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TESIS DOCTORAL

Contributions to distributed innovation management environments

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Que la presente memoria de tesis titulada "Contributions to distributed innovation management environments" ha sido realizada bajo nuestra dirección por D. Gonzalo Arévalo Nieto en el Departamento de Estadística e Investigación Operativa, para optar al grado de Doctor por la Universidad Rey Juan Carlos. Hacen constar que la citada Tesis reúne todos los requisitos necesarios para su defensa y aprobación.

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Que la presente Tesis Doctoral titulada

Contributions to distributed innovation management environments

Ha sido realizada por Don Gonzalo Arévalo Nieto bajo la dirección y supervisión de Don David Ríos Insua y Don Hans Riese Jordá y, que el Departamento de Estadística e Investigación Operativa ha dado su conformidad para que sea presentada ante la Comisión de Doctorado.

En Móstoles, a 14 de Mayo de 2013.

Fdo.: D. Antonio Alonso Ayuso

Dedicado a la memoria de mis abuelos especialmente a Ubaldo, con quien pude vivir y aprender más, y que para mi fue testimonio de lo que entiendo que tiene que ser la actitud vital.

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RESUMEN

En los últimos años venimos asistiendo a un cambio de paradigma en el proceso por el cual los individuos, las empresas, e incluso los países afrontan sus principales problemas. Existe cierta tendencia a que este proceso se realice de manera más participativa, haciendo cada vez mayor uso de entornos y procesos abiertos. En este sentido, el objetivo de este trabajo es plantear el uso de métodos del análisis de decisiones multi-criterio, y por tanto teniendo en cuenta diferentes puntos de vista, como herramienta para los procesos de toma de decisiones en proyectos o acciones de innovación. Precisamente, el estar en un entorno innovador hace que el componente de incertidumbre sea doble pues por un lado, está la incertidumbre asociada a cualquier toma de decisiones, pero por otro lado, la incertidumbre más difícil de tratar, es aquella intrínseca, asociada a la innovación, y que supone un cambio respecto a las prácticas habituales.

Con objeto de tratar este problema, se plantea todo un proceso desde la identificación, selección, hasta el filtrado y seguimiento de proyectos, todo ello en el marco de una herramienta web que facilita esta participación. Para ello, además de procesos de autoevaluación, se crea una función de utilidad, a la cual se le someten las restricciones pertinentes de acuerdo al problema estudiado, con objeto de encontrar la mejor solución, primero individual y, posteriormente colectiva, a la que se llega haciendo uso de esquemas participativos: arbitraje, negociación y votación, principalmente.

En esta tesis abordaremos los siguientes contenidos:

1. **Antecedentes** El capítulo 1, a título introductorio, versa en primer lugar, sobre un análisis en profundidad del concepto de innovación. Así veremos que, si bien la innovación es una capacidad inherente al ser humano, la primera vez en que la innovación se ha estudiado como tal, fue sólo en 1939 debido a Schumpeter, quien describió la innovación como una característica inherente al sistema capitalista, que actúa como motor de la economía, lo que favorece una mayor riqueza y prosperidad. Para este fin, veremos que Schumpeter propone varios patrones que suelen estar presentes cuando se da una innovación. Otro autor muy relevante en este campo es Porter, quien describe la innovación como la búsqueda de nuevas ideas a través de diferentes medios y

soportes, siendo ésta, la piedra angular de la competitividad de las empresas, regiones, o países. Porter basó su teoría de la innovación, en la búsqueda continua de un mejor rendimiento. Uno de los principales elementos introducidos por Porter es la cadena de valor, que consiste en un modelo teórico que describe el desarrollo de las actividades de una organización empresarial, mediante la creación de valor para llegar mejor a sus clientes. Así, según Porter, la mayor parte de este éxito empresarial está en el desarrollo de la relación con su entorno (clientes, proveedores, empleados, etc), y en su percepción, como la principal fuente para mejorar sus productos y servicios. Drucker también está presente en este capítulo, como el autor que hace especial hincapié en la necesidad de enfoques y procesos sistemáticos basados en protocolos, para la identificación y generación de innovación, y huir de la idea romántica sobre las fuentes de innovación, como hallazgos casuales sin búsqueda específica. Aunque los conceptos de innovación propuestos por estos autores no pueden considerarse plenamente complementarios, podemos extraer de ellos dos denominadores comunes: cambio y valor económico. El último de los autores al que nos referiremos en el capítulo 1 es Chesbrough, como principal autor sobre la teoría de la innovación abierta. Chesbrough ha demostrado empíricamente cómo el concepto de innovación y su gestión ha cambiado en los últimos años, pasando de un concepto cerrado, donde desde los primeras fases hasta el desarrollo final era un proceso enteramente interno a las empresas, hasta los entornos abiertos actuales que están implementando las principales compañías. Estos procesos están caracterizados por la colaboración entre diferentes entidades académicas y empresariales aprovechando las economías de escala, constituidos en el principal mecanismo en la actualidad para una explotación más eficiente de los recursos. El concepto de innovación abierta de Chesbrough, está doblemente presente en esta tesis bajo la metodología SKITES. En primer lugar, debido a que la flexibilidad de la arquitectura propuesta, puede ser implementado en entornos puramente abiertos abiertos. En segundo lugar, viene dado por el enfoque multdisciplinar que se plantea para afrontar cada problema, radicando la potencia del mismo precisamente en estas visiones diferentes. Para ello, SKITES propone incorporar asesores con diferentes conocimientos y experiencias, y una herramienta que promueve el intercambio

de opiniones entre ellos, así como facilita la recogida de información.

2. **Objetivos** El objetivo de esta tesis es demostrar no sólo que es posible otra forma de gestionar la innovación basada precisamente en entornos abiertos, sino que también puede trasladarse esta teoría a la selección de proyectos. Por ello, otra parte importante del capítulo 1, es la relacionada con la relevancia de la innovación y su articulación mediante políticas económicas, especialmente en el marco de la actual crisis. En un pequeño estudio en el que se analizó el desempeño en los últimos años de diferentes países de nuestro entorno, y de diferentes sectores económicos, hemos podido observar cómo tanto los países, como las industrias más innovadoras, o con políticas activas en innovación, están sufriendo en menor medida los efectos de la crisis. Por ello, no parece descabellado inferir, que la innovación, pueda implicar un mecanismo que ayuda a la sostenibilidad contra las oscilaciones del mercado. Así mismo, en el capítulo 1, revisamos algunos métodos utilizados para la evaluación de proyectos de investigación e innovación en la actualidad. Dado que en Europa principalmente hablamos de financiación pública, hemos realizado un estudio comparativo entre los mecanismos utilizados a nivel nacional en España, y los que se utilizan a nivel europeo, como es el caso del 7 º Programa Marco (7PM). La principal conclusión fue que a pesar de que los recursos públicos destinados a actividades de I+D+i han aumentado sustancialmente hasta 2010, los procedimientos y los sistemas de selección, evaluación de dichos proyectos y la asignación de recursos no han evolucionado paralelamente: además de la introducción de tecnologías TIC para evaluaciones a distancia, no existen mejoras relevantes introducidas recientemente, menos aún relacionadas con la comunicación activa entre evaluadores. Aunque a nivel de financiación europea, sí se han establecido reuniones de consenso y paneles, y que en estos paneles se cuenta con asesores de distintos orígenes, el intercambio de puntos de vista entre ellos, no se potencia, ni se protocoliza todo lo posible, lo que nos aleja de poder alcanzar objetivos mediante el ejercicio de compartir información y conocimiento. Así, en este punto al menos, existe margen de mejora con el uso de las herramientas como las que se proponen en esta tesis. Además, completaremos esta revisión del estado del arte, con la descripción de

algunos de los principios de gestión de la innovación y una revisión de algunas de las herramientas actuales de gestión de la innovación basados en la web, que pueden compartir algunas características con el esquema SKITES. Finalizamos el Capítulo 1, con un análisis sobre el uso de métodos de análisis de decisión multicriterio (MCDA) para la representación de los problemas comunes, que se ajustan a las preferencias de los miembros del grupo, y su uso potencial en el campo de la investigación y la innovación.

3. **Metodología para la gestión de la innovación en entornos distribuidos:** El capítulo 2, se ocupará de desarrollar la metodología asociada a la toma de decisiones en el marco de proyectos de innovación. Es importante considerar que cuando hablamos de innovación, nos enfrentamos a una doble fuente de incertidumbre. Por un lado, nos encontramos la incertidumbre asociada a cualquier proceso de toma de decisiones vinculado con el efecto de seleccionar una opción y descartar otras. Por otro lado, la otra fuente de incertidumbre, que es la de mayor envergadura, está asociada a la propia naturaleza de innovación que implica mayores riesgos, pero que, por otro, puede presentar mayores oportunidades y rendimiento. El reto que confrontamos es proponer una metodología, que permita tratar esta incertidumbre de doble naturaleza, y que pueda proporcionar soluciones óptimas. Para ello, el punto de partida y la singularidad de esta metodología, radica en buscar soluciones desde una perspectiva abierta, contando así con varios puntos de vista para estudiar el mismo problema, y posteriormente, compartir estas diferentes perspectivas en busca de una mejor solución. Hay que destacar que la metodología propuesta es flexible, y tiene la capacidad de adaptarse a diferentes tipos de organizaciones, incluso siendo adaptable tanto a ámbitos privados, como a entornos públicos. Para modelizar el problema, se parte de la definición de cuatro funciones, que siempre están presentes en todo proceso: Organización, Proponentes, Evaluadores y Facilitadores, con lo que el primer paso es definir estos roles. Una vez definidos estos, se estructura el problema en cuatro fases:

   a) *Generación de proyectos innovadores:* En esta fase, los proponentes identifican los potenciales proyectos. Para ello, se proponen tanto herramientas formales de

tipo TRIZ o PESTEL en las que los facilitadores tienen el protagonismo, como otras más informales. Además, esta fase incluye una auto-evaluación por parte de los proponentes, que sirve como primer filtro.

b) *Filtrado de proyectos:* Una vez que la cartera inicial de proyectos está definida, el siguiente paso viene marcado por la necesidad de ampliar los detalles sobre estos proyectos mediante información comparable. Para ello podemos contar con los indicadores financieros más tradicionales como: VAN, TIR, ROI, pero también es necesario tener en cuenta otros indicadores diseñados específicamente para la innovación, y que puede cubrir las deficiencias de los indicadores tradicionales, que suelen subestimar el potencial de los proyectos de innovación.

c) *Selección de Proyectos:* En este punto, es necesario definir, por un lado los recursos disponibles, y por otro, los recursos necesarios para ejecutar cada proyecto, tanto financieros como humanos. En esta fase se pueden introducir diferentes restricciones sobre la naturaleza de la solución, fijando, por ejemplo, unas características que ha de presentar la cartera seleccionada, o fijando proyectos complementarios o excluyentes. Este proceso de selección se hace también a través de diferentes etapas:

a Exploración individual del problema: En este punto, los evaluadores expresan en primer lugar sus preferencias, sobre los criterios de evaluación propuestos. A partir de ello, cada evaluador obtiene su cartera de proyectos óptima, de acuerdo a una función de utilidad individual calculada para cada uno de ellos.

b Resolución de Conflictos: Es de esperar que cada evaluador obtenga una solución diferente, y que deba buscarse una solución conjunta, para lo cual se describen métodos de arbitraje, negociación y votación, que serán coordinados por los facilitadores.

c Acuerdo a Posteriori: En el caso de que se haya llegado a un acuerdo sobre la cartera de proyectos final mediante la negociación o votación, puede ocurrir que existan otras soluciones mejores que resulten en carteras más eficientes.

d) *Seguimiento de Proyectos:* El objetivo de esta fase es hacer seguimiento sobre los proyectos seleccionados, tratando de identificar desviaciones, así como recabar información relevante para futuras rondas. Para mayor generalidad, en la metodología propuesta, haremos una reseña al tratamiento del problema en el caso en que existiera también incertidumbre asociada a los recursos disponibles, y para tal fin se propondrán diferentes algoritmos, tanto para las fases de negociación, votación y arbitraje.

4. **Arquitectura distribuida para la gestión de la innovación** El Capítulo 3 se centra en la descripción de un diseño que posibilite el tratamiento del problema conforme a la metodología detallada anteriormente. Para ello, se presenta una solución relativamente genérica, pues de esta manera es lo suficiente flexible para que cada organización pueda definirla y adaptarla de acuerdo a su propio proceso de innovación. En este sentido, son claves los conceptos de la Web 2.0 y su vinculación con la innovación abierta, así como el uso de los principales desarrollos que permiten el trabajo en grupo sobre un mismo problema. Esta flexibilidad no se contradice con la necesidad de definir indicadores y patrones homogéneos, que permitan la comparación entre las diferentes alternativas.

   La arquitectura propuesta se describe como un servicio orientado basado en un bus SOA, que puede estar vinculado con la plataforma de software de la empresa o entidad correspondiente. También, como alternativa, principalmente para pequeñas y medianas empresas o bien para primeros usuarios, sería posible un uso directo, sin necesidad de implantación previa.

   Esta arquitectura incluye dos bases de datos diferenciadas: un censo que recoge la información de usuarios, problemas y proyectos, y otra base de datos específica sobre Indicadores. Por otra parte, alrededor del BUS SOA (sistema digital para tratamiento y distribución de datos), tendríamos que implementar varios servicios o módulos, entre los que se incluirían:

   - *Módulo de Seguridad*, para la autenticación y la concesión de acceso.

- *Módulo de Innovación*, con objeto de crear y estructurar el proceso de innovación.
- *Módulo de Comunicación*, proporcionando y fomentando la comunicación y los debates entre evaluadores.
- *Módulo de Gestión de Recursos*, para almacenar y tratar la información.
- *Motor de Innovación*, para la promoción de proyectos innovadores.
- *Market Place*, como espacio para proponer problemas y soluciones.
- *Filtrado de Proyectos*, con objeto de definir indicadores sobre los proyectos de innovación.
- *Selección de Cartera de Proyectos*, para facilitar la exploración problema individual y resolución de conflictos.
- *Gestión de Proyectos*, para una correcta gestión de los proyectos seleccionados.
- *Control de calidad*, para asegurar un proceso de ejecución predecible y homogéneo.
- *Módulo de predicción*, para estudiar comportamientos a futuro.
- *Motor de Búsqueda*, como herramienta instrumental.

5. **Caso práctico:** El Capítulo 4 se ocupa del caso práctico donde hemos puesto a prueba la metodología y la arquitectura anteriormente descritas. Este estudio piloto se realizó sobre las dos fases de SKITES donde la colaboración entre los participantes es más necesaria: Fase 2: Filtrado de Proyectos, y Fase 3: Selección de proyectos. Para este estudio, hemos seleccionado diez proyectos innovadores relacionados con la salud en general, y más, en particular, con las tecnologías de la salud, por ser uno de los sectores estratégicos para la economía española y donde puede ser interesante probar el sistema. La información de estos proyectos fue tomada del mercado abierto sobre proyectos innovadores desarrollado por el gobierno norteamericano bajo el portal web: http://innovationsupplychain.com/. En este sitio se dan cita diferentes proyectos innovadores de distintas temáticas y con diferentes grados de desarrollo, pero con información armonizada y comparable que sirven al objeto del estudio. La financiación

requerida por los diez proyectos seleccionados, se estimó en 1.983.000 US$. Además de la información disponible en la web, se seleccionaron cuatro variables relacionadas con la situación actual del proyecto y su potencial de rendimiento, pasando a ser estos elementos, los criterios de evaluación. Para definir el problema, se introdujo como limitación presupuestaria 800.000 US$. Además, con el fin de diversificar la composición de la cartera, se incluyeron dos restricciones adicionales, basadas en la naturaleza y en el grado de desarrollo de los proyectos. A continuación se seleccionaron cinco evaluadores con diferentes perfiles pero, eso sí, todos ellos con experiencia en la evaluación de proyectos de I+D+i. Además, el autor de esta tesis participó como facilitador.

Una vez definido lo anterior y su introducción en forma de problema en el sistema, que ocupaba la fase de filtrado, se lanzó el proceso de evaluación con el siguiente calendario:

- *Exploración Individual:* Durante una semana, los evaluadores pudieron familiarizarse con el sistema, el problema, los proyectos y los criterios de evaluación. A la finalización de la misma, los evaluadores debieron expresar sus preferencias sobre los criterios de evaluación, así como definir sus utilidades para los puntos intermedios. La forma de evaluar sobre criterios, y no sobre proyectos por un lado, y el objetivo de buscar la máxima utilidad conjunta de varios proyectos y no la puntuación directa sobre proyectos individuales, no fue un elemento fácil de entender. No obstante, llegado el final de la semana, todos ellos expresaron sus preferencias. Los resultados fueron similares sólo para tres de los cinco evaluadores, con lo que hubo de pasar a la siguiente fase de resolución de conflictos.
- *Resolución de conflictos:* En la definición del problema, se estableció que se usarían la negociación en primera instancia, y en caso de no llegar a un acuerdo para 4 de los 5 evaluadores, se pasaría a la votación. Así, durante cinco días, los evaluadores pudieron acceder al sistema y enviar propuestas de carteras, así como comentarios. El acuerdo se alcanzó en la sexta propuesta, unas pocas horas antes del cierre de esta fase. Por ello, no fue necesario pasar a la fase de votación. Un

tema muy interesante en este ejercicio piloto, fue observar cómo uno de los evaluadores (eval 2), fue modificando sus preferencias desde su cartera óptima inicial (que era radicalmente diferente a la del resto de los evaluadores), a su última propuesta, que era casi coincidente con la cartera finalmente seleccionada. El resultado de este caso práctico puede considerarse como francamente positivo, aunque será necesario desarrollar ejercicios complementarios para confirmar la utilidad de SKITES.

6. **Conclusiones y trabajos futuros** En la parte final de esta tesis, se presentan reflexiones sobre posibles mejoras y desarrollos futuros. Como mejoras a implementar, y a partir de la experiencia del ejercicio práctico, se destacó la necesidad de no subestimar la necesidad de explicar adecuadamente la metodología, que huye de los métodos tradicionales al incidir sobre los criterios y no directamente sobre los proyectos. Como posible desarrollo teórico, se propone el hacer uso de la propia metodología SKITES en la selección de variables, al igual que se hace para los proyectos, así como incluir alguna variable que además de ser ponderada por los evaluadores, también pueda ser puntuada. Así, los evaluadores participarían en la definición del problema, lo que facilitaría un mejor conocimiento del problema y de la metodología asociada. Por último, en este capítulo se identifica el área de compra pública innovadora y compra pública precomercial, como un area incipiente, difícil de evaluar y en el que esta metodología puede tener especial potencial.

Palabras clave: Gestión de la innovación, Métodos participativos, Innovación abierta, Cartera óptima, Asignación de recursos, Compra pública innovadora.

ABSTRACT

From individuals, to policy makers and large companies, during the last years we are facing a paradigm shift in the decision making process from internal or closed environments towards open approaches. In parallel we are immersed in one of the biggest economic crisis in Europe since 1929. As shown in Chapter 1, innovation policies are one of the means to counteract against it. These innovation policies are also nowadays based on open approaches, thus, taking profit of the knowledge that may be learnt from third parties such as providers, employees and customers. Based on this, the aim of this study is to introduce SKITES as a tool for innovation decision making processes, based on multicriteria decision analysis methods. It is specially designed for processes related with innovative projects, and through filtering and assessment it may serve to identify the best innovation portfolio for a group of assessors. We propose this method as an alternative to the traditional means to assess innovative projects, usually based on directly scoring projects on an individual basis, thus lacking communication among assessors. We believe that, as far as assessors with different backgrounds can share their knowledge and expectations about innovative projects, we can better face the double component of uncertainty that is present in innovation decision making processes. To this end we have structured our study into the following chapters:

- Chapter 1, Innovation management: An introduction. In this Chapter we go through innovation concept and theories, and more in particular about the open innovation as a basis of the approach proposed. We also include herein, an analysis on the state of art on innovation management systems, and the use of MCDA methods in related fields.

- Chapter 2, A methodology for distributed innovation management. Herein, we formulate the problem, that we present as the opportunity of finding an alternative way to better assess innovative projects. Thus, to identify optimal projects portfolio, in the field of innovation, where uncertainty is larger.

- Chapter 3, An architecture for distributed innovation management. In order to assure the flexibility of SKITES, a generic solution is proposed in this Chapter, so it can be easily adapted to different environments, through the implementation of several modules. Therefore, herein is included the architecture outline and the functional requirements that it would have.

- Chapter 4, A Case Study. In order to check the viability of our proposal, we present in this Chapter the results of a pilot case study, in which we counted with five experts to filter and select an optimal portfolio, from ten possible projects and under a budgetary restriction.

- Chapter 5, Conclusions and future work. This chapter, presents the main learnt and conclusions about the study conducted and present possible SKITES developments.

Keywords: Innovation management, Participatory methods, Open innovation, Optimal portfolio, Resources allocation, Precommercial procurement.

Chapter 1

Innovation Management: An Introduction

1.1. Innovation

The aim of this study is to introduce the use of multicriteria decision analysis methods, as a tool for decision making processes, when the solutions proposed to be assessed are portfolio innovative projects. Therefore we will be in an innovative environment, being then necessary first of all to set out the understanding we have of what innovation is. Although, we will later go in detail through the innovation concept,we essentially understand it as the development of new customer value through solutions that meet new needs, unarticulated needs, or old customer and market needs in new ways. Innovation differs from invention in that innovation refers to the use of a better and, as a result, novel idea or method, whereas invention refers more directly to the creation of the idea or method itself, without considering its economic value.

Innovation is a phenomenon that has been flowing in parallel to human evolution. Since the transition from nomadic to sedentary societies, the development of agriculture, the invention of gunpowder, or, more recently, the introduction of social networks, are examples of innovations that have influenced the development of Humankind.

Kremer (1993) presents an economic study about human development and innovation. Under his model, all the inhabitants of a country theoretically have the same chance of

developing an invention useful to society. Kremer assumes that a revolutionary idea arises (named later as disruptive innovation) per each billion inhabitants / year. Thus, he suggests a possible direct relationship between population evolution and innovation. 300.000 years ago, a revolutionary idea appeared once every thousand years, as the world population at that time was around a million people. In 1800, with a billion inhabitants, one innovative idea was supposed to arise every year. Nowadays, with seven billion inhabitants in the world, there would be seven disruptive ideas per year.

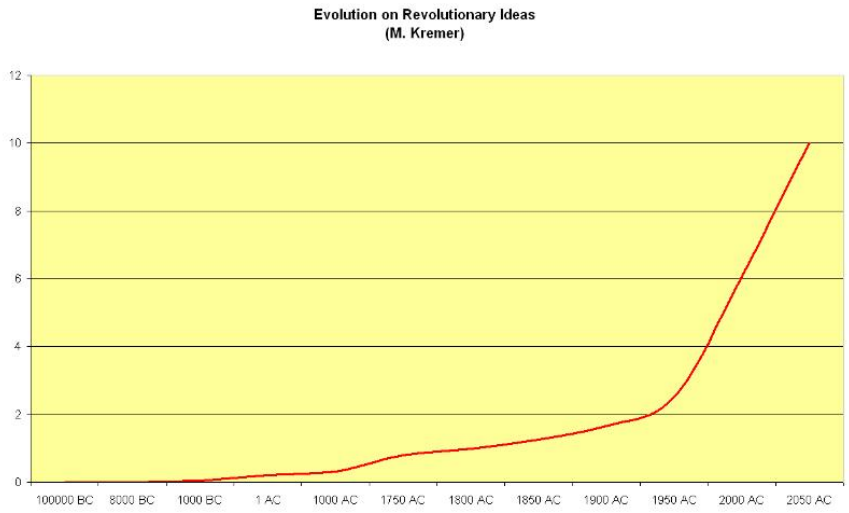


Figure 1.1: Acceleration in the number of Revolutionary Ideas M.Kremer

As shown in Figure 1.1, the growth rate of the number of breakthrough ideas since 1800 would be exponential according to Kremer's theory. What is specially important to note is the fact that the innovation potential is much higher on a collective basis than for individuals in isolation.

Under the current crisis, these are good news, and even more if we take into consideration the existing asymmetries in the access to education and communication around the world, as the potentiality of corrective measures, mixed with the potential number of revolutionary ideas that can be deployed could aid in correcting such inequalities. Therefore, progress could be even much higher and accelerated.

Nowadays, it is in the speech of leading politicians that innovation is the best formula

to fight against the crisis. Thus, it would be necessary to address more resources towards innovation to generate wealth, being then the key point to the development of knowledge based economies. This argument of deploying resources for innovation policies is however sometimes criticized, as some highly innovative sectors have been at the epicenter of the generation of the current economic crisis. For instance, this is the case of the financial field which led to the real estate bubble, or in the beginning of the 21st century the dot-com firms. However, it would be very difficult to argue against the fact that these technologies have been a source of wealth and progress. As with all breakthrough innovations, they need some time to mature and stabilize the markets, shaken by the entry of these revolutionary ideas, which represent real paradigm changes.

Finally, we should say, as we shall see later on, that innovation may be the best mean to counteract the stress over an economy in crisis periods. Therefore, we can consider that an economic model for growth based on innovation, results in sustainable growth.

1.1.1. Theories of Innovation

One of the first economists who specifically discussed the concept of innovation was Schumpeter, well known for his development of one Innovation Theory (1939). Under this theory, he explains the production function as a combination of product quantities and production factors. He defines innovation as the establishment of a new production function, based on the modification of the production factors (typically, land, labor and capital) rather than on product quantities. Consequently, innovation is understood not as minor variation in the trade margin, but as a historic and irreversible change in the production system, expressed through an application of new methods in production, transportation, industrial organization, production of a new articles, opening of new markets, new sources of materials, etc. As this definition does not cover the concept of innovation for products that do not exist up to date, Schumpeter generalized the definition of innovation, by establishing a new production function that comprises not only existing products, but also the reformulated existing products, or completely new ones.

Another approach to innovation theory, due to Schumpeter, comes from a monetary perspective. It is based on the fact that, in the absence of innovation, and with constant

prices, the marginal cost per product increases as production increases. As long as companies are able to increase production, maintaining the cost factors, they are introducing innovation in their production processes. This would be the case when the same production volume is reached, at a lower cost factor. Thus, fundamental changes in some of the elements of the production function, possibly occurring simultaneously, provide a competitive advantage to those who invest in innovation. Consequently, it produces the movement of markets, shifting demand towards these innovative products or services. This movement of markets is prompted by changes in the utility functions of consumers. Later, gradually, the adoption of these new production methods, by becoming standard in most cases of success, would move the market to a new stable position. Then, and before a new technology globalizes and markets get calmed, new inventions arise again shaking the market and keeping them in a continuous but not, constant movement.

In the end, Schumpeter describes innovation as an intrinsic element of the capitalist system, acting as an engine of the economy, favoring greater wealth and prosperity. It must be highlighted that for Schumpeter the main feature of any innovation is necessarily linked with an economic application, being this the main cause of movement in markets. In order to define innovation more precisely, Schumpeter proposes several patterns that are usually present in innovations:

- Requires significant resources in terms of time and investment,
- Usually behind disruptive innovations there are new companies, rather than established companies.
- The character of the individual entrepreneur

These patterns, despite they were proposed by Schumpeter in the first half of the 20th century, far from being obsolete in our society, continue to underpin current economic policies. Thus, we can see the efforts of governments in facilitating access to credit linked with innovation, as well as awareness of societies about the need of innovative entrepreneurship.

In a forward step, Schumpeter defined creative self-destruction as the continuous process through which companies generate new innovations. Thus, new competitive advantages

generated may destroy the old ones. The generalization of this creative self-destructive competition inspired by Porter(1985) who proposed as the basis of competitiveness the fact that the economy is constantly trying to improve its mechanisms for a better performance, in spite of some other theories that base competitiveness on low production costs, mainly for developing countries, or, on the other hand, of theories that base competitiveness of mainly 'developed countries' on national macroeconomic policies relaying on monetary policy, exchange rates, public deficit, etc. Thus, economies are continuously looking for new ideas. The link between Schumpeter and Porter is that both economic development theories are based on changes in the production function that can be applied to a company, a sector, or a whole country.

Porter proposed as a key element for competitiveness, the opening to international markets, so that each nation is specialized in the elements that are behind their competitive advantage and, on the contrary, be provided through the international market of products and services where it is not competitive. Thus, Porter proposes to place all efforts and address resources to the detection of sectors where either a company, or a country is more competitive, rather than trying to act globally in the economy, which leads to inefficient solutions. Hence, specialization becomes the key element behind his theory. Porter identifies four key characteristics that can promote the success of an industry at a national level:

1. The position of production factors, such as the production capacity, as tractors for the economy.

2. The demand conditions, based on the national domestic demand.

3. The complementary and auxiliary industries, such as presence/absence of suppliers, related industries, competitors, etc. In other words, the capacity of the own country in the strategic sector.

4. An entrepreneur strategy, as national conditions that facilitate the creation and development of new companies.

Thus, as far as these factors are present in a sector or a country, the enterprises located therein would be able to identify and exploit their competitive advantage allowing the

rapid generation of assets and profits. Porter describes these four factors as the "National Diamond", a system in which there is mutual reinforcement between the vertices, thereof making the economy increasingly strong.

Porter also identified the origin of the competitive advantage in continuous process improvement, change or innovation. In this direction, Porter defines innovation broadly, not only considering technological innovations, but also the development of new production methods or strategies. In fact, according to Porter's innovation theory, it is equivalent to speak about innovative products, and new organizational schemes, or different ways to access to the market, representing the three of them different innovation approaches searching for improvements.

In addition, Porter introduced Value Chain Theory as a set of processes involved in the creation or use of a product or service. He presents it as a theoretical model for describing the development of the activities of a business organization, creating value to better reach their customers.

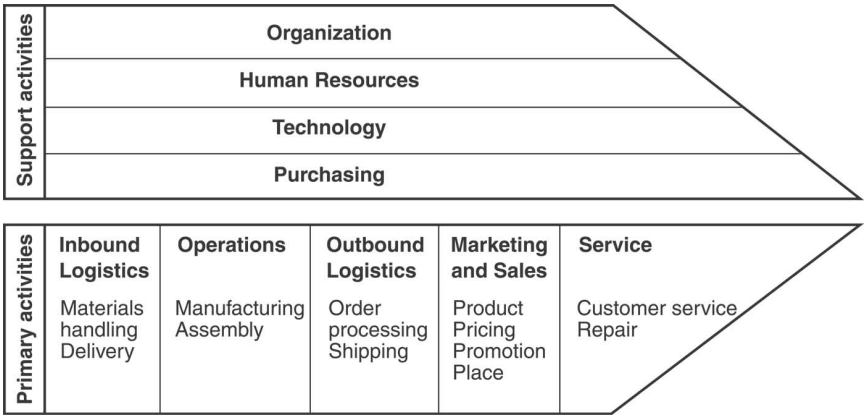


Figure 1.2: Porter's Value Chain

In fact, Porter proposes many key points to face the innovation challenge, based on the customers, either through the analysis of the success of certain customers, or even by analyzing why even under complex situations they remain as clients. This concept of innovation relates with the recent Open Innovation Theory paradigm, which we will review later in this Chapter.

Another major contribution to the current concept of innovation is due to Peter

Drucker, who introduced critical new concepts in the current understanding of management, linked with innovation: management by objectives, entrepreneurship and the knowledge society. Drucker (1985), based on similar principles as Porter and Schumpeter, understands that innovation is present when new applications for inventions can be translated into economic results. Thus, innovation is again undoubtedly associated with the concept of economic utility, more than to technology or technical development. As an example of innovation he proposed the introduction of oil. Until almost a century ago, rather than an economic resource, it was considered a dangerous element that hindered agricultural activities. Only when industrial oil uses were known and their fields of economic applications discovered through innovation, it became to be perceived as an economic resource.

