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Roland M. Miller
Otto von Guericke Universitat, Magdeburg, roland@knowledge-commerce.org

Stephanie Haiduk
Free University Berlin, s.haiduk@gmx.de

Nadine Heertsch
Free University Berlin, n.heertsch@gmx.de

Myra Spiliopoulou
Otto von Guericke Universitat, Magdeburg, myra@iti.cs.uni-bagdeburg.de

EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF DIFFERENT MARKET MECHANISMS FOR ELECTRONIC KNOWLEDGE MARKETS

Roland M. Müller[1], Otto-von-Guericke-University Magdeburg, roland@knowledge-commerce.org

Stephanie Haiduk, Free University Berlin, s.haiduk@gmx.de

Nadine Heertsch, Free University Berlin, n.heertsch@gmx.de

Hans-J. Lenz, Free University Berlin, hjlenz@wiwiss.fu-berlin.de

Myra Spiliopoulou, Otto-von-Guericke-University Magdeburg, myra@iti.cs.uni-magdeburg.de

Abstract

Knowledge sharing can be seen as a social dilemma. Mutual knowledge sharing can lead to a benefit for all the participants. However, establishing voluntary knowledge sharing can be difficult because each member benefits from the knowledge offered by others but gains little from the own contribution. Knowledge markets could overcome this problem. To analyze knowledge markets we designed and implemented the Data Trader Game. This computer-assisted game was used for the real-life experiments of different market mechanisms and their effects on knowledge sharing.

Keywords: Knowledge Markets, Knowledge Sharing, Market Mechanism.

1 INTRODUCTION

Studies about Knowledge Management have shown evidence that one of the most challenging problems is to motivate the employees to share their knowledge. Willingness to deliver knowledge to others can be low, since each individual benefits from the knowledge offered by others but gains little from the own contribution. This phenomenon is most acute in open knowledge repositories, where the members of an organization are expected to deliver knowledge for the benefit of all other members.

The contribution of knowledge to an open knowledge repository can be viewed as a public good game that leads to a social dilemma. In particular, a knowledge asset in form of a document is freely disseminated for marginal costs to everybody having access to the repository. Moreover, the consumption of a knowledge asset by one person does not influence the consumption by another. Hence, a knowledge asset in an open repository has the characteristics of a public good and its delivery can be considered as private contribution of a public good. For public goods in general, it has been observed that private contributions often lead to the "free riding" phenomenon and to an undersupply of the goods. In this study, we elaborate on knowledge markets as an alternative to an open knowledge repository.

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Knowledge markets can be observed as an incentive system for knowledge transfer. The trading of knowledge has the appealing characteristics of being applicable not only inside an organization, but also between organizations and individuals or in a virtual company. To evaluate the appropriateness of knowledge markets in this context, we experimentally test the hypothesis that a knowledge market leads to an increased contribution of knowledge as opposed to an open knowledge repository. Moreover we want to examine the efficiency of different market mechanisms for knowledge asset trading.

To this purpose, we have designed, implemented and used the *Data Trader Game*. This is a computer-assisted game to test different market mechanisms and their effects on knowledge sharing. The data-trader game consists of two elements, a business game and a knowledge contribution mechanism. In the business game, the players must solve a decision problem with uncertain information, as efficiently as possible. They may improve their decision by acquiring knowledge assets from others.

This paper is structured in the following way: First we show the related literature. Then we present a game theoretic framework for analyzing knowledge sharing and knowledge trading. After this we describe the Data Trader Game. This game is then used to test the efficiency of different knowledge market mechanisms in an experiment.

2 RELATED WORK

The need for knowledge sharing to enhance the competitive capabilities of an organization is numerously emphasized. Several motives for knowledge sharing have been identified (cf. Davenport and Prusak (1998)). The term *knowledge market* was first coined by Davenport and Prusak (1998), but they used the term in a more metaphoric way because the knowledge transfer was free of monetary charge. Prerequisites for knowledge trading but no analysis of market behavior are shown in Apostolou et al. (2002) and Skyrme (2001). Müller et al. (2002) analyze different quality management methods for knowledge markets and discuss the differences and commonalities between knowledge markets and traditional knowledge management systems.

There is also some work that tries to explain information and knowledge sharing with the prisoner’s dilemma (cf. Loebbecke et al. (1998)) and with the social dilemma (cf. Cabrera and Cabrera (2002); Wasko and Faraj (2000)). However, none of them discussed knowledge markets as a possible solution.

There exists an extensive theoretical auction literature (see Krishna (2002) for a survey). However, the actual behaviour in experiments differs partially from the theoretical predictions (see Davis and Holt (1993) and Kagel (1995) for a survey). This bounded rationality can be explained by cognitive and socio-cultural constraints. Therefore it is important to experimentally study the real actions and decisions in a knowledge asset auction.

