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Information Systems and Decision Quality: Lessons from Information Economics and Agency Theory

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ABSTRACT

One of the arguments for using information systems (IS) is the expectation to enhance decision quality and, thereby, to increase overall business value. Practical experiences as well as empirical evidence show that this expectation is not always fulfilled and explanations are manifold. The paper applies information economics and, especially, agency theory as explanatory framework for analyzing the relation among IS and decision quality. Thereby, novel insights for unfulfilled expectations related to effects of IS on decision quality are derived. The paper seeks to substantiate the claim for an intensified agency-based research into IS - not only to enrich the IS discipline but also to indicate that agency-based research on management information could benefit from the IS discipline.

Keywords (Required)

agency-theory, decision-making, IT-adoption, information asymmetries, information economics, opportunistic behavior

INTRODUCTION

The expectation is reasonable: IS hold enormous potential to provide managers with information of high quality so that managers can make good decisions in terms of the overall firm's objective. In this sense Information technology (IT) is an enabler for good decision-making. However, empirical evidence is somewhat disillusioning and the reasons identified range from measurement problems, inappropriate IS functionalities, missing strategic IT-alignment, IT-mismanagement to resistance of users (e.g. Brynjolfsson, 1993; Barua, Kriebel and Mukhopadhyay, 1995, Oh and Pinsonneault, 2007). Presumably, the reasons are interrelated.

The paper applies information economics and, especially, agency theory as explanatory framework for the relation among IS and decision quality which appears to be widely disregarded until now. According to agency theory the paper argues as follows: Managers (i.e., agents) consequently apply IS to maximize their own utility functions and this is not necessarily in accordance with headquarters' (i.e., the principal's) interest. Due to information asymmetries headquarters cannot exactly prosecute this kind of behavior. Two sorts of effects have to be taken into account:

- First-order effects result as IS directly affect information quality and costs and, thereby, inevitably influence the extent of information asymmetries. Information asymmetries may lead to efficiency losses from headquarters' perspective.
- Second-order effects arise because IS are subject to manifold decisions of managers. For example, often managers or decentral units participate in the IT-adoption and adaptation. So, the system might be biased in the manager's interest.

The underlying research objective of the paper is, firstly, to illustrate the potential contributions of agency theory for IS research. Secondly, we want to figure out that the elaborated, but very abstract agency-based research on management information could benefit from the IS discipline, as IS represent a wide area to apply and evaluate findings of agency research and to generate novel and practically relevant research questions.

The paper strictly applies the (rigid) framework of agency theory. However, although findings of formal agency-models are applied, we refrain from depicting these models.

The remainder of the paper is organized as follows: The following section introduces terms and assumptions that are essential for the analysis. Afterwards IS are interpreted from an agency perspective and a survey of agency-based research into IS is given. Subsequently, first-order and second-order effects of IS on decision-making are analyzed from an agency perspective. Finally, the findings are discussed.

DEFINITIONS AND ASSUMPTIONS

Decision Quality

First of all the term “decision quality” has to be clarified. In the following decision quality is used in terms of effectiveness and efficiency of decision-making as widely accepted in the IS discipline although the corresponding measures are not consistently defined (Clarke, Jones and Armstrong, 2007; Todd and Benbasat, 1999). However, a wide range of measures is seen as appropriate (Clarke, Jones and Armstrong, 2007) as, for example, (perceived) decision effectiveness varies across individuals or parties in an organization (Sabherwal and Bederra-Fernandes, 2003). From an agency perspective (at least) two different parties with conflicting interests have to be considered. Following the basic assumptions of agency theory, which are pointed out in the subsequent section, good decision-making from the agent’s point of view has not necessarily to be in line with good decision quality from the principal’s perspective. In this paper, decision quality is analyzed from the principal’s perspective taking the agent’s decision-making based on an IS into account.

