

Identifying IT impacts on organizational structure and business value

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Abstract. This paper presents a framework for analysis of how IT systems add business value by causally affecting the structuring of organizations. To aid our understanding of IT benefits related to organizational structure, we put the well established theory of organizational behavior developed by Mintzberg to use. Combining Mintzberg with more recent research on the business value of IT, the result is a qualitative multi-disciplinary theoretical framework that shows which business values are affected by IT in relation to the organizational structure. This framework can be used to analyze what kind of IT system should be used by an organization with a given structure to maximize its business value.

Keywords: IT benefits, organizational structure, Mintzberg, business value

1 Introduction

It has long been discussed in the IT value research area whether IT adds value to an organization or not. Following Brynjolfsson [1], the discussion in the literature increasingly supports the theory that IT can add business value to an organization. For instance, Bergsjö et al [2] have shown that the user satisfaction caused by functionality, usability, information structure etc. affects the quality, efficiency and innovations of IT users. Researchers (and practitioners) now turn focus to the question of how IT adds value to the organization [3]. This problem is approached here by an attempt to combine the traditional theory of organizational structures with more recent research on how aspects of IT might affect the structure or the workings of the organization. Dahlgren [4] stresses that organizational structure has a defining role on how information flows within an organization and, as a consequence, how well processes are performed and resources are spent. Other studies of the impact of electronic communication systems on business organizations are Fulk et al., [5], Andersen [6,] and Gurbaxani et al. [7].

Traditional organizational theory describes organizations; the behavior of groups of people in them, how strategies and structures influence the groups, how the organizations suit different purposes and how they can be managed to achieve goals. Research on the business value of IT, often within the enterprise architecture research paradigm, tends to focus on the relation between various information systems and

business values, not necessarily taking other organizational factors, such as the division of labor, unit size and grouping, training, etc. into account [8].

Our method is directed at the synthesis of traditional theories of organization and management and current research on the business value of IT. With this approach the organizational impact of IT is visualized, as in Fig. 1, instead of relating IT to the final business values directly.



Fig. 1. The relationship between IT and business value goes through organizational impact.

By including its impact on the organization in the analysis of IT, a more diversified and correct evaluation can be achieved. The goal of this paper is to identify IT systems that causally affect organization variables and business value. Since different organizations are structured in different ways, the organizations need different IT systems to complement their respective organizational structure and achieve high business value.

1.1 Outline

The remainder of this paper is structured as follows. Extended influence diagrams used for causal modeling are introduced in section 2. Section 3 presents the framework of business values used, in the shape of an extended influence diagram. Section 4 connects the organizational theory of Mintzberg [8] to these business values. In section 5 the extended influence diagram is further extended to include the connections to IT. The applicability of the metamodel is discussed in the subsequent section 6. Section 7 concludes the paper.

2 Extended Influence Diagrams

Extended influence diagrams (EID) are graphic representations of decision problems coupled with a probabilistic inference engine. These diagrams may be used to formally specify enterprise architecture analysis [9]. The diagrams are an extension of influence diagrams, as described by Shachter [10, 11] which in turn are an enhancement of Bayesian networks (cf. Neapolitan [12] and Jensen [13]). In extended influence diagrams, random variables graphically represented as chance nodes may assume values, or states, from a finite domain (cf. Fig. 2). A utility node could for example be “Organizational performance”. The utility node could be further described by other nodes that it has a definitional relation to. Causal relations capture associations of the real world, such as “an automation system affects the process efficiency”. In Fig. 2, this is visualized by “Scenario Selection” that causally affects the “Process efficiency” which itself causally affects the “Organizational performance”.

