Adaptive governance

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Adaptive Governance: The Role of Loyalty

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SOM Theme B: Inter-Firm Coordination and Change

Abstract

This paper is concerned with the governance of vertical interfirm relations, *i.e.* relations between buyers and their suppliers on industrial, intermediate-goods markets. Networks of interacting, adaptive buyers and suppliers are viewed as *complex adaptive systems* (Holland and Miller 1991), which leads to the use of computer simulations to explore the strategies that boundedly rational, adaptive agents learn to use to manage their relations with suppliers. Starting from a static transaction cost economic perspective, the model is extended with allowance for loyal behavior and for trust to build up, with network embeddedness of relations and with the possibility for the agents to adapt their governance to changing circumstances and to the changing relation, rendering economic organization path-dependent. The paper analyzes how relations develop in time: actors making and breaking relations, on the basis of evaluations of expected profitability and loyalty. When allowance is made for adaptation of the relative weights attached to each of these criteria, the result is that buyers adaptively shift the weight from profitability to loyalty.

Keywords

transaction cost economics, loyalty, adaptation, agent-based simulation

1 Introduction

This paper looks at problems of economic organization, specifically the governance of buyer-supplier relations on industrial, intermediate-goods markets. The principal theoretical framework is transaction cost economics (TCE),

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which states that economic organization should be done from a comparative institutional perspective. TCE is concerned with the organization of the interface between successive stages of activity and maintains that the *attributes of the transaction involved* should be matched with a *governance structure* in a discriminating (mainly transaction cost economizing) way. The relevant attributes of transactions are frequency, uncertainty and asset specificity and the alternative governance structures are markets, hierarchies (Williamson 1975) and some "intermediate modes of organization" (Williamson 1979, p. 234), such as bilateral and trilateral governance (Williamson 1985).

1.1 *Transaction cost economics*

TCE's behavioral assumptions are that economic agents are *boundedly rational* as well as potentially *opportunistic*. To the (generally large) extent that there is uncertainty, all future contingencies can not be foreseen at the moment contracts are drawn up, whence those are necessarily incomplete. To the extent, then, that non-redeployable or transaction-specific investments have been made, an agent is locked-in to the transaction and contingencies can arise that the partner may opportunistically exploit. Specifically (following Williamson 1979), holding uncertainty at an intermediate level, transactions that are not supported by specific investments are most efficiently organized on the market which offers superior incentives and economies of scale. The transactions are standardized, the relation is not independently valued and so it does not require specialized governance. If investments of a mixed or highly specific kind have been made, there is an incentive to see the contract through to completion, lest the specific investments be lost. In this case, the cost of designing a specialized governance structure can not be recovered if the transaction occurs only occasionally, in which case trilateral governance is favored. In case of a recurrent transaction, a transaction-specific governance structure *is* worthwhile. The alternatives, then, are bilateral governance, where the autonomy of the parties is maintained and unified governance, where the transaction is removed from the market altogether and is instead organized within the firm, subject to an authority relation.

1.2 *Criticism*

Three criticisms of TCE underlie the approach in the current paper. First of all, consider the assumption that agents can be opportunistic. Agents may be boundedly rational, but they are not non-rational, so they may be assumed to be able to foresee, with some accuracy, not just *that* a partner may be opportunistic, but also *when*, under which circumstances or with what probability and to take this into account in their decisions about economic organization. Whether or not an agent opportunistically exploits circumstances that arise, depends on its *incentives* and its *propensity* to be opportunistic (Nooteboom 1996). Incentives depend on the situation at hand whereas propensity (or inclination) is an agent's subjective characteristic that is inversely related to its *loyalty*. One may further assume that, on the basis of past experiences, the agent's partner can assess this propensity as a subjectively determined probability of loyal—non-opportunistic—behavior in the future. To the extent that, in some situation, an agent was loyal in the past, it may reasonably be trusted to be loyal again in similar situations in the future. In Weisbuch *et al.*'s (1997) model, similarly, an agent's preference for trading with a certain supplier—representing the agent's trust that a profitable transaction will ensue—is updated using past profits in their mutual relation.

