

Learning through alliances

Ashoka Mody*

World Bank, Washington DC, USA

Received September 1991, final version received October 1991

An alliance is a flexible organization that allows firms with complementary strengths to experiment with new technological, organizational, and marketing strategies. The flexibility is valuable because the project undertaken through the alliance is uncertain. Flexibility is traded off against the weak incentive structure of the alliance. Although the principle goal of the experimental set-up is to learn more about technical and market parameters, learning also occurs about working in an alliance and could lead to greater competence in managing alliances, partially alleviating incentive problems. Through demonstration and externality effects, a few successful alliances can trigger more widespread alliance formation.

1. Introduction

When International Business Machines (IBM) and Sumitomo Electric Industries shared their respective expertise in computers and lighting technology, they developed a system that would operate 'smart buildings'. Such links between firms are often described as alliances because they are neither market transactions nor do they represent 'planned coordination' within an integrated firm [Richardson (1972)]. Each firm may also have other alliances; thus, bilateral links are part of a larger multilateral network.

An alliance is a flexible organizational mode that allows firms to bring complementary strengths together in order to experiment with new technological and organizational ideas. Their number has increased briskly in the 1980s.¹ These collaborations are mediated only partly through prices; often

Correspondence to: Ashoka Mody, S-4141 The World Bank, 1818 H Street, N.W., Washington, DC 20433, USA.

*The views expressed in this paper are those of the author and should not be attributed to the World Bank or its affiliates. Comments from Raaj Sah are gratefully acknowledged.

¹The growth in alliances has been documented by Morris and Hergert (1987) who also found that joint product development was the primary reason for 38 percent of alliances in their sample, while another 26 percent included product development as one reason for collaborative activity. Similarly, a study of 70 alliances by Mariti and Smiley (1983) found that 40 percent shared complementary technologies and in another 30 percent, technology was exchanged for market information and access. Semiconductor producers and equipment suppliers expect that over the next five years product development alliances will grow at the expense of purely marketing alliances (*Electronics Business*, March 19, 1990). Case studies of individual industries also report a large increase in alliances: see Hagedoorn and Schakenraad (1989) on information technology, biotechnology, and new materials; and Ghemawat, Porter and Rawlinson (1986) and Mowery (1988) for a number of other sectors.

one set of techniques is paid for by an alternative or complementary technology, or by providing other intangibles such as market information and access, support for a standard, or even reputation and credibility.

Why has the number of alliances increased so rapidly in recent years? Is this a fad? Could it persist? Is an alliance an efficient organizational choice? What, if any, changes are required in antitrust policy to accommodate these emerging organizational forms? Should policymakers actively promote alliances?

The paper argues that learning (or the resolution of uncertainty) is a strong motive for forming and sustaining alliances. However, alliances have only weak incentives to prevent cheating or opportunistic behavior. Thus they may be thought of as experimental organizations that trade off the acquisition of knowledge against potential losses due to cheating and opportunism.

As new technologies emerge, the option of experimenting with various combinations to test their technical commercial potential increases. The pressure of competition, forcing firms to differentiate their products and bring them to market more rapidly, also acts as a powerful incentive to seek partners with complementary strengths.

Although complementary capabilities can be purchased, information (like other intangible strengths) is difficult to price; alliances may preserve rents when prices cannot be set in a meaningful manner. Alternatively, complementary knowledge can be acquired through a merger. Alliances, however, have the advantage of preserving flexibility in the face of uncertainty, while mergers lead to a rigid structure. Mergers, moreover, are unlikely when information has to be acquired from several different sources.

Alliances are unstable because contracts are incomplete and residual rights to profits are not well-defined. The arrangements take place between players of equal status; no authority relationship is specified. Well-defined measures of information transfer are used to monitor the reciprocal flow of information, but contracts contain no specific incentives or threats to prevent cheating other than the possible break-up of the relationship. The exact contractual form varies considerably, but shared output is common. Equity links are one mechanism of formalizing output sharing but are not necessarily present.

In this paper, I examine how a horizontal link with an incomplete contract comes into existence and then survives in that form rather than immediately disintegrating or consolidating into a hierarchical mode where the residual rights to profit are clearly defined. The paper uses a Bayesian framework in which the alliance allows an experiment during each period that it exists. Based on the outcome of the experiment, firms decide whether to break up, continue, or merge.²

²I will not directly examine the reasons for different contractual forms within the umbrella of alliances.

Both learning about the 'environment' and learning about the behavior of the partners are relevant. Learning about partner behavior leads to the evolution of rules governing the relationship and can mitigate the risks of opportunism and cheating. The existence and usefulness of such rule formation when agents have limited capacity to process information has recently been reiterated by economic theorists [e.g., Cremer (1990)] and behavioral analysts [e.g., Heath and Tversky (1991)].

Because classic firm theory typically maintains a sharp distinction between market and nonmarket transactions, alliances, which combine elements of market and nonmarket transactions, have not been systematically studied [see Williamson (1990, p. 7)]. An exception is Aoki (1988, 1990), who has advanced the concept of the *J*-firm, which uses horizontal coordination within the firm and with other *J*-firms. The contribution of this paper is to make explicit the process by which a system with little coordination can move to one with a sustainable level of coordination.

2. Alliance functions and bonds

2.1. What is an alliance?

An alliance does not require firms to give up their identity; yet the partners no longer deal with each other only through the market. Elements of planned coordination and market-mediated links coexist [Richardson (1972)]. Planned coordination implies that quantities of goods or services are transacted without specific reference to their prices. Since only part of the quid pro quo for goods and services delivered from one firm to another is in cash, an alliance may be thought of as an extended barter agreement. Here, the terms 'barter', 'quantity-based' and 'rule-based' (transactions based on rules of reciprocity rather than on prices) are used interchangeably.