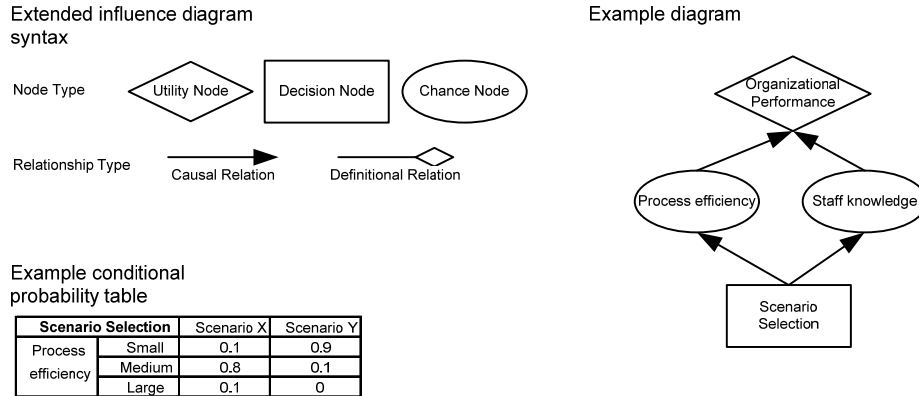


Fig. 2. An extended influence diagram and a simple example

Extended influence diagrams support probabilistic inference in the same manner as Bayesian networks do; given the value of one node, the values of related nodes can be calculated. With the help of a *conditional probability table* (CPT) for a certain variable *A* and knowledge of the current states of the causally influencing variables *B* and *C*, it is possible to infer the likelihood of node *A* assuming any of its states. With a chosen scenario, the chance nodes will assume different values, thereby influencing the utility node. For more comprehensive treatments on influence diagrams and extended influence diagrams see Johnson et al. [9], Shachter [10, 11], Neapolitan [12], Jensen [13], and Johnson et al [14].

However powerful a research tool the EID framework is, EID:s cannot be created *ex nihilo*. There exists a lot of research on how to elicit the quantitative estimates used to create CPTs, for example Druzdzel et al. [15] and Keeney et al. [16]. Nevertheless, these methods are applicable only if there already exists a qualitative framework, i.e. all the relevant nodes and arrows have been identified, even in the absence of figures. Only then is it clear which CPTs to create. The qualitative framework presented here has been developed following the methodology given by Lagerström et al [14]. The theory proposed in this paper consists only of positive or negative causal effects between variables, and indications of the strength of the relations. These relations should be represented in the EID so that the framework can be put to use in future empirical studies to improve the model.

Thus, we use the following qualitative relations inspired by Chung et al. [17]:

1. AND. The and relation reflects a relation where two or more quantities all need to be present for another quantity to emerge. This is denoted by an arc connecting the relevant influence arrows.
2. OR. The or relation reflects a relation where just one out of two or more quantities need to be present for another quantity to emerge. This is denoted by two arcs connecting the relevant influence arrows.
3. ENABLES. The enables relation expresses a strong positive influence of one quantity on another one. This is denoted by ++.

4. **SUPPORTS.** The supports relation expresses a positive influence of one quantity on another one. This is denoted by +.
5. **UNDERCUTS.** The undercuts relation expresses a negative influence of one quantity on another one. This is denoted by -.
6. **DISABLES.** The disables relation expresses a strong negative influence of one quantity on another one. This is denoted by --.

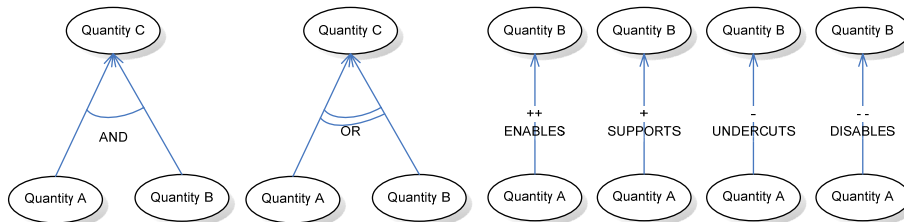


Fig. 3. Relations between quantities, used in qualitative modeling.