The theoretical and experimental auction literature mainly focused on goods with scarce supply like physical products. However market experiments for knowledge assets are not well known. The main differences between knowledge assets and physical products are (i) that knowledge assets have a value in enhancing a decision or action and (ii) that they can be reproduced for marginal costs. For a more detailed analysis of the characteristics of knowledge assets, see Müller et al. (2002). Connolly et al. (1992) experimentally analyze the behaviour dynamics in a discretionary database. Rafaeli and Raban (2003) analyze how the subjective value of information is influenced by the ownership. However, both haven’t checked different market mechanisms in detail. In Müller et al. (2004) we presented the Data Trader Game, but we only analyzed the Public Good and the Fixed Price situations.

3 KNOWLEDGE SHARING AND TRADING

We analyze knowledge sharing as a prisoner’s dilemma and present knowledge trading as a possible solution for this dilemma.

3.1 Knowledge Sharing as a Dilemma

Knowledge sharing between organizations or individuals can possibly result in benefit for all participants, but from a game-theoretical point of view it might not be the equilibrium strategy. First we analyze a situation with only two players and two possible actions: Knowledge Sharing (*s*) and Knowledge Hoarding (*h*). There are four possible outcomes (with the respectively payoffs): No contribution while the partner shares his knowledge (*hs*), mutual knowledge sharing (*ss*), mutual knowledge hoarding (*hh*) and contribution while the partner is not contributing (*sh*) (see table 1). The outcome (*O*) is a utility value and is defined through the function $action \times action \to O \in \{hh, hs, sh, ss\} \subseteq \Re$.

Player B / Player A	Knowledge Hoarding h	Knowledge Sharing s
Knowledge Hoarding h	hh / hh	sh / hs
Knowledge Sharing s	hs / sh	ss / ss

Table 1. Payoff Matrix of a Two-Person Knowledge Sharing Game (outcomes for both players)

Depending on the payoff of each outcome, these players can be trapped in a social dilemma. In a social dilemma, optimal individual behavior has the effect that everybody is worse off than they would be otherwise. Individual rationality leads to collective irrationality. In a social dilemma there is at least one outcome in which every person would be better off than in the equilibrium, cf. Kollock (1998).

We make the following assumptions for outcomes: The best option for a player is to hoard the knowledge while the other player shares the knowledge (*hs*). Only the second best option is that both share their knowledge (*ss*). This difference between *hs* and *ss* is caused by the cost of knowledge sharing and the benefit of being the only one who has this particular knowledge. The third best option is mutual knowledge hoarding (*hh*). Therefore both could be better off if they share mutually instead of mutual hoarding. The worst option is that the player spends time and efforts to share knowledge while the second player hoards his (*sh*). This leads to the following ranking of the payoffs: *hs* > *ss* > *hh* > *sh*. We also assume a situation where the best *collective* strategy would be mutual knowledge sharing rather than a collusion of sharing and hoarding: *ss* > (*sh* + *hs*)/2. This corresponds to the prisoner's dilemma game (Rapoport and Chammah 1965, p.34). In this situation it is always *individually* best not to share the knowledge, independent from the choice of the other person, viz. knowledge hoarding is a strictly dominant strategy. Consequently, mutual hoarding is an equilibrium.

3.2 Knowledge Trading as a Solution

A price *p*, which the players pay for a specific knowledge asset, can solve the prisoner's dilemma, see table 2.

Player B / Player A	Knowledge Hoarding h	Knowledge Sharing s
Knowledge Hoarding h	hh / hh	sh+**p** / hs-**p**
Knowledge Sharing s	hs-**p** / sh+**p**	ss / ss

Table 2. Payoff Matrix for Two-Person Knowledge Sharing Game with a price p

Each player only sells his knowledge asset if the price compensates him for the benefit of not sharing, cf. equation (1). This benefit consists of the value to be the only one who has this knowledge asset and the saved cost and time of sharing the knowledge asset.

$$\text{Benefit of Hoarding} = hs - sh < p \qquad (1)$$

Otherwise each player only buys the other's knowledge asset if the price is lower than his individual benefit of the other's knowledge asset. Therefore the players only buy, if the equation (2) is fulfilled.

$$p < hs - hh = \text{Benefit of Knowledge Asset} \qquad (2)$$

The question arises which payoffs and which prices must exist to lead conclusively to a (new) equilibrium? To ensure such a Pareto improvement for every change from knowledge hoarding to knowledge sharing, the price must be $hh - sh < p < hs - hh$, which means that the price p must be between the base value and the additional monopolistic value. A Pareto improvement is at least as beneficial for all the players and more beneficial for some of them (Gravelle and Rees (1992), p.476). With such a price *p* the new dominant strategy for each player is to share his knowledge, and the new equilibrium is mutual sharing.

