The Impact of Information Technology on Transaction and Coordination Cost

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Abstract

Coordinating work among individuals and groups belongs to the essential tasks of managing organizations. The arise of various kinds of teams support technology, such as groupware and workflow technology, can improve the coordination of work in different ways: automating existing routines, shaping new communication patterns and organizational structures, or reducing the need for coordination itself.

This paper investigates the organizational settings of hierarchy and market in the light of a transaction cost approach, and evaluates the IT impact on transaction and coordination cost. A new interpretation of IT's role in reducing coordination cost is proposed.

Keywords: Transaction cost, coordination cost, information technology, organizational structure

Introduction

The coordination of work has a critical impact on organizational performance. In an era of ever shorter product life cycles and lead times, it becomes a crucial necessity for companyies to manage the transactions between individuals and work groups in an efficient way, independent from the organization's structural variables. Information technology has become the major enabler for speeding up communication and improving information exchange. However, the expected gains in terms of reduced time and cost and improved quality can fall short if technology is used for supporting existing structures of information exchange, rather than for reshaping this flux. As we will show, the use of a traditional transaction cost perspective will result in sub-optimization.

The alternative strategy we are going to develop is to strive for a major reduction of transaction cost by questioning the need for maintaining a coordination and control structure as it is proposed in the bureaucratic paradigm, and advocated by the traditional transaction cost approach.

However, the purpose of this paper is not to argue for, or against, a certain way of organizing, since there is no such way (Galbraith 1977). On the other hand, we will outline aspects of transaction cost efficiency in the light of coordination cost, in various organizational settings and analyze them in accordance to the achievable cost/benefit.

Businesses and busy messes

Despite all recent trends in organizational change, such as Business Process Reengineering, time based management and others, advocating the abandoning of bureaucratic organizational structures, many companies still follow a structural model based on the hierarchical paradigm of the industrial age. Employing this model, extensive vertical communication mechanisms are used in order to satisfy the organization's needs for monitoring, directing and coordinating the tasks being performed by its members. The result, very often, can be expressed as a "busy mess" rather than a business, i.e. an organization where a considerable amount of effort is spent on coordinative work, rather than contributing to the organization's primary workflow and value streams.

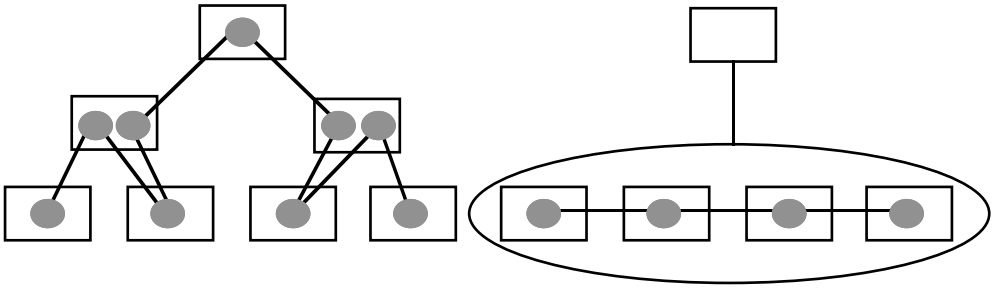

Figure 1: Workflow in hierarchy and flat organization

The above image conceptually describes the different concepts of hierarchy and "flat" organization. While hierarchy is characterized by a high number of vertical transactions, even exceeding the number of transactions being required for managing the direct workflow, the flat organization uses a minimum of transactions, focusing only on those being absolutely necessary to create the value stream of the company.

The problem of hierarchical structure and its need for exercising control on all levels has been addressed by a variety of theorists. Henry Fayol, in his book Administration Industrielle et Genèrale (1949) recognized the increasing workload managers would face when monitoring all activities performed by their sub-ordinates, and proposed that individual workers should be allowed to communicate directly, under the pre-condition that their supervisors had agreed upon it. This concept has become known under the name of "Fayol's bridge".

