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Tie Dissolution in Market Networks: A Theory of Vicarious Performance Feedback

Administrative Science Quarterly
2020, Vol. 65(4)972–1017

DOI: 10.1177/0001839219899606
journals.sagepub.com/home/asq
SAGE

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Abstract
Managers need to periodically evaluate any exchange partner to decide whether to continue or dissolve the exchange tie, but doing so can be challenging because of causal ambiguity: it can be difficult to attribute organizational performance to any specific underlying factor. One way managers may evaluate their exchange partners is by observing the performance trajectories of competitors who rely on the same exchange partners. We propose a theory of vicarious performance feedback and test it in the context of Formula One motor racing. We find that a firm building a Formula One racing car is more likely to end an exchange relationship with an engine supplier after that supplier's other customers experience an episode of poor performance relative to their historic track record. In line with an attention-based view of the firm, this behavior occurs when the firm's own performance is below its aspiration level. This work extends our understanding of how managers use vicarious learning to supplement their direct experience when evaluating their exchange partners, expands our thinking about network dynamics by showing how network neighbors' experiences can influence tie decisions made within a dyad, and contributes to the cognitive foundations of problemistic search by showing how external information is integrated into managers' responses to their own firm's underperformance.

Keywords: causal ambiguity, interorganizational relations, network dynamics, organizational change, performance feedback, problemistic search, vicarious learning

Economic activity is embedded in a network of social relations, such as the exchange ties between suppliers and buyers in an industry (White, 1981; Uzzi, 1997). Networks of interorganizational relationships have been found to impact many important outcomes for firms, including innovation, value creation and capture, and survival (Uzzi, 1996; Ahuja, 2000; Lavie, 2007; Gulati,

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Wohlgezogen, and Zhelyazkov, 2012). Understanding the dynamics of market networks is therefore a high priority for scholars of organization theory (Ahuja, Soda, and Zaheer, 2012; Sytch and Tatarynowicz, 2014). The formation and dissolution of exchange ties are managerial choices that hinge on managers' evaluations of the potential gains from a given relationship. Much research has addressed how managers evaluate potential exchange partners when making tie formation decisions (e.g., Gulati and Gargiulo, 1999; Podolny, 2001; Mitsuhashi and Greve, 2009), but less is known about how managers evaluate their current exchange partners (Rivera, Soderstrom, and Uzzi, 2010).

At first glance, it may appear that evaluating current exchange partners would be straightforward: through their experience of working with a partner, managers discover private information that was unobservable before forming the tie (Fichman and Levinthal, 1991). But research has shown that evaluating a given exchange partner is challenging (Sorenson and Waguespack, 2006; Azoulay, Repenning, and Zuckerman, 2010). Organizational experience—including experience working with a given exchange partner—is often deeply ambiguous (March, 2010). Causal ambiguity hinders managers' attempts to attribute organizational performance to the factors that underlie this performance (Mosakowski, 1997; King, 2007). A firm's performance depends on the interplay of its internal resources and the elements contributed by its exchange partners (Thompson, 1967), making the contributions of each element in the system hard to discern (Sterman, 1994). Furthermore, managers have a limited sample of direct experience with any given organizational partner with which to make an evaluation (March, Sproull, and Tamuz, 1991). In this paper we examine how organizations decide whether to dissolve a tie with a current exchange partner given such causal ambiguity.

Organizational learning research has found that when direct experience is insufficient for assessing the value of a technology or practice, managers can supplement it by observing other organizations (e.g., Baum, Li, and Usher, 2000; Terlaak and Gong, 2008; Posen and Chen, 2013). Work on vicarious learning has shown that despite the limitations of bounded rationality, managers attend and respond to salient information in their environment (Gavetti, Levinthal, and Rivkin, 2005; Baum and Dahlin, 2007; Mitsuhashi, 2012). Research has not yet addressed whether vicarious learning extends to the evaluation of existing exchange partners, but when there is uncertainty surrounding an exchange partner's quality, observing other organizations could provide useful information that helps managers interpret their ambiguous experience.

We develop the argument that firms learn not just from their direct experience with a given exchange partner but also from other firms' concurrent experience with the same partner. When two firms (A and B) procure the same component from a supplier (S)—a constellation we refer to as "joint component usage"—each firm can observe the other firm's performance and use such observations to supplement knowledge from its own direct experience with the supplier. Whether firm B performs above or below its aspirations likely affects firm A's decision to dissolve or keep the tie with the supplier. We thus develop a theory of *vicarious performance feedback* (VPF) in which a focal firm's behavior is influenced by the performance trajectories of other firms to which it is indirectly tied.

We test this theory in the context of Formula 1 (F1) motor racing. In this industry, a set of firms—known as constructors—manufacture cars, hire drivers, and compete in F1 (Grands Prix) races (Jenkins, Pasternak, and West, 2005). A constructor can opt to develop and build an engine in-house or, more commonly, procure an engine from an external supplier. We examine the factors that lead a constructor to dissolve its supplier relationship at the end of an F1 season. F1 exhibits several features that make it a particularly good fit with our research topic: joint component usage is prevalent (Aversa, Furnari, and Haefliger, 2015), firms' performance trajectories are readily visible to one another, and the annual design–build–race cycle of the F1 season allows us to relate one season's performance to the organizational changes made before the next season—an ideal scenario for testing performance feedback hypotheses. Scholars have previously used motorsports settings to shed light on the dynamics of interorganizational relationships (Castellucci and Ertug, 2010; Mariotti and Delbridge, 2012) and on organizational learning (Jenkins, 2014; Marino et al., 2015; Hoisl, Gruber, and Conti, 2017), validating the suitability of this setting for our research question. We propose that firms are more likely to dissolve a tie with a supplier if that supplier's other customers exhibit performance below their historic track records. We also investigate several moderating factors, address several alternate explanations, and supplement our quantitative analysis with interview research.

THEORY AND HYPOTHESES

Tie Dissolution in Market Networks

Prior work on the retention versus dissolution of interorganizational ties has underscored the challenge managers face in evaluating their firm's current exchange partners. Even when a firm already collaborates with an exchange partner, managers may face difficulty evaluating that partner's contribution to the firm's performance (Sorenson and Waguespack, 2006; Azoulay, Repenning, and Zuckerman, 2010).

