of delaying the deployment of good practices by one year (the impression of no impact on the first year of the project's implementation) creates a value that can be assessed using the binomial approach, that is discrete, i.e. participating in a set that introduces a relationship between the input variables and the output variables (shock-impact), in which these variables can only have a finite number of values for the dynamics of the underlying (the project). In general, this model provides a numerical method for the evaluation of options, but especially of project and financing costs (Hunzinger & Labuschagne, 2014). As a reminder, the risk-free rate is fixed at 0.5%. In this context, the net value of the project is updated per time-period, and the value of the project is established as follows:

	Actualised project value in t (considering occurrences probabilities)	Actualised project value in t+1	Project surplus-value	Project surplus-value in % of project value
	14 087 083,08 €			
Values- no shock (A_{vns})		14 554 275,32 €	467 192,24 €	3,89%
Values- incl. shock (A_{vs})		11 788 963,01 €	-2 298 120,07 €	-19%

Table 7 Project surplus-value in % of project value

Therefore, the project generates either:

- an increase in value of 14 554 275,32 € - 14 087 083,08 € = 467 192,24 € which corresponds to 3,89% of the project value.
- or a loss in value of €117,896,01 - €14,087,083.08 = €2,298,120.07, i.e. a loss in value of 19% of the value of the project.

Taking into account the cash-flow rate (F) - in other words, in this case, the payments of the planned investment tranches - i.e. (1200000/1200000 = 10%) allows us to determine the return on the project, which is then established at:

3.89% + 10%	13.89%
-19% + 10%	- 9%

The neutrality property of an action carried out by a project initiator, i.e. that there is no gain/no loss in not deploying (or deploying) the ACCORD (what is called in finance the zero expectation martingale property) on the discounted value of the project has as a consequence that the expectation of gain under the neutral risk probability is equal to the risk-free rate. The probability of neutral risk p is then p = 1.2%.

We have a 1.2% chance of finding ourselves in the situation where the deployment (or not) of the ACCORD would not be valued, which is a fairly low probability of neutrality. This also implies that in 98.8% of the case, the potential deployment (or not deployment) of the ACCORD will be valued, i.e : will impact project costs & value.

In this context, the value of the option is calculated as follows:

$$\frac{\mathrm{p}\ (A_{vns} - \mathrm{F})\ +\ (1 - \mathrm{p})\ (A_{vs} - \mathrm{F})}{(1 +\ \theta)}$$

1.2% (14,554,277 - 12,000,000) + 98.8% (11,788,963.01 - 12,000,000) /1.08245, i.e. -164302 Euros. The choice of deploying the option (i.e. deploying the ACCORD) would therefore reduce the cost of the project by about 1.4%, the choice of NOT deploying the option will enhance project cost at the same level. As a reminder, this is a calculation after only one year of implementation. The more time goes by, the more the cost of course grows correlatively.

Given the high risk on the value of the project, and the fact that the deployment of good practices generates a financial gain, the option of not implementing good practices in the current ecosystem is not feasible. Implementing the proposed ACCORD is not an option, it is an economic imperative.

IV - Conclusion

This final analysis carried out within the framework of the ProRes project allowed us to demonstrate the imperative of deploying the agreement in its relation to the value of the project. From a strictly economic point of view, the construction of a cost model (variables constituting the costs) indicating both the proportionality of the latter and the techniques of sourcing the data and calculating them provides a solid basis for evaluating the impact on these costs of the deployment or not of good practices.
The use of valuation techniques over time, widely known in the world of finance, allows us to propose results that are just as transparent as the methods used to obtain them.

In this context, we can affirm that, whatever the strategic choice made (deployment or not of good practices):

1. the value of the project is impacted from the start,
2. the value of the project is affected from the first year to the point of being below the investment value at the end of the period
3. the implementation has an impact on the cost of the project.

These calculations could have a significant institutional impact. For example, it could be interesting to weight the public funding given to research projects according to whether or not good practices have been implemented. An efficient way to ensure growth in adherence to the ACCORD. However, we are cognizant of the fact that ee offer something that still requires further testing. Similarly impact evaluation requires long-term assessment of use by the primary target audience, and thus the opportunity to apply this tool to the PRO-RES project was simply not suitable. An infographic has been created with a step-by-step process as an annex to this document.

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Annex – Step by Step block model - cost base decision-making model: choosing or not to implement best practices/join the ACCORD & related infographics

The purpose of this appendix is to guide anyone wishing to make use of the valuation methodologies and calculations deployed in the research from the ProRes project.

The process is detailed in the form of a block sequence, the preliminaries explained and the methods for collecting the information necessary for the precise calculations.

Each calculation step and its model (as well as the documentary sources, if any) are then detailed.

As it is an anticipatory (ex-ante) and risk measurement approach, it is useful to measure value variations during project deployments. The tool allows each organization investing in research to "cost" non-compliance with integrity/ethics rules, as a monetary value over time.

