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A Framework for Innovation Management

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Abstract

Over the last three years a niche has emerged for web based tools to support innovation management processes. However, these tools usually focus on a limited part of the innovation management cycle. Moreover, in spite of the inherent portfolio nature of many decisions in innovation management, these tools tend to lack group decision support capabilities, except for simple mechanisms based on discussion fora and voting systems. We describe a flexible framework based on collaborative decision analysis to support innovation management processes and outline a web-based architecture implementing such framework.

Keywords: Innovation Management, Group Decision Support, Resource Allocation, Portfolio Decision Analysis, Collaborative Decision Analysis, Web based tools.

1 Introduction

Over the last three years, a market niche for web based innovation management tools has emerged. This is probably related with the rising concern among CEOs that innovation is a key factor for companies to stay ahead of their competitors. Indeed, as Townsend et al (2008) indicate, innovation is a strategic priority for 93% of senior business executives.

This interest is well grounded on statistical data. For example, if we choose a macroeconomic approach to assess the importance of innovation in the development of an economy, the European Innovation Scoreboard (Pro Inno Europe, 2009) shows that countries that are more focused on innovation, such as Sweden or Germany, have suffered less in terms of their unemployment rate in the aftermath of the current financial crisis than less innovative countries, such as Greece or Spain. Similarly, at the enterprize sector level, based on the EUROSTAT (2010) New Cronos data base, the motor industry has faced a reduction of almost 20% in employment in the period 2007-2009, whereas the computing, consulting and related services sector only had a reduction of 0.1%. Similar conclusions hold even for longer periods. Thus, in a globalized economy, there is a need to innovate to increase flexibility and provide new services and products.

Building on the recent success of the Web 2.0 and cloud computing paradigms, several new innovation management tools are being deployed over the web. However, these tools support just a few phases of the innovation management process. Moreover, in spite of the many portfolio decisions in this application area, they provide few group decision support capabilities, typically based only on discussion fora or simple voting mechanisms.

This paper proposes a flexible framework for managing innovation processes and outlines how such a framework could be implemented through the web to support innovation. Our methodology is based on collaborative decision analysis and resource allocation procedures to select a portfolio of potentially innovative projects. It is inspired by our experience in relevant consulting and incorporates, from a decision analytic perspective, best practices as described in Luecke (2009). It is flexible in the sense that it may fit and can be adapted to several organizational cultures.

The paper is structured as follows. We first review some innovation management tools, emphasizing their decision support facilities and corresponding strengths and weaknesses. We then describe SKITES, a general framework to support all phases of the innovation management process, drawing heavily on recent *e*-participation and web based collaborative decision support methodologies, see Burstein and Holsapple (2008). We pay special attention to decision analytic issues. We conclude by discussing how such framework could be implemented in a generic architecture to support interactions over the web, in order to scale up a fairly complex procedure.

2 Web based innovation management process tools

The increasing relevance of innovation has led to the emergence of a vision of innovation as a creative and collaborative activity that needs to be managed proactively within organizations, see Howells (2005). Shane and Ulrich (2004) provide a literature review of relevant research issues. Typically, innovation management processes include phases where: i) some projects are proposed, which are then; ii) filtered; then, iii) a portfolio of projects is chosen, and; iv) their implementation is monitored. The need to manage such highly relevant processes appropriately has spawned a new market of web based innovation management tools.

2.1 GDS features of some innovation management platforms

Here, we briefly outline the key features of six innovation management platforms which benefit from the popularity of Web 2.0; see French (2010) for an introduction to such technologies. These platforms are currently running initiatives with varying levels of penetration in the innovation management market. We emphasize their group decision support (GDS) facilities and indicate which phases of an innovation process are supported. The first two tools provide marketplaces for matching of innovation offer and demand. Besides this, the third and fourth tools incorporate voting mechanisms and simple filters and ratings for decision support. The fifth one supports innovation management processes comprehensively. The last one is a system for benchmarking innovation in organizations. We claim no completeness of our list. Rather, the systems here described span all key activities in innovation management processes. They are also having a reasonable success in terms of growth in customers and investment funding.

Innoget (http://www.innoget.com/) is an open innovation portal connecting companies with a network of scientists, labs and R&D oriented companies. It allows users to publish problems and receive proposals, solicit technologies that meet their demands, and offer their products. No formal decision support is provided. The company seeking to launch innovative projects receives feedback from research experts, who may engage in a research collaboration. Some important firms such as Orange or Leche Pascual have used it to search for innovative projects.