Basic Assumptions of Agency Theory

Information economics which is the basis of (normative) agency theory analyze the effects of information in precisely specified situations of, at least, two parties. The parties have different levels of information, are aware of these information differences and interact strategically (Milgrom 1981). Agency theory concentrates on delegated decision-making in situations with information asymmetries and conflicts of interests between principal and agent. Some widely-used fundamental assumptions put the relation between principal and agent more into concrete (e.g. Eisenhardt, 1989; Richter and Furubotn, 2003):

- Both parties maximize their individual expected utility.
- The agent’s utility function consists, at least, of a positive component due to the compensation and a negative component (costs). One type of costs is the effort the agent has to employ for decision-making.
- The result of the agent’s decision is positively related to the agent’s effort. The result also depends on an exogenous random factor that the principal cannot observe. In consequence, the agent’s effort cannot perfectly be inferred from the result.
- The principal is often assumed to be risk neutral. Then the principal’s functions of expected utility can be simplified to expected result of the delegated decision less expected compensation to be paid to the agent.
- Risk aversion is the usual assumption about the agent’s attitude towards risk.
- In this situation a fundamental conflict of interests occurs: The principal wants the agent to employ high effort for low compensation whereas the agent wants the opposite.

Information System, Information Quality and Functions of Information

Agency-based research tries to figure out which contractual arrangements maximize the principal’s overall result in different situations (e.g. different information asymmetries). The term contract is used in a broad sense and includes, for example, incentive schemes, monitoring procedures or information systems.

Information systems in agency theory are defined in a very abstract meaning as a set of observable signals which might be complemented by likelihood probabilities (Gjesdal 1982). The likelihood probability represents the conditional probability to receive a certain signal given that a certain exogenous factor was realized or a certain decision/effort was made by the agent. Of course, signals could be more or less informative, for example, about the agent’s activities or the exogenous factors. In this sense information quality is an integral component of agency theory, although this definition is extremely restricted compared to the understanding in the IS discipline (e.g. Olson and Lucas, 1982; Zmud, 1978).

In the following the term information system is used in the broad sense of an IT-based IS as far as nothing different is indicated.

The differentiation between two types of information in principal-agent-relations is fundamental (Holmstrom 1979):

- *Decision-influencing information* is generated after the agent's decision. This type of information serves for performance evaluation and is used to rate the agent's compensation. This is ex-ante known to the agent and under the assumptions aforementioned the agent will take this into account for decision-making.
- *Decision-facilitating information* serves directly for decision-making and, in this sense, allows the agent to make better decisions which is the major concern of this paper.

However, it should be taken into consideration that in practice the two types of information cannot easily be separated from each other. For example, a given set of data that a modern Enterprise Resource Planning (ERP)-system with integrated Business Intelligence-functions yields might serve for performance evaluation and at the same time for decision-making.

The terminological considerations could be summarized as follows:

Subsequently we mainly concentrate on decision-facilitating information and how it is influenced by IS in a principal-agent-relation. Reasonably, this type of information is directly related to decision quality - the central issue of this paper. Decision quality in terms of decision effectiveness and efficiency is analyzed from the principal's perspective taking into consideration that the agent seeks to make decisions with respect to maximize the own utility function.

Figure 1 illustrates the framework of the analysis.

