2009

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Abstract

Assessing innovation alternatives is a difficult task especially in newly upcoming forms of organization like Business Value Networks. This paper highlights the use of Information Markets and discusses state of the art Market Maker models. We designed a Market Maker mechanism in order to enhance liquidity, and hence, efficiency in the market. Therefore, an agent-based simulation as well as a field experiment was run to evaluate the usefulness and performance of Market Maker. It can be shown that the introduction of automated trading techniques increases market efficiency and thus the quality of the forecasting results for service innovation assessment.

1. Introduction

During the last decade it could be observed that companies refocused on their core competencies and sold off business units which were out of scope. This has led to a highly specialized economic landscape. For instance, the value creation in the automotive industry was at only 35% in 2002 and is estimated to decrease to 23% in 2015 (Mercer Consulting[2]). The classical value chain transforms into so called Business Value Networks (BVN) in which enterprises collaboratively work together [16]. This increase of collaboration cannot only be observed in the automotive industry but also in other domains such as the software service industry or IT development and companies like IBM or SAP.

IT can support inter-organizational work in different ways. This paper focuses on the assessment of innovations and technologies as one important step for collaborative work. Therefore, it is necessary to forecast future trends and to collect and integrate opinions and assessments of different stakeholders. The assessment of new ideas and future trends is a difficult task since it is often based on vague information and uncertainty due to long forecasting horizons. Techniques exist for long-term forecasting such as the Delphi method or Information Markets (IM). Delphi uses an iterative process of distributing questionnaires to collect experts' opinions, aggregating the data, and presenting the results to the sample group along with a new questionnaire. Information Markets on the other hand rely on the fact that stock prices carry and aggregate diverse information in one single attribute *price.* Green et al. compared both methods to elicit forecasts from groups [6].

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2 Mercer Consulting Study "Future Automotive Industry Structure (FAST) 2015"

Compared to the Delphi method, Information Markets bear the advantage that the results (i.e. valuations of the participants) can be read immediately and continuously, that new information can immediately be integrated, and that trading itself is often intuitively understood by the participants. On the other hand, trading in Information Markets gets cumbersome for large studies with many questions and liquidity is low for very small sample groups. The use of Information Markets in the context of inter-organizational innovation processes and forecasting appears advantageous since the participants do not have to exhibit their complete knowledge. Thus, participants use their information at hand to gain profits from stock trading and report their opinion indirectly. Additionally, Information Markets have also a playful aspect.

In this paper we present the use of Information Markets within the innovation process of inter-organizational collaboration and study how to overcome existing liquidity problems by using automated Market Makers. Firstly, we give an overview about Business Value Networks and state of the art innovation management. Furthermore, an innovation lifecycle for Business Value Networks is introduced as well as an approach to tackle specific problems in idea evaluation. In the last sections we describe our market maker model simulation as well as results of the first field study.

2. Related Work

Business Value Networks were firstly introduced by Hagel in 1996. He describes Business Value Networks as a "set of companies that use a common architecture to deliver independent elements of an overall value proposition that grows stronger as more companies join" [7]. Tapscott et al. stated in 2000 that a "b-web is a distinct system of suppliers distributors, commerce services providers, infrastructure providers, and customers that use the Internet for their primary business communications" [17]. Zerdick et al. mentioned in 2000, that "Business webs are groups of companies that participate in the same value chain system independently of one another" whereas Steiner made a statement in 2005 that specialized firms "co-opetitively contribute modules to a product system based on a value-enabling platform [...] by extensive usage of information and communication technologies" [21][16]. It is obvious that companies, loosely organized in a Business Value Network[3], cooperate together using a common IT architecture. An open service platform equipped with a browseable service repository serves as a common hub for service usage and exchange. Companies specialized on their core competencies offer services to other companies in order to orchestrate a new business service based on multiple fine grained services or modules. Before services are provided to the network an idea and innovation process must be passed through. Therefore, services are derived from ideas and disembogue into innovation in order to realize advantages in competition.

