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NETWORK STRUCTURE AND BUSINESS SURVIVAL: THE CASE OF U.S. AUTOMOBILE COMPONENT SUPPLIERS

ABSTRACT

We examine how three elements of network structure affect supplier survival in the U.S. automobile industry, focusing on relationship duration, supplier autonomy, and customer status. These elements of network structure will influence performance when firms must create inter-firm routines that are beyond immediate managerial control. We examine the impact of these elements of network structure in two different competitive contexts, by considering differences in the characteristics of goods and differences in demand conditions. Using life-history data on all carburetor and clutch manufacturers in the U.S. from 1918 to 1972, we find that suppliers of architectural goods benefit from long-term relationships, high status customers, and actual autonomy, with the benefits of autonomy being most pronounced during periods of adverse demand. By contrast, structural autonomy is the only element of network structure that affects suppliers of modular goods, although the modular suppliers benefit from potential autonomy as well as from actual autonomy. This comparison speaks directly to the contingent nature of the influence of network structure, with the benefits and constraints deriving in large part from the nature of the inter-firm routines that firms must create in order to coordinate their relationships. Relationships that require extensive sets of inter-firm routines tend to lead to greater benefits and constraints of network structure, while relationships that require less intensive inter-firm routines garner lesser impact from network structure.
NETWORK STRUCTURE AND BUSINESS SURVIVAL: THE CASE OF U.S. AUTOMOBILE COMPONENT SUPPLIERS

Recent studies in strategy and organizational theory argue that the structure of a firm's network of inter-organizational relationships can both help and harm the firm's performance. Networks offer benefits through means such as providing access to information, creating shared understandings that facilitate decision-making, and sharing resources in order to gain scale and scope economies (Burt 1992; Ahuja 1997). At the same time, networks can create constraints such as making some firm dependent on others, diffusing proprietary information, and reducing independent adaptability (Mitchell and Singh 1996; Uzzi 1996; Podolny and Page 1998). Despite our increasing understanding that inter-firm networks affect firm performance, research is just beginning to scratch the surface of what we mean by networks and how different elements of a network will influence performance in different competitive contexts.

This study examines different elements of inter-firm networks by focusing on the performance of supplier firms in vertical relationships with customers. We argue that the structure of a supplier's network of customer relationships creates benefits and constraints that influence supplier performance. We address three elements of the structure of a supplier's network of customer relationships: duration of relationships, autonomy within a network, and status of relationships. We further consider how network effects will differ in two types of competitive contexts, including different types of goods and different demand conditions.

This approach contributes to developing a greater understanding of how individual decisions and transactions aggregate into firm-specific patterns of activities that influence strategy and performance. The work is rooted in a routine-based view of strategy (Nelson and Winter 1982). This perspective treats routines as the key unit of analysis for studying firm activities, where routines are repeated patterns of actions that span multiple actors (Winter, 1987), and views managers as boundedly-rational actors who face substantial limits in their ability to assess the benefits and risks of individual actions (Karim and Mitchell, 2000). A network of inter-firm relationships encompasses multiple firm-specific and inter-firm routines that provide access to resources, but often will be difficult for firms to adjust quickly. As a result, a firm's network of relationships is a meaningful unit of analysis and the structure of the network will have exogenous influences on firm performance, above and beyond the performance effects of the factors that caused the network to take its observed structure.
Our empirical study examines the effects of network structure on the survival of carburetor and clutch suppliers in the U.S. automobile industry from 1918 to 1972. The data include the populations of the component suppliers and the automobile assemblers to which they sold goods during the study period. The results help demonstrate how different elements of network structure affect business performance in different competitive contexts.

**BACKGROUND AND HYPOTHESES**

Studies of inter-organizational relationships often posit benefits or constraints that arise from particular dyadic relationships (Richardson 1972; Baum and Oliver 1991). A common theme is that long-term linkages provide several types of benefits to the firms involved. In the context of vertical relationships, such as those between buyers and suppliers, enduring relationships facilitates cooperative activities such as product design and marketing (Hayes and Wheelwright 1984; Womack, Jones et al. 1990; Clark and Fujimoto 1991). Long term relationships may also help firms to develop trust (Cusumano 1985; Heide and Miner 1992; Zaheer, McEvily et al. 1998) that helps exchange goods and services that are difficult to price or contract (Gulati 1995; Uzzi 1996). More generally, as interactions continue over time, the firms develop relationship-specific routines that facilitate their joint activities (Levinthal and Fichman 1988; Asanuma 1989; Martin 1996). At the same time, though, relationships may lead to loss of proprietary information and may create constraints that hinder a firm's ability act independently, thereby harming its performance (Caves and Uekusa 1976; Hamel 1991). The general conclusion to this argument is that inter-firm relationships may be positive or negative for the partners, depending on the competitive context and the capabilities of each firm.

The potential positive and negative influences of inter-firm relationships come together when one considers the network of relationships in which a firm is embedded, rather than simply the firm's discrete dyadic relationships with particular organizations. The network view emphasizes that, although decisions to form, continue, or terminate individual relationships may occur at a dyadic level, this series of decisions forms a network with performance implications of its own (Burt 1992; Uzzi 1996; Podolny and Page 1998). The network influences will arise in ways that may differ from the impact of any single relationship within the network because the network consists of interactions among individual relationships as well as of the summation of dyadic influences. The interactions among what may begin as simple relationships give rise to a complex web of relationships (Simon 1969). The complexity of this web of routines both
constrains managers' abilities to adjust obsolete activities and limits their abilities to undertake or even recognize seemingly desirable new activities.

Recent research has considered three key aspects of network structure that may influence firm performance. First, duration of relationships is one element of networks, building on the importance of relationship duration in discussions of dyadic relationships (Mitchell and Singh 1996). Second, several forms of firm autonomy (Burt 1992; Uzzi 1997; Podolny and Page 1998) have emerged as key elements of network structure. Third, partner status has recently received thoughtful attention as an important element of relationships (Podolny 1993; Shapiro and Varian 1999).

These three elements of networks are particularly relevant in the context of vertical relationships among suppliers and buyers. Buyer-supplier relationships offer an intriguing opportunity to study network structure because they tend to involve many firms of different size and status, through both direct and indirect relationships of varying length (Martin, Swaminathan et al. 1998). Moreover, buyer-supplier relationships play key roles in industry evolution, by influencing the development and distribution of new goods and services (Clark and Fujimoto 1991). Supplier performance is an important but under-emphasized outcome of competitive activity in an industry. The remainder of this section develops our arguments concerning how network structure influences supplier performance in the context of buyer-supplier relationships.

We state the predictions concerning supplier performance in terms of business failure. Failure is an appropriate measure for the empirical context of our study, in which financial performance measures are not available. Moreover, business failure is a strong sign of financial problems, particularly in commercial contexts in which business divestiture offers a means of exiting successful businesses that owners no longer wish to continue whether as single-business corporations or as units of multi-business corporations.

**Duration of Buyer-Supplier Relationships and Supplier Performance**

We begin our discussion of network structure with a discussion of relationship duration. Long-term vertical relationships are common in any context in which small numbers of buyers and suppliers exchange products or services that are complex or involve sensitive delivery systems. Examples include railroad transportation (Macaulay 1963), aerospace (Masten 1984), financial auditing (Levinthal and Fichman 1988), advertising services (Baker, Faulkner et al. 1998), the automotive industry (Cusumano and Takeishi 1991), advanced materials (Ahuja
1997), and apparel manufacturing (Uzzi 1997). Long-term inter-firm supply relationships provide an alternative to the simple make-or-buy choice in which firms locate transaction-specific assets internally and govern general assets through short-term contracts (Williamson 1975). Even for components that require transaction-specific investment, long-term relationships with suppliers are often superior to internal sourcing when suppliers can produce higher-quality or lower-cost goods than an internal operation (Nishiguchi 1994). Long-term supply relationships tend to be superior to short-term relationships when products are complex, technology is changing, there are complicated interactions among components, information transfer is difficult and uncertain, or when a trading relationship requires specialized human skills (Monteverde and Teece 1982; Helper 1987; Lyons, Krachtenberg et al. 1990; Masten, Meehan et al. 1991).

The benefits of long-term supply relationships arise from three related sources, the development of knowledge of each partner, the development of trust, and the development of relationship-specific routines. We will first discuss the implications of these three benefits. We will then turn to addressing their limits and the implications that the limits may have for negative implications of long-term relationships.