The question of the optimum span of control, i.e. the number of sub-ordinates a manager control, has been a widely discussed ever since Graicunas' attempt to develop a mathematics formula for its calculation in year 1933 (Gulick and Urwick, 1937). According to Mackenzie (1978), the span of control is defined as

"the number of subordinates with whom a supervisor interacts".

Naturally, each of these interactions consume a certain amount of resources, primarily time, and the limitation in time being available to managers for interaction with their sub-ordinates describes the problem of extensive vertical communication in a nutshell.

Closely related to this issue is the problem of hierarchical depth, i.e. the number of hierarchical levels from the top of the organization to the shop floor, in Fayol's terms the length of the scalar chain.

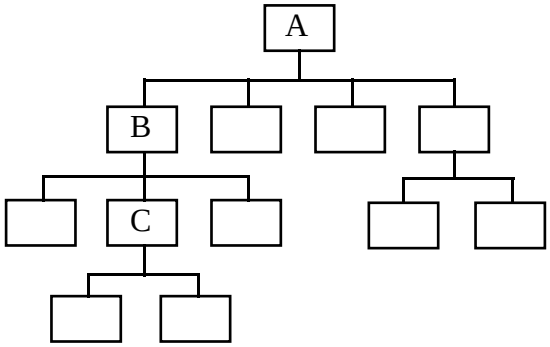

Figure 2: Basic hierarchical structure

In the above picture, A has a span of control of 4, B of 3, and C of 2. The hierarchical depth is 4, as there is a total of four hierarchical levels. As already Fayol had noted, the amount of information flowing through different nodes in this organizational tree can increase significantly with a broad span of control and a deep hierarchical structure. In the above case, B would be responsible for controlling and directing five people, and for A it would mean the supervision of 11 direct or indirect subordinates. For illustrating this effect for a larger organization, let us use the following, constructed example.

An organization uses the span of control of 2, i.e. each supervisor has exactly two subordinates. If the organization has around 1.000 employees, the result would be a scalar chain (hierarchical depth) with a length of 10, with a doubling number of people on each level. Of the total amount of people in the organization, ~50% would be supervisors, and the remaining shop floor personnel. Vice versa, the number of people to supervise doubles for each level upwards in the hierarchy. In this above example, we only have considered direct interactions between supervisor and subordinates, while a full adoption of the unity of command principle would require the inclusion of all interactions.

Graicunas distinguished three types of interactions–direct single relationships, cross-relationships, and direct group relationships–each of them contributing to the total amount of interactions within the organization.

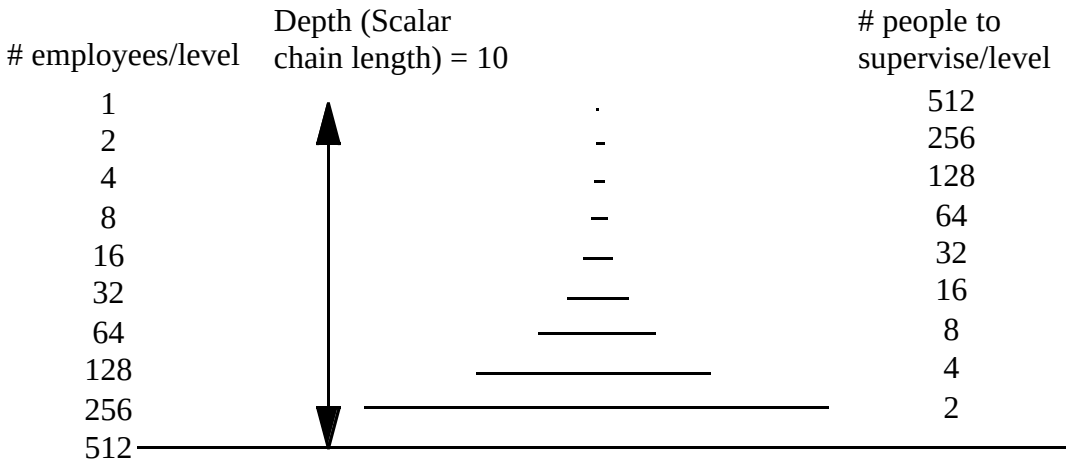

Figure 3: Supervision needs in hierarchical structures

The number of possible interactions can be computed in the following way. Let n be the number of subordinates reporting to a supervisor. Then, the number of possible relationships of direct single type which exist in the organization is identical with the number of organizational members:

n.