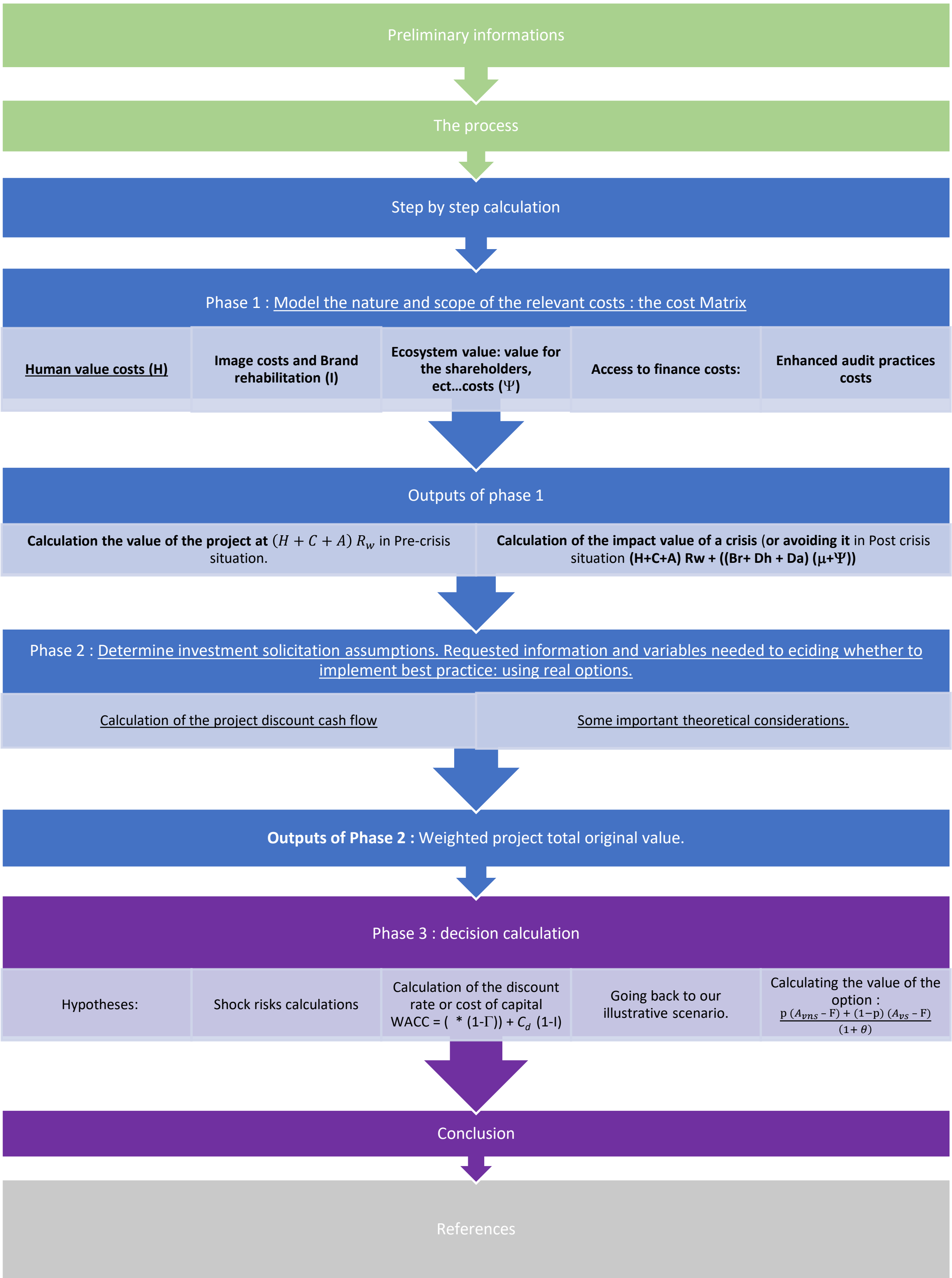
Applying it to a sequence of completed research allows us to indicate the growth/loss of the theoretical value of the program in question as a function of its malfunctions in terms of good practice (what we call shocks).

Nevertheless, a complementary research sequence could have allowed for the large-scale collection of data on European research programs, allowing European policymakers to envision the value creation/decrease of investments made with taxpayer funds in terms of compliance with good research practices, thus demonstrating the financial and monetary impact of compliance. Perhaps it would be useful in the future to have this sequence as a continuation of the ProRes project, especially since impact evaluation requires long-term assessment of use by the primary target audience.

Nevertheless, the tested tool is now usable by all, and it is up to each actor to appropriate it. To facilitate this, we provide below, as we said:

1. The detailed calculation sequence by logical blocks:

2. An infographic has been created with a step-by-step process on 6.3 utilisation and will be uploaded to the website. It should give a synoptic overview of applications of the deliverable.



Preliminary informations
The process
Step by step calculation
Phase 1 : Model the nature and scope of the relevant costs : the cost Matrix
Human value costs (H)
Image costs and Brand rehabilitation (I)
Ecosystem value: value for the shareholders, ect…costs (Ψ)
Access to finance costs:
Enhanced audit practices costs
Outputs of phase 1
Calculation the value of the project at $(H + C + A)\ R_w$ in Pre-crisis situation.
Calculation of the impact value of a crisis (or avoiding it in Post crisis situation (H+C+A) Rw + ((Br+ Dh + Da) (µ+Ψ))
Phase 2 : Determine investment solicitation assumptions. Requested information and variables needed to eciding whether to implement best practice: using real options.
Calculation of the project discount cash flow
Some important theoretical considerations.
Outputs of Phase 2 : Weighted project total original value.
Phase 3 : decision calculation
Hypotheses:
Shock risks calculations
Calculation of the discount rate or cost of capital WACC = (* (1-Γ)) + C_d (1-I)
Going back to our illustrative scenario.
Calculating the value of the option : $\frac{p\ (A_{vns} - F) + (1-p)\ (A_{vs} - F)}{(1+\theta)}$
Conclusion
References

1 - Preliminary information

A project is a set of costs and, therefore, a portfolio of costs.

