

A discussion of governance under conditions of technological uncertainty - suggesting hypotheses and a research model

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Abstract

The transaction cost theory (TCA) asserts that companies manage environmental uncertainty with adaptive governance mechanisms. Findings from the literature report that companies will favor an arms-length relation when they are exposed to technological uncertainty (Rindfleisch and Heide 1997). When there is uncertainty about what the agreed technology will be, it is better to leave all the options open, and achieve flexibility by shopping from the market. As such, companies avoid getting in a disadvantageous competitive position by investing in the wrong technology. However, the literature is somewhat inconsistent and does not discuss to what extent the companies are *dependent* upon this technology. Technological uncertainty may represent change in component design (Walker and Weber 1984), changes in the end products (Heide and John 1990), or changes in the underlying production process (Stump and Heide 1996). Such elements can be considered central to a company. However, if a company is choosing the market as the preferred organization when exposed to technological uncertainty, it has to per TCA be a reference to *non-specific assets*. Additionally, companies will leave their future development in the hands of their arms-length supplier relations. In the sense then they can be considered *strategy takers*. In this paper we will challenge this reasoning, as studies show that technological complexity and volatility have been found to be associated with the formation of alliances (Robertson and Gatignon 1998, Dickson and Weaver 1997, Hagedoorn 1993, Hladik 1988). We argue that further explanation of governance under conditions of technological uncertainty is found by paying attention to the perceptive dimension of environmental uncertainty (Milliken 1987).

1. Introduction

In this conceptual paper we discuss governance under conditions of technological uncertainty. Technological uncertainty is viewed as a source of environmental uncertainty, which is one of the well known characteristics of exchanges that are dealt with in transaction cost theory (TCA). The transaction cost theory asserts that companies manage uncertainty by implementing adaptive governance structures. An adaptation problem is created when firms whose decision-makers are limited by bounded rationality have difficulty modifying contractual agreements to changes in the external environment (Rindfleisch and Heide 1997). Williamson (1985) posits that, when faced with the need to adapt to an uncertain environment, a firm will seek to minimize its transaction costs through vertical integration. In the review by Rindfleisch and Heide (1997) this garners only partial support.

The results from the studies of governance mechanisms under conditions of technological uncertainty report findings of disintegration, or *arms-length* relationships (Rindfleisch and Heide 1997). In this sense, companies will avoid a lock-in situation and achieve flexibility to switch to partners with the appropriate technology (Heide and John 1990). However, these hypotheses of disintegration are not supported in all instances (e.g. Walker and Weber 1984), and the literature does not address adaptations that require coordinated responses (Folta 1998). Technological complexity and volatility have been found to be associated with the formation of alliances (Robertson and Gatignon 1998, Dickson and Weaver 1997, Hagedoorn 1993, Hladik 1988). As such, further research is needed. We argue that these contradictory findings are due to lack of understanding of how the companies actually depend upon the technology. Drawing on a model from Miles and Snow (1978) will help to illustrate this. In this paper we argue that paying attention to the perceptive dimension of environmental uncertainty (Milliken 1987), will provide further explanation to the reasoning of organizing under conditions of technological uncertainty. Specifically, the variable of decision-making uncertainty is introduced. Looking at the decision that correspond to technological uncertainty, we find that the reason companies delay cooperation is the lack of knowing what to do rather than consciously withdrawing their effort from developing the future basis of which they are dependent.

In the following we provide a brief literature review of research discussing technological uncertainty, present a view of adaptation based on Miles and Snow (1978), and discuss perceived environmental uncertainty before a discussion is presented suggesting hypotheses and a research model.