Companies have been pursuing innovation management for years. Managing ideas with structured processes should guaranty that valuable ideas won't get lost. For example, employees often have good ideas to improve processes or organizational structures. Instead of disregarding these ideas, the ability to innovate is a key success factor for growth and competitiveness [18][2]. Several frameworks and approaches for idea and innovation processes exist in literature. Wahren introduced an innovation process with three phases; idea generation, evaluation and implementation [19]. Wahren's process is one of the traditional examples of a structured process where generated ideas are screened by an innovation manager. Promising ideas are refined in further stages and finally implemented and used. In practice, one can observe that these kinds of innovation processes

3 BVN = Business Web = b-web

are not very fruitful. Getting ideas cannot be “enforced” or steered by structured processes. Many companies are running idea submission platforms where e.g. employees can put their ideas following a state of the art process. SAP, for example, runs Target Idea Management[4] in mySAP to get ideas from employees. But companies complain that the rate of submitted ideas decreases over time and it takes very long until an innovation manager is able to review ideas. Furthermore, that process isn’t transparent and leaks of realtime feedback for submitters.

Hamel developed a similar model which is more innovative [8]. Hamel’s “innovation wheel” is characterized by creating ideas, implement them fast, get feedback from users and innovate again. Small steps and continuous feedback leads to incremental improvement where promising innovations are encouraged and non promising innovation are dropped. Thus, innovations won’t come to a “final” state but stay in perpetual beta stages, which is more flexible than Wahren’s process, but does not address inter-organizational usage.

In summary, these models are designed for intra-organizational and do not respect requirements for inter-organizational use in Business Value Networks. Having Business Value Networks in mind, these state of the art approaches are not applicable since they are aligned for intra-organizational use. For example, a basic requirement for inter-organizational innovation is that ideas integrate the development by and the assessment through customers, partners as well as freelancers. Therefore, a generic innovation lifecycle for Business Value Networks considering its requirements is presented later on (Section 4). It utilizes Information Markets in order to integrate community’s opinions as well as real time feedback.

Long term forecasting and innovation evaluation are difficult tasks due to uncertainty and missing information. To deal with such problems, Information Markets deemed to be promising. Information Markets are a special kind of virtual markets, where market participants trade their expectation of future events [12]. For example, each trader has expectations (private information) concerning which technology will dominate the consumer market in the next months. Typically, traders have different private information which might be distributed asymmetrically. Following the Hayek-Hypothesis, the price mechanism is an efficient way to aggregate asymmetric information [11][4]. Even extremely distributed information can be aggregated so that a market system ensures that prices are information-efficient [13]. Following the efficient market hypothesis, market mechanisms are capable of efficiently aggregating information held by market participants into one variable – the stock price [4]. Traders’ information is mapped in market prices because traders buy or sell stocks in their portfolio so that it represents their private information, for example about innovative ideas. Thus, heterogeneous alternatives become comparable and participants indirectly reveal information or opinions respectively. Hence, market allocation mechanisms such as Continuous Double Auctions (CDA) allow market participants to trade their estimations as soon as new information is available in the market. Another form of market mechanism are Call Auctions for example. Usually, traders will be paid off according to their portfolio structure which is based on fixed payment rules once the event became true. Wolfers and Zitzewitz ran some experiments in 2006 showing that Information Markets meet the mean value of all traders’ expectation narrowly [20].

Soukhoroukova and Spann have already used Information Markets for product innovation successfully. Compared to conjoint analysis and other techniques, Information Markets with 8-12 participants are more robust and reliable compared to conjoint analysis with 307 participants [14].

[4] http://www.target-soft.com

Hence, Information Markets seems to be suitable for service innovation, which is a similar field of application. But besides all advantages, Information Markets only perform well if the market is liquid enough. Spann emphasizes that Information Markets must have an appropriate amount of traders to work well [12]. People do not want to trade if markets are thin and one way of adding liquidity is the application of Market Makers. In financial stock markets like NYSE or NASDAQ Market Makers are common in order to provide liquidity. To get an overview over existing Market Maker models, we introduce these models and discuss them. Afterwards, an own proposition of a Market Maker will be proposed.

