
Corporate Prediction Markets for Innovation Management

Theoretical Foundations and Practical Examples for Business Use

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Abstract

This chapter summarizes latest developments concerning prediction markets used by corporations during the innovation process. Though not widely-known yet, prediction markets provide the double possibility of organizing dispersed knowledge efficiently and producing accurate forecasts. Many theoretical aspects of prediction markets and also various practical fields of using them (mainly politics and sports results) have been extensively investigated and discussed before by other authors. This chapter deals with the practical use of prediction markets in business and innovation-driven environments. Major fields in which prediction markets can be successfully used in the innovation process are idea creation, idea screening and filtering, concept evaluation, lead user identification, market success forecasting and pricing, demand forecasting, project management and the forecasting of changes in a competitive environment.

1 Introduction

Where innovation marketing and product innovation are concerned, good knowledge of future market environments and conditions is needed to reduce product failure rates and to make sure that companies stay one step ahead of their competitors. Precise predictions in all stages of the innovation process, either long- or short-term, can help to manage marketing planning. For example, it is crucial to find out the best prototypes and ideas in an early stage of the innovation process in order to prevent failure of investments into products and services. In later

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stages, companies ask for the possible market shares of different product variants or for the number of units sold after going to market. To address this problem, it is necessary to improve the innovation process of a firm and support the innovation process with new tools and techniques (Brem 2008) as well as employing external (c.f. Chesbrough 2003; Franke et al. 2006) or internal sources (van Dijk and van den Ende 2002). Prediction markets (PM) are a tool that can help firms to innovate more successfully. They can be defined as

(virtual) markets that organize information with the help of market mechanisms, namely prices and trading. The stock prices of certain assets (e.g. predictions of future market conditions or ratings on new product ideas) represent the valuation of the market players and is assessed through trading on these topics with the help of (virtual) money.

This chapter shows how *prediction markets* (PM) can be used for forecasting tasks or for information aggregation in companies or other organizations. Though these and other fields of use are described, the focus lies on prediction markets that are used or organized by companies (*corporate prediction markets*, CPM). After introducing CPMs, the theoretical foundations of PMs¹ are explained. Practical examples for the use of PMs and more detailed aspects of prediction market design are discussed afterwards.

2 Application of Prediction Markets

2.1 General Fields of Usage

The online-supported use of prediction markets is relatively new, though theoretical foundations were set in the early twentieth century. In the 1920s, the New York Betting Markets already used market mechanisms to bet on the results of political elections (Berneburg 2008). Wall Street traders placed bets on election results. For scientific use, the first popular prediction markets were the *Iowa Electronic Markets* (IEM) that started in the late 1980s. These markets were set up at the University of Iowa to investigate the behavior of individual traders and the market design variable for prediction markets, mainly on political topics, such as presidential or gubernatorial elections. Also those markets were, due to technological progress, the first known to the public to be organized online instead of using real order books or trading agents. Other examples for an early use of PMs are the *Trade-Sports Markets*, where mainly sports results could be traded or the *Policy Analysis Markets*, which dealt with possible targets of terrorist attacks (Polk et al. 2003). Van Bruggen et al. (2010) stated that especially in institutional forecasting and information gathering, prediction markets can be useful.

Before focusing on the innovation management usage of prediction markets, a brief overview over general applications shall be given. Major applications are

¹Sometimes also called *preference markets* (Dahan et al. 2009), *idea futures* (Tziralis and Tatsiopoulos 2007), *information markets* (Hahn and Tetlock 2006) or *virtual markets*.

(1) Political Markets, (2) Sports Markets, (3) Movie Markets, (4) Business and Economic Markets and (5) other markets.

Years ago, Forsythe et al. (1992) or Berg et al. (2003a, b) and many others showed the superiority of the political markets for the prediction of political events, especially elections, over other forecasting methods. Open-to-the-public markets and closed-group markets were both researched. Areas of interest were for example presidential or gubernatorial elections.

Sports markets have been researched by e.g. Luckner et al. (2012). They give a good overview over other sports and sport-betting markets. Events that were forecast include soccer championships such as world cups, European cups, horse racing or American football matches.