The number of possible interactions between organizational members is

n (n - 1),

and the number of possible task interactions (assuming one task per person) is

$n (n-1)^2$.

Given a number of 1001 members in an organization, the number of possible task interactions is

$1001 \times (1001 - 1)^2 = 1.001.000.000$

Naturally, a high percentage of these interactions are reduced by applying a certain organizational logic (e.g. it is impossible to deliver a product before it is produced). However, the figure provides a good impression of the dilemma of coordinating work. A more realistic example for a single person can illustrate this. A manager having 3 subordinates and adding a fourth, faces 4 additional direct relationships to monitor, i.e. that each new subordinate increases the number of direct interactions with *(n+1)*. This figure does not even consider the fact of possible group interactions, which would boost the total number of possible interactions exponentially.

A general conclusion from this number game is, no organization can afford to maintain a control structure satisfying the requirements imposed by a fully bureaucratic design. Overcoming these limitations, and finding the optimum span of control has been a major challenge to organization design. As Mackenzie (1978, p 121) describes it:

> "One could argue that with larger spans, the costs of supervision would tend to be reduced, because a smaller percentage of the members of the organization are supervisors. On the other hand, if the span of control is too large, the supervisor may not have the capacity to supervise effectively such large numbers of immediate subordinates. Thus, there is a possible trade-off to be made in an attempt to balance these possibly opposing tendencies."

Transaction cost

At a macro-level, transaction costs are generally defined as being the cost for gathering information, evaluating alternative options, negotiating, contracting, and the physical transaction of the object through a defined interface.

This cost is due to the fact that not all the information needed for the exchange is available, i.e. an imperfect information system. Subsequently the exchange, as described in the neo-classical model of perfect competition, will not take place. In fact, it requires that transactors possess the same information and that this information is adequate to support the transaction.

The uncertainty being present in the market, due to imperfect information, bounded rationality, strategic behavior and incomplete market, jeopardizes the market exchange structure. As a consequence, different structures, implemented to reduce uncertainty, must be developed in order to support the exchange system. Hierarchy and clan are thus structures of governance that reduce transaction costs associated to a certain exchange (Coase 1937; Williamson 1975; Ouchi 1980).

A hierarchy can generally be described as an organizational form where the ”invisible hand of the market” (Smith 1776) is substituted by a set of goals and rules that prescribe behavior, drives individual choice in accordance with organizational needs and provides a common framework to be followed in situations where uncertainty occurs.

Considering that, uncertainty increases due to an unpredictable and dynamic environment, the bureaucratic structure becomes insufficient for coping with the reduction of uncertainty given the condition of limited information-handling capacity of the organization (Emery 1969). In accordance with traditional neo-institutional analysis, a different structure of governance must be developed and employed. An alternative structure, providing more efficient mechanisms for organizational governance in this context, is the clan. Using the clan as governance form for the organization reduces uncertainty by internalizing norms, values and traditions, developing a high identification of members with the group and a mutual sharing of goals.

These two different approaches, devoted to reduction of uncertainty, are associated to different costs embedded in the construction and maintenance of organizational structures. It implies, that every structure of governance is efficient, as long as the cost related to its employment is lower than the transaction cost reduction it has been associated.