Innocentive (http://www.innocentive.com/) is a platform that connects companies, academic institutions and public sector organizations with a network of researchers who earn prizes (and reputation) when solving proposed challenges. It may be seen as an open challenge marketplace with incentives, which are mainly in the form of prizes, although other rewards such as grants or collaborations may also be given. This tool is quite simple in the sense that it is just a matching mechanism. There is no evaluation of innovative projects, nor is any follow-up supported. Thus, Innocentive just covers the gap between innovation producers and demanders.

ideas4all (http://en.ideas4all.com/) is a recent startup which serves as a platform in which persons and organizations propose ideas that receive support via a voting system, based on usefulness and reasonableness. Users can also pose problems in search for assistance or support. Thus, ideas4all is essentially an open idea marketplace supported by a simple voting mechanisms, not focused on innovation. Any kind of idea can be proposed, and almost any person can act as evaluator. Neither the voting mechanism, nor the evaluation criteria match the specific needs of innovation markets.

Qmarkets (http://www.qmarkets.net/) is a company which builds on *collective wisdom* to provide several services. Specifically, its product (Idea Management) supports the implementation of a four stage innovation process (submit, interact, evaluate, decide) helping a company to find new products that match its strategic objectives. Nevertheless Qmarkets does not cover the implementation and follow up phases. As for decision support, they provide voting tools and a proprietary evaluation system based on filters and ratings. Qmarkets counts with a number of strategic partners specialized on innovation. However, their system is meant to be used internally within an organization, not allowing external participants.

Accept (http://www.accept360.com/) is an innovation management system combining modules for idea generation, portfolio management and product development based on best practices in innovation processes and business intelligence. Accept supports the idea generation, the selection and the execution phases. It includes several voting mechanisms and multicriteria value functions with fixed criteria that are adapted to the circumstances of each partner or market, to support portfolio selection. The system does not support the follow-up phase. Accept is more a software service than an innovation consultancy service supporting the entire innovation process.

Imp^{3}rove (`https://www.improve-innovation.eu/`) started from a project funded by the European Commission. Their most relevant decision support tool facilitates the benchmarking of an organization in terms of innovation, based on five criteria (innovation strategy, organization and culture, innovation life cycle processes, enabling factors, innovation results). This helps the company in comparing its results with those of competitors in the same sector. This tool is oriented mainly towards small and medium-sized enterprizes (SMEs). The resulting evaluation, which resembles the European Foundation Quality Management (EFQM) model for quality assessment, suggests improvements in an organization innovation process.

2.2 Discussion

The above tools are backed by expertise in innovation management and seek to promote and support innovation within organizations. However, these tools incorporate fairly simplistic methodologies and mechanisms for group decision support and resource allocation, mainly through facilitating discussions and voting protocols. Few tools use more sophisticated mechanisms based on group value functions, but they tend to use criteria that are fixed across organizations and/or weights fixed for all of them. Moreover, they are based on a fixed innovation management process that cannot be really adapted to any organizational culture: the organization needs to adapt to the tool, rather than the tool adapt to the organization.

This background sets the stage for our framework which supports such processes, from the generation of innovative projects, to their filtering, evaluation and selection, to the follow-up of their execution. This framework is intended to be flexible and adaptive, in order to embrace various organizational cultures and different enterprize sizes including public and private ones, SMEs and big firms, innovation networks, among others, with different innovation cultures, based on different criteria, business models, competitive advantages, target markets, sizes or business environments.

Because there are several portfolio decisions to be taken in innovation management, the framework should provide appropriate group decision support methodologies for assessing projects. This assessment could combine standard indicators with not so well-known indicators specifically designed for the evaluation of innovation projects. Our framework is based on best practices in innovation management, see Luecke (2009), which we augment by adding collaborative decision analysis tools, as in Raiffa et al (2002). Moreover, we design such framework to make it implementable through the web to better support distributed decision making and facilitate its application at a broader scale.

In doing this, we draw on recent developments and debates in the field of *e*-participation, see Rios Insua et al (2008), French et al (2007) and Rios Insua and French (2010), and the tradition in group decision support systems, see Burstein and Holsapple (2008). We also draw on portfolio resource allocation methods, see Vilkkumaa et al (2010) and Kleinmuntz (2007) for relevant pointers, as well as other chapters in this volume.

3 SKITES: A framework for innovation management

As described here, SKITES (Sharing Knowledge and Information Towards Economic Success) reflects an open approach to innovation for sustainable growth. We emphasize the decision support aspects of the framework for making choices about proposals for innovative projects.

