PREDICTION MARKETS AS AN INNOVATIVE WAY TO MANAGE R&D PORTFOLIOS

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Abstract

R&D portfolio management is a critical task with which the majority of the large companies are confronted. Despite its wide implementation in companies, there are no widely accepted and used methods to perform this task. Each company uses its own mix of various qualitative and quantitative methods to achieve its goal. The objective of this thesis is to explore the adequacy to use a prediction market for supporting the R&D portfolio management process. We chose prediction markets to perform this task since their aggregation mechanisms and information discovery process seems to solve most of the current issues of the R&D portfolio management process.

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1 INTRODUCTION

R&D portfolio management is a critical process in large organizations despite the fact that there are no well-established methodologies or tools to support it. As prediction markets are growing in importance, we propose to use such tools to support the R&D portfolio management process. This paper will describe the research question and the relevance of our work in the next section. Then, the methodology based on a design science framework will be reviewed in section 3. Next, related work will be exposed in section 4. Finally, the last section presents our contribution. There is also an appendix containing the progress report of the thesis.

2 RESEARCH QUESTION

The research objective is to explore the adequacy to use a prediction market for supporting the R&D portfolio management process. During this research, we will design and evaluate an IT artifact composed of different prediction markets instantiations.

The R&D project portfolio selection is a periodic activity that aims at optimizing the research effort of the company, while enabling it to select a portfolio, which corresponds to its strategic objectives and without exceeding the resources available. Several studies evaluated the practices in “Fortune 500” companies, finding that there is neither single method nor a solution applicable to all companies. The most recent investigations showed that to be effective, portfolio management must apply a mix of various qualitative and quantitative methods. However, the use of quantitative methods presents weaknesses, mainly for (1) selecting the right criteria, (2) collecting the data, (3) and negotiating the portfolio between the different stakeholders. Many authors proposed different frameworks for selecting R&D projects portfolio (Archer and Ghasemzadeh, 1999; Chien, 2002; Cooper, Kleinschmidt and Edgett, 2001). The invariants of these different frameworks are: (1) maximizing the value of the portfolio, (2) achieving a balanced portfolio and (3) building strategy into the portfolio.

Our research assumption is that a specifically designed prediction market could improve the R&D portfolio management process. In our situation, prediction markets are future electronics markets (e-markets) concerning the potential projects of the portfolio. Prediction markets collect information coming from different actors, who trade on the market, and aggregate this information in an automatically negotiated equilibrium price, corresponding to the valuation of the project. All actors directly or indirectly linked to the project, can trade (buy or sell) contracts concerning the projects, based on their own appreciation of the project. The traders are on one hand the leaders and the teams of the project, but also the senior management, people from marketing, finance, as well as from all the other businesses units concerned by R&D. Their narrowly expertise of a particular company activity, like research, but also marketing, sales, customer care or finance will enable them to build their own opinion about the project, under the particular lighting of their activity field. The result of all aggregated appreciations will de facto include a multitude of implicit criteria related to all company activities. Such market mechanism addresses the three weaknesses mentioned above: (1) no more criteria to be explicitly selected, (2) less data to be manually collected, and (3) fewer issues to be explicitly negotiated between actors. These three activities are implicitly replaced by the trading (buy and sell) of claims concerning the portfolio contents. In addition, the prediction markets are very powerful tools to discover and aggregate the information disseminated between many people. Thus, using prediction markets should not only make all the process more effective, but also increase the quality of the decisions, based on information that is more complete.

To support the whole process, we designed our IT artifact to support the three invariant steps included in most frameworks. Each step required specific prediction market design as presented in Figure 1.

2.1 Maximizing the value of the portfolio

The output of this first step is a dynamic ranking of all projects (new and running). The goal is to be able to discover the best projects between all propositions. To reach this goal, we propose to use a prediction market on which contracts are created for each project and put on the market by projects leaders via a simple IPO process. The contracts are then exchanged on a scale from 0 to 100, representing the probability that they achieve their goals. Each contract referring to a specific project proposal, gathering all useful information needed for the comprehension of the project goals. Contrary to the traditional methods, it is not necessary to collect specific indicators allowing a comparison between the projects, the comparison being done in an implicit way by the price equilibrium at a given time. The scale being the same for all projects, it becomes very easy to compare the various projects and to retain those of which the potential is the most promising, represented by a high price on the market.

2.2 Achieving a balanced portfolio

The second stage consists in balancing the portfolio so that the mix of projects is the most effective for the organization. Based on the principle that the sum of the best projects does not necessary correspond to the best portfolio (Cooper et al., 2001).