3.3 Knowledge Transfer Mechanisms

Among the various knowledge sharing mechanisms (cf. Skyrme (2001)), we focus on the following six knowledge transfer mechanisms. Figure 1 shows a classification of the knowledge transfer mechanisms. The highlighted ones are the ones we have analyzed.

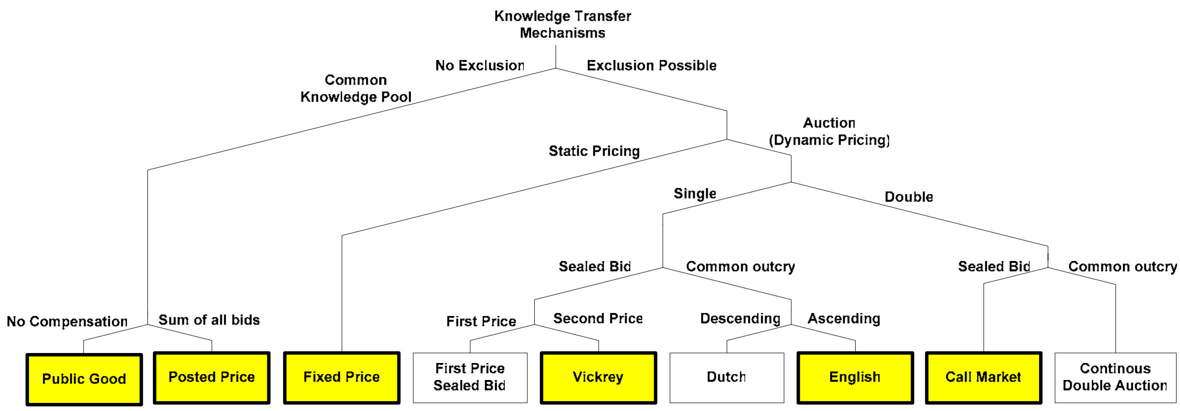

Figure 1. Classification of different Knowledge Transfer Mechanisms

Public Good Situation. The two-person knowledge-sharing dilemma (cf. sec. 3.1) becomes a public good problem if there are multiple persons who choose to share knowledge assets. We focus on knowledge in the form of documents. In our model there is no person-to-person knowledge sharing but all knowledge assets are shared through a central open repository. The purpose here is to motivate people to voluntarily provide knowledge assets to a knowledge repository, which can be accessed by every player. When a player provides knowledge assets, there will be no financial compensation through the other participants.

Posted Price Auction. Each player determines an overall selling price for a knowledge asset. The knowledge asset is sold, if the total of all bids exceeds this predefined price. Then the knowledge asset will be added to a public knowledge repository.

Fixed Price. Each player can sell knowledge assets for a take-it-or-leave-it price. There is no central repository and non-buyers are excluded from consuming the knowledge assets.

Vickrey Auction. The bids of each player are sealed. The highest bid will win the auction – but for the price of the second highest bid. We use a variation of this auction: The four highest bids win for the price of the fifth highest bid (cf. Vickrey (1961), p. 24).

English Auction. This mechanism is based on a common outcry ascending auction, in which the price is being increased until there is exactly one interested bidder left. The auction will be terminated, after a predetermined time span is expired. The seller can specify in advance how often the knowledge asset will be auctioned. This frequency number is not known by any buyer.

Call Market. The offerers make their offers and the bidders make their bids. The system then matches offers and bids and determines the overall price for the knowledge assets.

3.4 Hypotheses

In public-good games it has been observed that private contribution often leads to free riding and to an undersupply of the good (Samuelson (1954)). According to our analysis of sec. 3 we would assume free-riding behavior in the Public Good Situation because there is no sufficient reward for knowledge sharing.

H1. *Knowledge sharing mechanisms with compensation outperform mechanisms without compensation, with regard to knowledge transfer. That means that the Posted Price Auction as well as static and dynamic pricing outperform the Public Good Situation.*

The Posted Price Auction gives a compensation for the knowledge sharer. However, since there is no exclusion from the common knowledge pool, there is a second-degree social dilemma. Everybody hopes that the others will bid enough so that the knowledge asset is published.

H2. *Knowledge sharing mechanisms with exclusion outperform mechanisms without exclusion, in regard of knowledge transfer. That means that static and dynamic pricing outperforms the Posted Price Auction and the Public Good Situation.*

Fixed pricing often has the problem to set the optimal price due to a lack of accurate market data. If the take-it-or-leave-it price is set too high, too few assets can be sold. If the price was too low, the earning per asset would be too small. It is often more efficient to use auctions compared to fixed prices (cf. Wolfstetter (1999), p.184). The reason is that auctions let the bidders reveal information about their valuations.