The first benefit of long term relationships is they can lead to greater knowledge of each partner's routines as collaborative processes lead to interaction of people from the partner firms (Ring and Van de Ven 1994). This knowledge can serve as the basis for coordinating joint activities and for reacting to changing circumstances that the partners face in common by developing joint problem-solving arrangements (Fichman and Levinthal 1991; Kumar and Nti 1998; Larson, 1998 #1050]. As a result, firms' ability to reduce costs, increase quality, and achieve greater timeliness may increase as a relationship lengthens by learning from each other and about each other (Kogut and Zander 1992; Dussauge, Garrette et al. 2000). In turn, these operating advantages may lead to superior performance relative to firms that do not enjoy long term relationships.

Second, long-term relationships can lead to the development of trust. Trust in a supplier relationship includes both interpersonal trust between individuals who span the organizational boundary and interorganizational trust (Zaheer, McEvily et al. 1998). Long-term patterns of interaction between individual boundary-spanners allow role definitions and organizational structures and routines to become institutionalized. As new individuals enter the boundary-
spanning role, they are socialized into this institutionalized society. After sufficient time has passed for the institutionalizing process to take hold, trust between the organizations may then be more enduring than trust between individual boundary-spanners who come and go. Zaheer, McEvily and Perrone (1998) found that high levels of inter-organizational trust correlated with lower costs of negotiation and with superior performance for the exchange partners. They speculate that this is due to “transaction value” (Zajac and Olsen (1993), cooperation that goes beyond the efficiencies of eased negotiation. Similarly, in his examination of relationships among firms in the New York apparel industry, Uzzi (1996) found that relationships embedded in an ongoing social structure exhibited a high-degree of trust between participants. Trust allows firms to engage in cooperative activities that would be difficult to manage purely by contractual relationships (Cusumano 1985). Trust-enabled buyer-supplier cooperation includes shifting product development activity to the supplier and the exchange of technical and marketing personnel (Hayes and Wheelwright 1984; Womack, Jones et al. 1990; Clark and Fujimoto 1991).

Third, the act of interacting over a long period of time generates relation-specific routines. Each firm develops internal routines that are especially suited for interacting with the specific partner (Levinthal and Fichman 1988; Asanuma 1989; Martin 1996). Firms also develop beneficial routines that span the partner organizations (Nelson and Winter 1982; Mitchell and Singh 1996). Examples of such routines include just-in-time delivery systems, systems for exchanging information and personnel, and cooperation in product development, which require learning and investment on the part of both buyer and supplier (Clark and Fujimoto 1991). These routines allow the firms to gain further cost, quality, and timeliness advantages that in turn lead to superior performance.

The benefits of partner knowledge, trust, and relation-specific skills relate closely to each other. Greater knowledge of each other's capabilities facilitates the development of relation-specific routines, particularly as firms come to trust each other's intent. In parallel, to the extent that trust reduces transactional difficulties by reducing concerns about opportunistic behaviour, trust makes firms more willing to transfer fine-grained and tacit information which in turn leads to the creation of more fine-grained relation-specific routines. In a real sense, the growth of trust helps provide the assurance that firms need in order to use the knowledge that they gain of each other to create relation-specific routines that are potentially valuable but also create inter-firm dependence. Thus, the benefits of trust, knowledge, and inter-firm routines tend to inter-twine.
Because of the joint advantages of relationship-specific routines, trust, and knowledge, long-term relationships may generate performance advantages for their members. Dyer (1996) found a positive relationship between supplier-automaker specialization and performance in a study of U.S. and Japanese automakers and their suppliers. Interfirm human asset cospecialization was positively correlated with both quality and new model cycle time, while site specialization was positively associated with lower inventory costs. In a study of 136 industrial buyers and suppliers, Heide and Miner (1992) found that buyer-supplier cooperation increased both with future anticipated interaction and with higher frequency of contact in the existing relationships. The benefits derived from long-term relationships often generate a sustainable competitive advantage for suppliers, since creating a long-term buyer-supplier relationship, by definition, requires time and, moreover, can often be a difficult process (Eccles 1981; Heide and John 1990). Therefore, we expect supplier firms that have long-term relationships with their buyers will enjoy enhanced survival prospects.

**Hypothesis 1a.** The longer the duration of the relationship between a supplier firm and its assembler buyers, the less likely the supplier will fail.

A conceptual question arises with respect to the measurement of relationship duration, concerning whether the benefits of duration arise from a supplier's oldest existing relationship or from its pool of existing relationships. Operationally, the issue is whether maximum duration or mean duration is the appropriate measure of relationship duration. We view maximum duration as an appropriate measure of relationship benefits, particularly when one employs dissolution as the measure of performance. In this approach, a supplier derives benefits from its longest-standing partner, which provide a sales basis with which to protect itself from fluctuations and to attract new customers. Therefore, we will test the first hypothesis in terms of the maximum duration of a supplier's relationships with its customers. In sensitivity analysis, we will investigate the mean duration of a supplier's relationships, in which the benefits of relationships accumulate across partners. A conceptual issue arises with the mean duration measure, though, because this measure arithmetically penalizes suppliers that add new customers and thereby reduces the arithmetic mean duration of their relationships, such that suppliers that often add customers would have moderate mean duration rather than very high mean duration. Although further conceptual exploration of these issues would be valuable, data limits constrain us here to the comparison of maximum and mean duration.
In order to explore the causal logic of the relationship duration prediction, it is useful to consider a contingency that derives from the nature of the products that a supplier sells. We will distinguish between architectural components and modular components (Henderson and Clark, 1990). Architectural components are specialized goods that require substantial customization to fit within a customer's overall product and, indeed, may require refinement of the customer's product to adapt to changes in component technology. By contrast, modular components are more general goods that require little refinement to either component or end-product. To foreshadow our empirical analysis, we use carburetors as examples of architectural goods during our study period, because carburetor design and production required customization to and of automobile ignition systems, fuel systems, power train, and other automobile characteristics. We use clutches as examples of modular components because, by about 1920, the relatively simple single-plate clutch had become the dominant choice of most automobile manufacturers and required little customization for specific customer models.

The key point here is that the benefits of long-term relationships will tend to be greater for architectural components than for modular components. Architectural components tend to require relationship-specific investments and understandings, for which the benefits of coordination, trust, and relation-specific routines will often arise. By contrast, modular components will tend to require more general investments and understandings that are more transparent and give rise to fewer benefits from coordination, trust, and relation-specific routines.

**Hypothesis 1b.** The benefits of long-term relationships will be greater for suppliers of architectural components than for suppliers of modular components.

In addition to the benefits of long-term relationships, prior research suggests that long-term relationships may create problems for firms, owing to both opportunistic behaviour and adjustment rigidity. We address this issue in the next section, in a more general discussion of the concept of supplier autonomy.

**Supplier Autonomy and Performance**

We continue our discussion of network structure by considering supplier autonomy. We begin with a general discussion of dependence. We then develop a specific form of the structural autonomy concept, drawn from Burt's (1992) work, that views autonomy in terms of constraint and opportunity. In our approach, we will distinguish between actual and potential constraint and actual and potential opportunity.
Dependence

It is commonly recognized that suppliers that become dependent on their buyers often face performance problems. Some such problems may stem from opportunistic behaviour by partners. Williamson (1993) notes that firms in long-term relationships can face hold-up problems in partner behaviour if they do not have alternative partners. In addition, coordination problems may arise because firms become dependent on a partner's routines, but their partner lacks adequate understanding of how they need to use the routines. Singh and Mitchell (1996) found that firms commonly faced adaptation difficulties if they became too reliant on partners. Moreover, firms may come to rely on out-moded inter-firm routines in long term relationships, thereby missing innovations that take place outside a partnership. Uzzi (1996) found that if a firm became over-embedded in a network, the lack of arms-length relationships would isolate it from the market’s imperatives and increase its likelihood of failure.

The second element of network structure, then, is the degree of autonomy that a supplier enjoys in its relationships with buyers, where autonomy is the converse of dependence. We begin with a general discussion of supplier autonomy and next describe a measure of structural autonomy that includes both opportunity for independent action and constraint on independence.

Supplier autonomy is the degree to which a supplier can act independently of its buyers. Consistent with common usage, we will refer to dependence as the power of a buyer over its suppliers. As we discuss below, a buyer's power over a buyer incorporates both the potential for a buyer to act opportunistically with respect to a supplier and the potential that a buyer may lack knowledge needed to coordinate inter-firm activities effectively. Emerson (1962) defines the power of firm A over firm B as the difference of A’s dependence on B and B’s dependence on A.