2. Literature review

Technological uncertainty corresponds to the unpredictability of the environment, which is considered the most popular operationalization of the construct (Rindfleisch and Heide 1997). Walker and Weber (1984) were the first TCA researchers to uncover the multidimensional nature of environmental uncertainty in separating the concepts of volume and technological uncertainty. Technological unpredictability is defined as the *inability to forecast accurately the technical requirements* in the relationship (Walker and Weber 1984). Technological unpredictability may follow from change in component design (Walker and Weber 1984), changes in the end products (Heide and John 1990), or changes in the underlying production process (Stump and Heide 1996). The discussed governance mechanisms vary from ordinary make-or-buy decisions (Walker and Weber 1984), make-or-buy situations in competitive environments (Balakrishnan and Wernerfelt 1986, Walker and Weber 1987), relationship continuity (Heide and John 1990), and hostages (Stump and Heide 1996).

The findings are mixed however, to what extent these governance mechanisms actually cope with technological uncertainty. Walker and Weber (1984) find that technological uncertainty had no impact on make or buy decisions. Heide and John (1990) identify that adapting to technological uncertainty is best achieved by limiting the continuity of a relationship. If there is a risk of technological obsolescence firms need the flexibility to change partners. Further, Stump and Heide (1996) report that under conditions of rapid technological change, either in the purchased product itself or the underlying production process, suppliers is somewhat unwilling to offer a hostage that represents a lock-in with a particular buyer. From the buyers' perspective, the risk of technological obsolescence reduces the value of the supplier hostage. With respect to competition, Balakrishnan and Wernerfelt (1986) find that if the degree of competition is high, integration is affected negatively by the frequency of technological change. Walker and Weber (1987) find that technological uncertainties has no influence on integrate or not integrate when supplier competition is low but leads to a buy decision when competition is high.

Even though the findings are somewhat inconclusive, the main picture identifies that arms-length relationships are the preferred mode of governance for technological uncertainty. However, an alternative stream of research report of alliances as the preferred mode of governance when technology is identified as a future challenge (Dickson and Weaver 1997). Osborn and Baughn (1990) find that when the technological intensity is high, firms tend to establish agreements rather than joint ventures, and when the intention is joint R&D the relation is governed by joint ventures. Thus, when there is a higher uncertainty level, the governance form is weaker, but still the company retains a relation. Steensma and Corley (2000) argue in the same manner, when they identify that companies choose loosely coupled relationships as governance under conditions of technological dynamism. It is suggested that a relation give the firm a possibility to increase the engagement if the technology turns out to be successful, and visa versa. However, a certain initial relationship is a necessary 'ticket' for the future possibility to do so.

As Heide and John (1990) indicate, firms have to find means of coping with technological unpredictability. That is of course, unless the firms decide to close down its business in the prospect of technological change. On the contrary, if a company decide to continue operations Osborn and Baughn (1990) argue that a key factor for a firms survival in rapidly evolving technological areas is its positioning within a successful network of suppliers, manufacturers and distributors. However, they argue that companies will choose agreements as forms of governance rather than equity relationships. This will provide the basis for balancing the need for flexibility with the limited ability of protection in an equity relationship. In addition, an alliance may be a device partners are using for technological positioning that could evolve into an important new business area (Osborn and Baughn 1990).

In this sense we argue that the studies within TCA of adapting to technological unpredictability does not pay sufficiently attention to the fact that technology change is a necessity for continued business operation, rather than just a safeguarding challenge. That is, the dual side of the technological effect needs to be explored. Both the issue of safeguarding, and the issue of continued business needs to be explored in order to tell the complete story of technological uncertainty. We base our reasoning on the model suggested by Miles and Snow (1978).

3. Adaptation

The concept of adaptation describes to what degree adjustments can be made, in an unproblematic manner, when changes occur. The discussion is based upon TCA, which predict that exposure to high levels of uncertainty leads to vertical integration. However, some uncertainties result in market solutions, or arms-length governance mechanisms. Thus, the mechanisms in an adaptive governance structure vary across different exchange situations. In the following we will discuss adaptation as a construct and clarify the mechanisms.