As one of the first applications for business-related forecasting, the Hollywood Stock Exchange (HSX) was investigated by numerous articles and authors. Box office revenues of Hollywood movies were to be anticipated by using the principles of markets. Although these markets are well researched, the field of usage is rather special and not easily transferrable to other industries or forecasting tasks. Spann and Skiera (2003) as well as Gruca et al. (2003) or Pennock et al. (2001) have shown the feasibility of forecasting with the help of these public markets.

Field of usage number five is represented by *other* usages such as futures on terrorism targets by the US DARPA and predictions on rainfalls in Australia.

2.2 Corporate Prediction Markets

Although there are several fields where prediction markets have been used, not too many studies have been published on corporate prediction markets (CPM). It remains unclear if this is due to reasons of confidentiality or due to a small prevalence *in praxi*. There are reports about companies such as Abbott Labs, Arcelor Mittal, Best Buy, Chrysler, Corning, Deutsche Telekom, Electronic Arts, Eli Lilly, Frito Lay, General Electric, Hewlett-Packard, Intel, InterContinental Hotels, Masterfoods, Microsoft, Motorola, Nokia, Pfizer, Qualcomm, Siemens, and TNT, as Cowgill et al. (2009) or Graefe (2011) state. Graefe also shows in his literature review that prediction accuracy can be improved when prediction markets are used for business forecasting. But he also supports the call for more extensive research in this field, as Snowberg et al. (2012) do in their article. Following this call, the existing studies in this field shall be summarized and gaps in research will be identified.

The fields in which prediction markets are used for business are shown in Table 1. After that, innovation management usage for corporations is discussed in detail. The table only takes into account prediction markets run in real world setups rather than in hypothetical or experimental environments. Only cases with scientific reports about it were considered. Key design aspects, such as duration, employees involved and subjects of forecasting are shown in the columns.

Some examples are e.g. Ortner (1998), who used prediction markets to find out project timelines e.g. for software projects and showed that this tool is highly

Table 1 Prediction markets for business use: innovation management

Company	Duration	Traders involved	Further information	Innovation support in the field of . . .
General Electric	22 days	Employees	LaComb et al. (2007)	Technology assessment
Hewlett Packard	7 days	Employees	Chen and Plott (2002)	Sales figures
Siemens	3 months	Employees	Ortner (1998)	Project management
Technology Company	36 days	Employees	Soukhoroukova et al. (2012)	Idea sourcing and filtering
Communications	n/a	Employees	Spann and Skiera (2003)	Figures
Finance company	22 days	Employees	Van Bruggen et al. (2010)	Figures
Movie Industry	1 month	Public	Spann et al. (2009)	Lead user identification

accurate compared to qualitative methods of project deadline estimations. Project team members could trade contracts on which a deadline would possibly be realized.

Chen and Plott (2002) showed at Hewlett Packard that the printer sales forecast could be improved in 15 out of 16 cases compared to the official company forecast, with employees trading 1 week.

Yahoo's Tech Buzz Game was a platform to assess technological trends, but no scientific report was published on these markets.

2.3 Innovation Management with Prediction Markets

As shown above, prediction markets can be used in many different settings. Especially for the different stages of innovation management, this tool can be useful. Figure 1 shows the six different stages within the innovation process. In the following paragraph, the theoretical foundations provided by Soukhoroukova (2005) and Cooper (2008) shall be discussed and developed further. As prediction markets can also be useful for supporting product innovations directly after the initial introduction to the market, this phase is shown here as "Market Phase".