According to the theory of institutional economy (Coase 1937, Williamson 1975, Ouchi 1980) it is argued that an increasing amount of transactions, i.e. coordination cost, will result in failure of the coordination mechanisms within a market. Instead, as the complexity related to exchange increase, it becomes more efficient to use alternative governance models, e.g. formal organizations, or clans. These alternative forms are aiming at the reduction of uncertainty and opportunistic behavior. In the following, we will focus on aspects of formalized organizational structures.

Towards a model of transaction and coordination cost: The ”busy mess break-point”

On a micro-level, i.e. when considering the costs being generated in an organization, we have distinguished two different main categories - activity cost and transaction cost.

Activity cost consist of production cost and opportunity cost. Production cost consists of the expected cost for material, labor and overhead (Howell et.al. 1987), i.e. ”the physical or other primary processes necessary to create and distribute the goods or

services being produced". (Malone et.al. 1987). Opportunity costs are defined as the best alternative foregone (Parkin 1992).

Transaction cost contains infrastructure cost and coordination cost, i.e. costs due to uncertainty. Infrastructure cost means the cost for establishing the physical/communicational contact between members of the organization devoted to perform the primary processes (Bressand and Distler 1995, Malone et.al. 1987). Coordination cost includes cost due to imperfect information and opportunistic behavior of organizational actors (Milgrom & Roberts 1992), i.e. the factors contributing to uncertainty in the organization.

Following Brynjolfsson, Malone et al.(1994), we can make a further differentiation in coordination cost between internal and external coordination cost: The former is generated by the need to support hierarchical structure (management, control system, rule establishment and maintaining, etc.). The latter is the cost do to presentation (Williamson 1986) and establishment of a contingent claims contract.

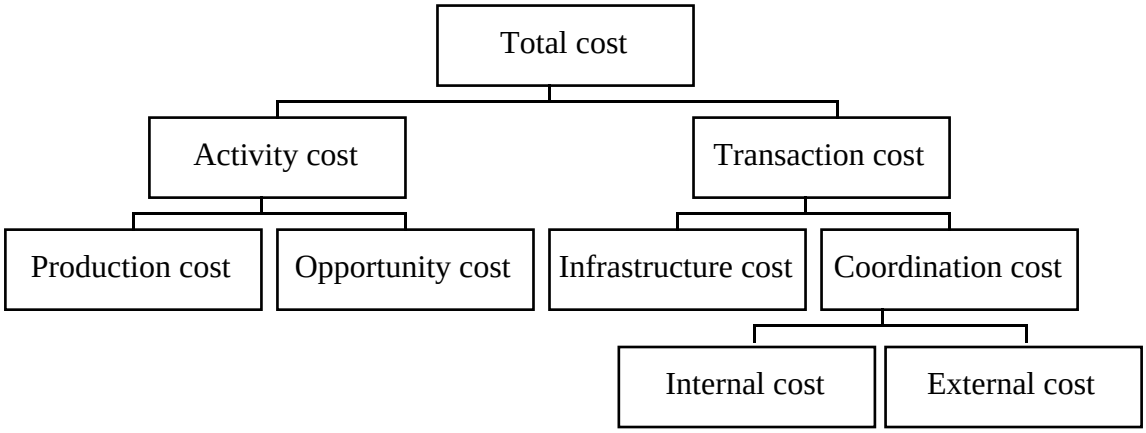

Figure 4: The firm's cost scheme

In the following, we will argue for a model building on the assumption that transaction cost is a function of infrastructure cost and coordination cost.
The firm's cost function will be:

$$C_F = C_T + C_{A,} \text{ where } C_t = f\,(C_I, C_C)$$

$$C_F = f\,(C_I, C_C) + C_A$$

where

C_F is the firm's total cost;
C_A is activity cost;
C_I is infrastructure cost;
C_C is coordination cost, *and*
C_T is transaction cost

According to Coase (1937), organizational size determines the amount of information to be communicated. Using a micro-economic perspective, we can derive that

the larger the organization, the larger the amount of information being required by top management for decision taking. Exceeding a certain size, i.e. after the “busy mess break-point“ as we have chosen to term it, the number of transactions in the organization needed to handle the internal coordination needs increases to an extent, that market mechanisms become again more efficient than the planning and control mechanisms imposed by hierarchical structure. Considering increasing complexity, above the busy mess break-point, the external coordination is in fact less expensive: No infrastructure costs must be supported.