One of the main contributions of Drucker in the innovation field, and very relevant for our study, lies in his proposal of innovation as a systematic approach to specific results based on protocols, towards identifying innovation sources. Therefore, he suggested systematic innovation as the organized search for changes in existing structures and running economic systems that could result into new products or greater value services. Drucker argued that, in general, these changes have already occurred, or are occurring and the opportunity is just to exploit them at the right moment. Drucker proposed seven opportunities for change grouped into two classes. The first group consists of four areas that can be exploited mainly from within the company / business / sector:

- The unexpected (success or surprise factor): This niche of innovation must be understood as the ability to adapt to changes in customer preferences, that causes movement in markets. Drucker suggested this area as the first element to study.

- The incongruence between reality obtained and the expected results, being precisely this discrepancy the invitation to innovate in order to achieve the final product / service actually expected.

- Innovation based on the need for new processes. This area exploits innovations based on the needs to develop new processes given market trends that can lead, in turn, to the adoption of other innovations. An example of such opportunities could be the

rise of new shelter materials (i.e. special gloves), to permit the use of tactile devices in cold environments.

- Decline or sudden change. This area responds to the sudden change in market structures and positioning opportunities that arise along the lines of paradigm shifts (i.e. USB sticks versus CDs)

The other three areas or niches of innovation that Drucker proposes are those that can be perceived mainly from outside the environment in which innovation occurs:

- Changes in population, mainly caused by demographic changes. They provide fairly predictable opportunities. An example of this type may be the effect of an ageing world population and its effect on pharmaceutical expenditure or use of health technologies.

- Changes in customer perceptions, and market structure. In line with the above mentioned example, we see that, although people are living longer and better, the greater volume of information available mainly through the web, makes society more hypochondriacal and more concerned with their health, which also offers more external business opportunities.

- New knowledge (scientific and non scientific): Drucker identifies this area as the main source for innovative entrepreneurship. However, Drucker states that these are very heterogenous. Therefore, uncertainty is much higher than in the above mentioned areas due to their lifetime, failure rate, low predictability, etc. Nevertheless once the barriers are over, this type of innovation that could qualify as 'disruptive', has tipically the highest performance and greater outcomes.

Drucker points out that the boundaries between these areas are not that narrow. However, given the emphasis on the emergence of innovations and opportunities for success, Drucker suggests following this order for the systemic search of innovation.

In summary, Schumpeter emphasized that economic value is always associated with innovation. Moreover, once an innovation arises, it produces the movement of markets and

economic progress. Later on, Porter places innovation as a key element for identification and exploitation of competitive advantages of companies / sectors / countries. He also introduced the concept of value chain and how they can produce innovations based on all actors involved in this chain, closely linked with open innovation. Finally, Drucker argued that innovation needs systematic search for new solutions and suggests seven areas as possible sources for the identification of innovation.

1.1.2. Innovation and Economic Crises

Over the last twenty years, and especially since the beginning of the current economic crisis, we have listened continuous messages, many coming from politicians whatever their affiliation is, proposing measures to promote policies that encourage innovation as the main way to exit from the structural problems of our economy. This message is not always well understood, as innovation should not be considered as an end, but as a mean to create jobs and generate wealth. Moreover, there is another more important consequence underlying the perception of innovation, which is to consider it as a specific mean to ensure sustainability beyond economic cycles. This sustainability would be better addressed in innovation-intensive economies, due to their better capacity to adapt to changes.

On the other hand, it is unlikely that innovation will arise if an innovation culture is not well grounded within an organization. The main feature of this innovation culture should be its tolerance to failure. As innovation is certainly a risk-taking exercise, creating an innovative culture will go much beyond than launching a press campaign. It should also affect all sectors: industrial, financial, educational, etc.

Analysis at Country Level

If we analyze how countries are positioned towards innovation, and how the economic crisis is affecting their economies, it seems reasonable to think that in those countries with higher level of innovation, the effects of the current crisis are not being so harmful. However, there are several indicators to assess innovation at a country level: percentage of GDP devoted to research and technological development, number of PhDs per inhabitants, number of high impact publications, expenditure on innovation, number of patents per million inhabitants,... Although all these indicators are valid to asses innovation, they have a common factor, as they are generated from the offer side, and, consequently, they are insufficient to perceive how innovation is absorbed. Thus, research and innovation demand are not considered. Therefore, in this section, we performed an analysis that takes into consideration how does innovation reach the market. To this end, it is necessary to analyze innovation from the demand side. Due to this lack of information, over the last years several indicators have been developed taking into consideration both the offer and the demand sides. In order to measure the impact of innovation policies in the market, we have considered the following recent studies on innovation:

- **GII 2011: Global Innovation Index**. elaborated by the INSEAD Business School, based in France and with headquarters in North - America and Asia. Conscious of the need to try and measure innovation in a different way, different from the traditional indicators, it elaborates its innovation report since 2007. Besides the global index we are using for our study, it includes other relevant indicators on the traditional components of innovation on the offer side, such as the human capital, or the number of patents, but also some demand side variables, such as the royalties and license fee payments and the joint ventures launched. http://www.globalinnovationindex.org

- **IUS 2010: The Innovation Union Scoreboard**. Elaborated by Pro Inno Europe, it is a report developed under the initiative of the European Commission. It is being conducted since 2006. It counts with specific chapters at country level for the UE27. In these chapters, the innovation behavior at a country level is analyzed under a common perspective, based on indicators from both the demand and offer sides,

and also in comparison with the European main competitors. http://www.proinno-europe.eu

- **AC 2009: The Atlantic Century Benchmarking**. Study conducted in 2009 by the ITIF(The Information Technology and Innovation Foundation), which is based in the USA. ITIF is a nonprofit, nonpartisan public policy think tank committed to articulating and advancing a productivity and pro-innovation public policy agenda internationally. It proposes 16 different variables to analyze innovation at the 36 most relevant countries. These variables are grouped into six topics: Human Capital, Capacity of Innovation, Entrepreneurship, ICT Infrastructure, Economic Policies and the General Economic Situation. http://www.itif.org

- **WEF 2011: Eglobal Competitiveness Report**. This is a synthesis indicator elaborated since 2005 by the World Economic Forum (WEF) and Michael Porter. It analyzes the innovation phenomenon from the competitiveness perspective and it proposes a Global Indicator of Competitiveness. This index measures national competitiveness by studying the microeconomic and macroeconomic concepts, as basis of national competitiveness. Besides presenting results for 2011, there is a very interesting analysis tracking the competitiveness evolution over the last 10 years. http://www.weforum.org

We present in Table 1.1 these global innovation results for the main European countries (EU15), as well as for: Australia, Brazil, Canada, Korea, China, The United States, Iceland, Israel, Japan, Norway and Switzerland.

Country	GII 2011	IUS 2010	AC 2009	WEF 2011
Switzerland	63,82	0,831	n/a	5,63
Sweden	62,12	0,75	71	5,56
Denmark	56,96	0,736	64,5	5,32
USA	56,57	0,672	63,9	5,43
Finland	57,5	0,696	59,6	5,37
Canada	56,93	n/a	54,4	5,3
Korea	53,68	n/a	64,2	4,93
Germany	54,89	0,696	55	5,39
United Kingdom	55,96	0,618	59,2	5,25
Netherland	56,31	0,578	58,4	5,33
Japan	50,32	0,641	59	5,37
Israel	54,03	n/a	n/a	4,91
Luxembourg	52,65	0,565	66,2	5,05
Belgium	49,05	0,611	56,3	5,07
Ireland	54,1	0,573	56,4	4,74
Austria	50,75	0,591	52,6	5,09
France	49,25	0,543	57,3	5,13
Australia	49,85	0,591	51,5	5,11
Norway	52,6	0,463	n/a	5,14
Iceland	55,1	0,487	n/a	4,68
China	46,43	n/a	36	4,84
Spain	43,81	0,395	43,7	4,49
Portugal	42,4	0,436	38,7	4,38
Italy	40,69	0,421	40,2	4,37
Brasil	37,75	n/a	30,1	4,38
Greece	34,18	0,364	31,5	3,99

Table 1.1: Innovation scores

As a first step, and in order to measure the relation of the information provided by these four indicators, we have calculated the correlation matrix in the Table 1.2. Therein, we can appreciate that there is a direct and robust relation between the four indices, with correlation ranging from 0,84 (between the Atlantic Century and the World Economic Forum reports) to 0,90s (between the Atlantic Century Report and the Global Innovation Index.

Innovation Indexes	GII 2011	IUS 2010	AC 2009	WEF 2011
GII 2011	1,00	0,85	0,90	0,88
IUS 2010		1,00	0,87	0,89
AC 2009			1,00	0,84
WEF 2011				1,00

Table 1.2: Innovation scores Correlations Matrix

Although these four indicators offer similar results at a global level, since the aim of these reports is different, it seems interesting to develop a single aggregate indicator that

takes all of them into consideration. As the proposed indicators have different bases, the first step is to harmonize them, which we have done based on:

$$I_i = \frac{v_i - min}{max - min}$$

With this transformation, the four indices are placed in the range [0,1]. This facilitates their comparison, and the use of linear combinations based on them. Once they are harmonized, the next step is to construct an aggregated indicator, which we have done through the arithmetic means.

$$\text{mean} = \frac{v+x+y+z}{4}$$

After the calculation of this aggregated index, we have listed the countries in Table 1.3 from the maximum to the minimum. We should note that for some countries the aggregated country does not count with the four proposed studies as the figure was not available (e.g. Korea, Canada, Israel or China), but we have considered their economies of sufficient importance to keep them in the study, replacing the missing value by the arithmetic mean of the remaining three indices.

$$z = \frac{w+x+y}{3}, \text{ thus Mean} = \frac{v+x+y+\frac{w+x+y}{3}}{4}$$

Country	GII 2011 AR	IUS 2010 AR	AC 2009 AR	WEF 2010-11 AR	Mean
Switzerland	1	1		1	**1**
Sweden	0,96	0,87	1	0,98	**0,95**
Denmark	0,84	0,84	0,87	0,89	**0,86**
USA	0,84	0,74	0,86	0,93	**0,84**
Finland	0,86	0,78	0,77	0,91	**0,83**
Canada	0,84		0,66	0,89	**0,8**
Korea	0,77		0,86	0,76	**0,8**
Germany	0,8	0,78	0,68	0,92	**0,79**
United Kingdom	0,82	0,65	0,76	0,87	**0,77**
Netherland	0,83	0,58	0,74	0,9	**0,76**
Israel	0,78			0,75	**0,76**
Japan	0,69	0,68	0,76	0,91	**0,76**
Luxembourg	0,75	0,56	0,9	0,8	**0,75**
Belgium	0,66	0,64	0,7	0,81	**0,7**
Ireland	0,78	0,57	0,7	0,69	**0,69**
Austria	0,7	0,6	0,63	0,81	**0,69**
France	0,67	0,52	0,72	0,83	**0,69**
Australia	0,68	0,6	0,61	0,82	**0,68**
Norway	0,75	0,39		0,83	**0,66**
Iceland	0,8	0,43		0,67	**0,63**
China	0,61		0,29	0,73	**0,54**
Spain	0,55	0,28	0,45	0,61	**0,47**
Portugal	0,51	0,34	0,35	0,57	**0,44**
Italy	0,47	0,32	0,38	0,57	**0,43**
Brazil	0,41		0,17	0,57	**0,38**
Greece	0,33	0,23	0,2	0,43	**0,3**

Table 1.3: Harmonized Scores and Mean

We observe that there are four countries with smaller average and a score lower than 0,50: Greece, Italy, Portugal and Spain. There are five EU countries with higher average value: Sweden, Denmark, Finland, Germany and United Kingdom. If we compare the result of this synthesis indicator, with the current status of the economies in these countries in terms of public debt, or GDP per capita performance, it seems reasonable to think that there is a relationship between the relevance of innovation in their economies, with the intensity of the crises phenomenon that they are facing.

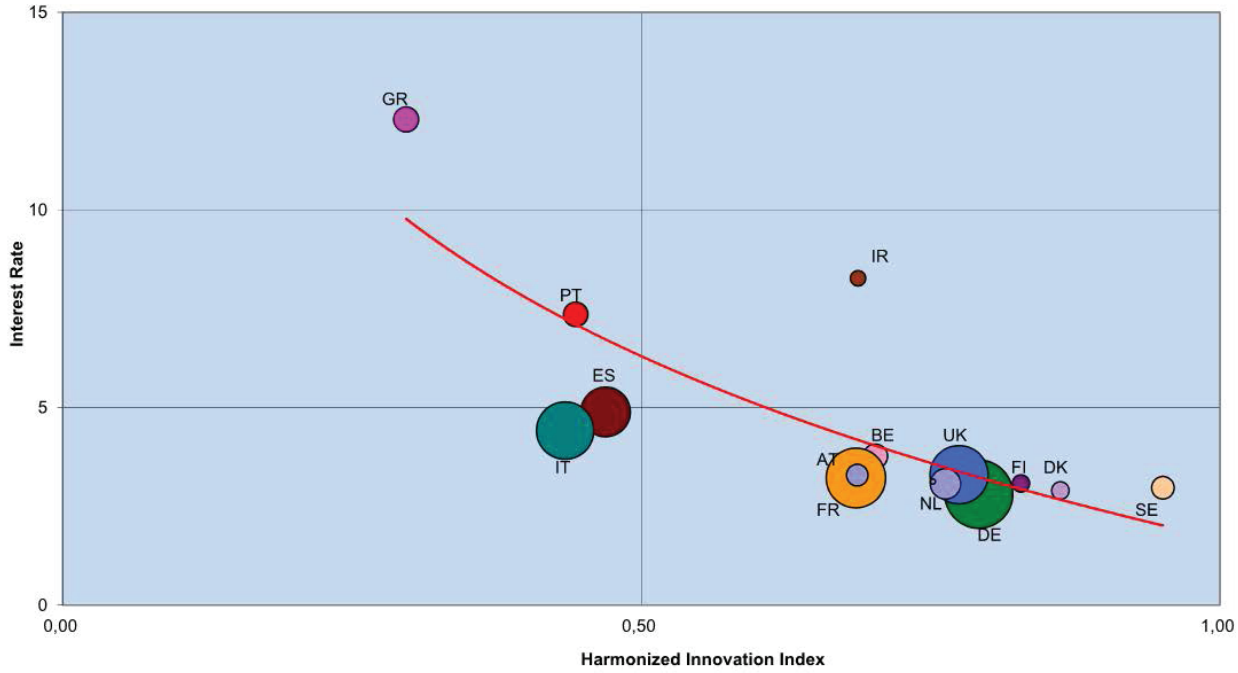


Figure 1.3: Innovation vs Interest Rate (Bubble size according to Population)

In Figure 1.3, we present a comparison between the average value of the harmonized innovation index and the interest rate of the national debt of the corresponding countries (expressed as the average between June 2010 to June 2011, on 10 years bonds, source: Eurostat). These values are also weighted as the circle area or size is related with the size of their population for each of these countries. It is clear from Figure 1.3 that those countries whose economies have been already rescued (Greece and Portugal) or are more exposed to risk (Italy and Spain) are placed in the quadrant with rate of innovation $< 0{,}5$. The Irish case is the unique exception to those countries that were intervened, or are in risk of being intervened. The case of Ireland is peculiar, in spite of having a relatively high rate of innovation. Nevertheless we consider that the type of economic crises suffered in Ireland differs substantially of the one happening in the remaining European countries. Indeed, the Irish economic growth was mainly motivated by financial entities that were holders of their main assets outside Ireland, and installed there due to the very convenient conditions for such entities, specially in terms of taxes. Dellepiene and Hardiman (2010) mention that this fact caused a sudden growth of its public deficit when the economic crisis exploded.

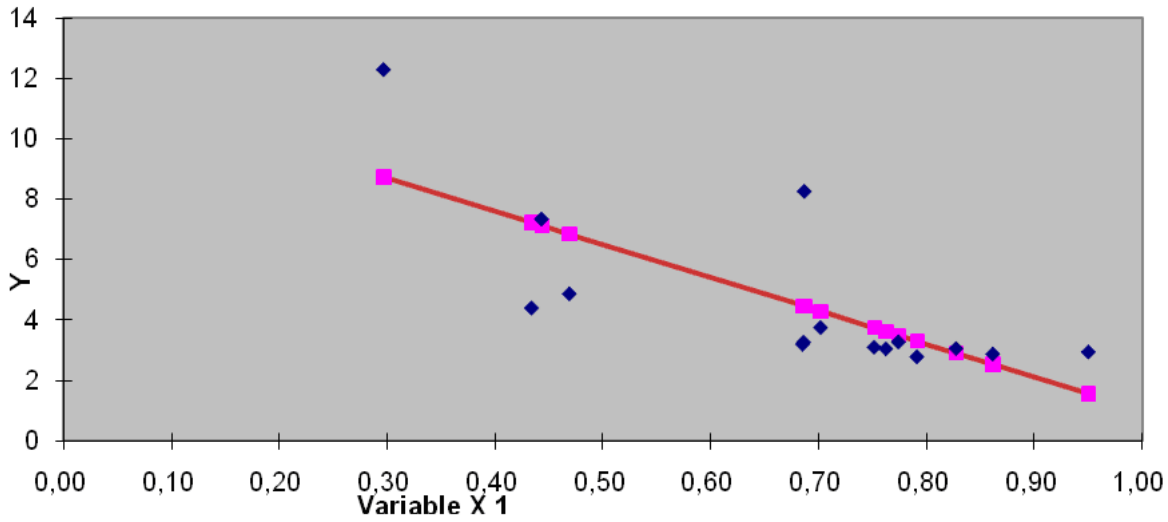


Figure 1.4: Linear Regression Innovation Score vs Rate of Interest

Although the correlation coefficient between both variables is $-0,75$, which places us in a clear inverse relation, the explanation of the independent variable (being this variable the Rate of interest) is characterized by an R^2 coefficient of determination of 55%. Thus, it can not be considered a strong linear relation. To verify the robustness of such relation, we used the F correlation test, whose statistics is 16.25, being its p-value 0.15.

Looking at Figure 1,3 and to the not so narrow dependence relation results achieved with the different coefficients, we may consider, that the relation between both variables is not linear, but logarithmic. To confirm such hypothesis we have transformed our original value 'innovation score', through logarithms. Moreover, as stated before, we can consider Ireland as an outlier, as their circumstances are different to the rest of the countries, so we opted for taking out Ireland, before measuring this dependence.

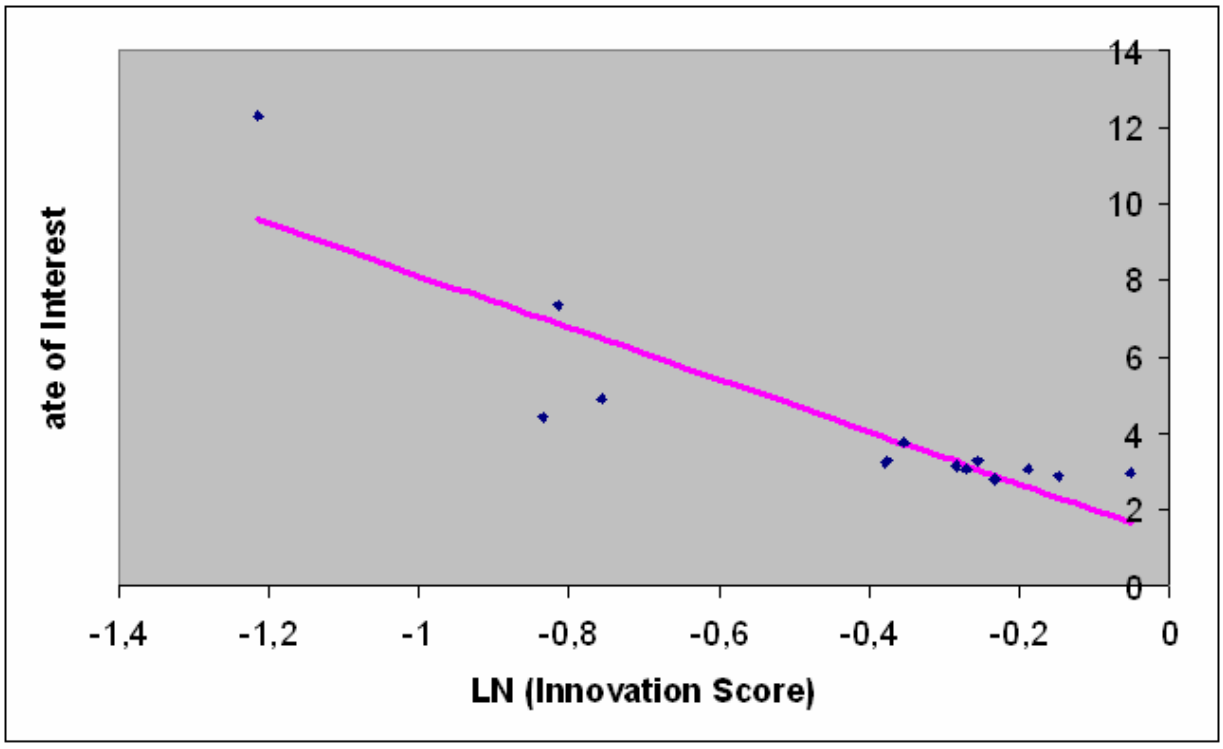


Figure 1.5: Linear Regression Ln (Innovation Score) vs Rate of Interest

By doing this, we can observe in Figure 1.5, that this transformation makes the relation close to linear. To confirm such affirmation we have calculated again the correlation coefficient which moves from 0.74 to 0.88; the R^2 coefficient shifts from 0.56 to 0.77, and

finally the *F-test* moves from 16.25 to 40.8, for a new p-value of 0.00003, supporting our earlier comment.

	Inn Score vs R. of Int.	**Ln (Inn Score) vs R. of Int.**
Correlation	0.74	0.88
R^2	0.56	0.77
F Value	16.25	40.80
P-Value	0.00142	0.00003
Obs	15	14

Table 1.4: Correlations table: Before and after logarithmic transformation

With the results observed so far, it is not possible to conclude that innovation is a determinant element for the current situation of national economies, since to be able to validate this affirmation it would be necessary to conduct a much more in depth analysis through the information that is behind the indicators that were proposed. In addition, a more exhaustive study would be necessary. It should be combined with the analysis of other variables, which could be related to the crisis. For instance variables in relation with: national debt, liquidity of markets, structure of the national economies, etc. Nevertheless, at least at a country level, according to the analysis conducted, it seems that innovation has entailed a mechanism for sustainability against market oscillations.

Analysis at Industry Level

We conduct an analysis parallel to the previous one, by observing the crisis effects over certain industrial sectors, trying to identify those which are innovation-intensive, verifying whether innovation could have been one of the differential elements that allow them to better stand the crisis.

As in the analysis at country level, there is no unique innovation index to asses the level of innovation at enterprise sector. Prestigious publications like Businessweek and Newsweek, elaborate periodically rankings that measure different elements for the most important international companies, being innovation one of the elements analyzed. Businessweek, in its report of 2010, selected the fifty most important companies worldwide in terms of innovation. The origin of this study was in 2005, when the same publication

started to rank them, but taking only in consideration the first 25 companies. Newsweek did a parallel analysis in 2012 and selected the 10 most innovative companies world wide. By comparing both studies, we observe that the first three companies coincide in both studies, but not in the same order. In total eight companies are in common in both lists: Microsoft, Apple, Google, Ford, Toyota, Amazon, LG and B&D. For our analysis purposes, we have selected eight other prestigious companies of different sectors (automotive, pharma, telecommunications and tourism) not included in the previous selection. These companies are: Volkswagen, GM, Pfizer, Novartis, Telefonica, France Telecom, Marriot and Wyndham.

The next step of our study is to assess whether their innovation score is related with their global performance. Thus, for these sixteen companies we have gathered information about their cash and commercial values for the years 2009 and 2010, and calculated its variation in both years:

$$Var_t = \frac{X_t - X_{t-1}}{X_t}$$

This variable is generally accepted as an indicator on the turnover company's capacity, see Informe Bankinter (2010). Its variation shows the trend of this variable in the period studied. If we observe Table 1.5, we note that, in general, those companies recognized as innovation-leading, not only do not move back in asset terms (cash and commercial value), but, in many cases, they have progressed despite the global economic situation

Nweek Rank	Bweek Rank	Enterprise	2009	2010	Vars 2009-10
2	1	Apple	31.555	41.678	0,32
1	3	Microsoft	49.280	55.676	0,13
3	2	Google	29.167	41.562	0,42
6	13	Ford	58.875	54.516	-0,07
na	5	Toyota	114.396	139.114	0,22
7	6	Amazon	9.797	13.747	0,4
na	7	LG	222.740	231.812	0,04
8	8	Becton and Dickinson	192.737	279.876	0,45
na	15	Volkswagen	76.173	77.766	0,02
na	na	General Motors	59.247	53.053	-0,1
na	na	Pfizer	61.670	60.468	-0,02
na	na	Novartis	33.691	26.685	-0,21
na	na	Telefonica SA	34.190	28.245	-0,17
na	na	France Telecom	31.157	20.298	-0,35
na	na	Marriot	8.903	7.933	-0,11
na	na	Wyndham	1.740	1.752	0,01

Table 1.5: Cash and Commercial Value. Source Yahoo Finances

We observe that from the eight companies that appear in both innovation rankings, only Ford, suffers a reduction in its assets rate, whereas for the eight remaining companies that do not appear in these classifications, only one of them did not suffer such reduction. In fact, their levels seems to be quite stable. We observe in Figure 1.6, that it also seems reasonable to think that the more 'innovative' companies are suffering less the economic crisis, if we measure this through their effective assets, which are linked with their liquidity.

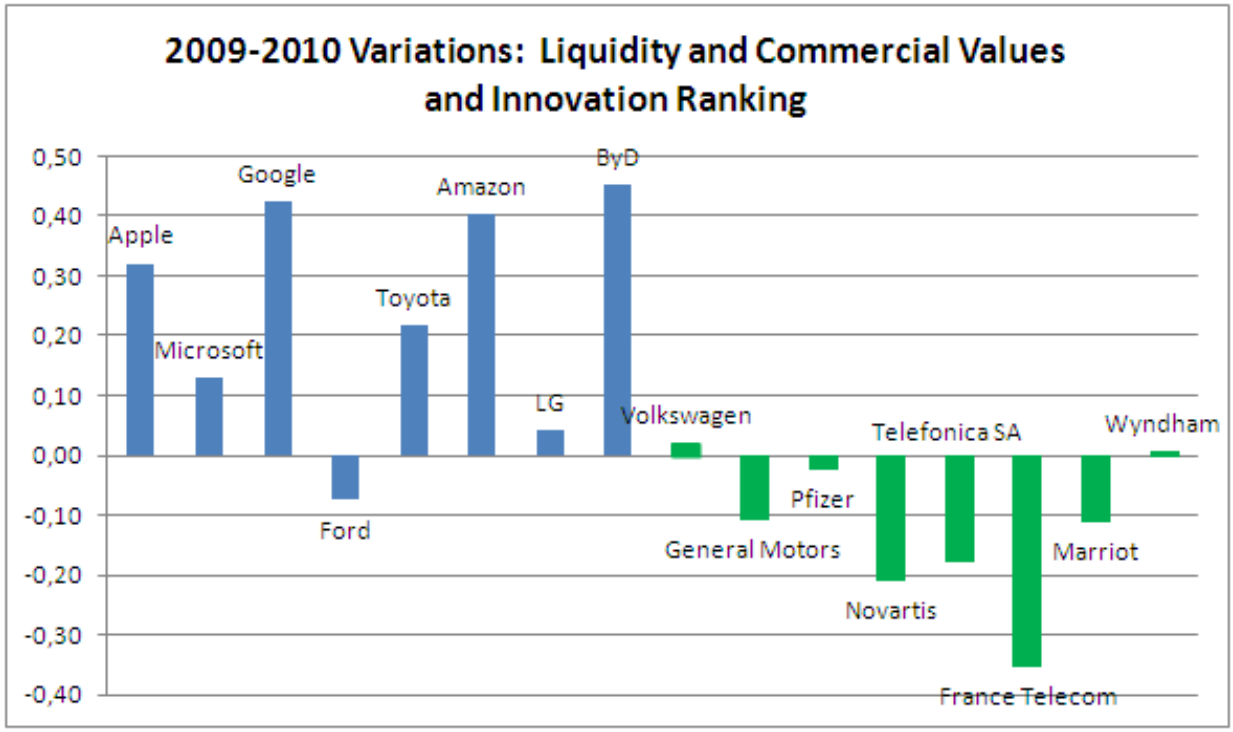


Figure 1.6: 2009-10 Variations on Commercial Assets and Liquidity

Again, as a result of this analysis, we cannot infer that lack of innovation is the unique cause for the current situation of many industries. To this end, it would be necessary to study much more in depth other industrial indicators. Nevertheless, it seems reasonable to suggest that innovation somehow has an influential element on how these companies have confronted the crisis, possibly due to their capability to adapt to market changes.

1.2. Open Innovation

Based on the results of the previous analysis, innovation seems a key element to stimulate growth and competitiveness in a modern economy. Moreover, we are facing the evolution of markets, which are increasingly becoming more and more interconnected, so that they can be conceived only in a global frame, due to the incoming speed in world wide information dissemination.

A few years ago, it was not conceivable the fact that from a household, an article could be sold to individuals, irrespectively of the distance. Nowadays, from selling and auction platforms like Ebay, we can see how these operations take place by thousands daily. This globalization effect has made that not only companies, but governments are changing the way in which they innovate, opening increasingly their innovation processes to third parties. Through this way of working, opening the global knowledge, risks associated with the uncertainty of any innovative process are reduced, and, as a consequence, products and services developed better satisfy the requirements of markets.

One of the authors that pioneered the concept of Open Innovation was Chesbrough (2003) who developed the basis for the open innovation concept, and placed its origin as an innovation within the own innovative process. Chesbrough suggests that close innovation has been a productive model up until the second half of the 20th century. Until then, the key for success was to have the full innovation process under control, so that companies keep generating their own ideas and developments and they were also the ones that brought them into market. The origin for such approach was also the lack of collaboration with Academia, due to the consideration by most scientists (mainly coming from basic sciences), that they needed a degree of isolation for proper development, considering market challenges as less relevant from a scientific perspective. Also the promotion of scientist careers did not stimulate a collaboration between Academia and Industry. Due to this fact, companies were forced to undertake their own foresight analysis, and create research and development centers, in order to find new products or evolutions of their products and services. This was called Closed Innovation. Some patterns behind such paradigm were:

- It was necessary to hire the best researchers.

- The success strategy was to arrive first to the market with an innovative product.
- It was crucial to monitor intellectual and industrial property rights, protecting them from competitors, and avoiding communication.
- The effort in research and development was linear. Thus, major efforts would suppose proportional leadership.

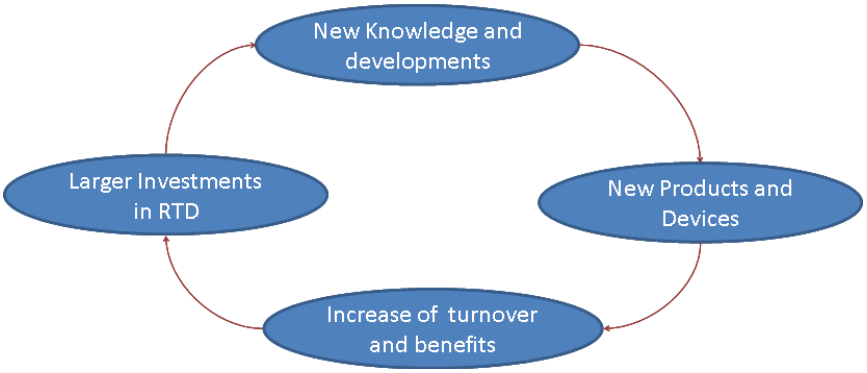


Figure 1.7: Close Innovation Virtuous Circle

The results of these patterns was called the virtuous circle of closed innovation, see Chesbrough (2003) and Figure1.7. Thus, the Close innovation model was understood as a close and endogamic circuit, so that the whole process, from pushing up an idea to the deployment into market, was governed exclusively by the manufacturing company. Moreover, it was mainly funded by the outcomes of the developed product and services, see Figure 1.7. Therefore, research and technological development was linked with the capacity of the enterprise to develop innovative products and services and its absorption by the market.