At the fuzzy front-end of innovation, there are mainly two problems for innovation managers: the creation and gathering of new ideas and the screening and evaluation of the many ideas that were created in the step before. Prediction markets can support both phases. Users and customers from "the crowd" (van Hippel 2005), as well as employees from different departments can hand in ideas and concepts to the prediction market tool. At the same time, those persons or experts can use the prediction markets for the evaluation of ideas with the help of virtual money and virtual stocks. For example, virtual money can be invested into new ideas for a product (stocks) that were entered by a user, by other users or

Traders (Experts)	Consumers, Marketing, Sales, R&D	Consumers, Marketing, Sales	R&D	Consumers, Marketing	Consumers, Marketing, Sales	Consumers, Marketing, Sales
Innovation Process Stages	Idea Generation and Screening	Concept Evaluation	Design and Engineering	Testing	Launch Phase	Market Phase
Use of Prediction Markets	<ul style="list-style-type: none"> • Idea Identification • Idea Evaluation • Lead User Identification 	<ul style="list-style-type: none"> • Concept Testing • Product Features Evaluation • Product Design 	<ul style="list-style-type: none"> • Decision Support • Collaboration Support • Project Management 	<ul style="list-style-type: none"> • Product Evaluation • Product Enhancement • Target Groups Identification 	<ul style="list-style-type: none"> • Pre-Launch Forecasting 	<ul style="list-style-type: none"> • Post-Launch Forecasting

Fig. 1 Based on Soukhoroukova (2005) and Horn et al. (2014)

employees. The ideas (stocks) with the highest virtual stock price are those which are the most promising ideas.

In the second phase, when ideas have been developed into concepts or mock-ups, a new evaluation phase can be started. Different stocks for different concepts can be presented on a virtual stock market and be traded e.g. by consumers, sales persons, or marketing experts.

During phase three, the design and engineering phase, prediction markets can help to find a consensus amongst persons that are relevant during the creation phase. The markets can act as tools where opinions can be gathered and those stocks that reach the highest virtual market value represent the “right” decision. With the help of this tool, it is possible to find decisions anonymously and thus eliminate problems that derive from hierarchical power structures in R&D teams. In settings, where certain persons shall have higher influence on the outcome of the market, it is possible to promote the opinion of those persons by giving them more virtual initial capital to invest into the markets. With the higher amount of money, they can e.g. influence the stock price more strongly than players with less capital.

Phase four differs little from the concept evaluation phase. Pilot products that are tested with only few customers can be evaluated by marketing personnel or the customers themselves.

During the launch phase and the post-launch or market phase (phases five and six), it is possible to forecast e.g. sales figures, market shares or possible reactions of competitors (Gruca et al. 2003). Traders that can be integrated in the market are again customers, sales staff or marketing managers.

Example 1 Idea Markets

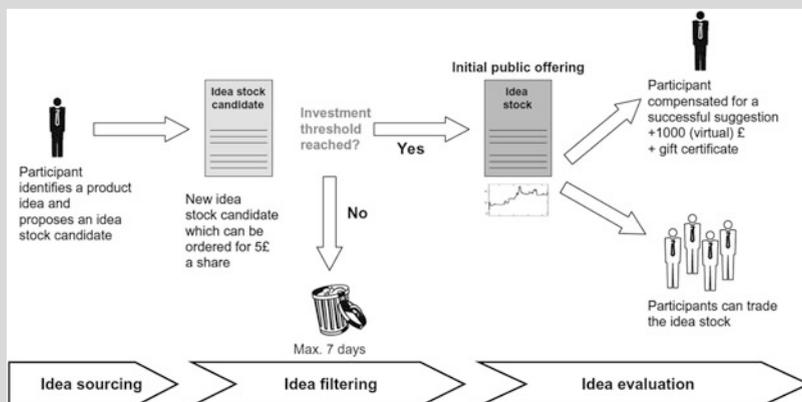
To show the use of prediction markets for the evaluation of ideas, another important example can be seen in the figure below. It shows how virtual markets can be used in a different way for idea finding and evaluation in the innovation process and is one of the few examples how the prediction market principles can be used in companies.

(continued)

The innovation process can also be supported by prediction markets in very early stages. The so-called “fuzzy front end” of innovation deals with the problem that many sources of ideas for new products or services can arise from intra- and extra-organizational sources. There can be only a small number but also thousands of variations or concepts. To evaluate the best ideas, it is necessary to find a lean, fast and cost-efficient process to screen and rate these ideas. Crawford and Di Benedetto (2006) show many tools and approaches to these issues.