A corresponding argumentation, building on the functional dependence of transaction cost on coordination cost, is found in the justification of multi-divisional organizational forms. A coordination cost level exceeding the ”busy mess break-point” results in a set of small hierarchical organizations, related to each other through a (internal) market system.

Thus we can conclude that the multidivisional form, being a hybrid between hierarchy and market, constitutes a solution to market failure due to complexity, and hierarchy failure due to coordination needs.

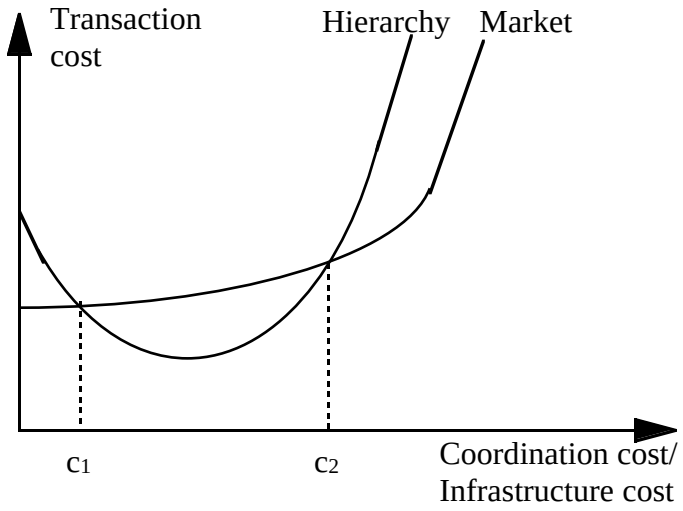

Figure 5: Transaction cost as a function of coordination cost

According to the model, it is advantageous to use a market model as long as external coordination cost is below c1. In the range c1 - c2, a formalized model is more cost efficient than the market. As internal coordination cost exceeds c2 , i.e. after the ”busy mess break-point”, the market becomes more efficient again. This argumentation is not exhaustively covered by conventional transaction cost formalization.

Following the argumentation imposed by the model, we can claim, that the reduction of internal coordination cost, and thus transaction costs, must be an imperative for the firm as far as the efficient management of business activities and their related workflows is concerned.

Transaction cost and information technology

As it was argued by Ciborra (1993), information technology can be used for reducing the cost being associated to transactions, This argument is based on the idea of using information technology to make more information available to decision makers, thus contributing to the reduction of uncertainty.

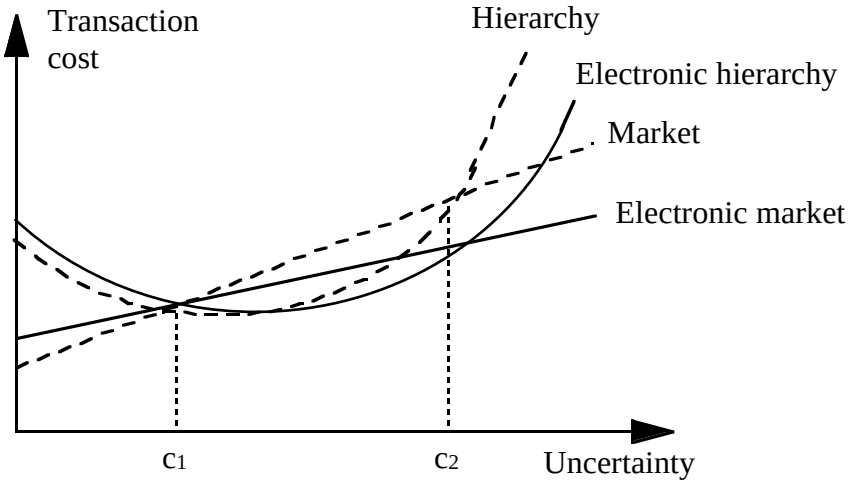

Figure 6: IT-impact on coordination and transaction cost

As we can see in the model, the reduction of uncertainty due to the introduction of IT basically results in a reduction of both coordination costs and transaction costs. However, due to the investments in infrastructure and technology, higher fixed costs are generated initially.