While there are advantages to a supplier becoming tightly bound to an assembler, dependence is likely to give the assembler significant power over the supplier, because most of the supplier’s efforts are involved in its relationship with the assembler. The supplier is dependent for the bulk of its sales on that assembler. Therefore, the assembler may use its power to extract rents from the supplier, limit the ability of the supplier to sell goods to other buyers, or otherwise disadvantage the supplier (Baker 1990; Cusumano and Takeishi 1991, Caves, 1976 #439). While negative effects of buyer power may arise from buyer opportunism, harm can also result from difficulties that arise if the buyer lacks knowledge of a supplier's routines needed to coordinate inter-firm activities effectively. Such negative influences of buyer power are compatible with the
positive cooperative activities associated with tight-linkages. Many relationships have both competitive and symbiotic elements (Pfeffer and Salancik 1978).

We note here that the opportunism and coordination elements of power do not separate neatly. Indeed, in a relatively simple world in which firms can make most decisions discretely, such that sets of decisions and transactions do not aggregate into only partially-understood routine patterns of activities, opportunism and coordination tend to converge to the same influence, as a fully altruistic buyer would ensure that it maintained sufficient knowledge of supplier needs to be able to provide appropriate coordination for discrete choices. In a more complex world of inter-related decisions, however, especially in a world of changing personnel, technology, and competitive conditions, even the most well-intentioned buyer may lose sight of its suppliers' capabilities as staff and objectives change. In this routine-based view of firms, there will tend be differential understanding of intra-firm patterns of activities, especially if there is greater control and retention of staff responsibilities within firms than across firm boundaries. To the extent that even altruistic managers, should they exist, require an understanding of each partner's routines to coordinate their behaviour, then problems can result if partners do not gain a needed understanding or lose a prior understanding.

Because of the risks of dependence, firms often seek to minimize their dependence on outside organizations. The most effective strategy for dealing with dependence driven by reliance on a single market may be to alter the organization’s purposes and structure so that it no longer serves only a few markets (Pfeffer and Salancik 1978). A supplier can diversify its customer base either within its current markets or by seeking out entirely new markets. Pfeffer and Salancik (1978) document the latter strategy among Israeli manufacturing companies, which sought out new customers predominantly in markets into which they did not already sell heavily. Diversification reduces dependence on a given buyer. But, diversification also reduces how closely the firm can coordinate its activities with any given customer, diminishing the advantages that come with such relationships.

Even within a close relationship, however, the supplier is not necessarily in a weak power position vis-à-vis the buyer. Although a tightly-coupled supplier is more dependent on its buyer’s business, if the buyer also becomes dependent on that supplier, the dependencies may balance each other. Following Emerson (1962), such balance creates a more even power relationship. Bilateral dependence would exist if the buyer had no alternative sources for the components that
the supplier provides or if complex routines had developed that spanned the boundaries of the two firms, making the assembler unable to easily replace the supplier (Baker 1990:594-595; Singh and Mitchell 1996). Thus, characteristics of the buyer and the supplier, their dyadic relationship, and the set of relationships throughout the entire network influence the distribution of power in each buyer-supplier relationship.

**Structural autonomy: Constraint and opportunity**

Burt’s (1992) concept of structural autonomy provides an indicator of a supplier’s relative competitive position in a network, built upon formal measures of the alternatives available to each party in each of a focal firm’s transactions. In Burt’s (1992) formulation, the structural autonomy of an actor is a function of two elements, constraint and opportunity. In simplified form, the autonomy measure for any firm \(i\) \((A_i)\) is a multiplicative function such that: \(A_i = C_i \times O_i\). We will discuss the general concepts of constraint \((C_i)\) and opportunity \((O_i)\) in this section of the paper, and will describe the operationalization of the concepts in the methods section.

Constraint \((C_i)\) is a measure of how severely an actor’s network of relationships constrains its actions, Burt (1983) used the concept of constraint to account for the extent to which the absence of alternatives affects dependence. The more constrained one actor is, the more another actor's actions, or inactions, impose limits on its performance (Mizruchi 1992). Constraint is an aggregate measure of the investment an actor has made in its relationship with a buyer and the alternatives available to the supplier (Burt 1992). In the commercial setting, the investment a supplier has made in its relationship to a buyer is equal to the proportion of the supplier’s business that comes from that buyer.

Burt's (1992) formulation of constraint has two elements, which we refer to as actual constraint and potential constraint. Actual constraint derives from a supplier's existing relationships with buyers, while potential constraint derives from the presence of potential buyers to which a supplier might sell its goods. Actual constraint is lowest when a supplier has relationships with many buyers, while potential constraint is lowest when there are many other potential buyers. Thus, total constraint is highest when a supplier is exclusively committed to a single buyer and has no other potential buyers. Such a captive supplier in a monopoly market has invested all its attention into that one buyer, making it highly constrained. By contrast, a supplier that sells to a single buyer in a market that is rich with potential buyers is less constrained than a
captive supplier in a market with few alternative buyers, so long as the supplier's goods are viable candidates for sale to the other customers.

Buyer opportunity ($O_i$) is the other component of structural autonomy, complementing supplier constraint. Buyer opportunity is a measure of the alternative partnership opportunities that are available to the focal actor’s exchange partners. In the buyer-supplier setting, how easily could a supplier’s buyers replace it? As in the case of supplier constraint, buyer opportunity arises as both actual and potential opportunity, where actual opportunity derives from a buyer's existing suppliers and potential opportunity derives from other existing suppliers of similar goods. Having many current suppliers, that is, actual buyer opportunity, makes any individual supplier more dispensable to a buyer, all else being equal, thus improving the buyer’s bargaining position. Baker, Faulkner, and Fisher (1998) found that clients that spread their business across a greater number of advertising agencies were more likely to dissolve any one of these ties. The presence of a large number of potential suppliers, that is, potential buyer opportunity, also may provide a buyer with alternative sourcing opportunities.

Combining constraint and opportunity within the concept of structural autonomy provides a rigorous restatement and combination of Emerson’s (1962) and Pfeffer and Salancik’s (1978) logic. A supplier has the greatest autonomy when it has many current buyers, each highly dependent on it, and many potential buyers. A supplier has the lowest autonomy when it has only one buyer, that buyer has many alternative suppliers, and there are no other potential buyers. The degree to which a buyer gains power over a tightly-bound supplier depends critically on the degree to which the buyer is tightly-bound to the supplier. Even in a monopsony situation, the degree of the buyer’s dependence on the supplier bounds the buyer’s ability to extract rents from the supplier.

We predict that higher autonomy will improve a supplier’s probability of survival. Higher autonomy captures two effects. First, higher autonomy provides greater ability to negotiate favorable terms from exchange partners and avoid demands from them (Burt 1992). Second, autonomy is an aggregate measure of a supplier’s dispensability in the eyes of its buyers and the importance of any single buyer to that supplier. Therefore, any given buyer is less likely to terminate purchases from the supplier, while, moreover, the supplier will be less affected if a buyer does exit the relationship.
Hypothesis 2a. The higher the structural autonomy of a supplier firm, the less likely the supplier will fail.

We will further distinguish between the influence of actual autonomy and potential autonomy. Actual autonomy focuses on the relationship between actual supplier constraint and actual buyer opportunity. In turn, potential autonomy focuses on the relationship between potential supplier constraint and potential buyer opportunity. To foreshadow our analysis, we will divide the number of assemblers to which a buyer sells components by the average number of suppliers from which the buyers purchase similar components to create the measure of actual autonomy. Similarly, we use divide the number of other assemblers divided by the number of other suppliers as the measure of potential autonomy.

The distinction between actual and potential autonomy becomes important when we consider the product-type contingency of architectural and modular components that we introduced in the prior section.

We expect potential autonomy to arise as an influence primarily for suppliers of modular components. Architectural components tend to face a high need for relation-specific coordination (Monteverde and Teece 1982; Podolny 1994; Weiss and Kurland 1997). In such cases, potential autonomy will tend to have lower influence, because buyers and suppliers cannot easily switch partners, even if there are many other seemingly potential suppliers and customers in the industry. By contrast, modular components incur lesser requirements for relation-specific coordination and, as a result, buyers and suppliers can switch partners more easily. Consequently, greater availability of potential partners offers greater easing of opportunism and coordination problems should they arise in a relationship.

Hypothesis 2b. Potential structural autonomy will have more influence on the failure rates of suppliers of modular components than of architectural components.

We leave investigation of whether actual autonomy has differential impact on architectural and modular component suppliers as an exploratory issue. It is possible that actual autonomy will have greatest influence on architectural suppliers, owing to the high need for relation-specific routines. Alternatively, though, actual autonomy may well provide benefits for all suppliers, by providing greater sales opportunities and by being able to resist the demands of a small number of customers.

A second contingency also arises here, concerning the degree to which demand conditions will moderate the influence of autonomy on supplier performance. We expect the
value of supplier autonomy to be particularly pronounced during periods of low end-product demand.