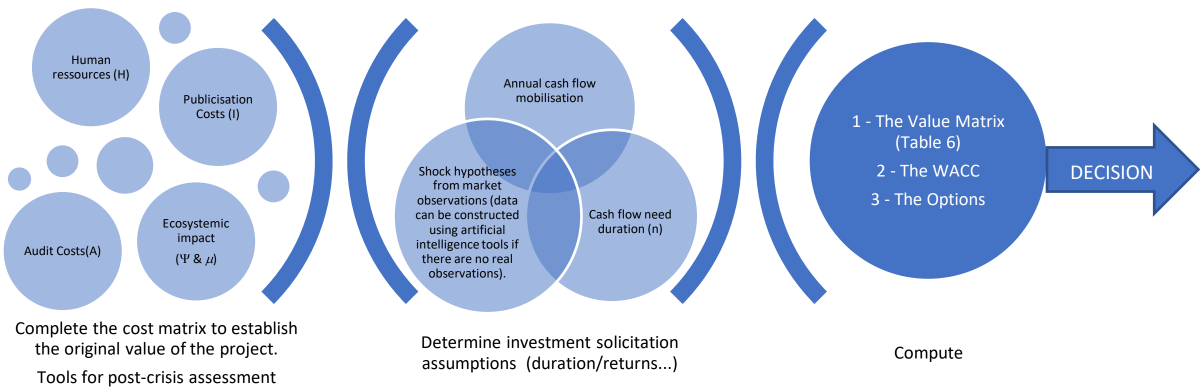
The simplified formulas & methodologies included in this document have a potential double use:
- Ex-ante situation (the crisis has not yet happened) => provide a basis for crisis simulation economic impact.
- Ex-post situation (the crisis has happened) => measure the impact of the crisis on the costs and value of a given project.

The objective: a methodology for evaluating the costs of a project produced without risk and the effect on project costs of a faulty practice to measure the potential impact on research projects budgets of non-compliant practices. What joining or not joining the ACCORD could mean in economic terms.

All needed Data are :

- **in organisations' accounting ledgers** (sections 5 or 6, depending on the numbering standards) or computed from the ledgers.
- **extracted from market sources**. When this is the case, sources are provided for references.

2 - The process



Stages needed towards implementing a decision-making model of whether or not to deploy the ACCORD

.

3- Step by step calculation.

Phase 1 - Model the nature and scope of the relevant costs: the cost Matrix

a – Human value costs (H)

Human value costs (H)	Formula	Composition	Source
Low granularity formula	$H = \sum_n^1 (S + s + Rt) + \sum_n^1 Tc$, n being the considered period of time.	Social (s) and salary costs (S), recruitment turnover costs (Rt) Training costs (Tc).	Roúca & Roúca, 2010
Calculation of Training losses	$Tc = \alpha + \sum \beta_i X_i + \varepsilon$	α: constant standing for the costs shared by all research centres (indirect costs). Xi: set of explanatory variables including all the environment costs calculated in relation to location, type of organisation in which the training is implemented, type of contract, duration, students' enrolment, training scheme (if any), staff, internal, campus number, (direct costs) β: measure of how much Cost changes for a one-unit change in each of the explanatory variables (i) and ε is an error term capturing the unexplained part of Costs, if any. Direct costs = related ONLY to research training. Include computing equipment, field trip expenses, salary costs for supervisors, etc. Indirect costs = Costs incurred by a university related to research training or a Higher degree by research student & are also shared by faculties, staff or other students: counselling services, IT services, etc.	Deloitte (Department of Innovation, Industry, Science and Research, 2011). Moussaoui, 2017
Enhaced granularity formula	$H = \sum_n^1 (S + s + Rt) + \sum_n^1 (\alpha + \sum \beta_i X_i + \varepsilon)$, n being the considered period of time.		

b - Calculation of Image costs and Brand rehabilitation (I)

Brand rehab (Br) = communication and higher pay and salaries as employees tend to refuse to work with structures having suffered image flaws due to fraud or malpractices. (Kahn, 2005).

In a post-crisis situation, data sources are again the ledgers. Brand Rehab is a calculation dedicated to post-crisis assessment as it observes data in pre and post-crisis situation (n and n+1).

Brand rehab is based on two variations:

- the post and pre crisis of communication costs
- the rise in pay and benefits as a variation of $\sum_n^1(S + s + Rt)$ that we will call *H*'.

Br is, therefore the expression of:

(1) A significant difference was observed between pre-and post-crisis H'.

Calculate H' at t and t+1 weighted by inflation (i). This value is $D_h{}'$ with, for t=0, $D_h{}' = \left(\frac{H'_{t+1} - H'_t}{100+i}\right) * 100$

As an example, if H' cost at t is 100 and 150 at t+1 with annual inflation of 2%, the actual cost of H' variation is not 50 but 49.01 that is ((150-100)/(100+2))*100.

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the same operation.

This approach is fascinating if one wishes to validate that a crisis may have impacted a structure over a given number of years.

(2*) There is a significant difference between pre-and post-crisis communication costs that we will call C'.*

The growth in communication costs comes essentially from actions taken overtime to counter the effects of a crisis (Farvaque, Refait-Alexandre & Saïdane, 2011).

Cost C = *sum of the budgets allocated to corporate communication excluding product/service launches and outliers events, over some time t*, and then to consider the growth of these costs about the time of their decrease until they reach the original level C.

In addition, the growth in communication costs also includes a human resources function. To avoid redundancy, we will only consider the variations in exogenous expenses accounted for in non-hr pure expenditures, as these are already included in H' above.

The components of C being known, we will then compute C at t and t+1 weighted by inflation (i). This value is :

$$D_c = \left(\frac{C_{t+1} - C_t}{100+i}\right)*100$$

If the cost is considered with t=n, the formula becomes the sum of all n iterations of the above-described operation.

For t=0, the cost of brand rehab can be expressed as such.
$Br = Indice*100$

Table 8 Brand Rehab exemple

Variables	Value
H'_{t+1}	300
H'_{t}	150
C_{t+1}	800
C_t	600
i	2.2

As an example, we suppose that the crisis is starting and that we are at t+1. In the accounts we have the following elements, the inflation being of 2.2%. If we apply the above formula, the real cost of I is (150+200/102.2)*100 = 342.46 and not 350. Inflation tends to minimize the financial impact of a crisis. Again, if the cost is considered with t=n, the formula becomes the sum of all n iterations of the same operation.

c - Calculation of Ecosystem value: value for the shareholders, ect…costs (Ψ)

It might seem that this variable does not apply to all organisations.