Alliances are a relevant organizational form when information is being shared and jointly acquired under conditions of uncertainty. Information is rarely sold in a purely market transaction. Rules governing the sale and use of the technology are generally an integral part of the deal [Caves and others (1982)]. Such rule-based transactions become particularly important when the value of assets being traded is highly correlated [Weitzman (1974); Williamson (1985)].

In the semiconductor industry, cross-licensing is the most common form of technology flow. 'The majority of these agreements do not involve any cash exchange, but rather a trade of know-how or technologies' [Suby (1985)]. The procedures for exchange are detailed and elaborate. The alliance between Intel Corporation and Siemens A.G. is an example:

'Every time you exchange something, you look at it and say: "What do you give me and what do I give you?" and you put it on a scale and see if they are equivalent.' (Alfred Prommer, Siemens' Components Group, quoted in *Electronics Business*, May 15, 1986.)

The existence of detailed quid pro quo arrangements does not guarantee success. In an alliance between Advanced Micro Devices Inc. and Intel Corporation new products were contributed to a common pool; either company could then produce and market the products in the pool. Points were awarded for contributing new products and an effort was made to equalize points over time. When that was not possible, cash settlements were made. The alliance broke up after Intel claimed that Advanced Micro Devices was not providing equal value.

Barter of information extends beyond the high technology sectors. U.S. steel mini-mills have a long tradition of information exchange. Competitors are allowed to visit plants provided they reciprocate. Similar implicit measurements apply to trouble-shooting and referral services. A survey by von Hippel (1987) showed that:

'Interviewees, including top management, were aware of know-how exchange patterns in their industry and emphasized that they were not giving know-how away – they were consciously *trading* information whose value they recognized. Thus, Bayou Steel: 'How much is exchanged depends on what the other guy knows – must be reciprocal'. Chaparral Steel: 'If they don't let us in [to their plant] we won't let them in [to ours] – must be reciprocal'.

An unusual example is the link between L.L. Bean, Inc. and Xerox Corp. L.L. Bean's experience in building and running a warehouse is relevant to companies doing business in many different areas. In return for learning about warehousing, Xerox taught L.L. Bean the importance and intricacies of 'benchmarking' – the systematic practice of comparing a firm's performance with that of its competitors.

The Japanese firm is the best-documented nexus of a network of alliances. Japanese alliances are formed in different dimensions. Large firms have clubs for information exchange [Goto (1982)]. Subcontracting relationships with suppliers are not only for acquiring inputs but also for learning. Geographically based or sector-based associations for sharing experience on production problems and for sharing minor innovations in the production process are also widespread [Cole (1989)].

Two explanations of how alliances are held together are discussed in the rest of this section. Both explanations are derived from the literature on transactions cost.

2.2. *Equity as the bond*

The transactions cost theory states that in certain situations comple-

mentary assets (know-how or machinery) are so specialized that they are not serviceable for alternative uses [Williamson (1975, 1985)]. Arms-length buying and selling of such specialized assets is not efficient (unless contracts specifying every possible contingency can be written and enforced). When assets are productive only in the specific buyer-seller relationship, the owner of a complementary resource can act opportunistically. If the partners have unequal access to information, cheating is likely; even if they have the same information, one or both of the partners may use its position to gain greater profits.

To overcome opportunistic behavior, transactions cost theory says that firms will seek close long-term relationships. The theory leads to the prediction that rule-based transactions will be correlated with the extent of equity commitment to the joint activity [see Pisano (1989)]. In practice, however, the correlation is far from perfect. Certain authors, in fact, argue that strong equity links could defeat the purpose of the alliance: Ohmae (1989) claims that when equity stakes in the partner rise beyond very low levels (3 to 5 percent), partners begin to worry about controlling each other and lose sight of the main advantage of an alliance, which is that it allows firms to learn from the experience.

Examples exist of firms with very little equity link but with transactions conducted mainly on a barter basis. The semiconductor and steel examples discussed above have virtually no equity ties. At the other extreme, when firms merge (and the equity commitment is complete), divisions within the firm can choose to conduct business with each other through price signals. A division of a large firm may have an alliance with another firm (with which it exchanges technology) but may have a market relationship with a division within its own firm (from whom it buys components).

Japanese alliances are held together by a mix of equity relationships and long-term implicit contracts. The system of reciprocity is not as well-defined as in Western alliances; the timetable for *quid pro quos* is more flexible, and the structure of the information exchange clubs is fuzzy. Even the renowned long-term subcontracting relationships with suppliers vary greatly. The extent of equity does not necessarily bear any relationship to the depth of supply commitment and information sharing. Agreements on exchanges of technology are loose and informal. Success in developing and manufacturing a product generally leads to a continuing relationship with new activities introduced over time [Sako (1988)]. The flexibility of these alliances and the wide variety of contractual agreements reflect the long experience with network relationships in Japan. This observation is discussed in section 5.

2.3. Hostages as the bond

Without the support of equity links, how do alliances enforce contracts?

One mechanism for preserving rents from information is the 'double hostage' system described by Williamson (1985, p. 191):

'... reciprocity involves the sale of specialized product to B conditioned on the procurement of specialized product from B. The argument here is that reciprocity can serve to equalize the exposure of the parties, thereby reducing the incentive of the buyer to defect from the exchange – leaving the supplier to redeploy specialized assets at greatly reduced value.'

Since, neither partner can independently sell information at a price that captures its true economic value, partners ensure that they receive maximum value for the information they supply by controlling its flow. In Williamson's terminology, 'hazards are equilibrated'.