H3. *Knowledge sharing mechanisms with dynamic pricing outperform mechanisms with static pricing, with regard to knowledge transfer. That means that the Call Market as well as the Vickrey and the English Auction outperform the Fixed Price situation.*

4 THE DATA TRADER GAME

We developed the Data Trader Game to experimentally test the hypotheses above, and analyze which auction types might be an appropriate medium for knowledge transfer. We established an experimental game environment in which different types of auctions can be tested on different groups of participants.

4.1 Overview

The Data Trader Game is a non-cooperative game – i.e. communication among the participants of the game is strictly prohibited, and the creation of obligatory agreements outside the market is not allowed as well. The game consists of two parts: a business game and a knowledge transfer mechanism. The business game gives the player the motive for knowledge sharing because the more knowledge assets the player has the better he can solve the decisions in the business game. The knowledge transfer mechanism allows the player to transfer knowledge assets to other players and to pay monetary compensations, if applicable.

The aim of the game – from the view of the market designer – is to maximize the benefit of all players while optimizing the allocation of knowledge and other goods. The tradable knowledge assets consist of information packages. Within the Data Trader Game, the knowledge market serves as a tool to optimize the knowledge transfer. In each round a player owns only one knowledge asset. However, it is possible to purchase usage rights for further knowledge assets during the game. After each round the profit for each player is being calculated.

4.2 Game Environment

The players act as managers from different countries. They all produce a different kind of product, which they want to sell to the other players' countries. For this reason they need to know the demand for their product in each foreign country. Each player knows the demand of all products including his own product in his own country. There is no competition between the players because the products from the different countries' markets do not compete with each other.

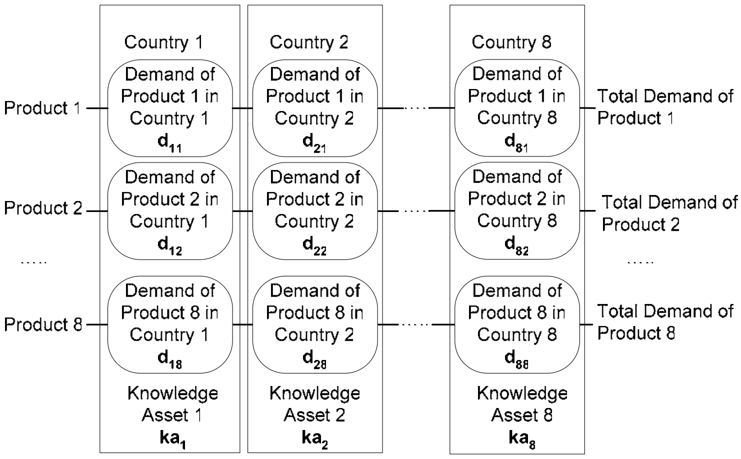

Figure 2. Knowledge Assets and Demand of Products

There are n=8 players. Each player i ($1 \leq i \leq n$) is the producer of product i. The player i resides in country i. As the origin for each player i is in the country i, the player has better market knowledge about his country than the rest of the players. He knows the demand d_{ij} in his country i of all products j ($1 \leq j \leq n$) including the demand for his own product i in country i. Therefore the tradable knowledge assets ka_i consist of the set of all demand-information in the country i, viz. $ka_i = \{d_{i1}, \dots, d_{in}\}$. However, the player *i* does not know the demand of his own product in the rest of the world, i.e. countries $j \neq i$. This knowledge is owned by the player of the respective country, (see fig. 2). An exception is the call market: To model also supply competition, each knowledge asset of a player additionally contains the demand information of their two neighbouring countries.

4.3 Running a Game

The game is sketched in figure 3 as a UML activity diagram.

Registration. Each player has to register before the game period can start. Each player receives a start capital of 800 tokens for period 1. Tokens are used as the currency of the game.

After the registration all players pass through the following steps, in each period:

Knowledge Trading. At the beginning of each round each knowledge account contains exactly one knowledge asset with information about the demand for the different products (including the own product) in the player's own country of a player. The demand is generated by the system and is randomly chosen with equal probability from the interval [1, 99]. At the beginning of each of the following periods each player will receive additional 80 tokens. Firstly, each player receives an overview of the demands of the products in his own country.

In the next step, the players can decide whether or not they want to offer their knowledge in a knowledge market. A player can simultaneously act as a seller and as a purchaser. If a player wants to purchase or sell knowledge assets, he has to make a bid. If a player submits one of the winning bids in one of the knowledge markets, he receives the usage rights for this asset. The sharing of knowledge is time consuming, and therefore costly for the contributor. Also he looses the (possible) advantage that he is the only one with that knowledge asset. Therefore explication costs of eight tokens (10% of the periodical pay-out of each player) will be charged as a transaction fee. This fee has to be paid by the seller. Depending on the knowledge sharing mechanism the player can now choose to sell and/or purchase the knowledge assets or bid for them.