Glosten and Milgrom (1985)
The authors proposed a model to compute bid and ask orders based on order flows from informed as well as uninformed traders. They assume that the Market Maker earns zero expected profits on each purchase and each sale and faces no transaction costs. The model computes bid and ask prices based on probabilities that the next order will be a buy or sell order respectively [5].

Hanson (2002)
Scoring rules are probability scores made by individual traders. Based on the quality of the score, traders get paid via a payment rule. Hanson developed Market Scoring Rules (MSR), where scores are incrementally improved by consecutive traders. Market Scoring Rules can be applied in Information Markets to serve as a Market Maker. Traders do only see the actual score and can decide whether to change or not. They trade against the Market Maker acting as a single point of contact and do not see scores from others [9].

Das (2005)
Das picked up Glosten and Milgrom’s model and enhanced it. The Market Maker tracks a density function about the true value of stocks whereby the Market Maker tries to learn that value in order to set appropriate bid and ask orders. The model considers the appearance of informed, noisy informed as well as uninformed traders. Furthermore, Das’ model considers Market Makers profits and provides inventory control [3].

Boer et al. (2007)
Boer et al. applied a model to overcome the shortcomings (discrete time slots per sequential trader) in Das’ model by extending it to a continuous model. The authors run several simulations and showed that the Market Maker can learn the fundamental value of stocks passably good in different scenarios [1].

3. Discussion of conceptual Design for Market Maker Models

While all of the described models are very good approaches to understand the dynamics of markets, all have shortcomings to use them in real world scenarios. For example, the models of Glosten and Milgrom, Das and Boer et al. use algorithms which are helpful to learn the fundamental value of stocks by tracking traders order flow. To maintain a density function about the fundamental value, the Market Maker needs to know about traders’ orders – even if a trader do not want to trade, the Market Maker must know it to update the density function. Furthermore, the fundamental value must be well defined which is very difficult in service innovation scenarios. Markets with both perfectly informed and noisily informed traders are not considered either. Glosten and Milgrom do not consider Market Makers profits whereas Das supports a turn based approach, which is not applicable in continuous double auction mechanism. Each model, except the Market Scoring Rule, maintains investors planning of only one step ahead, which is also unrealistic because traders are usually planning more than one step. All three models assume that the Market Maker knows the fraction of informed/uninformed traders in the market, which can't be maintained. Information Markets for service innovation on Business Value Networks are virtual markets which makes it impossible to determine what kind of trader is participating. But each model helps to understand the dynamic character of markets a bit more. Hanson's Market Scoring Rule is broadly used by several virtual Information Market platforms like Inkling Markets[5] of the WSX[6]. Market Scoring Rules perform very well to track trader's estimations. But what MSR lacks of is order transparency. Outstanding orders in order books transport information to traders which do not exist in MSR because traders do only deal with the Market Maker and do not see previous orders from other traders. Moreover, traders have to take the prices offered by the Market Maker and cannot draw their own orders.

Because of these shortcomings, an enhanced Market Maker has been designed. The current approach for the usage in Information Markets envisions two functionalities – an automated liquidity provider as well as an automated arbitrageur. Firstly, the liquidity provider is similar to the Market Maker in the model from Boer et al. mentioned above trying to track the fundamental value of stocks and provide bid and ask orders. The Market Maker maintains a record of recent trades and tries to learn if it is a "normal" trading behaviour to provide narrow spreads. If the Market Maker notices fluctuation in stock prices, the spread goes wider because of uncertainty about fundamental value. This is a normal behaviour because the Market Maker holds stocks in his inventory which can be less worth after a change in the fundamental value. Therefore he tries to minimize his risk by widening the spread. After other traders start to trade, the Market Maker tries again to learn the fundamental value by interpreting the order flow from other traders.