Secondly, Williamson's approach is essentially a static one whereas there should be adaptation of the resulting economic organization to fit changing circumstances through time. This is related to the previous point: if trust builds up *over time* (but also, for example, as partners learn from each other, tacit knowledge is made explicit and partners mutually co-adapt their respective competences (*cf.* Nooteboom 1992, Péli and Nooteboom 1997)), ways of action become feasible that would otherwise not have been feasible. As Marsh observes, "trust allows interactions between agents where there may have been no effective interaction possible before trust. Trust allows parties to acknowledge that, whilst there is a risk in relationships with potentially malevolent agents, some form of interaction may produce benefits, where no interaction at all may not" (1994, p. 94).

Furthermore, a relation should not be studied as a dyad, but as part of a larger network of interacting agents, where reputation may feed the experiences of an agent's opportunistic behavior in other relations back to its current partner and where a supplier's increased value as a result of learning from a certain buyer may spill over to relations that the supplier has with the buyer's competitors.

Such a network of interacting, adaptive buyers and suppliers is appropriately regarded as a *complex adaptive system* (Holland and Miller 1991) and in this paper, accordingly, studied by means of computer simulation. The next section discusses the simulation model. Section 3 presents the computer simulation experimental design and results and section 4 concludes.

2 The model

As explained above, the focus is on complex systems of adaptive agents. An agent is adaptive if (1) the agent's actions in its environment (that consists, partly, of other agents) can be assigned a value and (2) the agent behaves in such a way as to improve this value over time (Holland and Miller 1991, p. 365). In the current version of the simulation model, the agent's actions are limited to its choice of a potential partner to request a relation with and to its acceptance or rejection of such requests from others. The agents can have only one partner at a time: accepting a request from an agent other than the current partner, therefore, includes breaking the current relation, which may entail switching costs: the supplier makes investments and to the extent that those are specific, the partner that breaks a relation has to compensate the supplier. The degree in which investments are specific (to a buyer) depends on the extent to which the product that the buyer sells on the final market is differentiated, measured on a scale from 0 to 1.

The buyers in the model sell products that incorporate inputs from suppliers. Differentiation yields a higher profit margin but also increases the specificity of the assets required to produce the inputs. The buyer thus contributes his position on the final market to the profit that can be made through the relation. The supplier contributes efficiency of production, which, for now, like the buyers' products' differentiation, is given exogenously. The profit in a relation is assumed to be shared equally among the partners.

The agents make their decisions on the basis of expected profits. A (potential) partner is given a 'score' on the basis of the profit that the agent expects to make in a relation with that partner. This expected profit is the product of the profit that can potentially be made and the probability that this potential will actually be realized. Potential profit (per product traded) is a function of both partners' contributions, *efficiency* and *differentiation* as $\Pi_{\text{buyer}} = \Pi_{\text{supplier}} = 1 + \mathit{diff}_{\text{buyer}} + \mathit{eff}_{\text{supplier}}$, where $\mathit{diff}_{\text{buyer}}, \mathit{eff}_{\text{supplier}} \in \{0, 0.5, 1\}$. Potential profit is normalized, by dividing it by the maximum potential profit, *i.e.* the profit that would be obtained in a relation with an 'ideal' partner. The probability that this potential profit will actually be realized in a relation with the appropriate partner, is the agent's subjective interpretation of the partner's loyalty (or the extent to which the agent trusts the partner), which is adapted over time according to the agent's experiences in their mutual relations. The partner's 'score' is then determined as

$$\mathit{profit}^{\alpha_1} \cdot \mathit{loyalty}^{\alpha_2},$$

where $\alpha_1 + \alpha_2 = 1$. In this Cobb-Douglas functional form, the exponents represent elasticities: if

$$s = p^{\alpha_1} \cdot l^{\alpha_2},$$

then

$$\log s = \alpha_1 \cdot \log p + \alpha_2 \cdot \log l$$

and

$$\frac{\mathrm{d}(\log s)}{\mathrm{d}(\log p)} = \alpha_1,$$

which is the 'profit-elasticity of score' that represents the weight (or the importance) that the agent—in determining scores—attaches to differences in profit between (potential) partners. Varying the exponential weights of profit and loyalty can thus be thought of as reflecting differential preferences for risks and returns.