Tie dissolution has been linked to relational, structural, assortative, and proximity-based antecedents (Rivera, Soderstrom, and Uzzi, 2010). Table 1 provides an overview of the mechanisms studied in this literature. Relational antecedents of tie dissolution are particularly relevant to our research question as they concern how a manager's experience with an exchange partner affects their decision to continue or terminate the partnership (Gulati, 1995a; Polidoro, Ahuja, and Mitchell, 2011). After a tie is formed, ongoing interactions reveal information about the partner and the quality of the match, leading the hazard of tie dissolution to initially rise as dyads that discover a poor match dissolve, and then fall because the remaining dyads are better matched (Fichman and Levinthal, 1991). This nonlinear duration-dependent tie dissolution has been documented across numerous kinds of ties including marriage ties (Weiss and Willis, 1997; Kulu, 2014) and employment ties (Jovanovic, 1979; Mortensen, 1988), as well as interorganizational relationships (e.g., Levinthal and Fichman, 1988; Baker, Faulkner, and Fisher, 1998; Greve et al., 2010). Social and emotional processes of interpersonal attachment also strengthen interorganizational ties over time (Seabright, Levinthal, and Fichman, 1992; Sorenson and Rogan, 2014), to the extent that the departure of top executives or exchange

Table 1. Overview of the Literature on Tie Dissolution in Market Networks

High-level mechanism categories	Definition	Example findings	Illustrative studies
Relational mechanisms	The ways in which the history of interaction between partners strengthens or weakens the tie between them	Hazard of tie dissolution follows an inverted-U-shape relationship with tie duration.	Levinthal and Fichman (1988) Baker, Faulkner, and Fisher (1998) Greve et al. (2010)
		Departures of top executives or exchange managers raise the hazard of tie dissolution.	Broschak (2004) Rogan (2014) Bermiss and Greenbaum (2016)
		Trust and reputation affect how well a tie withstands a dispute or an adverse event.	Malhotra and Lumineau (2011) Park and Rogan (2019)
Assortative mechanisms	The ways in which attributes of exchange partners make them more or less compatible	Social similarity and resource complementarity can generate cohesion, which makes the relationship more stable.	Rowley et al. (2005) Greve et al. (2010)
		Resource differences can lead to inefficiency, which raises the hazard of tie dissolution.	Greve et al. (2010)
		Overlap in product-market scope can cause competitive tension and thereby weaken the tie between the partners.	Park and Ungson (1997)
Structural mechanisms	The ways in which the broader social network, beyond the dyad itself, can stabilize or destabilize a tie	Ties to common third parties (i.e., structural embeddedness) lower the likelihood of tie dissolution.	Polidoro, Ahuja, and Mitchell (2011)
		Structural status or power differences can strain a relationship, raising the hazard of dissolution.	Rowley et al. (2005) Piskorski and Casciaro (2006) Greve et al. (2010)
		Networks with dispersed tie strengths may contain subgroups of actors with fragile ''faultlines'' between them.	Heidl, Steensma, and Phelps (2014)
		Outside opportunities to form ties can raise the hazard of dissolving the current tie.	Greve, Mitsuhashi, and Baum (2013)
Proximity-based mechanisms	Actors' closeness in social, cultural, and geographic spaces	Country-level cultural proximity lowers the hazard of dissolution of international joint ventures.	Park and Ungson (1997) Barkema and Vermeulen (1997) Hennart and Zeng (2002)
		Geographic proximity may reduce the likelihood of tie dissolution.	Xia (2011)

managers from an organization can lead to the dissolution of exchange ties (Broschak, 2004; Rogan, 2014; Bermiss and Greenbaum, 2016).

Surprisingly little work has explicitly studied firm performance as an antecedent of tie dissolution (exceptions include Baker, Faulkner, and Fisher, 1998). Instead, poor performance is inferred from the empirical observation of tie dissolution, or conversely, satisfactory performance is inferred from tie continuation (Park and Ungson, 2001). The robust empirical finding that the number of partners' past interactions predicts their likelihood of collaborating in the future (e.g., Gulati, 1995b) is consistent with the premise that satisfactory performance leads to the renewal of exchange relations. However, the focus on tie renewal often ''black boxes'' the actual process of partner evaluation and is largely agnostic to the degree of difficulty managers face when interpreting their experience of working with a given exchange partner (Ariño and De La Torre, 1998). Several studies have suggested that evaluating current exchange partners is challenging and that managers have difficulty inferring partner quality from their own performance outcomes. On the one hand, Sorenson and Waguespack (2006), in their study of the movie distribution industry, found evidence of a self-confirming positive bias in how distributors evaluate producers. On the other hand, in a study of the contract research sector, Azoulay and colleagues (2010) found a dynamic of negatively biased exchange partner evaluations leading to the phenomenon of embeddedness failure. How an exchange partner's inputs affect the focal firm's performance is subject to substantial causal ambiguity. Past research provides a rich conceptualization of causal ambiguity that constitutes one foundation of our theory of exchange partner evaluation.

Causal Ambiguity

When making calculative decisions under uncertainty, managers apply a logic of consequences (March, 1994). Managers rely on their cognitive models of cause and effect to try to anticipate the outcomes associated with each choice (Simon, 1996), and then they select the choice they perceive as most likely to fulfill whatever organizational goal(s) they are currently attending to (Cyert and March, 1963; Ocasio and Joseph, 2005). Managers' cause-and-effect models form through the accumulation of experience in similar circumstances (Huber, 1991; Gavetti, Levinthal, and Rivkin, 2005). Organization theorists have documented how ambiguity in the interpretation of past experience can lead to mis-specified causal models (Weick, 1995; March, 2010).

Causal ambiguity—the ''basic ambiguity concerning the nature of the causal connections between actions and results'' (Lippman and Rumelt, 1982: 418)—can arise from the tacitness, complexity, or specificity of the factors that contribute to firms' performance (Reed and DeFillippi, 1990). In a foundational essay on causal ambiguity, Mosakowski (1997) provided a typology of levels of causal ambiguity based on the *ex ante* and *ex post* reducibility of uncertainty over causal relations and input quality. She noted that at the extreme of ''fundamentally irreducible causal ambiguity,'' organizational learning is impossible: no amount of experience will generate useful causal knowledge (Mosakowski, 1997: 417). At the opposite extreme, if ambiguity is reducible *ex ante*, investment in information shifts the decision-making regime to one of risk, i.e., the probabilities of outcomes are known (Mosakowski, 1997).