The argument to strive for transaction cost reduction through the use of information technology for improving the organization's information flow is very powerful until internal coordination cost exceeds c2. As internal coordination cost exceed the "busy mass break-point", the effort of processing further information due to the need of coordination is higher than the achievable gains. Following our earlier argumentation about the "busy mess", the result will be an increasing number of non-value adding information transactions, devoted to support the organizational framework that links and coordinates internal activities (Penrose 1959), rather than supporting a more efficient way of managing work.

Reducing transactions, not only costs

As we have shown, there is a direct correlation between the number of transactions devoted to coordinate tasks. As the amount of coordinative work increases, subsequently transaction cost increase radically. This implies, that a focus on transaction cost reduction requires high efforts for achieving conceivable gains.

On the other hand, due the functional relation between coordination and transaction cost, a reduction of coordination itself would allow to drastically decrease transaction cost with relatively small efforts.

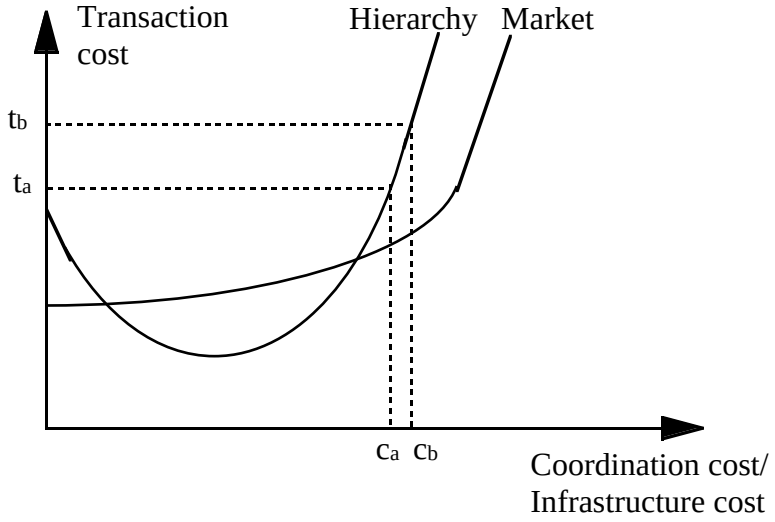

Figure 7: Impact of coordination cost reduction on transaction cost

As we can see in the picture above, a reduction of internal coordination cost from c_b –> c_a will result in a reduction of transaction cost from t_b –> t_a ,where ∂t > ∂c. This relationship underpins the claim for a necessity to focus on the reduction of coordination cost, rather than transaction cost.

Following our definition of transaction cost (being a function of infrastructure cost and coordination costs), we can identify two useful strategies for their reduction. The first one is aiming at the reduction of uncertainty through increased information processing capacity, thus increasing infrastructure cost. Our alternative proposal is a strategy devoted to reduce uncertainty and infrastructure cost, thus contributing to a flattening of the organization.

Strategy 1

This approach, following traditional theory, builds on the idea of improving information processing capabilities for managing the complexity coming along with increasing size, as it has been described by Brooks (1995). Pursuing this strategy means to invest in information infrastructure to reduce uncertainty, without reconsidering structure itself. This strategy is valid, as long as the reduction of uncertainty cost exceeds the additional investments in infrastructure. In any case, there is a trade-off between both factors. As it was explained in the example of Mackenzie above, this strategy looses power as the infrastructure no longer can manage complexity efficiently. From the “busy mess break-point“, this process accelerates exponentially, resulting in an implosion of the organizational information processing capability.