To understand how these qualitative relations work, consider Fig. 4. Using the relations specified above we can refurbish a diagram, such as the simple AND-example below, into a set of *tentative* CPTs, where the figures reflect the relations used. While these CPTs are somewhat arbitrary – both the (a) and the (b) alternatives are acceptable representations – they are well-defined in the sense that CPTs such as (c) are clearly unacceptable. Furthermore, these CPTs can be *updated* in a non-arbitrary fashion, using the well-known learning algorithms of Bayesian networks described for instance by Jensen [13], whenever empirical data is available.

In this paper, when there are three or more quantities that causally affect the same quantity the binary relations should be considered first and the unary relations should follow. Several binary relations are only used here when they are identical and thus commute.

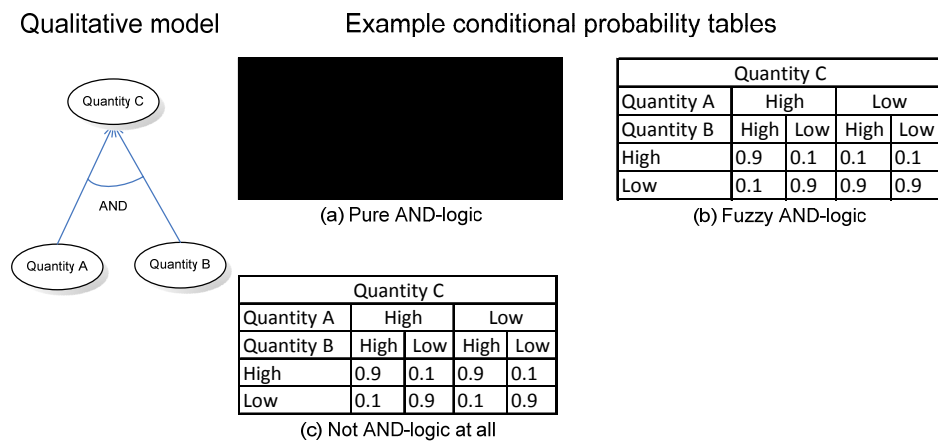


Fig. 4. Sample CPT interpretations of a qualitative model.

The relations proposed by Chung et al. [17] pertain to goals. Often, however, we use these relations between chance nodes. The rationale for this extension is that some

of our chance nodes could properly be considered utility nodes on a more local scale. Locally, they are goals to be fulfilled, even though focus and clarity would be lost if they were portrayed as such in global diagrams.

In summary, the qualitative relations reflect *how* entities influence each other – the CPTs of full EIDs reflect the *extent* of this influence.

3 Categorization of business values

Business value is a debated subject within the research literature. Several ways to categorize possible IT benefits, differing in scope and granularity, have been suggested. In this work, the categorization of business value dimensions suggested by Gammelgård et al. [18] is used to map the business values Mintzberg mentions [8] to common IT business value categories. The categorization Gammelgård proposes is based on a literature study combining more than 650 business value dimensions from 200 different sources.

Since the research focus here is the organization, only a subset of those IT benefits classified by Gammelgård et al. as related to the organizational structure and the resources within the company were related to by the Mintzberg theories. Consequently, business values not related to the organizational structure or the resources within the organization are not included. The business values relevant for this paper are visualized in Fig. 5.

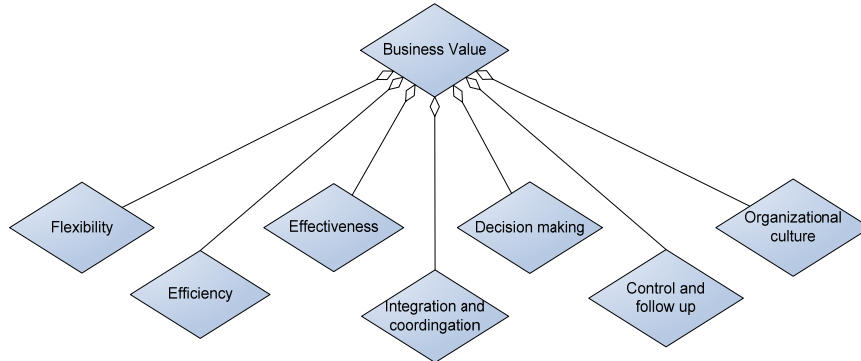


Fig. 5. The business values organizational structure affect, based on Gammelgård et al. [18].