In the theoretical development that follows, we focus on intermediate levels of causal ambiguity. Here, uncertainty about causal relations and input quality is reducible *ex post*. Managers can learn from experience, but they still face uncertainty over forward-looking decisions. This level of causal ambiguity arises when the environment is turbulent, which hinders the *ex ante* reduction of ambiguity, and when system-level complexity is moderate to high

(Mosakowski, 1997). These qualities characterize the decision-making context of Formula 1—and many other industries—very well.[1]

Causal ambiguity has been studied at the intrafirm and interfirm levels of analysis (King, 2007). Prior work at the intrafirm level has shown that managers often face causal ambiguity over which factors contribute to their own firm's performance (King and Zeithaml, 2001; Denrell, Arvidsson, and Zander, 2004). Work at the interfirm level has highlighted the difficulty managers face in discerning the factors that underlie another firm's competitive advantage (Simonin, 1999; Argote and Ingram, 2000). We bring together the intra- and interfirm perspectives to argue that managers face causal ambiguity when assessing their exchange partners' contributions to their own firm's performance. We next consider how a firm's level of performance may influence how managers evaluate exchange partners, with consequences for tie dissolution in market networks.

Performance Feedback and Exchange Partner Evaluation

Performance feedback theory, grounded in the work of Cyert and March (1963), suggests that organizational change is triggered by performance below aspiration levels. Managers may generally satisfice—maintain the status quo as long as organizational performance meets or exceeds their aspiration level (March and Simon, 1958)—but when performance falls below aspiration, they engage in problemistic search. This leads to changes in organizational factors that might have caused the poor performance (Greve, 1998a), and managers become more open to taking risks, such as pursuing exploratory courses of action (Baum et al., 2005; Kacperczyk, Beckman, and Moliterno, 2015). A growing body of empirical work supports performance feedback theory (Shinkle, 2012; Greve and Gaba, 2017; Posen et al., 2018). By itself, this theory would lead us to expect a firm would change a key exchange partner after an episode of poor performance, purely as a matter of problemistic search for change.

This expectation is strengthened when we consider a firm's evaluation of an exchange partner, which is likely to shift negatively when the focal firm's performance is weaker. In a complex organization, performance depends on the interplay among many internal and external elements, making it difficult to decompose performance and attribute it to specific factors (Thompson, 1967; Sorenson and Waguespack, 2006). Because of the psychological tendency for individuals to make self-serving attributions (Staw, McKechnie, and Puffer, 1983)—which biases managers toward making external attributions for failure and internal attributions for success—the supplier of a key component is likely to face at least some of the blame when a firm underperforms. This leads us to a baseline expectation that the lower a firm's performance falls below its aspiration level, the more likely the firm is to terminate a supply relationship.[2]

[1] Environmental dynamism and system-level complexity are therefore scope conditions of our theory. We revisit these and other scope conditions in the Discussion section.

[2] One of the 23 hypotheses in Baker and colleagues' (1998) study of tie dissolution suggests that an improvement in sales is negatively related to the hazard of dissolving a market tie. This provides an initial test of performance feedback behavior with a tie-dissolution dependent variable, despite not being presented in terms of this theory. Other authors relating performance feedback to network dynamics are Baum et al. (2005) and Shipilov, Li, and Greve (2011), who show that performance below aspirations can stimulate a more distant search for new exchange partners.

Baseline hypothesis: The further a firm's performance falls below its historic and social aspiration levels, the more likely it is to end an exchange relationship with a key component supplier.

Vicarious Performance Feedback

When managers have difficulty interpreting their organization's experience, they may look to the other organizations in their immediate environment (Levitt and March, 1988). For example, when interpreting whether their organization's performance level should be considered satisfactory, managers engage in social comparison, comparing their firm's performance with that achieved by an appropriate reference group, such as their immediate competitors (Cyert and March, 1963; Mezias, Chen, and Murphy, 2002; Beckman and Lee, 2017). Managers are also motivated to achieve a level of performance that affirms the organization's membership in its social reference group (Moliterno et al., 2014). Although performance feedback theory has shown that managers pay attention to competing firms' performance, it has not yet fully explored the range of inferences that managers might draw from observing that performance.

We argue that managers attend to competitors' performance in order to draw inferences about the value of commonly used resources. A competitor's performance allows a focal firm to make inferences about the value of that competitor's choices, such as its strategy, practices, and exchange partners (Haveman, 1993; Haunschild and Miner, 1997). When a focal firm engages with the same exchange partners as its competitors (as in joint component usage), it will likely compare the competitor's current performance to its historic track record to evaluate the shared exchange partner.

The first pillar of this argument is the network-theoretic notion of structural equivalence, which exists when two actors have the same structural relationship with respect to the other actors in a social network (Wasserman and Faust, 1994). Burt (1987) theorized that this is an inherently competitive relationship that leads to mutual monitoring (see, e.g., Piezunka et al., 2018). When two firms purchase a component from the same supplier, they are structurally equivalent with respect to that supplier, so we can expect these firms' managers to pay heightened attention to one another. Greve's (2009) study of the shipbuilding industry showed that structural equivalence in buyer–supplier networks influences managers' decisions to adopt a new technology. We argue that structural equivalence focuses managers' attention on competitors' performance, which they then incorporate into evaluations of the shared exchange partner.

The second pillar of our theory is the organizational salience of competitors' historic performance. The relevance of a firm's own historic performance is a well-established element of performance feedback theory, forming the basis of its historic aspiration level. Competitors' current performance levels form the basis of a firm's social aspiration level, but their historic track records do not enter into conventional performance feedback models and have not received much attention in organization theory more broadly. Yet managers likely pay attention to their competitors' historic track records. Not only do managers have direct experience competing in the market, but the market's social infrastructure—consisting of intermediaries such as stock analysts, consultants, and media pundits—collects and analyzes performance data, drawing attention to historical trends and making contemporary comparisons (Zuckerman, 1999; Espeland and Sauder, 2007).

The third pillar of our theory is the asymmetry between inferential learning from positive and negative performance. Prior work has suggested that distinct processes underlie vicarious learning from others' failures versus others' successes (Dahlin, Chuang, and Roulet, 2018). Managers try to emulate success by adopting the practices of high-performing firms (Haveman, 1993; Strang and Macy, 2001) and to avert failure by distancing themselves from a practice after observing negatively valenced information related to it (Greve, 2011; Gaba and Dokko, 2016). In the context of tie dissolution, managers may be particularly attuned to negative information. We expect that the observation of negative deviations from past performance by structurally equivalent firms will weigh heavily on managers' decision to terminate an exchange tie. These negative performance deviations provide a salient informational input for managers' deliberate, cognitive process of supplier evaluation (Ito et al., 1998; Greve, 2013) and can reveal to managers the precariousness of their own firm's position. As a result, managers will likely be motivated to take actions that might avert failure, even if those actions are risky (Bothner, Kang, and Stuart, 2007).