Secondly, stocks in Information Markets represent probabilities for stocks' underlying event in the real world. For example, if a stock is traded at 84$, the probability for that event is 84%. It is clear that all stocks must sum up to 100%. Otherwise the market is inefficient. The arbitrage agent as a functionality of the Market Maker constantly checks and draws orders for arbitrage trading to buy or sell portfolios for a given portfolio price from the market operator. Every trader can do that – but we expect that in markets with many stocks traders won't put orders in each stock in order to realize arbitrage benefits. On the other hand, having an automated arbitrageur in the market enforces trading activity which may attract traders to update their own estimation. Hanson investigated that "noise trading" can be an accelerator for trading activity altogether and thus, increasing market accuracy [10]. Trading activities from uninformed traders is so called "noise", because uninformed traders are trading with some variance while they don't know the true value of stocks exactly. An informed trader has *better* information and thus can exploit uninformed traders. Nevertheless, having noise traders in the market increases trading activity and can lead to better market accuracy. *Table 1* summarizes the introduced models including our own model by three criteria. "Realistic approach" of the model describes how realistic is the model based on the outcome and the benefit

Table 1: Market Making Model comparison

	Glosten&Milgrom	Hanson MSR	Das	Boer et al.	Own model
Realistic approach	+	+	+	+	+
Assumptions	-	**o**	-	-	**o**
Intuitiveness	+	**o**	**o**	+	+

[5] http://inklingmarkets.com/

[6] http://www.thewsx.com

for real world usage. That criterion is independent from the assumptions being made for each model. The second criterion cares about the assumption being made and if they are realistically maintainable. The third criterion is about how intuitive is the behaviour of the models from traders' views.

All models show a realistic behaviour in terms of setting appropriate orders in the market. But some models have shortcomings in assumption being made which are not maintainable in Business Value Networks. For example, one cannot determine the fraction of informed and informed traders in the market. Regarding "Intuitiveness", two models are not very intuitive while Das provide a turn-based approach and in Hanson's model, orders of other traders are not visible, which may carry additional information to other traders. In the following, we present an innovation lifecycle for Business Value Networks. In the Idea Evaluation phase, Information Markets using our own model with the market maker are applied.

4. Innovation Lifecycle for Business Value Networks

The innovation process we use was introduced by Stathel et al. and is depicted in *Figure 1*[15]. In early product and service stages respectively, an innovation idea usually is developed either by inspiration or clever combination of fragments. Therefore, the proposed innovation lifecycle starts with these two ways (Phase 1 and 2) of how ideas may arise. Typically, such idea generation is done with group workshops or think tanks where the result is stored in the idea/innovation repository (A). After the idea generation, the developed ideas and innovation alternatives can be evaluated trough communities (B) in Phase 3. Once idea alternatives have been evaluated by the community, the idea (e.g. a service or product) can be (prototypically) implemented (Phase 4). This phase is greyed out because the implementation of services is not in the scope of our research and can be done with state of the art information technology and software engineering. To see if the community accepts services or products, an evaluation phase collects opinions as well as usage information from the community (Phase 5) based on information derived from the service repository (C). The result obtained at the end of the five phases may be used as feedback for the prior phases in order to initiate new ideas or refine already implemented services.

