SERVICE INNOVATION WITH INFORMATION MARKETS - A MARKET MAKER BASED APPROACH

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Abstract:	Assessing innovation alternatives is a difficult task especially in newly upcoming forms of organisation like Business Value Networks because of inter-organisational requirements. This paper highlights the use of Prediction Markets and discusses state of the art Market Maker models. For the use in Business Value Networks, an analysis of requirements for service evaluation is presented. In order to get a high result quality it is necessary to provide efficient markets that also work in especially small user groups as it might be the case in inter-organizational collaboration. We designed a Market Maker mechanism named ELIAS in order to enhance liquidity, and hence, efficiency in the market. Therefore, an agent-based simulation was run to evaluate the usefulness and performance of Market Makers. 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.

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 2003). The classical value chain transforms into so called Business Value Networks (BVN) in which enterprises collaboratively work together (Steiner 2005). 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.

IT can support the inter-organizational work in different ways. One important step for collaborative work this paper focuses on the assessment of innovations and technologies. 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 Prediction Markets (PM). 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. Prediction 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. (2007) compared both methods to elicit forecasts from groups. Compared to the Delphi method, Prediction 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 Prediction Markets gets cumbersome for large studies with many questions and liquidity is low for very small sample groups.

The use of Prediction 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, Prediction Markets have also a playful aspect.

In this paper we present the use of Prediction 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.

Related Work

In the following, related work about Business Value Networks, Innovation Management as well as Market Making will be presented. Business Value Networks were firstly introduced by Hagel (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" (Hagel 1996). Tapscott et al. (2000) stated 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". Zerdick et al. (2000) mentioned, that "Business webs are groups of companies that participate in the same value chain system independently of one another" whereas Steiner (2005) made a statement that specialized firms "co-opetively contribute modules to a product system based on a value-enabling platform [...] by extensive usage of information and communication technologies". It is obvious that companies, loosely organized in a Business Value Network, cooperate together using a common IT architecture. An open service platform equipped with a searchable 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.

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 (Vandermerwe 2003; Clayton 2003). Several frameworks and approaches for idea and innovation processes exist in literature. Wahren (2004) introduced an innovation process with the three phases idea generation, evaluation and implementation. Wahrens'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 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[1] in mySAP to submit 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 currently used process isn't transparent and leaks of realtime feedback for submitters.

Hamel (2002) developed a similar model which is a bit more innovative. 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-organisational 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-organisational use. For example, a basic requirement for inter-organizational innovation is that ideas integrate the development by and the assessment trough customers, partners as well as interested freelancers. Therefore, a generic innovation lifecycle for Business Value Networks considering its requirements is presented later on. It utilizes Prediction 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, Prediction Markets deemed to be promising. Prediction Markets are a special kind of virtual markets, where market participants trade their expectation of future events (Spann 2002; Luckner et al. 2005). 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 (Hayek 1945; Fama 1970). Even extremely distributed information can be aggregated so that a market system ensures that prices are information-efficient (Spann et al. 2004). Following the efficient market hypothesis, market mechanisms are capable of efficiently aggregating information held by market participants into one variable – the stock price (Fama 1970). 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. 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 (2006) ran some experiments in 2006 showing that Prediction Markets meet the mean value of all traders' expectation narrowly.

Soukhoroukova and Spann (2005) have already used Prediction Markets for product innovation successfully. Compared to conjoint analysis and other techniques, Prediction Markets with 8-12 participants are more robust and reliable compared to conjoint analysis with 307 participants. Hence, Prediction Markets seems to be suitable for service innovation, which is a similar field of application. But besides all advantages, Prediction Markets only perform well if the market is liquid enough. Spann (2002) emphasizes that Prediction Markets must have an appropriate amount of traders to work well. People do not want to trade if markets are thin and one way of adding liquidity is the application of Market Makers. In financial stocks 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**

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

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 (Glosten and Milgrom 1985).

- **Hanson**

  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 Prediction Markets so 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 (Hanson 2003).

- **Das**

  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 (Das 2005).

- **Boer et al.**

  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 (Boer et al. 2007).