SKITES is structured along the following phases:

1. innovative projects are generated and proposed,
2. they are filtered and documented,
3. they are chosen for implementation, and, finally,
4. they are followed up with a view towards project management and gathering data to support future innovation rounds.

As we shall see, decision analysis methods are core to this approach in phases 1, where we aim at screening projects, and 2, where we need to allocate the available resources to a portfolio of projects.

We distinguish four roles within SKITES:

- *Organization*. It refers to the organization (company or public body) which sets up the innovation process, according to specified rules.
- *Proposers*. These are the individuals or teams that respond to a call for proposals issued by the organization proposing innovative products or services.
- *Assessors:* These are experts whose role is to evaluate and manage the innovation process and decide which proposals are to be implemented. The size, composition and involvement of this group may vary from one organization to another. They will be accountable for the final portfolio of projects chosen. This group might be formed by experts from the organization, external advisors or, even, by the whole set of constituents, in tune with recent e-participation experiences, see e.g. Lavin and Rios Insua (2010).
- *Facilitators:* These will be experts engaged in SKITES. They will have a sound background in innovation management and a two-fold role: on one hand, to assist proposers and experts with difficulties encountered using this framework, and, on the other, to revise the information supplied by the proposers looking for coherence and consistency.

We consider two different operation modes for SKITES:

- Closed. In this case, the organization restricts the innovation process only to designated members. This is typical of large organizations with sufficient human resources to deal with their innovation challenges. However, an open innovation paradigm is starting to gain importance, see e.g. Chesbrough et al (2008), and more organizations are adopting such approach to reach more disruptive innovations.
- Open. Conceptually, see Herzog (2008), Open Innovation is defined as the use of external and internal resources to accelerate internal innovation, and, at the same time, the use of external pathways to market for internal knowledge. In this case, an organization releases its demands for innovative products, projects or services, by proposing challenges for specific markets. This will be typical of small organizations which may be too small to innovate effectively on their own. This may be the case also of public bodies, which must strive for transparency, fairness and publicity when funding projects. Many sources of open innovation can be identified, mainly based on licensing, joint agreements, venture capital and spin-offs.

Methodologically, both innovation modes are handled in the same fashion, the only difference being the inclusion of external participants. This entails the need to develop appropriate security mechanisms to allow individuals to take part in innovation processes as their permissions indicate.

3.1 Phase 0: Generation of innovation projects

In this phase, innovative projects are generated for later detailed evaluation. Although Kleinmuntz (2007) suggests that there is always an abundance of proposals among which we need to allocate our limited resources, this may not be the case, which is why an organization might be interested in an open innovation approach.

The systematic generation of innovative project proposals may be pursued with informal and more formal tools. Among the informal ones, brainstorming is the most popular approach. The nominal group technique is an evolution of brainstorming; however, in order to avoid underperformance of less confident participants, the collection of ideas is done in a systematic way through a written procedure. Other informal sources for innovative projects that can be considered are ideas from customers that are lead users of products and ideas contests through a call linked to a specific subject or area. More formal approaches are based on checklists (like PESTEL, SWOT or PROACT) or rich picture diagrams that are described in French et al (2010). TRIZ, which is a problem-solving, analysis and forecasting tool based on patterns of invention in the global patent literature that may be used to generate innovative project proposals in a formal manner, see Altshuller (1999). Value focused thinking (Keeney, 1997) is also relevant in the creation of alternatives. Luecke (2009) and Shane and Ulrich (2004) contain further pointers to this important topic. The proposals generated should be described using a same format to facilitate the comparability of projects.

We focus here on decision making aspects to facilitate the evolution of ideas towards innovative projects. For that purpose, rough estimates of the required indicators are needed. Innovative projects may then be discussed among proposers and filtered through a voting system. As a consequence of such a debate, innovative projects may evolve and/or be eliminated for later phases, for example if they do not receive sufficient votes from the pool of potential voters, as in e.g. ideas4all.

During this generation phase, it may be interesting to include a first project filter based on a self-assessment by the proposers, specially in those cases in which there is a large number of project proposals. This auto-analysis serves proposers as a reflective exercise about their proposals. This filter could be based, e.g., on a Rough Cut Analysis, see Luecke (2009), which uses three key questions:

1. Does the proposed innovation fit the strategy of the company?
2. Does the proposer have sufficient technical competence to make it work?
3. Does the company have sufficient business competence to make it successful?