An adaptive agent's behavior to improve the value of its actions over time, thus consists of adaptively changing the value that is uses for α_1 (and $\alpha_2 = 1 - \alpha_1$), which can take on the values 0, 0.5 and 1. Each of these values is attached a 'strength' that the agent updates according to the performance it obtains when using that particular value for α_1. The strengths add up to 1 and updating of any given value's strength is done by first multiplying it by the ratio of the profit the agent made in the relation it was deciding upon when using the value to the profit the agent expected to make in that relation and by subsequently renormalizing the three strengths. In each decision where the agent needs to assess certain (potential) partners' scores, it randomly chooses a value for α_1 with selection probabilities equal to the values' strengths. This increases the selection probability of the value that allows the agent to perform well, which is exactly what an adaptive agent is supposed to do.

3 Simulation design and results

Before the adaptive agent simulations, a benchmark study was performed in which a series of simulations was run under a variety of distributions of differentiation, efficiency and values for α_1, *i.e.* with non-adaptive strategies for governance. The full experimental design is shown in Table 1. Some of those results will be discussed before moving on to the results with adaptive agents. In all experiments, there were 9 buyers and 9 suppliers. The buyers were evenly distributed over 3 market 'segments' which vary in their degree of differentiation and the suppliers over 3 efficiency 'groups'. The 3 columns under 'differentiation' and 'efficiency' give values for each of the three segments/groups whereas the 3 columns under 'loyalty weight per segment/group' give values for α_2 for each of the three agents within each segment/group. The results that will be presented are the buyers' normalized profits, *i.e.* their actual profits divided by the maximum potential profits they would make if they always satisfied their demand with optimal partner contribution.

The results for the buyers in the first 4 experiments are like those in the first experiment (see Figure 1); the results in experiments 2 and 3 are even identical, as are the results in experiments 1 and 4. Essentially, all the buyers perform equally well and the fact that the suppliers use different 'strategies' has no effect. In Figure 1, there happen to be 2 buyers that do slightly worse than the rest, but this is due to random factors: they just take a longer time before they find a supplier that accepts their request to enter into a relation with them. All the buyers are equally attractive to the suppliers, so suppliers that have a relation are not willing to switch from their current partner (specific assets being in place). The 'equilibrium' level of normalized performance can

Exp. no.	Buyers						Suppliers					
	Differentiation			Loyalty weight per segment			Efficiency			Loyalty weight per 'group'		
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0	0.5	1	0.5	0.5	0.5	0	0.5	1
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	1
5	0	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0	0.5	1	0	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5
7	0	0.5	1	0	0.5	1	0.5	0.5	0.5	0	0.5	1
8	0	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	1
9	0	0.5	1	0.5	0.5	0.5	0	0.5	1	0.5	0.5	0.5
10	0	0.5	1	0	0.5	1	0	0.5	1	0.5	0.5	0.5
11	0	0.5	1	0	0.5	1	0	0.5	1	0	0.5	1
12	0	0.5	1	0.5	0.5	0.5	0	0.5	1	0	0.5	1
13	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	1	0.5	0.5	0.5
14	0.5	0.5	0.5	0	0.5	1	0	0.5	1	0.5	0.5	0.5
15	0.5	0.5	0.5	0	0.5	1	0	0.5	1	0	0.5	1
16	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	1	0	0.5	1

Table 1: First experimental design.

easily be calculated as

$$\frac{1 + \mathit{eff}_{\mathrm{s}} + \mathit{diff}_{\mathrm{b}}}{1 + 1 + \mathit{diff}_{\mathrm{b}}} = \frac{1 + 0.5 + 0.5}{1 + 1 + 0.5} = 0.8.$$

The numerator is the buyers' potential profit and the denominator is their maximum potential profit; both are the same for all buyers, since all buyers' products' differentiation as well as all suppliers' efficiency is 0.5.