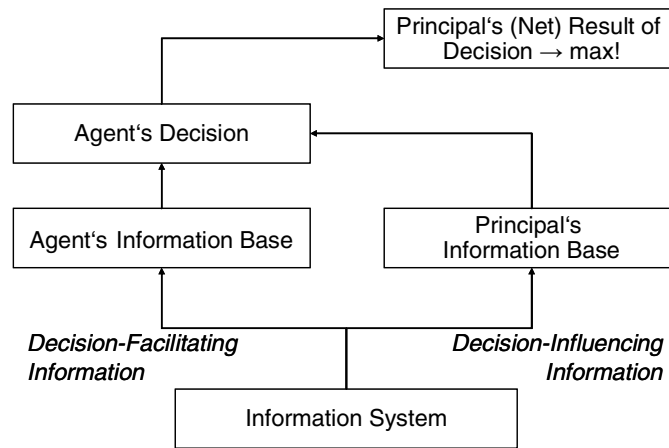


Figure 1. Framework of Analysis

INTERPRETATION OF INFORMATION SYSTEMS FOR DECISION-MAKING FROM AN AGENCY PERSPECTIVE

Information Systems in Agency-Based Research

Agency-based research into management information has generated a large pool of results about the value of additional decision-influencing and decision-facilitating information, especially, in combination with incentive schemes. Furthermore, a nearly unmanageable amount of insights exists with respect to situational (dis-)advantages of different accounting information and monitoring instruments for affecting departmental managers (overviews in Lambert, 2001; Levinthal, 1988; Prendergast, 1999). This type of research applies the abstract aforementioned meaning of information systems. In our paper we try to transfer findings of this area to IS.

A considerable body of research analyzes IS by an approach based on information economics (e.g. Ahituv, 1980; Barua, Kriebel and Mukhopadhyay, 1989; Kriebel and Moore, 1982) whereas the literature on effects of IS in principal-agent-relations is not comparably extensive. It was argued that IT-adoption induces oppositely directed effects on organizational structures. On the one hand monitoring costs are reduced and, in consequence, more decentralized organizational structures become efficient (Gurbaxani and Whang, 1991; West and Courtney, 1993; Karake, 1992). On the other hand decision-facilitating information could be processed more efficiently and faster. Therefore, headquarters does not need to delegate decisions so that structures become more centralized. Furthermore, middle management, as it is mainly responsible for monitoring, is assumed to lose relevance and hierarchies might be flattened because monitoring is rationalized and more efficient incentive schemes can be established (West and Courtney, 1993; Picot, Ripperger and Wolff, 1996).

A relatively elaborated branch of agency-based research focuses the contractual relation between headquarters (principal) and the (internal or external) *IT-service provider* (agent) and seeks for optimal incentive structures (e.g. Rasch and Yost, 1997; Richmond, Seidmann and Whinston, 1992; for an overview Wall, 2006).

However, detailed analyses of IS and decision quality in the contractual relation between headquarters and a professional manager, e.g. plant manager, seem to be rare. Subsequently, we try to provide a contribution to reduce this gap.

Technology-Induced Enhancement of Information

“In agency theory, information is regarded as a commodity: It has a cost, and it can be purchased“ (Eisenhardt 1989, p. 64). The idea is the following: While accepting information costs a better information quality can be achieved. Information costs and information quality are seen as the two sides of the same coin: A high level of information principally can be achieved, but may be information costs are (prohibitively) high.

Information technologies could differ in the costs caused for generating additional or improved information. For example, costs caused by a revenue report for different sales regions and products in a manual system might be prohibitive, whereas marginal costs in an existing data warehouse system might be reduced to some mouse-clicks.

To migrate to an enhanced information technology could be seen from two sides: Certain additional information is generated with reduced marginal costs or a given additional sum of costs leads to an increased marginal quality of information (Picot, Ripperger and Wolff, 1996).

Informational Decisions in Principal-Agent-Relations

Altering information technology from an agency perspective primarily means to alter the relation between information costs and quality. However, whether the full potential of an IS is tapped depends on the informational decisions of headquarters and managers to actually use the system: Before making the “professional” decision, e.g. production planning, the manager (agent) has to make informational decisions whether to search for additional decision-facilitating information. Similarly, when designing the contract offered to the agent, the center (principal) has to decide whether additional decision-influencing information is to be used for performance evaluation.

Each party will decide to generate additional information if and only if the resulting expected benefit at least covers the marginal information costs. Unfortunately, information generating is exposed to risk as often it could not be taken for granted which information will be generated. The information paradox results: To be able to evaluate the benefit of additional information in advance, i.e. for informational decisions, in fact the information has already to be generated and used in the party’s decision-problem (Feltham, 1968). Furthermore, of course the costs of information have to be taken into account.