Nonetheless, it needs to be analysed if there is involvement of third-party funders at the top end of the balance sheet (capital holdings) but also because some data exist to be use for a-priori not concerned structures.

When a crisis occurs, the loss of value for this type of actor can be extreme due to the intrinsic volatility of the markets. This was demonstrated during the 2008 financial crisis (Blot & Timbeau, 2009). To calculate the impact of this loss of value, it is necessary to calculate the time taken to return to the original value, the time taken to erase the loss.

This will give a multiplier factor that makes it possible to measure the financial impact of a loss more simply than by successive concatenations of data sequences that can be complex to implement.

If the organisation does not have capital funding, the market indices of the relevant sector can be used to calculate the factor in question.

The calculation to be implemented is as follows.

Consider the value s of the share at t and t+1.

The two values are subtracted and weighted by inflation to obtain V_s .

The result is a crisis cost amplification factor Ψ that must be applied to the monetary sums calculated that represents in a way the ecosystemic impact of the loss of confidence, the shock wave of the loss of confidence, which has been observed for several recent crises (Colvin, 2020).

$$V_s = \left(\frac{s_{,t=1} - s_{,t}}{100+i}\right) \text{ with } \quad \Psi = 1 - V_s$$

d - Calculation of Access to finance costs:

Access to finance is another barrier to identifying the costs of not implementing good practices.

Apart from the fact that any organisation considered "at-risk" will - if it borrows - have to pay a higher premium, i.e. a higher interest rate, the question does not necessarily arise in these terms for an unconcerned actor, such as research centres dependent on public money and grants.

It is clear that a break in the liquidity chain has a high cost for any economic actor, but assessing this cost is complex.

On the other hand, it has been observed that the shorter the time to return to access to funding, the faster the value of the structure is recovered (Kahle & Stulz, 2013).

We, therefore, propose here the practical implementation of a second factor (μ) giving a relative weight to access to finance.

The cost of risk would be multiplied by *X* for a structure banned from all financing until it is only *X*=1 for a design retaining full access to its original funding, i.e., unaffected, knowing that the actual situation must be considered.

To calculate this starting point, we will use the ratings of the structures established by the central financial bodies (for example, the rating of the Banque de France: https://www.fiben.fr/modules-0) which rates the economic actors according to their capacity to honour their commitments. (μ) will be calculated by the ratio between the old Banque de France ratio (R_t) and the worst possible one if the structure is excluded from any access (R=9).

$$(\mu) = \frac{R_t}{R_{t+1}}$$

As soon as $R_t = R_{t+1}$ the ratio will be neutralised, implying the structure is back to normal as per its financing capacity.

e - Calculation of enhanced audit practices costs (A)

Auditing is now part of economic actors' routine analytical monitoring actions.

Therefore, there are observable audit costs through the deployment of management control and the use of monitoring service providers. It has been observed that this type of cost tends to increase sharply in the event of organisational problems observed in economic structures and is part of both the overall costs to be included in pricing and the costs impacted by shocks within the considered projects (Fairchild, Gwilliam & Marnet, 2019).

We will call A the audit costs observed at the original time t of our approach.

The components of A being known, we will then compute A at t and t+1 weighted by inflation (*i*). This value is :

$$D_a = \left(\frac{A_{t+1} - A_t}{100 + i}\right) * 100$$

If the cost is considered with t=n, the formula becomes the sum of all n iteratioof ns of the above-described operation.

Outputs of Phase 1

Calculation the value of the project at t (this is the basis for the decision-making final analysis below) => $(H + C + A)\ R_w$ in Pre-crisis situation.
All other things being equal, i.e., the project represents a relative weight for the ecosystem which must be factored and considered (Rw). Rw is the considered project cost divided by the total research investment of the institution.

Calculation of the impact value of a crisis (increase in costs observed at t+1) or the **impact value of avoiding a crisis** (decrease in costs observed at t+1) in Post crisis situation => **Both being modelled in the same way, i.e.: (H+C+A) + ((Br+ Dh + Da) (μ+Ψ))**

Phase 2 : Determine investment solicitation assumptions. Requested information and variables needed to deciding whether to implement best practice: using real options.

Calculation of the project discount cash flow.

To get as close as possible to the reality of a project, the anticipated costs must be put into perspective over time. This makes it possible to give active substance to theoretical costs.

For this purpose, the present value, the future value or the discounted value is calculated according to the time of the project. This also allows comparing the reality of an announced investment with an advertised amount.

Some critical theoretical considerations.

Abel, Dixit, Eberly, & Pindyck (1996) suggested that an organisation with an investment opportunity 'held' something akin to a financial call option, i.e. *'the right, not the obligation, to acquire an asset that corresponds to the right of access to the profit stream generated by a project at a time of its choosing in the future*. The realisation of the investment then corresponds to the call option's exercise.

We assume that the research project resembles an investment opportunity that will or will not be realised not according to market criteria but according to value creation criteria.

To do this, we will use the approach of Blais (2005), which postulates the **existence of a correspondence table between the parameters of real options (assimilated to investment options) and those of financial options, which we will transform by a new translation towards realisation parameters.**

The calculation will link the expected value of the action, i.e. the impact on the value of a research project of the implementation or not of good practices => obtain the vision of sensitivity to the risk of implementing or not implementing good practice in a project:

Real option to realise	Variable	Real option to invest	Variable	Financial call option
Total project cost	S	Present value of assets to be acquired to complete a project.	S	Price of the underlying asset
Investment to be made to complete the project	E	Investment to be made to complete the project	E	The exercise price of the option
The period during which the action can be delayed.	τ	The period during which the action can be delayed.	τ	Time remaining until the option expires.
Time value of money	r	Time value of money	r	Risk-free rate
Risk measure of non-performance on the value of assets.	α	Risk measure of project assets	α	Volatility

Correspondence between the parameters of real options and projects' implementations choices (Adapted from Blais).