Notice, however, that although holding another firm hostage can preserve rents when the alliance is in existence, it does not prevent the cheating (or misreading of environmental signals) that can break up the alliance.

The hostage model offers a plausible mechanism for bonding alliances, and is particularly relevant as the partners increase their ties with each other. The model, however has two related drawbacks. First, it makes no attempt to analyze the dynamics (length and stability) of an alliance. To the extent instability is studied, it is viewed as undesirable. Second, the model does not provide a link between the strength of bilateral alliances and the evolution of a network of alliances. In the learning framework discussed in the next three sections, the dynamics of an alliance are integrated with an explanation of why alliances may be widespread at certain times. The proposed approach is not an alternative to the transactions cost hypothesis; rather, it complements and extends transactions cost analysis.

3. Learning as the incentive for alliances

3.1. A Bayesian framework for studying alliances

In what follows I develop a framework for analyzing the trade-off between a merger and a more loosely structured alliance. The argument rests on the need for flexibility in an uncertain environment. Flexibility to acquire knowledge before making irreversible investments is obtained at the cost of an imperfect incentive structure and a (possibly) inferior physical organization of work.

Firms not only supply products and services, but also learn and make strategic choices in imperfect markets. Often learning and strategic development are related. For example, a firm that is experimenting with new technologies to differentiate its product is learning with a clear strategic goal in mind. Here, I focus on the learning process.

When alliance partners engage in joint learning, they have an incentive to keep the organizational form as flexible as possible. Irreversible investments in joint subsidiaries or mergers that involve large financial commitments,

movement of personnel, and reorganization of the firm's architecture and decisionmaking processes will be avoided until there is some confidence in the success of the project. In a study of several hundred alliances, Harrigan (1985, p. 324) concludes that:

'In order to avoid long entanglements in arrangements that could prove to be wrong later, firms adopted less binding relationships within embryonic settings. ...To facilitate easy transitions, agreements were formed to last for only a few months at a time and proceeded on the basis of a handshake rather than a voluminous legal document.'

Notice that this reasoning for avoiding mergers is quite different from that proposed by transactions costs theorists who argue that mergers may eliminate the high-powered discipline of market incentives.

An alliance is expensive since its ad hoc organization typically implies that the activity is not organized as efficiently as possible. In addition, the possibility that the firm is being cheated by its partner continually exists and such cheating is not easy to distinguish from poor performance on account of technical and market factors. As a result, transactions costs are higher in an alliance than in a hierarchically organized structure. This requires the cooperating partners in an alliance to spend greater resources on communicating and bargaining with each other than would be the case in a hierarchy [see Aoki (1990, p. 8)].

The initial trade-off, therefore, is between the flexibility of the alliance and the superior incentive structure of the merger. The phrase 'initial trade-off' is used here because I shall argue that the incentive framework of the alliance can improve through repeated interactions and through demonstration effects of other alliances to the point where an alliance can become a self-reinforcing and dominating organizational form.

If we view the alliance as an experiment, then in each period the partners obtain an outcome of the experiment that becomes the basis for further action. The observed outcome improves the information available to the partners, but is typically an imperfect signal of the 'true' state of affairs.³ If the outcome is poor, the firms may infer that alliance prospects are poor and decide to discontinue partnership; if the outcome is good, they may decide that further resources need to be invested in the activity and that, therefore, it makes sense to merge or establish a joint subsidiary.

Fig. 1 shows the cut-off points for merging or terminating an alliance. If the outcome is within the bounds of the 'good' and the 'bad' limits, the firms will continue the alliance for another period before making a decision. The 'continuation region' (during which time the collaboration is in effect) is shown in fig. 1 to narrow over time. Two factors are at work. First, the value of additional information declines over time. And second, the expense

³See DeGroot (1970) and Lippman and McCardle (1987) for models of sequential sampling.

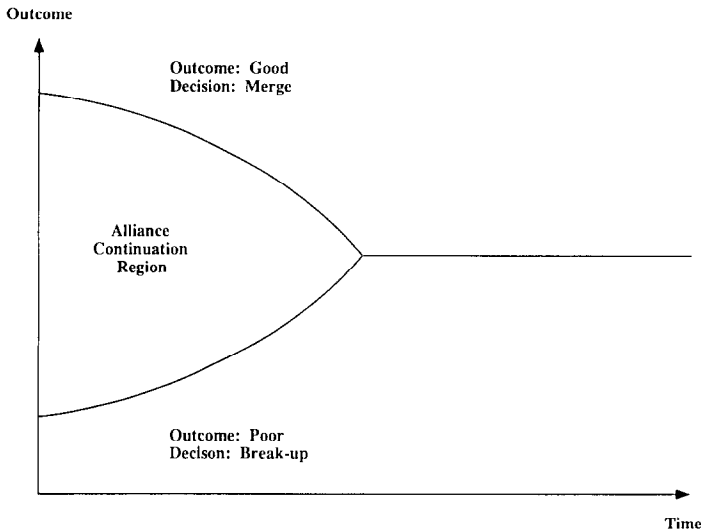


Fig. 1. Dynamics of organizational form under uncertainty.

eventually is too high to justify continuing the search and the partners will stop searching, even if they do not have complete information.

Since the good and bad cut-off points are imperfect indicators of the potential success or failure of the project and since the costly experimentation must eventually stop, mistakes are likely to be made in determining the appropriate organizational form.

Proposition 1. An alliance will initially tend to accept a wide range of both good and bad news without changing its status; over time, the probability of either dissolving the alliance or merging will increase.