At the end of the 20th century, this model began to lose validity due to different factors, named by Chesbrough erosion factors. The main cause for this 'erosion' was determined by the change on employment patterns and the increase of mobility of top-level employees. Until then, they have never thought before about working out of their 'mother' company, but they started to move to other firms or develop their own start-ups. Thus, these employees had profitable opportunities to go out of their current companies, with an accumulated

experience and, therefore, with a very deep specific knowledge in their corresponding field.

Venture capital has also been an important factor, as the funding source for the new ideas of these top-level staff, that were not possible to be financed under their firms. In addition, other financing sources were also present, as the ones known as the three 'f's' (family, friends and fools), that also were encouraging to entrust part of the savings to these new ideas.

The third factor was the even higher pressures for reducing the time to market, due to the caducity of generated innovations in more globalized economies, and the acceleration of breakthrough ideas, as we posed in the first section.

According to Chesbrough's theory, these three factors make the virtuous circle to move towards an open circuit, as it raises diverse entries and exits, as well as not necessarily linear interactions. Thus, it modifies completely the innovation model, as shown in Figure 1.8:

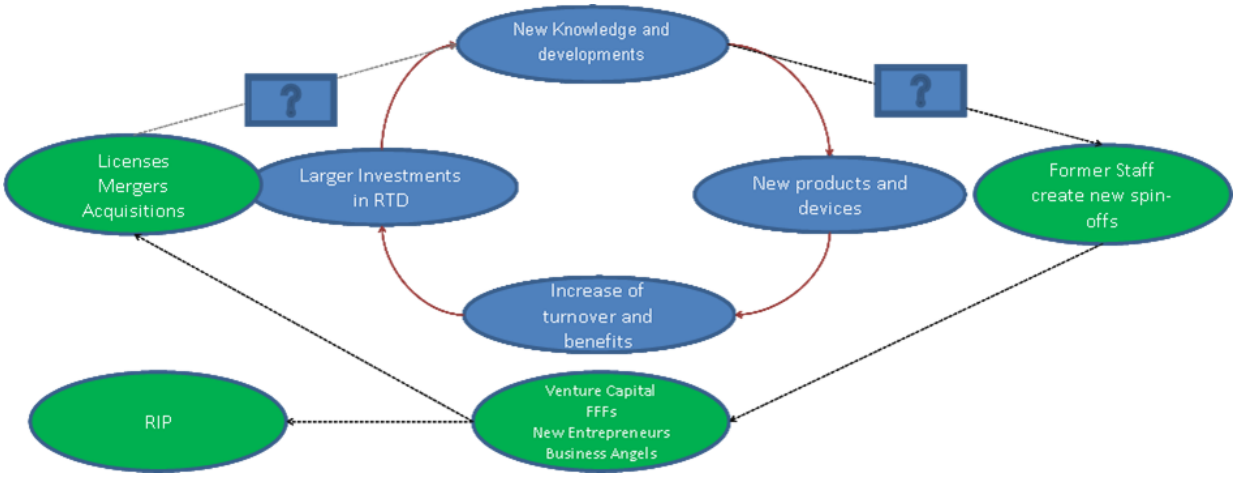


Figure 1.8: Open Innovation Virtuous Circle

The breaking of Chesbrough's circle is justified by the fact that new companies were founded from ideas arose from parent companies, that were not able to exploit commercially such ideas as we will see hereinafter. Moreover, although in some cases these start-ups generated huge benefits, it must be taken into consideration that many of these ideas that went out of the circle did not succeed.

The XEROX PARC Case

The case par excellence of breaking the virtuous circle of innovation is the one that happened at the Xerox's Technological Development center located in Palo Alto (California), known as PARC.

Founded in 1970 as a division of Xerox Corporation, PARC has been responsible for very well-known and important innovations, such as laser printing systems, the ethernet device, the modern PC, the user's graphical interface (GUI), ubiquitous computation, as well as of products as extended as the mouse that we use daily with our PCs. Xerox invested a great amount of resources in this center: more than 100 million dollars, but it never managed to make profitable such investment in economic or financial terms. Very often, these inventions did not fit with the Xerox business model, so they were disregarded. When this was the case, sometimes the top-staff that developed the idea went away from PARC. In such way, PARC became the main source of inspiration for new technologies of the 70's and a good part of the 80's. As a result, Xerox financed the development of technologies that ended up being commercialized by third companies, without receiving a fair compensation. In that sense, PARC was tremendously intensive in invention, but very little innovative in developing the appropriate business models.

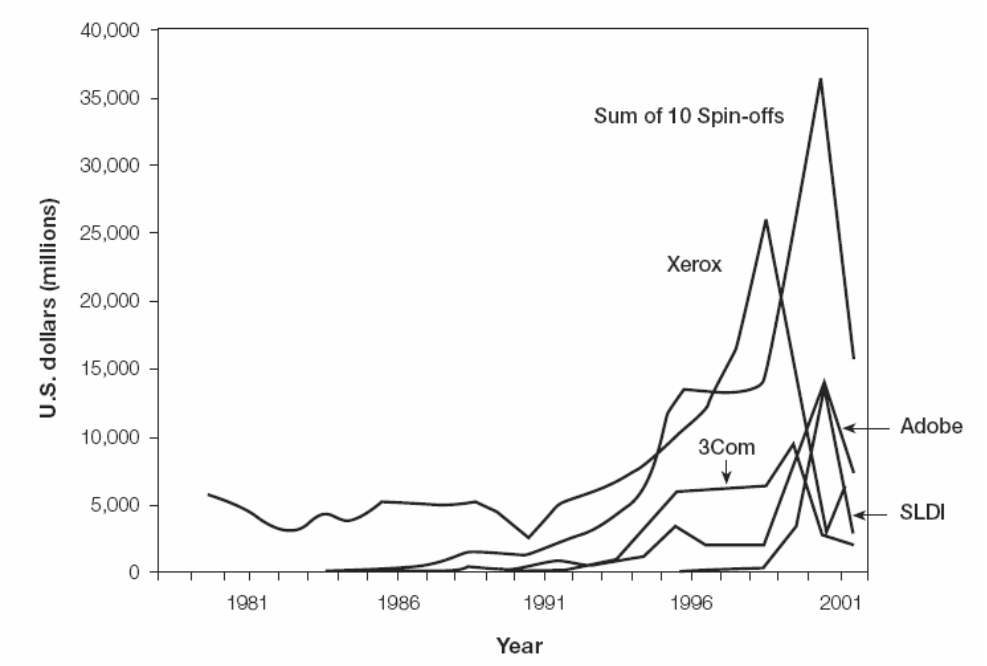


Figure 1.9: Xerox Commercial Value and its most famous Spin-offs

As shown in Figure 1.9, the sum of the commercial value of the companies arisen externally as spin-offs of PARC's overcame by 20% the own value of Xerox. Chesbrough indicates that the main reason for which these companies should seek for light out of Xerox, was not lack of XEROX's innovative policy, but the lack of a business model facilitating them reaching the market. We should mention that Figure 1.9 shows only the 10 biggest spin-offs arisen from XEROX, but that there were also other many companies that did not prosper, or that had to close just a little bit after entering into market.

This fact, that happened more than thirty years ago in Palo Alto, is in full force today. We just need to analyze the scientific production of many universities and research centers in Europe, where many processes and products are developed, but only in very limited cases they are being commercialized.

1.2.1. Open Innovation and Sources for Innovation

The concept proposed by Chesbrough for innovation is not exclusively based on the issue that a company should be open to outside in order to obtain good ideas. What Open

Innovation proposes is that good ideas are to be developed no matter where they come from, and they are to be deployed to the market not only, or always, from the developer company, but also through joint ventures, making this decision based on the best path identified to reach the market. Therefore, the most suitable approach would be that with a best business model for such idea, see Figure 1.10. In some cases, if the most appropriate tool is not identified, the path to the market could be identified as developing a specific spin-off.

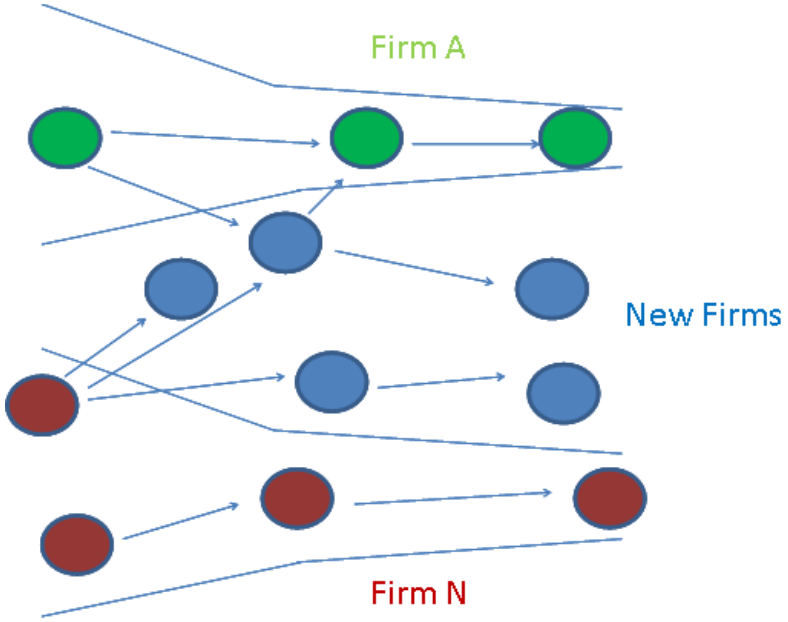


Figure 1.10: Idea evolution in an Open Innovation environment

Chesbrough indicates that open innovation requires a change in business models and, more specifically, in commercialization plans. Due to this fact, it becomes a critical issue to embark in the innovation process and ideas, not only to the company as producer, but to strategic partners as they are: employees, clients and suppliers. They will be of great help as a source for innovation, as we shall see below.

Behind this approach, we find what was known as the 'Democratization of Innovation' whose principal contributions, besides those of Chesbrough, have been mainly done by Von Hipel (2005). Under this study he proposed the "lead users theory", that identify those users as the persons or entities that identify before than nobody a market need. Sometimes

this need is due to their direct production activity, some others due to the commercialization process. These lead users would be the first ones in adopting an innovative product or technology, and those who would receive directly their benefits. It is to be noted that they would be the ones that are in the position of assuming risks.

According to Von Hipel, an element that characterizes these lead users is that they cannot wait until they receive the innovation that they are looking for in the market, so they go beyond, being capable of developing innovations that answer their needs. This lead users are always present and, specially, in some relevant sectors such as in medicine, or agriculture. The niche market for this innovation source is mainly present in cases of massive products and services, where the generality of the offered articles correspond to a large number of users with a high margin of improvement in the degree of usefulness of the product or service. As an example, the development of open source software is characterized by making the source code open, so that users may adapt the tool to their needs, being then in the business of customizing such products.

Unfortunately, the time needed for innovation to be developed by lead users to reach the market, is more than what is desirable. Nevertheless, nowadays, with the increasing variety of tools for global communication and the new commercialization ways and self-promotion, who can aid in changing the lack of coordination and accelerating the process. To this end, Von Hipel proposed strategies based on alliances with leading users, in order that their developments could be equally exploitable in a joint way.

Innovation in the Biomedical Area. Merck Virtual lab, GSK and IMI

The first approach to open innovation in the biomedical sector was led by the multinational pharma Merck, which is probably the company in that sector that invests more in research and development. Already in its 2.000 annual report, Merck indicated that it was not sufficient to be the leader in terms of research investments, as this amount only represented 1 % of biomedical investigation research funds worldwide. In this report, Merck raised the issue that it was essential to launch a new strategy to know what were the 99% of the remaining resources devoted for.

This point entailed a complete change in their research and innovation policy. Since

then, Merck activated all mechanisms to develop alliances with universities and research centers, keeping always in mind that their aim was to obtain the best products and technologies to satisfy market needs. To that end, they developed the 'Virtual Labs', a fixed channel for continuous exchange of information between Merck researchers and the most important scientists in the world, with the common goal of searching new developments and technologies. Currently, Merck continues applying the open innovation model. A result of its application is that, in 2008, 65% of Merck's income was coming from alliances and joint projects. In addition to this, they have launched the 'X-DPS Group', where external and internal researchers from the whole research and innovation chain work together jointly, in order to include the whole agents process. Merck expects that one fourth of their product portfolio products will be developed in the future from these joint groups, .

Another recent case in which a pharma company decided to give a step forward in the open innovation model is the case of Glaxo Smith Kline (GSK), that in 2010 decided to launch an open innovation policy based on three specific measures:

- Giving more flexibility to the use of the IPR generated by GSK, opening 800 patents and patent applications for research related with the often neglected tropical diseases. In a second phase, they proposed to create an IPR pool, to which different centers and universities might adhere in order to extend the available knowledge to a critical researchers sufficient mass. In order to ensure the transparency of the process, the management of this pool is not done directly by GSK, but by a non-profit entity, in the called Global Joint Bioventure for Health.

- Creation of their first Openlab, as a platform for technological innovation for neglected tropical diseases. Through this initiative, GSK opened the possibility for sixty scientists of the whole world to access to their laboratory at Tres Cantos (Madrid), making available for them not only their infrastructures, but, what is more important, their background and knowledge of GSK research teams in this area. With this support, invited researchers can further develop their research projects. Additionally, GSK promised to contribute with an amount of eight million dollars, to support the development of such projects.

- Open and free access to 13.500 active principles already developed by GSK addressed towards malaria. These 13.500 molecules were originally part of more than two million active principles, that had gone already through a strict process of screening for several years, demonstrating to have some inhibition capacity against the malaria parasite. Thus GSK, made available for the whole research community and with no conditions, the chemical structures they developed, as well as the most relevant information of their studies.

The Innovative Medicines Initiative (IMI) is Europe's largest public-private initiative aimed at speeding up the development of better and safer medicines for patients. IMI supports collaborative research projects and builds networks of industrial and academic experts to boost pharmaceutical innovation in Europe. IMI is a joint undertaking between the European Union and the pharmaceutical industry association EFPIA. This joint undertaking has a total budget of 2 Billion Euros for the 2007-2013 period, being funded fifty-fifty by the EU and EFPIA. IMI's overall goal is to build a more collaborative ecosystem for pharmaceutical R&D in Europe and speed up the development of more effective and safer medicines for patients. To reach such objective, IMI creates unique, large-scale networks of innovation in pharmaceutical research working on an open basis. Joining forces within IMI research and training projects, competing pharmaceutical companies collaborate with each other and academia, SMEs, regulatory agencies and patients' organisations in order to tackle major challenges in drug development.

Beyond the issue of corporate responsibility, under the above initiatives of Merck, GSK and IMI, an open innovation model clearly emerges, in which the main feature is to have an alliance culture and policy between academia and the industry. As Chesbrough suggests, not only there are new ideas behind innovation, but also changes in the business model of the involved companies.

1.3. Evaluation of Public Sector Research and Innovative Proposals

Over the last fifteen years, the world domestic expenditure on RTD has almost doubled in real terms. The rates of this increase vary quite a lot among countries: in Europe this increase was around 50%; 60% in the United States; 145% in BRIS countries (Brazil, Russia, India and South-Africa) and 855% in China, see Pro Inno Europe (2011).

In the case of Europe, the main factor for the increase of this expenditure in RTD comes from the public sector, that raised from 0.64% over the GDP in 2000 to 0.74% in 2009, while the expenditure in the private sector shifting from 1.22% to 1.27%. If we aggregate public and private expenditure in RTD, we observe a shift from 1.86% in 2000 to 2.01% in 2009. Considering that the gross Domestic Product (GDP) in Europe for 2009 was 11.752 billion euro, this means that the public resources allocated to RTD activities is around 150 billion euros per year.

At an international level, the main source for RTD funding is the Seventh Framework Programme for Research and Innovation (FP7). In January 2014, the new framework programme, Horizon 2020 (H2020), is to be launched for the periodo 2014-2020. Both programmes will last for seven years. The FP7 programme has a total budget of over euro 50 billion, being the European Commission proposal for H2020 of 80 billion. This represents a substantial increase compared with the previous Framework Programmes. Nevertheless, the main source of funding within Europe continues at national level, representing about 95% of the public expenditure for RTD activities, or 80% if we just consider the funding available at a national level for RTD projects. As stated in the Innovation Union Competitive Report for 2011, national funding has also increased significantly, being Spain the country within the EU27 with the highest increase (2.43) times, for an average at EU level of 1,51. Nevertheless, this acceleration seems to collapsed, due to shortcuts in public funding in general in 2012, and the stagnation of the RTD budget.

Despite the public resources for RTD activities having risen so much, the procedures and systems for the selection and evaluation of such projects have not practically evolved, apart from the introduction of ICT tools for remote assessment, but not so much for communication among experts. We review in what follows subsections 1.3.1 and 1.3.2.

1.3.1. Evaluation Procedure for Projects Funded by the Spanish Research and Development National Plan

The Spanish State Programme for Research and Innovation, formerly known until 2012 as Spanish National Plan for Research and Development, is the main instrument for funding basic and applied research activities at Spanish national level (1999). It was established through the Spanish law for Science in 1988. The first National Plan was launched then and lasted until 1991. Its intention was to provide global coverage to the effort done by the different ministries involved in research and technological development issues. Since then, a number of national programmes were launched. 2012 was the year in which this Plan was evolved into a new conception by the integration, under a common national strategy, not only the Research Plan, but also the Innovation Plan.

As the majority of the funds allocated to this Plan are launched through competitive calls, there are several evaluation criteria which depend on the nature of each instrument. Nevertheless, in general, in almost all of the funding instruments we can identify two phases:

1. The first one is usually a scientific evaluation most often carried through an external evaluation agency, which is frequently the ANEP (Agencia Nacional de Evaluación y Prospectiva). These agencies have a complete database with a large number of experts that are the ones that asses projects. The evaluation criteria for basic research projects tend to be the scientific relevance of the proposal and of the research team. As an example, in the 2012 call for competitive research projects, the specific criteria were:

    - Scientific excellence of the research group (50 points)
    - Scientific excellence of the proposal (50 points)

For applied research, technical development and innovation, the criteria were

- Economic viability of the proposal (10 points)
- Scientific and/or technical excellence (30 points)
- Understanding and layout of the proposal (10 points)
- Impact of the proposal (20 points)
- Projection of the RTD group (10 points)

In both cases, the assessment is done on a remote basis by two experts, that do not communicate. Only in case of major discrepancies, a third expert participates to reach a solution for the final assessment. Once the projects are scored, they are ranked and pass to a second phase.

2. This one analyzes the opportunity of the proposal and its integration within the general plan. This phase is mainly the chance that the funding authorities have to do research and development policy making, as although they have to consider the results of the evaluation, they can decide which proposals are the most pertinent to reach the objectives proposed and with the budget allocated. Usually this phase tends to balance the funds available with best assessed projects and the 'science demand'.

It must be highlighted that, there have been some experiences, as the case of the evaluation process for the 'Fundació Telemarató de TV3' call (2003) in which alternative ways of assessing research projects were tested, avoiding the potential bias of the traditional individual peer review, due to the lack of communication among evaluators, nor with the funding agency. The final results were the aggregation of individual evaluations, with virtually no room for discussion of the proposal details at the first evaluation stage. Moreover the evaluators tend to come from the academia, and just a few have experience from industry, being therefore a deficit on knowledge and application to industry.

If we have to highlight a characteristic about this evaluation process is that it is a close and expensive system, almost endogamic, not far away from the Close Innovation paradigm described by Chesbrough. It can be the case that the implementation of the new Research and Innovation strategy, may change this perception.

1.3.2. Evaluation Procedure for FP7

The EU Seventh Framework Programme for Research and Technological Development(FP7), runs from December 2006 and lasts until December 31st 2013. The budget for this programme is about 50 billion euros and is divided into four specific programmes: Cooperation, Capacities, People and Ideas, being the most important international funding source for research. All actions funded by this programme are launched through competitive calls, and assessed by independent experts from relevant fields. For H2020, the main change on evaluation seems to be the order of the evaluation criteria, being impact the second evaluation criteria, after scientific or technological excellence, in spite of implementation.

The evaluation of proposals is carried out by the European Commission, or sometimes through one of its executive agencies, but always with the assistance of independent experts. The evaluation criteria vary among specific programmes, but not the autonomy of external evaluators to decide on the proposals to be funded. In this sense within this programme the funding decision resides to a large extent on the evaluators.

The European Commission (EC) staff ensures that the process is fair, and in line with the principles contained in the Commission's rules. Experts perform evaluations on a personal basis, not as representatives of their employer, their country or any other entity. They are expected to be independent, impartial and objective, and to behave throughout in a professional manner. They sign an appointment letter, including a declaration of confidentiality and absence of conflict of interest before beginning their work.

In addition, an independent expert will be appointed by the EC to observe the evaluation process from the point of view of its working and execution. The role of the observer is to provide independent advice to the EC on the conduct and fairness of the evaluation sessions, on the way in which the experts apply the evaluation criteria, and on ways in which the procedures could be improved. The observer will not express views on the proposals under examination or the expert opinions about the proposals.

Depending on the specific programme, the evaluation is carried in a one or two stage process. At the beginning of the evaluation, experts will be briefed by the EC, covering

the evaluation procedure, the experts responsibilities, the issues involved in the particular area/objective, and other relevant material (including the integration of the international cooperation dimension as well as the innovation dimension).

Each proposal is first assessed independently by, at least, three experts. The proposal is evaluated against pre-determined evaluation criteria. For research collaborative projects, the main grants funded by the EU, there are three evaluation criteria to asses over a maximum score of five for each evaluation criteria:

- Scientific and/or technological excellence
- Quality and efficiency of the implementation and management
- Potential impact through the development, dissemination and use of project results

Usually there is a minimum threshold under each criteria of 3 over 5, but a global minimum of 10 over 15.

The scores indicate the following with respect to the criterion under examination:

- 0: The proposal fails to address the criterion under examination or cannot be judged due to missing or incomplete information
- 1: Poor. The criterion is addressed in an inadequate manner, or there are serious inherent weaknesses.
- 2: Fair. While the proposal broadly addresses the criterion, there are significant weaknesses.
- 3: Good. The proposal addresses the criterion well, although improvements would be necessary.
- 4: Very Good. The proposal addresses the criterion very well, although certain improvements are still possible.
- 5: Excellent. The proposal successfully addresses all relevant aspects of the criterion in question.

The evaluation process is done in three different stages:

Individual Evaluation

This part of the evaluation is carried out remotely on the premises of the experts concerned. At this first step, the experts act individually. They do not discuss the proposal with each other, nor with any third party. The experts record their individual opinions in an Individual Evaluation Report (IER), giving scores and also comments against the evaluation criteria. When scoring proposals, experts only apply the above evaluation criteria.

Experts assess and mark the proposal. They do not make any assumptions or interpretations about the project in addition to what is in the proposal. Concise justifications are to be given for each score. Recommendations for improvements to be discussed as part of a possible negotiation phase are also provided to successful stage 2 proposals, if needed.

Consensus Meeting

Once all the experts to whom a proposal has been assigned have completed their IER, the evaluation progresses through a consensus assessment, representing their common views. This entails a consensus meeting to discuss the scores awarded and prepare comments. The consensus discussion is moderated by a representative of the EC. The role of this moderator is to seek to reach a consensus between the individual views of experts without any prejudice for or against particular proposals or the organisations involved, and to ensure a confidential, fair and equitable evaluation of each proposal according to the required evaluation criteria. The group moderator may designate an expert to be responsible for drafting the consensus report ("rapporteur"). The experts attempt to agree on a consensus score for each of the criteria that have been evaluated and suitable comments to justify the scores. Comments should be suitable for feedback to the proposal coordinator. If during the consensus discussion it is found to be impossible to bring all experts to a common point of view on any particular aspect of the proposal, the EC may ask up to three additional experts to examine the proposal.

The outcome of the consensus step is the consensus report. This is signed/approved (either on paper, or electronically) by all experts, or as a minimum, by the "rapporteur" and the moderator, who is responsible for ensuring that the report reflects the consensus

reached, expressed in scores and comments. In case that it is impossible to reach a consensus, the report sets out the majority view of the experts, but also records any dissenting views.

The EC takes the necessary steps to assure the quality of the consensus reports, with particular attention given to clarity, consistency, and appropriate level of detail. If important changes are necessary, the reports are referred back to the experts concerned. The signing of the consensus report completes the consensus step.

Panel Review

This is the final step involving independent experts. It allows them to formulate their recommendations to the EC having had an overview of the results of the consensus step. The main task of the panel is to examine and compare the consensus reports in a given area, to check on the consistency of the marks applied during consensus discussions and, where necessary, propose a new set of scores. The panel comprises experts involved at the consensus step, new experts and /or a mixture of both. Several panels cover the different indicative budget lines for each call. The outcome of the panel meeting is a report recording, mainly:

- An evaluation summary report (ESR) for each proposal
- A list of proposals passing all thresholds
- A list of evaluated proposals having failed one or more thresholds
- A list of any proposals having been found ineligible during the evaluation by experts
- A summary of any deliberations of the panel. The report may contain multiple lists according to the different indicative budget lines

Following the final scoring and ranking by the Panel Review, the EC apply the rules fixed in the call to allocate funds to the best evaluated projects. After these three phases, the proposal enters the next phase called negotiation, in which the technical annex (proposal submitted) is modified according to the outcomes of the experts review and the priorities of the EC as the funding body.

If we compare the evaluation of FP7 projects with the Spanish National Plan ones, we must admit that FP7 is more open, once the remote phase is over, but is also far from the open innovation scheme as proposed by Chesbrough. Sometimes, evaluators that are members of the panel have a lack of information, when they have not been evaluators for the same projects at the first phase. Moreover this process does not allow to put into communication and even merge two projects to avoid duplication of efforts and resources. Hence, there is clear room for improvement.

1.4. Innovation Management Systems

1.4.1. Some Principles on Innovation Management

Over the last few years, we are witnessing the development of a large number of ICT platforms, based on the web, supporting innovation management decision making processes. As we shall see, such developments have been a consequence of the evolution of the web conception through simpler and participating tools, as we can see through the web 2.0 and web 3.0 paradigms. Up until now, the majority of such participatory applications have not been fully translated to the entrepreneurship sector to improve innovation management, being therefore a potential market niche.

ICT tools, and specifically Internet, are becoming a key instrument and source for change and innovation. In fact, nowadays even politicians are using more and more the web as a tool for continuous communication with citizens. In most cases, such communication takes place only during the selection processes, but we cannot disregard that such means may serve as participatory tools also for decision making processes. In this direction, some pilot actions are being developed. For instance: The Milton Keynes Council launched a public consultation on what the new town should look and feel like over the next 20 to 30 years, and 10 Downing Street has the *Take Part* section as a one-stop shop for citizens wishing to feed in their views on a range of topics from: children, families, retirement, and even the economy evolution (http://www.number10.gov.uk/take-part/). In summary, there seems to be a slow trend, that goes parallel to the social changes linked with the

development of ICT that will generalize participatory methods in social, political and economic processes, to a great extent. This is not a matter that affects only to local policies, but also to the application of these methods in many contexts and, especially relevant for us, in the innovation managerial field. The fundamental idea is that, as a consequence of the evolution of ICT tools, the spread of information, and the opening of the decision making process to more actors, there are more stakeholders to consider. That can help us in reaching the best solution or select the most appropriate project portfolios. These groups, beforehand, were not reachable in an easy and rapid manner, so their information was not used for the decision making process. These groups do not need to be always decision makers, but can provide suggestions, recommendations, establish priorities, etc.

If we transfer this argument to the entrepreneurial sector, we have a number of possibilities that can help us in promoting the role of employees, customers, providers, etc to improve products and services, whose knowledge is very often disregarded. The after herein mentioned ICT tools that for the moment are mainly used for social purposes, may play a facilitating role in the development of innovative solutions, that are closer to users, providers and customers.

The issue we would like to test within this study is the introduction of a new vision on the concept of managerial democracy. We could view this reappearance of the interest for managerial democracy as part of the corporate social responsibility (CSR) trend and the set of practices related with corporate governance. CSR appeared as such, in the fifties in the USA with the ISR funds, and that were generally adopted in the eighties/nineties with events such as Chernobyl or textile industry scandals in South-Asia with high well known firms. With respect to innovation, CSR policies are related to engaging employees or customers, taking into consideration their ideas. In this respect, we refer to topics such as sustainability, spirit of cooperation of a company with its clients, suppliers, competitors and governments, as well as a commitment to transparency.

Many of the existing decision making processes, running usually through a hierarchical mechanism, tend to turn to the open innovation paradigm through the participation of different actors. Thus, we might speak about a real managerial democracy, with all the advantages previously commented. In a related context, Freire (2007) indicates that social

innovation is usually implemented in a limited manner, through a misunderstood vision that assumes that it is enough to use technology, which on its own provides information to the citizen so that a participatory system is established. But technology on its own, does not ensure that the rest of process will run smoothly, as not all information collected from the system is equally useful. For example, citizen participation in urban spaces requires information detailed in space and time for such developments, to be able to understand the dynamics and consequences of urban processes. These are extremely complex and difficult to capture with the available statistical information, or a few monitoring sites (for example, traffic, environmental variables). But this information, in order to be really useful and operational, must be integrated in databases, processed and visualized (statistically or graphically) for analysis and consultation. Given the importance of the spatial component, geographical information systems, and their evolution towards neo-geographical platforms, become a must.

Indeed the combination of innovation with the use of ICT systems close to the web 2.0 and 3.0, is the basis for SKITES, which is proposed in this dissertation to break the limits and open innovative content and participation to all relevant individuals.

Undoubtedly, all the concepts until now commented can promote the arrival of a new age in business management topics. On one hand, management can be done in a distributed manner, not needing a heavily centralized protocol. The solution proposed by SKITES, as we will see in the next chapters, would have the following advantages:

- The decentralization of the decision making process
- Saving on fixed and variable costs, through the use of ICT
- Employees, customers and providers are part of the decision making mechanism, so they feel more protagonists and, therefore, more linked with the supplying company.
- Increase of efficiency, due to the direct incorporation of new requirements learnt from clients, employees and providers.
- The capacity of adoption as the change is the continuous status, and all actors are participants in the suggestion of changes.

1.4.2. Innovation Management Research

As stated, we can strictly speak on innovation as a concept on its own, since the beginning of the 20th century, and it is treated as subject by business schools as a main component for competitiveness of the enterprise, only after 1950. Shane and Ulrich (2004) provide a literature review of relevant research issues in innovation management over the last fifty years. These authors conducted a review of 250 articles related with Research, Development, Innovation, Product Development and Entrepreneurship, published over the previous 50 years and qualified them into twelve major themes within that domain. Although all of them are relevant for our purposes, the following ones are the most relevant for our study:

- **The role of the individual:** This area is one of those that have aggregated a major number of publications, although the studies have come from many different fields: management, organizational behavior, psychology, sociology, etc. The studies conducted are mainly quantitative, rather than qualitative.

- **Technology Strategy:** Articles on this subject were published only after the late eighties, maybe due to the increasing relevance of this subject for business schools. The authors propose to divide these technology strategies into three sub-categories: Economic Explanation, Behavioral Approaches and Strategy Processes.

- **Product Planning and Portfolios:** The articles qualified under this category focused on the kind of innovative projects to pursue, studied from a double perspective: assessing the inherent characteristics for a single project to be a success, and understanding the relation among projects, so as to determine the value of a portfolio of projects as a whole, and more in depth in order to achieve the optimal portfolio of projects. This theme provides many of articles, but just a very few have provided positive and practical results.

- **Adoption and Diffusion of Innovation** This topic covers the biggest number of articles. This field has had the biggest impact in innovation research. According to

the authors, this is because models for the diffusion of literature have their roots in physical diffusion processes, well known in science and engineering.

These four topics are relevant to our study in different ways. As we shall see in Chapter 2, individuals, as entrepreneurs, will be the first ones on assessing their own innovative ideas, before going beyond the process. Beginning by this, we propose to identify in the proposer certain skills and attitudes that will be key for their success. Regarding the technology strategy, the sub-categories identified by the authors will be the way we shall suggest for evaluating proposals. Product planning and portfolios are directly linked with the identification of the optimal portfolio through Multi-Criteria Decision Analysis (MCDA) procedures that we will see later in this Chapter. The last topic also involves our study, as we propose to develop such activity within an open environment.