Benefits related to resources of the business include the business values of (i) flexibility, (ii) efficiency, (iii) effectiveness, (iv) integration and coordination, (v) improved decision making and (vi) improved organizational culture. Flexibility relates to organizational ability to adjust to the external factors.

Efficiency relates to that the organization is doing the right things, while effectiveness is a measure of doing these things right. Integration and coordination is a measure of internal synchronization of the organization and better decision making concerns the support and process of decision making. Organizational culture is the least clearly defined business value and could include lower employer turnaround, lower sick leave etc.

All of the business values in [18] are not covered by the studied organizational theory; using a familiar vocabulary thus permits incorporating this work to previous research.

4 Organizational theory

Henry Mintzberg [8] proposes a theory of organization that is now classic within the field. Based upon a synthesis of the literature, Mintzberg attempts to model the form and functioning of organizations by structuring those external and internal factors that have been subject to investigation. Mintzberg's theory is used because it allows for an organisation wide view of IT benefits. Mintzberg's 'Structure of Fives' has been used by Farbey et. al. [23] to analyze organizational structures and their impact on an IT project.

Our focus here is on the internal factors, the design parameters, i.e. those factors that can be consciously affected by management decisions. By structuring these into a qualitative EID, we pave the way for linking them both to the business values described in section 3 and to the IT systems to be described in section 5.

Mintzberg [8] presents four design areas; (i) design of positions, (ii) design of superstructure and (iii) design of lateral linkages. Since the areas are applicable for all organizations, no business specific views can be included in the analysis, such as degree of functional fit.

Several concepts used in the literature do not express a clear causality chain, but implies that most concepts are related to each other, sometimes in circular causality. To avoid circular causality chains, and to minimize the complexity of calculations, only a subset of Mintzberg's relations are included. Excluding relations have only been made when there is no direct causality between two concepts.

A short description of each area follows, along with a description of how these have been interpreted into a qualitative EID.

4.1 Design of positions

As defined by Mintzberg, the design of positions within an organization determines (i) the level of specialization of work tasks, (ii) the formalization of behavior, and (iii) the training and indoctrination of workers.

Work can be *specialized* both horizontally and vertically. The horizontal specialization separates work tasks that are of different character from each other. Horizontal specialization is used to increase productivity by streamlining work tasks and lowering switching costs between different tasks. Vertical specialization, on the other hand, is defined as separating “the performance of the work from the administration of it” [8]. The level of horizontally specialized work is modeled as a factor supporting effectiveness in Fig. 6.

An organization can formalize the behavior of the workers through *standardization* of the output of the processes or by regulating the work flows. The organization could also use formalization by rules, regulating the limits of the work. This is reflected in Fig. 6, where a certain overall level of standardization can be achieved through the standardization of skills, processes, or output.

Discussing the standardization of skills, Mintzberg makes the distinction between training and indoctrination. Training refers to the learning of job related skills and knowledge, while indoctrination refers to the internalization of organizational norms. Mintzberg suggests that training and indoctrinations are substitutes: most organizations put more emphasis on either the one or the other. In Fig. 6, these aspects are modeled by having internal training programs and recruiting based on relevant education disjunctively influence the standardization of skills.