Though from a small sample, direct support for this proposition is available from Kogut (1989), who followed the fortunes of 92 alliances. In the first three years, 3.8 percent of the alliances dissolved per year; and in the next four years, 6 percent decided to discontinue the arrangement. The rate of acquisition or merger similarly increased over time.

Other empirical studies have observed that surviving alliance partners increase their irreversible commitments over time. Lyle (1988) and Mody (1989a) show that the depth of the relationship increases as the product cycle matures. Links tend to be loose in the product development phase and often there is no equity participation; multiple alliances with many partners are formed for overlapping purposes. Equity involvement is more common in the transitional phase; and mergers tend to increase in the mature period.

As noted above, engaging in a learning phase is no proof against making a

mistake. IBM and Rolm Corporation collaborated on computing and communications technologies to develop small telephone exchanges that route data and voice. The learning process started with a joint venture; after a few years, prospects looked good and the two decided to merge. When the market for the phone exchanges suddenly slowed as substitute products appeared, the relationship became untenable. IBM finally handed over controlling interest in Rolm and Siemens, which has a deeper commitment to and greater experience in the design and production of telephone exchanges.

The empirical application of transactions costs theory emphasizes a one-time motive for the contractual commitment [Joskow (1987); Pisano (1989)]. When transactions costs are high, the possibility of renegotiation is considered highly undesirable. But according to the view developed here, dissolving the alliance should be considered an integral part of the learning process and an inevitable cost of diffusing information. It is even likely that the social costs will be higher than necessary. In order to preempt competitors, firms are liable to form more alliances than the optimum. Although many of these alliances will dissolve, policies that aim at restricting the number of alliances run the risk of restricting the flow of information as well.

3.2. *Multiple alliances*

In principle, alliances discussed here are no different from other mechanisms to share technology, such as conferences, informal professional networks, or industry associations. The common feature of all these mechanisms is an implicit understanding that over time information of equal value will be exchanged. Some of these arrangements, such as conferences, are 'multilateral' in that everyone has equal access to the information being disseminated. Reciprocity is only loosely enforced. Reciprocity is more stringent in other multilateral forums, such as alliances directed towards establishing standards and the so-called precompetitive alliances (designed to develop generic technologies that have been encouraged by all industrial countries).

Most alliances are bilateral, but some of these relationships are embedded in larger networks. Fig. 2 shows Rolls Royce's links to a wide network through a number of bilateral alliances. Hagedoorn and Schakenraad (1989) have mapped elaborate networks in information technology, biotechnology, and new materials for several international companies (see especially their figures 6 through 11). Although a bilateral relationship may contain conditions that restrict the flow of information, diffusion does occur. In this sense there are no purely bilateral relationships.

As fig. 2 shows, each alliance is associated with a well-defined objective, although some projects overlap technically. Multiple alliances are in a sense a portfolio of information sources. Diversification in information sources is

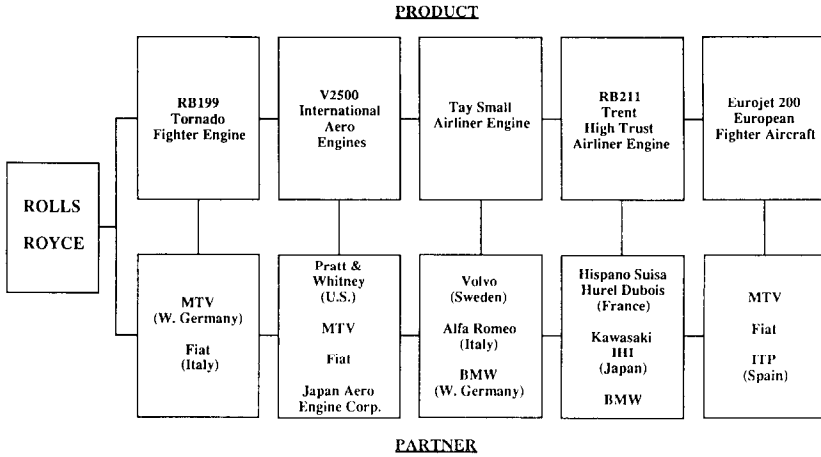


Fig. 2. Rolls Royce's main relationships (Source: Financial Times, May 4, 1990).

desirable because it increases the probability of acquiring the desired information; unlimited diversification is not possible because of the cost.

However, multiple alliances are not merely diversified sources of the same information. New product creation (the object of Rolls Royce's alliances) or process improvements often requires substantial specific information. Multiple alliances allow firms to source specific information.

A natural explanation now follows for preferring loosely defined contractual arrangements to complete mergers. The alliance can discover whether complementary capabilities make sense from a technological and/or market perspective, and whether the firms can work together (that is, whether their 'corporate cultures' are compatible).⁴ If firms merge before this information is available, the expense of merging will be compounded by the expense of terminating the merger. These costs are especially high if firms form many alliances.

4. Conditions for learning

The above framework can help predict the extent of alliance activity. The predictions are stated as four propositions. Proofs relating to the sequential sampling aspect of the propositions can be found in Lippman and McCardle (1987); here, intuitive explanations are provided.

Proposition 2. Uncertainty creates two opposing effects on alliances. Greater

⁴Cremer (1990, p. 54) defines corporate culture as 'the stock of knowledge that is common to a substantial portion of the employees of the firm, but not to the general population from which they are drawn'.

uncertainty increases the value of information and thus makes experimenting through alliances more desirable. In terms of fig. 1, the bounds between good and bad cut-off points increases, expanding the period of time during which the partners will capitalize on the alliance. Uncertainty also increases the possibility of opportunistic behavior – and hence the perceived cost of the alliance – and tends to reduce the period of alliance activity.