1.4.3. Web Based Innovation Management Process Tools

The increasing relevance of innovation and, more specifically, of Open 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). 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 processes appropriately has spawned a new market of web based innovation management tools, which we review, from a decision support perspective.

Group Decision Support (GDS) Features of Some Innovation Management Platforms

We outline the key features of several 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 innovation offer and demand matching. Besides this, the third and fourth tools incorporate voting and simple filter and rating mechanisms for decision support. The fifth one supports innovation management processes comprehensively. The sixth one is a big open market with detailed information. The last one is a system for benchmarking innovation in organizations. 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/`) Developed by Spanish entrepreneurs, it is conceived as an open innovation tool, through and internet 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. At the market place, organizations seeking for innovative solutions meet innovation-generating organizations. Users capture external knowledge (via publication of Technology Requests) and promote the knowledge generated within their organizations (via Technology Offers). The transfer of information is done confidentially between applicants and suppliers through the website. Based on the information exchanged, they may decide to maintain contact off-line. No formal decision support is provided. A 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 US platform that aims at connecting companies, academic institutions and public sector organizations with a network of researchers. These researchers earn prizes (and reputation) when solving proposed challenges. Moreover, Innocentive seeks innovative solutions, not only from the academic sector, but also takes into account suggestions from employees, customers and partners. In order to identify appropriate solutions, Innocentive uses the Challenge Driven Innovation (CDI) methodology, based on the definition

of challenges with a defined methodology process, and tools to help organizations develop and implement operational solutions to their key problems, opportunities, and, therefore, meet the challenges. The framework lives alongside or can even replace the stage-gate paradigm that has dominated innovation business processes for decades. In CDI, the innovation is partially formulated as a challenge, in which it essentially represents the problem statement for a block of work that can be modularized and, in most cases, rendered portable. Such a block of work can be outsourced or insourced as an integral unit. Innocentive 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 be also given. Moreover a systematic approach to achieve the challenges is included. Thus, we can say that although it looks quite simple, in the sense that it seems just a matching mechanism, it is more than a simple market innovation place. There is no evaluation of innovative projects, nor is any follow-up supported. Thus, Innocentive strictly covers the gap between innovation producers and demanders.

- **ideas4all** (`http://en.ideas4all.com/`) is a Spanish 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 challenges in search for assistance or support. Thus, ideas4all is essentially an open idea marketplace supported by a simple voting mechanism, not specifically focused on innovation. Nevertheless the proposed solutions, or the problems posed, are classified in several categories, being the top categories: Science and Technology, Lifestyle and Health and Environment and sustainability. There are also much more ideas proposed than problems shared, being about ten ideas per problem. Any kind of idea can be proposed, and almost any person can act as evaluator. Neither the voting mechanism, nor the evaluation criteria are developed to match with the specific needs of innovation markets. Its business model is based on advertisements and fees paid by organizations to pose challenges.

- **Qmarkets** (`http://www.qmarkets.net/`) is a multinational company with headquarters in Israel 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. In the process of seeking solutions they involve not only the employees, but also the company customers. Nevertheless Qmarkets does not cover the implementation and follow up phases. Moreover, the product is to be installed in mid/big firms as it is requested about 100-500 employees/customers to be operational. 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: Henkel, Swiss Comm and EDF. However, their system is meant to be used internally within an organization, not allowing external participants, except customers. Its business model is based on license fees.

- **Accept** (`http://www.accept360.com/`), developed by a US company, 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. Its main target is to develop specific solutions. Accept supports idea generation, selection, and execution. During the idea generation phase they involve not only employees, but also partners and customers. Moreover, a specific application compatible with Oracle has been developed. 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. Its business model is mainly based on software as a service (SaaS)

- **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.

- **USA INNOVATION** (`http://innovationsupplychain.com//`) developed by the National Institute of Standards and Technology (NIST), under the USA Department of Commerce, and operated by Merwin Research Inc. This site is an open market place conceived as an online service that connects manufacturers to technology and business opportunities resulting in new markets and new products necessary for success. As a marketplace, there is room for investors to buy technology, for developers seeking for funding to develop their projects, and for manufacturers offering their services for the development of the projects. The information given for all the ideas is quite complete and includes: sales forecasts according to different scenarios and marketing efforts, and information on the development and patent status. This site gives a lot of information for a wide number of ideas, nevertheless it is conceived just as a market, without including steps forward.

- **InnoCash** (`http://www.innocash.es/`) is a tool originally developed by Genoma España, a governmental foundation whose leading trustee is the Ministry for Economy and Competitiveness, which mainly focuses on the transfer of intellectual assets, technology and innovation and entrepreneurship, mainly in biotechnology, to business. The aim of this tool is to identify, financially assess and nurture applicable research results and technologies, generated mainly by public research centres and universities, so that they can become innovation projects and enter in the market through business

and financial investors. Nowadays Genoma España does not exist, being its activities integrated, including InnoCash, under FECYT foundation.

InnoCash (IC) tackles the following four aspects of market innovation projects:

1. Select technologies with clear market potential among the pre-offers that are identified and sent by researchers and/or by their technology transfer agents.

2. Perform a financial valuation of potential technologies, by analyzing the relevant information provided with respect to their applicability and marketing opportunities.

3. Generate public outreach to these offers or technology opportunities in a flexible, intuitive and well documented manner.

4. Co-finance innovation projects (InnoCash projects) with investors to serve as market tuning and growth.

IC distinguishes two phases: Valuation phase, that starts with the submission of a pre-offer and its validation and improvements until it reaches the status of a complete technology dossier; and the Financing phase, where once the offer is public the investors are open to express their interest. If this is considered sufficient, the own IC programme may finance the pending budget gaps to the good end of the project.

This tool provides a market place where investors and innovators can interact and form venture alliances. Moreover, it assists entrepreneurs in developing and valuating their innovative project, so they can capture interest earlier from potential capital investors. IC provides just a little room for the demand side to pose problems, but does not foresee the possibility of involving other relevant actors as the customers, suppliers and providers to complete the full chain. Thus, it does not fit fully with what we understand as open innovation. The IC programme aims at opening dialogues among the different projects or problems.

1.4.4. MCDA Methods for Resource Allocation in Research and Innovation

The methodology proposed in this thesis for the optimal selection of innovative projects, suggests the use of a multicriteria decision analysis (MCDA) to elicit the best portfolio of projects based on different criteria assessed by experts with different backgrounds. MCDA methods offer several advantages in agenda building processes. Primarily, they have the potential of being used as tools for the representation of common problems which fit the group members' preferences. Secondly, they have the advantage of being perceived as a communication element that show the preferences of experts transparently. Thirdly, MCDA methods are perceived as creativity tools that foster the formulation of innovative solutions see Salo et al (2003); and Rios and Rios Insua, (2008). Finally, MCDA methods provide a systematic and transparent framework for developing decision recommendations, even if the information about the group members'preferences remains incomplete, see, e.g., Clìmaco and Dias, (2006), Mateos, et al. (2006), or Salo (1995). MCDA methods have been used previously in the following related cases, among others:

- Bana and Costa (2001) used multicriteria modeling to analyze conflicts in choosing a subset of road projects that would maximize the quality of the road network in the Lisbon Metropolitan Region.

- Salo and Liesiö (2006) developed a multicriteria framework for priority setting in a Scandinavian research program using a participatory approach. In this case study, different kind of assessors, evaluated complementary research themes, rating also their own level of expertise for each criterion. Results were presented graphically with regards to the two higher level criteria,without a more formal approach. In a facilitating workshop, results based on the statements expressed were shown separately, in order to convey similarities and differences in their viewpoints.

- Könnölä et al (2007) used Robust Portfolio Modeling (RPM) (Liesiö et al. 2007), to screen innovative research themes applied to forest-based industries. Themes were generated by researchers, and afterwards evaluated. RPM was then used to prepare

short lists of potentially interesting themes in terms of their evaluation means and variances, thus highlighting not only themes that received broad consensual support, but also themes for which the referees had expressed dissenting statements.

- Grushka-Cockayne et al (2007) developed a portfolio model for the selection of operational improvements to the European air traffic management system. They defined the group value considering individual and group members' subproblems. The group value was maximized subject to coordination constraints, and an alternative decision recommendation was provided by applying the minimax-regret decision rule to the group members' individually preferred portfolios.

- Rios and Rios Insua (2008) used MCDA to support participatory budget elaboration. Specifically, they first formed Pareto optimal portfolios based on the group members' holistic project evaluations and then determined a so-called disagreement point and a bliss point. Recommendations for group decision were offered by moving towards the Kalai-Smorodinsky solution, see, e.g., Moulin, (1984) through an iterative negotiation process. Using the concept of status index: cf core index in Liesiö et al (2007), they showed that the negotiations could be focused on borderline projects.

- Vilkkumaa and Salo (2009) used MCDA for the selection of shared agendas of action topics that are implemented by expending available resources, being the case study done for the development of shared research priorities. The development of these shared agendas involve several stakeholders with different backgrounds, that may have different views about the importance of the global objectives. To this end, they propose an additive multiattribute value, identifying the dominant portfolios for a first stage resource allocation and seeking agreement through different collaborative tools for those non-dominated.

- Salo et al (2011) provide a complete update on decision analytic methods to assist enterprises and public bodies in the allocation of resources using financial and non-financial evaluation criteria and the existence of alternative opportunities. This book synthesizes the state of play in portfolio decision analysis (PDA), describe new

methodologies, foster the development of these methodologies, and contribute to the research in PDA. Our SKITES methodology is introduced in a specific chapter of this book, see Arévalo and Ríos Insua (2011).

1.5. Outline of Thesis

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 facilitated 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).

In Chapter 2, we will continue our study by developing a methodology, based on MCDA, that we propose to use in decision making processes linked with innovative solutions. As we will see, the methodology proposed is flexible. Thus, it can be adapted to different environments.

Chapter 2

A Methodology for Distributed Innovation Management

2.1. Introduction

As we have mentioned, over the last five years, a market niche for web based innovation management tools has emerged. This is probably related with the rising concern among CEOs and politicians that innovation is a key factor for companies and countries to stay ahead of their competitors, or for sustainable growth. Indeed, as Townsend et al (2008) indicate, innovation is a strategic priority for 93% of senior business executives.

From the public sector perspective, the European Commission, in November 2011, presented its proposal for the next European Research and Innovation Programme (Horizon 2014-2020). Although the EC global budget for all policies during the next programming period (2014-2020) does not practically vary in comparison with the previous period (2007-2013), the European Commission is demanding to allocate about a 60% more of resources towards research and innovation policies, therefore shifting resources from other policies (agriculture, cohesion, etc), giving a clear message to the countries about how to face this crisis.

The interest of policies on research and innovation is well grounded on statistical data. As we saw in Chapter 1, the innovation index built from the most currently relevant ones, suggests that countries that are more focused on innovation, such as Switzerland, Sweden

or Germany, have suffered less in terms of debt rate in the aftermath of the current financial crisis than less innovative countries, such as Greece, Portugal, Italy or Spain. Similarly, at the enterprise level, we have learnt that those with higher innovative scores, are stronger in asset terms and have increased or maintained their capacity in comparison to those with lower innovation scores. Thus, it seems that in a globalized economy, there is a need to innovate, to increase flexibility and provide new services and products.

As we have seen in Chapter 1, building on the recent success of 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 group portfolio decisions in this application area, they provide few group decision support capabilities, typically based only on discussion fora or simple voting mechanisms.

In this chapter, we propose a methodology for the problem of innovation management that we implement in later chapters.

2.2. Problem Formulation and Outline of the Proposed Methodology

In the adoption of innovative projects, as in many other decision problems, we face a situation in which we have limited resources and a large number of potential project portfolios to choose from. As in other sectors, carrying out all of them is not feasible, not only because of the limited resources, but also because some of them can be mutually contradictory, or entail rather different policies to implement by an organisation.

Moreover, we should consider that uncertainty, when we deal with innovative projects is double:

- On one hand, we have the traditional uncertainty that goes back to back with any decision making process and, therefore, linked with the effect of selecting some projects and disregarding the non-selected ones.
- On the other hand, we have a major source of uncertainty, intrinsic to innovative

projects. This uncertainty is much higher, when we are closer to the most breakthrough projects, as they are also closer to potential failures.

The problem we are facing is double. Firstly, we need to identify innovative proposals. These can come out spontaneously, or can respond to specific calls or demands, being the framework proposed, adaptable to both cases. Secondly, we are facing a problem of limited resource allocation to different alternatives. Therefore, the main constraints will be those referring to limited resources, although there can be some others, as can be the incompatibility of certain proposals, among others. We shall see in Section 2.3 that, to this end, we propose a double stage process (filtering and evaluation).

Taking into consideration that the challenge on decision making is even more difficult when we are deciding about innovative projects, it seems relevant to count with several assessors working on an open basis. SKITES (Sharing Knowledge and Intelligence Towards Economics Success) is proposed as framework for the identification, filtering, evaluation and monitoring of innovative proposals. The main strength of the proposed scheme, relies on the use of the joint knowledge of the different actors that participate in the whole process. For instance, in SKITES we foresee that assessors will have different backgrounds and skills. From these different profiles, we expect different assessments about the evaluated projects. This means that, on an individual basis, they would have different proposed solutions, but through discussion and exchange of views, they would be able to identify a common final portfolio that would be acceptable to all of them, if possible without reaching a voting mechanism.

Our methodology proposes a flexible framework for managing innovation processes. It is based on collaborative decision analysis, see Raiffa et al (2002), and resource allocation procedures, see Salo et al (2011), to select a portfolio of potentially innovative projects. It is inspired by previous experience in relevant consulting and incorporates, from a decision analytic perspective, best practices in innovation management, as described in Luecke (2009). The methodology proposed is flexible, in the sense that it may fit and can be adapted to several organizational cultures.

After reviewing some innovation management tools in Section 1.4, emphasizing their decision support facilities and corresponding strengths and weaknesses, we describe herein

SKITES, as 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, and we emphasize the decision support aspects of the framework for making choices about proposals for innovative projects. In Chapter 3, we discuss 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.

SKITES reflects an open approach to innovation for sustainable growth. It 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 2, where we aim at screening projects, and 3, where we need to allocate the available resources to a portfolio of projects.

2.3. Methodology Details

We distinguish four roles within our framework:

- *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. Lavín and Ríos Insua (2010).

- *Facilitators:* These will be experts engaged in SKITES. They will have a sound background in innovation management and a dual role: on one hand, to assist proposers and experts with difficulties encountered using this framework, and, on the other, to review the information supplied by the proposers looking for coherence and consistency.

We consider two different operation modes for SKITES:

- Close. 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, as the open innovation paradigm is starting to gain importance, see Chapter 1, large organizations are adopting open approaches to reach more disruptive innovations collaboratively by sharing resources and knowledge towards a common goal.

- Open. Conceptually, see Herzog (2008), Open Innovation, as seen in Chapter 1, foresees 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 ap-

propriate security mechanisms to allow individuals to take part in innovation processes as their permissions indicate.

2.3.1. Phase 1: 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 always the case. This is one of the reasons for which an organization might be interested in an open innovation approach and, therefore, on identification of potential opportunities.

The systematic generation of innovative project proposals may be pursued through informal and more formal tools. Among the informal ones, brainstorming is the most popular approach. The nominal group technique, see Sample (1984) 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 coming from customers that are lead users of products, and idea contests through a call linked with a specific subject or area. An example for such is the *Ideas* project. This a web portal launched by Nokia, based on an online community for everybody from all around the world to brainstorm. It enables a two-way exchange of ideas between users and developers around innovation, see `http://www.ideasproject.com`. More formal approaches are based on checklists and auto-assessments, like PESTEL, SWOT or PROACT, or rich picture diagrams that are described in French et al (2010). A step forward is 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). Also, Keeney (1992) proposed a systematic approach for creative decision making, called value-focused thinking, based on fixing objectives and structuring them. Then, the degree on the achievement of objectives is measured. Thus, finally he proposes to introduce value models, to transfer these achievements into values.

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 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* in Chapter 1.

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. 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 organisation?
2. Does the proposer have sufficient technical competence to make it work?
3. Does the organisation 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, see Armstrong (1987) items or yes-no answers as required:

- Strategic fit.
    1. Score (from 1 to 5) the technical fit of the innovative project to the organization.
    2. Indicate (yes or no), whether 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. Indicate (yes or no), whether it is feasible to develop the innovative project with the current staff.

2. Indicate (yes or no), whether it is feasible to launch the project given the organization current workload, or would be necessary to deploy more resources.

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 respect to m screening criteria $(a^1, a^2, ..., a^m)$. We could build a simple weighted value function, $v(a) = \sum_{j=1}^{m} w_j a^j$, see e.g. French et al (2010), for the organization to filter innovative projects. Based on such criteria, only projects improving a threshold value b would be retained. 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 $v(a_j) \geq b_j \ \forall j$. Note that we could use both filters in combination, i.e. retain proposals with high enough value and high enough criteria evaluations, that is:

$$v(a) = \sum_{j=1}^{m} w_j a^j \geq b, \text{and}, v(a_j) \geq b_j \ \forall j$$

.

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.

2.3.2. Phase 2: Project Filtering

After Phase 1, an initial portfolio of innovation projects is available. This needs to be documented by the proposers with a pre-business plan, with indicators, the novelty of the project and other relevant information which might facilitate project comparison. This information gathered is very often used also as an initial guide for project management during the begining stages of the projects. 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. Our list is clearly not an exhaustive one:

- **Net Present Value (NPV)** is a monetary unit, defined as the sum of the present values of annual cash flows. Therefore, it serves to analyse the total expected profit in global terms, being then directly affected by the size of the investment needed. It is usually measured on an annual basis, but it can be calculated also on a monthly basis. NPV is a standard method for using the time value of money to appraise long-term projects. It measures the excess or shortfall of cash flows, in present value terms, once financing charges are met. It is defined as:

$$NPV(N, i) = \sum_{t=1}^{N} \frac{R_t}{(1+i)^t}$$

  where:

  - N is the time of the cash flow.
  - i is the discount rate
  - R_t is the net cash flow at time t.

If NPV > 0, the investment will produce income beyond the minimum expected profitability. Kleinmuntz (2007) discusses various issues around NPV within Portfolio Decision Analysis (PDA), including the effects of risk, typical of innovation processes. A critical assessment of NPV in risky contexts is given in Aven (2010).

- **Internal Rate of Return (IRR)** is used in capital budgeting to measure and compare the profitability of investments, as an indicator for the efficiency, quality, or yield of an investment. Thus, it does not consider the investment size. It complements the NPV which, as described before, was related with the value or magnitude of an investment.

  Given a collection of pairs (time, cash flow), the NPV can be expressed as a function of the IRR. Thus, the IRR could be calculated by making this function equal to zero.

  The eligibility criteria based on the IRR compares it with the interest rate. As long as the IRR is higher than the interest rate, the decision will be to go ahead with the investment. Also, the IRR allows us to compare the profitability of different potential investments.

- **Modified Internal Rate of Return (MIRR)**: There are some criticisms, see Lin (2007), on the lack of robustness of the IRR methods, as it assumes that reinvestment is always possible at the discount rate or IRR. The MIRR avoids this problem and provides a different and more accurate measure of financial feasibility. The MIRR is almost identical to the IRR, except that the MIRR does not assume that all cash flows are reinvested at the calculated IRR, but rather assumes that negative cash flows are obtained at the cost of capital.

- **Payback Period** is the time needed to recover the initial investment. Therefore, it intuitively measures how long something takes to "*pay for itself*". The shorter this period, the higher the success. Its main advantage is its simple application and understanding.

- **Return on Assets (ROA)** is an indicator on how profitable a company or a project is in relation with its total assets. ROA gives an idea as to how efficient management

is at using its assets to generate earnings. It is calculated by dividing a company's annual earnings by its total assets, displayed as a percentage:

$$ROA = \frac{\text{Net Incomes}}{\text{Total Assets}} \times 100$$

The ROA for companies can vary substantially and will be highly dependent on the incumbent industry. This is why, when using ROA as a comparative measure, it is best to compare it against the company's previous ROA numbers or the ROA of a similar company.

- **Earnings before interest and taxes (EBIT)** is a measure of a firm's profit that excludes interest and income tax expenses. By definition, it is the difference between operating revenues and operating expenses. To calculate the EBIT, expenses (e.g., the cost of goods sold, selling and administrative expenses) are subtracted from revenues. Profit is later obtained by subtracting interest and taxes from the result. An evolution of EBIT is the EBITDA, that also deducts from the profits, depreciation and amortization costs.

- **Return on Investment(ROI)** Taking EBIT or EBITDA as a reference, the ROI is a profitability ratio that, when taken over time, helps in measuring the performance of the capital employed. It is a key indicator for investment decisions and is comparable across different industries. Its formula is:

$$ROI = \frac{EBITDA}{ttllsse}$$

being, *ttllsse*, the total liabilities and shareholders' equity

- **Cost-Benefit Ratio**: It is often used for public projects. This method compares project benefits to the cost of the project. For a project to be viable, benefits have to be greater than costs. By definition, project benefits are the favorable consequences of the project to the public, and project costs are the financial resources required from the public sector. For comparing mutually exclusive alternatives, the Cost-Benefit Ratio is not sufficient, unless using incremental analysis, see Mishan (2007), which

is a decision-making technique used in business to determine the true cost difference between alternatives. Incremental analysis ignores sunk costs and costs that are the same for the compared alternatives to look only at differential costs.

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). In their view, the use of IRR, NPV and Payback frequently causes decision makers to underestimate the real returns and benefits of innovation projects, specially in disruptive ones, 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. Christensen also makes the point that decision makers, too often assume that organisations' overall revenues continue on a steady trend even if they do not invest in innovative projects.

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 corresponding level of sales. Finally, we answer, whether we are capable of reaching such level.

- 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 the innovation **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 parameters pertaining to human resources, such as the percentage of staff working on re-

search 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 with human capital, these indicators could be used also to monitor the project.

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, a number of variables are to be selected to be used in the next phase. As we conclude in Chapter 5, projects can ideally be also scored by the assessors, e.g. from 1 to 5 on a number of evaluation criteria. Usually these general topics would be related with the rough cut analysis conducted by proposers during phase 1, but it will be the responsibility for the entity interested in the resource allocation problem to fix the appropriate ones, for both phases, and aligned to their interests. Based on phase 1, we can propose the following ones:

- **Strategic/Potential Opportunity:** under this criteria, the assessors will check how the proposal technically fits in the organization standard products or services, and how it is aligned with their business plan. Some elements that can be helpful for scoring are: the convenience of exploiting the project on their own, or have an outsourcing strategy; the opportunity given to become or continue as a market leader; the opportunity of opening new markets; etc.

- **Operational Impact:** Measured in terms of the positive effect of the introduction of such innovative project into the market and its potential consequences. This is to be observed not only from the competitors', but also from the project proposer perspective.

- **Difficulties to enter into market, in terms of competitors:** Herein, the assessor will evaluate how feasible is to enter into the market with such project, the need to

adapt their capabilities, need of marketing efforts, etc.

Considering that we have:

- q projects to filter, from $i = 1$ to q
- m evaluation criteria, from $j = 1$ to m
- n assessors, from $k = 1$ to n

Once all the assessors have input their scores,or the relevant variables are identified, a first filter could be to check if in average the global evaluations are sufficiently high, based on a threshold system and/or a multicriteria value function, like

$$V(a_i) = \frac{1}{n} \sum_{k=1}^{n} \sum_{j=1}^{m} w_{jk}^{i} \times a_i^m \geq B$$

It would be possible also to fix a minimum score per criteria B_j, so that not only the final scores, but the partial ones apply, as it is shown below for a threshold for the j-th criteria.

$$V(a_i^j) = \frac{1}{n} \sum_{k=1}^{n} w_{jk} \times a_{jk}^{i} \geq B_j$$

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 project opportunities, covering the full business plan.

2.3.3. Phase 3: Project Selection

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

As mentioned before, 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, at this stage, we assume that we have a sufficiently precise estimate of each project cost and features. Thus, we do not deem uncertainty relevant, but see Section 2.4. We represent this information through Table 2.1:

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

Table 2.1: Project Information

Assume that the total cost of the proposed projects is greater than b and the total workforce 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 ones would be:

- If we deal with q projects $(a_1, a_2, ...a_q)$ that can be part of the selected portfolio, and these q projects are from h different areas. Thus we can group our projects as: $\overbrace{a_1^1, a_1^2, ...}, \overbrace{a_2^1, a_2^2, ...}, \overbrace{a_h^1, a_h^2, ...}$. Being $h < q$ and not necessary each area contains the same number of projects. We can fix a maximum budget allocated to one of the areas. If e_h in euros, is the limit for the $h-th$ area, it would be:

$$\sum_{h \in F} c_h^i \leq e_h$$

being c_h^i the cost of the project i, that is included in the $h-th$ area.

- Again, following the same approach, we can fix, instead a budget constraint, a maximum number of P_h projects to support the h-th area. Thus,

$$\textstyle\sum_{i \in F} f(a_i^h) \leq P_h, \, \forall h$$

being P_h the maximum number of projects for the h-th area, with $f(a_i^h) = 1$ if project a_i^h is selected for that area and $f(a_i^j) = 0$, otherwise

- We can also have dependence relations among projects. One example could be that a certain project a_d can be only possible if another specific project a_c is implemented before. Therefore we would include a condition such as: $a_d \subset F_d$; subject to $a_c \subset F_d$, being F_d the selected portfolio

Apart from these examples, by definition, we will have limited access to financial and human resources. This constraints will be expressed as:

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

being c_i the financial resources needed to implement project i, and c the maximum budget available,

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

being: d_i the human resources necessary to implement project i, and d the maximum human resources available.

Let us designate the set of feasible portfolios by $A = \{F^1, F^2, \ldots, F^s\}$. Once the feasible portfolios are identified, the allocation process may be undertaken in several ways. Many of the tools described in Chapter 1 introduce only voting mechanisms to support such decision. A classical approach is based on maximizing the net present value, assuming that group members agree on such criteria, as described in detail by Kleinmuntz (2007). Vilkkumaa et al. (2010) provide a framework based on a group value functions, 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 suggested.

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.

2.3.3.1 Individual Problem Exploration

At this stage, we elicit the participants' preferences about the consequences of the projects, e.g. in terms of their value functions. Assume, therefore, that each assessor's preferences are modeled 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	$\ldots$	v_1^j	$\ldots$	v_1^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_i	c_i	d_i	v_i^1	$\ldots$	v_i^j	$\ldots$	v_i^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_q	c_q	d_q	v_q^1	$\ldots$	v_q^j	$\ldots$	v_q^n

Table 2.2: Innovation Management Process Matrix

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,

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

Theoretical issues underpinning such additivity assumption are discussed in, e.g., Golabi (1987) and Golabi et al (1981), that proposes standard multi-attribute value assessment procedures, in order to measure the technical worth of a proposal. Notwithstanding this, the additive-linear portfolio value function assumes that, the value added resulting from adding a project into the portfolio does not depend on what other projects are included in the portfolio, being this due to the independence condition. This does not always apply to projects, specially if they are focused in solving common or similar problems.

The assessors may use this information to determine their preferred portfolios and the reasons for such choice. 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):

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

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, this 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 (2010), which shows the value given by each assessor to each feasible portfolio:

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

Table 2.3: Portfolio Individual Assessesment

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.

2.3.3.2 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, see Thomson (1994). To do this, we need to describe the resource allocation problem in terms of a value set of potential portfolios 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), who analyze the importance of an adequate baseline score for the decision on not going ahead with a project. This is specially important in multiattribute value analysis, as the results of such analysis are consistent for individual projects, but in a portfolio approach, this does not ensure that the same portfolio of projects will be included in the optimal portfolio. To this end, they performed in parallel a multiattribute value

analysis and a pricing-out analysis, resulting both consistent in their rankings of individual projects, but not for the projects to be included in the optimal portfolio. The main finding was that these two analysis assume different baseline values for not doing a project. In the multiattribute value analysis case, the assumed value score of zero for not doing a project, implicitly reflects that not doing each project gives the worst possible result. Thus it is feasible under this method, that it can have a financial income or cost, but it is assumed. While in the second method, the zero levels that is the decision point for the pricing-out analysis, means that not doing a project results on not obtaining a financial contribution (balance point in 0). Thus, they show that this baseline score it is not necessarily linked with the worst possible scores on all the assessed attributes.

In this way, we represent the group resource allocation problem as a pair (S, d), where S is a finite, but potentially, large set of potential portfolios. 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, that will end in an arbitrated projects portfolio solution, is a rule associating with each resource allocation problem (S, d), one projects 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* solutions, for reaching an arbitrated solution for this resource allocation problem.

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. Each assessor would be allowed to vote in favor of its favorite feasible portfolio, according to this shared information. Then, the portfolio with the highest level of acceptance among assessors could be considered as an agreement. To this end, we will obtain an s-dimensional vector, with the results of the voting for each feasible portfolio, being the selected portfolio the one with the highest value. A minimum level of votes could be settled, which would be equivalent to a minimum value h to be agreed, before the negotiations starts. 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, see Brams and Fishburn (2002). For reasons outlined in Brams and Fishburn (2007) we tend to favor approval voting, that, in our case, allows assessors to vote for, or approve of, as many feasible portfolios as they wish, being the selected portfolio, that one with more votes. Each assessor can vote a maximum of s portfolios. Then for a portfolio i we will have a vector composed by the n votes of the assessors $(v_1(F^j), ..., v_i(F^j), ..., v_n(F^j)$, being the values of the vector 0, if the project is not voted by the assessor, and 1 otherwise. Then, the selected portfolio, would be the one that obtains the maximum sum:

$$\sum_{i \in F} v_i(F^j)$$

The main advantage of the proposed methodology is its flexibility that can adapted accordingly to each problem. 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.

2.3.3.3 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. As defined in the individual problem exploration phase, a feasible portfolio F_a^i composed of $(a_1, a_2, ...a_n)$ (representing the scores of the n assessors of such portfolio, after the negotiation), is dominated by another feasible portfolio $F_b^i = (b_1, ..., b_n)$, $F_a^i \prec \mathrm{F}_b^i$, if:

1. $a_i \leq b_i$ for all $i \in 1, ..., n$, and
2. $a_i < b_i$ for at least one $i \in 1, ..., n$

In the case we have strict domination then the unique condition would be:

3. $a_i < b_i$ for all

Therefore, assessors through this post-settlement process 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 outcomes previously obtained. 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. They propose to combine the bargaining process models associated accordingly in a flexible negotiation support method, so assessors can reach a satisfactory solutions. Starting from the bliss point for each assessor, a balanced down-backward minor concession makes easier to reach the agreement point. Note that the information obtained at the exploration phase, in which the assessors provide their scores to the different projects, would be useful not only for computing the assessors' preferred resource allocation among projects, thus identifying the feasible portfolios. This information, as far as it is shared, would be also used 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), as we describe in Chapters 3 and 4.

2.3.4. Phase 4: 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 rounds of filtering and selection of innovative projects.

To that end, once a project is selected, several indicators will be defined in relation with resource consumption, in financial terms, and outcomes. These indicators will be mainly the financial ones explained in Subsection 2.3.2. They will be integrated in the business plan and 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.

2.3.5. Summary of the SKITES Phases

As shown in Figure 2.1 we start with the generation of innovative projects or ideas. This generation could be the result of the use of more formal or informal tools. At the end of this first phase, there could a self-assessment of these ideas, by the project proposers. Afterwards, we enter into the project filtering phase, in which relevant indicators, taking

into consideration the traditional financial indicators, but also making use of those that better capture the specificity of innovation. In phase 3, the selection of innovative projects is done by assessors with different backgrounds. They start by an individual problem exploration, and make use of conflict resolution tools to reach a satisfactory solution. The last phase of SKITES is that one devoted to follow-up the selected projects and gathering information for future rounds.