After presenting the state of the art models for innovation management and market making, we propose our own model of service innovation in Business Value Networks as well as our own Market Maker model "ELIAS" for low liquidity Prediction Markets. We use the term ELIAS[2] (Efficiency and Liquidity In AuctionS) interchangeably.

Market Maker Models Supporting the Service Innovation Lifecycle

Our proposed innovation process is depicted in Figure 1. 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 are 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 reused as feedback for the prior phases in order to initiate new ideas or refine already implemented services.

The advantage in our model is that loosely organised 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 another fraction for evaluating promising ideas via virtual Prediction Markets. While participants in the community are customers as well, they can actively influence and steer innovation they like best. Furthermore, they can track the impact of their trading activity in the market directly after trading in realtime. Our model overcomes state of the art models by collecting service usage information of in order to derive, if a service needs to be reworked or if new service seems necessary. In the following, we focus on the service evaluation step applying Prediction Markets with Market Maker functionality.

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[2] ELIAS was the project name under which the Market Maker model was developed and simulated

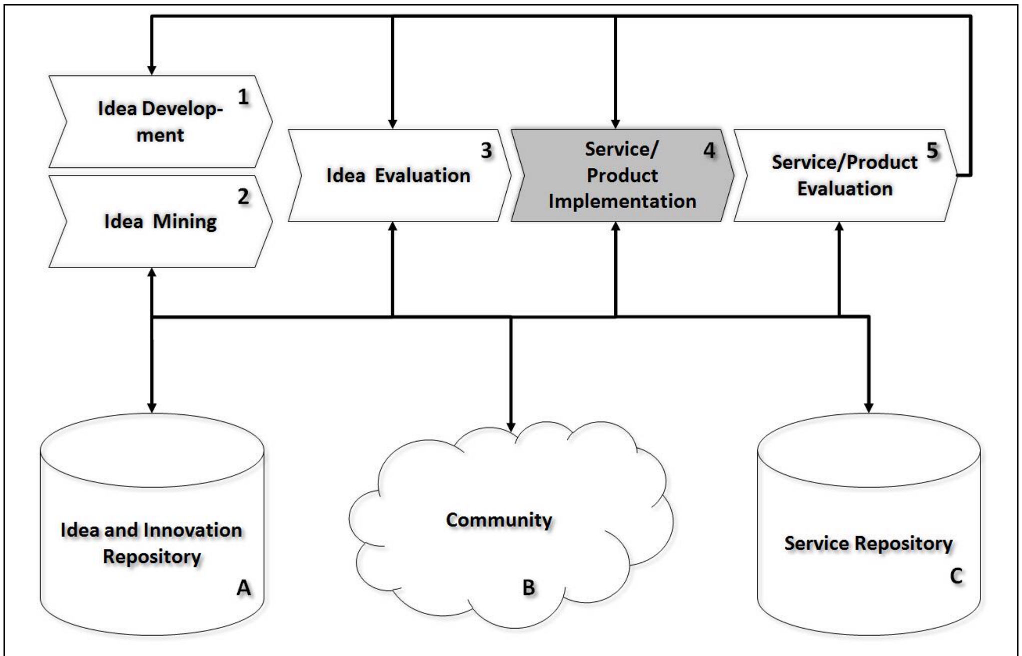

Figure 1. Innovation Lifecycle

While all of the described models are promising approaches contributing to the common understanding of the dynamics of markets, all have shortcomings for the usage in real world scenarios. For example, the models of Glosten and Milgrom, Das and Boer et al. use algorithms which are great 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. Prediction 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 Prediction Market platforms like Inkling Markets[3] of the WSX[4]. 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 own Market Maker has been designed. The current approach for the usage in Prediction Markets envisions two functionalities – an automated liquidity provider as well as an automated arbitrageur. 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

[3] http://inklingmarkets.com/

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

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.

Moreover, stocks in Prediction 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 (2007) investigated that "noise trading" can be an accelerator for trading activity altogether and thus, increasing market accuracy. 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 Market Maker models including our own model by three criteria, which are derived from the discussion of the Market Maker models introduced in the related work. We will conduct a comprehensive requirement analysis of market maker models in further steps to improve the brief comparison. "Realistic approach" of the model describes how realistic is the model based on the outcome and the benefit 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.