As we noted above, research on buyer-supplier networks has identified positive interdependence between buyer and supplier firms, arising from the firms’ possession of complementary sets of resources. Positive interdependence in organizational communities often leads to the emergence of collective strategies, especially under conditions of resource scarcity (Laumann, Galaskiewicz et al. 1978:461-462). Strategies are collective when the interests of other firms in the community are taken into account as part of each firm’s decisions. Collective strategies may arise through conscious planning and coordination by a central firm (Lamming 1990) or emerge through repetitive patterns of interorganizational activity (Dollinger 1990: 269).

From the organizational community perspective, the existence of a collective strategy means that the actions of any single firm are constrained by the network structure made up of all links within the network. Assemblers vary in the degree to which they create networks that are tightly coupled. During the past two decades, for instance, a general trend toward supplier rationalization, especially among U.S. assemblers, has greatly increased the strength of ties between buyers and suppliers as many suppliers have virtually become captive to their buyers. Tight coupling between suppliers and buyers allow for the development of strong firm-specific interorganizational experience that may confer competitive advantages on suppliers (Lamming 1990), but also creates constraints on adaptation. Following Simon (1962) and Weick (1979:185-187), Aldrich and Whetten (1981: 388) (1981: 388) argue that organizations embedded in tightly-coupled networks find it difficult to adapt to environmental changes affecting any single member of the network (see also Aldrich 1979: 325-327). The deleterious impact of external shocks diffuses rapidly through tightly coupled networks where individual firms are constrained in attempts at local adaptation. The key actor in tightly coupled vertical groups of firms in the automobile industry is the assembler and supplier performance is highly susceptible to performance swings at the assembler level. Adverse environmental conditions such as industry downturns are more likely to force suppliers out of the market if they are tightly coupled to buyer firms. Conversely, suppliers with high structural autonomy, embedded in loosely coupled networks, have an additional survival advantage over suppliers with low structural autonomy when faced with adverse environmental conditions. Put most simply, suppliers with greater
autonomy will have more opportunities to maintain sales levels during difficult demand periods in an industry.

**Hypothesis 3.** Under adverse demand conditions, suppliers with higher autonomy will experience lower failure rates than suppliers with lower autonomy.

**Supplier Status and Performance**

We now turn to status, which is the third element of network structure that we consider. Status, the degree to which a firm is viewed as an important firm in an industry, may provide economic benefits to a firm (DiMaggio and Powell 1983; Podolny 1993). An important source of status is a firm’s network of affiliations. If a firm is affiliated with organizations that possess legitimacy or status, the firm may derive legitimacy or status from that affiliation (Podolny and Page 1998). Therefore, it is not only the number of partners in a firm’s network, but also the identity of these partners that determines the value of the network to the firm. Because of this, firms may actively seek out high-status partners. For example, Han (1994) argued that firms seek out the services of high-status auditors because of the impact of this affiliation on their own status. Multiple studies have found benefits to this strategy. Baum and Oliver (1991; 1992) found that daycare centers with links to legitimate organizations such as churches were more likely to survive. Stuart, Hoang, and Hybels (1999) found that ties to prominent alliance partners benefited private biotechnology firms by reducing the time until a start-up goes public and the market value of the firm upon going public. Furthermore, they show that much of this benefit is due to the transfer of status through the affiliation, rather than the flow of resources from the partner firm. In a study of investment banks’ activities in the non-investment grade market, Podolny and Phillips (1996) find that the higher the status of a bank’s affiliates, the greater the bank’s growth in status itself.

Affiliations provide legitimacy by providing information, which helps resolve doubts about the quality of a firm. Third parties often trust the ability of prominent organizations to judge the quality of their partners (Stuart 1998). Because of this combination of the prominent organization’s incentives and perceived good judgment, affiliation with a prominent organization provides a strong signal to third parties about the firm’s quality.

In the context of a buyer-supplier network, legitimacy that arises from high-status buyers provides at least two benefits. First, legitimacy improves the supplier firm’s chances of attracting and retaining customers. When buyers have incomplete information about the relative technical
sophistication, reliability, and quality of potential suppliers, they will often look for such secondary indicators of supplier characteristics (Podolny 1993:831). The tendency of buyer firms to imitate the behavior of competitors further accentuates status effects (Haveman 1993; Mezias and Lant 1994; Miner and Haunschild 1995). Such status effects are especially likely in highly uncertain environments (Spender 1989). In such environments, firms are especially likely to imitate the supplier selection strategies of successful high-status buyers (DiMaggio and Powell 1983). Empirically, Walker, Kogut, and Shan (1997) found that biotechnology firms with higher status were likely to have more relationships with new partners in the subsequent time period (see also Powell, Koput et al. 1996). Baker, Faulkner, and Fisher (1998) found that advertising agencies with high social status were more likely to maintain links with clients.

Second, increased status via the implicit endorsement of a prominent buyer provides improved access to financial resources by legitimizing the firm in the eyes of potential investors and lenders. This endorsement could be vital in times of fiscal distress (Baum and Oliver 1991). Similarly, Singh, Tucker, and House (1986) found that the legitimacy provided by external linkages played a more important role in improving the survival prospects of new voluntary service organizations than did internal coordination.

Both of these advantages of status require that the signal generated by the affiliation disseminate among potential buyers, investors, and lenders. Industry participants, the business press, and analysts are more likely to notice the actions of prominent buyers. Therefore, the signal generated by affiliation with a prominent buyer is valuable not only because it is a strong endorsement, but because it is likely to be widely disseminated (Stuart, Hoang et al. 1999). Therefore, we hypothesize that selling to a high-status customer will improve a supplier's survival chances.

**Hypothesis 4a.** The higher the status of a supplier’s highest status customer, the less likely the supplier will fail.

We phrase the prediction in terms of a supplier’s highest status buyer. Our conceptual reason is that the highest status customer will be the focus of other firms' search for information about a supplier's capabilities. The fact that a highly respected customer has chosen a firm to supply components will act as a strong signal of that suppliers' skills and, in turn, will attract more customers, possibly including both high status and lower status customers. Thus, taking
alternative approaches to conceptualizing status, such as focusing on mean status of a supplier's customers, would inappropriately reduce the impact of having a high status customer.

Moreover, we do not expect that having low status customers will be damaging for supplier firms. In some social situations, a prominent organization would place its own status at risk if it affiliated a low-quality partner, so that prominent organizations have strong incentives to be cautious in their selection of partners (Podolny 1994; Podolny and Phillips 1996; Stuart, Hoang et al. 1999). This dynamic is unlikely to affect the buyer in the buyer-supplier relationship. Having a high-status customer provides legitimacy to the supplier for the reasons discussed above. The fact that the supplier also sells its goods to lower-status customers does not detract from this endorsement.

As in the prior two sections, we will use the distinction between architectural and modular components to illustrate the causal logic of the status prediction. The value of customer status derives from ambiguity about assessing supplier capabilities before entering into a relationship. Such ambiguity will tend to be much stronger for architectural components than for modular components. Because architectural components and the end-products that use them require substantial refinement in a specific buyer-supplier relationship, potential buyers will incur difficulties in evaluating how well a potential supplier would fit their needs. This ambiguity gives rise to the value of using a high status firm's judgement as a signal of supplier quality. By contrast, potential buyers of modular components can assess a potential supplier more easily before entering into a relationship and will have less need to rely on the judgment of high-status firms.

**Hypothesis 4b.** The status of a supplier’s highest status customer will have more influence on the failure of suppliers of architectural components than for suppliers of modular components.

In summary, the predictions address three elements of the structure of buyer-supplier networks that we expect to influence supplier survival. We expect failure rates to decline as the duration of buyer relationships increases, particularly for suppliers of architectural components. We expect failure rates to decline with greater structural autonomy, with potential autonomy having affecting only suppliers of modular components. Moreover, we expect the benefits of autonomy to be particularly pronounced during periods of adverse demand. Finally, we expect failure rates to decline with customer status, again particularly for suppliers of architectural components. For architectural suppliers, then, survival chances increase with relationship
duration, actual structural autonomy, and customer status. For modular suppliers, meanwhile, survival chances increase with potential autonomy as well as with, possibly, actual autonomy. Together, these predictions describe a set of influences in which potential benefits typically often co-exist with possible negative side-effects unless a supplier can both maintain tight linkages with existing customers while also creating new linkages that provide concurrent autonomy. While some suppliers may be able to develop this balanced network evolution for many years, others will quickly falter and fail. The predictions help demonstrate why firms that face substantial bounds in their ability to adjust firm-specific routines and inter-firm routines will often struggle, despite the best efforts of their managers.