Market Clearing. After all bids are collected from the players, the experimental system decides (1) who gets access to which knowledge assets and (2) how much each player must pay, depending on the knowledge transfer mechanism. The players can then study the knowledge assets they have access to. When all players have finished their transactions, they can proceed to the next step.

Decision on the Production Level. The player has to determine the supply of his product for each country. The goal is to try to be as close to the actual demand as possible.

Calculating Earnings. Subsequently the production levels are being evaluated in the form of a status report. The status report shows the success of the business decisions. The player will receive a surcharge if his estimated demand differs from the actual demand. In this case the difference will be subtracted from his deposit.

New Round. After the round is finished, the system updates the payoff account of each player, and announces and launches a new round, provided that the previous round wasn't the last one.

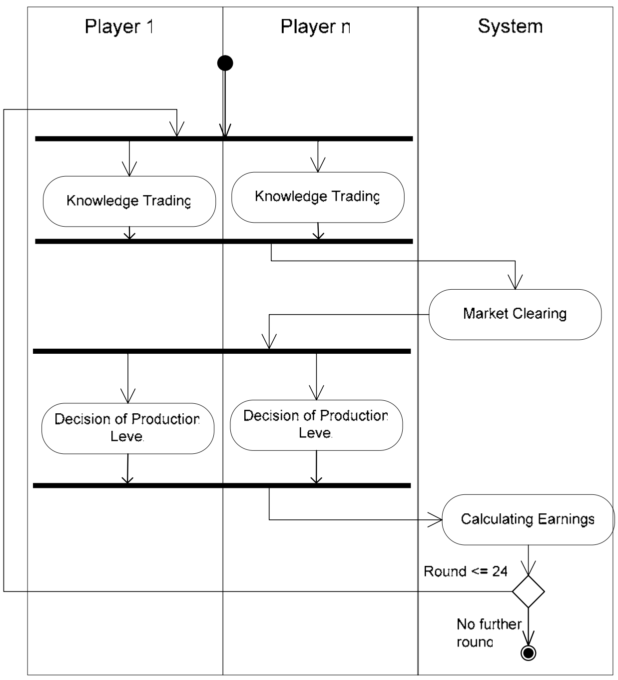

Figure 3. Activity Diagram of the Game

5 EXPERIMENTS AND EVALUATION

5.1 Experimental Design

The motivation of test persons is a critical aspect in experimental economic research. The main problem is to apply the incentive system of the model perfectly to the test persons, in order to provide for high identification and to ensure adequate relevance in the decision behavior of the test persons. For this purpose the participants usually receive a financial reimbursement, to eliminate the risk of bias caused by individual preferences in non-monetary reward systems (Wendel 1996, p.44ff). The announced prize for the winner of the game was 40 Euros. Given a duration of the game of approximately 45 minutes with 8 players this means that the expected reward per hour was approximately 6.66 Euro. This is about the wage level of a student job. Therefore the incentives are relevant for the players.

The software of this computer supported experiment is web based, however, all experiments were conducted under laboratory conditions. The players were divided randomly into groups each with eight people. Within each experiment there were 24 rounds to play (exception: English Auction with 12 rounds). There were six different playing varieties representing different market mechanisms.

It was possible to recruit 80 students as test persons for the experiment. 56 participants were students from the Free University Berlin, and 24 were students from the Otto-von-Guericke University, Magdeburg. Although the participants were students, the transferability of our reasoning is warranted according to Davis and Holt (1993), p. 17ff.

The local conditions and the number of experiments were designed as follows: 7 experiments have been carried out in the computer labs of the Department of Economics at the Free University Berlin, and 3 experiments were held at the Department of Information Systems of the Otto-von-Guericke University, Magdeburg. 4 of the 6 game varieties have been conducted 2 times; the remaining 2 varieties were executed only once (Fixed Price and English Auction).

The computer labs were each equipped with 9 computers, where 8 were destined for the test persons, and one for the supervisor. Partition walls separated the different workplaces. Therefore the information displayed on the screens or entered via the keyboard were not visible to the other participants. Moreover any discussion among the test persons was not allowed. To ensure the necessary anonymity and impartiality of the decisions, the participants were being personally supervised.

The Data Trader Game provided all required information. The test persons entered their decision values by mouse and keyboard. The entered data was simultaneously processed by the system, which stored it in a database for further statistic analyses. After all the game activities were finished, the winner was determined, and he received the announced amount of money in cash. All the participants were advised not to talk about their results to other students in order to avoid any interactions and confounding with further experiments.