Luecke (2009) includes categorical answers to the above questions, which may be difficult to answer. Thus, we suggest a simpler answer format, which details the previous questions, and uses responses based on five-point Likert items or yes-no aswers as required:

- Strategic fit.
    1. Score (from 1 to 5) the technical fit of the innovative project to the organization.
    2. Indicate if it is more suitable for the organization to launch the project on its own, or license it to a third party.
    3. Score (from 1 to 5) how feasible is, in case of success, that this innovative project opens up new markets.
- Technical competence.
    1. Determine whether it is feasible to develop the innovative project with the current staff.
    2. Determine whether it is feasible to launch the project given the organization current work load.
    3. Estimate, if so, the percentage of extra personnel effort needed to develop the project.
- Business competence.
    1. Score (from 1 to 5) the perception of the increment in marketing effort needed to launch the project.
    2. Score (from 1 to 5) the perception of the extent to which current products/services consumption would be negatively affected, because of the potentially new product or service.
    3. Score (from 1 to 5) the perception of the effort necessary to train staff.

After such assessment, each project a is evaluated with regard to r screening criteria $(a^1, a^2, ..., a^r)$. We could build a simple weighted value function, see e.g. French et al (2010), $v(a) = \sum_j w_j a^j$, for the organization to filter innovative projects based on such criteria, retaining only projects improving a threshold value. Alternatively, we could use minimum thresholds b_j to retain only those projects which are sufficiently good on all relevant criteria, that is, such that $a_j \geq b_j, \forall j$. Note that we could use both filters in combination, i.e. retain proposals with high enough value and high enough criteria evaluations.

Such auto-assessments have two-fold risks. First, some proposers could overestimate the performance of the projects they are proposing in order to pass this stage. Note, however, that these projects could be detected and excluded later on, when the assessors evaluate proposals. Second, other proposers could underestimate the performance of their projects, mainly because of their inexperience in areas such as strategy, marketing, technology and business competence. Yet a key element for innovative projects would be the engagement and enthusiasm of the proposers. Therefore, we would expect from them at least an appropriate concept and expectations about their innovative projects. It may be the case that the proposer feels unable to answer the pertinent questions. Thus, we should open communication channels with relevant actors within the organization in the case of a closed innovation process and supply external advice within open innovation processes. This would be supported by the facilitators.

3.2 Phase 1: Project filtering

After Phase 0, an initial portfolio of innovation projects is available. These need to be documented by the proposers with a pre-business plan, with indicators, the novelty of the innovative project and other relevant information which will facilitate project comparison. The information gathered may be used also as an initial guide for project management, if the corresponding project is eventually launched. Clearly, the indicators chosen may vary among organizations. For example, objectives and evaluation criteria will usually differ from the private sector to the public one. We briefly discuss some of the most relevant ones.

From the financial side, the following are well-known:

- the Net Present Value (NPV) is defined as the sum of the present values of the individual cash flows. It is usually measured on an annual basis, but it can be calculated also on a monthly basis.

- the Internal Rate of Return (IRR) is the rate used in capital budgeting to measure and compare the profitability of investments. It is an indicator of the efficiency, quality, or yield of an investment.

- the Payback Period is the time needed to recoup the initial investment.

These financial indicators are widely used to assess traditional investment projects. However, they are not necessarily that helpful when applied in isolation to the innovation sector, as illustrated by Christensen et al (2008) or Aven (2010). The use of IRR, NPV and Payback frequently causes decision makers to underestimate the actual returns and benefits of innovation projects, as they tend to focus on the difficulty of foreseeing future cash flows, in comparison to similar measures for incremental projects. Thus, routine projects tend to get the green light more often than really innovative ones.

In order to mitigate this shortcoming of classical financial indicators with respect to innovation projects, we could use, on a complementary basis, the following concepts:

- Discovery-Driven Planning. This method, proposed by McGrath et al (1995), starts by the end, estimating the minimum profit level that make innovative projects acceptable. Then, the price of the innovative product or service is calculated, together with the ensuing level of sales. We then answer whether we are capable of reaching such level of sales.

- The R-W-W Method. This method is based on a practical approach developed by Day (2007) which draws on three categorical questions:

  1. Is it **R**eal? Is there really such a need in the market?
  2. Can we **W**in? Would the product or service be competitive?
  3. Is this innovation **W**orthy? This question is concerned with the strategic fit of the proposal and whether it has potential from the financial point of view.