We propose to transfer the projects that were adopted during the first stage on a new prediction market. To reach a balanced portfolio, we propose to create a market joining all projects into a single portfolio. So that all projects are interdependent and the variations of a project's price will have effects on all projects in the portfolio. The balance between the projects will be done in a gradual way according to the price trends of each project. At the end of the process, we will retain the most valued projects. Thus, we obtain the best portfolio according to the available projects.

2.3 Building strategy into the portfolio

The last stage of the process takes the internal and external environment of the organization into account.

In this case, we again propose to use a prediction market to obtain and aggregate the required information. However, we propose that this last stage directly influence the second stage. Consequently, we will use a prediction market tool to study the environment. This prediction market will gather individual contracts related to the interest centers of the organization as well as to the elements of its strategy. The contracts, relating to the evolution of a particular technology or research field, will be used as indicators to support the transactions made during the second stage. We consequently propose to make this third stage implicit. This market will be continuously run alongside the two others, so that information gathered from this market could be used by traders as indicators to support their trades on the two others one. This results in an implicit aggregation of strategic and environmental information during the establishment of a balanced portfolio.

Relevance of our approach

We propose to use a new method, based on three prediction markets designs, and gathered in an IT artifact. This IT artifact supports the selection and balance of R&D projects portfolios process. Our approach is based on the intuition that the information needed to manage the portfolios is generally available within the company in a subjective form. On the other hand, prediction markets are able to discover and incorporate this information without the need of quantifying these data through a resources intensive process. Consequently, supported by this artifact, managers should be able to make their decisions in a faster way, while being better informed.

We will evaluate the relevance of our research assumption in three ways: the global process improvement (wider participation, effective data collection and userfriendliness of the method), the better data accuracy (accurate and up-to-date data) and the increased quality of decisions. These evaluations will be made during the testing of our different prototypes and completed by interviews with decision makers involved in the process.

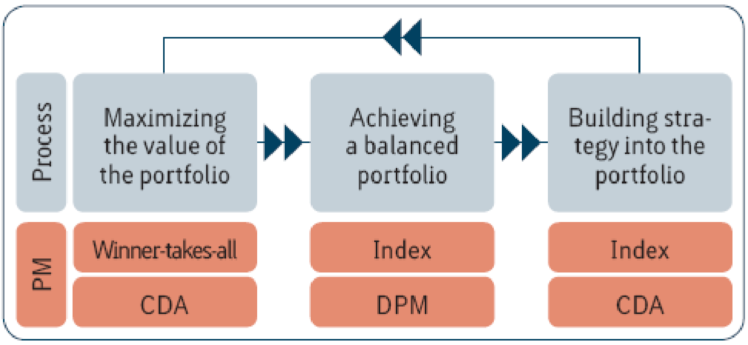

Figure1: Three Steps of the R&D Portfolio Management Process and the Related Prediction Market Design

3 METHODOLOGY

Our research methodology is based on a design science approach

As a matter of fact, a suitable research paradigm (design science) applied to information systems has been recently formalized. According to Weber (1987), design science offers IS a much needed paradigm, carving out a niche for that discipline of research. Moreover, according to March and Smith (1995), there are two legitimate kinds of scientific interests in the information systems domain: (i) a natural and social sciences approach seeking to understand reality, (ii) a design science approach aiming at creating artifacts that serve human purposes. Moreover "rather than being in conflict, however, both activities can be encompassed under a broad notion of science that includes two distinct species termed natural and design science" (March and Smith, 1995).

We adopted the IS Research Framework suggested by Hevner et al. (2004) to conduct and structure our research (see Figure 2). The principal elements of the framework are:

- The relevance, that is our research question, as presented in Section 2;
- The rigor, that is the related work and will be presented in Section 4;
- The Application in the Appropriate Environment (lessons for practitioners) and Additions to the Knowledge Base (scientific contribution) that presents our contributions and will be detailed in Section 5;
- The Develop/Build and Justify/Evaluate loop, which is the object of this Section.

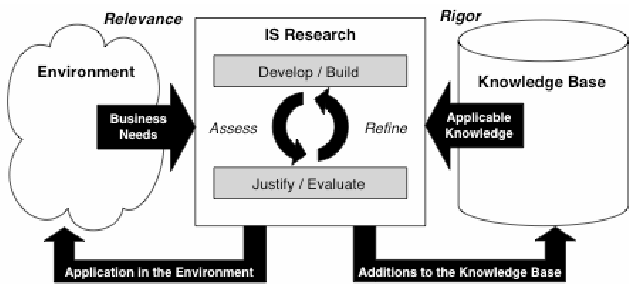

Figure 2: Design Science Research Framework According to Hevner et al.