Together, these three pillars lead us to hypothesize a vicarious analogue to performance feedback, in which a focal firm's behavior responds to the track-record deviations of firms that are also exchange partners of its own partners.[3]

Hypothesis 1: When firms jointly use a component, the further other users' performance falls below their historic levels, the more likely a focal firm is to end an exchange relationship with the component's supplier.

Moderating Hypotheses

We expect several factors to moderate managers' reactions to vicarious performance feedback. We assume throughout that managerial behavior is purposive, boundedly rational, and socially embedded. Factors that draw managers' attention toward the supplier or the firm's structurally equivalent competitors should strengthen vicarious performance feedback, while substitute opportunities for learning about the supplier should weaken vicarious performance feedback.

Interaction of direct and vicarious performance feedback. We expect managers to react more strongly to negative vicarious performance feedback when the firm's own performance is below its aspiration level. Cyert and March (1963: 121–122) argued that a firm's failure to meet a goal on an important dimension will trigger a process of problemistic search, which they described as follows:

[3] Vicarious feedback was introduced by Strang and Patterson (2014) in a study of U.S. baseball teams hiring and firing managers. Hiring was found to be influenced by the performance trajectories of teams with which the manager had previously been affiliated. We build on Strang and Patterson's theory by showing that direct and vicarious feedback operate simultaneously, by testing moderating factors, and by linking vicarious performance feedback with network structure.

> Search is based initially on two simple rules: (1) search in the neighborhood of the problem symptom and (2) search in the neighborhood of the current alternative. . . . When search, using the simple causal rules, is not immediately successful . . . the organization uses increasingly complex (''distant'') search.

We draw on this theory in three ways. First, the theory suggests that problemistic search focuses managers' attention on possible causes of the firm's disappointing performance (Cyert and March, 1963; Posen et al., 2018). Managerial attention is a scarce resource, and its allocation has a major impact on decision making (Ocasio, 1997; Sullivan, 2010; Joseph and Ocasio, 2012; Piezunka and Dahlander, 2015). As performance decreases relative to aspirations, managers are likely to allocate more attention toward analyzing their suppliers' contribution to firm performance. The allocation of attention leads managers to engage in more cognitively sophisticated processes of supplier evaluation, such as drawing inferences by analyzing the performance of the supplier's other customers.

Second, in situations with high causal ambiguity, problemistic search triggered by disappointing performance is likely to progress from simple rules to a more complex and distant type of search (Cyert and March, 1963). This point builds on prior work in several ways. Studies of organizational search for network partners have found that performance below aspirations leads managers to increase the network range of their search (Baum et al., 2005; Shipilov, Li, and Greve, 2011). In the context of tie dissolution, an increase in network range suggests that managers pay more attention to the partner's other partners when their firm's own performance is below aspirations. Studies of organizational learning have also suggested that managers engage in more vicarious learning—a more distant source of knowledge than the firm's own experience—when the firm's own performance is below its aspiration level (Baum and Dahlin, 2007).

Third, a recent stream of work has examined circumstances in which managers pay more or less attention to their competitors. Performance feedback theory incorporates an element of social comparison (Festinger, 1954): managers pay attention to a social aspiration level, which is based on competing organizations' performance (Greve, 2003a). Blettner and colleagues (2015) found that firms whose own performance is very low pay more attention to their competitors' performance. In the context of vicarious performance feedback, this suggests that low performance may lead managers to draw more inferences from competitors' performances.

These cognitive mechanisms are coupled with the behavioral tendency to be more willing to make changes when firm performance is below aspirations than when it is above aspirations (Greve, 1998a). Performance below aspirations, we argue, both shifts managerial attention and shifts managers' tendency to act on the evaluations that result from this heightened attention. These proposed processes lead us to predict that firms exhibit a stronger response to vicarious performance feedback when their direct performance feedback is negative (i.e., below aspiration).

Hypothesis 2: The effect of vicarious performance feedback on the focal firm's decision to terminate its supplier relationship is stronger when its own performance is below its aspiration level.

Number of joint component users as a moderator of vicarious performance feedback. We expect that managers are more likely to react to negative vicarious performance feedback when there are more other firms using the same component (i.e., joint component users) for them to draw inferences from. Prior work on vicarious learning has found that managers respond not only to the direction of vicariously observed signals but also to the number of firms from which those signals arise (Rhee, Kim, and Han, 2006). Negative performance deviations by multiple joint component users provide a consistent signal about the possible cause of the poor performance (Gaba and Terlaak, 2013). The presence of multiple signals from multiple joint component users helps to reduce the causal ambiguity managers face in evaluating the supplier.

In our empirical analysis we study the main effect of vicarious performance feedback (H1) by taking the average of the joint component users' deviations from their historic record. Here, we suggest that for a given average level of vicarious performance feedback, managers will respond more strongly if that average is derived from a larger number of joint component users (Rhee, Kim, and Han, 2006). To the extent that managers intuitively treat the mean performance of the reference group as a summary statistic, deriving this mean from a larger number of joint component users reduces the variance of the statistic and thus the risk associated with acting on this information.[4]

> **Hypothesis 3:** The effect of vicarious performance feedback on the focal firm's decision to terminate its supplier relationship is stronger the more other firms use the same component.

Geographic distance as a moderator of vicarious performance feedback. We expect a firm that is geographically close to a supplier to have alternate channels for evaluating the supplier, reducing the extent to which managers respond to vicarious performance feedback. Scholars have shown that knowledge flows more easily over shorter distances (Audretsch and Feldman, 1996; Sorenson and Audia, 2000). Geographic proximity raises the likelihood of knowledge flowing through informal interpersonal ties and employee mobility (Henry and Pinch, 2000; Sorenson and Stuart, 2001) and makes it easier for managers of buyers to visit suppliers' sites and learn from face-to-face meetings with the suppliers' managers (Dyer, 1996). Knowledge acquired through proximity can influence strategic decisions, such as firms' adoption of uncertain production technologies (Greve, 2009; Greve and Seidel, 2015). Among the different forms of knowledge, Tallman and colleagues (2004) suggested that component-related knowledge is particularly likely to spread within geographically localized industrial clusters, such as those in the motorsports industry (see also Jenkins and Tallman, 2010).