Apart from financial indicators, innovation projects are frequently evaluated also with indicators pertaining to human resources, such as the percentage of staff working on research and development activities, or the percentage of staff with a PhD. Other relevant indicators refer to information about competitors, state of the art products, market targets, associated technologies, as well as required resources, expected sales and funding. These indicators also supplement the weaknesses of traditional financial indicators, when innovation is concerned. Moreover, as innovation is strongly linked to human capital, these indicators could be used to monitor the project. Again, they should be collected through templates to facilitate project comparison.

Once the above data is entered, it is checked for consistency. This analysis will be based on automatic controls and validations, such as, for instance, whether there is proportionality between staff and expected revenues, comparisons between cash-flow sales, and so on. Nevertheless, the process will be accessible as well to the facilitators in charge of this stage.

After this initial checking, projects are scored, now by the assessors, from 1 to 5 on three general topics in relation with the rough cut analysis, conducted by proposers during phase 0:

- Strategic/Potential Impact.

- Operational Impact.

- Difficulties to enter in the market, in terms of competitors.

If the scores are sufficiently high, based on a threshold system and/or a multicriteria value function, then a full study of the pre-business plan is launched. Note that this is similar, for example, to the standard proposal screening procedure in research, technical development and innovation projects funded by the European Commission, where it is necessary to overcome a minimum threshold for each criteria as well as a minimum value for the sum of them.

The proposals identified in this phase are deemed to have sufficient potential and opportunities to enter the market and will be asked for more details regarding costs, financial sources and an in-depth analysis of the project opportunities, covering the full business plan.

3.3 Phase 2: Project selection

We enter now the phase of selecting projects for implementation. The decision needs to take into account the scarcity of resources (financial, human, materials,...). Methodologically, we need to allocate several resources among several projects, subject to one or more several resource constraints. This resource allocation process needs to, somehow, maximize the satisfaction of the selecting group. This may be done in several ways, as specified below. Moreover, the group will select the projects based both on current and future opportunities. Thus, some good projects could be withheld and delayed for later implementation.

From a technical point of view, there is a group of n assessors that has to decide how to allocate resources, say a budget b and amount d of personnel. There is a set of q potential projects, $X = \{a_1, \ldots, a_q\}$. Project a_i has an estimated cost c_i, employs d_i persons and is evaluated with respect to m criteria, with values x_i^j, $j = 1, \ldots, m$. For simplicity, we assume that we have a sufficiently precise estimate of each project cost and features, i.e. we do not deem uncertainty relevant. Alternatively, we would have probability distributions over such features, which would be treated as outlined below. We represent this information through a table:

Project	Cost	H.Res.	Criteria
a_1	c_1	d_1	$(x_1^1, \ldots, x_1^m)$
....	...	...	....
a_i	c_i	d_i	$(x_i^1, \ldots, x_i^m)$
....	...	...	....
a_q	c_q	d_q	$(x_q^1, \ldots, x_q^m)$

Assume that the total cost of the proposed projects is greater than b and/or the total number of work effort required is greater than d. Otherwise, all projects could be started. In addition to resource constraints, there may exist other constraints that restrict portfolios. Typical constraints would be: the maximum budget allocated to one topic will be e euros; we shall support at most f projects of a given type; or, we can implement a certain project only if another project is implemented. A feasible portfolio will be a subset of projects, defined by the corresponding subset of indices $F \subseteq I = \{1, 2, \ldots, q\}$, which satisfies

$$\sum_{i \in F} c_i \leq b,$$

$$\sum_{i \in F} d_i \leq d,$$

and other possible constraints. In case of uncertainty about the project features, we would have stochastic constraints that could be handled, for example, by requiring that the constraint is satisfied with a sufficiently high probability. The set of feasible portfolios will be designated $A = \{F^1, F^2, \ldots, F^s\}$.

The allocation process may be undertaken in several ways. Many of the tools described in Section 2 introduce only voting mechanisms to support such decision. A classical approach is based on maximizing the net present value, assuming that the group members agree on such criteria, as described in detail by Kleinmuntz (2007). Vilkkumaa et al. (2010) provide a framework which assumes a group value function, aggregating the multicriteria value functions of the participants. Possibly incomplete information is obtained about the weights and values in order to identify potentially interesting portfolios. Additional information is solicited in case there are no clear cut recommendations. If no additional information is actually available, voting and bargaining mechanisms are introduced. See also the companion chapters in this book for various other possibilities.