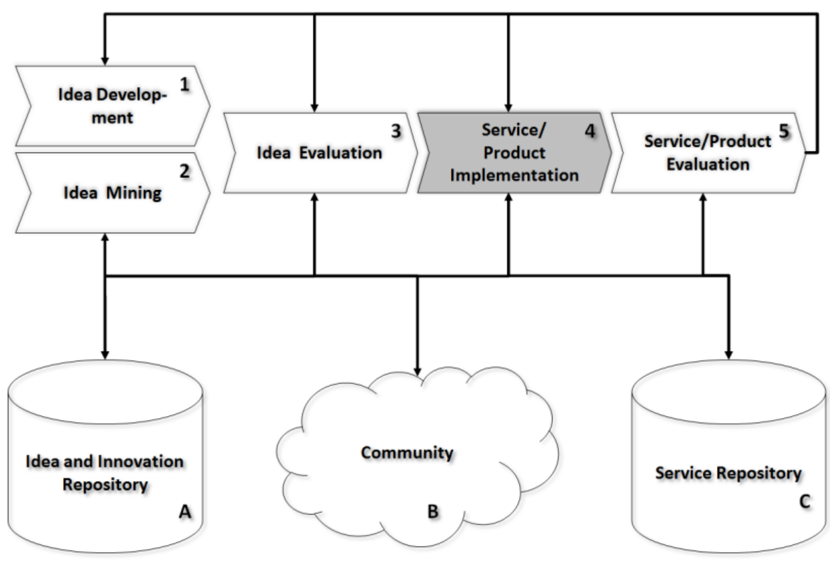

Figure 1: Innovation Lifecycle

The advantage of the model we use is that loosely organized participants in Business Value Networks can be integrated in every stage of the process. One can integrate an interesting fraction of the community to take part in brainstorming sessions as well as evaluating promising ideas via virtual Information Markets. While participants in the community are customers as well, they can actively steer and influence innovation they like best. Furthermore, they can track the impact of their trading activity directly after trading in realtime. The lifecycle in *Figure 1* overcomes state of the art models by collecting information about the implemented service in order to derive, if a service needs to be reworked or if a new service is necessary. In the following, results of our Market Maker model are described, which was tested in a field experiment.

5. Experiment results

In June, the UEFA Euro 2008 Soccer Championships[7] were held in Austria and Switzerland. Therefore, an information market system based on Groovy&Grails was set up to provide a field test system for automated market making. There were two identical markets where only one is equipped with our own Market Maker model. Market participants traded on the outcome of the tournament and will be routed into these markets by turns. Due to that soccer events are most publicly interesting, it was necessary to keep the amount of participants relatively low in order to test our automated Market Maker in thin markets. As a result, a better market accuracy in the Market Maker enabled market was expected.

In total, we invited ca. 250 people to participate in the market via email invitations whereby people were allowed to forward the invitation. In total, 88 people registered as participants. Each participant was endowed with 100.000 virtual currency units (EM€) and 100 shares of each stock. Each stock represented one corresponding team out of 16 teams taking part in the tournament. From the 7th till the 18th of June participants were supposed to trade the 8 teams reaching the final round of the tournament. After the group round, the account from every trader was paid out. Holding stocks of teams reaching the finals were paid out with 100 EM€, other with 0 EM€. At that moment, traders had no shares in their account due to the payouts.

From the 19th till the 29th of June traders were newly equipped with 100 shares of each team participating in the finals and were supposed to trade the champion. After the final match, which was Spain vs. Germany, shares of the winner were paid out with 100 EM€, others with 0 EM€. As mentioned before in this paper, an automated market maker with the two functionalities (Liquidity and Arbitrage) were permanently active in one of the two markets.

Table 2 shows some descriptive statistics from both markets' liquidity. The number of active traders is nearly equal in both markets. An active trader was counted if a trader made at least one trade after registration.

The number of transactions indicates how often a transaction occurred whereby the following explains how the total number of 11.265 transactions is proportioned:

M-M: Transaction Market Maker against Market Maker
M-H: Transaction Market Maker (buyer) against Human Trader (seller)
H-M: Transaction Human Trader (buyer) against Market Maker (seller)
H-H: Transaction Human Trader against Human Trader

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7 http://www.euro2008.uefa.com/index.html

Table 2: Market liquidity

	Market Maker Market	Non Market Maker Market
# Participants	44	44
# active Participants	33	35
Transactions total	11 265	346
Transactions M-M	6 981	./.
Transactions M-H/H-M	3 877 (1 473/2 404)	./.
Transactions H-H	407	346
# Orders/day	1 423	15
Volume/day	33 246	1 631

Figure 2 shows the amount of trades of both markets compared over time. It is easy to see that the number of transactions in the market maker market (MM) was higher at every time. Furthermore, the number correlates very well to the matches of high interest. Even in the finals, where the trading activity in the non market maker market (NMM) was very low, several hundreds of trades occurred in the market maker market.