We reason that information gained from proximity to a supplier is likely to substitute for—rather than reinforce—the inferences managers draw from vicarious performance feedback. Information from vicarious performance feedback is inherently backward-looking. It helps managers interpret the ambiguity of past experience. In contrast, information gained from proximity to a supplier is both backward- and forward-looking, as the component buyer may learn through informal channels about the supplier's future plans, and managers

[4] We thank an anonymous reviewer for this suggestion.

from the buyer may visit the supplier's premises and become aware of investments the supplier is making in next-generation technologies.

The role of geographic proximity in the sharing of forward-looking information is underscored by the finance literature on investment managers' proximity to portfolio firms (Coval and Moskowitz, 1999). Investment managers' decisions about what stocks to hold in their portfolios are intrinsically forward-looking. The finance literature shows that investment managers obtain superior investment returns when they invest in geographically proximate firms (Coval and Moskowitz, 2001), which is consistent with the proximity providing superior access to forward-looking information (Malloy, 2005). Because managers who are geographically proximate to suppliers may obtain forward-looking information on the suppliers' next product generation, this information could outweigh the backward-looking inferences they make from vicarious performance feedback.

In addition, to the extent that geographic proximity leads to interpersonal ties between managers of the focal firm and supplier firm, proximity may imply a degree of social and emotional attachment, mutual obligation, or cultural solidarity between managers of the two firms (Powell, 1990; Laursen, Masciarelli, and Prencipe, 2012). Such embeddedness could make the focal firm's managers less likely to attribute negative performance deviations of joint component users to the supplier firm, lowering their sensitivity to vicarious performance feedback.

Hypothesis 4: The effect of vicarious performance feedback on the focal firm's decision to terminate its supplier relationship is weaker the lower the geographic distance between the focal firm and its supplier.

METHODS

Research Context and Sample

We tested our hypotheses in the empirical setting of Formula 1 (F1), an annual motor racing series in which firms, known as *constructors*, build cars and hire drivers to race them in Grands Prix around the world. An F1 car is a complex system of interdependent components, including chassis, engine, gearbox, brakes, and electronic control unit (Marino et al., 2015). In line with rules set by the industry's governing body, the *Fédération Internationale de l'Automobile* (FIA), constructors must build the car chassis in-house but may procure other components from external suppliers. A constructor's relationship with its engine supplier is strategically significant because the engine is a material determinant of a car's performance (Castellucci and Ertug, 2010). While certain engine attributes, such as horsepower, are objectively measurable, the engine is interdependent with the other car components, so it is challenging to assess its impact on a constructor's Grand Prix performance. The supply structure for engines displays considerable variation among constructors and over time, with joint component usage a frequent arrangement. New engine models are developed each year to incorporate technical advances and to conform with F1's evolving rules. A constructor gains experience of the new engine primarily by using it in Grands Prix; this limits how much experience it can accumulate directly and raises the question of whether it can learn from other constructors' use of the same engine (Aversa, Furnari, and Haefliger, 2015).

F1's position at the frontier of automotive technology, a highly dynamic field, renders it very appropriate for studying organizational change (Marino et al., 2015). The industry's temporal pacing also makes it ideal for untangling questions of performance feedback. The F1 season in a given year starts in March and ends in October, November, or December. Constructors undertake an annual cycle of designing, building, and testing a car in the months leading up to the first Grand Prix of the season (Jenkins, Pasternak, and West, 2005). The performance of a constructor's car in a given year has therefore been observed by the time the constructor has to choose a supply arrangement for the following season.

Although the first F1 championship was held in 1950, in our dataset we focused on the period since 1981, when the sport was professionalized through the Concorde Agreement between F1 constructors, the FIA, and the F1 administration. This agreement instituted a broad framework for the racing series, according to which constructors must build their own chasses but may acquire other components from external suppliers. While the detailed rules of F1 change annually, this broad framework remains in place at the time of writing. We therefore chose as our sample period a 33-year window from 1981 to 2013.[5] The database we used is from Motorsportarchiv, which is assembled from data supplied by the FIA.[6] We supplemented these data with records of organizations' addresses from the industry publication *Who Works in Formula 1* (e.g., Grégoire, 2013) and used article counts drawn from searches of the Factiva database to construct the status variable described below. On average, 13 constructors competed each year, for a total of 432 constructor–years in our sample window.

To better understand the empirical setting and to enrich our evidence base, we conducted 55 qualitative interviews with 46 Formula 1 professionals between July 2016 and December 2018. The interviews were conducted in English, French, and German by one of the authors, and 42 of the 55 interviews were recorded. We did not record the remaining 13 either because the interviews were conducted on site, where recording devices were not allowed, or because the interviewees asked not to be recorded; for these interviews we took detailed notes. The average length of an interview was 42 minutes. We also had various informal conversations with employees during site visits.

Most of our interviewees were employed at F1 constructors or at F1 engine suppliers. We also interviewed journalists and industry experts. See table A1 in Online Appendix A (http://journals.sagepub.com/doi/suppl/10.1177/0001839219899606) for a detailed overview of our interviewees. Given the global distribution of F1, most of our interviewees were based in the UK, France, Italy, Austria, and Japan. Combined, the 46 individuals we interviewed had more than 450 years of F1 experience. We enjoyed the trust of our interviewees as most interviews resulted from referrals by previous interviewees.

Our interviewees confirmed that assessing an engine—and, respectively, an engine supplier—is an important and difficult challenge in F1. One engineer pointed out that it would be easy to see that a car had a problem, but "finding

[5] Where historic data were needed to construct independent variables, we used earlier data. We observed constructors' engine suppliers in 2014 in order to define the dependent variable for the 2013 season.

[6] Retrieved from http://www.motorsportarchiv.de on March 18, 2015.

the cause is, as you may imagine, definitely more difficult.'' The technical head of an F1 constructor noted the need and challenge to ''decompose performance into its constituents.'' Our interviewees also outlined the specific challenges of decomposing performance: ''it's difficult to do because it's hard to discriminate between engine power and drag, aerodynamic drag.''