The 4 experiments in the second set are also generally the same. As an indication, Figure 2 shows the results in experiment 5.

Because the buyers differ in attractiveness, there is some switching initially. Eventually, there are three levels at which the buyer's profits stabilize. Given that all suppliers' efficiency is 0.5, normalized potential profits for the buyers as a function of the differentiation of their profits,

$$\frac{1 + 0.5 + \mathit{diff}_{\mathrm{b}}}{1 + 1 + \mathit{diff}_{\mathrm{b}}},$$

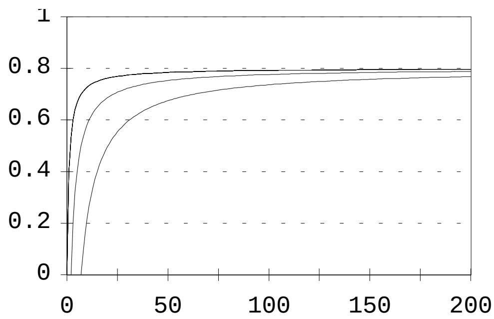

Figure 1: Buyers' profit in experiment 1.

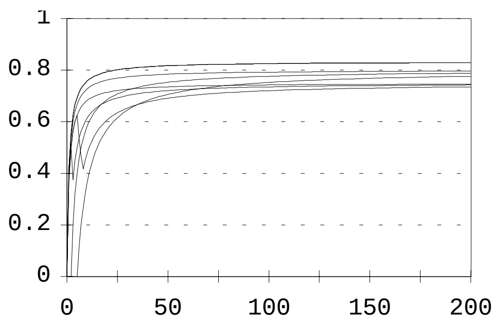

Figure 2: Buyers' profit in experiment 5.

is 0.75, 0.8 and 0.833 for $\mathit{diff}_{\mathrm{b}} = 0$, 0.5 and 1, respectively. Again, there are no effects of the suppliers using different strategies. If there are differences between buyers in the same segment, there is slight indication that buyers using lower weights for loyalty do a little worse in the long run, because they have a harder time finding a supplier quickly. This effect is stronger in the low-differentiation segment than in the high-differentiation segment, where *all* buyers consistently do very well: the buyers in the low-differentiation apparently can not afford not to care about their partner's loyalty.

The real differences between buyers' profits appear if there are differences between suppliers in terms of their efficiency of production, as in the final 8 experiments, in the first 4 of which the buyers are also positioned in different segments. To illustrate, Figure 3 shows the buyers' normalized performance in experiment 9.

In general, more (less) attractive buyers have little (a lot of) trouble in

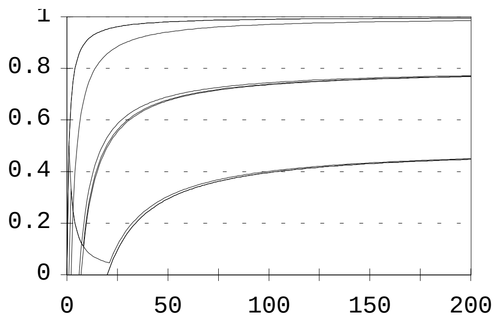

Figure 3: Buyers' profit in experiment 9.