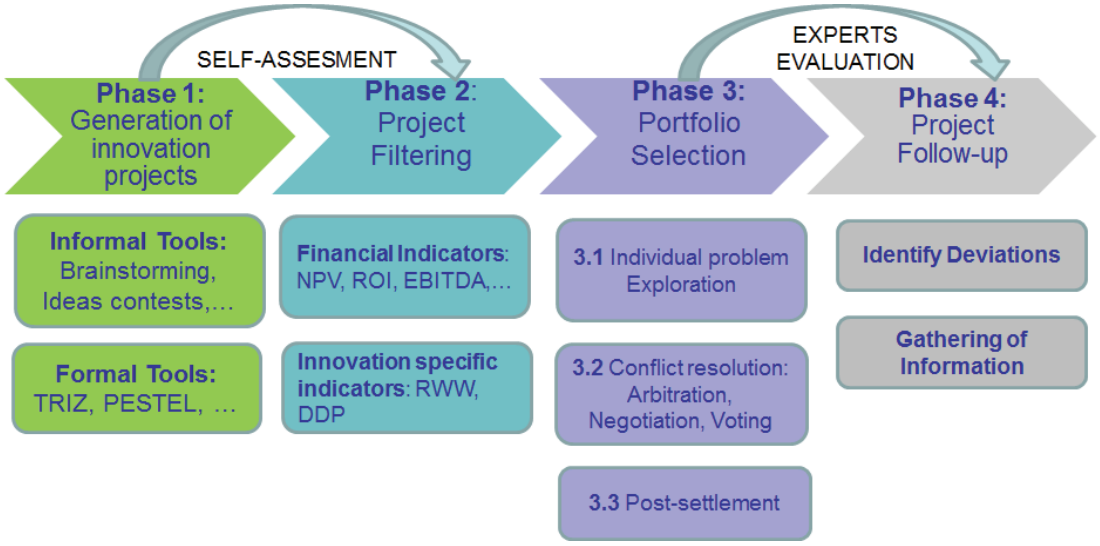


Figure 2.1: Phases proposed under the SKITES process

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.

1. 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.

2. 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.

3. 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.

2.4. When Uncertainty is Present

The previous approach assumes that we have sufficiently precise estimates of the resources consumed by projects and their performance. Since we are referring to innovative projects, we would expect uncertainty about some of these estimates. The approach proposed for this case may follow similar stages to that outlined in Section 2.3. Note, however, that we shall need to modify the corresponding stages to accommodate the stochastic elements. Firstly, we would have probability distributions over the project features. Moreover, we would have stochastic constraints that could be handled, for example, by requiring that the constraints are satisfied with a sufficiently high probability. Finally, we would substitute values by expected utilities.

We start by building Table 2.4, which parallels Table 2.1, by introducing uncertainty in project features, where $\sim$ indicate that such feature is random. For example, $\underset{\sim}{c_i}$ would be the random cost of project i

Project	Cost	H.Res.	Criteria
a_1	$\underset{\sim}{c_1}$	$\underset{\sim}{d_1}$	$\underset{\sim}{x_1^1} ... \underset{\sim}{x_1^m}$
...	...	...	...
a_i	$\underset{\sim}{c_i}$	$\underset{\sim}{d_i}$	$\underset{\sim}{x_i^1} ... \underset{\sim}{x_i^m}$
...	...	...	...
a_q	$\underset{\sim}{c_g}$	$\underset{\sim}{d_g}$	$\underset{\sim}{x_g^1} ... \underset{\sim}{x_q^m}$

Table 2.4: Projects' Information

Assume that $\underset{\sim}{b}$ and $\underset{\sim}{d}$, the budget and human resources available, are both random. To simplify, assume that there are no additional constraints. Each assessor will have a utility function u_i, modeling his preferences and risk attitudes over project consequences, see French and Ríos Insua (2000). This entails that Table 2.4 is transformed into:

Project	Cost	H.Res.	Utilities
a_1	$\underset{\sim}{c_1}$	$\underset{\sim}{d_1}$	$u_1(\underset{\sim}{x_1^1}, ..., \underset{\sim}{x_1^m}) ... u_n(\underset{\sim}{x_1^1}, ..., \underset{\sim}{x_1^m})$
...	...	...	...
a_i	$\underset{\sim}{c_i}$	$\underset{\sim}{d_i}$	$u_1(\underset{\sim}{x_i^1}, ..., \underset{\sim}{x_i^m}) ... u_n(\underset{\sim}{x_i^1}, ..., \underset{\sim}{x_i^m})$
...	...	...	...
a_q	$\underset{\sim}{c_g}$	$\underset{\sim}{d_g}$	$u_1(\underset{\sim}{x_g^1}, ..., \underset{\sim}{x_q^m}) ... u_n(\underset{\sim}{x_g^1}, ..., \underset{\sim}{x_q^m})$

Table 2.5: Summary Information with Assessors' utilities

We convert it through expected utilities into Table 2.6, where $u_i^j = E(u_j(\underset{\sim}{x_i^1}, ..., \underset{\sim}{x_i^m}))$ is the expected utility of project i for assessor j. This table parallels Table 2.2 in the case of uncertainty:

				Assessors Expected Utilities				
		Cost	HR	1		j		n
Projects	a_1	$\underset{\sim}{c_1}$	$\underset{\sim}{d_1}$	u_1^1	$\dots$	u_1^j	$\dots$	u_1^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_i	$\underset{\sim}{c_i}$	$\underset{\sim}{d_i}$	u_i^1	$\dots$	u_i^j	$\dots$	u_i^n
	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
	a_q	$\underset{\sim}{c_q}$	$\underset{\sim}{d_q}$	u_q^1	$\dots$	u_q^j	$\dots$	u_q^n

Table 2.6: Summary Information with Assessors' expected utilities

Among various approaches to stochastic programming, we shall adopt that based on independent probabilistic constraints, see e.g. Kall and Wallace (2007). Therefore, the constraints $\left[\sum_{i\in F} \underset{\sim}{c_i} \leq \underline{b}\right]$ and $\left[\sum_{i\in F} \underset{\sim}{d_i} \leq \underline{d}\right]$ in Subsection 2.3.3 are transformed into:

$$P\left(\sum_{i\in F} \underset{\sim}{c_i} \leq \underline{b}\right) \geq q_1$$
$$P\left(\sum_{i\in F} \underset{\sim}{d_i} \leq \underline{d}\right) \geq q_2$$

for sufficiently high q_1 and $q_2 \in [0,1]$. In principle, this allows us to identify through simulation the set of feasible portfolios $\{F^1, ..., F^S\}$, with a scheme like the one below where m is the cardinal of the portfolios satisfying the deterministic constraints, N is the Monte Carlo sample size, and, for simplicity, we only assume the first probabilistic constraint, i.e., $P\left(\sum_{i\in F} \underset{\sim}{c_i} \leq \underline{b}\right) \geq q_1$

$i = 1$
FILTER $(j) = 0$, $j = 1, ..., m$
GENERATE $b_j \sim \underline{b}$, $j = 1, ..., N$
UNTIL CONDITION=FALSE or $i > m$
GENERATE c_{ij} (COST OF PORTFOLIO F_i), $j = 1, ..., N$
COMPUTE $p = \frac{\sharp(c_{ij}: c_{ij} \leq b_j)}{N}$
IF $p \geq q_1$, CONDITION=TRUE
FILTER(i)=1
$i = i + 1$

ALG 1: Identification of feasible portfolios under uncertainty

Those portfolios with final condition FILTER $(j) = 1$, would be retained as satisfying the probabilistic constraints with big enough probability. We could build then a negotiation table, shown in Table 2.7, which parallels Table 2.3:

		Assessors				
		1		j		n
Feasible portfolios	F^1	$u_1(F^1)$	$\dots$	$u_j(F^1)$	$\dots$	$u_n(F^1)$
	$\vdots$	$\vdots$		$\vdots$		$\vdots$
	F^s	$u_1(F^s)$	$\dots$	$u_j(F^s)$	$\dots$	$u_n(F^s)$
Individual optimal portfolios		F_1^*		F_j^*		F_n^*

Table 2.7: Portfolio Individual Assessesment under uncertainty

where $u_i(F^j) = \sum_{a \in F^j} u_i(a)$, is the expected utility of portfolio F^j, which we have assumed is the sum of the expected utilities of the corresponding alternatives. The individual exploration phase will be similar to the case under constraints, with individuals seeking maximum expected utility portfolios and dominance based on expected utilities.

We now turn to the adaptation of conflict resolution approaches which take into account uncertainty. These are required when optimal individual portfolios do not coincide. For simplicity, we shall assume that there is just one probabilistic constraint referring to budget, i.e.,

$$P\left(\sum_{i \in F} \underset{\sim}{c_i} \leq \underset{\sim}{b}\right) \geq q_1$$

2.4.1. Voting under Uncertainty

We focus on approval voting. We may consider two approaches:

1. Each participant votes based on approval voting, respecting the probabilistic constraint. Then, votes are aggregated according to approval voting, respecting such constraint.

2. Each participant approves as many candidates as he wants. Then, votes are aggregated respecting the constraint

Let us consider case 1. The i-th participant has ordered projects a_j based on their expected utilities $E[u_i(a_j)]$. Without loss of generality, assume that:

$$E[u_i(a_1)] \geq E[u_i(a_2)] \geq ... \geq E[u_i(a_j)] \geq E[u_i(a_{j+1})] \geq ...$$

Then, we would proceed as follows, for each assessor, where VOTE $(j) = 1$ indicates whether the corresponding assessor is voting, or not, (VOTE $(j) = 0$) to alternative a_j:

$i = 1$
VOTE $(j) = 0$, $j = 1, ..., q$
DO $d_j = 0, \quad j = 1, ..., N$
GENERATE $b_j \sim \underset{\sim}{b}$ (budget samples) $j = 1, ..., N$
UNTIL CONDITION=FALSE or $i > q$
GENERATE $c_{ij} \sim \underset{\sim}{c_j}$ (cost of project i sample) $j = 1, ..., N$
$d_j = d_j + c_{ij}, \ i = 1, ..., N$
COMPUTE $p = \frac{\sharp(d_j : d_j \leq b_j)}{N}$
IF $p \geq q_1$, CONDITION=TRUE
VOTE(i)=1
ELSE CONDITION = FALSE
$i = i + 1$

ALG 2: Voting under uncertainty

We would then, aggregate votes for the alternatives (in VOTES (a_i)) and rank them according to such votes. Assume that we relabel them so that:

$$VOTES(a_1) \geq VOTES(a_2) \geq ...$$

We would then apply a similar algorithm, where PORT(j) indicates whether project a_j is included in the final portfolio, PORT$(j) = 1$, or not, $(j) = 0$:

$i = 1$

PORT $(j) = 0,\ j = 1, ..., q$

DO $d_j = 0,\ j = 1, ..., N$

GENERATE $b_j \sim \underset{\sim}{b},\ j = 1, ..., N$

UNTIL CONDITION=FALSE OR $i > q$

GENERATE $c_{ij} \sim \underset{\sim}{c_j},\ j = 1, ..., N$

$d_j = d_j + c_{ij},\ i = 1, ..., N$

COMPUTE $p = \frac{\sharp(d_j : d_j \leq b_j)}{N}$

IF $p \geq q_1$, CONDITION=TRUE

PORT(i)=1

ELSE CONDITION = FALSE

$i = i + 1$

ALG 3: Inclusions of projects under uncertainty

The final portfolio would be the set of alternatives such that PORT(i)=1

2.4.2. Negotiating under Uncertainty

As we have mentioned, there are many variants of negotiation approaches. We shall describe how some of the elements typical of negotiation algorithms are modified when uncertainty is taken into account:

- Some algorithms, like negotiation by posting, require that negotiations create portfolios of alternatives to be posted as proposals to other participants. This may be done by a simple modification of algorithm 3 outlined above.

- Other algorithms, like BIM, require the precomputation of the set of nondominated portfolios. This can be done as follows:

  1. Consider all portfolios.
  2. Filter all portfolios which do not satisfy the deterministic constraints.
  3. Filter all portfolios which do not satisfy the probabilistic constraints (as described beforehand).

4. Compute the expected utilities of all remaining portfolios $(U_1(F), ..., U_n(F))$, $\forall F$ feasible.

5. Compute the nondominated portfolios. If S is the size of the set of feasible portfolios, and DOM designates the set of dominated alternatives:

```
FOR i = 1 TO S
  IF F_i ∉ DOM
    FOR j = 1 TO S DO
      IF (i ≠ j) AND (F_j ∉ DOM) THEN
        IF (U_k(F_i) ≥ U_k(F_j)) ∀k THEN
          DOM = DOM ⋃(F_j)
        END IF
        j = j + 1
    END FOR
  i = i + 1
END FOR
```

ALG 4: Computation of non-dominated portfolios

- Another element that negotiation algorithms typically require is the computation of bliss points, see e.g. Raiffa et al(2002), given a reference value x. This may be done by solving the stochastic programming problem:

$$\max_{F \subseteq I} E(\underset{\sim}{u}_j(F)) = b_j$$

$$s.t.\ \xi$$

$$E(\underset{\sim}{u}_j(F)) \geq x_i \ i = 1, ..., n$$

where ξ designates the set of constraints. Then, $b = (b_1, ..., b_n)$ is the bliss-point.

- Finally, another typical element in negotiation algorithms is the computation of the Kalai-Smorodinsky solutions $K(S, x)$ solution given a reference x.

  In order to compute it, we may proceed as follows:

  a) Generate random portfolios satisfying $E(\underset{\sim}{u}_j(F)) \geq x$. This may be done through:

FROM $i = 1$ TO N
GENERATE F.
CHECK IF F IS FEASIBLE. IF NOT, NEXT i.
CHECK IF $E(\underset{\sim}{u}_j(F)) \geq x_i$. IF NOT, NEXT i.
REGISTER F
$i = i + 1$

ALG 5: Generation of feasible portfolios under uncertainty

b) The above provides us with a set of portfolios $(F_1, F_2, ..., F_m)$. Compute the nondominated portfolios within that set (as with the ALG4, described in this Subsection), which lead us to the set $(G_1, G_2, ..., G_l)$

c) Compute the element in $(G_1, G_2, ..., G_l)$ which is closest to the segment $(x, B(S, x))$ and disclose this as $K(S, x)$.

Based on these elements, we may easily translate standard negotiation algorithms to incorporate uncertainty. For example, the Balanced Increment Method (Ríos and Ríos Insua, 2010) is described as follows:

CHOOSE α
CHOOSE $x^0 = d$, $t = 0$
COMPUTE $B(S, x^0)$, $K(S, x^0)$
OFFER $K(S, x^0)$
WHILE ASSESSORS DO NOT ACCEPT $K(S, x^t)$ DO
IF x^t IS CLOSE TO $K(S, x^t)$ THEN
STOP
ELSE
$x^{t+1} = x^t + \alpha(K(S, x^t) - x^t)$
ENDIF
$t = t + 1$
COMPUTE $B(S, x^t)$, $K(S, x^t)$
IF $K(S, x^t) \neq K(S, x^{t+1})$ THEN
OFFER $K(S, x^t)$
ENDIF
ENDWHILE

ALG 6: Balanced increment methods under uncertainty

2.4.3. Arbitrating under Uncertainty

Again, we have mentioned various arbitration methods. A main modification required is the computation of the set of nondominated portfolios uncertainty, which we have described above. Other arbitration algorithms requiring computing elements like $B(S, x)$ and $K(S, x)$, as is the Balanced Concession Method, which would easily be generalized as we have done with the BIM.

2.5. Discussion

In this Chapter we have introduced SKITES as a framework for the identification, filtering, selection, and follow-up of innovative projects. We could discuss 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 framework. 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. Moreover, we should stress again the flexibility of the methodology proposed, that can fit different level of problems analysed from a fully open approach, through an in-house analysis, or by a mixed audience. Apart from this, the level of indicators and documentation to be gathered is also flexible. This flexibility is also shown on the way to conduct the conflict resolution after the individual problem exploration, that can be just a simple voting system, or incorporate arbitration and negotiation modules with different levels of uncertainty. Thus, SKITES is a powerful tool that can serve to a wide range of stakeholders.

In the next Chapter, and once the SKITES methodology is settled down, we will de-

scribe the architecture proposed, conceived also as a generic platform, flexible and adaptable, that can be used by different kind of organizations. To this end an analysis on the architecture online and on the functional requirements, is carried out.

Chapter 3

An Architecture for Distributed Innovation Management

3.1. Introduction

SKITES is conceived as a generic framework to fully support innovation management processes. Because of the relevance of current distributed organizations, we shall describe here an architecture to support such generic framework allowing an organization to define its own innovation process. SKITES would provide support for:

- Facilitating the comparison of innovative projects (blind benchmarking), identifying synergies, niches and possible clusters to enter into a market in a better position.
- 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.
- Building cost estimators, indicators, market projections, etc. This kind of information is valuable, especially for the preparation of future innovation rounds.
- 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 information will evolve continuously.

- 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. Using the stored information, some early warning alarms can be implemented.

SKITES would be fully adaptable to the web 2.0. This concept was first mentioned during the O'Reilly conference about the world wide web future (2004). This evolution of the web concept has entailed a revolution, mainly coming from the new features that permit users to interact among them, and going beyond being only receivers of information, as was happened in the beginning of the Internet with static pages. Currently, under this new concept, users are able to create and maintain on the spot their own contents, besides providing opinions about other contents. In the end, with this evolution, the border between web editors and users is becoming more and more narrow. The corresponding applications run through interactive web systems that generate and facilitate collaboration and contacts on a permanent basis. According to Miller (2005), web 2.0 tools are very close to the SKITES concept as they:

- Provide a participatory framework.
- Permit to share opinions, ideas, contents, problems, etc.
- Are adaptable to the user and to these frameworks according to the needs and available resources.

As stated in previous chapters, the problem to be analyzed through this tool is the assessment of innovative projects, by several actors, taking into consideration a number of indicators and certain limited resources. The aim is, thus, to select the best portfolio of projects, taking also into consideration their level of complementarity. The actors that we foresee from a functional point of view for SKITES are (see Figure 3.1):

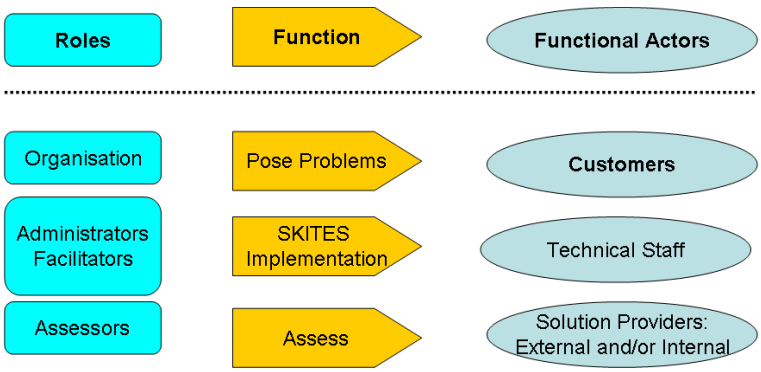
- **Customer:** Will be the organisation that has a problem and uses SKITES in order to find solutions. Although the main function of the organization is to post prob-

lems, according to Open Innovation theory, the customer can also take part in the multidisciplinary team that proposes the solution.

- **Technical staff:** For SKITES maintenance. To this end, an administrator will hold all the rights to register users, modify and adapt the tool to requirements, etc. Moreover, under this category, we will count with Facilitators with the functions described in Chapter 2.

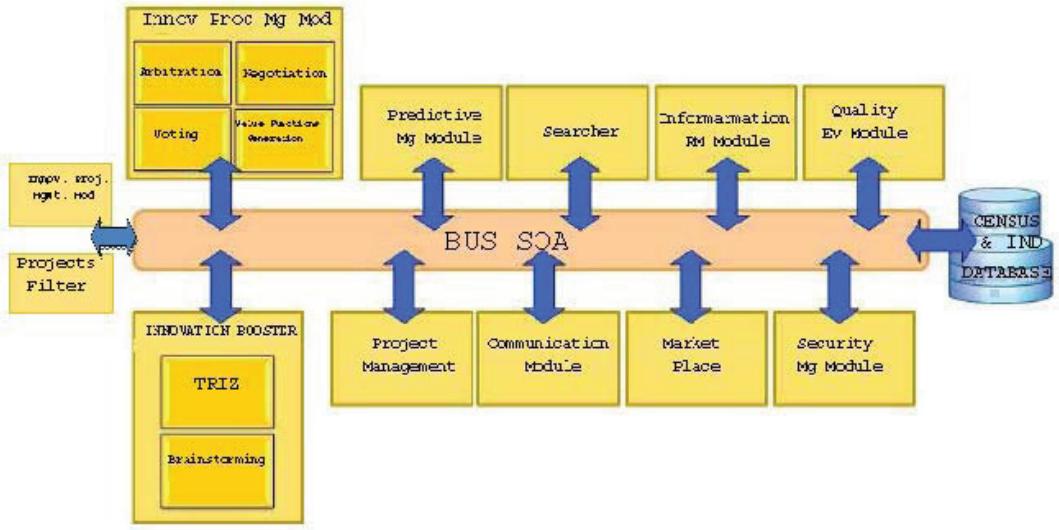
- **Solution Providers:** Under this group we will find the actors that participate in the process with the aim of finding the best solution to the problems posed. Therefore, herein we shall include, the proposers and assessors, as described in Chapter 2.

Figure 3.1: SKITES: Roles and Functions



The architecture proposed is service oriented based with a SOA bus, see Figure 3.2. Such architecture should somehow be linked with the corresponding enterprize software platform. For SMEs, such enterprize platform may not exist. Therefore, is also conceived to be used on an isolated basis.

Figure 3.2: SKITES: The Architecture



3.2. Architecture Outline

The architecture would include two different databases that would be the information sources for the whole framework:

- A Census Database would contain the data of users allowed to participate in the process, such as their roles or permissions to take part at various stages. A different approach is to be considered depending on whether the problem is posed and treated on an open or a closed base.

- An Indicator Database would contain the set of indicators potentially usable by the organization for the identification, evaluation and follow up of projects. As mentioned in Chapter 2, there are many potential indicators relevant in innovation processes. By including this database, we facilitate such choice.

According to Chapter 2, we would deploy various services around a SOA Bus, corresponding to the various activities described, that will act along the previous four phases:

1. *Security Manager Module.* It would take care of user authentication and granting of permissions to undertake the activities associated with the roles described in Chapter 2 (proposers, assessors and administrators / facilitators).

2. *Innovation Process Manager Module.* This module would be involved in creating, specifying and structuring the innovation process, by defining indicators, stages, etc. For each of them, details such as the tools, iterations, schedules, roles and authorised users are to be determined. It is important to notice, as stated in Chapter 2, that the SKITES framework is generic. Then it is designed to accommodate various possible schemes. Once the innovation process is specified, agreed and scheduled, this module would be in charge of controlling its correct execution.

3. *Communication module.* This module would facilitate communication among participants and users, thus providing interface facilities. It would support debates among proposers and choosers.

4. *Information Resource Manager Module.* This would save and manage information resources related with a decision making problem, such as Internet links, book references, electronic documents, etc. In open innovation problems it may also include computer supported collaborative work tools, for example wikis, to share information cooperatively among participants, as in Parker and Chao (2007).

5. *Innovation booster module.* This module would aid in promoting the generation of innovative projects, e.g. through tools for electronic brainstorming or promotion of creativity like TRIZ.

6. *Marketplace module.* This would facilitate the publication of problems and solutions so as to facilitate a matching between innovation offer and demand.

7. *Project filtering module.* SKITES would facilitate filtering innovative projects based on methods like Rough Cut Analysis, which would consist, as tested in Chapter 2, of a self-assessment tool for the initial filtering of innovative projects. It would be based on the opinions of the proposers; a scoring module, which would serve to generate

the scoring and comments allocated by the evaluators to a project; and a screening module.

8. *Portfolio selection module.* This would be a generic group decision support module allowing various group decision support strategies, as described in Section 3.3. Thus, it should include modules to support voting, arbitration, negotiation, individual value/utility functions and group value/utility functions, optimization and risk analysis. These modules would be chosen from a menu, when the organization designs its innovation management process.

9. *Project management module.* This module would facilitate project management during implementation based on standard project management methodologies and relevant ISOs like the whole 166000 UNE norms and standards dedicated to innovation management. Thus, we would consider innovation, not only as defined in Chapter 1, but as the whole cycle, starting from basic research and ending with deployment to market.

10. *Quality evaluation module.* It would support better innovation management, possibly based on the six sigma methodology, see Harry and Schroeder (2006).

11. *Predictive management module.* It would include models that facilitate performance forecasting during project management and project evaluation.

12. *Search module.* It would facilitate searches within SKITES to match offer and demand of innovative projects, and outside for grants.

Modules 5 and 6 would address the project generation phase. Module 7 would be core to the project filtering phase. Module 8 would be core to the resource allocation process and would differentiate SKITES from the platforms described in Section 1.4. Modules 8, 9 and 10 would be core to the follow up phase. The remaining modules would be transversal to the whole innovation management process. Note that most of the tools described are already available as open source.

3.3. Functional Requirements

In this section we shall describe the main functional requirements needed for the implementation of SKITES. Requirements, in general, are characteristics or restrictions that are to be accomplished by a system in order to run in an appropriate manner. Functional requirements are the ones that define how the system is going to run, and how it is going to interact with the environment, in this case the clients of the SKITES platform, see Roman (1985). In order to define these functional requirements, we have to decide the functions that are going to be provided by SKITES.

To this end we shall analyze, module by module, these main functional requirements:

3.3.1. Security Module

This module will permit the registration and follow-up of users within the application. The main features of the Security Module are:

1. **Authentication:** The framework will implement an access control through user and password. This module will work back to back with the users database.

2. **Authorization:** The framework will have a role hierarchy. Based on it, the user will be able to perform the corresponding actions.

Notwithstanding the above mentioned security functions, and depending on the approach of the client, SKITES will have the capacity of being accessible on an open basis, as is the case of some open market platforms, as we observed in Chapter 1.

3.3.2. Communication Module

The functional requirements for this module are:

1. **Visualize Current Users:** Once a user is logged in, he/she will have the capacity to visualize other users that are logged, so they can contact each other.

2. **Contact Users:** The users will have the facility to contact among them through internal messages.

3. **Visualize incoming messages:** The users will be able to read the messages received.

4. **Visualize outgoing messages:** The users will also have the capacity of accessing the messages sent.

3.3.3. Gathering of Information

This module will serve to assist with the automatic collection of information from users. To this end, the functional requirements of this module are:

1. **Information for phase 0: Idea Filtering.** Users that are proposers will be able to submit information related with self-assessment.

2. **Information for phase 1: Project selection.** Users will be able to include information needed for project evaluation.

3. **Information for phase 2: Project Follow-up.** Users responsible for gathering the information about running projects will be able to upload the relevant information through this module.

3.3.4. Market Place Module:

For a better understanding of the functional requirements for this module it is necessary to specify the terms: 'Problem' and 'Solution'. As 'Problem' we understand, a challenge proposed by a user, seeking for solutions. As 'Solution' we understand the proposals made by users seeking ways to deal with the posed problem.

The functional requirements for this module are

1. **Problem Publication:** Users with the appropriate permission will publish problems for which they ask for solutions.

2. **Problem Visualization:** Users with the appropriate permission will be able to access the proposed problems.

3. **Problem Deletion:** SKITES will provide to some users the facility to delete problems proposed.

4. **Solution Proposals:** Users with the permission to propose solutions will have the power to pose solutions.

5. **Solution Visualization:** Registered users will be able to see the proposed solutions.

6. **Edition of Published Solutions:** Users that have proposed a solution will be able to edit fields related with a solution.

7. **Solution Deletion:** SKITES will provide to certain users (solution proposers or system managers) the facility to delete solutions associated with the projects

8. **Document Generation:** SKITES will allow users to upload documents related with the problem or with the solutions.

9. **Download of Associated Documents:** SKITES will offer to the user the possibility of downloading documents associated with the problem or the solutions.

3.3.5. Search Module

The main functions for the search module will be:

1. **Proposed Solution Search:** The users will be able to do a query to the database, so that the solutions that match will be listed and accessible by the appropriate users.

2. **Users Search:** The users will be able to do a search into the users database to recover those that contain the requested features.

3. **List of projects:** SKITES will have the facility to list and show the details of existing projects.

3.3.6. Quality Evaluation

This module may serve to do quality control checks on the execution of the selected projects. It will be based on six-sigma tools, and shall take into consideration the whole DMAIC cycle:

- **Define:** A user with this role will be able to establish clear facts and the objectives of the project.
- **Measure:** A user decides the way in which the project is going to be monitored by eliciting the critical control variables.
- **Analyze:** Data collected is analyzed to determine root causes or defects.
- **Improve:** Users can identify creative solutions to fix and prevent process problems.
- **Control:** Users can monitor improvements to ensure continuous success.

3.3.7. Project Management Module

This module will permit the follow-up of projects through:

1. **Project Generation:** A user with the permission of proposing new projects, will be able to publish them in the market place.
2. **Project Edition:** Only users that have this role will be able to edit and modify project details.
3. **Query about project details:** All users allowed to access SKITES will be able to view the project details.
4. **Delete Projects:** Only users with appropriate permission will be able to run this process. The elimination of projects will also imply the deletion of the proposed solutions, if any.

3.3.8. Innovation Portfolio

This module is developed to promote agreements among the assessors when there is a conflict and they do not agree about the final portfolio selection. The first decision making process would be through the acceptance of the results coming from the value function. Besides this, it quite often happens that there is a conflict among assessors or the scores of the projects are so close that we need to use conflict resolution tools to find the final portfolio selection. To this end, in SKITES we need the following three submodules to facilitate conflict resolution:

3.3.8.1 Negotiation Sub-module:

As it has a negotiation module, it is necessary that SKITES supports the following functions:

- **Visualization of proposals:** Show to assessors the proposals to be negotiated.
- **Proposal selection:** SKITES will gather the scores from assessors for all evaluation criteria, and show their preferences.
- **Generation of feasible portfolios:** With this information, SKITES will propose a number or potential portfolios.
- **Acceptance of proposed portfolios:** SKITES will select the portfolios with higher degree of acceptance by assessors.
- **Initiation of the negotiation process:** A user with the appropriate role will be able to open a negotiation process when needed.
- **Selection of assessors:** SKITES will provide the right to share opinions with appropriate users and access to the opinions of the remaining users with the same role for the same process.
- **Closing the negotiation process:** The negotiation process will be automatically closed, once the last opinion is submitted or a given deadline is reached.

- **Moving to the arbitration/voting submodules:** It would be possible to move to the arbitration or voting modules.
- **Visualization of results:** Once the process is completed, SKITES will show the results.

3.3.8.2 Arbitration Sub-module:

If through negotiation is not possible to reach a satisfactory agreement among assessors, then we may go through an arbitration process. In such process, a disagreement point is defined for each assessor, giving as solution the portfolio that is closer to the assessors preferences, but that would be the one proposed as solution on an isolated basis. To that end, SKITES must support the following functions:

- **Visualization of proposals:** Show the assessors the proposals that enter into the arbitration phase.
- **Disagreement point:** SKITES will gather the opinions from assessors for all proposals and show their non acceptable portfolios.
- **Initiation of the arbitration process:** A user with the appropriate role will be able to open an arbitration process when needed.
- **Closing the arbitration process:** The arbitration process will be automatically closed once the last non accepted portfolio is entered, or a given deadline is reached.
- **Moving to the voting/negotiation submodules:** It would be possible to move to the negotiation or voting modules, if a final decision is not reached, and it is designed accordingly.
- **Visualization of results:** Once the process is complete, SKITES will display the results.

3.3.8.3 Voting Sub-module

We suggest that this module is the last one to be implemented, as in this one there is no interaction among assessors. This module would need the following functions:

- **Visualization of proposals:** Show to the assessors the proposals to be voted.
- **Proposal selection:** SKITES will gather the votes from assessors for all proposals, and show the winning proposals.
- **Initiation of the voting process:** A user with the appropriate role will be able to open a voting process when needed.
- **Selection of assessors:** SKITES will give the right to vote to the appropriate users.
- **Closing of the voting process:** The voting process will be automatically closed, once the last vote is submitted or a given deadline is reached.
- **Visualization of results:** Once the process is completed, SKITES will show the results.

3.3.9. Innovation Promotion

This module is a complementary one and would serve for the proposal of innovative ideas, based mainly on two approaches:

Brainstorming

Through this module, the appropriate users will be able to propose innovative ideas for resolution of problems. These problems can be proposed by other users, or by the same user that is proposing the idea. To that end, we would need the following functions:

1. **Opening of a brainstorming phase**: When necessary, the appropriate user will open a brainstorming process.