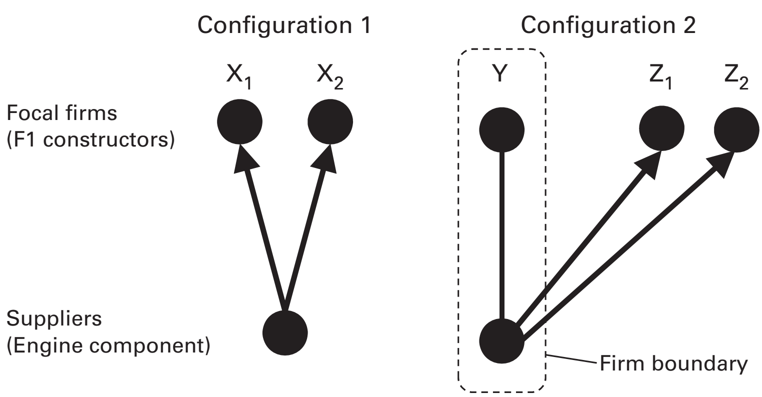
Figure 1 depicts the two distinct supply arrangements in which multiple F1 constructors are supplied with the same engine. In the first configuration, the supplier is a third-party engine manufacturer that sells engines to multiple customers, labeled X_1 and X_2. In the second configuration, there is a vertically integrated constructor, labeled Y, which produces engines for its own use and also sells engines to customer constructors labeled Z_1 and Z_2. We define a constructor's set of joint component users on the basis of structural equivalence: firm X_1's joint component users are X_2, X_3, etc., and firm Z_1's joint component users are Z_2, Z_3, etc., but not firm Y.

Measures

Dependent variable. We measured the dependent variable of whether the tie is dissolved at the constructor-supplier-year level of analysis. We coded for termination of a supplier relationship with a dummy variable set to 1 if a constructor uses a different engine supplier in the following season than in the current season. Thus our dependent variable measures dissolution between year t and year $t+1$. We learned in our interviews that the decision to terminate the collaboration is generally made by the constructor, not the supplier. One interviewee with many years of experience across multiple constructors said, ''99 percent of the time I put my money on it that it was the team.'' A senior manager directly involved in such a decision confirmed that ''normally it is the team.'' Our interviewees also shared multiple reasons why suppliers would generally not terminate the relationship with a constructor; we document these in table A2 in Online Appendix A.

Independent variables. The independent variables in our main analyses are defined at the end of the season in year t. To create our variables for

Figure 1. Configurations of joint component usage.



performance–aspiration gaps, we first specified a performance measure. We used the constructor's total number of points scored in the World Championship in the focal year (i.e., the sum of points awarded in each Grand Prix) divided by the total points awarded to all teams, to normalize for differences in the scoring scheme between years (Castellucci and Ertug, 2010).

Focal performance–aspiration gap (baseline). We created measures of the aspiration level for the focal firm (i) using a weighted average of social and historical aspiration level (Greve, 2003a). The social aspiration level was calculated as the mean performance level, which is by construction the reciprocal of the number of constructors in the World Championship in the focal year. The historic aspiration level (L_{it}) was calculated using an exponential updating function of the focal constructor's past performance (P_{it-1}) (Greve, 2003a):

$$L_{it} = \alpha_1 L_{it-1} + (1 - \alpha_1) P_{it-1}$$

The updating parameter α_1 specifies the weight placed on past aspirations versus the weight placed on recent performance, so that lower values of α_1 correspond to faster updating. In line with the literature, we set the updating parameter based on the best model fit (α_1 = .5) and tested for robustness to a range of values on either side (Greve, 2003a).[7] Similarly, when specifying the relative weights of historic and social aspirations, we based the parameter on the best model fit and tested for robustness.[8] The focal constructor's performance–aspiration gap in the focal year was calculated by subtracting its weighted average aspiration level from its performance and using a spline specification to separate performance below aspirations from performance exceeding aspirations. We reverse-coded the negative part of the spline to ease interpretation of the coefficients—that is, so that our baseline hypothesis corresponds to a positive coefficient.

Vicarious performance–aspiration gap (H1). With this variable, we aimed to capture the deviation of the focal constructor's joint component users (denoted $j = 1, \ldots, N$) from their historic levels of performance, as perceived by the focal constructor. We therefore calculated a distinct "vicarious" aspiration level $\left(V_{jt}\right)$. We do not see any *a priori* reason that managers' own historic aspirations and vicarious expectations about competitors' performance should update at the same rate. For this reason, we allowed those two parameters to vary independently. We calculated the historic aspiration level as outlined above, with an updating parameter based on best model fit (α_2 = .6).[9] This aspiration level was subtracted from the joint component user's performance to create a vicarious performance–aspiration gap. When there was more than one joint component user (other than the focal firm), these were aggregated by taking the mean value:

[7] Our results are robust to setting α_1 between .3 and .7.

[8] We defined the mixed aspiration level with .9 weight on the historic aspiration and .1 weight on the social aspiration. Our results are robust to setting a weight on the social aspiration between 0 and .3. When new constructors entered the panel, we had insufficient data to calculate historic aspiration levels; thus in the first year in which a constructor appears we used the social aspiration level.

[9] Our results are robust to setting α_2 between .5 and .8. See Online Appendix B for details of parameter selection for the performance feedback and vicarious performance feedback variables.

$$VPF_{it} = \frac{\sum_{j=1}^{N} \left(P_{jt} - V_{jt}\right)}{N}$$

This vicarious performance–aspiration gap was subjected to a spline transformation about zero, and the negative component of the spline was reverse-coded to ease interpretation. For constructors with no joint component users, we coded this variable as zero.

Moderating variables. *Direct × Vicarious interaction.* We tested the interaction between direct and vicarious performance feedback by interacting the continuous measures of vicarious performance feedback with dummy variables indicating whether the firm's own performance is above or below its aspiration level. This allowed us to directly compare the strength of vicarious performance feedback in the domains in which direct performance feedback is satisfactory (i.e., above aspiration) or unsatisfactory (i.e., below aspirations, predicted to trigger problemistic search).[10]

Number of joint component users. This variable is a count of the number of structurally equivalent constructors who use engines from the same supplier as the focal firm. As depicted in figure 1, for firm X_1 this variable is a count of firms of type X with the same supplier, and for firm Z_1 it is a count of firms of type Z with the same supplier.

Geographic proximity. We calculated the geographic distance between the focal firm and its engine supplier in units of 1,000 km based on the latitude and longitude associated with the organizations' addresses recorded in *Who Works in Formula 1*. We took the log of this variable to reduce skewness. To test hypothesis 3, we standardized this variable in our interaction terms, which eases the interpretation of coefficients.