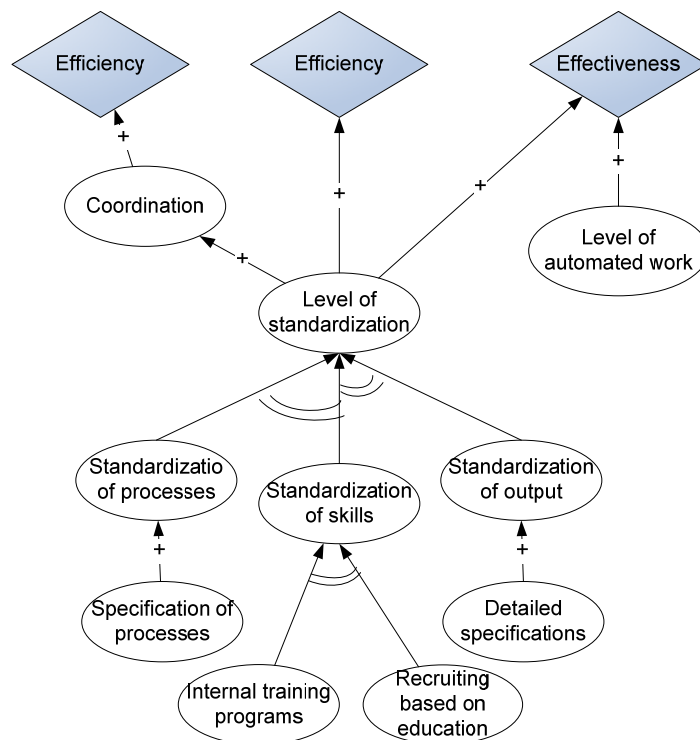


Fig. 6. An EID describing relations between quantities related to the design of positions.

4.2 Design of superstructure

The superstructure of an organization describes the highest level of its organization diagram; the grouping and size of the constituent units.

Two major types of organizational grouping can be distinguished; (i) grouping by function and (ii) market based grouping. In Fig. 6, this is modeled in the underlying organizational structure node, capable of assuming either value. Depending on which value this node assumes, the correspondingly named parent node assumes a higher value. Functional grouping is more common when there are significant interdependencies of process and scale, and where standardization works well. Market based grouping is more common when there are significant interdependencies of workflow, and where standardization works poorly. Market based division supports a clear work flow since production, marketing and sales of a certain output, client or graphical area all work closely together. This can be compared to the functional grouping, where the marketing division is separated from the production and sales divisions. Roughly, market based grouping leads to higher efficiency while functional grouping leads to higher effectiveness. The well-known matrix organization attempts to combine the desirable features of both types of grouping. These notions are modeled in Fig. 6, by the influence of the level of liaison. A high level of liaison will raise the value assigned to the structure not assumed by the underlying structure. If both structure nodes assume high values, this corresponds to a matrix organization.

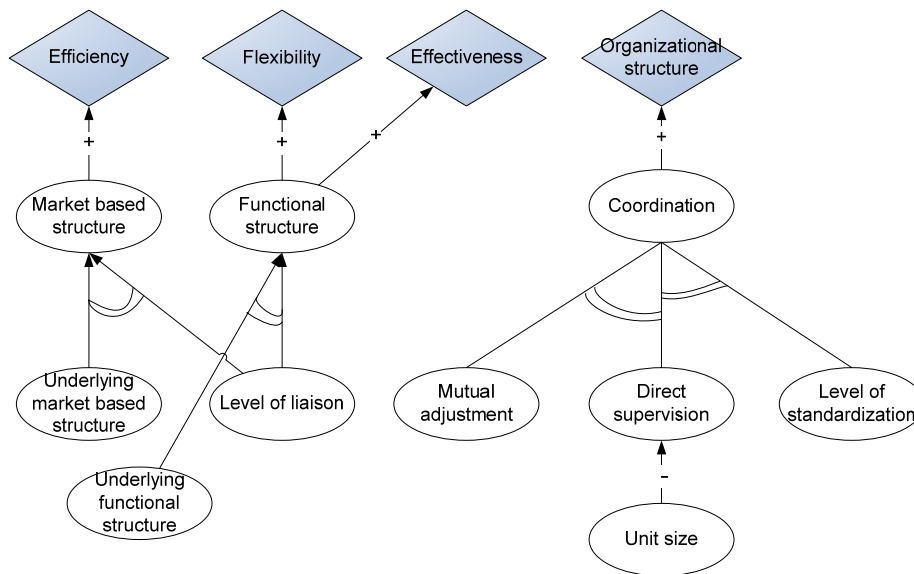


Fig. 7. An EID describing relations between quantities related to the design of superstructure