2. **Posing of problems:** SKITES will allow users to pose problems for which they look for solutions.

3. **Posing of solutions**: SKITES will permit to propose solutions through the appropriate users to those problems posed.

4. **Closing a brainstorming phase**: When the last user has expressed the solution proposed or a given deadline is reached, the brainstorming process will be finished.

TRIZ

This module is an evolution of the former one. It would support the pursuit of solutions to the problems posed, through a systematic approach as is the case of the TRIZ methodology, mentioned in Chapter 1. To this end, the following functions are needed:

1. **Opening of a TRIZ phase**: When necessary, the appropriate user will open a TRIZ process

2. **Closing of a TRIZ phase**: When the last user has expressed the solution proposed, or a given deadline is over, the TRIZ process will be finished.

3.3.10. Databases

SKITES would need to run two databases, one for the users with their corresponding roles, and another with the main indicators, and templates for gathering the requested information.

Participants Database

This module will store the information concerning the users of the SKITES framework. To build such database, the following functions should be developed:

1. **User Registration and Validation:** For the registration of users and role validation, to be done by the database master.

2. **User Detail Edition:** SKITES will allow users to edit and update their roles

3. **Deletion of Users**: SKITES will permit users to be deleted, through their own initiative, or the initiative of the data base manager.

Indicator, Form and Template Database (IFTD)

This module would store the information regarding the indicators, forms and templates for the proposed projects. To build such database, the following functions are to be developed:

- **IFTD Registration:** The aim would be the registration of indicators, forms and templates. It would be done by the database master, in a flexible manner so as to adapt SKITES to different circumstances.
- **IFTD Details Edition:** SKITES will allow the database manager to edit and update IFTDs already included in the database.
- **Delete of ITFDs:** SKITES will permit the database manager to delete existing IFTDs.

3.4. Some SKITES Screenshots

We have developed a prototype implementation of SKITES. Here we provide some of its screenshots. In Chapter 4, we describe a realistic case study. To start with, Figure 3.3, shows the registration window to enter into SKITES:

Figure 3.3: Registration entry at SKITES

In Figure 3.4, we can observe how a problem can be published at the Market Place,

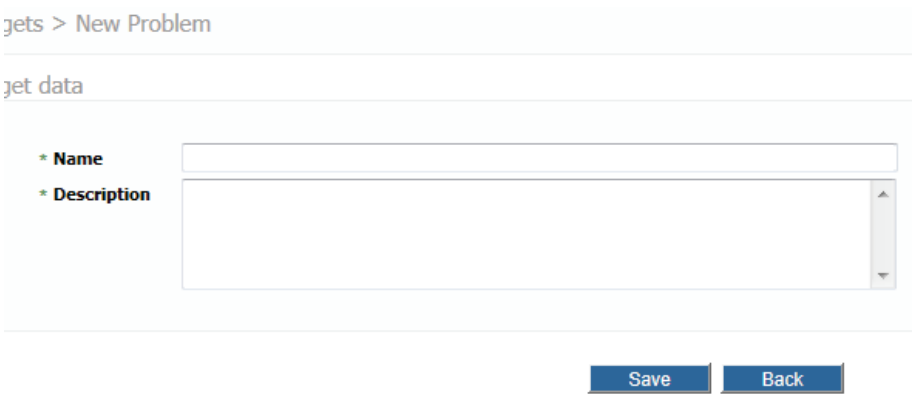


Figure 3.4: Posing a problem in SKITES

and how a project can be posted in Figure 3.5:

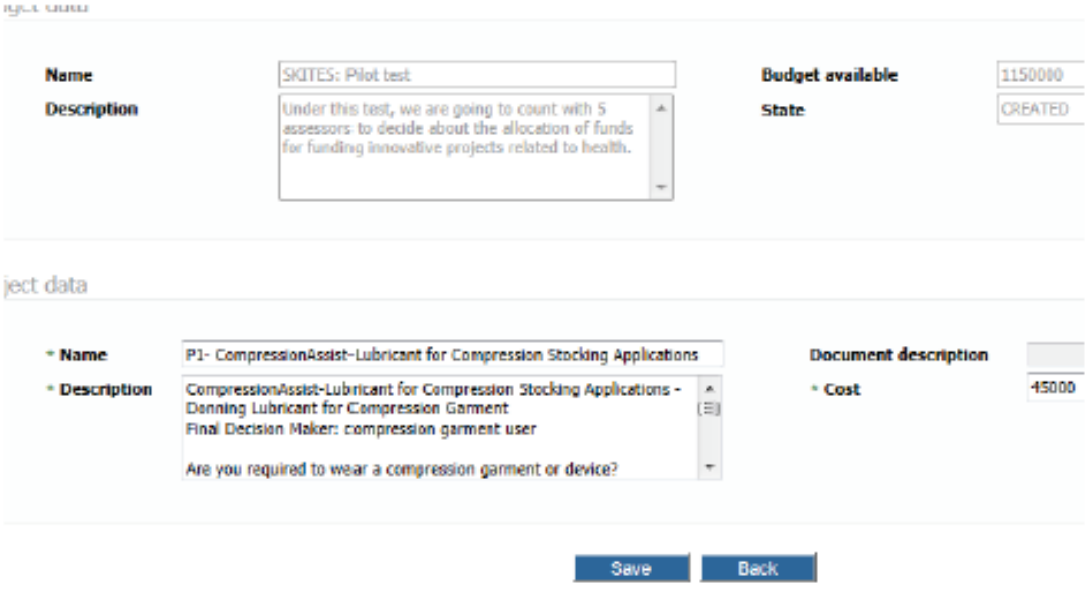


Figure 3.5: Proposing a project in SKITES

3.5. Discussion

In this chapter we have described the architecture proposed under the SKITES framework, as a tool for supporting the whole process, from when the problem is posed, until the final decision when the selected proposals are implemented, even giving the possibility to follow-up their evolution once they are implemented.

As referred in this Chapter, SKITES will implement concepts of Web 2.0 in order to enhance communication among actors, whose final effect will be the identification of the most suitable solutions, based on the sharing of information and knowledge.

Then, the SKITES functional requirements have been fixed. They are conceived jointly as a flexible framework that can be customized according to the specific requests. As mentioned in Chapter 2, although SKITES is more oriented towards innovation and, therefore, to the private sector, its flexibility allows it to be used also within the public sector and,

specifically, for the assessment of R&D development projects. Moreover, although its philosophy is oriented towards solving problems based on an open innovation process, its flexible architecture allows its use also in closed environments, being defined such environments by the customers.

We illustrate it now in a realistic case study.

Chapter 4

A Case Study

4.1. Introduction

In Chapter 2, we have described the SKITES methodology as an open approach for resource allocation filtering and selection of a portfolio of innovative projects. This filtering and selection exercise is conducted through the participation of several experts, with different backgrounds that, on an isolated basis, would typically reach different solutions. However, we expect that by sharing their knowledge they can reach a common ground. In Chapter 3, we have described SKITES as a flexible architecture, that can be adapted to the needs of different kinds of organisations for the different phases of the SKITES process.

In this Chapter, we shall undertake a case study to test the methodology and proposed architecture. This case study will deal with two of the intermediate phases among the four proposed, see Figure 4.1. These phases are the ones in which collaboration among assessors is indeed more needed, in order to identify the most appropriate portfolio:

- Phase 2: Project Filtering
- Phase 3: Portfolio Selection

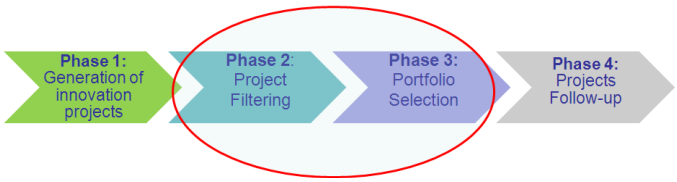


Figure 4.1: SKITES Phases

To this end, we have recruited assessors and gathered information from ten innovative projects. The selected projects are related with the health area and they are to be filtered and evaluated. These projects would need funding, and with the resources available, only some of them would get funding. Moreover, some restrictions will be added in order to have a broader project portfolio and diversify risk.

4.2. The Problem

For this experience, we have selected several innovative projects. They have been extracted from the United States National Innovation Market Place, described in Chapter 1. In this market place, there is a special feature for the identification of innovation business opportunities. Each opportunity is well described, and a link to the corresponding web site is available. Moreover, a description of potential decision makers concerning the adoption of such opportunity is incorporated. Therefore, under each proposed opportunity, the potential users of such services are identified (hospitals, doctors, citizens, etc). Different expected sales scenarios depending on the investment on marketing policies (Ultra-low, Low, Medium, High and Ultra-high) and expected sales (conservative, likely and aggressive) are included. Moreover, each business opportunity is classified according to its development status (from 1-In development, to 5-Shipping and Selling) and the proprietary protection status in terms of intellectual propriety rights (from 1-Potential protection, to 5-Granted Patent Claims). In such way, investors or manufacturers can have quite a balanced idea about the degree of development and potential position for each project in the market.

We selected ten projects. All of them are related with the health theme, and, more specifically, with health technologies. The decision for choosing such specific theme is based

on the convenience of having a common scope and not to open excessively the process. This would also affect also the assessors selection, and the search of expertise. The Health technology sector has been chosen because it has a great potential in Spain, as, on one hand, there are sufficient challenges (population ageing, financial sustainability of the social protection system, etc) but also a sector characterized by a large number of SMEs which each year re-invest in research and technology activities, between 3 to 6 percent of their turnover, see the FENIN and PWC report (2010).

The selected projects are listed in Table 4.1:

Code	**Title**	**Status**	**Proprietary Status**	**Fund. Req (US$)**
P1	Compr. Assist.	5-Ship and Selling	2- Pat. Pending	60.000,00
P2	Neonatal Elect.	1-In development	2- Pat. Pending	56.000,00
P3	Between Teeth	2- Success Prot	5-Granted Pat. Cl.	220.000,00
P4	TalkToYourDoc	3-Final Design	1-Potential for Protect.	80.500,00
P5	Carotid Patch	1-In development	5-Granted Pat. Cl.	360.000,00
P6	Catheze	5-Ship and Selling	2- Pat. Pending	42.000,00
P7	Quickpure Technology	1-In development	5-Granted Pat. Cl.	360.000,00
P8	ADAM	2- Success Prot	5-Granted Pat. Cl.	208.000,00
P9	Cardiac Devel Res.	1-In development	5-Granted Pat. Cl.	138.000,00
P10	Respiderm	2- Success Prot	2- Pat. Pending	459.000,00
			Total	**1.983.500,00**

Table 4.1: SKITES Case Study Proposed Projects. Source: USA NIST

As the website did not identify the required funding level for the projects, we have done a simulation to estimate their corresponding funding. We assume, that we are under the most likely sales level and a low marketing and sales support, as described in Figure 4.2:

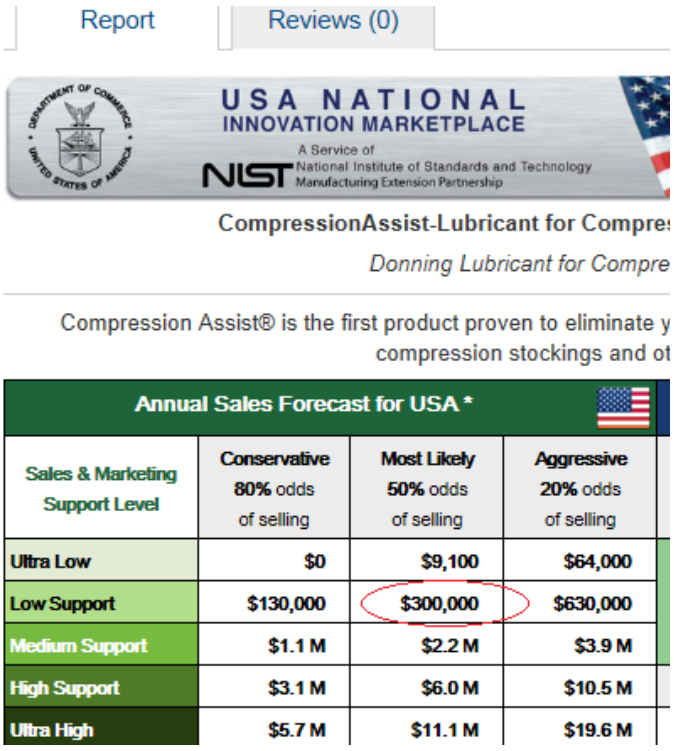


Figure 4.2: Example sales table. Source: USA Nat. Innov. Marketplace

Then, the level of funding was calculated as a share of such expected sales, between 10 to 50 percent, according to the status of the idea and the level of protection. We assume that the more developed a product or service is, the more it is protected, and the lower the funding would be needed. In Table 4.1, we can observe that, based on this, the estimated funding needed for the ten projects is 1.983.500. Originally for the aim of our case study, we set-up that the maximum funding available was 1.150.000, but after a first experiment, and due to reasons explained in the results section, we decided to reduce the available funding to 800.000, all the quantities being in US$.

In order to have a broader portfolio, and, therefore, to diversify the risks, we also propose two constraints:

- A maximum of two projects from the selected portfolio should be in the development stage 3 or above. This means that in the selected portfolio, a maximum of two projects ($P1$, $P4$ or $P6$) should be included.

- A maximum of three projects from the selected portfolio should have granted patent claims. Therefore in the selected portfolio, three out of the following projects ($P3$, $P7$, $P8$ or $P9$) would be included.

By imposing these constraints, our portfolio will include a maximum number of projects of the above mentioned characteristics: development status, (thus quite incipient and able to become a breakthrough), and a well grounded and protected in IPR terms.

In order to do the filtering, we have obtained the following general features for the projects (see also Figure 4.3):

- **Project Development Status (from 1 to 5)**: As mentioned, it is the degree of development of the project. The possible values are:

    1. In Development Process.
    2. Successful Prototypes Available.
    3. Final Design Ready.
    4. Manufacturing Ready.
    5. Available for Shipping and Selling.

- **Proprietary Status (from 1 to 5)**: Provides information about the IP Rights of the project proposer.

    1. Potential for Protection.
    2. Patent Pending.
    3. Tactical Protection.
    4. Major Trade Secrets.
    5. Granted Patent Claims.

- **Likely Annual Sales Forecasts (US$)**: It is a prediction for the turnover that the projects will make, under the most likely level of sales and low marketing and sales support. For the ten selected projects, these expected sales are between 140.000 and 1.800.000 US$.
- **Producer Profit (EBTD)**: Expressed in percentage, it is the rate of profitability before taxes and depreciations, (see Chapter 2 for EBTDA) that a manufacturer can expect with the given project.
- **Time to first Sale**: Minimum time to the first sale.
- **NIST Concept Score**: A global indicator built by NIST. It aggregates information about sale expectations, IP Rights, market size and marketing effort needed.
- **Funding needed**: Financial requirement in order to launch the project.

As we shall see in the results section, after the first experiment, we decided to reduce these variables to the following five:

- **A-1 Proprietary Status**
- **A-2 Likely Annual Sales Forecasts**
- **A-3 Producer Profit**
- **A-4 Time to first Sale**
- **A-5 Funding needed**

The fifth variable, will not be used for assessment purposes, but is needed to fix the budgetary restriction.

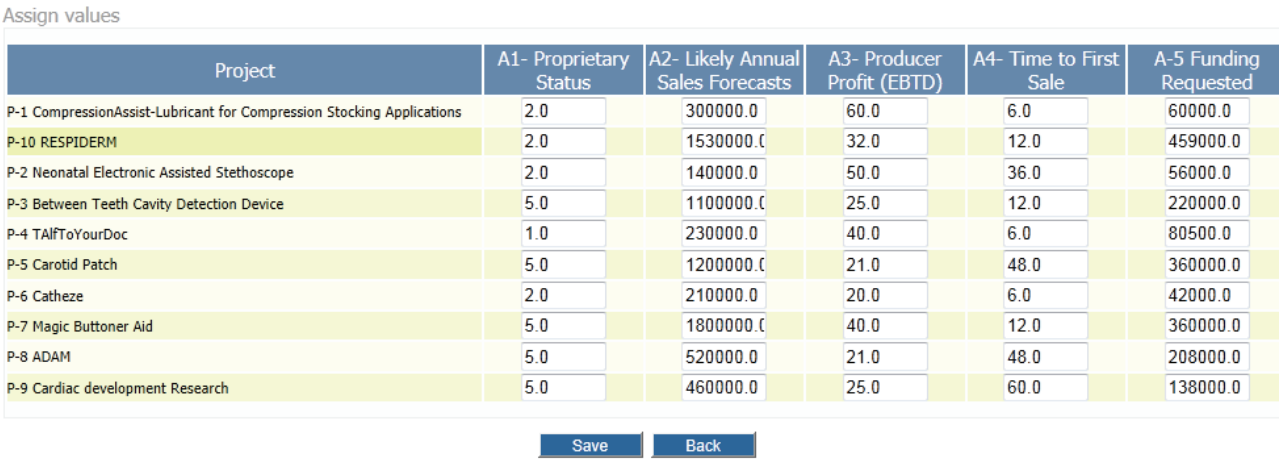


Figure 4.3: Attribute values for the selected projects

The assessors selected for this case study are professionals coming from the private and public sectors, counting with key different background. All of them have been evaluators for national and international organizations in the research, development and innovation areas. The selected assessors are:

- Dr. Hans Riese, Biochemist, with background in the Pharma Industry and currently National Contact Point for FP7-Health.
- Dr. Andrés Arévalo, Industrial Engineer who worked for more than 20 years in the private sector, being at the same time Professor of Chemical Technology for Engineers.
- Dr. Luis Guerra, Medical Doctor and Director of the National Health Studies Center at the Carlos III National Health Institute. Previously, he was the Head of the Ramón y Cajal Biomedical Research Institute.
- Mr. Juan Manuel García Camús, Chemist and Technology Transfer Officer a the Rey Juan Carlos University, having worked also as environmental consultant for the private sector
- Mr Francisco Hernández, Mathematician and Deputy Director at the Spanish Statistical Institute.

The first part of this study is the individual problem exploration. To that end, access to the SKITES framework was granted to the assessors mentioned above. Figure 4.4 is the entry to SKITES:

Figure 4.4: SKITES: Entry window

Once registered, an assessor can move to the functions: problem search, preference communication and results in terms of utilities.

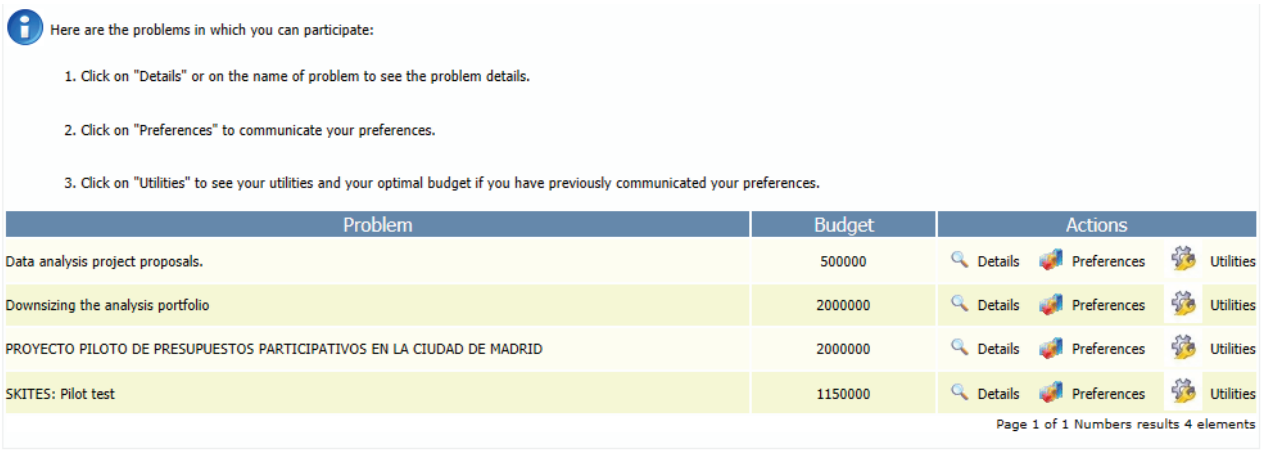


Figure 4.5: SKITES: Main menu for assessors

The first action to be performed by the assessors is choose the problem, in this case SKITES Pilot Test, and communicate their preferences about the general features described

before, see Figure 4.5. Each assessor communicates its preferences by:

1. Fixing the worst and best values for each evaluation criteria.

2. Allocating the weight for each of these evaluation criteria.

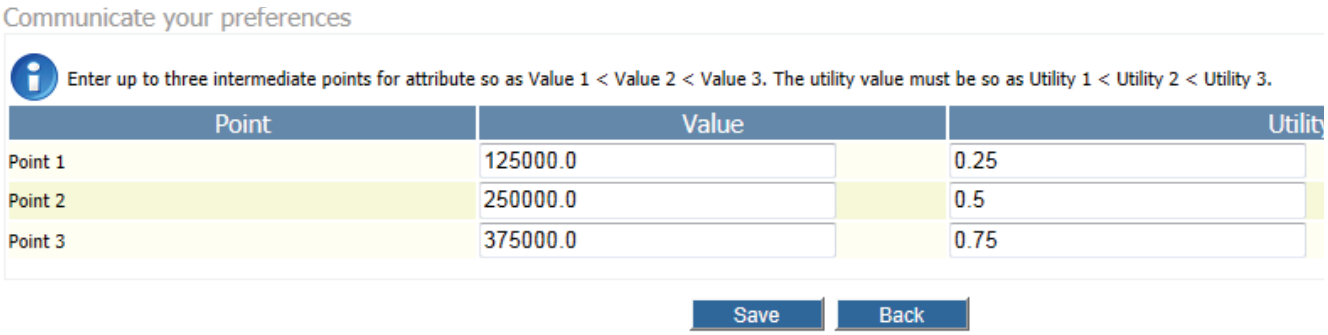


Figure 4.6: SKITES: Communication of preferences

As shown in Figure 4.6, the system also allows to define the intermediate possible scores for each value. If nothing is defined herein the application create intermediate points, and attributes them 0.75, 0.50 and 0.25 on value terms.

4.3. Results

As described above, we conducted a first assessment exercise taking into consideration the seven mentioned variables, and a maximum budget of 1.150.000 US$. During this first evaluation, we were only able to get on board four assessors. Once they communicated their preferences for the filtering phase, we observed that the selected portfolio for each of them was exactly the same for three assessors, and varied only on one project for the forth one. Thus, we did not practically find discrepancies. As the aim of the case study was to see how participatory methods perform with innovative projects, we decided to repeat the exercise, but reducing the variables from seven to four, and also the budget available from 1.150.000 to 800.000 US$. We expected that the fact of having less resources available would make that the individual priorities would imply different project portfolios. Moreover, by having

also less variables, we expect that the communication of preferences would be simpler, as assessors might be more for considering extreme values for weighting each assessment criteria, as well as for the definition of interim points. In the reduction of variables, we tried to disregard those that seemed less objective and/or that were related with others. Thus, we eliminated 'Development status' as it was clearly linked with 'Time to market'. We also eliminated 'NIST Score', as was somehow subjective and difficult to understand. It must be noted that we did not introduce changes in the restrictions, except the budget available, as previously mentioned.

With this new problem description, we proposed the assessors the following schedule:

- Exploring the problem and communication of preferences: One week
- Negotiation: Five days
- Voting, only in case that a common solution was not reached: Two days

In order to facilitate the assessors' work, we facilitated them a guidelines document (Appendix A) before the evaluation exercise started.

4.3.1. Case Study: Problem Exploration and Preference Communication

This phase lasted one week. During this time, the assessors were able to know more in depth and get familiar with the projects to evaluate. Once this was accomplished, they were asked to provide weights to each criteria, and define intermediate points, and score them, as can be observed in Figures 4.7 and 4.8, respectively.

Figure 4.7: SKITES: Allocation of weigths

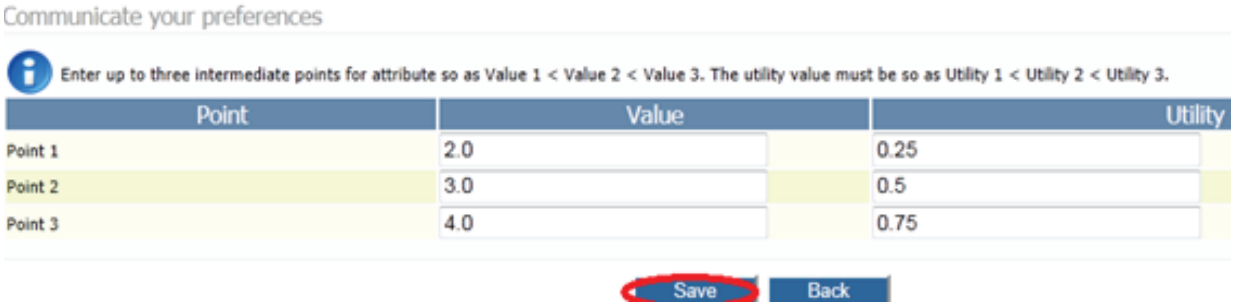


Figure 4.8: SKITES: Definition of intermediate points and utility

As a result of this exercise, we found the optimal individual portfolios for the five assessors, as summarized in Table 4.2:

	Portfolio	Utility	Cost (US$)
Eval 1	P1, P2, P3, P4, P8, P9	248	762.500
Eval 2	P1, P2, P3, P4, P7	365	716.500
Eval 3	P1, P2, P3, P4, P8, P9	269	762.500
Eval 4	P1, P2, P3, P4, P8, P9	363	762.500
Eval 5	P1, P2, P3, P6, P8, P9	351	724.000
	Averages	**319**	**745.600**

Table 4.2: Optimal portfolios

We observe in this exploration phase that $P1$, $P2$ and $P3$ were present in all the selected portfolios. Moreover, $P4$, $P8$ and $P9$ were in four out of the five proposed portfolio. $P6$ and $P7$ were only present in one of the portfolios. $P5$ and $P10$ were not considered by any of the assessors. Moreover, it must be noticed that all portfolios except one (eval2), counted with six projects in total, being all of them over 700.000, 745.600 US $ on average, out of the 800.000 US$ available. Individual utilities vary from 240 (eval 1) to 366 (eval 2).

	Eval 1	Eval 2	Eval 3	Eval 4	Eval 5	N pflio's in	Util Av.
P1	32,10	67,19	41,90	68,39	50,68	5	52,05
P2	45,20	79,09	44,60	39,36	48,10	5	51,27
P3	55,30	75,20	65,50	81,60	78,20	5	71,16
P4	20,80	54,14	28,10	50,39	18,28	4	34,34
P5	58,10	62,28	62,40	59,30	77,10	0	63,84
P6	19,60	40,40	22,70	47,14	38,88	1	33,74
P7	69,00	90,00	85,00	94,80	94,40	1	86,64
P8	49,10	30,60	46,70	57,40	67,50	4	50,26
P9	45,50	43,48	42,60	65,80	67,72	4	53,02
P10	46,60	84,00	42,60	62,70	65,40	0	60,26

Table 4.3: Utilities per assessor and project

In Figure 4.9, we represent in the x axis the average utility per project, in the y axis the projects presence in the original proposed portfolios, being the size of the bubble the requested funding. As we can observe, project $P7$, with the maximum utility on average, but also with the maximum utility for each of the five assessors, was only present in one of the proposed portfolios (eval 2). This seems to be due to the large funding requested by this project (360.000 US$) that makes it difficult to be combined with the rest of projects when reaching an optimal portfolio.

As a common solution was not reached in this phase for four out of the five assessors, the negotiation phase was launched, as foreseen.

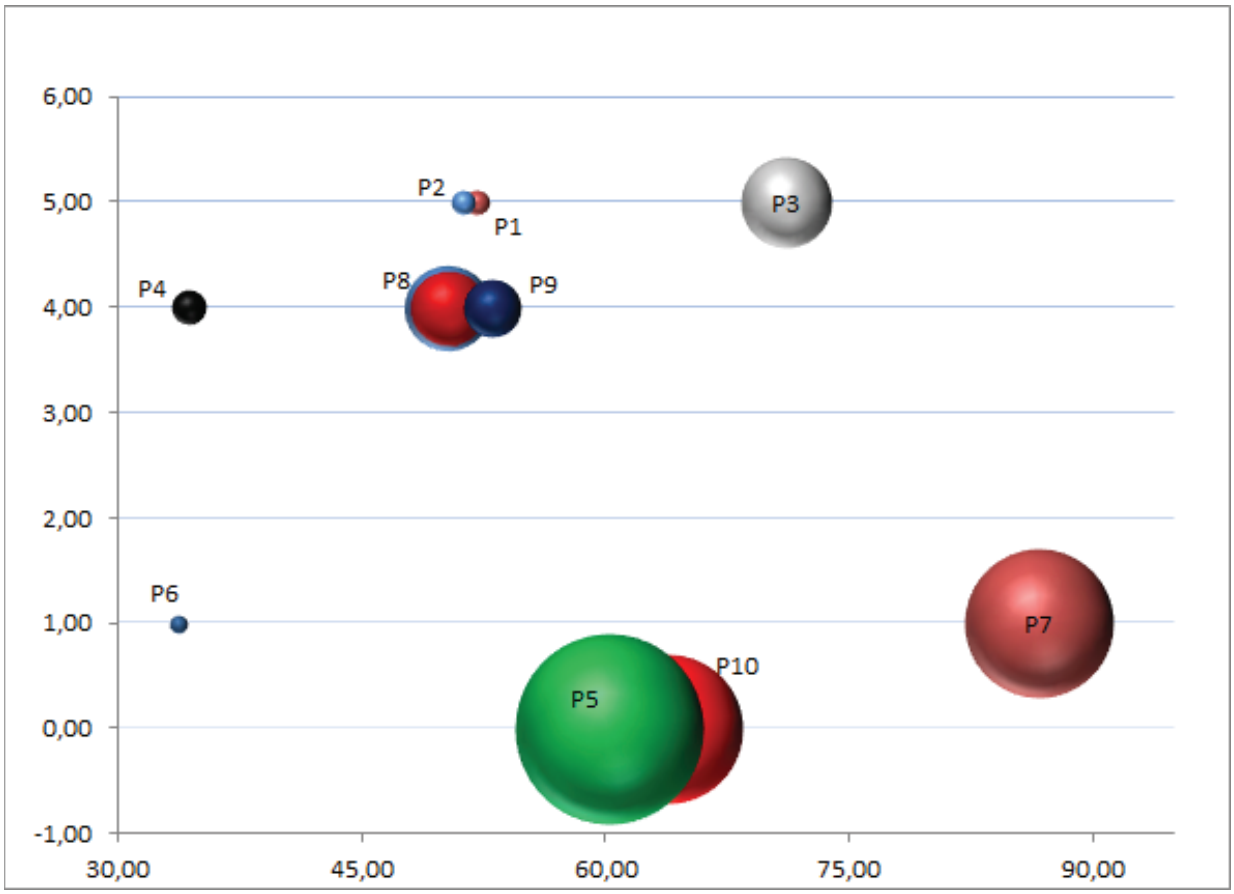


Figure 4.9: SKITES: Results of the Individual exploration phase

4.3.2. Case Study: Negotiation phase

For this phase, the assessors had five working days in total. Firstly, we invited assessors to enter into the SKITES negotiation module and submit proposals to the rest of assessors. It was agreed that if at the end of this phase, a proposal was accepted by four out of the five assessors, it would be finally accepted.

In total, six proposals were submitted as can be shown in Table 4.4:

Offer	Proposed	Favour	Against	Messages	Portfolio
1	eval1	3	2	2	P1, P2, P3, P4, P8, P9
2	eval2	2	3	4	P5, P6, P8, P9
3	eval4	2	1	0	P1, P2, P3, P8, P9
4	eval5	1	4	2	P1, P7, P8, P9
5	eval2	1	2	1	P1, P2, P3, P6, P7
6	eval1	4	1	2	P1, P2, P3, P6, P8, P9

Table 4.4: Offers proposed

We observe that, initially, some assessors proposed their individual optimal portfolios. That is why offer number 1 was approved by three of them. Also eval4 proposed its optimal portfolio for which he got the agreement from two assessors.