As an example of the variety of approaches regarding group portfolio resource allocation decisions, within the related problem of participatory budget formation, Alfaro et al. (2010) describe numerous procedures which differ in the involved stages and group decision tasks employed at those stages. Thus, the allocation process depends essentially on the organization: the framework should be able to support various basic group decision making tasks including voting systems, negotiation methods, arbitration and group value functions. Efremov and Rios Insua (2010) describe these and other collaborative decision analysis methodologies with a view towards implementing them through the web.

In SKITES, we emphasize the following flexible approach to allocating resources by a group:

1. *Individual problem exploration*. At this stage, we elicit the participants' preferences about the consequences of the projects, e.g. in terms of their utility or value functions, depending on whether uncertainty is deemed relevant or not. We focus on this last case; otherwise, we would substitute values by expected utilities. Assume, therefore, that we each assessor's preferences through a multiattribute value function v_j, $j = 1, \ldots, n$, that he aims at maximizing, see e.g. French (1986). Therefore, we may associate with an innovation management process a matrix of valuation entries v_i^j, the value that assessor j gives to project i

				Assessors				
		Cost	HR	1		j		n
Projects	a_1	c_1	d_1	v_1^1	$\dots$	v_1^j	$\dots$	v_1^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_i	c_i	d_i	v_i^1	$\dots$	v_i^j	$\dots$	v_i^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_q	c_q	d_q	v_q^1	$\dots$	v_q^j	$\dots$	v_q^n

To simplify matters, we shall assume that the value given by the j-th assessor to a feasible portfolio F will be the sum of the values of the projects in F, that is,

$$v_j(F) = \sum_{i \in F} v_i^j \ , \ j = 1, \dots, n.$$

Theoretical assumptions underpinning such additivity assumption are discussed in, e.g., Golabi (1987) and Golabi et al. (1981).

The assessors may use this information to determine their preferred portfolios and the reasons for their choices. The preferred feasible portfolio $F_j^\star$ for assessor j will be that giving him maximum value. Should there be just the maximum budget constraint, $F_j^\star$ would be obtained through a knapsack problem, see Martello and Toth (1990):

$$\begin{array}{ll} \max_{F \subseteq I} & \sum_{i \in F} v_i^j \\ s.t. & \sum_{i \in F} c_i \leq b \end{array}$$

In general, there will be other constraints and we must use general implicit enumeration algorithms to compute the participants' optimal portfolios, like those based on constraint logic programming, see Marriott and Stuckey (1998). For smaller problems, integer programming and combinatorial optimization techniques might be sufficient.

Logically, if all assessors prefer the same optimal portfolio, that would be the group decision. However, typically, various individuals will obtain different optimal portfolios, since their preferences may represent a wide variety of conflicting interests. Consequently, an agreement should be sought as a joint decision. We may view this phase of the innovation management process as a negotiation table, see Rios and Rios Insua (2009), which shows the value given by each assessor to each feasible portfolio:

		Assessors				
		1		j		n
Feasible portfolios	F^1	$v_1(F^1)$	$\dots$	$v_j(F^1)$	$\dots$	$v_n(F^1)$
	$\vdots$	$\vdots$		$\vdots$		$\vdots$
	F^s	$v_1(F^s)$	$\dots$	$v_j(F^s)$	$\dots$	$v_n(F^s)$
Individual optimal portfolios		F_1^*		F_j^*		F_n^*

To start with, we could compute the set of nondominated portfolios. Based on the previous table, we associate a score vector with each feasible portfolio F: $v(F) = (v_1(F), \ldots, v_n(F))$, from which a dominance relation between portfolios may be defined in a standard way. Indeed, a portfolio F' is dominated by another portfolio F ($F' \prec F$), if $v_j(F') \leq v_j(F)$, for all individuals $j \in \{1, \ldots, n\}$, and $v_j(F') < v_j(F)$, for at least one $j \in \{1, \ldots, n\}$. Dominated portfolios may be removed from the previous table, retaining only the nondominated ones. Relatively efficient methods to determine the whole set of nondominated portfolios may be used, see Vilkkumaa et al. (2010) or Rios and Rios Insua (2008). If this set is very diverse, we still need to manage the conflict. Note, however, that if some projects are contained in all nondominated portfolios, these will be uncontroversial, thus reducing the problem. See Liesio et al. (2007) for developments around the concept of core.