Table 1. Market Making Model comparison

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

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, no orders of other traders are 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, Prediction Markets using ELIAS are applied.

Simulation of ELIAS

Until now, we have simulated ELIAS in a simple scenario as a proof of concept without using probabilities that the following order is a buy or sell order as used in state of the art models. ELIAS will act like a human trader and can loose and win money. In general, the Market Maker must not withdraw money from the market and if the Market Maker makes profits she returns it back to the market by offering buy and sell orders. We used a Java based market simulation framework named JASA – Java Auction Simulator API – by Steve Phelps. In this framework, a Continuous Double Auction mechanism can easily be used to set up agents following a free definable strategy.

Figure 2 shows preliminary simulation results for two markets – with and without a Market Maker. In the first market, two stocks were simulated with i zero intelligence agents putting orders in the market. In order to determine, if the next order is a buy or a sell order (${}^{i}v_{t}^{b}, {}^{i}v_{t}^{s}$), the agents draw randomly between 0 and 1, where 0 leads to sell orders, 1 to buy orders respectively. Hence, the agent has to determine the value of the order by drawing randomly between 0 and 100, while the volume is fixed by 10 shares in every order $({}^{i}v_{t}^{b}, {}^{i}v_{t}^{s} \in [0;100])$. The same setting was applied for the second stock. The intention was to simulate extreme noise trading, where uninformed traders are not sure of stock's real value. The result is high price fluctuation and high price prediction uncertainty. Consequently, extracting information from stock prices can be rarely interpreted. The overall stock sum does not sum up to 100% which indicates inefficiency. If stock prices in Prediction Markets do not sum up to 1, the market is inefficient. It is obvious that only one event can turn out to be true, so the overall market probability of 1 must split into all stocks. If the probability of an event is 1, then the price of the correlated stock must be 100 currency units. All other stock's probability are then 0. Consequently, their prices must be 0 to be efficient.