Although eval2 was not successful in his offers, it is quite interesting to analyze the trajectory of his proposals. We observe in Table 4.4 that he proposed in a first instance (Offer 2) a portfolio composed of: $P5$, $P6$, $P8$ and $P9$. After this one was rejected, and upon reception of offers 3 and 4, he proposed a new one (Offer 5) composed of: $P1$, $P2$, $P3$, $P6$ and $P7$. Note that only one project remains from his first proposal, and we must highlight that this proposal is not far away from the final portfolio adopted.

As shown in Table 4.4, offer 6 counted with the agreement of four out of the five assessors. Therefore, this portfolio, formed by $P1$, $P2$, $P3$, $P6$, $P8$ and $P9$ projects and with a cost of 724.000 US$, was the one approved. The projects included in this portfolio are shown in Table 4.5.

Code	Title	A-1 Prop. St.	A-5 Fun. Req. (US$)
P1	Compres-Assist-Lubricant	2- Pat. Pend.	60.000,00
P2	Neo-Elect. Ass. Stethoscope	2- Pat. Pend.	56.000,00
P3	Bet. Teeth Cavity Detect. Device	5-Grant. Pat. Claims	220.000,00
P6	Catheze	2- Pat. Pend.	42.000,00
P8	ADAM	5-Grant. Pat. Claims	208.000,00
P9	Cardiac Devel. Research	5-Grant. Pat. Claims	138.000,00
		Total	**724.000,00**

Table 4.5: Approved portfolio after negotiation

We observe that the selected portfolio is quite diverse counting with projects with granted patent claims, but also patent-pending, being this imposed partially by the introduced constraints. In terms of requested funding, the amounts also vary from 42.000 to 220.000 US$. In more detail, we can see that two projects are above 200.000 US$ and other two close to 50.000 US$.

It must be noted that this portfolio coincides with the original individual solution for assessor 5. In Table 4.6 we can see how the portfolio changes for each assessor and their expected utilities based on individual preferences.

Assessor	Enters	Exits	Former Utility	New Utility
eval 1	P6	P4	248	247
eval 2	P6, P8, P9	P4, P7	365	305
eval 3	P6	P4	269	264
eval 4	P6	P4	363	360
eval 5	none	none	352	352

Table 4.6: Entry and exit of projects per assessor

Comparing these results with Table 4.2, we observe that $P1$, $P2$ and $P3$ were in all the proposed portfolios, $P8$ and $P9$ were in four of the five portfolios, and only $P6$ was present in one portfolio. Nevertheless it must be noted that, as shown in Figure 4.9, the utility

for $P4$, not selected in the final portfolio, but present in four of the original individual portfolios was not far away from the average utility for $P6$.

Due to the fact that during the negotiation an agreement from four of the five assessors was reached, it was not necessary to move on to the voting phase.

4.4. Discussion

During this case study, we have conducted a pilot exercise consisting of assessing actual innovative projects, through the SKITES methodology. To this end, under a budgetary constraint, a number of variables were observed for the ten projects to assess. Five experienced experts with different backgrounds were asked to participate as assessors. Instead of using traditional evaluation procedures, assessors were not asked to evaluate projects directly according to a set of evaluation criteria, but to express their preferences about the evaluation criteria, by giving weights to these variables, and define scores for intermediate points observed. Thus, firstly they undertook an analysis on an individual basis, and afterwards, they were asked to collaborate to try to identify a common portfolio of projects acceptable for them.

The singularity of SKITES as an evaluation method was the first difficulty we faced. All the assessors counted with experience as evaluators for different programmes, but were not familiar with the fact of assessing indirectly the projects through the weights given to the evaluation criteria. Moreover, the issue of considering the projects on a portfolio basis, and not on an individual basis, was also difficult to understand. In order to facilitate their work, we act as facilitators on a continuous basis and provided them a guidelines document (Appendix A). We also held separate meetings with them. Therefore, the efforts required for an appropriate understanding of the SKITES methodology are not to be underestimated for future actions.

During this process, we also learnt that too many variables, complicates the assessors' task of discriminating and scoring variables. Therefore, we should try to simplify the number of variables. Moreover, these variables should be as objective as possible.

Nevertheless, we observed that, although the assessors had different profiles, all of them

were able to reach on an isolated basis quite close results, and that, afterwards, they were able to reach an agreement during the negotiation phase. It must be noted that this phase was easier to be understood by assessors, as here they were able to identify and propose portfolios on a project by project basis.

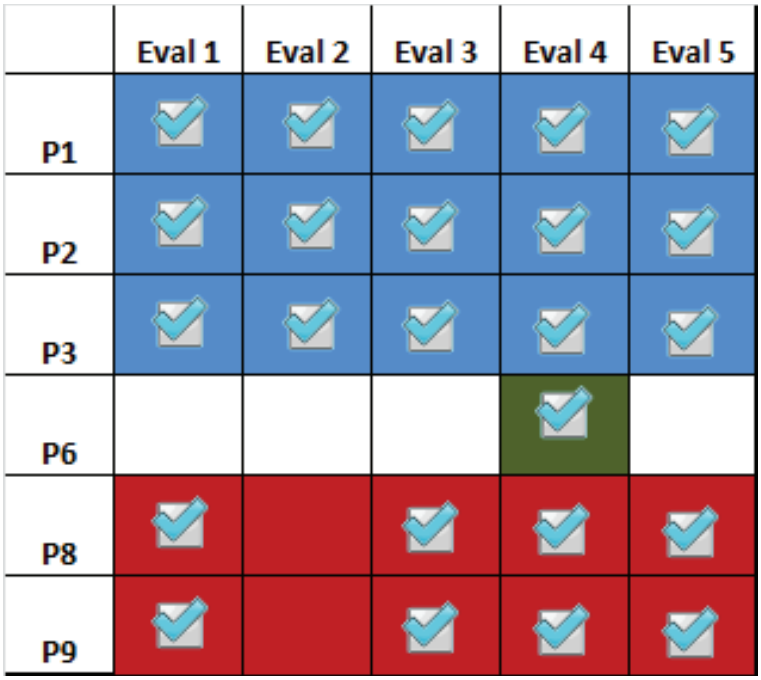


Figure 4.10: SKITES: Final portfolio vs Individual preferences

In Figure 4.10, we can observe how the original individual preferences are present in the final selected portfolio, and how a project ($P6$) that was almost disregarded by assessors during the submission of proposals, over the negotiation phase, was finally the leverage point for reaching an agreement.

Although more examples need to be explored to confirm the utility of SKITES methodology, it must be stated that as a first step, this pilot test can be considered as a success, as it made possible that assessors with different backgrounds to reach an agreement on a final portfolio.

Chapter 5

Conclusions and Future Work

5.1. Conclusions

As we have suggested in Chapter 1, innovation is not only the introduction of new ideas, but also they must have an economic impact to be considered as such. Therefore, it is considered as a key element for enterprises, regions or countries to remain competitive and, thus, staying alive. Moreover, because of its own nature, innovation entails changes. Thus, this makes uncertainty to be present behind the adoption of innovations. Due to globalization, the way on how innovation is understood has changed drastically, from closed to open environments. What we propose with SKITES is a novel way to propose, filter, select and agree about innovative projects, based on open environments, through a flexible tool and assisted by assessors with different backgrounds, from which we expect to reach a common solution, based on the exchange of knowledge among them.

In Chapter 1, we have started with an in depth analysis of the concept of innovation. We have seen that although innovation is an inherent capacity of the human being, the first time that innovation has been studied as such, was only in 1939 due to Schumpeter, who described innovation as an intrinsic feature of the capitalist system, acting as an engine of the economy, favoring greater wealth and prosperity. To this end, Schumpeter proposed several patterns that are present when an innovation arises. Another key author in this field is Porter who describes innovation, as the search of new ideas through different means and media, as the basis of competitiveness. Porter presented his innovation theory as a search

for better performance. One of the main elements introduced is Porter's Value Chain, which consists of a theoretical model describing the development of the activities of a business organization, by creating value to better reach their customers. It bases the greatest part for this successful development on the relation with its environment (customers, providers, employees, etc), and in its perception, as the main source to improve their products and services. Drucker is also mentioned as the author that emphasizes the need for a systematic approach to specific results based on protocols, towards identifying innovation sources, and not only to consider it as a non targeted search. Although innovation concepts given by these authors cannot be considered fully complementary, we can extract from them two common elements when we talk about innovation: change and economic value. Another author that we referred to in Chapter 1 is Chesbrough and his open innovation theory, who has shown empirically how the innovation concept and its implementation has changed in the last few years, moving from a closed concept to open environments. Chesbrough's Open innovation philosophy is doubly present in SKITES. Firstly, because the SKITES architecture, due to its flexibility, can be implemented in open environments. Secondly, because we always propose to study each particular problem from different perspectives, to incorporate assessors with different background, and a tool that promotes this exchange of views.

Another important part of Chapter 1 is that related with the importance of innovation in relation with the current economic crisis. In a short study, in which we compared, on one hand, countries and, on the other, industries versus their performance in the last years, we have shown how more innovative countries or industries are suffering less the effects of the crisis. Innovation, thus, may entail a mechanism for sustainability against market oscillations. We have reviewed also state on the art methods used for evaluation of research and innovation projects. As they are mainly addressed towards public funding, we have performed a comparative study between the mechanisms used at National Level in Spain, and the ones used at European Level, as it is the case of the 7th Framework Programme (FP7). The key conclusion was that despite public resources for RTD activities have risen so much over the last years, the procedures and systems for selection and evaluation of such projects and allocation of resources have not practically evolved. Apart from the

introduction of ICT tools for remote assessments, no further key improvements have been introduced recently. Although at a European level consensus meetings are well established, and that these panels count with assessors with varied backgrounds, the exchange of views among them is not protocolled, being there room for improvement with the use of tools similar to the ones proposed in this thesis. We completed our review describing some principles for innovation management and a review on the existing web based management tools that can share some characteristics to the one proposed under SKITES. We finalized Chapter 1 with an analysis on the use of multicriteria decision analysis (MCDA) methods, and their use in the field of research and innovation.

In Chapter 2, we described the methodology associated with SKITES. As stated before, in the case of innovative projects we face a double source of uncertainty. On one hand, we find the traditional one that is behind any decision making process. On the other, as major source of uncertainty, we have the one intrinsic with the nature of innovation , that by itself entails larger threats, but also larger opportunities. Our challenge is then to propose a methodology that deals with this uncertainty. To this end, we rely on the need of treating innovation from an open perspective, thus counting with several point of views to study the same problem, and afterwards by sharing these different perspectives. Moreover, the proposed methodology is flexible, and can be adapted to different types of organisations, both from the private and public sectors. Nevertheless, a common problem structure and a common sort of actors are to be present in the definition of the problem. There are four roles always present: Organization, Proposers, Assessors and Facilitators. Once these roles are defined, we structure our problem in four stages:

- **Generation of Innovative Projects:** The posible projects are identified. To this end, we encourage the use of formal tools (TRIZ, SWOT,...), but we do not disregard the use of more informal ones like brainstorming, or even spontaneous proposals. At this stage a sort of assessment is included.

- **Project Filtering:** Once an initial portfolio of projects is available, there is a need to document these projects with comparable information. For this, we may use traditional financial indicators as: NPV, IRR or ROA, but also we propose to gather

other indicators specifically addressed to innovation, and that cover the gap of underestimation of the traditional ones.

- **Project Selection:** Once all these homogenous information is gathered for all the filtered projects, it is time for the selection of projects. For this, we would also need to define for each project its costs, considering the financial resources, but also the effort required in terms of human resources. Lastly, it is necessary to determine the resources available and, if any, other relevant constraints. The project selection is done through several steps:

  - *Individual Problem Exploration:* At this stage, we elicit the participants' preference in terms of their utility or value functions.

  - *Conflict Resolution:* Due to the different assessors backgrounds, we expect that they would not reach an agreement in the previous phase, being then necessary to use one or more conflict resolution methodologies like Arbitration, Negotiation, or Voting

  - *Post-settlement:* If the outcome of the conflict resolution is reached through negotiation or voting, it could be the case that there are portfolios which are more efficient than the agreed one. Thus, there would be the possibility to improve it through a negotiation process.

- **Follow up of the selected portfolio:** The aim of this stage would be to observe the evolution of the selected portfolio in order to identify deviations from the original project schedule, and gather information to be considered for future rounds.

Within Chapter 2, we also included a full section for modeling the case in which there is uncertainty not only on the selection of innovative projects, but also on the resources available. We propose several algorithms to be used during the conflict resolution phase, for voting, negotiation, or arbitration.

Chapter 3 describes an architecture proposal for SKITES. It supports on a generic framework allowing an organization to define their own innovation process following the

flexibility principle mentioned above. This approach, that implements the Web 2.0 concepts, will be linked with Open Innovation Theory, and incorporates communication facilities. SKITES is conceived thus to support comparison among projects, providing a flexible and user friendly system, building estimators and indicators, and setting up procedures and alarms to monitor project execution.

The architecture proposed is described as service oriented based on a SOA bus. Such system should somehow be linked with the corresponding enterprise software platform. Alternatively for SMES, such enterprise platform may no exist, so it would be also possible to use them on an isolated basis. SKITES would include two different databases: a Census Database, and an Indicator Database. Moreover, around the SOA Bus, we would need to deploy various services.

Once we have defined the SKITES scheme, in Chapter 4, we have conducted a pilot case study to test the methodology and how does the proposed system runs. This pilot test was done for the phases in which the collaboration among participants is more necessary (Phase 2; Phase 3). For the case study we have selected ten innovative projects related with health technologies. The corresponding information was taken from a public market place (NIST). According to some figures provided in the market place, we estimated the funding needed by these projects, in total 1.983.000 US$. We also selected four variables related with their current status, and their potential performance, being them the evaluation criteria. We included a budget limit of 800.000 US$. Moreover, in order to diversify the composition of the portfolio, we included two additional restrictions, based on the nature, and in the degree of development of the projects. We also selected five assessors with different backgrounds, with experience in assessing RTD projects. The author of this thesis took part as facilitator.

A very interesting issue in this pilot exercise was to observe how one of the assessors, upon the exchange of information, moved from his original optimal portfolio (that was radically different to the rest of assessors), to his last proposal that almost coincided with the selected portfolio. Although more exercises are to be done to confirm the SKITES utility, the results were quite positive, so as at to suggest at least to continue developing it as a useful tool.

SKITES as a full process, like other existing methodologies for innovation management,

can be somehow perceived as too complex to be implemented at an organisation. Nevertheless, we would like to stress again here, that the flexibility of SKITES methodology, and its adaptability to different organisations, makes it possible to use less sophisticated methods, with different structures specially in the conflict resolution phase, so that it can be accommodated accordingly. Moreover, the role of facilitators would serve to its smooth implementation and understanding.

5.2. Topics for Further Research

During the execution of this study, we found some topics for further research or improvement. We have grouped them into two categories:

- Theoretical developments
- Development and Improvement of the SKITES platform

5.2.1. Theoretical Developments

As we have developed SKITES, we do not give assessors the capability to decide on the evaluation criteria, as they are fixed according to the problem formulation. It might be interesting to test the possibility of including an additional stage. This stage would be at the problem formulation phase, and the aim would be that also assessors participate at the assessment criteria selection, thus, being able to decide among a range of variables observed, and proposing, the ones they prefer to be used as the final evaluation ones. We could start from a wide range of variables, and a problem definition, then, we would ask assessors, using the same participatory methodology described above to propose, filter and select, the most relevant characteristics to be used. In order to guarantee the objectiveness, this can be done, without having detailed information on the projects to be assessed at this criteria selection stage.

A mixed approach might can be considered. It would be an evolution of the above idea, following the difficulty of assessors on this kind of evaluation, based on weighting assessment criteria, instead of scoring projects directly. An additional development could be therefore

to ask assessors: on one hand to give weights to some assessment criteria already defined, but also to leave some variables to be directly scored and weighted by them. For this, the assessors would be granted access to the problem formulation phase. For instance, three of these evaluation criteria, that are quite related with the auto-assessment done by project proposers, see Chapter 2, can be formulated as:

- **Strategic/Potential Opportunity:** Under this criteria, the assessors will check how the proposal fits technically with market needs, or how feasible it is that they create new market needs. Some elements that can be helpful for scoring are: the convenience of exploiting the project in its own, or having outsourcing strategies, be linked with existing firms, the opportunity given to become/maintain as market leader; the opportunity of opening new markets, etc.

- **Operational Impact:** Measured in terms of the positive effect of the introduction of such innovative project into the market and its potential consequences. This is to be observed not only for the competitors, but also from the project proposer perspective.

- **Difficulties to enter in the market, in terms of competitors:** Herein, the assessor has to evaluate how feasible is to enter into the market with such project, the need to adapt their capabilities, marketing effort needs, etc.

Another action that can be explored for future developments is the use of SKITES in the implementation of Pre-commercial Procurement (PCP) and Public Procurement of Innovation (PPI). Public procurement at EU level reaches 2 trillion euros yearly, around the 17% of the EU GDP, see the Europe 2020 Flagship Initiative Innovation Union (2010). Moreover, we face the fact that at EU level the private investment on innovation is lower than in other developed economies like USA or Canada. Therefore, public procurement linked with innovation or pre-commercial development is perceived as a huge opportunity to revert this situation. For this reason, EU and Member States are launching policies to enhance its use. This is not an easy task, as by its nature, public bodies are not familiar with the fact of assuming the risks that are under these processes. Being SKITES a methodology based on open innovation approaches, built to assess, based on different backgrounds risks

and gains of innovative proposals, we feel that can be explored its use as a useful tool for this purpose.

5.2.2. Development and Improvement of the Platform

During this study, and in particular during the pilot exercise described in Chapter 4, we realized about some room for improvement of the SKITES platform. On one hand, the way in which the information is displayed, could be improved. It would be helpful also to count, for instance, with specific boxes to gather and display information. Moreover, during the portfolio selection phase, we could consider incorporating additional facilities, that, for instance, can show assessors different opinions and preferences. Moreover, further developments could consider its use through other systems, so not only being able to provide opinions by typing a text or submitting opinions through the web, but by other means. This can be done through virtual meetings, creating a blog, attaching documents, links to a website, use of twitter, etc. s.

On the other hand, due to the novelty of the proposed methodology, some assessors difficult to understand how the process runs, and how their utilities and values were calculated. Thus, it would be interesting apart from providing guidance documents as we have done so far, to:

1. Show a demo/video on how the whole process is conceived

2. Once all the innovative projects are included in the system, show the feasible portfolios

Last, but not least, a report once every case is over should be automatically launched, gathering at least information like time spent, accessibility to the system, quality of the information, role of the facilitator, main difficulties encountered.

As stated above, the aim of these suggestions is to make SKITES a more user friendly system. We expect that taking profit of its users (assessors, proposers, facilitators,...), thus, following the open innovation approach, it can be improved based on a continuous learning process.

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Appendix A

SKITES Guide for Assessors

GUÍA RÁPIDA EN EL PROCESO DE EVALUACIÓN INDIVIDUAL Y PARA USO DE PARBUD EN EL EJERCICIO DE EVALUACIÓN DE SKITES

A.1. Introducción

En primer lugar, quiero daros las gracias por vuestra colaboración como evaluadores en este caso piloto de evaluación de proyectos basado en la metodología SKITES, que es el núcleo principal de mi tesis doctoral. El objeto de la tesis y de SKITES se centra en la gestión de la innovación y se basa en el cambio de paradigma sobre el proceso por el cual desde los individuos hasta las grandes empresas, e incluso los propios países, afrontan sus principales problemas. Esto se realiza cada vez de manera más participativa, haciendo cada vez mayor uso de entornos y procesos abiertos. En este sentido, el objetivo de este trabajo es plantear el uso de métodos de análisis de decisión multi-criterio, y por tanto teniendo en cuenta diferentes puntos de vista, como herramienta para los procesos de toma de decisiones en proyectos o acciones de innovación dados unos recursos limitados. Precisamente, el estar en un entorno innovador hace que el componente de incertidumbre sea doble pues, por un lado, está la incertidumbre asociada a la toma de decisiones, pero por otro lado la más difícil de tratar que es aquella intrínseca asociada a la innovación y que supone un cambio del

propio proceso. Con objeto de tratar este problema, en la tesis se plantea todo un proceso desde la identificación, selección, hasta el filtrado y seguimiento de proyectos, todo ello en el marco de una herramienta web. Para ello, además de unos procesos de autoevaluación que no nos ocupará en este piloto, se crea una función de valor, con objeto de encontrar en primer lugar la mejor solución individual asociada a cada uno de vosotros, a la que se llega tras una primera exploración individual del problema. Posteriormente, en una segunda fase se usan esquemas participativos: negociación y votación, principalmente. Para esta fase de selección y filtrado de proyectos, recurro a vosotros, como expertos en diferentes áreas y con experiencia en investigación e innovación. Voy a recabar vuestra ayuda en dos partes diferencias. Por un lado, en el proceso de exploración individualizada en primera instancia, y luego en la fase de toma de decisiones participativas. De nuevo os agradezco vuestra colaboración en este trabajo.

A.1.1. Planteamiento del Problema

Con objeto de desarrollar este ejercicio piloto, se han seleccionado diez proyectos reales, tomados de http://innovationsupplychain.com. Este sitio, es un espacio público web, de acceso gratuito, en forma de mercado abierto de la innovación, soportado por el Gobierno Norteamericano, concretamente por el Instituto Nacional de Estándares y Tecnología. Este portal presenta numerosos proyectos de todos los ámbitos, recogiendo información de diverso tipo para ayudar a los analistas y a los inversores en la toma de decisiones. Los proyectos seleccionados para el estudio son los expuestos en la tabla A-1.

Code	Title	F. Requested (US$)
P1	CompressionAssist-Lubricant	60.000
P2	Neonatal Electronic Assisted Stethoscope	56.000
P3	Between Teeth Cavity Detection Device	220.000
P4	TalkToYourDoc	80.500
P5	Carotid Patch	360.000
P6	Catheze	42.000
P7	Quickpure Technology	360.000
P8	ADAM	208.000
P9	Cardiac Development Research	138.000
P10	Respiderm	459.000
	Total	**1.983.500**

Tabla A.1: Proyectos seleccionados para el ejercicio piloto SKITES

El resumen de cada uno de estos proyectos está disponible al final de esta guía. El problema planteado es la selección de proyectos, frente a la restricción presupuestaria, que para el caso en cuestión se ha limitado a 800.000 US$, es decir, no todos los proyectos pueden ejecutarse.

Para cada uno de los proyectos, se han tomado del sitio web sobre cinco variables, que son lo que llamaremos atributos, véase la Tabla A.2. A diferencia de los procesos habituales de evaluación, esta metodología, plantea un ejercicio de evaluación, basada en la ponderación que deis a cada uno de estos atributos, que ya han sido medidos. Es decir, el ejercicio de evaluación, no es puntuar los dies proyectos contra un número de criterios, sino tras la lectura de los proyectos, y de los valores que toman sus atributos, proponer un peso para cada una de esas variables.

Los atributos seleccionados para este ejercicio piloto representan información disponible de manera directa o indirecta en el sitio web http://innovationsupplychain.com/ . Concretamente, los atributos seleccionados para este ejercicio son:

- Derechos Propiedad Industrial o Conocimientos disponibles (de 1 a 5): Respondiendo

los valores a:

1. Potencialmente Protegible
2. Pendiente de Patentar y / o Proteger
3. Protección Táctica
4. Secreto Industrial
5. Capacidad de Licenciar Derechos

- Facturación anual esperada (en US $): predicción sobre la cifra anual de ventas, bajo el escenario más probable y bajo una intensaidad baja de política de marketing y apoyo a las ventas.
- Margen Comercial esperado del productor (%): Calculado como beneficios antes de impuesto antes de impuestos y amortizaciones (EBTD).
- Periodo de carencia mínimo hasta la primera venta (meses).
- Financiación requerida (US$): Importe necesario para poder dar el apoyo solicitado al proyecto.

Todos los proyectos, ver Tabla A.1, se incardinan en el sector salud, presentan diferentes enfoques, más básico, aplicados o de mercado y guardan relación con las tecnologías sanitarias.

Code	Title	Status	Proprietary Status	Funding Req ($)
P1	Compr. Assist.	5-Ship and Selling	2- Pat. Pending	60.000,00
P2	Neonatal Elect.	1-In development	2- Pat. Pending	56.000,00
P3	Between Teeth	2- Success Prot	5-Granted Pat. Cl.	220.000,00
P4	TalkToYourDoc	3-Final Design	1-Potential for Protect.	80.500,00
P5	Carotid Patch	1-In development	5-Granted Pat. Cl.	360.000,00
P6	Catheze	5-Ship and Selling	2- Pat. Pending	42.000,00
P7	Quickpure Technology	1-In development	5-Granted Pat. Cl.	360.000,00
P8	ADAM	2- Success Prot	5-Granted Pat. Cl.	208.000,00
P9	Cardiac Devel Res.	1-In development	5-Granted Pat. Cl.	138.000,00
P10	Respiderm	2- Success Prot	2- Pat. Pending	459.000,00
			Total	**1.983.500,00**

Tabla A.2: Proyectos seleccionados y variables

El ejercicio de evaluación se compone de, como máximo, tres etapas, ya que en función de que se llegue a una solución en cada una de ellas, no sería necesario pasar a la siguiente. El calendario previsto para todo el ejercicio de evaluación es el siguiente:

1. Fase de Comunicación de Preferencias (exploración Individual): Del 5 al 12 de marzo.
2. Fase de Negociación: Del 15 al 20 de marzo.
3. Fase de Votación: Del 21 al 24 de marzo.

A.1.2. Módulo de Comunicación de Preferencias

Una vez planteado por el administrador el problema en SKITES, es el momento para que los evaluadores introduzcan en el sistema sus preferencias, en la parte denominada como exploración individual del problema. Para acceder a este módulo, hay que entrar en el vínculo previsto al efecto. A continuación, según se indica en la figura A.1, hay que registrarse en el sistema, introduciendo usuario y clave que se ha proporcionado.

Figura A.1: SKITES: Registro de entrada

A continuación, según se muestra en la Figura A.2, se plantean los problemas para los que se buscan soluciones, siendo el que nos ocupa SKITES Pilot test, Preferencias:

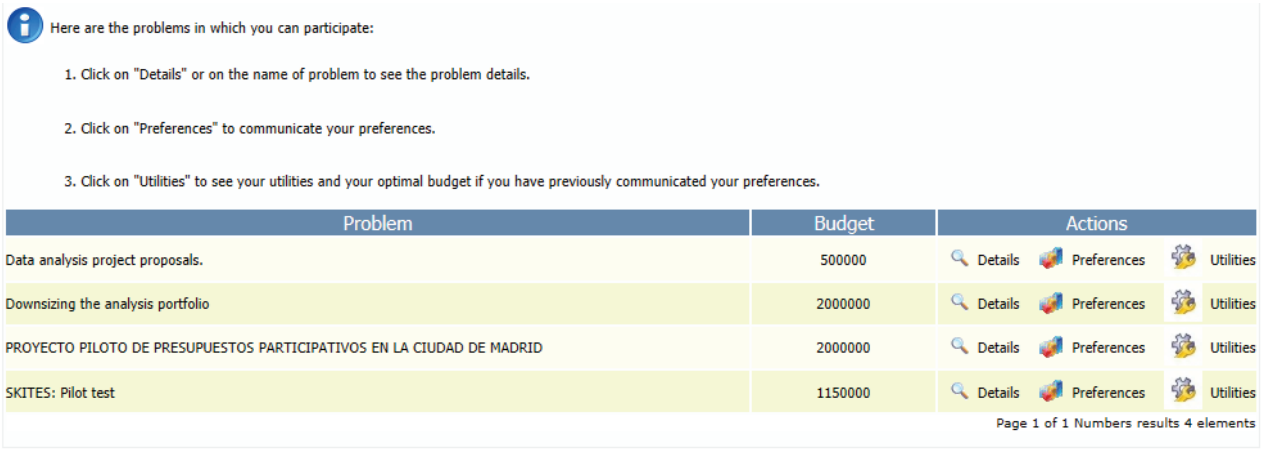

Figura A.2: SKITES: Selección de Problema

En este punto, y de acuerdo con la metodología, el evaluador, de acuerdo a sus preferencias debe comunicar, qué peso quiere dar a cada uno de los atributos, y el valor mínimo y máximo que daría a cada uno de ellos. Para facilitar el ejercicio los valores mínimos y máximos , ya han sido incluidos por el administrador. Los atributos seleccionados para este ejercicio piloto representan información disponible de manera directa o indirecta en el sitio

web http://innovationsupplychain.com/.

De acuerdo con la Figura A.3, los evaluadores deben introducir la información relativa al peso que cada evaluador quiere dar a cada uno de estos atributos. Se recuerda que la suma de los pesos a otorgar, tiene que ser obligatoriamente 100:

Figura A.3: SKITES: Comunicación de pesos a variables

El siguiente paso, los evaluadores deben definir los puntos intermedios para cada atributo. Para ello, como se ilustra en la Figura A.4, deben pulsar en el botón de *Quantifying Preferences*:

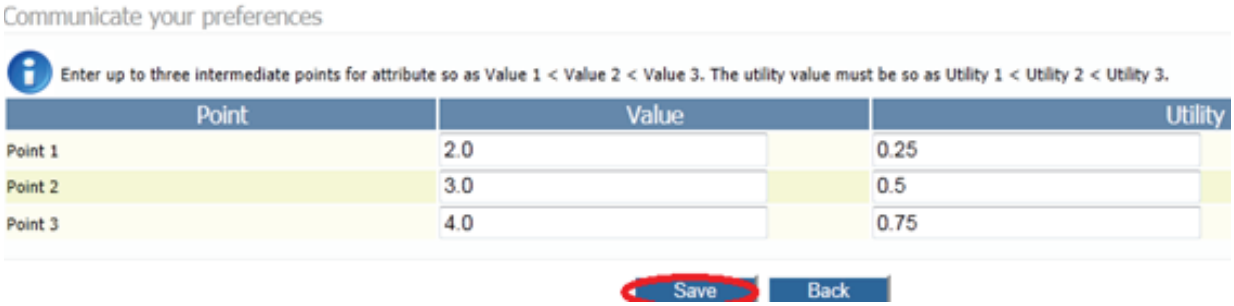

Figura A.4: SKITES: Definición de Puntos intermedios

En caso de que un evaluador quiera redefinir estos valores intermedios, puede hacerlo pulsando sobre *requantifying preferences*. Una vez concluido este proceso, el evaluador debe pulsar como se ilustra en la Figura A.5, sobre 'Finish'.

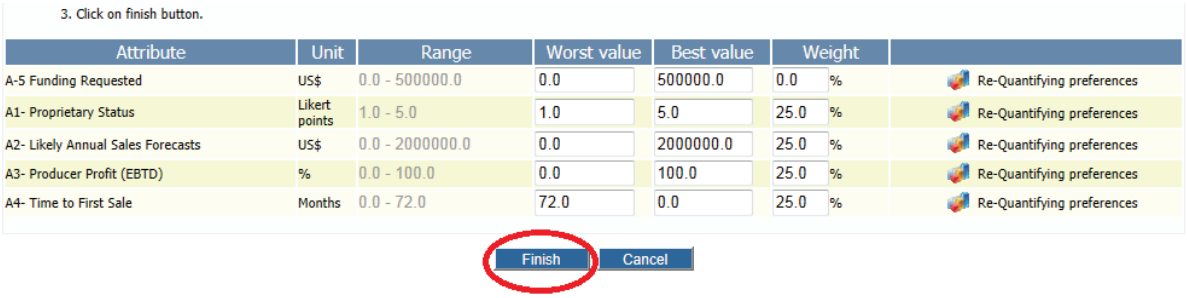

Figura A.5: SKITES: Comunicación de Preferencias

Una vez hecho esto, el sistema nos devuelve a la pantalla principal, como se ilustra en la Figura A.6. Para conocer la cartera de proyectos óptimo para el evaluador es necesario pulsar sobre *Utilities*, en la línea correspondiente a SKITES Pilot-test.