When the environment is changing, it is necessary for managers to adjust their organizations accordingly. Miles and Snow (1978) report that organizational survival may be said to rest in the quality of the “fit” which management achieves among such major variables as the organization’s product-market domain, its technology for serving that domain, and the organization structures and processes developed to coordinate and control the technology. Miles and Snow (1978) view the *strategic choice approach* (Child 1972) as the most accurate way of conceptualizing how organizations are aligned to the environment. This approach argues that organization structure is only partially preordained by environmental conditions, and it places heavy emphasis on the role of the top decision-makers that serve as the primary link between the organization and its environment. The strategic choice approach essentially argues that the effectiveness of organizational adaptation hinges on the dominant coalition’s perceptions of environmental conditions and the decision it makes concerning how the organization will cope with these conditions.

The three central problems of entrepreneurial, engineering and administration are identified (Miles and Snow 1978). The *entrepreneurial* problem involves developing new products and or services to secure or gain a target market or market segment. Basically it addresses the need for updating an organization’s product-market domain. The *engineering* problem involves the creation of a system that puts the entrepreneurial problem into operation. The *administrative* problem is primarily that of reducing uncertainty within the organizational system. That is, in terms of the present model, rationalization and stabilizing those activities, which successfully solved problems, faced by the organization during the entrepreneurial and engineering phases. However, there is a duality combined with the administrative problem, as it also involves formulating and implementing those processes that will enable the organization to continue to evolve (innovation).

The administrative problem thus balances two somewhat conflicting needs. In the ideal organization, management would be equally adept at performing two somewhat conflicting functions (Miles and Snow 1978). It needs to create an administrative system (structure and process) that could smoothly direct and monitor the organization's current activities, without allowing the system to become so ingrained that future innovative activities would be jeopardized. Such a perspective requires the administrative system to be viewed as both lagging and leading variable in the process of adaptation (Miles and Snow 1978). As a *lagging variable*, the administrative system must rationalize, through the development of appropriate structures and processes, the strategic decision made at previous point in the adjustment process. As a *leading variable*, on the other hand, the administrative system will facilitate or restrict the organization's future capacity to adapt depending on the extent to which management articulates and reinforces the paths along which such activity can proceed. The adaptive cycle is illustrated below:

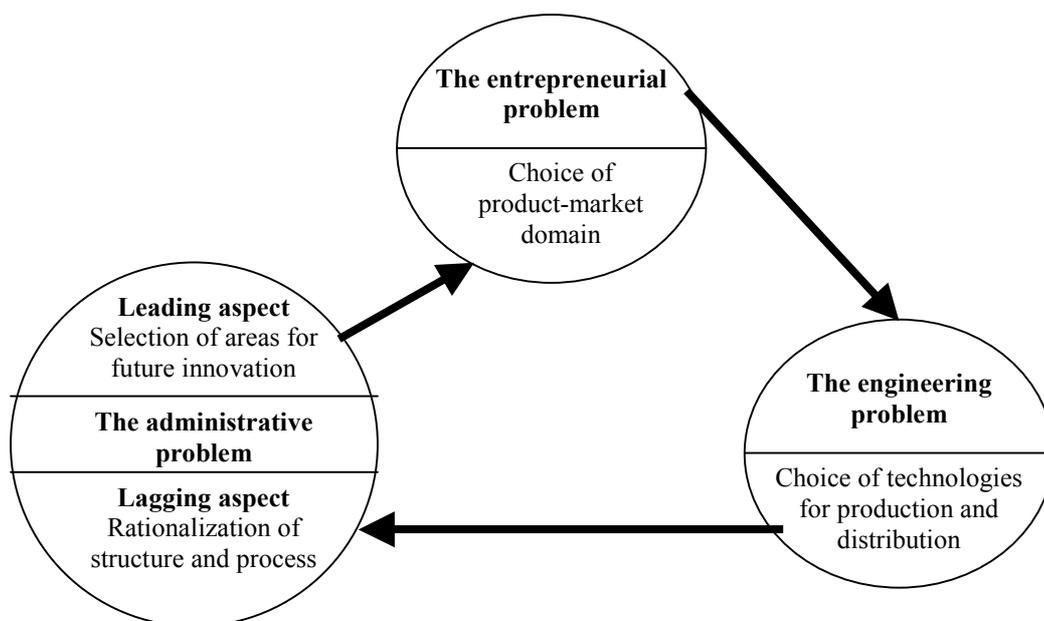


Figure 1: The adaptive cycle (Miles and Snow 1978)