We will now focus essentially on the heart of the framework: Develop/Build and Justify/Evaluate. Hevner (2004) describes the process as iterations of the build and evaluate loop.

We already run three iterations to test our intuitions in different prediction markets settings applied to the first stage of the R&D Portfolio Management Process (Gaspoz and Pigneur, 2008). As presented in the last section, the artifact will be composed of three parts. Each part will consist of a particular prediction market instantiation, specifically designed to support the various portfolio management process' stages.

3.1 Maximizing the value of the portfolio

The first part consists of a winner-takes-all market, supported by a market-maker algorithm and based on the continuous double auction mechanism (CDA). This market was already used and evaluated within small and large-scale experiments.

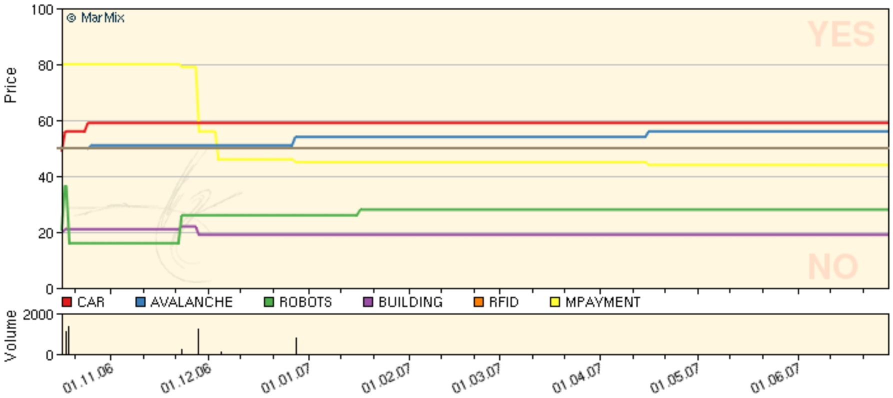

Figure 3: Claims and Quotations from our Prediction Market (MarMix)

The results of the evaluation led us to improve our design in different ways during the build-evaluate loop. From these improvements, we formulated five design propositions for designing a prediction market for R&D portfolio management.

1. It should integrate a standard framework to support claim formulation.
2. It should integrate an easy IPO mechanism to support the innovation process.
3. It should occult the financial mechanisms to reduce the trader's learning curve and increase his incentive.
4. It should allow the combination of group sessions with individual sessions to increase the incentive of the traders.
5. It should integrate an automatic negotiation agent (i.e. market maker) to increase the quality of the evaluation.

These propositions are described in greater detail in (Gaspoz and Pigneur, 2008).

3.2 Achieving balanced portfolio

The second part of the thesis will consist in developing a prediction market composed of unit portfolios and droved by a Dynamic Pari-Mutuel (DPM) algorithm (Pennock, 2004). This configuration enables the creation of interdependent projects portfolios. The settlement price will be indexed on the equilibrium price of the claim at the closing time.

This part is under testing with an expert group in the field of mobile payment. The results will then be compared with results collected with traditional MCDM approaches. They will then be completed by qualitative evaluations based on interviews with selected experts.

3.3 Building strategy into the portfolio

The third part of our work will be devoted to the environment study. It consists on a market constituted by proportional contracts, droved by a market-maker algorithm and based on the continuous double auction mechanism. It will be instantiated within a SNF project constituted by a population of 150 researchers in the mobile information and communication systems (MICS) field. The experiment will last six months and will be followed by a quantitative evaluation based on the researchers' feedbacks as well as on objective indicators (scientometrics).

Finally, following these three instantiations, we will be able to finalize the IT artifact and evaluate it within research centers. It will be used to support the entire process of R&D project portfolio selection in an academic environment on one hand and in a private R&D center on the other hand. The IT artifact evaluation will be done by carrying out, in parallel, the process according to a traditional method, and by comparing the obtained results. This will enable us to evaluate the relevance of our research idea as described in Section 2. This evaluation will then be completed by a qualitative one, based on interviews with selected people, to obtain information on the advantages and disadvantages of this new approach. This qualitative evaluation will permit us to test the relevance of our approach.