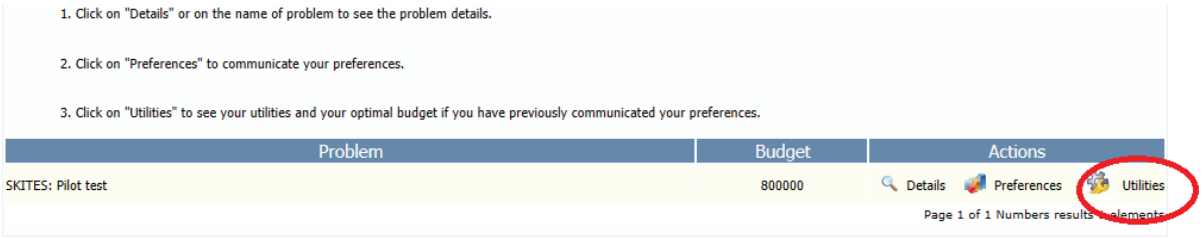

Figura A.6: SKITES: Acceso a resultados exploración individual

Así, en primer lugar, el sistema nos ofrece los resultados individuales sobre las utilidades, en términos porcentuales, ordenando los proyectos de acuerdo a tales utilidades, véase Figura A.7:

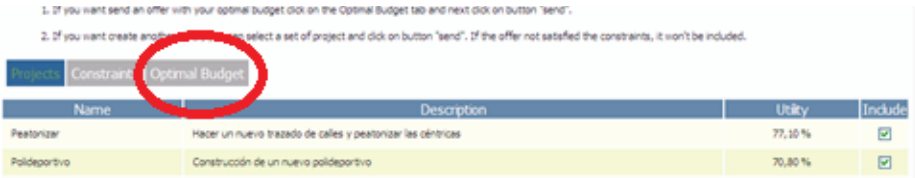

Figura A.7: SKITES: Resultado de Utilidades asignadas a proyectos

Pulsando sobre *optimal budget*, seleccionamos la cartera óptima de proyectos, de acuer-

do a la valoración que se ha dado sobre cada uno de los atributos, como se ilustra en la Figura A.8.

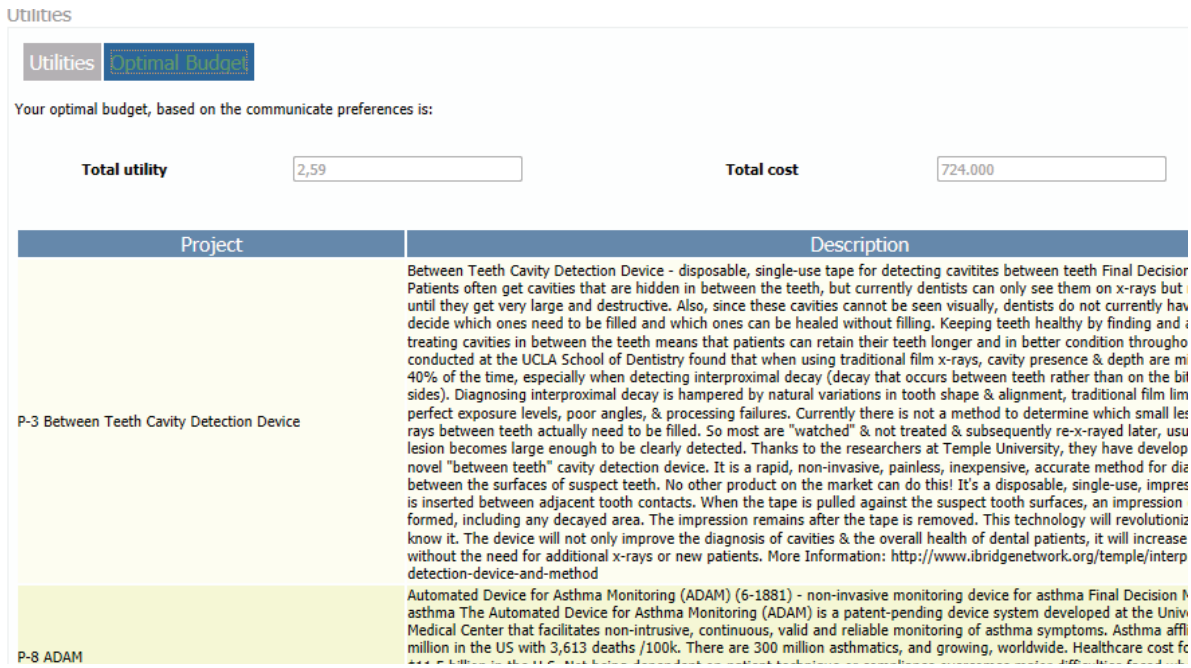

Figura A.8: SKITES: Proyectos seleccionados por un evaluador

A.1.3. Módulo de Negociación

Lo más normal es que tras la fase de comunicación de preferencias, haya discrepancias entre los evaluadores, y por ello, sea necesario activar procesos de comunicación para determinar si se puede llegar a una solución conjunta estableciendo comunicación entre ellos. En esta fase, los evaluadores, de acuerdo a su exploración individual y las utilidades identificadas para los diferentes proyectos, pueden hacer propuestas al resto de evaluadores. Para ello, lo primero es entrar en el módulo de negociación

Al entrar en SKITES, los evaluadores podrán ver el listado de todos los proyectos junto con las utilidades respectivas para cada uno de ellos, como se ilustra en la figura A.9:

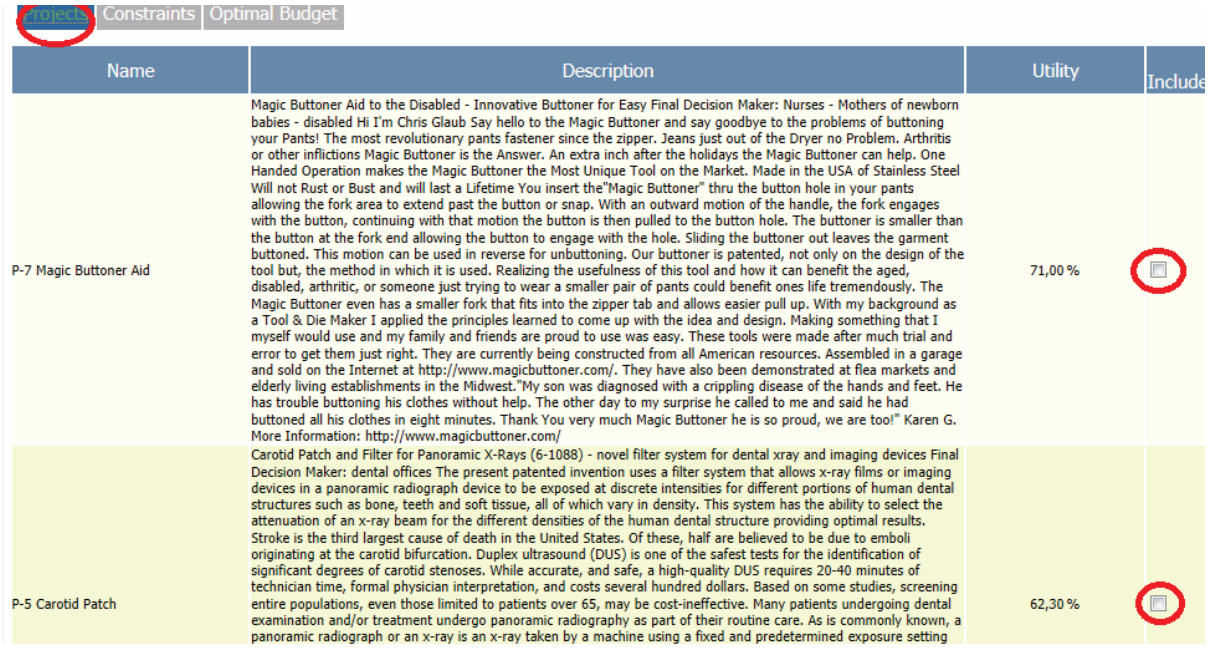

Figura A.9: SKITES: Selección de proyectos por un evaluador

Sobre todos los proyectos, los evaluadores pueden o bien compartir su cartera de proyectos, de acuerdo al presupuesto óptimo identificado en la fase de exploración individual, o bien seleccionar los que ellos vean como más relevantes, cumpliendo los requisitos de las restricciones incluidas y enviarlas al resto, como en las figuras A.10 y A.11:

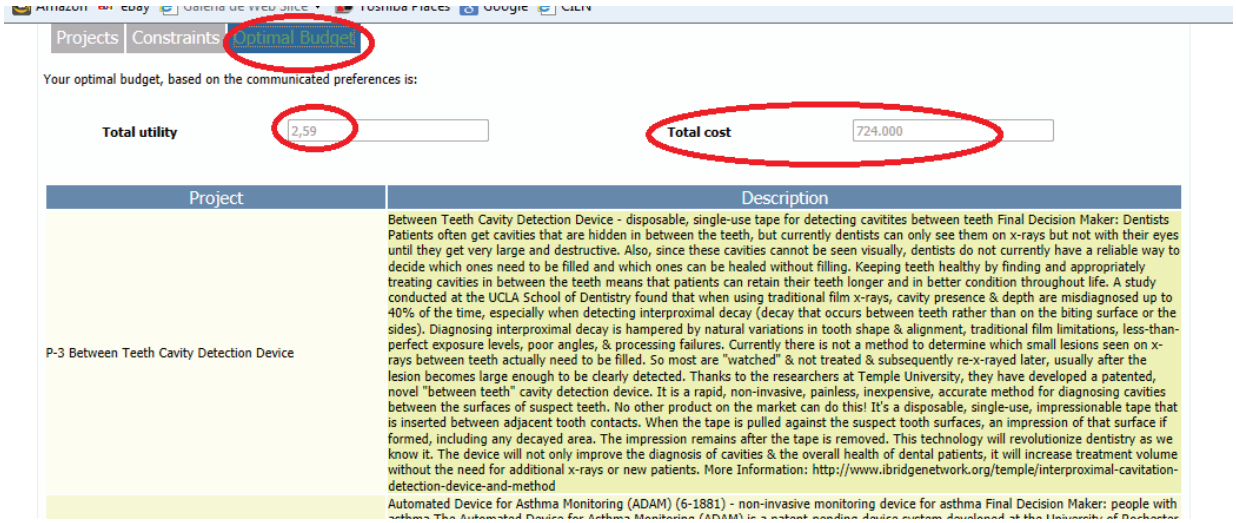

Figura A.10: SKITES: Envío de Presupuesto óptimo

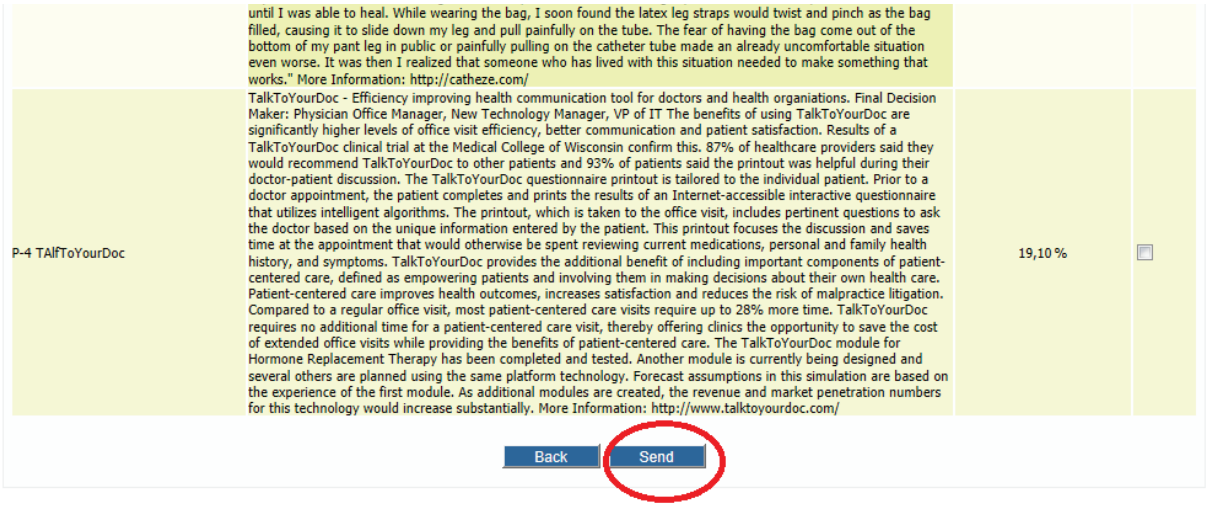

Figura A.11: SKITES: Envío de Propuesta

Tras ello, la oferta queda publicada en el sistema como ilustra la figura A.12, y el resto de evaluadores pueden acceder al sistema para aceptar alguna de esas ofertas, o rechazarlas, o publicar sus propias ofertas.

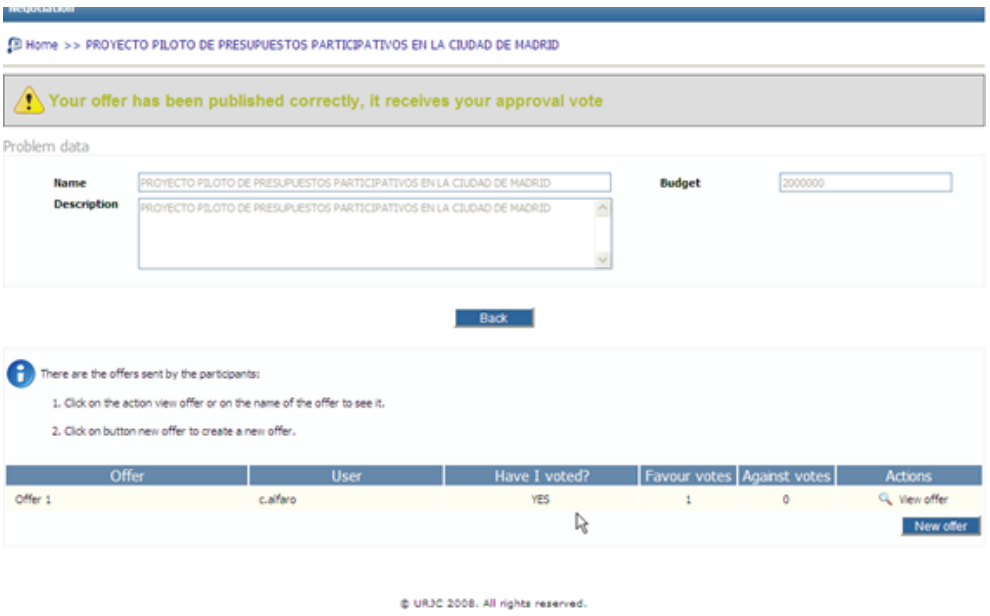

Figura A.12: SKITES: Publicación de Oferta

A.1.4. Módulo de Votación

A este módulo sólo será necesario acceder, si no se alcanza un acuerdo en la fase anterior. En este punto, cada evaluador accederá al módulo de votación y tan sólo tendrá que hacerse un ejercicio de votar sobre los proyectos. La forma de votación será la selección (1) o no (0) de los proyectos que estime conveniente, como se ilustra en la Figura A.13. Se observa que votar por todos los proyectos es equivalente a votar por ninguno de ellos. De esta manera, se seleccionarán los proyectos con más votos y que cumplan con las restricciones establecidas.

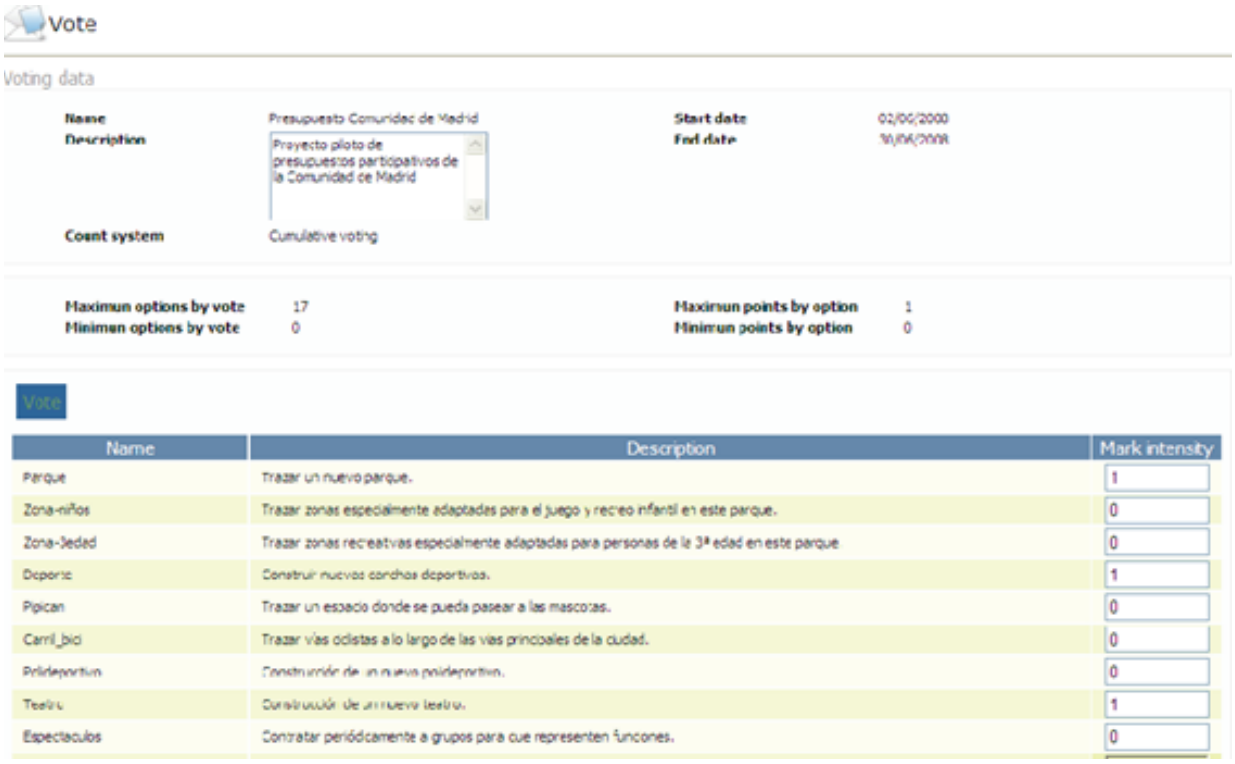

Figura A.13: SKITES: Publicación de Oferta

Si el voto no satisficiera las restricciones, el sistema devolverá un aviso de voto no válido, mientras que si es válido el programa lo grabará.

MUCHAS GRACIAS

A.2. Detalle de los Proyectos a Evaluar

Project 1:

CompressionAssist-Lubricant for Compression Stocking Applications - Donning Lubricant for Compression Garment

Final Decision Maker: compression garment user

Are you required to wear a compression garment or device?

Compression Assist® is the first topical skin lubricant that has been proven to eliminate your daily struggle to put on and take off medically required compression stockings, arm sleeves and other compression support devices.

It is the only product that leaves no greasy residue or odor. Patient comfort is increased 80% by reducing perspiration and chafing. It eliminates the need for assistance to apply pressure garments over 50% of the time.

CompressionAssist reduces the risk of potentially life threatening complications resulting from not being able to correctly put on medically required compression garments. Comes in a 2-oz. easy-application dispenser, enough for 6 weeks or more of daily use.

CompressionAssist has already improved thousands of satisfied patients' quality of life and is highly recommended by health care professionals. It was developed specifically for use with compression devices. Why continue to suffer with mechanical application aids, or inefective creams when CompressionAssist is available?

Investment Required: 60.000 US$. More Information: http://innovationsupplychain.com/innovations/report.php?id=5496 and http://www.compressionassist.com/

Project 2:

Neonatal Electronic Assisted Stethoscope

Final Decision Maker: Doctors, interns, nurses in neonatal units

FIT Kits Family Activity Kits- The first activity system for families of those suffering from dementia Final Decision Maker: Consumers who have a family member suffering from dementia Caring for a family member with memory loss can be physically and emotionally demanding. It can be challenging to find ways to have fun together as communication skills, motivation, and mood often diminish. It's important to create opportunities to use existing capabilities to bring out the best in everyone.

Introducing FIT Kits Family Activity Kits - the first and only activity materials designed for families to use with their loved one with dementia to promise that interactions, visits, and the time spent together will be less stressful and more enjoyable for everyone.

The Kits' interactivity materials can be enjoyed together or by oneself at all levels of memory loss and in any setting by people of all ages. FIT Kits can help you enjoy time together with your family member with dementia in a meaningful activity or give you a break while your loved one is safely occupied.

FIT provides a variety of activity materials to choose from ensuring there are always items to try depending on your family member's mood or preference that day. The Kits' resource materials include a video and written guide that show different ways to use the materials.

FIT Kits have been designed based on research that the FIT team has been involved with over the past 15 years. This research showed that doing meaningful activities together, something that's appealing and fun, can transform a stressful or negative experience into something calming and positive.

The development and testing of FIT Kits was made possible through a grant provided by the National Institute on Aging (NIA). NIA is part of the U.S. NIH.

Investment required: 56.000 US$. More Information: http://www.fitkits.co/

Project 3:

Between Teeth Cavity Detection Device - disposable, single-use tape for detecting cavitites between teeth

Final Decision Maker: Dentists

Patients often get cavities that are hidden in between the teeth, but currently dentists can only see them on x-rays but not with their eyes until they get very large and destructive. Also, since these cavities cannot be seen visually, dentists do not currently have a reliable way to decide which ones need to be filled and which ones can be healed without filling. Keeping teeth healthy by finding and appropriately treating cavities in between the teeth means that patients can retain their teeth longer and in better condition throughout life.

A study conducted at the UCLA School of Dentistry found that when using traditional film x-rays, cavity presence and depth are misdiagnosed up to 40% of the time, especially when detecting interproximal decay (decay that occurs between teeth rather than on the biting surface or the sides). Diagnosing interproximal decay is hampered by natural variations in tooth shape and alignment, traditional film limitations, less-than-perfect exposure levels, poor angles, processing failures. Currently there is not a method to determine which small lesions seen on x-rays between teeth actually need to be filled. So most are "watched" and not treated and subsequently re-x-rayed later, usually after the lesion becomes large enough to be clearly detected.

Thanks to the researchers at Temple University, they have developed a patented, novel "between teeth" cavity detection device. It is a rapid, non-invasive, painless, inexpensive, accurate method for diagnosing cavities between the surfaces of suspect teeth.

It's a disposable, single-use, impressionable tape that is inserted between adjacent tooth contacts. When the tape is pulled against the suspect tooth surfaces, an impression of that surface if formed, including any decayed area. The impression remains after the tape is removed.

Investment required: 220.000 US$. More Information: http://www.ibridgenetwork.org/temple/interproximal-cavitation-detection-device-and-method

Project 4:

TalkToYourDoc - Efficiency improving health communication tool for doctors and health organiations.

Final Decision Maker: Physician Office Manager, New Technology Manager, VP of IT

The benefits of using TalkToYourDoc are significantly higher levels of office visit efficiency, better communication and patient satisfaction. Results of a TalkToYourDoc clinical trial at the Medical College of Wisconsin confirm this. 87% of healthcare providers said they would recommend TalkToYourDoc to other patients and 93% of patients said the printout was helpful during their doctor-patient discussion.

The TalkToYourDoc questionnaire printout is tailored to the individual patient. Prior to a doctor appointment, the patient completes and prints the results of an Internet-accessible interactive questionnaire that utilizes intelligent algorithms. The printout, which is taken to the office visit, includes pertinent questions to ask the doctor based on the unique information entered by the patient. This printout focuses the discussion and saves time at the appointment that would otherwise be spent reviewing current medications, personal and family health history, and symptoms.

TalkToYourDoc provides the additional benefit of including important components of patient-centered care, defined as empowering patients and involving them in making decisions about their own health care. Patient-centered care improves health outcomes, increases satisfaction and reduces the risk of malpractice litigation. Compared to a regular office visit, most patient-centered care visits require up to 28% more time. TalkToYourDoc requires no additional time for a patient-centered care visit, thereby offering clinics the opportunity to save the cost of extended office visits while providing the benefits of patient-centered care.

The TalkToYourDoc module for Hormone Replacement Therapy has been completed and tested. Another module is currently being designed and several others are planned using the same platform technology.

Investment required: 80.500 US$. More Information: http://www.talktoyourdoc.com/

Project 5:

Carotid Patch and Filter for Panoramic X-Rays (6-1088) - novel filter system for dental xray and imaging devices

Final Decision Maker: dental offices

The present patented invention uses a filter system that allows x-ray films or imaging devices in a panoramic radiograph device to be exposed at discrete intensities for different portions of human dental structures such as bone, teeth and soft tissue, all of which vary in density. This system has the ability to select the attenuation of an x-ray beam for the different densities of the human dental structure providing optimal results.

Stroke is the third largest cause of death in the United States. Of these, half are believed to be due to emboli originating at the carotid bifurcation.

Duplex ultrasound (DUS) is one of the safest tests for the identification of significant degrees of carotid stenoses. While accurate, and safe, a high-quality DUS requires $20 - 40$ minutes of technician time, formal physician interpretation, and costs several hundred dollars. Based on some studies, screening entire populations, even those limited to patients over 65, may be cost-ineffective.

Many patients undergoing dental examination and/or treatment undergo panoramic radiography as part of their routine care. As is commonly known, a panoramic radiograph or an x-ray is an x-ray taken by a machine using a fixed and predetermined exposure setting that rotates around the head of a patient to give the dentists a picture of the patient's teeth, jaws and other important information.

The present invention has several advantages. First, using the carotid filter will improve the diagnostic realm and quality of an otherwise routine dental exam. Secondly, embodiments of the present invention will improve the positive predictive value for carotid disease and prompt further evaluation of carotid disease with, for example, duplex ultrasound.

Investment required: 360.000 US$. More Information: http://www.urmc.rochester.edu/technology-transfer/find-technologies/index.cfm?TechnolID=25957

Project 6:

Catheze - secure leg bag holder for patient

Final Decision Maker: Patient

Catheze helps anyone who uses a catheter leg bag regain the freedom of an active and mobile lifestyle. Users of Catheze can confidently get out in public- and even engage in activities such as bicycling,running, or walks with the family. They can return to their normal, active lifestyle.

Catheze is the only catheter bag system that fully relieves the weight of the catheter bag by using a patented system that holds the catheter bag firmly so it will stay in place all day long! The patent pending Catheze is the only catheter system that helps you to move freely, with no pinching of your skin, pulling of the catheter tube, or worrying about the bag sliding down your leg. Catheze is lightweight,adjustable, secure, discrete and comfortable. Catheze helps you return to your active lifestyle-and not leave you homebound.

Dwight says "Until I finally found Catheze my life was very limited with fear of the catheter slipping down, as the leg is tapered and this the natural tendency for the supports for most bags.The Catheze system has totally given me my life back in on one of the hottest summers on record."

Inventor Deirdre Cozzens says "My 1st hand experience with the catheter bag was after my bladder was cut during my C-section. I was required to use a catheter until I was able to heal. While wearing the bag, I soon found the latex leg straps would twist and pinch as the bag filled, causing it to slide down my leg and pull painfully on the tube. The fear of having the bag come out of the bottom of my pant leg in public or painfully pulling on the catheter tube made an already uncomfortable situation even worse. It was then I realized that someone who has lived with this situation needed to make something that works."

Investment required: 42.000 US$. More Information: http://catheze.com/

Project 7:

Quickpure Technology. Small ozone based water purifiers and health related products. - Water purification Counter top purifier for Home/Office

Final Decision Maker: Anyone who buys bottled water.

Alab offers licenses for patented breakthrough Quickpure Technology for small ozone based water purifiers and health related products. The inventor/president has a PhD in Chemistry, with 25 years of R&D work at Alab. He has received 17 U.S. patents and was named Inventor of the year by the Rochester, NY Patent Lawyers Association. Why not make your own bottled water No more plastic bottles, to add to the recycling and environmental problems! Many people have gotten sick from city or tap water. The Quickpure technology eliminates that possibility. No more bad tasting nor foul smelling water. Water filters currently on the market, only filter particles. This is the only water purifier on the market (only one meeting EPA legal requirement of killing all germs).

Health Impact: This is the ONLY personal use purifier that kills ALL water-borne bacteria! Many people have gotten sick from city or tap water. The Quickpure technology has been tested by independent laboratories. The laboratory reports show proof of the product claims. The product patent is Worldwide. Only water purifier on the market (only one meeting EPA legal requirement of killing all germs). Taste improvement using same process as bottled water. Reduction of dissolved water contaminants such as iron, sulfide, arsenic and oxidizable organic chemicals.

Economical Impact: Much less expensive and more convenient than bottled water. No installation required, very quick and easy to use, fun to watch. Filter replacement only once a year.

Environmental Impact: Many consumers will switch from bottled water for lower cost, greater convenience, reliable supply in emergencies, OR will upgrade from cheap filters to gain the health benefit of purification and faster, more effective water treatment. Marketing will be aided by adverse bottled water publicity about environmental impact of used bottles.

Funding required: 360.000 US$.More Information: http://www.quickpure.com/

Project 8:

Automated Device for Asthma Monitoring (ADAM) (6-1881) - non-invasive monitoring device for asthma

Final Decision Maker: people with asthma

The Automated Device for Asthma Monitoring (ADAM) is a patent-pending device system developed at the University of Rochester Medical Center that facilitates non-intrusive, continuous, valid and reliable monitoring of asthma symptoms.

Asthma afflicts nearly 24 million in the US with $3,613$ deaths /100k. There are 300 million asthmatics, and growing, worldwide. Healthcare cost for asthma is about 11.5 billion $ in the U.S.

Not being dependent on patient technique or compliance overcomes major difficulties faced when using other monitoring devices. Continuous automatic symptom monitoring, in real-life environments, with selective capturing of identified parameters as well as activity levels would provide more accurate monitoring, treatment and management of asthma.

Investment required: 208.000 US$.

More Information: http://www.urmc.rochester.edu/technology-transfer/find-technologies/index.cfm?TechnolID=1377230

Project 9:

Cardiac Development Research (UAMS 4-20) - novel research for cardiovascular disease

Final Decision Maker: research labs

It is well appreciated that the mammalian adult heart undergoes a number of changes with advancing age and the identification of therapeutic targets to influence these age dependent changes would improve the quality of life for many elderly. Recent studies indicate that one of the key proteins in muscle and other tissues, SRF, is implicated in the regulation of cardiac genes during development and during adult. These factors regulate a number of immediate-early and muscle-specific genes, and also serve to regulate cell proliferation, cell size, and cell survival.

This available technology describes a gene and protein sequence for a protein that is associated with development and remodeling of the heart in humans and mice. This is the first time any researchers have isolated this particular protein that holds much promise in the cardiac field.

The regulation of the levels of this protein and it impact on the biology of cardiac tissue offer a unique new target for control of events involved in cardiovascular aging and the potential to reduce the rate of development of various forms of cardiovascular disease.

This patented research was developed at the University of Arkansas for Medical Sciences.

Investment required: 138.000 US$.

More Information: http://www.uams.edu/update/absolutenm/PPL.Search$_{b}$*ioventures.asp*

Project 10:

Respiderm non-invasive medical gas delivery system - 100% Natural Therapy for Patients with peripheral arterial disease

Final Decision Maker: Home User

Respiderm is the first and only non-invasive and portable product used to heal diabetic and non-healing wounds and manages high blood pressure in the same time in a home environment. It requires only a 3 min. preparation and the treatment only takes 20 minute. Measurable health effect can be observed after the first use. The Respiderm device does not require any special skills or training to use. It is completely safe and user friendly for almost all ages. It is easy to use as changing a light bulb. The product can be used while watching television or reading a book. The Respiderm device can be used practically anywhere where the user can sit down or lay down and only a cup of hot water is needed.

Respiderm provides a low cost treatment to patients. It is also a great income generating product to home healthcare service providers. Tests conducted in Europe and in the US shows that Respiderm balances high blood pressure during the first USA and heals diabetic wounds in 30-60 days.

Investment required: 459.000 US$.

More Information: http://www.respiderm.com/