The discount rate calculation is paramount to determine the appropriateness of investments by comparing different cash flows over different periods. A discounting operation is carried out on the financial flows to calculate the present value of a sum to be received in the future. The formula for discounting a flow is as follows: V(0) = V(n) / (1 + i)^n Where: - V(0) is the present value of the flow -

V(n) is the value of the flow in year n - i is the annual interest rate on risk-free investments - n is the number of years between now and the payment of the flow. To calculate the present value of an investment, all the flows (year 1, year 2, .., year n) generated by the investment must be added together.

If you implement the ACCORD, what will be the value gain for your project – If you don't implement the ACCORD, what is the risk of value loss of the project. Answering the is of particular interest for policymakers accountable for the use they are making of taxpayers' money.

Outputs of Phase 2

Weighted project totals original value.

Phase 3: decision calculation

a - Hypotheses:

Contents	Values	Comments
Weighted project total original value (budgeted costs)	12 million Euros	Total cost calculated or evaluated using the pricing matrix above. It can also be a planned budget to be allocated to a project.
Project duration	Ten years	
Yearly investment	1 200 000 Euros	
Project failure chance/shock (s)	45%	Non-implementation of best project practices (França & Haddad, 2018).
Project failure due to poor ethical practices (e)	14%	Failure due to poor ethical practices, including Fraud (Fazekas, Ugale & Zhao, 2019).
s and e are ponderated		statistical over-or under-representation of the risk avoidance
Equiprobable probability		Tests have shown this hypothesis converge with more complex approaches, and are well within the confidence range.
Average theoretical loss in value (Δ) due to the shock		
	10% excluding inflation	Directly from the ledgers or predictively using the domain cost analogies (Button & Gee, 2013). It is known that losses due to fraud vary between 5 and 15% of total company revenues. (Cohn, 2020). Calculation based upon the loss in value (P) from the ACFE valuation as reported by Cohn, weighted by the proposals of Böhme & Moore (2009) and Fazekas, Ugale & Zhao (2019).

b – Shock risks calculations

Designation	Formula	Results	
No shock probability (s)	1-s	0.55	
No shock probability (e)	1-e	0.86	
Shock probability due to poor ethical practices	s*e	0.311	
No shock probability due to poor ethical practices	1- (s*e)	0.689	

c- Calculation of the discount rate or cost of capital (WACC)

Total value (T) of the project= 12 000 000
Expected investment period n = 10
Theoretical annual value of the investment = T/n = 1,200,000
As a synthesis of hypotheses, this gives us the table below (table 6: the value Matrix).

Values	Amounts in €	Amounts in € at t+1	Likelihood of occurrence	Models
Total Project value (T)	12 000 000			
Theoretical annual Project Value (Λ).	1 200 000			
Shock Value (P) – current time t	1 200 000	1 080 000		$= P_t - \Delta P_t$
Annual value – no shock (V_{ns})	1 200 000	1 200 000	68.9%	
Annual value – incl. shock (V_s)	1 080 000	972 000	31.1%	$\Lambda_t = \mathrm{P} - (P_t - \Delta P_t)$

To calculate our option value, i.e. what impact the shock will have on the value of the project => important variable : the discount rate (DR). It also allows arbitration between different potential investment projects for an economic actor.

The discount rate or cost of capital is a rate that corresponds to the profitability expected by all the providers of funds (institutional financiers, shareholders, creditors) of an economic actor, it is also called weighted average cost of capital.

- Indicates to a third party the potential cost of financing, because financing has a cost.
- Useful for the EU to make visible the real market cost of the institution's research funding.

The discount rate allows the potential cash flows to be generated by an investment project to be discounted in order to assess its profitability while taking into account the value of money over time.

The EU could add an objective economic indicator to the subjective perception of scientific experts in order to provide input for research funding decisions other than by a simple personal reading of actors, however competent they may be, but necessarily biased by their professional background and perimeter.

Use of the indirect method to calculate the DR: assumptions.

- ✓ the investment project is financed in a continuous and identifiable manner throughout the duration of the project (no financing mix);
- ✓ the risk class of the organisation is stable and like that of the investment project.

From a mathematical point of view, the discount rate or cost of capital (WACC) for a structure is an average profitability which, according to this model, corresponds to the market value of the overall weighted equity or equity allocated to the project, by the rate of return required by the financiers (if the organisation is listed), plus the market value of its net financial debts weighted by the cost of the debt (if the organisation is indebted).

The following formula is used: $WACC = (T_r * (1-\Gamma)) + C_d\ (1-I)$

With:

- Financial leverage Γ = net financial debt / (equity + net financial debt)
- Company risk rate T_r = Risk free rate + Company risk premium
- Company risk premium ρ = Market risk premium x Company beta
- Company Beta β = Deleveraged Company Beta x (1+(1-TheIS) x (Net Financial Debt / Equity))
- Cost of debt C_d which is the market interest rate after tax (as the company saves tax on interest payments to its creditors).
- I = corporate tax.

The values of net debt and equity are market values. The cost of capital depends only on the risk of the economic asset and it pre-exists the financial structure. Indeed, it is according to the risk of this economic asset and the financial structure that creditors and shareholders will determine the rate of return they require on the company's debt and equity. The cost of debt is the after-tax market interest rate (because the company makes a tax saving on the interest payment to its creditors).

Important Notice: The reference to market values tells us that this type of calculation is dependent on local situations. It is therefore up to the users of this method to integrate the data specific to its geographical perimeter and the situation of its markets, all data being public and accessible on the websites of central banks or international financial organisations such as the ECB or the IMF.