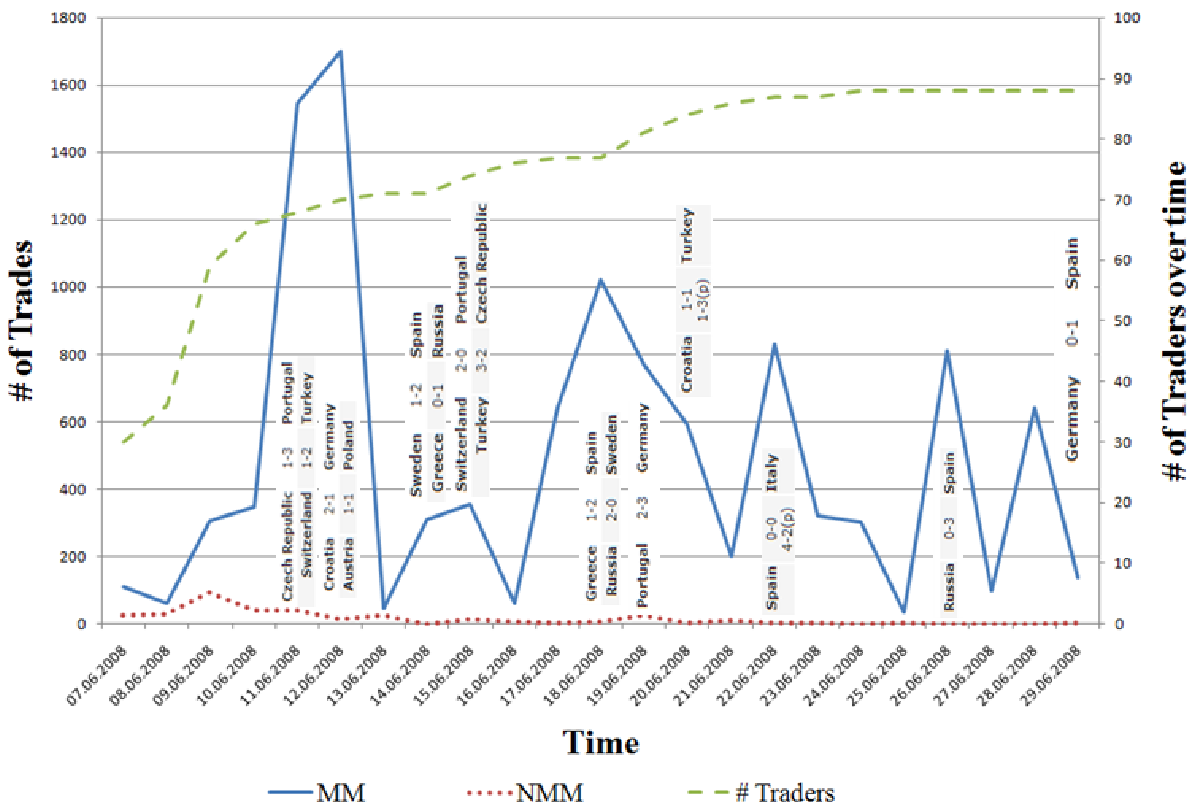

Figure 2: Market activity

Figure 3 shows error measures of both markets. The mean absolute error indicated how "wrong" both markets were during the first 12 days of trading, which was the group phase of the tournament. We decided to take the group phase of the tournament for error measures because in the finals the trading activity in the non market maker market was too low to compare it against the market maker market.