teaming up with more (less) attractive suppliers: because, eventually, the most (least) attractive buyers end up with the most (least) attractive suppliers, the levels at which performance stabilizes are those where $\mathit{diff}_{\mathrm{b}} = \mathit{eff}_{\mathrm{s}}$, such that

$$\frac{1 + \mathit{eff}_{\mathrm{s}} + \mathit{diff}_{\mathrm{b}}}{1 + 1 + \mathit{diff}_{\mathrm{b}}}$$

is 0.5, 0.8 and 1 for $\mathit{diff}_{\mathrm{b}} = \mathit{eff}_{\mathrm{s}} = 0$, 0.5 and 1, respectively. Less attractive buyers take progressively longer to find a suitable partner. Their requests have to be rejected by very attractive suppliers fairly often before those highly efficient suppliers' scores to them become so low that less efficient suppliers become interesting. The least attractive buyers additionally have to be turned down by the moderately efficient suppliers, before they 'realize' that they have to settle for the least attractive suppliers. An interesting observation is that one of the least attractive buyers—being the lucky one to have the first choice of supplier—manages to team up with a highly efficient supplier that, of course, quickly switches to a more attractive buyer as soon as one comes along.

In experiment 10 there is a strong effect of the buyers using different values for α_2: the buyers that attach a lower weight to their partner's loyalty perform poorer, especially in lower-differentiation segments. The results in experiment 11 are less clear, because of interference with the suppliers' also using different strategies. In experiment 12, not all buyers end up at the performance level indicated by their position on the market (see Figure 3). Because different suppliers attach different weights to loyalty, some buyers manage to form lasting relations with relatively attractive suppliers on that account, rather than on account of the buyers being relatively attractive *economically* in return.

The most interesting and, of course, least clear-cut outcomes are those where the buyers are all the same, while suppliers differ in their efficiency: which buyers end up with most attractive suppliers? The final 4 experiments show these results. In experiment 13 (Figure 4), profits for the three groups of buyers, distinguished on the basis of the efficiency of the supplier they end up with, approach

$$\frac{1 + \mathit{eff}_{\mathrm{s}} + 0.5}{1 + 1 + 0.5},$$

which yields profits of 0.6, 0.8 and 1 when $\mathit{eff}_{\mathrm{s}} = 0$, 0.5 and 1, respectively. The three buyers that start out with the most efficient supplier happen—in this particular run of the experiment—to subsequently lose them to some of their more fortunate competitors. This is because requesting a supplier increases that supplier's interpretation of the requesting buyer's loyalty, so that the requesting buyer has an advantage over other buyers at the contract renewal moment (contrary to TCE's 'fundamental transformation' where the current partner has the advantage).

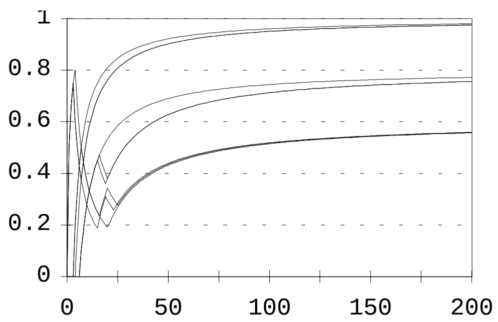

Figure 4: Buyers' profit in experiment 13.

In experiment 14, the buyers that end up at the highest performance level are the ones that attach the lowest weight to loyalty (see Figure 5). Furthermore, there are indications of a non-linear effect, in that the buyers with $\alpha_2 = 0$ perform the best, while the buyers with $\alpha_2 = 1$ also seem to perform better than the buyers with $\alpha_2 = 0.5$.

The results from experiments 15 and 16 are less clear; in general, the results should be analyzed more carefully. Furthermore, many of these results are caused by random factors, which should be eliminated by performing multiple

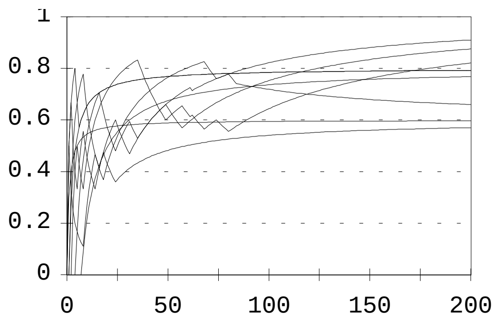

Figure 5: Buyers' profit in experiment 14.

runs of the various experiments. The initial results presented here, however, already show a multitude of interesting phenomena.