Corresponding to the discussion of the adaptive cycle, Milgrom and Roberts (1992) argue that coordination, or resource allocation problems, may be characterized by two particular attributes – *design and innovation attributes*. Milgrom and Roberts (1992) argue that certain ways of coordinating economic activity has great impact on efficiency, and that the characteristics of the activity subject to coordination has great impact on the choice of solutions.

Two common kinds of problems with *design attributes* are synchronization and assignment (Milgrom and Roberts 1992:91). *Synchronization* involves coordinating several transactions in such a way that they work in a unified manner, and deciding on the level of performance for each transaction. The challenge of coordination combined with the *assignment problem* is to ensure that every task is done and that there is no wasteful duplication of effort. Centralized directed solutions are argued to be the best way to solve these tasks, even though one is not fully responsive to information of decentralized actors of the system. The great advantage about a synchronized system is that the action of individual actors is *coordinated*, making their individual efforts more effective. Design problems that arise repeatedly and call for largely the same solution every time, may be solved by establishing *routines* that guide decentralized solutions to the recurrent problems. With well-established routines, each part of the organization can rely on the others to do their parts.

When organizations are trying to do something that is outside its experience, an *innovation attribute* is according to Milgrom and Roberts (1992) present within the coordination problem. This could be introducing a new product, entering a new market, or adopting a new approach to manufacturing. Such situations may be initiated by changes in the environment. Old routines may then become counterproductive and new routines are needed if the organization is to continue to achieve its goals. When innovation attributes are present, effectively solving the coordination problem involves someone gathering or developing the needed information and then communicating it to the decision-makers in the organization.

From the discussion we find that the adaptation problem consist of two separate aspects. On one side it is necessary to provide rationalization of structure and process, termed the lagging aspect. The mechanisms as such may be described as the design problem, in which the challenge is to secure synchronization of transactions and assignment of tasks. This is predicted achieved through centralized decision making. On the other side it is necessary to secure selection of areas for future innovation, termed the leading aspects. The mechanisms as such may be described as the innovation problem, in which the challenge is to secure development, by communication of information to the decision-makers in the organization. This seems to best be achieved through decentralized operations.

4. Perceived environmental uncertainty

Objective and perceived viewpoints may be taken when studying environmental uncertainty, but the latter is likely to be more productive (Achrol, Reve and Stern 1983). This view shifts the focus from objective characteristics of environments to characteristics of the *decision process* by which organizations select and ignore information (Pfeffer and Salancik 1978). Leblebici and Salancik (1981) observe that “uncertainties can only be experienced through decision making in an organization”. The organization is then characterized by “decision-making uncertainty” (Achrol and Stern 1988). Specifically, Walker and Weber (1984) identify that understanding cognitive processes “would help to ground the transaction cost concept in processes of managerial perception and judgement, which bear on the decision of how to govern a particular contracting situation (p.387)”. Heide and John (1990:34) identify that more research is needed to understand the unique perceptions of uncertainty of individual observers, as predicted by the enactment theories. Buvik and Grønhaug (2000:451) have also identified this shortcoming in the literature.

Milliken (1987) refer to the same reasoning when proposing that three differentiated types of environmental uncertainty can be experienced by an organizations’ administrators as they (1) try to understand, (2) make sense out of, and (3) respond to conditions in the external environment. It is argued that a source of confusion is created because “environmental uncertainty” is used as both a descriptor of the state of organizational environments, and of a person who perceives himself/ herself to be lacking critical information about the environment (Milliken 1987). Therefore it is necessary to be more precise in defining, using, and measuring the construct of environmental uncertainty, and in particular it is critical to reexamine the conceptualizations and measurement of the construct of “perceived environmental uncertainty” (Dickson and Weaver 1997, Milliken 1987).