This paper mainly focuses on decision quality. Therefore decision-facilitating information is in the foreground and the costs the manager has to employ. Let us assume the manager could be quite sure about the information (quality) and the resulting benefit that will be generated. Then the manager decides for information search if the benefit at least equals information costs. Obviously, information costs related to IS could be of different nature as for example:

- *Effort/opportunity costs*: To make use of the IS the manager (or his department) for example has to employ learning costs. Furthermore, perception and processing of information require effort. Due to scarce resources these information costs might also come along as opportunity costs.
- *(Direct) IT-costs*: Costs for *additional* decision-facilitating information generated by an IS obviously depend on the IT infrastructure itself but also on the modalities of cost allocation. For example, cost apportioning is customary. Then the manager is not necessarily charged with IT-costs for generating *additional* information. Contrarily, direct cost allocations reflect the actual usage of the IS and a certain internal transfer price is attributed to a certain “output”, e.g. revenue report. With direct cost allocations the *marginal costs* of additional decision-facilitating information are affected.

UNFULFILLED EXPECTATIONS: EXPLANATIONS FROM AGENCY THEORY

First-Order Effects

Extension of Information Asymmetries

Let us take for granted that IS enhance the information basis which the manager (agent) could use for decision-making. However, from the principal’s perspective this is a double-edged sword:

- On the one hand with enhanced information the manager is able to better adopt to exogenous conditions and, by this, to make better decisions in terms of the principal's objectives.
- On the other hand information asymmetries between agent and principal are enhanced. The manager might use the (enhanced) informational advantage opportunistically in favor of the own interest accepting losses with respect to the principal's objective. In terms of agency theory: the hidden-information situation is aggravated.

Findings of the - admittedly abstract - agency research into management information indicate that in some situations the principal is better off with an uninformed agent than with a well informed agent. A crucial factor seems to be the expected profit situation (Schiller, 2001; Pfeiffer, 2004): If profit margins are low or the risk of losses is high the manager in tendency should decide on a broad information basis. Then the information system serves to avoid losses whereas adverse-selection effects are not that relevant. In contrast, if circumstances are more fortunate the probability of wrong decisions with substantial losses is lower whereas the manager might be tempted to make decisions in his own best interest. Depending on the profit situation and risk exposure the trade-off between loss-avoiding effects and adverse-selection effects of information varies.

Obviously, the center should take these findings into account when assessing costs and benefits of an IS in the course of IS-investment decisions.

Avoidance of Information Search

In the following we assume that the center wants the manager to be well-informed (for example due to low profit margins as aforementioned) and, therefore, to actually use the IS. However, the principal cannot be sure offhand, i.e. without further cost-causing monitoring or incentives, whether or not the manager searches for further information and uses the system for decision-making. In terms of agency theory a hidden-action situation exists.

Agency-based research on management information has shown that the higher information costs the higher is, ceteris paribus, the manager's incentive to remain uninformed and to decide on a limited information base and vice versa; particular (e.g. super-high powered) incentive schemes are capable to counteract this kind of behavior (Lewis and Sappington 1997). These findings can be transferred to IS as IS affect information costs. Furthermore, costs of information search depend on the individual cost function of the agent and, as mentioned above, might consist of several monetary and non-monetary components.

Therefore, it depends on the individual utility function whether a rational manager avoids or intensifies information search with an IS. (Partly) Avoiding information search might be one (further) reason why the IS-potential for decision-making might not be fully tapped. Furthermore, the findings indicate that the center should carefully balance the modalities of IS cost allocation.

Second-Order Effects

Second-order effects on decision quality arise because the IS itself might be subject to decisions of the agent. Subsequently, two exemplary problems are analyzed. In the first one the manager decides on the function he attributes to the IS for decision-making. In the second problem the agent actively influences the functionality of the IS.

Substitution of Creative Decision-Making

Ideally decisions should result from a systematic procedure (e.g. Eisenführ and Weber, 2003). Decision-making based on IS contributes to the implementation of this ideal. IS to some extent are capable to control decision-making and, by that, managers' latitude in decision-making is reduced due to technology-based restrictions. In this sense IS serve as substitute for institutions (Picot, Dietl and Franck, 2002). Empirical results indicate that in many companies strategic planning is based on IS-based procedures which prescribe in detail the data and planning instruments that have to be applied (Weber, Hamprecht and Goeldel, 1997). The authors conclude that managers are put down to pure data suppliers and that their creativity to develop and adopt strategic alternatives is disregarded.