BUYER-SUPPLIER RELATIONSHIPS IN THE AUTOMOTIVE INDUSTRY

We now briefly describe the empirical context of our study, the U.S. automotive supplier and buyer industries between the early part of the 20th century and the 1970s. The automotive sector is especially suited to studying the hypotheses we developed above. Automotive assemblers and their suppliers are structured as networks of vertically related communities (Fombrun 1988), in which positive interdependence and constraints on independence arise commonly. Substantial changes in supplier autonomy and customer status occurred during our study period, with direct implications for supplier performance.

During our study period, overall production of automobiles increased dramatically, but the number of assemblers and suppliers declined precipitously (Carroll and Teo 1996), providing an intriguing study setting in a highly dynamic industry. In 1918, manufacturers built 943,436 automobiles in the United States. In 1972, they produced over 8.5 million. Over the same period, there were dramatic changes in the populations of buyers and suppliers. There were 71 assemblers in 1918 (Seltzer 1928:65). The number of assemblers grew to a 1921 peak of 88 firms before falling by 50% within a five year period, to only 44 firms in 1926 (Seltzer 1928:65). The number of auto assemblers then fell to four by 1972. Over the same period, the number of firms supplying components directly to the automobile manufactures changed dramatically. Overall, there were 764 component manufacturers in 1914. This number increased to 2,123 in 1919, and fell to 936 by 1939 (Katz 1977:270). Changes in the assembler population, as well as the relationship between the assembler and supplier population influenced both the high overall mortality of suppliers and the survival of individual suppliers. The effects of these changes
provide a useful qualitative illustration of how autonomy and status have influenced supplier performance. The level of supplier autonomy changed drastically during the period. Early in the industry’s history, suppliers held the upper hand. Prior to 1909, auto assemblers relied on suppliers who had experience in the manufacture of carriages and bicycles and provided much of the automobile design expertise. An indicator of the importance of suppliers is that Ford depended almost entirely on independent suppliers before 1914 (Helper 1991). There were many assemblers, with frequent entry and exit resulting in the continued presence of small, inexperienced assemblers. In some cases, the suppliers also provided funding for assemblers (Kennedy 1941:62). With a wide range of available buyers and possessing the critical resources of design expertise and financial capital, suppliers possessed high autonomy.

By 1920, however, changes began to occur which dramatically curtailed the autonomy of suppliers. Over the decade of the 1920s, major assemblers developed much of the technical expertise that had previously resided with suppliers (Hochfelder and Helper 1996). This trend reduced assembler dependence on suppliers and allowed leading assemblers, which now held much of the technical expertise, to shift among suppliers and cause the dissolution of suppliers that lost business. Also during the 1920s, product and process innovation became progressively less important in the auto assembly sector, with greater emphasis being placed on costs (Langlois and Robertson 1989). As costs became a greater issue, it became more important to use specialized technology for parts production. This trend had two results. First, assemblers that were financially and managerial capable of doing so vertically integrated into many of the functions that suppliers had previously carried out (Seltzer 1928; Hochfelder and Helper 1996). Nonetheless, in order to maintain flexibility in the face of demand changes, near-total integration was rare (Katz 1977:266), leaving a substantial continuing role for suppliers. Second, though, the larger assemblers were also able to force their suppliers to make investments in specialized equipment and techniques. Suppliers that did not make such investments had higher costs (Helper 1991), lost the business of the large assemblers, and risked going out of business.

These trends reduced the autonomy of suppliers. The drastic reduction in the number of assemblers during the 1920s reduced the number of potential buyers, even though total automobile production was increasing. Suppliers that made extensive relationship-specific investments became almost entirely dependent on those relationships with assemblers. Suppliers
that did not make these investments became dependent on the purchases of the small assemblers for their survival. With parts production activity being absorbed by the major assemblers, it became harder for suppliers to achieve a minimum efficient scale of operation (Hochfelder and Helper 1996), increasing their dependence on each buyer.

Predictably, the balance of power shifted dramatically from the suppliers to the assemblers as the number of assemblers declined and their technical sophistication increased. Major assemblers had a high rate of return, while many suppliers had low profitability (Helper 1991). The difference was partially due to the ability of major assemblers to demand that suppliers provide detailed cost of manufacturing information. As a result, the major assemblers were able to expropriate many of the benefits of cost reductions. Furthermore, the assemblers were able to insist that their suppliers share their technical developments with competitors that also served the assembler (Helper 1991; Hochfelder and Helper 1996).

Dramatic changes in the mix of assembler size that occurred between 1914 and 1972 also influenced supplier autonomy. Initially, there was at least a moderate degree of assembler variety. By 1916, Ford and General Motors were already the largest assemblers, but seven other firms, including Dodge and Packard, were recognized as middle-tier independents, making profits of about one-quarter General Motors’ profits (Kennedy 1941:90). In 1919, Ford, GM and the seven middle-tier independents produced approximately 1,500,000 cars, about seventy-five percent of total production in the United States. Ford and GM still dominated, making 750,000 and 391,000 cars respectively, but the middle-tier independents were still substantial contributors, ranging from Dodge’s 124,000 production to Packard’s 12,397 (Kennedy 1941:105). By 1923, the top thirteen companies produced ninety-five percent of total U.S. production (Kennedy 1941:159). Fifty-seven companies vied for the remaining five percent (Seltzer 1928:65). This degree of concentration continued throughout the 1920s but then became somewhat more concentrated during the Great Depression. By 1938, the Big Three of Ford, General Motors, and Chrysler, which had acquired Dodge, led the industry. These three firms produced almost ninety percent of U.S. production (United States Federal Trade Commission 1939:27). The middle-tier independents had been winnowed to five (Kennedy 1941:307), which had about ten percent of total production. The lowest-tier assemblers produced only two percent of total U.S. production (United States Federal Trade Commission 1939:27).
After the war, there was a temporary surge of success for the remaining independents, due partially to difficult labor negotiations at the Big Three and partially to pent-up demand from the war years (Katz 1977:421). Six middle-tier independents, including Studebaker and Willys, increased their share of the market to fifteen percent by 1949, while several other small lower-tier companies, such as Crosley, continued to operate. The 1950s, though, saw the number of independents reduced to two firms, American Motors and Studebaker-Packard, through exit and merger. Studebaker-Packard then failed in 1963, leaving American as the only independent operating in 1972 (Katz 1977:422).

In summary, the assembler population was a relatively undifferentiated pool of firms early in the history of the auto industry. Over the 1920s, the industry moved to having an upper-tier of firms, a smaller middle-tier that was within an order of magnitude of the upper-tier firms, and a lower-tier that became progressively smaller and weaker. With the exception of the immediate post-War period, the general pattern was the continuing withering away of the lower-tier firms and an increasing distance between the upper-tier and middle-tier assemblers. This decline in the number of potential buyers reduced supplier autonomy significantly.

The changed mix of assembler size also increased the importance for suppliers of selling components to large, high-status buyers. Early in the industry’s history, there were many assemblers that could provide the economic benefits and status advantages of a large buyer. Even in the 1920s, a supplier could gain substantial sales and establish legitimacy through supplying a firm such as Studebaker, even if the supplier was unable to sell to Ford, Chrysler, or GM. By the 1930s, this was increasingly less viable. There were fewer major independents, each of which fell farther and farther short of the Big Three. The lower tier provided very little demand or status. As the smaller firms exited and were not replaced by new entrants, it became necessary to be able to supply at least the middle-tier companies. Then, by the post-War period, even the middle-tier of assemblers did not provide the opportunity for a reasonable level of aggregate sales. In order to establish scale efficiencies and status, it was almost a requirement that a supplier supply at least one of the Big Three buyers.

These changes in the assembler population had predictable effects on the mortality of suppliers. With their autonomy reduced and fewer opportunities to establish legitimacy, mortality among suppliers was high. For example, in 1918, there were 18 carburetor suppliers. In 1931, there were only 8. In 1971, there were only 2 independent carburetor suppliers.
Two examples illustrate the importance of these changes. Rayfield was an early entrant in the carburetor field. In 1918, Rayfield supplied twenty-two auto assemblers, often supplying multiple models to individual buyers. Of those twenty-two buyers, none was a Big Three assembler and only one buyer, REO, was a middle-tier firm. By 1924, Rayfield was down to nine buyers. Many of its 1918 buyers had failed and Rayfield lacked the status of ties with a leading buyer to gain more substantial buyers. In 1926, Rayfield was down to five buyers. Moreover, its middle-tier customer REO had switched to Schebler as a carburetor supplier, leaving Rayfield with only lower-tier buyers as customers. In 1926, Rayfield had only one buyer, McFarlan. When McFarlan switched to Schebler as a supplier, imitating the behavior of the more prominent manufacturer REO, Rayfield shut down.