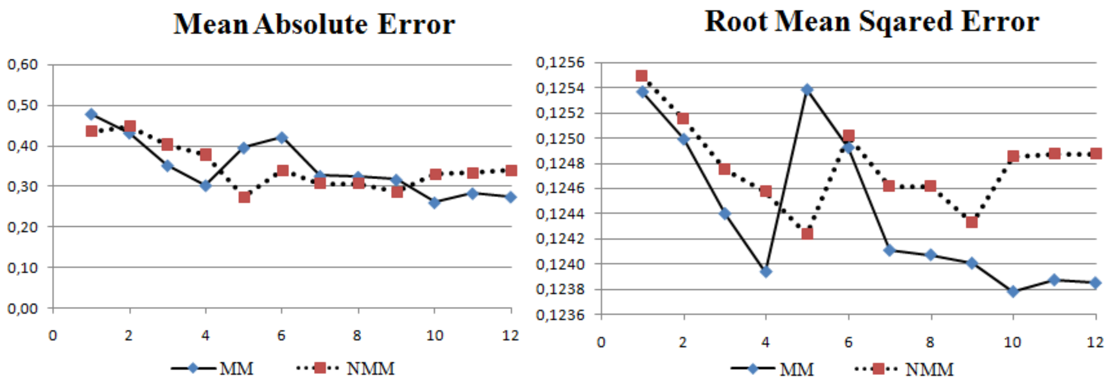

Figure 3: Error measures

On day 5 of the tournament there is a significant knuckle in both measures. That is because on the 5th day traders realized how they can bring down stock prices and as a result get cheap shares from the liquidity providing market maker. These activities of course distorted stock prices and therefore the error of stock prices increased for that time. In the following tournament, no other distortions of prices were identified. In order to test which market was significantly better than we ran a t-test. The t value of the mean absolute error was 0.988, which indicates no significance. But considering the root mean squared error, the t-value is 0.046, which is significant, even with the price distortions on the 5th and 6th day of the tournament. We assume that the significance level would have been higher if there were no price distortions.

In summary, we tested our new developed market system in a first field experiment. Even if the market maker strategies were very simple in the first setting, we showed that the market maker market's results were significantly more accurate, even if the market maker was exploitable in that experiment. Hence, we like to develop smarter strategies for automated market making and test them in service innovation related contexts.

6. Conclusion and open issues

In this paper, the concept of Business Value Networks has been introduced, which will be the state of the art in B2B communication in the next years. Due to those companies recently adapted Service Oriented Architectures mainly for internal communication between applications, they will open their communication channels and cooperate with other companies while specializing on core competencies. Thus, managing innovation in Business Value Networks will become more sophisticated due to more complexity in fast growing networks.

To manage innovation in BVN's, state of the art models for innovation management from Wahren and Hamel have been introduced and discussed. Due to several shortfalls for using them in BVN's, the model from Stathel et al. was briefly outlined and discussed [15]. In the idea evaluation phase of the model, information markets will be used to assess ideas with a virtual market system by integrating the community, which will be customers, partners or freelancers in BVN's. They *trade* their expectations about ideas and thus, will steer innovations. But, in information markets, a typical shortcoming is the thin market problem where insufficient trading activity leads to inaccurate market results. One way of overcoming the thin market problem is the usage of Market Makers. While virtual information markets are used, an automated Market Maker will be used to encourage trading activity and hence, lead to more accurate market results. Traders should be more attracted to markets where sufficient orders are on hand. Several state of the art mechanisms for market making were introduced and discussed in this paper. Most of them show realistic behaviour in putting bid and ask orders and are also very good in tracking the real value of stocks by interpreting other trader's behaviour. But, they make assumptions which are not applicable in real world scenarios. Therefore, an own model of an automated Market Maker was outlined and evaluated in a field experiment during the UEFA Soccer Championships in 2008.

In further steps, details of the state of the art Market Maker mechanisms will be analyzed to work with our own model in order to make it more powerful without making unrealistic assumptions for innovation assessment in Business Value Networks. Simulation results as well as experimental results already showed that the proposed model works out well in order to improve market efficiency and accuracy. The approach seems promising to improve market maker strategies as well as to apply them in further experiments in service innovation related contexts. Moreover, we will develop smarter strategies for the market maker in order to make it more robust against exploitation approaches from traders. We recommend that the opportunity of using market makers should be considered by companies in innovation processes in BVN's to overcome the problems of illiquidity.

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The project was funded by means of the German Federal Ministry of Economy and Technology under the promotional reference "01MQ07012". The authors take the responsibility for the contents.