However, from an agency perspective the interpretation could differ to a certain extent:

Decision-making causes efforts for managers. IS might reduce the efforts for routine tasks related to decision-making like data-collection and -analysis (Todd and Benbasat, 1992). In this sense, an IS serves to rationalize decision-making. Of course, there are more challenging subtasks of decision-making, e.g. creation of strategic alternatives. May be, the put down to data suppliers claimed above is in accordance with the manager's utility function as the creative subtasks of decision-making require effort which he is able to replace by using the IS.

From the principal's perspective it is desirable that the manager applies IS to rationalize his decision-making as far as it makes sense and to refrain from applying an IS for unsuitable subtasks of decision-making. However, it is to be taken into account that from the manager's perspective effort causes costs and therefore the manager might be tempted to rely on an IS even for those subtasks of decision-making which require effort in form of creative and innovative problem-solving. In other words, managers might purposefully apply an IS as inappropriate substitute for effort-causing problem-solving.

Participation in IS-Projects

Often departmental managers or business units (agents) participate in IS-adoption and adaptation. Actually, departmental participation in IS-projects is regarded as success factor par excellence for the IS. One argument states that departments could - due to their familiarity to business processes - better specify requirements of the system than headquarters or IT-specialists and, furthermore, user acceptance is assumed to increase with participation (e.g. Clarke, Jones and Armstrong, 2007, Gluchowski, Gabriel and Chamoni, 1997).

In terms of agency theory precisely information asymmetries yield the essential argument to let the agent participate in IS-adoption and adaptation. In consequence, the manager has two tasks or two decisions to make: Firstly, the manager has the "main" or professional decision area (e.g. production planning). Secondly, the manager has to make decisions related to the functionality of the IS. These two decisions are interrelated. When participating in the IS-projects the rational manager has in mind how the IS-related decision affects his/her professional decision and, in the end, the compensation he/she receives. So, a rational agent will make the IS-decision in maximizing the own expected utility received from the contractual relation including the IS-decision as well as the professional decision. Then the IS is not exogenously given but emerges *endogenously* within the contractual relation.

When participating in IS-adoption and adaptation the manager has at least two different incentives.

- The first might be named as *incentive to assure quality*: The manager is interested in an IS which provides information with high quality. This is obvious for *decision-facilitating information* as this allows the manager to make better decisions with respect to the own utility function. As far as the manager's utility function is in line with the overall result of the center (e.g. due to appropriate result-based compensation) this leads to better decisions from the center's perspective. Furthermore, the manager seeks to increase the quality of *decision-influencing information* provided by the IS. If the IS would provide information with low quality (i.e., with "noise") the manager would be charged for effects he/she is not responsible for. In consequence, the manager seeks to (nearly¹) assure that quality of performance indicators that is reflected in the weights they have in the compensation scheme (Banker and Datar, 1989). The incentive to assure quality is, all else equal, the higher the higher performance information provided by the IS are weighted in the compensation (Wall 2006).
- Following the assumptions of agency theory the agent has an *incentive to manipulate*: The manager involved in the project of IS-adoption seeks to opportunistically bias decision-influencing information used for his/her performance evaluation. Presumably, the peril of being detected in manipulation decreases with increasing degree of participation. Then the system might provide systematically biased performance information because the agent (mis-)used his influence in the course of IS-adoption. From agency research it is known that each contract inducing biased information could be replaced by an equivalent contract inducing truthful reporting (so-called *revelation principle*) (Myerson, 1979). However, this does not mean that the principal realizes a better overall result under the truth-inducing contract; rather the principal has to leave an information rent to the agent².

Participation in IS-adoption and adaptation means that the manager is able to influence the system that will later on serve for decision-making and for evaluating the manager's performance. As precisely the information asymmetry is the reason for participation the center offhand neither is able to evaluate the agent's IS-decision nor to perfectly assess the properties of the IS for example with respect to the provided information quality (Wall, 2006).

