Knowledge Sharing and Trading on Electronic Marketplaces

Inaugural-Dissertation
zur Erlangung des akademischen Grades eines
Doktors der Wirtschaftswissenschaft
des Fachbereichs Wirtschaftswissenschaft der
Freien Universität Berlin

vorgelegt von

Dipl.-Volkswirt Roland M. Müller

aus

Berlin

Berlin, 2005

Dekan: Univ.-Prof. Dr. Michael Kleinaltenkamp

Erstgutachter: Univ.-Prof. Dr. Hans-J. Lenz

Zweitgutachterin: Univ.-Prof. Dr. Myra Spiliopoulou

Tag der Disputation: 15.12.2005

Abstract

Knowledge is becoming more and more important compared to other factors of production, such as land, capital, and work. As a reaction to this phenomenon, more and more companies have established knowledge management systems. However, the lack of motivation of the participants to share their knowledge has become one of the most challenging problems when implementing knowledge management solutions.

We distinguish between two knowledge transfer mechanisms: (1) the sharing of knowledge through an open knowledge repository, which is accessible to everybody inside the organization and (2) the trading of knowledge on electronic knowledge markets. This thesis introduces a theory of knowledge sharing, and presents a prototype for an electronic knowledge market.

The contributions of the dissertation are shown here in detail:

- *Analysis of Knowledge Assets*

  The characteristics of knowledge assets and their effect on knowledge sharing and trading are analyzed.

- *Development of a Knowledge Sharing Theory*

  – We present an economic model for knowledge sharing, which offers possible reasons for opportunistic behavior in a knowledge management system. This model designs knowledge contribution as a public-good game and as a prisoner's dilemma respectively.

  – The economic model is extended by some factors identified as relevant by experimental economics when analyzing public-good games. Among these factors are knowledge-sharing motives such as altruism, conditional cooperation, reputation, and social norms.

  – Incentives for knowledge contribution are analyzed by using the economic model on the one hand, and by means of a possible crowding-out of intrinsic motivation on the other hand.

  – The effect of culture on knowledge sharing is analyzed by using the knowledge sharing theory.

- *Empirical Test of the Influence of Incentives and Culture on Knowledge Sharing*

  The influences of incentives and culture on knowledge contribution—as derived from the economic model—are empirically tested by using actual transaction data from a multi-national knowledge management system.

- *Development of a Model for Knowledge Marketplaces*

  - We present a model of an electronic knowledge market that describes the different elements of a knowledge market in a framework. The model includes the following elements: marketplace strategy, market mechanism, matching services, fulfillment services, quality assurance services, IT infrastructure, behavior of the market participants, overall market outcome, as well as evaluation measures.
  - Different methods are analyzed that are able to reduce the quality uncertainty on knowledge markets and ensure the matching of expert and advice seeker.

- *Experimental Evaluation of different Market Mechanisms for Knowledge Markets*

  We developed an experimental testing environment in order to evaluate different knowledge-sharing mechanisms. The different mechanisms were tested experimentally under laboratory conditions for their effect on knowledge trading.

- *Development of an IT Infrastructure for Electronic Knowledge Markets*

  We developed an IT architecture for knowledge markets based on Web Services, and demonstrated its feasibility with a prototype.

Keywords: Knowledge Sharing, Knowledge Trading, Electronic Markets, Knowledge Management

Zusammenfassung

Wissen wird gegenüber den Produktionsfaktoren Land, Kapital und Arbeit immer wichtiger. Darauf reagierend haben in den letzten Jahren immer mehr Firmen Wissensmanagementlösungen implementiert. Jedoch stellte sich die oft mangelnde Motivation der Beteiligten zum Wissensaustausch als eines der größten Probleme bei der Einführung einer Wissensmanagementlösung heraus.

Es wird zwischen zwei Wissenstransfer-Mechanismen unterschieden: Die Wissensteilung durch ein offenes, im Unternehmen frei zugängliches Repositorium und der Wissenshandel durch elektronische Wissensmärkte. Die vorliegende Arbeit stellt zum einen eine Theorie der Wissensteilung vor, zum anderen wird ein Modell für elektronische Wissensmärkte entwickelt.

Die Beiträge dieser Dissertation sind im Einzelnen:

- *Analyse von Wissensgütern*

  Die Eigenschaften von Wissensgütern und deren Einfluss auf Wissensteilung und -handel werden analysiert.

- *Entwicklung einer Theorie der Wissensteilung*

  – Ein ökonomisches Modell der Wissensteilung wird präsentiert, das mögliche Ursachen für opportunistisches Verhalten in einem Wissensmanagementsystem aufzeigt. Es modelliert die Wissensbereitstellung als Öffentliches-Gut-Spiel bzw. als Gefangenendilemma.

  – Das ökonomische Modell wird um Faktoren erweitert, die die experimentelle Ökonomie bei der Untersuchung von Öffentlichen-Gut-Spielen als relevant erkannt hat. Dazu zählen Wissensbereitstellungsmotive wie Altruismus, konditionale Kooperation, Reputation und soziale Normen.