To manage this task, the special form of *idea markets* can be used. In the figure below, the concept of Soukhoroukova et al. (2012) is described. Users can enter their ideas as virtual stocks to the markets. All users can invest an amount of their virtual money into these stocks if they think the stock representing the ideas is useful and worth being supported. Only ideas that have reached a certain investment threshold at a certain point in time are kept as virtual stocks. After that, the virtual stock market can be closed or even kept open for further evaluation of those ideas.

The concept of virtual IPOs is rather complex for participants not used to principles of markets, but was successfully described by Soukhoroukova et al. (2012).



Screening process for floating new product ideas (Soukhoroukova et al. 2012)

3 The Details: Theoretical Foundations of Prediction Markets

3.1 Efficient Market Hypothesis and Basic Mechanisms

A prediction market is organized for the primary purpose of accumulating (asynchronously) information dispersed amongst a group of informants (or traders). Von Hayek hypothesized in 1945 that the market price mechanism is an efficient instrument for the aggregation of dispersed knowledge amongst a group of informants who may be major players in an economy or in lower-level contexts. Snowberg et al. (2012) defined a prediction market as

...a wager or outcome (or contract) that pays out if a particular outcome, such as an economic indicator taking a particular value y , occurs.

The theoretical principles of efficient markets were postulated by Eugene Fama. At any given time, the market price on an efficient market represents all available information about the future development of the contract the price is about. Plott and Sunder (1982, 1988) and other authors showed that the efficient-market hypothesis (by Fama 1970) can be used for forecasting tasks besides financial markets. In their fundamental article, Wolfers and Zitzewitz (2004) described three aspects of those markets that are crucial for efficiency. Firstly, markets are incentives for market players to seek information and use new sources of information in order to realize gains and earnings from those markets. Superior information enables players with accurate and highly valuable information, so-called *marginal traders*, to outperform less informed traders. Secondly, markets make players reveal the most accurate information they can find, as gains can usually only be realized through virtual capital invested into the right information “stocks”. Thirdly, to get back to von Hayeks assumptions, markets are efficient in aggregating information from different persons.

Example 2 Prediction Markets: Basic Mechanisms

To explain the theoretical foundations with a practical and simplified example, we choose the predicting of future sales figures for clothing in the next time period with an *Index*-contract.

In a prediction market, the initial price for the number of polo-shirts sold in the next fall collection is at 30,000 (virtual currency units) at the moment, which represents a total sales number of 30,000 pieces. In Fig. 1, these values can be seen.

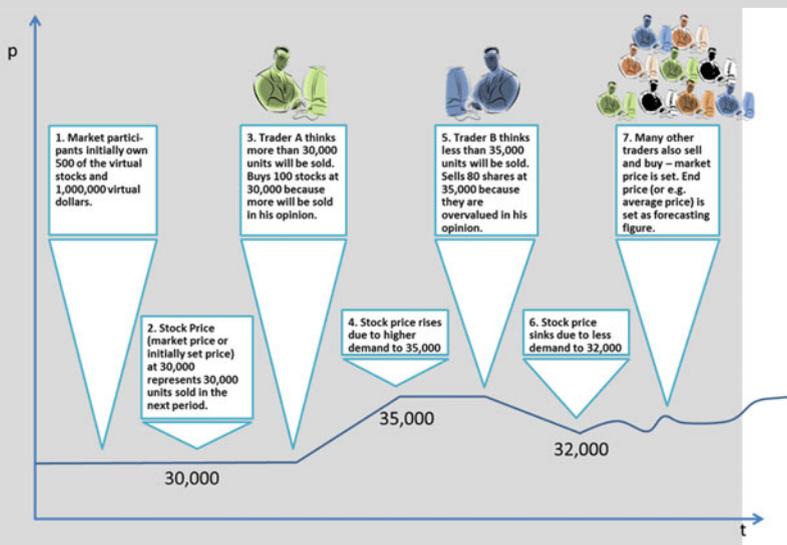
If player A anticipates a sales number of 35,000 pieces, he will buy this stock, because he thinks it is undervalued and its price will rise in the future. Thus, the stock price rises due to higher demand on the market, e.g. to a price of 35,000. Player B thinks that the price of 35,000 is too high; as he holds

(continued)

these stocks, he sells a large number. The market price decreases to e.g. 32,000, the forecast being that 32,000 units will be sold in the next period.