The next parameter relevant to organizational superstructure is the size of units. As it turns out, the primary factor governing feasible unit sizes is the mechanism of coordination employed by the organization. Whenever standardization is used as a means of coordination, the need for supervision decreases and the ability of a single manager to keep track of a larger group of subordinates increases. If direct

supervision is used, on the other hand, group sizes cannot grow very large, as is reflected in Fig. 6, where unit size undercuts the level of direct supervision.

According to Mintzberg, there are three different basic means of achieving coordination: (i) mutual adjustment, (ii) direct supervision, and (iii) standardization. This is reflected by the disjunctive relations between these concepts with respect to coordination, as illustrated in Fig. 6.

4.3 Design of lateral linkages

Two sorts of lateral linkages within an organization are discussed by Mintzberg; (i) liaison devices and (ii) planning and control systems.

Liaison devices, that interconnect distant parts of an organization, are common in modern organizational structures. Their basic rationale is the coordination of complex, interdependent activities. Mintzberg identifies a number of liaison devices that characterizes the spectrum between a purely functional and a purely market oriented organization. Using (i) liaison officers, (ii) task forces or standing committees, and (iii) integrating managers, functional and market based organizations can be blended. The most radical liaison measure is the introduction of the matrix organization, which fully does away with unity of command. All these measures are reflected in Fig. 8, where the three liaison measures listed above all support the overall level of liaison. As illustrated in Fig. 7, this level then affects the type of grouping of the entire organization.

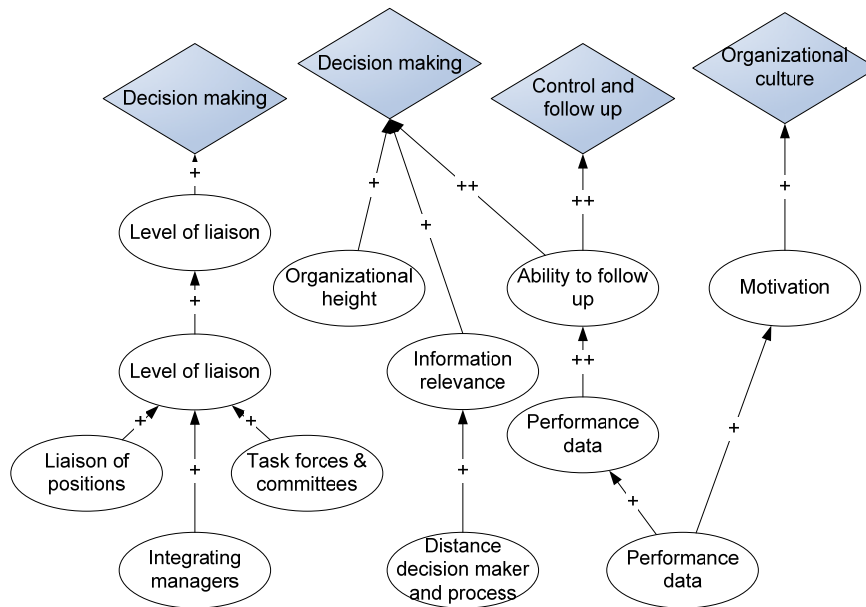


Fig. 8. An EID describing relations between quantities related to the design of lateral linkages

Performance control is a tool for management to measure the results of a unit, but also a tool that gives feedback to the unit. Some such qualities, taken from Mintzberg, are reflected in Fig. 8, where they are connected to the business values of decision making, control and follow up and organizational culture. The two first are intuitive, and the third business value is achieved through higher motivation of employees who get feedback on how well they meet goals according to Mintzberg [8].