  – Anreizsysteme für die Wissensbereitstellung werden einerseits anhand des ökonomischen Modells und andererseits anhand der möglichen Verdrängung intrinsischer Motive analysiert.

  – Die Wirkung kultureller Faktoren auf die Wissensbereitstellung wird anhand des Modells analysiert.

- *Empirischer Test der Einflüsse von Anreizsystemen und Kultur auf die Wissensbereitstellung*

  Die aus dem Modell vorhergesagten Einflüsse von Anreizsystemen und Kultur auf die Wissensbereitstellung werden anhand des tatsächlich aufgezeichneten Verhaltens in einem multi-nationalen Wissensmanagementsystem empirisch getestet.

- *Entwicklung eines Modells für Wissensmärkte*

  - Wir präsentieren ein Modell für elektronische Wissensmärkte welches die einzelnen Elemente eines Wissensmarktes in einem aufeinander aufbauenden Rahmenwerk darstellt. Das Modell beinhaltet folgende Elemente: Marktplatzstrategie, Wissensmarktprozess, Marktmechanismus, Matching-, Ausführungs-, und Qualitätssicherungsservices, IT-Infrastruktur, Verhalten der Marktteilnehmer, Marktergebnis und Evaluationsmaße.
  - Es werden Methoden untersucht, die die Qualitätsunsicherheit auf Wissensmärkten reduzieren können und das Matching von Experten und Ratsuchenden sicherstellen.

- *Experimenteller Test des Einflusses verschiedener Marktmechanismen für Wissensmärkte*

  Es wird eine experimentelle Testumgebung entwickelt um verschiedene Wissensaustauschmechanismen zu evaluieren. Verschiedene Marktmechanismen werden experimentell unter Laborbedingungen auf ihre Wirkung für den Wissenshandel getestet.

- *Entwicklung einer IT Infrastruktur für elektronische Wissensmärkte*

  Es wird eine Webservice-basierte IT-Architektur für Wissensmärkte entwickelt und die Durchführbarkeit prototypisch gezeigt.

Schlagwörter: Wissensteilung, Wissenshandel, Elektronische Märkte, Wissensmanagement

Acknowledgements

Writing this thesis would not have been possible without the support of my doctoral advisor Professor Hans-Joachim Lenz. I thank him for his guidance and his encouragement throughout my work. Also, I would like to thank my co-advisor Professor Myra Spiliopoulou for her constructive suggestions and her invitation to the Information Systems group at the Otto-von-Guericke Universität Magdeburg.

Special thanks go to all members of the Information Systems groups of the Freie Universität Berlin and the Otto-von-Guericke Universität Magdeburg as well as to the colleagues of the Graduate School in Distributed Information Systems (Speaker: Prof. Oliver Günther). In particular, I am grateful for the constructive discussions with Markus Schaal and Tanja Falkowski.

Furthermore, I would like to thank the students who wrote their master theses under my supervision: I am in particular grateful to Christine Weiß, Raminder Kalsi, Gregor Wobbe, Stephanie Haiduk, and Nadine Heertsch.

I thank the German Research Society for the financial support (DFG grant no. GRK 316/3). I am also grateful to the “Freundeskreis Wirtschaftswissenschaft FU Berlin e. V.” for their financial support of the experiments.

Last but not least, I would like to thank Katja, for everything.

Contents

List of Figures

List of Tables

List of Symbols

Symbol	Description	Section
U	Utility of player	3.1.1
$\mathcal{A}$	Action Space: $\{s, h\}$	3.1.1
h	Knowledge Hoarding	3.1.1
s	Knowledge Sharing	3.1.1
hh	Outcome of Mutual Knowledge Hoarding: $U(h, h)$	3.1.1
ss	Outcome of Mutual Knowledge Sharing: $U(s, s)$	3.1.1
sh	Outcome of Sharing while the partner hoards his knowledge: $U(s, h)$	3.1.1
hs	Outcome of Hoarding while the partner shares his knowledge: $U(h, s)$	3.1.1
π	Firm's profit	3.1.2
U_i	Utility of employee i	3.1.2
x_i	Time for working of employee i	3.1.2
s_i	Time for knowledge sharing of employee i	3.1.2
b_i	Fixed time budget of employee i	3.1.2
w_i	Fixed wage of employee i	3.1.2
$P_i(x_i, K)$	Production function of employee i	3.1.2
K	Amount of useful knowledge in repository	3.1.2
$\partial P_i/\partial x_i$	Marginal work productivity of employee i	3.1.2
$\partial P_i/\partial K$	Marginal knowledge productivity of employee i	3.1.2
$\partial K/\partial s_i$	Marginal knowledge externalization efficiency of employee i	3.1.2
$\frac{\partial K^2}{\partial s_i \partial s_j}$	Knowledge complementarity of knowledge externalization of employees i and j	3.1.2
φ	Fraction of payment from employee performance	3.1.2
s_i^*	Individual optimal time for knowledge sharing of employee i (Nash Equilibrium)	3.1.2
$s_i^\diamond$	Company optimal time for knowledge sharing of employee i (Pareto Optimum)	3.1.2
$K^\diamond$	Company optimal amount of useful knowledge in repository	3.1.2
UA	Unfairness Aversion	3.2.3
A	Altruism	3.2.2
I	Incentives	3.4.1
$M^\diamond$	Optimal Contract Menu	3.4.2
C^E	Contract intended for Experts	3.4.2
C^I	Contract intended for Implementers	3.4.2
$U^q(C^c)$	Utility for an Employee of Type $q \in \{E, I\}$ choosing Contract C^c, $c \in \{E, I\}$	3.4.2