Due to Player B's high confidence in his information, he invested more virtual money from his depot than player A, thus, the price decreased more strongly than it increased from player A's order. If many players are trading on the markets, the equilibrium price represents the information dispersed amongst all market participants at any point in time. Payoffs of the contracts are set by the market price of the stock, in contrast to *winner-takes-all* contracts, where a payoff for the players can only be realized if the *right* contract is bought.

Naturally, a number of practical and theoretical problems are not shown in this example but will be addressed later.



Practical example of the principles of a prediction market (Authors' own figure)

3.2 Design Aspects of Prediction Markets for Innovation Management

The design of prediction markets depends on several conditions. Markets can employ different kinds of market mechanisms to set the prices and organize the bids. Main factors for the design will be discussed here and further advice for setting up one's own prediction markets is given.

3.2.1 Traders and Trading Activities

In prediction markets designed for use in innovation management, it is especially crucial to employ the right “experts”. Experts can be customers, employees, scientists and researchers, depending on the industry, product, or information that is to be found. In topics where staff from a company wants to know what prototype is liked most by customers, only customers should be employed as traders. In other cases, if the R&D department wants to organize and evaluate their ideas, both external customers and employees can be asked. In some settings, for example where confidentiality about newly developed products is necessary, only employees or researchers are invited and the number of traders is much lower.

Experiments on the *Iowa Electronic Markets* that were set up to predict election results showed that a small group of traders performed significantly higher numbers of trades, invested more capital and placed their stop-and-buy orders closer to market prices. Therefore, they had higher returns from the markets (Forsythe et al. 1998). Such *Marginal Traders* (cf. Sect. 3.1), are extremely important for entering the *relevant* and *right* information to the markets, as they push the market price to its right value. *Noise traders*, in contrast, are relatively uninformed players who help to keep the market liquid but push prices towards incorrect levels. As they are less active and less successful in gaining (virtual) money, due to their limited funds, their influence on prices is not very powerful, though. Surowiecki (2004) opposes the marginal trader concept, but lacks a convincing alternative theory for explaining market behavior. However, to implement the available information, trader motivation is an important issue in prediction markets. Servan-Schreiber et al. (2004) argued that players should have intrinsic motivation to participate in the markets, other authors and practitioners also used lotteries or prizes for the best players to motivate participants (Horn et al. 2014; Soukhoroukova et al. 2012).

3.2.2 Liquidity and Motivation

The number of market participants depends, as shown above, on two main factors: the information that potential participants hold and the availability of those informants for participation.

A crucial aspect that is strongly connected with the latter is the motivation of participants. Unless it is possible to motivate participants to input their knowledge to the market, it will not work properly (Rosenbloom and Notz 2006), as also stated above. The higher market liquidity (the number of transactions) the better, as every offer will find a buyer more quickly. Thus, prediction market designers need to motivate participants not only to take part in the market regularly, but also to buy *and sell* stocks, as selling is less intuitive than buying stocks, especially in the early phases of the market when only the initial stock is found in the virtual depot and no buy orders have been placed so far. Also, a more liquid market can help to prevent the manipulation of results. Especially in public markets, this aspect can be important. In corporate markets, participants are often employees that have no motivation to manipulate the results of the markets, e.g. to enter data they do not believe is true. In public markets, participants possibly try to achieve gains, e.g. through showing speculative behavior that is not induced by fundamental

data, but solely by market and equity price data. Guarnaschelli et al. (2003) show that manipulation can be avoided through preventive measures in the design of prediction markets.

3.2.3 Contracts

Basically, there are three types of prediction market contracts or “stocks”: *winner-takes-all* markets, *spread* markets and *linear* or *index* markets.

Winner-takes-all contracts occur quite frequently in prediction markets, as they are simple to understand for players. For these contracts, each virtual contract held by one player pays a fixed amount of (virtual) money if the event to which it relates occurs—and zero if it does not. Cowgill et al. (2009) showed that prices for those contracts reflect the current probability of the realization.