5 Influence of IT

Having thus structured business values and their connections to the inner workings of organizations, it is now time to connect this structure with the impact of IT. The literature provides a few different taxonomies of information systems employed in the industry.

After identifying areas where IT can complement and support the organization, two main system types have been discerned; IT systems that enable communication (vertically and horizontally) between organizational units, and systems that control the processes; either completely (through automation) or partially (through directing the work flow). Hence, we propose this fourfold taxonomy of IT systems, based on the function they fulfill:

1. **Horizontal communication.** This applies to the communication among peers, for example in a project group using a collaboration system. Bidirectional communication is a distinguishing feature.
2. **Vertical communication.** This includes both the upward stream of data that generates decision support for top and middle management (aggregation of information) and the downward stream of data that directs the work of subordinates (dissemination of orders). The unidirectional (either way) communication is a distinguishing feature.
3. **Work flow.** This is the class of systems that standardize work behavior by forcing the user to do things in a certain order or by a certain procedure. This is a semi-automated form of manual labor, where the actual work is still performed by a human, but the process is coordinated by a machine.
4. **Automation.** This represents a further step, as compared to work flow. Work is now fully automatic, performed by a machine. The human operator performs only supervisory tasks.

A similar typology has been created by Mooney et al [24] where IT effects on business processes are categorized into three kinds: (i) automational, (ii) informational, and (iii) transformational effects. As compared to this typology, we have identified a work-flow aspect not easily squared within the typology of Mooney et al., while we have not identified the function of transformation to be affecting organizational concepts distinct enough to warrant a separate category.

Our categorization is based on the functionality the system should have on a very high level. Functional fit is not considered here since the required functions would be

different for each business area. Table 1 lists a couple of systems that could fulfill the required functionality.

Table 1. Examples of systems that could provide an organization with requested functionality.

Horizontal communication	Vertical communication	Work flow	Automation
Collaboration system	Quality management system	Order management system	CAM system
Knowledge management system	Sales system	Supply chain management system	SCADA system

Horizontal communication could for instance be achieved by a collaboration system that simplifies cooperation between different unit groups within the organization or a knowledge management system that spreads knowledge between different groups.

Any system that collects data at one organizational level and presents it at another level is a vertical communication system. Examples of such are quality management systems or a sales system where management can keep track on the sales record.

The work flow systems could for instance be an order system or a supply chain system if the systems conduct the flow of the activities within the order or supply chain process.

The automation system could be a SCADA (Supervisory Control And Data Acquisition) system that is conducting a whole process, or it could be a system that only automates part of the process, for instance as a report making system.

5.1 Connecting IT to the organization variables

Fig. 9 assembles the different parts so far discussed only separately; the business values, organizational variables and IT.

Vertical communication systems support the control and follow-up process, which according to Mintzberg [8] affects the data used for following up the work in the organization, and affects the motivation of the workers in a positive way. Vertical communication systems also has a positive effect on the direct supervision leading to unit groups not needing to be small to achieve direct supervision , hence the OR relation.

Horizontal communication systems affect the level of liaisons between unit groups. A high level of liaison can according to Mintzberg [8] make a functional oriented or market oriented organization to become a matrix organization, which effects both flexibility, efficiency and effectiveness.