Milliken (1987) has identified three *types* of perceived environmental uncertainty, which are linked to what kind of understanding the decision-maker has towards a specific change in the environment. First, the question arises whether there will be a change at all. The uncertainty created by the change itself was by Milliken termed “*state uncertainty*”. The second dimension refers to the fact that it is not clear what effect the change will have to the focal organization. Milliken term this dimension “*effect uncertainty*”. Third, in light of a change, the question arises whether the change will influence the focal organization. This concerns the fact that organizations do not always know what actions to implement in response to

situations in need of change. As a number of responses can be implemented, this uncertainty is termed “*response uncertainty*”. Milliken (1987) identified that these three types of uncertainty seem quite different conceptually. They have however, not been differentiated from each other in previous work regarding the environmental uncertainty construct. This may partially explain some of the confusing results of past research.

5. Discussion

Research of technological uncertainty has been identified as inconclusive. In the discussion above we have clarified some reasons that may cause these inconsistencies. In particular we have identified that it is necessary to understand both the particular source of environmental uncertainty, and the type that is experienced by the decision-maker (Milliken 1987). Dickson and Weaver (1997:421) identify that using perceptive environmental uncertainty in an examination of the choice of governance forms is a compelling extension of this research. E.g. although Heide and John (1990) find support for their hypotheses concerning technological uncertainty, the construct does not converge across the dyad. Consequently, Heide and John (1990) discuss to what extent they have failed to capture the notion of unpredictability, however they argue that a possible explanation is that perceptions of uncertainty are unique to individual observers and that consistency may not be expected. While specifying the *source* of uncertainty identifies the domain of the environment which the decision-maker is uncertain about (e.g. competitors, suppliers, technological development), specifying the *type* of uncertainty focuses on delineating the nature of uncertainty being experienced. The separation of these two variants of uncertainties is argued to provide further understanding towards the research of governance under conditions of technological uncertainty. In particular, the introduction of decision-making uncertainty will clarify when governance mechanisms are implemented to cope with the lagging dimension (i.e. rationalization) or the leading dimension (i.e. innovation) of organization.

Concerning technological uncertainty, the prediction from the extant TCA based literature is to secure a flexible situation in order to have a range of possible decision alternatives. The changes are expected to influence how a company does its present business. Such a change may be dramatic and in a worst case scenario it can set a company out of business. As such, an arms-length relation will prevent a company to being locked into the ‘wrong’ technological solution. State uncertainty refers to the fact that one does not understand how components of

the environment might be changing (Milliken 1987). This represents a situation where the question is whether there will be a change at all. Then, it is not expected that companies will make any adjustments in their present operations, but keep working within the existing relationships. We do not expect that the perceptive dimension of state uncertainty will have an effect that interacts with technological uncertainty.

If the change itself is certain however, but not whether it will influence the focal company (effect uncertainty), we expect that a company will impose arms-length relations. The reasoning correspond with the prediction of TCA where companies seek to achieve flexibility. The strategy of flexibility take care of getting access to several options, when there is an uncertainty as to which one will be a better one. In such a case, the company expect that new technology will be developed, but is not certain of what to do, and want to keep their autonomy while the development take form. An option in this case may also be that change is not relevant for the focal organization (e.g. the famous example of Facit). Thus the following hypotheses is proposed:

H1: *The less it is expected that a technological change will influence the focal company (in terms of effect uncertainty) the more likely it is that the company governs its operations through arms-length relationships.*