5.2 Results

A comparison of the different knowledge transfer mechanisms shall help to detect the most efficient type for an electronic knowledge market.

Cut-offs. The first two rounds of the game were not taken into account for analysis due to inertia effects, but were considered as test rounds. However, the test persons were not aware of this situation (according to Seifert and Strecker (2003), p.13).

Metrics. The first variable is the *transaction ratio*. It is the ratio between the actually executed transactions and the amount of possible transactions. This measure is used to make the different knowledge sharing mechanisms comparable, which is difficult because these different mechanisms allow varying numbers of transactions. We define the transaction ratio *TR* in round *k* as $TR_k = \sum_j T_j^k / TP$, where *TP* is the maximal number of possible transactions, and $\sum_j T_j^k$ is the sum of all actual transactions of all players ($1 \leq j \leq n$) in round k.

The maximum number of transactions (*TP*) is for Public Good, Posted Price, Fixed Price and English Auction 56 (8 players each can sell their knowledge assets to the other 7 players). For the Vickrey Auction *TP* is 32 (8 players can sell knowledge assets to the highest 4 bids) and for the Call Market *TP* is 24 (8 players can buy 3 knowledge assets). The second measure is the *decision error* (*DE*), which is the difference between the estimated and actual demand. It measures the success of the decision-making in a business game. Let be d_{ij}^k the demand of product j in country i in round k. For the player j the decision error DE_j^k in round k is the sum of all the absolute differences of his supply decisions s_{ij}^k with the respective demand d_{ij}^k viz. $DE_j^k = \sum_i | d_{ij}^k - s_{ij}^k |$. The total decision error in round k is consequently $DE_k = \sum_j DE_j^k$.

Four knowledge sharing mechanisms have been repeated two times, and two mechanisms have been conducted once under experimental conditions. To ensure comparability of the different mechanisms, data from those knowledge sharing mechanisms repeated twice, was aggregated further.

Group Effect. The question has to be answered whether the data from both available random samples may be aggregated or not. For this purpose, the U-Test was used to test for significant differences between the groups. The U-Test (or Mann and Whitney Test) can be used to compare two independent random samples according to their level or mean. The U-Test is a two-sided non-parametric test, which can be used even if the data is not normally distributed. The results of the U-Test with a significance level of $p = 0.05$ show that the two samples from the Posted Price Auction as well as from the Vickrey Auction can be viewed as one sample from a uniform population. Therefore it is possible to aggregate the two experiments of each auction. The two samples for the Public Good Situation and for the Call Market were significantly different. Therefore we analyze these samples separately.

Round Aggregation. Samples which can be merged are aggregated as follows: The average is being computed for the transaction ratio (*TR*) for each round TR_k for the Posted Price Auction and the Vickrey Auction, respectively. Therefore the transaction ratio of round *k* is

$$TR_k = \frac{1}{2}(TR_k^M + TR_k^B)$$

where B refers to an experiment in *Berlin* and M to *Magdeburg*.

To check the efficiency of a knowledge sharing mechanism, the different market mechanisms were compared with each other. A market mechanism is appropriate for knowledge sharing, when the average of the transaction ratio is high. In the following test procedures the dependent variable is the transaction ratio.

Analysis of Variance (ANOVA). The Single-Factorial Analysis of Variance (ANOVA) is a method to compare average transaction ratios of the different market mechanisms. Normal distributed test statistics corresponding to the random samples, as well as the homogeneity of the variances are assumed. First of all, the Kolmogorov-Smirnov-Test is applied to find out whether the transaction ratios are normally distributed. However, this test as well as a graphical analysis of the histograms showed that not all mechanisms were normally distributed.

Second, the Levene-Test is used to find out whether the variances of the dependent variables differ significantly. The homogeneity of variance is being rejected if the p-value is lower than the level of significance, which was fixed to $\alpha = 0.05$. The Levene Test results in a p-value of 0.005.

		Transaction Ratio			
Mechanism	Location	Mean	SD	Rank	N
Vickrey Auction	B,M	0.898	0.141	1	22
English Auction	B	0.823	0.075	2	10
Call Market	B	0.795	0.116	3	22
Fixed Price	B	0.567	0.109	4	22
Posted Price	B,B	0.518	0.177	5	22
Call Market	M	0.383	0.156	6	22
Public Good	M	0.248	0.093	7	22
Public Good	B	0.183	0.112	8	22

Table 3: Descriptive Statistics of Knowledge Sharing Mechanisms

Consequently, there is a heterogeneity of variance. However, due to the low power of non-parametric test methods, we conducted ANOVA as a kind of pilot test, and backed-up the results by Box plots, as shown in fig. 4. The ANOVA shows that the knowledge sharing mechanism has a significant effect on the transaction ratio (df=7, F=87.87, p=0.000).