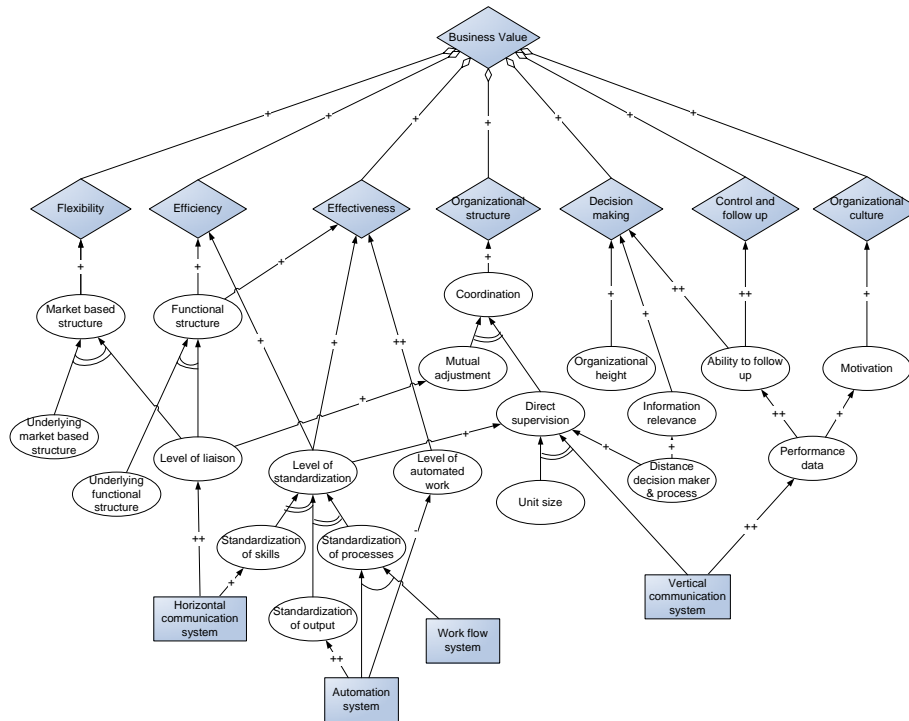


Fig. 9. An EID combining the business values, organizational variables and IT systems.

Automation systems and **work flow systems** are systems that achieve the same benefits, but to different degrees. The main advantage of these kinds of systems is that the work process is formalized. A completely automated process also lead to standardized output. Work flow systems indicate that there are still people performing large parts of the process, but in a standardized manner. This leads to that a work flow system also affects the level of bureaucracy. The business values affected by the two systems are efficiency, effectiveness and coordination.

6 Discussion

This paper provides a qualitative causal framework of how IT affects organizations to create business value. This framework provides the basis needed to form a complete extended influence diagram to support further research. Three crucial steps can be identified on the path from the present study to the envisioned full EID.

Firstly, qualitative relations (AND, OR, supports, undercuts etc.) should be replaced with more quantitative relations as embodied in CPTs. This is an iterative process, where the initial CPTs are set somewhat arbitrarily but are then updated in a non-arbitrary fashion as empirical evidence becomes available. Therefore, this stage also includes the collection of such evidence, for instance through case studies.

Secondly, the framework should be extended in a fashion that it could be expressed in a modeling language. This would include setting values for the variables; i.e. how large a unit could be to have a positive effect on the ability to perform direct supervision etc. A modeling language would also increase the possibility of analysis.

Thirdly, the framework only concerns areas related to organizational theory, and several of the business values suggested by Gammelgård [18] are not covered. Hence, the framework should be extended to cover all of the business values.

7 Conclusions

We have seen that the business values of IT can be derived through analysis of the impact IT has on organizational structure. The framework suggested differentiates between communication systems (vertical and horizontal), work flow systems and automation systems. Furthermore, the framework identifies those organizational variables that are affected by IT, while themselves affecting business values.

We see that horizontal communication systems affect organizational flexibility and connections between components (i.e. coordination); vertical communication systems affect organizational culture, decision making and coordination; and finally work flow systems and automation systems affect effectiveness, efficiency and coordination. These relations are summarized in Table 2.

Table 2. Summary of which business values each system type affects.

Horizontal communication	Vertical communication	Work flow	Automation
Organizational flexibility	Coordination	Efficiency	Efficiency
Coordination	Organizational culture	Effectiveness	Effectiveness
	Decision making	Coordination	Coordination

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Proceedings of BUSITAL 2008

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