In conclusion, using Hevner's framework we will iteratively run IT artifacts in three different configurations. This will allow us, by successive adaptations, to design an IT artifact supporting the complete R&D portfolio management process. Finally, this IT artifact will be instantiated and evaluated in two different environments in order to test our research assumptions. The relevance of our research, already been presented at Section 2, and the rigor, being presented in the following Section, we still have to present our contributions in the environment as well as in the knowledge base. This will be the subject of the Section 5

4 RELATED WORK

The related work relies on three separated domains: R&D portfolios management, prediction markets, technology foresight and environment scanning.

Our research is at the crossroad of three research domains. We will first present the R&D portfolio management literature and raise the most frequent issues, before presenting the prediction markets and their possible contributions.

4.1 R&D Portfolio Management

Chien (2002) provided an extensive literature review on portfolio selection and showed the inherent limitations in the existing R&D project selection models as follows: (1) inadequate treatment of multiple, often interrelated, evaluation criteria; (2) inadequate treatment of interrelationships among projects; (3) inability to handle non-monetary aspects; e.g. diversity among projects; (4) no explicit recognition and incorporation of the experience and knowledge of the R&D managers (i.e. the decision makers) and (5) perceptions by R&D managers that the models are difficult to understand and use.

Cooper (2001) showed that the combination of individually good projects unnecessarily constitutes the optimal portfolio for the firm. This is often the case with firms having too many trivial projects and not many projects to yield major competitive advantage. Many authors proposed different frameworks for selecting R&D projects portfolio (Archer and Ghasemzadeh, 1999; Chien, 2002; Cooper et al., 2001; Stummer and Heidenberger, 2003).

Liyanage refers to more than 200 quantitative and qualitative methods for selecting R&D projects in his study (1999). All these methods rely on various data, which must be collected/evaluated or estimated before being used in the models. The principal issue concerning these data is their inaccuracy or unreliability, making the financial methods yielding the worst portfolio results (Cooper et al., 2001). This is not so much from the fact that these models lack rigor; rather, it results from very poor data and forecasting in new product projects.

4.2 Prediction Markets

There are many definitions of prediction markets, idea futures (IF) markets, information markets, virtual stock markets (VSM), securities trading of concepts (STOC) markets. Hanson, one of the inventors of this concept wrote:

"Information markets can be used to elicit a collective estimate of the expected value or probability of a random variable, reflecting information dispersed across an entire population of traders. The market prediction is not usually an average or median of individual opinions, but is a complex summarization reflecting the game-theoretic interplay of traders as they obtain and leverage information, and as they react to the actions of others obtaining and leveraging their own information." (Hanson and Oprea, 2004).

Prediction markets have been used in many different public contexts and used as case studies in many scientific papers (Bell, 2006; Berg and Rietz, 2003; Hanson, 1992; Plott and Chen, 2002; Wolfers and Zitzewitz, 2004). They have also been used inside corporations like HP, Google, Microsoft, Siemens, GE, Eli Lilly and much more.

Researchers from different disciplines study prediction markets: politics, economies, law, finance, decision science, and computer science.

A considerable amount of recent research in this domain was conducted to evaluate the potential use and different design possibilities of prediction markets (Berg and Rietz, 2003; Spann and Skiera, 2003; Wolfers and Zitzewitz, 2004, 2006a; 2006b), understand their information aggregation mechanism (Plott and Chen, 2002; Wolfers and Zitzewitz, 2006b), discover how extra accuracy can be obtained by using real money versus play money (Servan-Schreiber, Wolfers, Pennock and Galebach, 2004), study the various implementations of market-makers (Hanson, 1992, 2002, 2003a, 2003b; Pennock, 2004) and to describe the effects of manipulations (Rhode and Strumpf, 2006).

No research really addresses the use of prediction markets to support the R&D portfolio management process.

4.3 Technology Foresight & Environment Scanning

As conveyed by the widely quoted definition (Martin, 1995), “technology foresight is the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and emerging generic technologies likely to yield the greatest economic and social benefits,” the determination of research priorities can be seen as one of the salient foresight objectives (MacLean, Anderson and Martin, 1998; Martin, 1995; Martin and Johnston, 1999). It is also acknowledged that it support the formation of collaborative networks and contribute to the success of innovative activities (Grupp, 1994).

Environment scanning is seen as a necessary first step in the strategic decision-making process providing managers with the necessary information for crafting strategies that are aligned with the environment where they must be implemented (Aguilar, 1967; Beal, 2000; Daft and Weick, 1984; Hambrick, 1982). We identified four principal environmental domains that are considered of strategic importance for the organization: market, value proposition, actor and issue (Camponovo and Pigneur, 2006).