Recent observations are consistent with the proposition that uncertainty may be conducive to high alliance activity, which then potentially declines as the uncertainty is resolved. Alliance activity has increased, particularly in high-technology sectors where research and product development are characterized by substantial uncertainty. Hagedoorn and Schakenraad (1989) moreover find that the number of new alliances in segments of the information technology, biotechnology, and new materials may in fact have started to decline as the technological complementarities are becoming clearer. The depth of the existing relationships (measured by the number of projects in a relationship) has increased, however.

Crocker and Masten (1988) also show that in periods of greater uncertainty (measured by uncertainty in product price) firms favor more flexible relationships (shorter contracts). (They do not examine whether these short-term contracts were renewed over longer periods of time to resolve part of the uncertainty.)

Conversely, Pisano (1989) argues that higher uncertainty (represented by the inclusion of R&D in the alliance) creates the basis for more formal relationships.⁵

In transactions cost analysis, firms treat uncertainty as a constraint and devise contractual forms to minimize its ill effects. A central premise of this paper is that firms actively seek to resolve the uncertainty they face. Alliances are the result of efforts to simultaneously devise appropriate contracts and resolve uncertainty. Aoki (1988, 1990) suggests that in situations of 'moderate' uncertainty, the learning incentive will dominate and alliances will be formed; when uncertainty is high, the risk of cheating and opportunism will be the major influence and hierarchical modes of organization will be sought. This proposition needs to be pursued both theoretically and empirically. Indirect support may be found in the observation that most alliances deal with small incremental innovations rather than breakthrough research. Of course, the strength of an effectively functioning alliance network is that small innovations accumulate to provide major benefits.

Note also that while uncertainty is conventionally treated as arising from factors outside the control of the firm, this is often not the case. It may be in the strategic interest of the firm to create uncertainty. For example, firms

⁵R&D is not the best measure of uncertainty. R&D could be a measure of the scale of the relationship, among other things.

producing relatively mature products that face price competition have an incentive to experiment with new product characteristics. Alliances between automobile producers and plastics manufacturers working on new materials for car bodies are an example.

The evolutionary process may, therefore, be seen as one that seeks uncertainty by attempting to introduce new products, new processes, and new organizational methods. The firm then attempts to resolve the uncertainty through various means, including alliances.

Alliances that last are those that periodically generate uncertainty by introducing additional products or by entering new markets. In doing so, the partners recreate the need for each other on a continuing basis. IBM and Microsoft, for example, started with an alliance linking IBM's personal computer to Microsoft's operating system, MS-DOS. The partners then went on to create graphical interfaces ('windows') for users of personal computers. Such renewals are common in Japanese relationships.

Proposition 3. For a given level of uncertainty, better information processing capability (through better personnel or organization of the firm) enlarges the period of continuation. More alliances will exist when information processing capabilities are higher. Also, fewer mistakes will be made in decisions to terminate or enlarge the scope of the alliance. This is important because if alliances have demonstration effects, better decisionmaking will encourage others to form alliances.

Although I refer to alliances between firms, ultimately the information exchange occurs between individuals. The quality of these individuals is critical to the effectiveness of the alliance. Firms that provide incentives to workers to learn will benefit more from alliances. Thus it is not surprising that Japanese firms emphasize learning and also participate widely in inter-firm alliance networks.

In addition to substantial worker training, Japanese firms emphasize employee flexibility, cooperation among workers, and decentralization of authority to the shop-floor level. All these features have direct or indirect influences on alliance formation and stability. Workers acquire substantial experience in cooperating across several boundaries within the firm which then allows them to effectively interact in alliances across firms.

Aoki (1990) suggests that in Japanese firms specialization may be sacrificed to ensure efficient communication in the firm. In contrast, U.S. firms emphasize specialization, which reduces internal communication. These structural differences are not unrelated to the complaints by U.S. auto and electronics firms that they benefit much less than do their Japanese counterparts from alliances with Japanese firms. Studies suggest the Japanese devote much larger resources to the alliance than U.S. firms.

Many Western corporations are moving toward a Japanese organizational structure and this is likely to reinforce the use of alliances. A particularly interesting example is the case of U.S. steel minimills, arguably one of the most dynamic sectors in the U.S. economy. These mills have many of the organizational features of Japanese firms: emphasis on worker training, flexibility, and autonomy. There are fewer levels of hierarchy in minimills than in the average American company and responsibility rests at the point of action. Minimills, as noted above, also have had an extremely active and longstanding system of industry-wide alliances.

Proposition 4. A higher rate of growth and/or a lower rate of discount encourage alliance activity. High growth and low discount rate are, in turn, reinforced by the alliance organizational form.

Rapidly growing firms have a higher payback from learning and tend to invest in greater learning, which in turn, induces more rapid growth [Mody (1989)].

A more subtle mechanism operates as follows. Learning, like any investment, is encouraged by low discount rates (longer time horizons). It is widely believed that time horizons have been longer in Japan than in the United States. But how are time horizons determined? One possibility is that when firms form an alliance, they are forced to take a longer view. Even a loose and informal alliance involves the costs of finding a partner and creates a commitment (to the relationship and to tangible investments); it is not rational to walk out of the partnership unless major changes occur. Wilson (1987) notes that when competitive pressure is high, firms will become more 'impatient' to make deals. If they have a long-term understanding with their partners, they will be less impatient.

It should be emphasized that the size of the operation per se is not the factor that drives the change in time horizon. It is the investment in identifying and developing the relationship that is critical. In fact, if firms merge, some of this ongoing investment in building relationships may stop and hence the horizon may actually decline as firms move from informal to more formal and structured relationships [See Hakansson (1987)]. As noted above, Ohmae (1989) has argued that equity stakes shift the firms' orientation from learning to worrying about control.