2. *Conflict resolution*. When several assessors have very different optimal portfolios we shall need specific methodologies to reach a reasonable group choice. Some of the potentially usable approaches are:

    - *Arbitration*. If we know the assessors' preferences, an arbitration approach can be based on an algorithm to compute the chosen arbitrated solution based on some equitable criterion (Thomson, 1994). To do this, we need to describe the resource allocation problem in terms of a value set and a disagreement point. The set A of feasible portfolios will be transformed to the assessors' value set $S = \{(v_1, ..., v_n) : \exists F \in A \text{ s.t. } v_i = v_i(F), i = 1, ..., n\}$. The disagreement point is a vector $d \in R^n$ whose j-th coordinate represents the value that the j-th assessor would give to an initial reference portfolio to be improved. d could be related with the values associated with implementing no project, or with those projects in the core. Such d is related with the baseline scores whose choice is discussed in Clemen and Smith (2009). Thus, we represent the resource allocation problem as a pair (S, d), where S is a finite but potentially large set. The problem consists of trying to reach a consensus over the set $P(S, d)$ of nondominated assessors' values which are better than the disagreement point d. An arbitration resource allocation solution concept is a rule associating with each resource allocation problem (S, d), one portfolio in A, based on the selection of a point in $P(S, d)$. Among the various arbitration concepts, for reasons outlined in Rios and Rios Insua (2010), we favor the *balanced increments* and the *balanced concession* solution concepts.

      A shortcoming of the arbitration approach is that these solutions could be seen as imposed. An advantage is the possibility of mitigating the complexity due to the presence of a potentially large pool of assessors discussing advantages and disadvantages of portfolios. Note that group value and utility functions may be superseded within arbitration schemes.

    - Negotiation. Instead of arbitration, we could use negotiation. Though there are various generic schemes, negotiations consist of processes in which portfolios are offered iteratively, until one of them is accepted by a reasonable percentage of assessors. Otherwise, no offered portfolio is globally accepted. Because of the potential discrepancies in preferences, we allow assessors to discuss portfolios. Kersten (2008) provides a comprehensive review of negotiation methods.

  Rather than using a formal negotiation method, we could allow assessors to post portfolio offers and debate them through a discussion forum. In such way, they would interact and share knowledge when they propose portfolios. They could receive analytical aid through several indices to evaluate posted offers. Assessors could be allowed to vote in favor or against offers. The offer with the highest level of acceptance among assessors could be considered as an agreement, if this level is sufficiently high, followed by a postsettlement. Otherwise, no offered portfolio will be globally accepted through negotiation.

- Voting. We could directly move on to voting, but this might have the shortcoming that we do not motivate sufficiently deliberation among assessors. Again, we could appeal to numerous voting schemes (Brams and Fishburn, 2002). For reasons outlined in Brams and Fishburn (2007) we tend to favor approval voting.

We may tailor these three approaches in several ways, to address the requirements of various organizational styles. Among several possibilities, we could directly implement an arbitration scheme. Or, we could implement a negotiation scheme and, if negotiations end up in a deadlock, we may solve it through arbitration or through voting. Or we could directly move towards voting. See our discussion for our preferred choice.

3. *Post-settlement*. If the outcome of the conflict resolution is reached through negotiation or voting, it could be the case that it is dominated in a Pareto sense: there would be portfolios which are better for all the assessors. Therefore, they should try to improve it in a negotiated manner, through a negotiation scheme designed to converge to a nondominated portfolio, which is better than the outcome obtained previously. One example of such method is in Rios and Rios Insua (2010), which combines both balanced increments and balanced concessions movements in a single negotiation algorithm.

Note that the information obtained at the exploration phase would be useful not only for computing the assessors' preferred resource allocations among projects, but could be used also to evaluate portfolios offered through the negotiation phase, to vote in a better informed fashion and, finally, to check whether the negotiated or voted outcome is dominated and, consequently, start at stage 3. One possible comment is that assessors may be reluctant to reveal their preferences. We assume in this design that they will provide this information to a secure and trusted intermediary, in a framework that is called FOTID (full, open and truthful intermediary disclosure), see Rios Insua et al (2008). Such intermediary could be a secure web server, in line with recent *e*-participation developments, see Rios Insua and French (2010).

3.4 Phase 3: Follow up of the selected portfolio

The aim of this phase is to follow the evolution of the selected portfolio with a double objective:

- Identify deviations (positive or negative) with respect to the original project schedule and resource consumption plan.
- Gather information and experience to be considered for the future phases of filtering and selection of innovative projects.