In some of the experiments presented above, some of the agents performed very poorly, due to unsuccessful strategies hard-wired in them, while real-world agents would rather change such apparently unproductive behavior. Therefore, the remainder of this section presents some preliminary results with *adaptive agents* that use the setup that was described at the end of section 2. There were only 4 experimental circumstances, namely the different combinations of equal *vs.* varying levels of differentiation and efficiency. The results in terms of adaptation are shown as the development of the weighted average value of the importance of profit, α_1, *i.e.* the sum of all possible values (0, 0.5 and 1) multiplied with their weights. The lower this weighted average, the higher the strength that the value $\alpha_1 = 0$ has, because that value does not increase the average.

In all the experiments, the buyers normalized performance was as expected: influenced mostly by the supplier's efficiency and only slightly by their own contribution, as in the first series of experiments. In all the experiments, also, the evolution of the weighted average α_1 showed a decreasing importance of profit relative to loyalty over time (see Figure 6 for these results in the first experiment). The buyers learn that a lower value for α_1 leads to the best performance.

To illustrate further, Figure 7 shows the results for one of the most successful buyers in experiment 2. The thick black line is normalized performance, the thick grey line is the weighted average α_1 for this buyer and the thin black

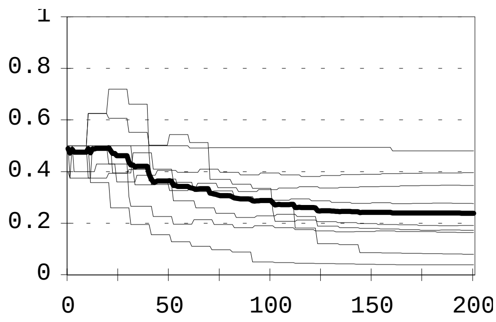

Figure 6: Weighted average α_1 in experiment 1.

line is the actual value for α_1 that this buyer used at any time.

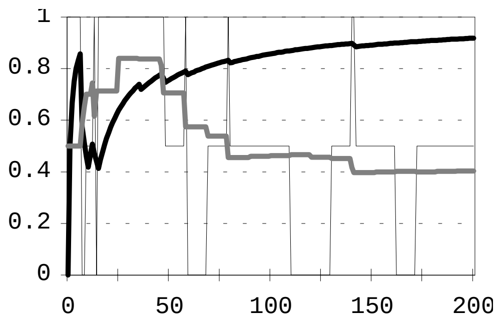

Figure 7: Buyer 9 in experiment 2.

4 Conclusions

According to the results, adaptive agents decrease the weight of profitability in their evaluation of a relationship, with a corresponding increase of the weight they attach to the partner's loyalty. This is an important result, because, although partners are evaluated on the basis of both profitability and loyalty, adaptation takes place only on the basis of profit. Furthermore, in the current version of the model, only suppliers can switch and it is assumed that the agent that breaks the relation carries the cost of switching, *i.e.* compensating the supplier for scrapping specific assets. Thus, there is no need for the buyer to value loyalty in order to prevent switching costs. The reason why a supplier's loyalty matters to a buyer is only that it indicates to what extent potential profit will be realized. A loyal supplier means continued supply and hence no loss due to discontinuity.

Different heights and distributions of switching costs may yield different results for the profit generating potential of loyalty. This will be investigated in further research. Another point is that while agents attach different weights to their partners' loyalty, there is no variation in the loyalty they exhibit: this is determined in the same way for all by the short term profitability of disloyalty. Further work will therefore allow for variation in the inclination towards loyal behavior and relate it to the weight attached to partners' loyalty.

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