Strategy 2

Considering the use of information technology, we can equivalently claim, that IT should not primarily be used for supporting existing coordination mechanisms, but to reduce the need for coordination itself, thus emphasizing on flattening the organizational structure, i.e. reducing hierarchical depth (scalar chain length) and width (span of control). An

argumentation for this strategy has been developed, among others, by Ciborra (1996) and Brynjolfsson an Malone (op.cit.). This strategy will not necessarily result in the abandonment of all coordinative activities, but can reduce their amount to those contributing to the value creating activities of the organization.

Accordingly, we are proposing a use of IT not solely focusing on internal coordination cost minimization, but as a powerful tool to enable the reduction of coordination needs. This argumentation is supported by the fact that approximately 80% of the information in an organization is of local character, and that only a small percentage must be globalized (Langefors 1974).

The pros and contras of this strategy, and the organizational means for achieving it, have been extensively discussed by Emery (1969), March and Simon (1958), and others.

Discussion

The analysis of coordination and transaction cost as it has been conducted in this paper has led us to the following, we think more exhaustive, analysis of the impact of IT on the way business are organized.

The use of a transaction cost approach is a powerful way of describing the potential of information technology for improving the organizational information flow and reducing cost, thus improving the organization's capacity for managing complexity. A typical example is the use of Electronic Data Interchange (EDI) in supplier-retailer collaboration settings (Simon 1996). However, this does not necessarily imply a reduction of the number of transactions. On the contrary, the number of transactions often increases, while the volume of the individual transaction is reduced. Nevertheless, a reduction of transaction cost can be achieved, since the decreasing cost per transaction exceeds the cost associated with the increasing number of transactions.

This strategy, however, faces its limitation at the point we have chosen to call the ”busy mess break-point”. At this point, when satisfying coordination needs exceeds the benefits associated with the use of a structural organization, the market model becomes more efficient than the hierarchy. In fact, increasing information exchange in this setting will result in significantly increasing transaction cost (see figure 7). Subsequently, the use of information will not be able to significantly contribute to a more efficient information handling, but will contribute to the creation of an ”electronic mess” and a sub-optimality in the organizational setting.

The “traditional” strategy is undoubtedly efficient on the left side (phase 1, figure 8) of our graphic. Speeding up and increasing the amount of available information and its exchange rate, IT rends easier and more efficient the organizational activities, reducing coordination costs (as it has been shown in figure 6) and thus transaction cost.

When considering the effect of an increasing information flux on the right side (phase 2) of the graphic, we can easier understand that the amount of coordination, needed to support this information mass, is growing rapidly, i.e. that close to the busy mess breakpoint, IT related effect on the busy mess condition becomes really evident.

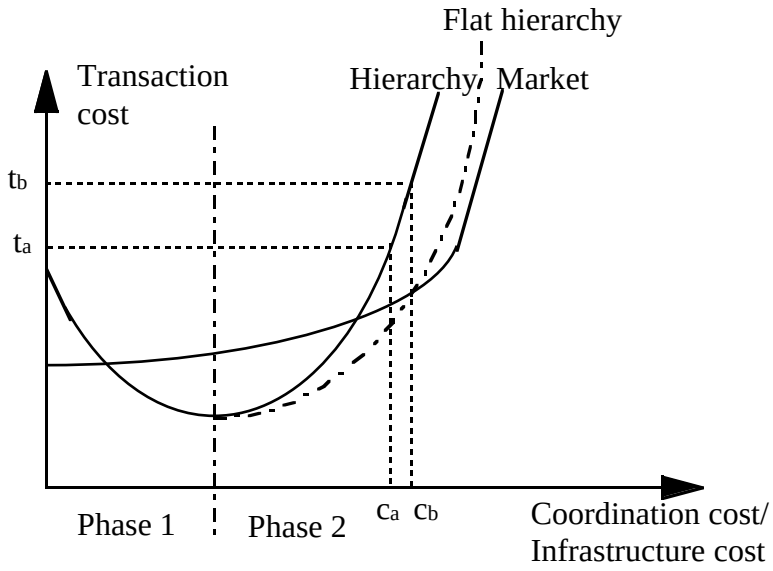

Figure 8: IT effect on different organization phase of organization structure

In the above figure, the reason for our proposal of a different consideration of coordination structure and use of IT is provided graphically. Reducing the amount of information, filtering it and reducing the coordination needs it is possible to reduce the internal coordination and the related cost and thus maintain the organization setting more efficient than the market.