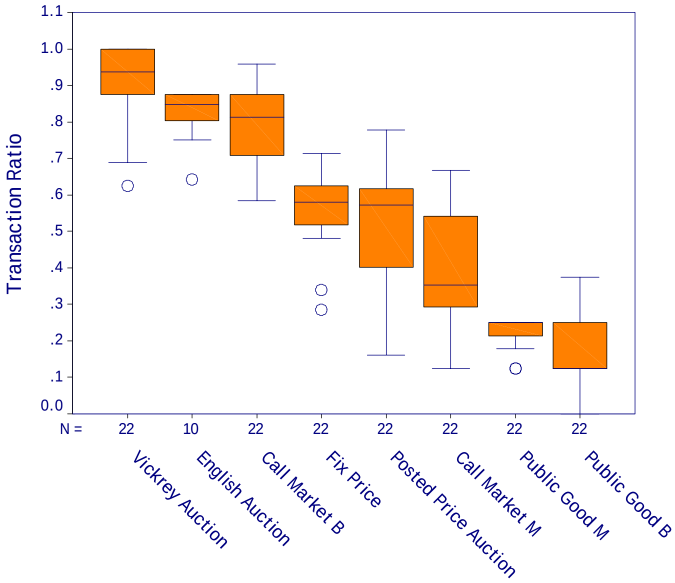

Figure 4. Boxplot of the Transaction Ratio of different Knowledge Transfer Mechanisms

Comparison of the Market Mechanisms. The aggregated subgroups show significant differences, whereas there is no evidence of any significant within group effects. The previously described test methods can be used to derive a ranking of the market mechanisms. The analysis of the overall average of transaction ratios shows that the Vickrey Auction ranks highest whereas the English Auction had the second highest and the Call Market in Berlin had the third highest rank. The lowest transaction ratio occurred in both Public Good experiments (see table 3).

The Multiple Ranking Test of Duncan shows, which market mechanisms differ significantly from each other. The p-value from the Duncan Test is being tested again with a level of significance of $\alpha = 0.01$. As a result from the Duncan Test there are four homogeneous subgroups (see table 4). The group with the highest transaction ratio includes the Vickrey Auction, the English Auction, and the Call Market (Berlin). In the middle there is the group of the Fixed Price situation and the Posted Price Auctions. The Call Market (Magdeburg) is a separate group according to the Duncan Test. The Public Good Situations showed the lowest transaction ratio and were therefore gathered in the last group. The results of the analysis are displayed in a Box plot (see fig.4).

Knowledge Sharing Mechanism	N	1	2	3	4
Vickrey Auction	22	0.898			
English Auction	10	0.823			
Call Market (B)	22	0.795			
Fixed Price	22		0.567		
Posted Price	22		0.518		
Call Market (M)	22			0.383	
Public Good Situation (M)	22				0.248
Public Good Situation (B)	22				0.183
Significance		0.021	0.240	1.000	0.123

Table 4. Ranking according to the Duncan Test (p = 0.01)

High knowledge transfers lead to low decision errors. Consequently, there is a negative correlation between the transaction ratio and the decision error in all market mechanisms (p=0.006). Regression models for each market mechanism explain the variance between 80% and 50%. The ranking of the decision error is nearly identical to the ranking of the transaction ratio, except of one market mechanism. Therefore the results of the analysis of the transaction ratio metric are consistent with the decision error metric.

Hypotheses. According to ANOVA, the Public Good Situations were located at the end of the ranking. This was also confirmed by an additional analysis of variance with n = 10 rounds. Therefore knowledge-sharing mechanisms with compensation outperform mechanisms without compensation and the hypothesis 1 is supported.

The Call Market experiment in Magdeburg was not consistent with our hypothesis 2. Except of this outlying experiment, all mechanisms with exclusion outperform the Posted Price Auction. The Fixed Price ranked better than the Posted Price Auction but the ranking was not significant at the level p=0.01. Therefore we can conclude that knowledge-sharing mechanisms with exclusion mostly outperform mechanisms without exclusion, and the hypothesis 2 is also mostly supported.

Evidently, the different dynamic pricing mechanisms generally showed a better result than the Fixed Price and the Public Good Situations. If the outlier (Call Market in Magdeburg) is again omitted, it became evident that the Vickrey Auction, the English Auction, and the Call Market provided the best results with regard to the highest transaction ratio. Therefore knowledge-sharing mechanisms with dynamic pricing outperform mechanisms with static pricing and hypothesis 3 is supported.