Example of WACC calculation with current data:

Assumptions:

- 7-10 year government bond rate (risk-free rate): 0.5%.
- Market risk premium: 5.0
- Current corporate tax rate: 25%.
- Sector beta of comparable "deleveraged" organisations: 1.10. We consider that there is no debt attributable and charged to the project.
- There is no market capitalisation to take into account. We consider this to be a non-quoted institution.
- Project debt (DFN): €0
- Project Value (PV) of €12M.
- Normative cost of debt of 6.0%.

[2] Calculation of the organisation Beta:

Organisation Beta at zero debt = (Benchmark Beta)1.10 + no mark-up given due to structure's market capitalization; it is not listed. 0 = 1.1.

Hence, Organisation Beta $\beta = 1.1$

[2] Calculation of the organisation risk premium

Organisation risk premium = Market risk premium x Organisation beta = 5.0% x 1.1 = 5.5%.

Hence Organisation risk premium ρ = 5.5%.

[3] Calculation of the Company risk rate

Company risk rate T_r = Risk free rate + Company risk premium = 0.5% + 5.5% = 6%.

Hence Company risk rate T_r = 6%.

[4] Calculation of the financial leverage

There is no financial leverage Γ as there is no debt. We will thus consider that the leverage Γ is neutralized (Bancel, Lathuille & Lhuissier, 2014).

$$WACC = (T_r * (1-\Gamma)) + C_d \ (1-I) \ \Gamma$$

= (6%*1) + (6%* (1-25%) 1)
= 6% + 0.045

WACC = 6.045%

We therefore obtained a discount rate (θ) of 6.045% excluding inflation, or 8.245% based on the average inflation rate currently observed, freely available on the International Monetary Fund's website (Long & Ascent, 2020) or from Eurostat.

Going back to our illustrative scenario.

A research center plans to set up a system for monitoring good research practices. This has a cost, and it needs to know when this implementation is the most optimal to preserve the value of its research projects and investments.

The center wants to know the optimal time to implement these practices, i.e. when the trade-off between operational costs and the impact on project value will be most beneficial, or when it will be possible to observe a financial increase in value from x to z, or a decrease in value from x to z. If the centre has the possibility to postpone its investment by one year, it will know the real value of the invested flow with certainty, otherwise, it will have to be satisfied with the predictive.

The table below summarizes the calculations to be carried out and their results for the hypotheses outlined above.

	t	t+1	t+2	t+3	t+4
Annual value – no shock (V_{ns})	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €	1 200 000,00 €
Annual Value - incl. shock (V_s)	1 080 000,00 €	972 000,00 €	874 800,00 €	787 320,00 €	708 588,00 €
Project Net present value actualised – ns (V')	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €	14 554 275,32 €
Project Net present value actualised - s (V'')	13 098 847,79 €	11 788 963,01 €	10 610 066,71 €	9 549 060,04 €	8 594 154,03 €

Table Valuation calculations - Shock/Crisis impact

According to the data observed, the shock - i.e. an impacting crisis on our give project - affects the latter to the extent of 10% of its value excluding inflation (on average). To compare the present value of the project given its implementation. The two net present values V' and V'' are compared, V' being V_{ns}/WACC and V'' being $V_s/WACC$.

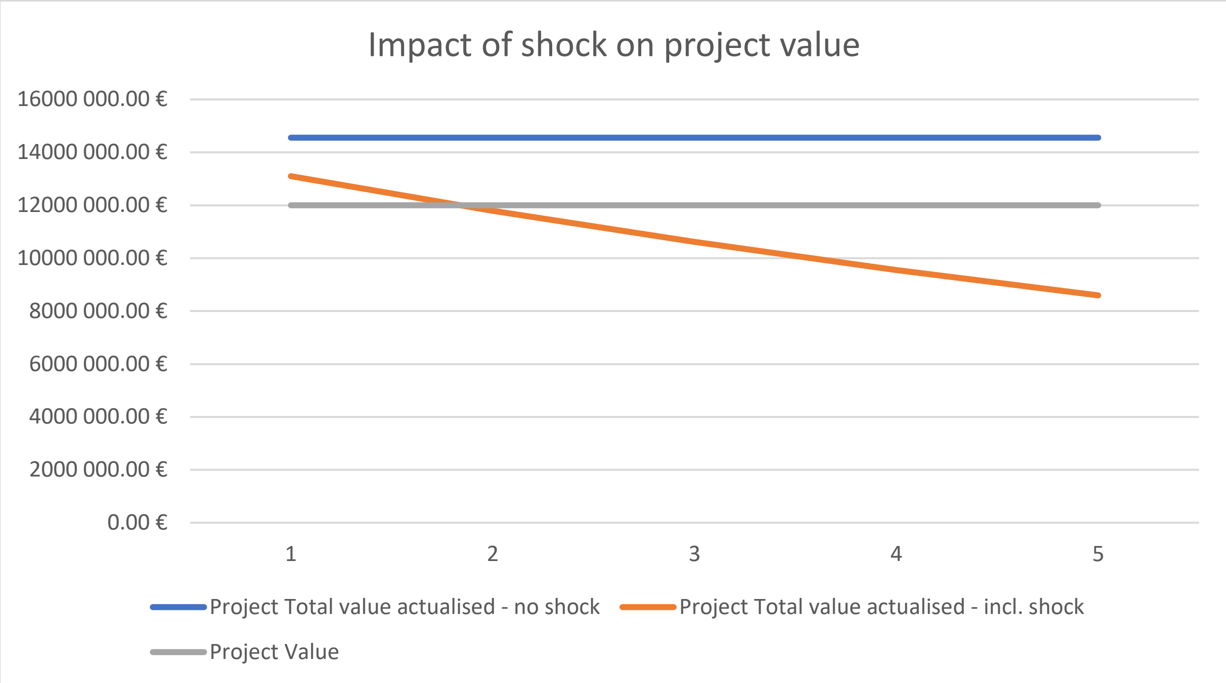


Figure 4 Impact of shock on project value

In year t, the project is certainly impacted by the shock but retains a slight surplus value. The promoters could therefore be lured by this figure and consider that the value of the project is not called into question by a potential credibility crisis, and that the risk/cost trade-off is not in favour of an institutional change.