To this end, once a project is selected, several indicators will be defined in relation with resource consumption. All these indicators will be integrated in the business plan and they will guide the first phases of the project. The integration of each indicator will be analyzed, so that indicators that are not relevant for tracking a project once it has been selected will be discarded. The indicator system should be flexible enough to allow for the inclusion of new indicators when deemed relevant. Therefore, SKITES would provide support for:

- According to the specificities of innovative projects, defining the information to be gathered during the follow-up phase. As the process is based on collective common knowledge and on a continuous learning process, this new information will evolve continuously.
- Providing a flexible, user-friendly and adaptive system with templates to facilitate the consistent collection of information, thus simplifying comparisons. Automatic validations of the information gathered should be implemented, allowing for checks concerning data quality and coherence.
- A system allowing to set up alarms not only when we have had deviations, but also when these deviations are foreseen, based on appropriate prediction models. Based on the stored information, some early warning alarms can be implemented.
- Building cost estimators, indicators, market projections, etc. This kind of information is valuable, especially in view of future innovation rounds.
- Facilitating the comparison of innovative projects (blind benchmarking), identifying synergies, niches and possible clusters to enter into a market in a better position.

3.5 Discussion

SKITES is based on some recent consulting projects and motivated by the need to scale such framework to more and bigger groups over the web. We could question whether SKITES, as a more formal decision framework, may actually be more of a burden, rather than a solution in innovation management, as innovation is a creative activity per se, and such formal tools may deter creativity. However, recall that creativity is actually very frequently undertaken based on a deliberate methodological approach, aimed at generating new knowledge, and only a few inventions are the fruit of spontaneous research activity, see Clemen (2003). From the user's perspective, the development of a more encompassing approach does not necessarily entail a much more sophisticated system. We consider SKITES more powerful than other available tools because it incorporates relevant Collaborative Decision Analysis methodologies. The proposed approach profits from the knowledge of a group as a whole, as a framework in which its members provide their opinions, share them and reach a better solution based on knowledge sharing among diverse participants.

As cogently argued in Salo and Kakola (2005), timeliness may impose intrinsic constraints within innovation processes. This entails that the organization must adapt the scheme to its culture and time available, by choosing the appropriate stages and allocating the appropriate time to each of them. As an example, an organization requiring a fast decision process can simplify the above scheme by just choosing a 'debate and vote' resource allocation making process. In a similar fashion, there may be many different decision making styles and levels of analytical sophistication among the assessors. We could conceive an alternative framework. Phase (1) would allow the assessors to manipulate the problem to better understand it and the implications of their judgments; these could be based on less sophisticated methods such as goal programming or just debating with other assessors. Phase (2) would entail the construction and manipulation of the problem by the group, allowing sophisticated negotiation methods using value functions as well as simple methods like those based on debating the pros and cons of options in a forum and voting on options. Phase (3) would entail, in this case, exploring whether the outcome may be improved. Indeed, by potentially adapting to numerous collaborative schemes SKITES may actually adapt to varied organizational innovation styles.

Notwithstanding this, if possible cognitively and timewise, we would support an implementation in which assessors' value functions are elicited and, if conflict arises, they negotiate supported by a formal negotiation method iterating towards a nondominated outcome.

4 Conclusion

Innovation is critical for competitive success. Building on the successes of the Web 2.0, there is an emerging market for web based innovation management tools. These tools seek to facilitate the management of innovation processes within organizations. However, these tools tend to focus on just some parts of the process and they impose fairly rigid management innovation processes to which an organization should conform. Quite importantly for the theme of this book, they tend to oversimplify the methods by which the portfolio of projects is chosen.

We have described SKITES, a flexible framework that supports innovation management processes, with especial emphasis on the embedded group decision support problems related with choosing innovation projects. We believe that organizations could benefit from adopting such framework, introducing a more transparent, fair and cost efficient system.

Given its potential, we have developed a web based architecture supporting SKITES and implemented a Java prototype of it. The relevance of web based architectures is specially appropriate in distributed organizations, where firms are working globally with employees, delegations and departments distributed among different countries. Our architecture allows an organization to define its own innovation management process from the basic SKITES scheme. It is based on a Service Oriented Architecture (SOA) bus, supporting several databases and several services and would be connected to the corresponding enterprize software platform if one exists. SMEs might not have such enterprize platform, and they could use SKITES, e.g., through a cloud computing environment. The databases supported refer to innovation indicators and participants, in their four roles. The services so far supported include brainstorming, a discussion forum, preference modeling, a simple negotiation system, voting, and innovation management process definition.

As has happened with many other aspects of our lives, we believe that innovation management may benefit from the use of flexible, comprehensive, well-founded solutions implemented through the web.

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