Proposition 5. Alliance formation will be higher when the costs of merging are greater.

In sum, greater uncertainty, better worker quality and experience in horizontal communications, a longer time horizon, and constraints on merging are important factors in alliance formation. These variables may, in turn, be influenced by the structure and experience of the alliance. In particular, longer time horizons lead to greater alliance activity; but commit-

ment to the alliance may lead firms to implicitly adopt a longer planning horizon. Similarly, superior ability to communicate leads to fewer mistakes in the choice of the appropriate organizational form; in such an environment, past experience with alliances will have a more credible demonstration effect on influencing further alliance activity. Finally, uncertainty leads to a greater propensity for experimental organizational forms such as alliances; in turn, alliances functioning well may be induced to undertake new and uncertain activities. These self-reinforcing properties can result in the formation of self-sustaining alliance networks.

5. The evolution of networks

While alliance partners will on occasion choose to go their separate ways in response to changing conditions, the broader question is: will they then seek alternative alliances or will they reduce their dependence on alliances? Two reinforcing properties exist: (1) the behavior of others in the network has a demonstration effect; (2) networks generate externalities: the larger the network, the greater the value of the network to its members [Boorman (1975)]. Thus a system with a small number of alliances could stay that way because of the system's inertia, but the 'positive feedback' from the success of a few alliances could generate a momentum towards alliances becoming a more pervasive phenomenon. It is therefore, not easy to predict how the system will evolve. Such indeterminacy has been noted by Arthur (1991) in other contexts.

Faced with imperfect information and bounded rationality, firms develop rules through a number of cues. Experiences of similar firms are a key input in determining their strategy. The demonstration effect augments the network externality effect, but is conceptually different.

This paper has noted two routes by which firms make a greater commitment to a relationship. First, the horizontal, informally coordinated association can evolve into a more structured, formal, hierarchically organized relationship. Greater equity participation over time can culminate in a merger of firms (or of the relevant activity) into a joint subsidiary.

The other route to deepening the relationship is through renewal for a new project or increased contact in the form of several projects. Multiple ties reinforce each other (the number of hostages increases) and the need for a hierarchically organized incentive structure declines. Kogut (1989) shows that relationships tend to be more stable when the firms have several ties to each other.

The two routes have significant implications for the evolution of the network. The first results in the alliance being a purely transitional organizational form that finishes its function when the experimentation is over. The

second leads to horizontal coordination through alliances becoming a more permanent organizational form.

Which of these two routes is taken will depend on three factors. First, if a longstanding alliance confronts dramatic changes in the market indicating that the alliance should be dissolved, partners may break up that particular alliance but form new alliances. If, on the other hand, the alliance dissolves early on, the participants are likely to view alliances with greater suspicion and be more reluctant to enter into new alliances. Second, if other alliances are perceived as having served a useful function, the propensity to enter into such agreements will be high. And finally, the larger the number of members in the network, and the greater the pool from which an individual firm draws information, the more likely that alliances will grow.

The key point is that if a few prominent alliances fail quickly, the firms engaged in those alliances are likely to be averse to further alliance activity. In addition, through the demonstration and network externality effect, formation of other new alliances could be dampened.

The previous section reviewed some reinforcing characteristics of individual alliances. In this section I have argued that the reinforcement can occur at the level of the entire system. Thus the system is capable of supporting different modes of behavior through creating new norms or rules and thereby rewarding different actions. Once norms get set, they tend to recreate inertia in the system. This clearly does not imply that the systems will remain unchanged forever. Indeed, as noted above, Western firms have made conscious efforts to emulate Japanese organizational methods. The next section will discuss policy measures that can be effective in joggling the system.

A further implication of this section for empirical analysis is that past experience and the history of the network influence contractual forms. For this reason, studying contractual differences at a given moment is likely to have less payoff than tracing specific relationships and networks over time. Examining mechanisms of reinforcement is a particularly important research task.

6. Policy instruments

A policymaker needs to decide whether alliances should be promoted and, if so, what is the best mechanism for doing so. I argue here that on balance alliances are likely to create beneficial effects for the economy and that policy measures can be crafted to minimize potential anticompetitive effects.

Alliances promote information diffusion and thereby increase efficiency across the economy. Moreover, since the value of an alliance to an individual firm grows as the network grows, stimulation through government policy is desirable. When a self-sustaining network of alliances develops, the be-

havioral mode of the network of firms may change towards greater emphasis on knowledge generation (and, correspondingly, a reduced concern about cheating and opportunism).

Alliances can be socially wasteful if relationships are intended mainly to preempt others from partnering. The possibility of collusion among cooperating firms also needs to be assessed. Clarke (1983) argues that the incentive to collude is so high that it justifies actively discouraging information exchange. Even more strongly, Vernon (1987) cautions that alliances will not only create cartels in product markets, but will eventually restrict the development and diffusion of technology:

‘...Parties to such alliances, it is true, usually have an initial intention of pooling their technology in the interest of increasing productivity or generating new final products, not of holding back on technological advance. But one must realistically entertain the possibility that a spell of hard times will alter the original direction of the alliances, especially when the alliances have linked the technological leaders in any product lines.’

Cooperation, therefore, must be tempered with competition. In precompetitive alliances, an attempt is made to blend cooperation and competition. Firms pool their resources – capital, scientists, engineers, and specialized knowledge – to do basic research; the collaborating firms then develop marketable products on their own.

Sematech in the United States, the European Strategic Programme for Research and Development in Information Technology (ESPRIT), and Japan’s Fifth-Generation Computer project are all examples of such projects. These are large-scale ventures; Sematech’s annual budget, for example, is \$250 million. These precompetitive alliances are jointly financed by industry and government. The government contribution is usually substantial; half the financing in the European and U.S. programs comes from government sources.