¹ Of course, the agent employs costs (effort) in the IS-projects. If no compensation for these costs is offered, the IS will provide less significant information than is reflected in the given compensation scheme. This is due to the fact that the agent maximizes his utility function which is the difference of utility from salary (enhanced by higher information quality and, for that, more effort) and the disutility of effort.

² Furthermore, the application of the revelation principle depends on certain conditions like unlimited information transfer (e.g. Lambert 2001).

Theoretically both parties see through these interrelations. The principal offers a contract that maximizes the overall result with respect to the agent's IS-decisions and professional decisions and that the manager accepts. Of course, *in practice* the interrelations will hardly be foreseen in the contract - at least because contracts usually are not changed when an IS is implemented or modified. In consequence, an imbalance between compensation, information costs and information quality occurs. This kind of imbalance leads to efficiency losses (Lambert, 2001). By that, a further reason is identified why potentials of IS might not be fully tapped and expectations remain partly unfulfilled.

CONCLUSION

The findings of our analysis are summarized in table 1. From an agency perspective the overall effect of IS on decision-quality in terms of the principal's objective could be positive or negative as the single effects analyzed might go in both directions. Several aspects were identified why the anticipated (net) benefit of IS actually might not be realized as far as opportunistic behavior of managers is not taken into account: Managers as rationally acting agents seek to achieve their own objectives and, for that, they opportunistically apply and – if possible – affect the IS.

No.	“Mechanism”	Direction of Effect	Agent's motivation/ Context Factor
First-order-effects			
1.	Extension of Information Asymmetries	+/-	Range of Profit Margin; Risk Exposure
2	Avoidance of Information Search	+/-	Avoidance of Costs depending on Individual Cost Function
Second-order-effects			
3.	Substitution of Creative Decision-Making	-	Avoidance of Effort
4.	Participation in IS-Projects	+ -	Quality Assurance Manipulation
Table 1. Effects on Decision Quality			

The findings were derived by strictly applying the (rigid) framework of agency theory. Obviously, IS providing decision-facilitating information were, in the end, reduced to a technology which is characterized by a certain relation between information quality and information costs. By that, findings of agency-based research on (management) information in contractual relations could be applied to IS. Obviously, we concentrated on quite simple contractual relations and in further research activities the considerations should be refined, for example by differentiating the analysis with respect to types of IS, IS-competencies of managers, decision-problems, modalities of IS-cost allocation or incentives schemes. Further research activities should be directed towards the evaluation of the theoretical findings. Following the tradition of agency research mathematical modeling could be the next step. By that, for example, the interplay among first- and second-order effects on decision quality or optimal incentive structures for decision-making with IS could be figured out. However, with respect to the multiplicity of effects as they were derived in this paper the applicability of optimization models might be limited. Therefore, may be simulation models could be the more appropriate approach for evaluation.

However, the findings could be seen from a different perspective in that agency-based research into management information could benefit from the IS discipline: One problem of agency-based research is that - due to analytical rigor - the situations and problems investigated are “under-complex” and incapable to reflect practice (e.g. Eisenhardt, 1989; Richter and Furubotn, 2003). Therefore, the explanatory power of the generated findings is assumed to be limited. The paper indicates that insights of agency-based research seem to be applicable to IS and, therefore, the wide and practically relevant area of IS is opened up for the application of the abstract findings of agency-based research into management information.

Furthermore, the IS discipline reveals novel research questions for for agency-based research into management information: For example, it was addressed in the paper that in actual IS (e.g. ERP-systems) information can serve for decision-facilitating as well as for decision-influencing purposes – in one contractual relations or in different relations. Special aspects arising from the “hybrid” character of information appear to be widely uninvestigated in agency research. To (better) reflect practice

agency research could be directed towards “hybrid” information. Moreover, information technology - abstractly seen as cost-quality-relation - plays an important role in agency-research, but information technology usually is regarded as exogenously given in the contractual relation in the agency research into management information. As the case of user-participation in IT-projects has shown this appears to be an inappropriate simplification which should be overcome in further research.

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