Contract type two, the *spread*-type, is rather rarely used. It can predict the median expectations of all players. Luckner et al. (2012) describe this contract more extensively.

Index contracts are not often used either, but especially for forecasting sales figures in business, for instance, they are often the best choice (cf. e.g. Horn et al. 2014). Payoffs are assigned to the price of the index contracts, as seen in example 1. The contracts pay off, e.g. the value of virtual currency units at a certain point in time or a fixed share of it.

3.2.4 Mechanisms

The mechanism most commonly used is that of *Continuous Double Auction*, where offers and bids are matched with the help of order books. This ensures high market liquidity even on relatively thin markets with few traders. Usually, such markets are designed to avoid the risk of losing (virtual) money for the organizers of the markets (Berg et al. 2003a, b). Other markets such as Combinatorial Market Maker mechanisms usually cannot avoid the risk of having to compensate some of the traders' gains by the organizers of the market. Therefore, and due to their complexity, they are not so commonly used.

3.2.5 Stock and Formulation of Stock Sets

Prediction questions and variables can aim at dichotomous outcomes, such as “Will our competitors enter the market within two months after product launch?” or to numbers or numeric relationships and represent the virtual “stocks”. The wording of the prediction is crucial for the use of prediction markets in practical environments.

The formulation of the stocks and prediction questions has to meet several criteria. The statements must be correct and precise, free from ambiguity, and easily understood by participants (Borison and Hamm 2010; Christiansen 2007). Firstly, it has to be clear for the traders, not only for the organizers of the market, what the stocks they trade on are about. Therefore, the formulation has to be made as simple as possible. At the same time, the formulation should give as much information about the innovation-relevant questions to the organizers as possible. For example to find the best prototype out of five options, it is necessary to give

enough information about the differences between the variants. Also, it should be clearly communicated what the goal of the market is: For example to find out the best design, the best set of features or the product with the highest probability to succeed on the markets later on.

Second, the stocks and trading phase must be explained well enough for the participants to realize the relevance of the tool (especially for employees) or the mechanisms and the “rules of stock trading”, especially for customers that usually have not been trading on an online market or with stocks before.

4 Future Developments

It can be seen that prediction markets have had a long time of development since their first larger-scale use in the 1920s and their return in the 1990s with the *Iowa Electronic Markets* and succeeding implementations, which became possible with the emergence of information technology. Potentially successful fields of application for prediction markets in business environments are those where knowledge is dispersed and predictive reports are needed continuously or periodically. Especially in innovation management, these capabilities are needed for the evaluation and rating of huge amounts of ideas, concepts, alternatives and new product market entries.

To give an example of the future use of prediction markets in innovation management, sales figures for newly developed consumer goods which are important e.g. for logistics could be predicted on a weekly basis. Store managers could trade together with product managers in markets for the weeks following market entry and give quick and direct qualitative feedback to innovation and marketing managers. It seems possible that for consumer goods, experienced users or customers could be better experts than employees such as marketing managers or product developers. This can especially be true in industries that are strongly driven by trends and fads and where market research usually is difficult such as fashion, consumer electronics or fast moving consumer goods. Thus, including customers into the forecasting with prediction markets could be promising, but has rarely been investigated yet. Customers could be integrated in traditional markets or preference markets for concept testing, sales predictions, idea creation and evaluation.

Also, practical issues of the integration of prediction markets into existing organizations can occur, e.g. motivational problems and not limited to problems coming from internationally working, or intercultural teams. Virtual markets can be intuitive in usage, but there is little experience in keeping these systems running. In this context, the long-term motivation of employees or customers to trade can be problematic. Besides experimental and scientific markets such as the *Iowa Electronic Markets*, there is little knowledge about long-term motivation. From the numerous prediction markets software providers, such as *Crowdcast*, *Crowdworkx*, *Inklingmarkets*, *Kenforx* or *Voycer AG*, there is a huge potential for the commercial success of prediction markets software.

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