5 OUR CONTRIBUTION

Our contribution corresponds to a new and unified R&D portfolio management approach using prediction markets, based on a design science approach

Our contributions span three dimensions: the IT artifact, the prediction market based R&D portfolio management approach, and a new application of prediction markets. Our IT artifact will be an original working prototype of prediction market designed to support the R&D portfolio management process in real situations. This IT artifact will help managers and teams to support their periodical portfolio review using continuously updated information about their projects. Finally, this IT artifact should be viewed as a proof of concept to build new tools or to incorporate this new approach in existing tools, supported by our five design propositions.

We also will contribute to the R&D portfolio management literature, developing a new management methodology. This prediction market based approach should partially solve the recurring problem: the data collection process. Using this innovative approach, the whole process should be more efficient and transparent for projects leaders. Active on the market, projects leaders are able to introduce new ideas or concepts on the market via IPO and to follow their valuation in real time through the equilibrium price. If our entire hypotheses are verified, this should be a new and innovative way to support the R&D portfolio management process, applicable to all research types. The main advances made with our new methodology are: a highly distributed and participative process, a continuous actualization of the portfolio value, an efficient and cost effective way to discover and aggregate the information disseminated between all actors and an easy to understand resulting indicators.

Finally, our research will support the continuous effort made by the prediction market community to study new and innovative applications for e-markets. Currently, the applications are concentrated around forecasting public events like political elections, new technology adoption or sport results. The utilization of prediction markets in organizations is still at an early stage, more as an opportunity to test the concept than as productive applications. We think that such new applications would help organizations to enter in a new dynamic concerning prediction markets. This would then help to democratize the utilization of this concept and leverage new application opportunities for supporting critical business process.

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A PROGRESS REPORT

This appendix shows the progress of the thesis and what should be done in order to complete it. The thesis is estimated to be done by mid 2009.

A.1 Study of the context (late 2005)

This phase objective was to understand the body of the knowledge of my domain of research. This phase is almost finished but in constant revision.

The prediction markets and R&D portfolio management domains were primarily studied during the writing process of my MS thesis (Gaspoz, 2005). Beside the literature review, some interviews were conducted with researchers in Switzerland to test our research assumption.

A.2 First build and evaluate phase (2006-2007)

During this phase, we developed and experimented a working IT artifact. This prototype is based on a continuous double auction market with a market-maker. It was developed with Python programming language. It was used in three different contexts allowing us to gather many data and a better comprehension of the adoption process by researchers. The first run was a small-scale market instantiated with the collaborators of the IS department, supporting claims on various technical and environmental topics. The goal of this first attempt was to test our main design as well as our interface. The second run was a large-scale market with more than 100 students playing on technological, sociological and economical claims. We tested our market-maker algorithm implementation and various design improvements. Finally, we run our prototype in the MICS community to test the claims formulation, the various incentive mechanisms and the adoption by the researchers. The evaluation of the various experiments conducted with our artifact led us to formulate five propositions to design a predictions market for R&D portfolio management:

A prediction market for R&D should:

- integrate a standard framework to support claim formulation;
- integrate an easy IPO mechanism to support the innovation process;
- occult the financial mechanisms to reduce the trader's learning curve and increase his incentive;
- allow the combination of group sessions with individual sessions to increase the incentive of the traders;
- integrate an automatic trading agent i.e. market maker to increase the quality of the evaluation.

The results were presented and published in various papers. We wrote a working paper presenting our instantiation of the design science framework (Gaspoz and Pigneur, 2007) and we published and presented a paper describing the application of prediction markets to support the first stage of the process at the HICSS Conference (Gaspoz and Pigneur, 2008). Moreover, another paper about prediction market versus MCDM for technology foresight was presented and published in an international workshop (Ondrus, Gaspoz and Pigneur, 2007). We are also part of the National Competence Center on Research (NCCR) for Mobile Information & Communication Systems (MICS) which give us access to a large research center and many researchers.

A.3 Second build and evaluate phase (2007-2008)

This phase is in progress and should be done by the beginning of 2009. The main steps are already described in the previous sections. We will principally assemble the three prediction markets design to form an unified artifact and evaluate its instantiation with mobile payment experts and MICS researchers. The focus of this phase will be principally on the evaluation of our artifact and the validation of our research assumptions.