Control variables. We controlled for numerous factors that have been linked to interorganizational tie dissolution in prior research. We controlled for supplier relationship length and its squared term to capture the nonlinear duration-dependence in the fragility of interorganizational ties (Levinthal and Fichman, 1988). We coded relationship length in years, capping the variable at five years so that a small number of very long relationships do not distort the coefficient estimates.[11] We used three dummy variables to control for the main effect of a constructor's engine supply configuration: the first is set to 1 for constructors that produce their engine in-house, the second is set to 1 for constructors that procure an engine from one of those vertically integrated teams, and the third is set to 1 for constructors with an exclusive relationship with a third-party supplier.

Prior work has found that interorganizational ties with a larger status inequality between members are less stable (Rowley et al., 2005). We therefore controlled for the status difference between a firm and its supplier. We measured a constructor's status as described and validated by Castellucci and Ertug

[10] We checked the robustness of our findings to other interaction specifications, i.e., interacting two continuous variables or interacting two dummy variables, and found consistent results (see table C2 in Online Appendix C).

[11] Without this cap, the results show the same pattern of statistical significance, but the model fit is substantially worse, with adjusted R^2 of 17.4% instead of 20.1% in the full model.

(2010): we used the count of its press mentions in the previous year, based on searches of the Factiva database, which was then residualized on its performance. Supplier status is defined as the mean status of the constructors it supplies (Castellucci and Ertug, 2010). We controlled for a firm's tendency to switch exchange partners often by including a measure of supplier churn: the number of terminated relationships in the preceding five years (Baker, Faulkner, and Fisher, 1998). Because prior work has found that tie breakage is more likely if a firm has more "outside options," we controlled for the number of engine makers active in the focal year (Greve, Mitsuhashi, and Baum, 2013).[12]

Prior work has found that personnel mobility, such as the departures of key decision makers and exchange managers, often precedes interorganizational tie dissolution (Broschak, 2004; Rogan, 2014; Bermiss and Greenbaum, 2016). We collected personnel data for a subset of our panel (for the years 1994 to 2013) from the annual publication *Who Works in Formula 1* (Grégoire, 2013).[13] This publication lists names and job titles of senior managers and selected technical employees for both constructors and engine suppliers. We assembled a list of job titles and qualitatively coded which of them refer to decision makers who influence whether to dissolve a supplier tie. We then identified, for each constructor-year, the set of managers at the constructor who are likely to be the key decision makers. To control for personnel mobility, we defined a variable, *constructor decision maker exits*, as a count of decision-making managers who departed the constructor between the prior year and focal year of analysis.[14]

Model Specification

We followed the literature on dissolution of interorganizational ties (e.g., Rowley et al., 2005) by specifying a discrete-time hazard model. A constructor makes a decision about its engine supplier as part of an annual cycle of designing a car for the following F1 season. Our unit of analysis is therefore the constructor-supplier-year. To control for time-invariant tendencies for constructors to change suppliers, we used constructor-level fixed effects. Consequently, we used the linear probability model (LPM), rather than the logit or probit models, to circumvent the incidental parameters bias that can afflict nonlinear models with fixed effects. Standard errors are clustered by constructor and by supplier to address the non-independence of error terms introduced by repeated observations of the same actors (Cameron, Gelbach, and Miller, 2011).

Descriptive statistics are reported in table 2. The mean value of the dependent variable is .24 indicating that, on average, a constructor changes its engine supplier about every four years.

[12] Our results are robust to specifications that weight these "outside options" according to the supplier's performance. This gives us confidence that our results are not an artifact of constructors dissolving ties in order to form a new tie with a better-performing engine supplier.

[13] Because we have incomplete data on exchange manager mobility, we created a dummy variable that is coded 1 when data are missing.

[14] Our findings are robust to specifications that control for contemporaneous decision-maker mobility and to the inclusion of an analogous mobility variable relating to managers at the engine supplier.

Table 2. Descriptive Statistics and Correlations

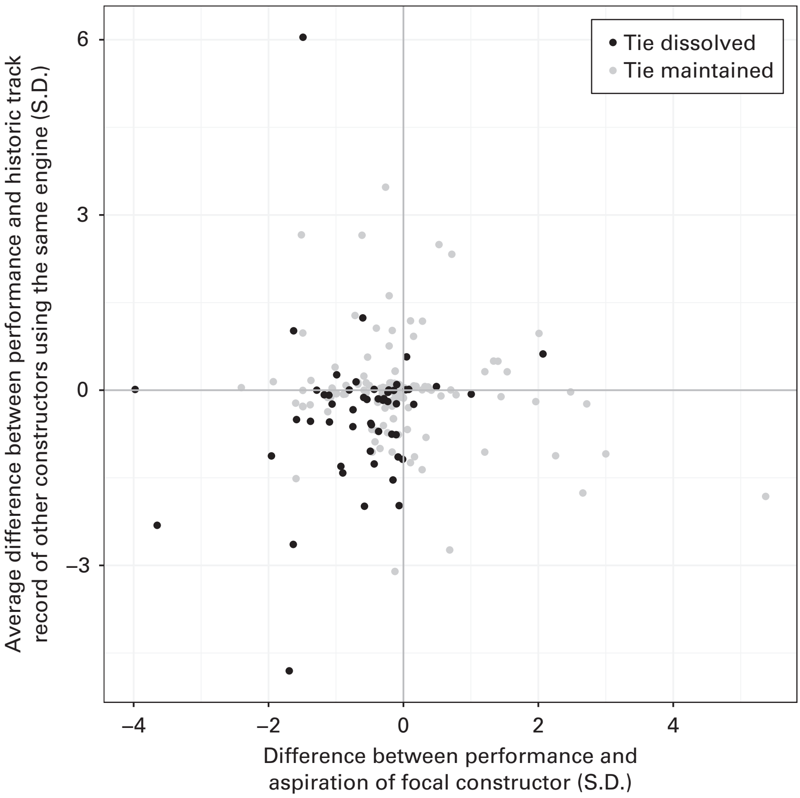
	Mean	S.D.	Min.	Max.	1	2	3	4	5	6
1. Change of engine supplier	.24	.43	0	1						
2. Change of driver lineup	.62	.49	0	1	.22					
3. Supplier relationship length (years, max. 5)	1.93	1.97	0	5	−.2	−.17				
4. Engine supplied by competitor	.11	.31	0	1	−.09	−.09	−.06			
5. Vertically integrated constructor	.18	.39	0	1	−.24	−.17	.42	−.17		
6. Exclusive third-party supplier	.31	.46	0	1	.13	.11	−.11	−.24	−.32	
7. Status difference	.63	.94	0	7.84	.18	0	−.27	.04	−.16	−.15
8. Supplier churn (5 years)	.98	1.17	0	4	.23	.18	−.5	.03	−.36	.26
9. Number of engine makers	7.58	1.79	4	10	.19	.16	−.15	−.32	−.09	.33
10. Constructor decision-maker exits	.26	.63	0	4	−.01	−.12	.03	.18	.1	−.06
11. Distance to engine maker (‘000 km)	.81	2.01	0	9.87	.16	.07	−.21	−.08	−.17	.28
12. Number of constructors using engine	2.74	3.10	1	12	−.02	.11	.03	−.14	−.27	−.38
13. Performance below aspirations	.02	.03	0	.22	.15	.05	−.03	−.05	.04	−.06
14. Performance above aspirations	.02	.04	0	.30	−.19	−.2	.2	0	.15	.03
15. Vicarious performance below historic level	.01	.02	0	.23	.13	−.08	−.12	.16	−.12	−.26
16. Vicarious performance above historic level	.01	.02	0	.29	−.03	−.04	.03	.09	.02	−.17