The potential provided by the possibility of delaying the deployment of good practices by one year (the impression of no impact on the first year of the project's implementation) creates a value that can be assessed using the binomial approach, that is discrete, i.e. participating in a set that introduces a relationship between the input variables and the output variables (shock-impact), in which these variables can only have a finite number of values for the dynamics of the underlying (the project). In general, this model provides a numerical method for the evaluation of options, but especially of project and financing costs (Hunzinger & Labuschagne, 2014). As a reminder, the risk-free rate is fixed at 0.5%. In this context, the net value of the project is updated per time-period, and the value of the project is established as follows:

	Actualised project value in t (considering occurrences probabilities)	Actualised project value in t+1	Project surplus-value	Project surplus-value in % of project value
	14 087 083,08 €			
Values- no shock (A_{vns})	14 087 083,08 €	14 554 275,32 €	467 192,24 €	3,89%
Values- incl. shock (A_{vs})		11 788 963,01 €	-2 298 120,07 €	-19%

Table Project surplus-value in % of project value

Therefore, the project generates either:

- an increase in value of 14 554 275,32 € - 14 087 083,08 € = 467 192,24 € which corresponds to 3,89% of the project value.

- or a loss in value of €117,896,01 - €14,087,083.08 = €2,298,120.07, i.e. a loss in value of 19% of the value of the project.

Taking into account the cash-flow rate (F) - in other words, in this case, the payments of the planned investment tranches - i.e. (1200000/1200000 = 10%) allows us to determine the return on the project, which is then established at:

3.89% + 10%	13.89%
-19% + 10%	- 9%

The neutrality property of an action carried out by a project initiator, i.e. that there is no gain/no loss in not deploying (or deploying) the ACCORD (what is called in finance the zero expectation martingale property) on the discounted value of the project has as a consequence that the expectation of gain under the neutral risk probability is equal to the risk-free rate. The probability of neutral risk p is then p = 1.2%.

We have a 1.2% chance of finding ourselves in the situation where the deployment (or not) of the ACCORD would not be valued, which is a fairly low probability of neutrality. This also implies that in 98.8% of the case, the potential deployment (or not deployment) of the ACCORD will be valued, i.e : will impact project costs & value.

Calculating the value of the option :

$$\frac{\mathrm{p}\ (A_{vns} - \mathrm{F})\ +\ (1-\mathrm{p})\ (A_{vs} - \mathrm{F})}{(1+\ \theta)}$$

1.2% (14,554,277 - 12,000,000) + 98.8% (11,788,963.01 - 12,000,000) /1.08245, i.e. -164302 Euros. The choice of deploying the option (i.e. deploying the ACCORD) would therefore reduce the cost of the project by about 1.4%, the choice of NOT deploying the option will enhance project cost at the same level. As a reminder, this is a calculation after only one year of implementation. The more time goes by, the more the cost of course grows correlatively.

Given the high risk on the value of the project, and the fact that the deployment of good practices generates a financial gain, the option of not implementing good practices in the current ecosystem is not feasible. Implementing the proposed ACCORD is not an option, it is an economic imperative.

IV - Conclusion

This final analysis carried out within the framework of the ProRes project allowed us to demonstrate the imperative of deploying the agreement in its relation to the value of the project. From a strictly economic point of view, the construction of a cost model (variables constituting the costs) indicating both the proportionality of the latter and the techniques of sourcing the data and calculating them provides a solid basis for evaluating the impact on these costs of the deployment or not of good practices.
The use of valuation techniques over time, widely known in the world of finance, allows us to propose results that are just as transparent as the methods used to obtain them. In this context, we can affirm that, whatever the strategic choice made (deployment or not of good practices):

4. the value of the project is impacted from the start,
5. the value of the project is affected from the first year to the point of being below the investment value at the end of the period
6. the implementation has an impact on the cost of the project.

These calculations could have a significant institutional impact. For example, it could be interesting to weight the public funding given to research projects according to whether or not good practices have been implemented. An efficient way to ensure growth in adherence to the ACCORD.

A cost base decision-making model: Choosing or not to implement best practices

01 Introduction

A project is a set of costs and, therefore, a portfolio of costs.

Objective

A methodology for evaluating the costs of a project produced without risk and the effect on project costs of a faulty practice to measure the potential impact on research projects budgets of non-compliant practices. What joining or not joining the ACCORD could mean in economic terms.

02 Process Description

- **Complete the cost matrix to establish the original value of the project. Tools for post-crisis assessment.**

Human ressources (H) | Publicisation Costs (I) | Audit Costs(A) | Ecosystemic impact (Ψ & μ)

- **Determine investment solicitation assumptions (duration/returns)**
  - Annual cash flow mobilisation
  - Cash flow need duration (n)
  - Shock hypotheses from market observations (data can be constructed using AI tools if there are no real observations).
- **Compute**

The Value Matrix → The WACC → The Options

Stages needed towards implementing a decision-making model of whether to deploy the ACCORD.

03 Step by Step Calculations – Phase 1

Phase 1 : Model the nature and scope of the relevant costs : the cost Matrix

Human value costs (H).
Image costs and Brand rehabilitation (I).
Ecosystem value: value for the shareholders etc. (Ψ)
Access to finance costs.
Enhanced audit practices costs.

Outputs of phase 1

Calculation the value of the project at $(H + C + A)\ R_w$ in Pre-crisis situation.
Calculation of the impact value of a crisis (or avoiding it in Post crisis situation (H+C+A) Rw + ((Br+ Dh + Da) (μ+Ψ)).

Calculations – Phase 2

- **Determine investment solicitation assumptions. Requested information and variables needed to deciding whether to implement best practice: using real options.**

Calculation of the project discount cash flow.