Tillotson, another early carburetor supplier, is the second example. Tillotson was somewhat more successful than Rayfield but also eventually failed. Tillotson also supplied primarily lower-tier companies, with one middle-tier buyer, Willys. Despite having no upper-tier buyers, Tillotson was able to survive until World War Two, but lacked the resources and status to gain additional middle-tier buyers, much less gain one of the Big Three as a buyer. Willys did not return to production of passenger automobiles after the War, leaving Tillotson totally dependent on the minor third-tier assembler, Crosley. With severely limited status and autonomy, Tillotson ceased being a carburetor producer in 1951, one year before Crosley itself failed.

DATA AND METHODS

Data

We studied the survival of U.S. suppliers of carburetors and clutches in the automotive industry. We chose these components because they represent important inputs into the automobile production process, there is substantial diversity of firms within these populations of component manufacturers, the cases provide appropriate opportunities to compare architectural and modular components, and data was consistently available for them. Our primary data are drawn from the annual Statistics and Specifications issue of Automotive Industries, which was produced from 1918 to 1972. Automotive Industries identifies the firms that sold components directly to assemblers, which the industry commonly refers to as first-tier suppliers, listed by automobile model. Since Automotive Industries provided specifications at the level of the division or model without listing the overarching company, we used information from Baily
(1971), Smith (1968), Mandel (1982), Gunnell (1982) and Kimes (1989) to construct life histories of assemblers and to connect divisions and models to the appropriate company. Using these data, we constructed the network of buyer-supplier relationships for carburetors and clutches for each year.

*Automotive Industries* professes to list every model of automobile produced in the United States. This allows us to overcome two common challenges in network studies, defining the boundaries of the network and gathering complete information on the relevant relationships. We can sharply define two populations, including all U.S. commercial assemblers of automobiles and all of their suppliers for these components. We also gathered a complete inventory of the buyer-supplier relationships for these components.

We gathered information on the performance and life history of individual suppliers from several sources, including annual reports, *Poor’s Industrial Manual, Moody’s Manual Of Industrial Securities, the Thomas Register of American Manufacturers, Ward’s Automotive Yearbook*, the trade press, corporate web sites and correspondence with suppliers. The *Statistics and Specifications* issue of *Automotive Industries* provides information on annual shipments for assemblers of at least medium size. We supplemented this with data from the *Automotive News 100-Year Almanac and 1996 Market Data Book* (1996). The *Statistics and Specifications* issue of *Automotive Industries* also lists total automotive industry shipments for each year.

For an understanding of the early automotive industry, we relied on both historical and contemporary studies including Epstein (1928), Seltzer (1928), Kennedy (1941), Lewis (1947), Rae (1959; 1965; 1984), Smith (1968), Katz (1977) and Carroll et al (1996). We gained additional insights on the development of buyer-supplier relationship in the auto industries from works including Fombrun (1988), Womack, Jones, and Roos (1990), Clark and Fujimoto (1991), Cusumano and Takeishi (1991) Helper (1991), and Hochfeld and Helper (1996).

**Methods and dependent variable**

We define supplier failure as business dissolution, that is, cases in which supplier firms shut down the component business. We estimate the instantaneous rate of supplier dissolution, denoted by \( r(t) \):

\[
\lim_{\Delta t \to 0} \frac{p_i(t, t + \Delta t)}{\Delta t}
\]

where \( p_i \) is the probability that a supplier fails between two discrete time points and \( t \) measures firm age. We used a piece-wise exponential model. The model is extremely flexible with respect
to the form of age dependence, about which we have no theoretical prediction. The model is also appropriate in the presence of left-censoring (Guo 1993), which is a feature of our sample. The model assumes a baseline transition rate that is constant within each of multiple time periods, but varies across periods.

The model we estimate can be written as: 

\[ r(t) = r(t)^* \exp(\alpha P_t + \beta S_t) \]

where \( r(t)^* \) is the baseline hazard rate, \( P_t \) is a matrix of variables measuring environmental conditions (time-varying, but invariant across suppliers), \( S_t \) is a matrix of time-changing variables describing the suppliers and \( \alpha \) and \( \beta \) are parameters to be estimated.

We used four time-periods in our estimation, dividing the data into firm ages of less than 5 years, 6-10 years, 11-15 years and greater than 15 years. Our results are robust to the selection of other cutoff points, as well as to the selection of other parametric forms of age dependence in the mortality rate including the Weibull, log-logistic, and log-normal specifications.

Our data are annual, so we update all time-changing covariates each year. We treated each annual spell as right-censored, except those spells that ended with the dissolution of the supplier. Given the small number of divestitures, we treated divestiture as a censoring event, rather than estimating a competing risks hazard model. Following Petersen (1991), we treated dissolutions as having occurred midway though the year to reduce potential estimation bias.

We estimated separate failure rate models for the two populations of carburetor and clutch suppliers. For carburetor suppliers in the years, there were 302 firm-year observations involving 37 separate carburetor suppliers between 1918 and 1972. Of these, 24 carburetor suppliers exited through dissolution and 11 exited through divestiture; as we noted above, we treated divestitures as right-censored cases. For clutch suppliers, there were 178 firm-year observations involving 32 separate clutch suppliers between 1918 and 1972. There were 24 clutch supplier dissolutions and 6 divestitures. These counts do not include assemblers that vertically integrated into production of the components. We took these assemblers into account in our calculations of structural autonomy, as described below, but did not include them in our estimation because the forces driving their involvement in component production differed from those of the independent suppliers. Figures 1 and 2 describe trends in density and dissolutions of carburetor and clutch suppliers respectively.

********** Figures 1 and 2 about here **********
Independent Variables

Table 1a and Table 1b provide descriptive statistics for the variables we used in this study.

********** Table 1a and Table 1b about here **********

Focal variables

To test our predictions, we needed variables for relationship duration, customer status, structural autonomy, and demand conditions. In addition, as we discussed earlier, we used carburetors as examples of architectural components and clutches as examples of modular components.

We measured the duration of a supplier’s relationship with an assembler as the cumulative years it had supplied the given component for at least one model produced by that assembler. We reset this count to zero if there was a span of greater than five consecutive years during which the supplier did not supply at least one model produced by that buyer. Rezeroing the count captures the effect of the decay of inter-firm routines. In the case of an acquisition by either a supplier or an assembler, we based our calculations on the acquiring firm, assuming its routines will dominate. We defined our focal variable as the duration of the longest relationship. For sensitivity analysis, we also defined a measure of the mean duration of a supplier's relationships.

For possible measures of customer status, we considered two approaches, with the first based on status categories and the second approach based on sales levels. The first approach relies on a generally-accepted recognition of three status categories within the automobile industry. The contemporary literature clearly indicates that there were three distinct groups of assemblers by 1918: (1) the major assemblers (Ford, General Motors and, following the acquisition of Dodge, Chrysler); (2) the so-called major independents (e.g., Hudson and Packard); and (3) minor independents (all others, e.g., Dort). We assigned each assembler to one of the three status categories based on the year-by-year commentary of Kennedy (1941), supplemented by Smith (1968) for later years. As a check, we compared these categorizations to the descriptions in the contemporary texts we listed above. The status categorization of assemblers changed slightly over time. Three assemblers spent several years straddling two categories. For example, in the mid-1930s, Graham hovered between being a major independent and falling into the ranks of minor independents. Our results were robust to moving these three
assemblers between the higher and lower of their possible status categories. For the second possible approach to determining customer status, we measured assembler status according to the percentage of total automotive sales for which it accounted each year. The contemporary literature clearly correlated firm sales with firm reputation. Also, firms with high sales were more prominently covered in the trade and general press. We found that the two measures of supplier status were highly correlated with each other.

For our analysis, we chose to use the categorization approach to measuring customer status. The status categories exhibit less year-to-year variation than the measure based on sales. Theoretically, we prefer the categorization measure, which Tables 1a and 1b summarize, because status effects will be less affected by yearly changes in the sales of a supplier’s largest customer than by the knowledge that a supplier sold components to a major assembler or only to minor independents. Empirically, our results are robust using either measure.

We set the status of a supplier equal to the status of the highest-status assembler to which it sold components. This provides a maximum status scale, with values from 1 to 3. For sensitivity analysis, we also defined status in terms of mean customer status and minimum customer status.