Though similar in their motivation and broad dimensions important differences exist among these ventures. Sematech has been set up as a new laboratory staffed by engineers and scientists of the member firms. The group will be disbanded once the task is complete, and the facilities will be sold. Governments favor large firms because they are viewed as having the best prospects for regaining the leading edge. Moreover, small innovative firms are suspicious of joining larger firms: they are reluctant to bring to the table highly developed niche technologies that represent their primary sources of income. The larger companies are also suspicious; rules for technology sharing have to be devised carefully if such ventures are to be viewed as mutually advantageous.

In contrast, European precompetitive ventures, such as ESPRIT, are oriented toward developing multiple intercompany links. Instead of focusing on one major effort, they subsidize several specific projects on condition that two or more companies agree to cooperate in the research and development.

Firms are required to seek out specific links. This strategy has greater influence in creating an information sharing network.⁶ In contrast, clubs are less effective in diffusing information and are more liable to develop collusive practices.

A similar – but more directly activist – strategy has recently been adopted in Taiwan. The government, with the help of an international consulting firm, engineered six alliances between Taiwanese and foreign firms. Such a policy is very much in consonance with the framework of this paper. Since system-wide effects can be very powerful, this is a sensible course of action. The possible demonstration effects of these alliances and their establishment as key nodes of the network can be expected to give a fillip to further alliance activity in that country.⁷

A general lesson is that successful diffusion of knowledge from these cooperative ventures requires high quality personnel that actively link the participating company to the joint activity. This principle applies particularly to precompetitive collaboration but is also important for alliances at all stages of the product cycle. The mere formation of an alliance is no guarantee that a diffusion of knowledge will occur. Policies that contribute to worker training and to greater decentralization of authority indirectly promote more effective alliance activity.

A less activist policy would address three aspects of antitrust laws. First, by making mergers more difficult, alliances would be promoted. Second, a movement in the opposite direction, would be the reduction of antitrust constraints on the formation of joint ventures [Ordovery and Willig (1984) and Jorde and Teece (1989)]. Such policy change can facilitate network development, although it may also merely increase the scale of production, with little or no impact on learning and diffusion of knowledge. Moreover, the possibility that firms may try to preempt alliances requires that antitrust law continue to monitor alliance formation, weighing each case on its merits.

Finally, antitrust policy that dissuades buyers and suppliers from forging close links (note the move against strong relationships between Japanese plants in the United States and their long-term subcontractors) is misguided. Such long-term relationships promote incremental innovation; moreover, competition between alternate subcontractors has in the past been sufficient to keep them honest.

Policy can play an important role by encouraging open standards through industry-wide cooperation. Open standards, as distinct from proprietary

⁶Sematech has 14 members. In mid-1987, the Alvey program in the United Kingdom, which is linked to the Europe-wide ESPRIT program, had 311 interrelated projects with an average of 3.9 members per project (typically between 2 or 3 firms and 1 or 2 academic institutions). See Hobday 1988.

⁷This description is based on a discussion with William Reinfeld, one of the consultants involved in engineering the alliances.

standards, allow firms and individuals to interface products and allow communication between machines and people without recourse to special equipment or permission. Standards set through cooperative efforts are more efficient than those set unilaterally by a single or small group of firms [Farrell and Saloner (1988)]. Moreover, cooperative standards result in wide dissemination of technical information and prevent monopolies.

7. Conclusion

This paper has attempted to identify factors that strengthen an alliances. The essential trade-off lies in the generation and sharing of knowledge versus the possibility that the partner may act opportunistically. As the knowledge content of the relationship grows, the aversion to opportunistic behavior is likely to decline. This will lead to a change in rules of behavior which de facto imply greater trust in each other. 'Trust,' therefore, is not necessarily an exogenous characteristic but is an outcome of the nature and success of a relationship. Trust is likely to augment the capability to search for and share new knowledge, thereby further reducing the aversion to cheating and increasing trust. An important item on the research agenda should be to identify the types of rules of behavior that can be identified with 'trust' and examining how these rules may appear in an evolutionary setting.

Empirical studies need to examine the determinants of the length of specific relationships and also the reasons particular partners choose to renew relationships. These questions are different from the focus on identifying reasons for specific contractual forms, although the nature of the contractual form is likely to have a bearing on the length of a relationship. The reason for focusing on the length and renewal of relationships is that their determinants will provide clues to the evolution of 'trust'.

Of particular interest would be studies of the effect of different forms of uncertainty on alliance length and frequency of renewal. Recently, Heath and Tversky (1991) have argued that the sources of uncertainty determine behavioral response because the competence to deal with different types of uncertainty varies. This may partly explain why alliances appear to grow in particular industries or geographical settings.

References

- Aoki, Masahiko, 1988, *Information, incentives and bargaining in the Japanese economy* (Cambridge University Press, Cambridge).
- Aoki, Masahiko, 1990, *Toward an economic model of the Japanese firm*, *Journal of Economic Literature* 28, no. 1, 1–25.
- Arthur, Brian, 1990, *Positive feedbacks in the economy*, *Scientific American* 262, 92–99.
- Boorman, Scott A., 1975, *A combinatorial optimization model for transmission of job information through contact networks*, *Bell Journal of Economics* 6, no. 1, 216–249.