To get as close as possible to the reality of a project, the anticipated costs must be put into perspective over time. This makes it possible to give active substance to theoretical costs.
For this purpose, the present value, the future value or the discounted value are calculated according to the timeline of the project. This also allows comparing the reality of an announced investment with an advertised amount.

- **Some critical theoretical considerations.**

We assume that the research project resembles an investment opportunity that will or will not be realized not according to market criteria but according to value creation criteria.

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Use of Blais' approach (2005). Postulates the existence of a correspondence table between the parameters of real options (assimilated to investment options) and those of financial options, which we will transform by a new translation towards realisation parameters.

Real option to realise	Variable	Real option to invest	Variable	Financial call option
Total project cost	S	Present value of assets to be acquired to complete a project.	S	Price of the underlying asset
Investment to be made to complete the project	E	Investment to be made to complete the project	E	The exercise price of the option
The period during which the action can be delayed.	τ	The period during which the action can be delayed.	τ	Time remaining until the option expires.
Time value of money	r	Time value of money	r	Risk-free rate
Risk measure of non-performance on the value of assets.	α	Risk measure of project assets	α	Volatility

- **Outputs of Phase 2**

Weighted project totals original value.

Calculations – Phase 3

- **Hypothesis**

Contents	Values	Comments
Weighted project total original value (budgeted costs)	12 million Euros	Total cost calculated or evaluated using the pricing matrix above. It can also be a planned budget to be allocated to a project.
Project duration	Ten years	
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- **Shock risks calculations**

Designation	Formula	Results
No shock probability (s)	1-s	0.55
No shock probability (e)	1-e	0.86
Shock probability due to poor ethical practices	s*e	0.311
No shock probability due to poor ethical practices	1. (s*e)	0.689

- **Calculation of the discount rate or cost of capital (WACC)**

Values	Amounts in (€)	Amounts in € at (t+1)	Likelihood of occurrence	Models
Total Project value (T)	12 000 000			
Theoretical annual Project Value (Λ).	1 200 000			
Shock Value (P) – current time t	1 200 000	1 080 000		$= P_t - \Delta P_t$
Annual value – no shock (V_{ns})	1 200 000	1 200 000	68.9%	
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*To calculate our option value, i.e. what impact **the shock** will have on the **value of the project** => important variable: the discount rate (DR). allows arbitration between different potential investment projects for an economic actor.*

- **Example of WACC calculation with current data:**

Assumptions:

- *7-10 year government bond rate (risk-free rate): 0.5%.*
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[1] Calculation of the Organisation Beta

Organisation Beta at zero debt = (Benchmark Beta)1.10 + no mark-up given due to structure's market capitalization; it is not listed. 0 = 1.1.
Hence, Organisation Beta β = 1.1

[2] Calculation of the organisation risk premium

Organisation risk premium = Market risk premium x Organisation beta = 5.0% x 1.1 = 5.5%.
Hence Organisation risk premium ρ = 5.5%.

PRO-RES

[3] Calculation of the Organisation risk rate

Organisation risk rate T_r = Risk free rate + Company risk premium = 0.5% + 5.5% = 6%.
Hence Organisation risk rate T_r = 6%.

[4] Calculation of the financial leverage

There is no financial leverage Γ as there is no debt. We will thus consider that the leverage Γ is neutralized (Bancel, Lathuille & Lhuissier, 2014).

$$WACC = (T_r * (1 - \Gamma)) + Cd_{(1-I)}\Gamma = (6\% * 1) + (6\% * (1-25\%)\ 1) = 6.045\%$$

We therefore obtained a discount rate (θ) of 6.045% excluding inflation, or 8.245% based on the average inflation rate currently observed, freely available on the International Monetary Fund's website (Long & Ascent, 2020) or from Eurostat.

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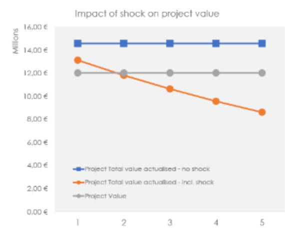

Impact of shock on project value

In year t, the project is certainly impacted by the shock but retains a slight surplus value. The promoters could therefore be lured by this figure and consider that the value of the project is not called into question by a potential credibility crisis, and that the risk/cost trade-off is not in favour of an institutional change.

Parameter	Actualised project value in t (considering occurrences probabilities)	Actualised project value in t+1	Project surplus-value	Project surplus-value in % of project value
	14 087 083,08 €	-	-	-
Values- no shock (A_{vns})	14 087 083,08 €	14 554 275,32 €	467 192,24 €	3,89%
Values- incl. shock (A_{vs})	-	11 788 963,01 €	-2 298 120,07 €	-19%

Therefore, the project generates either:

- an increase in value of 14 554 275,32 € - 14 087 083,08 € = 467 192,24 € which corresponds to 3,89% of the project value.
- or a loss in value of €117,896,01 - €14,087,083.08 = €2,298,120.07, i.e. a loss in value of 19% of the value of the project.

02 Conclusion

This final analysis carried out within the framework of the ProRes project allowed us to demonstrate the imperative of deploying the agreement in its relation to the value of the project. From a strictly economic point of view, the construction of a cost model - variables constituting the costs) - indicating both the proportionality of the latter and the techniques of sourcing the data and calculating them provides a solid basis for evaluating the impact on these costs of the deployment or not of good practices. The use of valuation techniques over time, allows us to propose results that are just as transparent as the methods used to obtain them.

In this context, we can affirm that, whatever the strategic choice made (deployment or not of good practices):

I. The value of the project is impacted from the start,
II. The value of the project is affected from the first year to the point of being below the investment value at the end of the period.
III. The implementation has an impact on the cost of the project.

These calculations could have a significant institutional impact. For example, it could be interesting to weight the public funding given to research projects according to whether or not good practices have been implemented. An efficient way to ensure growth in adherence to the ACCORD.

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