For our measures of structural autonomy, we draw on the work of Burt (1980; 1982; 1983; 1992). As we discussed earlier, supplier autonomy encompasses both how constrained a supplier is by its relationships with its customers and the opportunities buyers have to use suppliers other than the focal supplier (Burt 1992, chapter 2). A customer constrains a supplier more as its purchases represent a greater proportion of the supplier’s total sales (Burt 1980). Since we did not have information on each supplier’s sales to each assembler, we used the number of assemblers to which the supplier sold as our measure of constraint. For our measure of actual constraint, the greater the number of assemblers to which a supplier sold, the less constraint it faced. For our measure of potential constraint, the greater the number of assemblers to which a supplier did not sell, the less constraint it faced. For actual and potential buyer opportunity, we include the mean number of suppliers the focal supplier’s customers have (actual buyer opportunity) and the mean number of suppliers from which the focal supplier's customers do not buy components (potential buyer opportunity). We then combine the measures of supplier constraint and buyer opportunity to create measures of actual and potential structural autonomy, following Burt (1992).
Recall from the prior section that we defined autonomy as $A_i = O_i \times C_i$, where $C_i$ is a measure of supplier $i$’s constraint and $O_i$ is a measure of the opportunity supplier $i$’s customers have to use suppliers other than the focal supplier. For actual autonomy ($A_{Ai}$), we divide our measure of actual supplier constraint ($C_{Ai}$), the number of assemblers to which a supplier sold, by our actual buyer opportunity ($O_{Ai}$) measure, the average number of suppliers the focal supplier’s customers had (that is, we multiply opportunity by the inverse of the constraint term in Burt’s formulation). Similarly, we divide our potential constraint measure ($C_{Pi}$), by our potential opportunity measure ($O_{Pi}$) to obtain the measure of potential autonomy ($A_{Pi}$). Thus, a large number of actual or potential customers and a low average number of actual or potential suppliers for those customers both contribute to high autonomy.

We also defined a complementary measure of autonomy, based on customer vertical integration. An assembler can also generate greater opportunity to replace a supplier by vertically integrating production of the component in question. Therefore, we include the proportion of the focal supplier’s customers that are vertically integrated in the measure of autonomy. High values indicate greater buyer opportunity and lower supplier autonomy. We use the proportion of customers that are vertically integrated as a separate variable, which we expect to have a positive effect on the dissolution rate of suppliers.

Our measure of adverse demand conditions is based on trends in overall domestic automotive sales. We measured the proportion of recent years for which there was a year-on-year decline in total sales. We report results based on a three year window; our results are robust to windows of varying lengths.

**Control variables**

We defined control variables for customer production, supplier size, supplier age, and competitor density. The customer sales variable recorded the aggregate sales of all of a supplier’s customers in a given year. Ideally, we would also record supplier-specific sales to customers, but data about how many clutches or carburetors each supplier sold to each assembler in a given year are not available. However, it is reasonable to assume that, on average, suppliers that sold to large assemblers such as General Motors and Ford would have greater aggregate sales than suppliers that sold components to much smaller firms such as Dort and Geronimo.

We take our measure of supplier size from the *Thomas Register of American Manufacturers*. Suppliers in our sample range from size E (credit rating of $5,000-$9,999) to
AAAA (greater than $1,000,000). The variable, large supplier, takes a value of 1 if the supplier is classified in the category AAA or greater ($500,000 or greater), and a value of zero otherwise.

The variables for customer sales and supplier sales help differentiate between the benefits of scale and the benefits of customer status. High status firms also tend to be larger firms, but there is substantial variation in the measures. Similarly, suppliers that sell components to large buyers will be more likely to become large themselves. Thus, although the benefits to the supplier of assembler scale, supplier scale, and status may correlate, we can disentangle the effects empirically by controlling for supplier and customer size. The scale benefits of selling components to a large buyer arise only if the supplier actually achieves larger size itself. The benefits of selling to a high status customer, however, arise whether or not the supplier achieves greater size. We expect hypothesis 4 concerning customer status to hold controlling for supplier size and customer size.

Finally, we created age and density variables, which are common measures in studies of business failure. We measured firm age from supplier birth. When that information was not available, generally for smaller suppliers, we generated a random date of birth between 1907, when the earliest suppliers appear, and 1917, the year prior to our observation period. We included a dummy variable indicating firms for which the left-censoring applied. For competitor density, we used the count of the number of suppliers of the component in a given year.

RESULTS

Tables 2a and 2b report the results of the analysis of carburetor and clutch supplier failure. We begin by discussing the results for the carburetor analysis, which Table 2a report. These results apply to the case of producers of architectural components.

********** Table 2a about here **********

The baseline model 1 in Table 2a contains only the control variables, including supplier age periods, competitor density, supplier size, aggregate sales of the supplier’s customers, and the indicator of left censoring. Model 1 provides statistically significant explanatory power, based on the significance of the model log-likelihood chi-square statistic. The piecewise analysis with four age periods in model 1 is a statistically significant improvement over an unreported model holding the rate constant. The positive sign on the coefficient for left-censored firms in model 1 indicates that these firms, which were primarily small firms, exited at a somewhat faster rate. This result suggests that left-censoring does not create major problem of bias for the study,
as the size information provides the major common influence on business survival. Greater aggregate sales of a supplier’s customers lowered the hazard of exit. The coefficient for supplier size is negative, with moderate significance.

Model 2 in Table 2a supports hypothesis 1a, which predicted that failure rates would decline with relationship duration. For each additional year’s duration in the supplier’s longest customer relationship, the rate of exit declines by a factor of 0.76 ($e^{-28*1}$). This means that about three additional years reduces the rate of exit by half. The effect retains at least moderate statistical significance, although with slightly smaller magnitude, in subsequent models. We note that customer aggregate production loses significance in model 2, owing to the correlation between customer production and relationship duration (see Table 1a), but that model 2 provides a statistically significant improvement over model 1 based on the log-likelihood ratio statistic.

Model 3 in Table 2a shows that failure rates for carburetor suppliers, that is, of suppliers of architectural goods, declines with actual autonomy, consistent with hypothesis 2a. Each increase of one in the structural autonomy score reduces the exit rate by a factor of 0.82 ($1-e^{-1.74}$). This result persists in later models, with the exception of the models in which we interact autonomy with adverse demand conditions.

Model 4 in Table 2a supports hypothesis 4a, which predicted that failure rates will decline with customer status. We find that maximum status has a significant effect for carburetor manufacturers. Therefore, supplying the top tier (status equal to three, e.g. Ford) is associated with an exit rate only 11 percent that of firms supplying only the minor independents (status equal to one, e.g. Dort; $e^{-1.11*(3-1)}$).

Model 4 also shows an intriguing change in the supplier age results, as we find that the lower failure rate associated with increasing age in model 1 becomes weaker in model 4. The change occurs as we add the relationship duration, autonomy, and status variables to the analysis. Clearly, the network structure variables will tend to associate with greater supplier age, as Table 1a shows, so that the network structure effects overwhelm the firm age statistical effects on failure. At the same time, though, the results provide a conceptual implication about how supplier age influences survival. The point here is many older suppliers do not achieve long-term relationships, autonomy, or high status customers. The results suggest that older suppliers with only short-term relationships, low autonomy, and low status gain fewer benefits from age, which instead apply only to suppliers that achieve reasonable levels of autonomy and/or gather high
status customers as they age. Moreover, note that the incremental log-likelihood chi-square statistics in models 2, 3, and 4 report significant improvement, showing that the network structure measures add independent explanatory power to the models, even controlling for supplier age.

Models 5 and 6 in Table 2a test hypothesis 3, that autonomy leads to lower fail rates during periods of adverse demand conditions. Model 5 first introduces the main effect of adverse demand, which has an insignificant impact on failure. Model 6 then interacts the actual and potential autonomy measures with the adverse demand variable. We now find that the main effect of actual autonomy disappears, but that actual autonomy emerges as an interactive effect with adverse demand. That is, the benefits of autonomy arise most strongly when suppliers face reduced overall demand in their industry and, in turn, benefit from opportunities to sell to as many customers as possible during such periods. Potential autonomy, meanwhile, has no influence on the failure of architectural suppliers, whether as a main effect or as an interaction with demand conditions. We note that the incremental chi-square statistic in model 6 is not a significant improvement over model 5 ($\chi^2 = 4.1$, with 2 degrees of freedom), but that a model that omits the insignificant ADC * Potential autonomy variable, thereby adding only the ADC * Actual autonomy measure, does provide a statistically significant improvement. The ADC * Actual autonomy result in model 6 supports hypothesis 3.