- Caves, Richard E., Harold Crookell and Peter J. Killing, 1982, The imperfect market for technology licenses, Discussion paper no. 903 (Harvard University).
- Clarke, Richard N., 1983, Collusion and the incentives for information sharing, *Bell Journal of Economics* 14, 383–394.
- Cole, Robert E., 1989, Strategies for learning: Small-group activities in American, Japanese and Swedish industry (University of California Press, Berkeley).
- Cremer, Jacques, 1990, Common knowledge and the coordination of economic activities, in: M. Aoki, O.E. Williamson and B. Gustaffson, eds., *The firm as a nexus of treaties* (Sage Publications Ltd., London).
- Crocker, Keith J. and Scott E. Masten, 1988, Mitigating contractual hazards: Unilateral options and contract length, *Rand Journal of Economics* 19, no. 3, 327–343.
- DeGroot, Morris H., 1970, *Optimal statistical decisions* (McGraw-Hill Book Company, London).
- Farrell, Joseph and Garth Saloner, 1988, Coordination through committees and markets, *Rand Journal of Economics* 19, no. 2, 235–252.
- Ghemawat, Pankaj, Michael E. Porter and Richard A. Rawlinson, 1986, Patterns of international coalition activity, in: Michael E. Porter, ed., *Competition in global industries* (Harvard Business School Press, Cambridge).
- Goto, A., 1982, Business groups in a market economy, *European Economic Review* 19, 53–70.
- Hagedoorn, John and Joseph Schakenraad, 1989, Partnerships and networks in core technologies, A paper for the conference on *The Economies of Technical Change* Maastricht, Nov. 2, 1989.
- Hakansson, Hakan, 1987, Introduction, in: Hakan Hakansson, ed., *Industrial technological development: A network approach* (Croom Helm, London).
- Harrigan, Kathryn R., 1985, *Strategies for joint ventures* (Lexington Books, Lexington, MA).
- Heath, C. and A. Tversky, 1991, Preference and belief: Ambiguity and competence in choice under uncertainty, *Journal of Risk and Uncertainty* 4, 5–28.
- Hobday, Michael, 1988, Evaluating collaborative R&D programmes in information technology: The case of the U.K. alvey programme, *Technovation* 8, 271–298.
- Jorde, Thomas M. and D.J. Teece, 1989, Competition and cooperation: Striking the right balance, *California Management Review*, Spring, 25–37.
- Joskow, Paul L., 1987, Contract duration and relationship-specific investments: Empirical evidence from coal markets, *The American Economic Review* 77, no. 1, 108–185.
- Kogut, Bruce, 1989, The stability of joint ventures: Reciprocity and competitive rivalry, *The Journal of Industrial Economics* 38, no. 2, 183–198.
- Lippman, Steven A. and K.F. McCardle, 1987, Does cheaper, faster or better imply sooner in the timing of innovation decisions? *Management Science* 33, no. 8, 1058–1064.
- Lyle, Marjorie, 1988, Learning among joint venture sophisticated firms, *Management International Review*, Special issue, 85–97.
- Mariti, P. and R.H. Smiley, 1983, Co-operative agreements and the organisation of industry, *The Journal of Industrial Economics* 31, no. 4, 437–450.
- Mody, Ashoka, 1989, Firm strategies for costly engineering learning, *Management Science* 35, no. 4, 496–512.
- Mody, Ashoka, 1989a, *Staying in the loop*, World Bank Discussion Papers 61 (Washington, DC).
- Morris, Deigan and Michael Hergert, 1987, Trends in international collaborative agreements, *Columbia Journal of World Business* 22, no. 2, 15–21.
- Mowery, David, 1988, ed., *International collaborative ventures in U.S. manufacturing* (Ballinger, Cambridge).
- Ohmae, Kenichi, 1989, The global logic of strategic alliances, *Harvard Business Review*, March–April, 143–154.
- Ordoover, Janusz A. and Robert D. Willig, 1984, Antitrust for high-technology industries: Assessing research joint ventures and mergers, C.V. Starr Center for Applied Economic, *Economic Research Report* 84-16 (New York University, New York).
- Pisano, Gary P., 1989, Using equity participation to support exchange: Evidence from the biotechnology industry, *Journal of Law, Economics and Organization* 5, no. 1, 109–125.
- Richardson, G.B., 1972, The organization of industry, *The Economic Journal*, Summer, 883–896.

- Sako, Mari, 1988, Neither markets nor hierarchies: A comparative study of the printed circuit board industry in Britain and Japan, A paper prepared for the second conference of the project Comparing Capitalist Economies: Variations in the Governance of Sectors, Bellagio, May 29–June 2, 1989.
- Suby, Carol, 1985, The ins and outs of IC cross-licensing agreements, *Electronics Business*, Sept. 1, 150–151.
- Vernon, Raymond, 1987, Coping with technological change: U.S. Problems and prospects, in: Bruce R. Guile and Harvey Brooks, eds., *Technology and global industry: Companies and nations in the world economy* (National Academy Press, Washington, DC).
- von Hippel, Eric, 1987, Cooperation between rivals: Informal know-how trading, *Research Policy* 16, 292–302.
- Weitzman, M.L., 1974, Prices vs. quantities, *Review of Economic Studies* 41, no. 128, 477–491.
- Williamson, Oliver, 1975, *Markets and hierarchies: Analysis and antitrust implications* (St. Martin's Press, New York).
- Williamson, Oliver, 1985, *The economic institutions of capitalism* (Free Press, New York).
- Williamson, Oliver, 1990, The firm as a nexus of treaties: An introduction, in: M. Aoki, O.E. Williamson and B. Gustafsson, eds., *The firm as a nexus of treaties* (Sage Publications Ltd., London).
- Wilson, Robert, 1987, Game-theoretic analyses of trading processes, in: Truman F. Bewley, *Advances in economic theory fifth world congress* (Cambridge University Press, Cambridge).