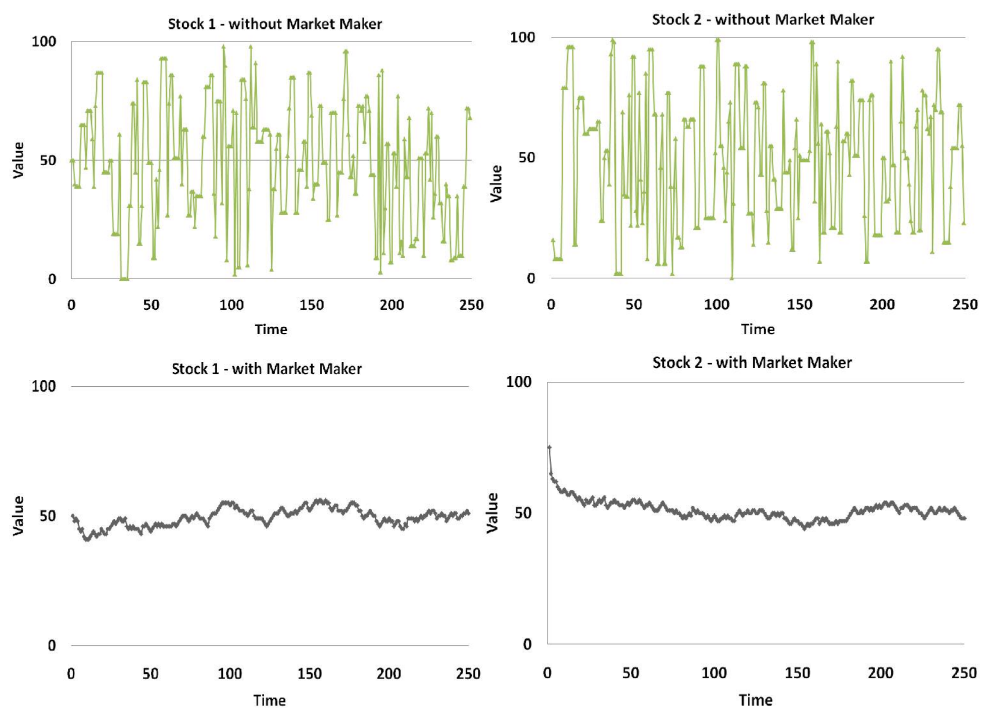

Figure 2. Simulation Results

In an additional scenario, the market based on the first scenario was equipped with the Market Maker providing liquidity as well as arbitrage trading. Based on the last price (k_t) an order was executed, the Market Maker puts a buy as well as a sell order $({}^M v_t^b, {}^M v_t^s)$ with fixed volume of 20 units in order to provide a contemporary trading possibility in the market. The ask order was set one currency unit above the last transaction price, whereas the corresponding buy order one currency unit below $({}^M v_t^b = k_{t-1} - 1, {}^M v_t^s = k_{t-1} + 1)$. If a trade occurs by matching corresponding orders with one of the zero intelligent traders, the trade is settled and the Market Maker cancels all orders in the queue and set new orders immediately.

In Prediction Markets, stock prices can be interpreted as probabilities for a future event. If all stock prices do not sum up to 100, the market is inefficient. To avoid inefficient markets, the Market Maker puts appropriate orders to equalize all stocks via arbitrage trading. Thus, the Market Maker maintains market efficiency, where the probabilities of each stock can easily be identified. By pursuing an arbitrage strategy, the Market Maker cannot lose money while buying stocks (market sum less than 100) in the market and selling it for 100 currency units. Respectively, buying a portfolio of all stocks for 100 currency units and sell it into the market if the stock market sum is greater than 100. If the Market Maker earns money trough arbitrage trading, it will be used for setting bid and ask orders on order to provide liquidity.

In the scenario without a Market Maker, one cannot derive stock's underlying probabilities for the event being predicted due to high price fluctuation. Compared to the scenario with Market Makers, the aggregated valuation of the stocks can easily be identified as 50 currency units in each stock which implies, that both events have equal probabilities of 50% according to the trader's valuations. Agents had randomly drawn between 1 and 100, where the expected mean value is 50.

The simulation results depicted in Figure 2 show, that the Market Maker model is capable of keeping Prediction Markets efficient via portfolio trading in a simple scenario. Preliminary results in more complex scenarios, where several zero intelligence traders vary their volumes as well as their valuation for certain stocks show, that the Market Maker works also well with the above mentioned strategy.

In summary, the results of the simulations of ELIAS as a proof of concept are promising. In further steps, we focus on refinements and improvements in order to make ELIAS more accurate and adjustable to more complex scenarios. Hence, learning algorithms will be applied to improve the strategy how the Market Maker in ELIAS will put bid and ask orders as well as adjustable volumes per order based on market liquidity. Furthermore, we will analyze different scenarios to investigate, if the Market Maker will realize a monetary deficit or if possible losses can be bounded to a threshold.

Conclusion and Open Issues

In this paper, the concept of Business Value Networks has been introduced, which will definitely 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, an own model was briefly outlined and discussed. In the idea evaluation phase of the model, prediction 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 prediction 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 to use Market Makers. While virtual prediction 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 realistic in real world scenarios. Therefore, an own model of an automated Market Makers was outlined.

In further steps, details of the state of the art Market Maker mechanisms will be evaluated to work with ELIAS in order to make it more powerful without making unrealistic assumptions for innovation assessment in Business Value Networks. Simulation results had already showed that the proposed model works out well in simulations in order to improve market efficiency and accuracy, so an extensive testing will be conducted.

In June, the UEFA Euro 2008 Soccer Championships are held in Austria and Switzerland. Therefore, a web based prediction market system based on Groovy&Grails is already set up to provide a field test system for automated market making. There will be two identical markets where only one is equipped with ELIAS. Market participants will trade 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 is necessary to keep the amount of participants relatively low in order to test ELIAS in thin markets. As a result, a better market accuracy in the Market Maker enabled market is expected. First field experiment results are expected by the end of July 2008. In addition, to simulate more comprehensive scenarios immediately, the introduced market system will be used for simulation purposes too. In order to simulate orders from traders, a web service interface is already implemented capable of accepting and deleting orders. In the next steps, the interface will be used to stress the system under heavy load in order to test the robustness of the system as well as the behaviour of the Market Maker in different market liquidity settings.

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