Symbol	Description	Section
$\widehat{U}^q(C^c)$	Anticipated Maximal Utility of Type $q \in \{E, I\}$ with Contract C^c, $c \in \{E, I\}$	3.4.2
$\overline{U}^q$	Reservation Utility	3.4.2
p	Price	5.1
$\mathcal{AC}$	Set of Actors	5.8
$\mathcal{S}$	Set of Skills	5.8
$\mathbf{D}$	Decision Matrix	5.8
$\mathbf{E}_i$	Expertise vector of expert i	5.8
$\mathbf{w}$	Weighting vector	5.8
$\mathcal{T}$	Set of Documents	5.8
$\mathcal{C}$	Set of Quality Criteria	5.8
S_j^+	Separation from the ideal solution of expertise j	5.8
S_j^-	Separation from the negative-ideal solution of expertise j	5.8
C_j^+	Closeness to the ideal solution of expertise j	5.8
TR	Transaction Ratio	6.2.2
TP	Maximal Number of Possible Transactions	6.2.2
DE	Decision Error	6.2.2
d_{ij}^k	Demand of product j in country i in round k	6.2.2
s_{ij}^k	Supply of product j in country i in round k	6.2.2

List of Abbreviations

DCOM	Distributed Component Object Model
DRM	Digital Rights Management
DTD	Document Type Definition
HR	Human Resource
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IDV	Individualism Index
IIOP	Internet Inter-ORB Protocol
IS	Information Systems
IT	Information Technology
KM	Knowledge Management
KMS	Knowledge Management System
PDA	Personal Digital Assistant
PDI	Power Distance Index
RMI	Remote Method Invocation
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
UAI	Uncertainty Avoidance Index
UDDI	Universal Description, Discovery and Integration
UML	Unified Modeling Language
WLAN	Wireless Local Area Network
WSDL	Web Service Definition Language
XML	Extensible Markup Language
XSD	XML Schema Definition

List of Propositions

no.	Proposition	Related Hyp.	Page
13	Group communication influences knowledge sharing positively.		86
14	Incentives influence knowledge sharing positively.	1,5	88
15	If the company has complete information about the work and knowledge productivity of its employees, it can achieve optimal knowledge sharing by setting a linear incentive function.		89
16	The crowding-out effect of intrinsic motivation may lower the incentive effect.		96
17	Individualism influences knowledge sharing negatively.	2	103
18	Power Distance influences knowledge sharing positively.	3	103
19	Uncertainty Avoidance influences knowledge sharing negatively.	4	104
20	Knowledge-transfer mechanisms with compensation outperform mechanisms without compensation.	5	137
21	Knowledge-transfer mechanisms with exclusion outperform mechanisms without exclusion.	6	137
22	Knowledge-transfer mechanisms with dynamic pricing outperform mechanisms with static pricing.	7	138

List of Hypotheses

no.	Hypothesis	Related Prop.	Page
1	The higher the Incentives Intensity in a country, the higher the average knowledge-sharing activity of the country.	14, 3	111
2	The higher the Individualism Index of a country, the lower the average knowledge-sharing activity of the country.	17	111
3	The higher the Power Distance Index of a country, the higher the average knowledge-sharing activity of the country.	18	111
4	The higher the Uncertainty Avoidance Index of a country, the lower the average knowledge-sharing activity of the country.	19	112
5	Knowledge-transfer mechanisms with compensation outperform mechanisms without compensation with respect to the knowledge transfer, measured with the transfer ratio. That means that the posted-price auction as well as static and dynamic pricing outperform the public-good situation according to the transfer ratio.	20,3,14	169
6	Knowledge-transfer mechanisms with exclusion outperform mechanisms without exclusion with respect to the knowledge transfer, measured with the transfer ratio. That means that static and dynamic pricing outperform the posted-price auction and the public-good situation according to the transfer ratio.	21	169
7	Knowledge-transfer mechanisms with dynamic pricing outperform mechanisms with static pricing with respect to the knowledge transfer, measured with the transfer ratio. That means that the call market, as well as the Vickrey and the English auction outperform the fixed-price situation according to the transfer ratio.	22	169
8	In the public-good situation the majority of the participants is free riding with respect to knowledge sharing (transaction ratio < 0.5).	1	173

no.	Hypothesis	Related Prop.	Page
9	In the public-good situation the transaction ratio is much less than the Pareto Optimum, which would be that everybody is sharing all his knowledge assets (transaction ratio = 1).	2	173
10	If the majority will free ride in the public-good situation there is a negative downward trend for knowledge sharing.	5, 6	174