6 CONCLUSION

Overall our hypotheses are supported. Market mechanisms are more efficient in respect of the sharing of knowledge than Public Good Situations, which result in suboptimal private knowledge sharing, as it is the case in knowledge pools. We are aware that there are some aspects that are relevant in knowledge asset trading which we omitted. For example, in the above described game we haven't analyzed the problem how to overcome the asymmetric information about the quality of the knowledge assets and the related question of trust. For this purpose different quality management procedures have been suggested (see e.g. Müller (2002)). Regarding a classification of dynamic auction mechanisms it is yet not possible to give a conclusion with high likelihood. Further empirical investigations and advanced experiments are mandatory.

References

Apostolou, D.; Mentzas, G; Abecker, A.; Eickhoff, W.-C.; Maas, W.; Georgolios, P.; Kafentzis, K. and Kyriakopoulou, S. (2002). Challenges and directions in knowledge asset trading. In:

Proceedings of the 4th International Conference on Practical Aspects of Knowledge Management, PAKM 2002. Vienna, Austria. Springer.
Cabrera, Á. and Cabrera, E. F. (2002). Knowledge-sharing dilemmas. Organization Studies, 23 (5), 687–710.
Connolly, T.; Thorn, B. K. and Heminger, A. (1992). Discretionary databases as social dilemmas. In:W. B. G. Liebrand; D. M. Messick and H. A. M.Wilke (eds.). Social dilemmas: Theoretical issues and research findings, 199–208. Pergammon Press, New York.
Davenport, T. and Prusak, L. (1998). Working Knowledge: How Organizations Manage What They Know. Harvard Business School Press, Boston.
Davis, D. and Holt, C. (1993). Experimental Economics. Princeton University Press, Princeton.
Gravelle, H. and Rees, R. (1992). Microeconomics. 2nd Edition. Longman, New York.
Kagel, J. H. (1995). Auctions: A Survey of Experimental Research. In: Kagel, J. and A. E. Roth (eds.). The Handbook of Experimental Economics, 501-557. Princeton University Press, Princeton.
Kollock, P. (1998). Social dilemmas: The anatomy of cooperation. Annual Review of Sociology, 24, 183–214.
Krishna, V. (2002). Auction Theory. Academic Press, San Diego.
Loebbecke, C.; van Fenema, P. and Powell, P. (1998). Knowledge Transfer under Co-opetition, In: Larsen, T., Levine, L., DeGross, J. (eds.). Information Systems: Current Issues and Future Changes, Chap. 14, 215–229. IFIP, Laxenburg.
Müller, R. M.; Haiduk, S.; Heertsch, N.; Lenz, H.-J. and Spiliopoulou, M. (2004). Studying Knowledge Trading with a Business Game. In: Proceedings of the International Conference on Computer Science, Software Engineering, Information Technology, e-Business, and Applications (CSITeA'04), Cairo, Egypt.
Müller, R. M.; Spiliopoulou, M. and Lenz, H.-J. (2002). Electronic marketplaces of knowledge: Characteristics and sharing of knowledge assets. In: Proceedings of the International Conference on Advances in Infrastructure for e-Business, e-Education, e-Science, and e-Medicine on the Internet (SSGRR 2002w). L'Aquila, Italy: Scuola Superiore G. Reiss Romoli.
Rafaeli, S. and Raban, D. R. (2003). Experimental investigation of the subjective value of information in trading. Journal of AIS, 4 (5), 119–139.
Rapoport, A. and Chammah, A. M. (1965). Prisoner's Dilemma. University of Michigan Press, Ann Arbor.
Samuelson, P. (1954). The pure theory of public expenditure. Review of Economics and Statistics. 36 (4), 387–89.
Seifert, S. and Strecker, S. (2003). Mehrattributive Bietverfahren zur elektronischen Beschaffung. In: 65. Jahrestagung des Verbands der Hochschullehrer für Betriebswirtschaft (VHB Pfingsttagung 2003).
Skyrme, D. J. (2001). Capitalizing on Knowledge. Butterworth-Heinemann, Oxford.
Vickrey, W. (1961). Counterspeculation, auctions, and competitive sealed tenders. Journal of Finance, 16, 8-37.
Wasko, M. and Faraj, S. (2000). 'It is what one does': why people participate and help others in electronic communities of practice. Journal of Strategic Information Systems, 9 (2-3), 155– 173.
Wendel, M. (1996). Spieler oder Spekulanten? - Eine spieltheoretische und experimentelle Studie menschlichen Entscheidungsverhaltens auf interdependenten Güter und Kapitalmärkten mit unvollständiger Information. Physica, Heidelberg.
Wolfstetter, E. (1999). Topics in Microeconomics: Industrial Organizations, Auctions and Incentives. Cambridge University Press, Cambridge.