IT and organization setting

New technology and ways of employing it, such as agents and various forms of team support, may help to achieve these goals, allocating information where necessary, filtering it and reducing the information's surf and overloading in the organization, thus providing an "information just-in-time" concept.

An agent may be considered as a "personal assistant who is collaborating with the user in the same work environment" (Maes 1994). It is a concept, that provides new way of human-computer interaction. The user is involved in a cooperative process where different tasks are performed by users or agents, without a clear distinction between those categories. It follows that as a consequence of an interactive process both (human and agent) provide new ways to enhance communication, to collect, scan, filter and distribute information, according to the prerequisite needs of the user. Through different algorithms, the agent is able to learn and increase its efficiency over time. Accordingly, agent technology opens new opportunities for using IT to achieve a considerable impact on organizational structure. As a consequence, technology is not only considered a tool speeding up daily work. It becomes part of the organization activity, working autonomously as other single or aggregate organizational actors.

The traditional IT analysis on transaction cost in phase 1 leads us to consider the shifting impact of technological support on the exchange system (see figure 6). Following our model, the arguments provided by traditional analysis are not sufficient to describe what happens in all phases of organization development. As a consequence of our analysis, we are proposing a shifting effect on the hierarchical asset due to a reduction of

coordination efforts in phase 2. Obviously, following our argumentation, this effect is enhanced by IT when it is used as a tool to reduce coordination need, information overload, and supporting the organization's growth.

This shift will result in a reduction of the hierarchical function slope. Thus, the coordination cost effect on transaction cost will become less effective, because the cost related to implementation will be positively affected by the substitution effect caused by the reduction of internal coordination cost: The process flattening process (see figure 8).

Consequently, we are proposing to focus the use of IT on coordination costs in a double sense. Reducing uncertainty through the application of information technology for improving information exchange in phase one, and as a tool aiming at the reduction of coordination needs among transactors, thus contributing to a flattening process in the organization, in phase two.

Conclusion

In this paper we have tried to analyze the effect of coordination cost on transaction cost. Following this analysis, it has been possible to evaluate, in the light of these themes, possible effects of IT on organizational structure.

We have distinguished two different approaches: the "traditional" one and the "flattening" one. The former is mainly based on the analysis of the impact of IT on transaction cost. It argues, that using IT it is possible to reduce transaction cost, thus achieving a more efficient exchange structure.

Considering coordination cost as an independent variable of the transaction cost function, it has been possible to divide the analysis of structural efficiency in organizations into two different phases. Phase 1 is well analyzed by the traditional approach which, on the other hand, does not provide a description of phase 2.

In this paper, we have used coordination cost as the basis of our analysis, thus being able to develop an explanatory model for phase 2. The analysis has shown, that it is necessary to evaluate the effect of information technology in the light of coordination cost. The outcome of the argumentation has been a proposal for using information technology in the organization in a different way than explained by the traditional approach.

Accordingly, we are proposing to use IT as a tool for reducing information flux, coordination needs inside the organization, and organizational structure devoted to support coordinative activities. Following this strategy, it is possible to reduce internal coordination cost, and thus transaction cost. It is also possible to avoid the implosion of the organization as a consequence of information overload and structural growth.

Emerging technologies, such as agents, can provide the techical support for realizing the strategy being proposed in this paper, e.g. the support for "new traditional" activities, such as managing incoming information.

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