Response uncertainty concerns which choice to actually implement. The company knows that there will be a technological change, however it is not certain which solution to go for. There is “a lack of knowledge of response options and/or inability to predict the likely consequences of a response choice” (Milliken 1987). However, “there is a perceived need to act because a pending event or change is perceived to pose a threat or to provide some unique opportunity to the organization” (Milliken 1987). We expect the companies will seek closer coordination. Dickson and Weaver (1997) also predict alliance use when managers perceive high technological uncertainty. A close relationship will in such a case be a guarantee that the partners do not make a change, leaving the focal organization out of business. Also, it is expected that the focal company want to be close to the changes, imposing their influence in order for it to be compatible to its current business. Steensma and Corley (2000) identify that objectives a firm can have for sourcing external technology (e.g. capability development, keeping the pace with competitors, gaining a window into state-of-the-art technology, and entering a new product market for sourcing a technology) will likely be idiosyncratic across firms and technologies. The situation will in such a case correspond to the leading dimension

of Miles and Snows (1978) administrative problem. Thus the following hypotheses is proposed:

H2: *The more it is expected that a technological change will influence the focal company (in terms of response uncertainty) the more likely it is that the company governs its operations through closer coordinated relationships.*

Summing up the arguments, the following research model is suggested:

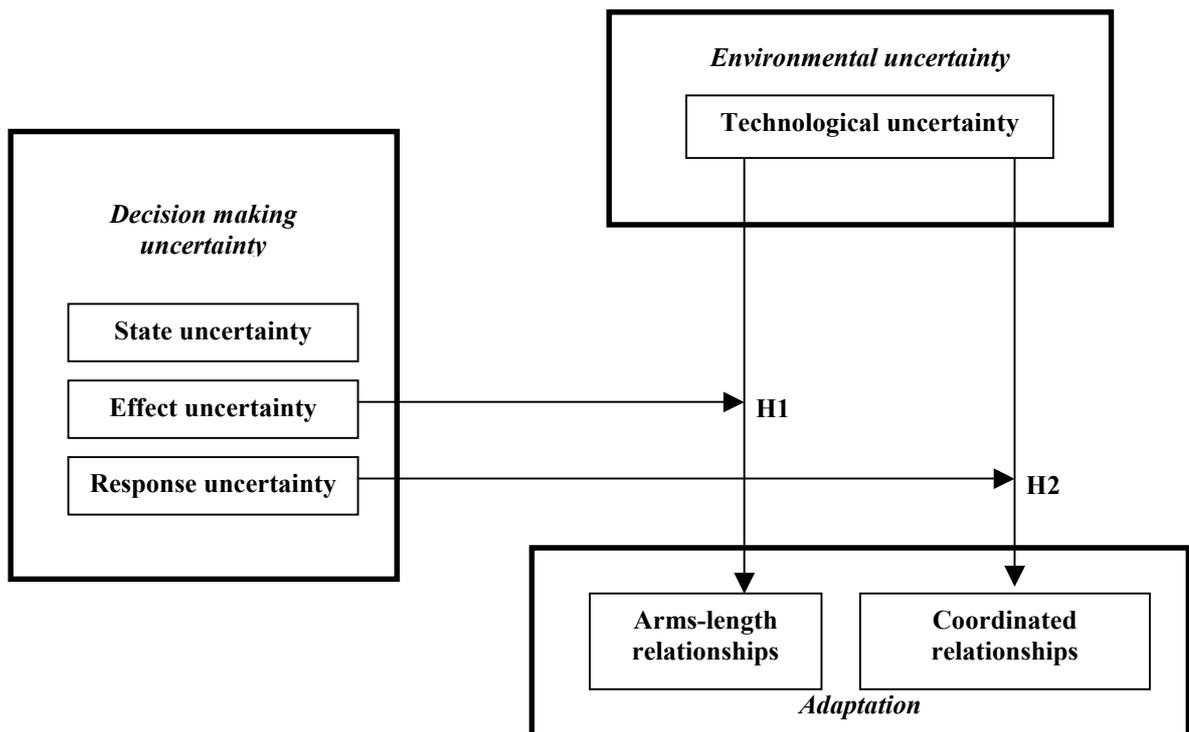


Figure 2: *Research model*

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