To illustrate the interaction of adverse demand conditions and actual autonomy, Figure 3 shows the effect of increases in autonomy when one of the last three years have had decreasing sales and when none of the last three years have had decreasing sales. Figure 3 indicates that the impact of actual autonomy is much greater during adverse economic conditions. In good economic times, corresponding to ADC=0, a firm with autonomy of 1.25 had an exit rate approximately 60% that of a firm with the minimal observed autonomy, 0.25. In poorer economic times, corresponding to ADC=.33, the exit rate of the firm with autonomy of 1.25 was only approximately 10% that of the firm with autonomy of 0.25. Therefore, the advantage provided by the additional autonomy is much larger in poor economic times, even if the overall rate of exit is higher under adverse economic conditions.

********** Figure 3 about here **********

Models 7a through 7c of Table 1a report sensitivity analyses, in which we investigate alternative measures of relationship duration and customer status. We find no influence of mean
duration of customer relationships (model 7a), unlike the significant influence of maximum
duration. We note, though, that mean duration was statistically significant in a model that
paralleled model 2, that is, when we added mean duration to the control variables, so that
maximum duration and mean duration provide only minimal discrimination; indeed the two
measures correlate highly (0.91 in Table 1a). We find a moderately significant influence of
customer mean status (model 7b), although with somewhat lesser magnitude than maximum
status. We find no impact of customer minimum status (model 7c).

We now turn to Table 2b, which reports the results of the clutch supplier analyses. These
results test the hypotheses concerning suppliers of modular components. Overall, Table 2b
provides significant explanatory power, based on the model log-likelihood chi-square statistic.

************ Table 2b about here ************

Model 1 in Table 2b introduces the control variables. The age results here are somewhat
more significant than in the carburetor analysis, while the other control variables tend to have the
same sign but at lower levels of significance.

The subsequent models in Table 2b provide parallel analyses to those that we discussed
for carburetor suppliers. Model 2 shows that the duration of customer relationships does not
affect the failure of modular suppliers. This result is consistent with hypothesis 1b, which
predicted that the benefits of long-term relationships will be greater for suppliers of architectural
components than for suppliers of modular components.

Model 3 of Table 2b shows that the failure of modular suppliers declines with potential
autonomy, unlike the architectural autonomy case in which potential autonomy had no influence.
Each increase of one in the structural autonomy score reduces the exit rate by 23 percent (1-
e^{-0.26}). This result is consistent with hypothesis 2b, which predicted that potential autonomy will
have more influence on the failure rates of suppliers of modular components than of architectural
components. Model 3 also shows that actual autonomy influences modular component supplier
failure, as it did in the case of architectural components. Each increase of one in the structural
autonomy score reduces the exit rate by a factor of 0.76 (1-e^{-1.74}). The implication here is that
actual autonomy is a major influence on the performance of all suppliers by providing immediate
alternatives and/or direct negotiation power with existing customers should needs arise, while
potential autonomy provides benefits mainly for producers of general components that face few
switching costs.
Model 4 of Table 2b shows that customer status does not affect the failure rates of modular suppliers. This result is consistent with hypothesis 4b, which predicted that customer status would have more influence on the failure of suppliers of architectural components than for suppliers of modular components.

Models 5 and 6 of Table 2b then show that autonomy arises only as a main effect for modular suppliers. That is, autonomy has no differential effect during adverse demand conditions for modular suppliers.

Models 7a through 7c repeat the sensitivity analyses that we discussed in Table 2a. These analyses show little impact of mean relationship duration, mean customer status, or minimum customer status.

Overall, comparing the results in Tables 2a and 2b supports the argument that network structure will have different influences for suppliers of modular and architectural components. For modular components, only autonomy has major influences, with benefits arising from both actual and potential autonomy. By comparison, architectural components, which tend to involve substantial switching costs and relation-specific investment, benefit from relationship duration and customer status, as well as from actual autonomy, while achieve little benefit from potential autonomy. Moreover, actual autonomy provides particularly strong benefits for architectural suppliers during adverse demand conditions, whereas demand does not differentiate the autonomy benefits for modular suppliers.

This comparison speaks directly to the contingent nature of the influence of network structure, with the benefits and constraints deriving in large part from the nature of the inter-firm routines that firms must create in order to coordinate their relationships. Relationships that require extensive sets of inter-firm routines tend to lead to greater benefits and constraints of network structure, while relationships that require less intensive inter-firm routines garner lesser impact from network structure. Nonetheless, even producers of seemingly standard products benefit from having actual autonomy from their customers.

**DISCUSSION**

Podolny (1999) describes two views of networks, as pipes and prisms. The concept of autonomy assumes that a network is a pipe or conduit through which resources flow. Firms create an advantageous position for themselves by creating networks that are high in structural autonomy. An alternative view of networks as prisms is captured by the status order among firms
in a market. Third parties ascribe higher status to firms that are linked to other high-status firms. We find that both elements of network structure affect supplier survival. Suppliers with higher autonomy and higher status experience higher survival chances.

In this paper we also explore a tension between the interorganizational relationship and network views of the firms involved in vertical relationships. The interorganizational relationship view draws attention to the benefits of strong exclusive ties with a few firms (Levinthal and Fichman 1988; Baker, Faulkner et al. 1998). Such tight coupling results when firms are strongly reliant on each other, often having many interdependent business routines. Tight coupling between suppliers and buyers permits the development of strong firm-specific interorganizational experience that may confer competitive advantages on suppliers (Lamming 1990), and we did find that longer-term relationships with buyers enhanced the survival chances of suppliers.

But such tightly coupled relationships also create constraints on adaptation by buyers and suppliers. Network views of the firm draw attention to the potential disadvantages of such arrangements because they often correspond to low structural autonomy of the focal supplier firm. Low autonomy will often have adverse effects on firm performance because the focal supplier firm derives fewer control and information benefits from its network and because the dominant partner can extract rents from its partner (Caves and Uekusa 1976; Pfeffer and Salancik 1978; Burt 1992). These adverse effects are magnified when there is an environmental shock because the focal firm in a tightly coupled network has fewer alternatives to buffer itself against a shock (Singh and Mitchell 1996). The network view, therefore suggests that suppliers that have higher structural autonomy are better able to withstand environmental shocks that affect the network. We find that suppliers of greater actual structural autonomy experience lower dissolution rates, especially in adverse environmental conditions.

Organizations that are embedded in tightly coupled networks find it difficult to adapt to environmental changes affecting any single member of the network (Simon 1962; Weick 1979, 185-187; Aldrich and Whetten 1981:388). In the extreme case, selection itself may shift to a higher level and result in the failure of the entire network. The failure of entire industrial groups, chaebol, in South Korea during the recent economic crisis illustrates the risks associated with being embedded in tightly coupled networks. Longitudinal studies of network structure and organizational performance will help us understand both the evolution of an organization’s network structure and its effect on organizational performance.
Figure 2: Carburetor firms by year
Figure 3: Effect of actual autonomy on failure rates (carburetor suppliers)
REFERENCES


Bailey, L. S. (1971). The American car since 1775; the most complete survey of the American automobile ever published. [New York?].


Crane Communications (1996). The automotive news 100-year almanac and market data book. Detroit, Crane Communications, Inc.


Table 1a. Carburetor suppliers, descriptive statistics (n=302)

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Table 2a. Carburetors: Piece-wise exponential estimates of influences on failure rates of architectural component suppliers
(negative coefficient = lower dissolution rate; 302 spells for 37 firms, 24 failures)

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<td>-0.16</td>
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<td>-57.8</td>
<td>-49.2</td>
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<td>-44.2</td>
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* p<.10, ** p<.05, *** p<.01
# p=.10 (one-tailed test)
Table 2b. Clutches: Piece-wise exponential estimates of influences on failure rates of modular component suppliers
(negative coefficient = lower dissolution rate; 178 spells for 32 firms, 24 failures)

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<thead>
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<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>6</th>
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<th>7b</th>
<th>7c</th>
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<td>Supplier age 0-5 yrs.</td>
<td>-1.24 *</td>
<td>-0.98 #</td>
<td>2.06 #</td>
<td>1.55</td>
<td>2.27 #</td>
<td>2.79</td>
<td>2.69</td>
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<td>1.82</td>
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<td>Supplier age 6-10 yrs.</td>
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<td>-2.21 **</td>
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<td>1.16</td>
<td>1.88</td>
<td>2.40</td>
<td>2.32</td>
<td>1.82</td>
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<td>-1.92 **</td>
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<td>-1.98 **</td>
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<td>Left-censored</td>
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<td>0.86 #</td>
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<td>0.34</td>
<td>0.34</td>
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<td>-0.40</td>
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<td>H2 Actual autonomy</td>
<td>-1.42 **</td>
<td>-1.48 **</td>
<td>-1.46 **</td>
<td>-1.81 *</td>
<td>-1.85</td>
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* p<.10,  ** p<.05,  *** p<.01
# p<.10 (one-tailed test)