	7	8	9	10	11	12	13	14	15
8. Supplier churn (5 years)	.2								
9. Number of engine makers	.03	.24							
10. Constructor decision-maker exits	.06	.05	−.16						
11. Distance to engine maker (‘000 km)	.03	.27	.16	.01					
12. Number of constructors using engine	−.01	−.14	−.21	−.16	−.09				
13. Performance below aspirations	.24	−.12	.03	−.07	−.03	−.06			
14. Performance above aspirations	−.1	−.06	−.02	.09	−.09	−.14	−.3		
15. Vicarious performance below historic level	.39	.09	−.06	.04	−.05	0	.07	.07	
16. Vicarious performance above historic level	.06	.03	−.15	0	−.05	−.04	.1	−.05	−.09

RESULTS

Figure 2 displays a scatter plot of all the observations in our data for which a constructor has at least one joint component user. The horizontal axis depicts the constructor’s own performance versus aspirations, and the vertical axis depicts the vicarious performance feedback that the constructor might observe. Points in the scatter plot are color-coded: black represents a constructor–supplier tie that was dissolved, while grey represents a constructor–supplier tie that was retained. Black points appear disproportionately to the left of the vertical axis, where own performance is below aspirations (31 percent dissolve, compared with 12 percent above aspiration). This provides some nonparametric evidence supporting the baseline hypothesis. Dissolutions also appear disproportionately below the horizontal axis, where vicarious performance feedback is negative (28 percent dissolve compared with 23 percent above the axis). This provides some nonparametric support for hypothesis 1. In addition, dissolutions appear disproportionately in the lower-left quadrant, where the firm’s own performance and vicarious performance are both below aspirations (34 percent dissolve), providing some nonparametric evidence in support of hypothesis 2.

Figure 2. Scatterplot of tie dissolution versus retention at varying levels of own and vicarious performance feedback.*



* Each point represents one constructor-supplier-year observation for a constructor that has at least one joint component user.

Main Regression Analyses

Table 3 reports the results of the linear regression models. Model 1 contains control variables and the direct performance feedback variables testing the baseline hypothesis. Model 2 tests hypothesis 1; models 3 through 5 test hypotheses 2 through 4 separately. Model 6 tests all hypotheses together using two-way interaction terms. Model 7 tests whether direct performance feedback (H2) interacts with the other two moderating variables.

Coefficients on the control variables are fairly consistent in magnitude across the seven models. Five of the control variables have statistically significant coefficients. The linear and quadratic variables for *supplier relationship length* are significantly positive and negative, respectively, generating an inverted-U-shaped duration dependence with an inflection point at approximately 3.7 years. This finding is consistent with prior work suggesting that interorganizational ties exhibit a ''honeymoon period'' followed by a ''liability of adolescence'' (Levinthal and Fichman, 1988; Fichman and Levinthal, 1991; Baker, Faulkner, and Fisher, 1998). A constructor supplied by a competing team is less likely to dissolve that tie than constructors with other supply arrangements. A

Table 3. Linear Regression of Change of Engine Supplier, 1981–2013*

	Model 1 Baseline	Model 2 Test H1	Model 3 Test H2	Model 4 Test H3	Model 5 Test H4	Model 6 Full	Model 7 Three-way interactions
Supplier relationship length (years, max. 5)	.15••	.15••	.13•	.14••	.14••	.12+	.13•
	(.05)	(.05)	(.06)	(.05)	(.05)	(.06)	(.06)
Supplier relationship length^2	–.04••	–.04••	–.03••	–.04••	–.04••	–.03•	–.03•
	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)
Engine supplied by competitor	–.23•	–.19+	–.21+	–.20	–.18+	–.22+	–.21+
	(.11)	(.11)	(.11)	(.12)	(.11)	(.12)	(.13)
Vertically integrated team (0/1)	.00	.04	.01	.03	.02	–.01	.01
	(.14)	(.14)	(.14)	(.17)	(.15)	(.18)	(.20)
Exclusive third-party supplier	–.02	.02	–.00	.01	.03	–.01	–.02
	(.13)	(.13)	(.13)	(.14)	(.13)	(.15)	(.16)
Status difference	.04	.02	.02	.01	.02	.02	.01
	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)
Distance to engine maker	.01	.01	.01	.01	.00	.00	–.03
	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)	(.03)
Supplier churn (5 years)	–.11•	–.12•	–.12•	–.11•	–.12•	–.12•	–.14••
	(.05)	(.05)	(.05)	(.05)	(.05)	(.06)	(.05)
Number of engine makers	.02	.01	.01	.01	.01	.01	.01
	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)	(.02)
Number of constructors using engine	–.02•	–.02+	–.02+	–.03	–.02+	–.03	–.02
	(.01)	(.01)	(.01)	(.02)	(.01)	(.02)	(.03)
Constructor decision-maker exits	.04	.04	.04	.03	.04	.03	.01
	(.03)	(.04)	(.04)	(.04)	(.04)	(.04)	(.06)
No data on constructor decision maker (0/1)	.02	.02	.03	.00	.01	.00	–.01
	(.07)	(.07)	(.08)	(.07)	(.07)	(.08)	(.07)
Performance below aspirations	2.14•	2.08•	1.46+	2.07•	2.10•	1.53+	1.55+
	(.93)	(.94)	(.84)	(.97)	(.94)	(.90)	(.94)
Performance above aspirations	–1.26•	–1.42•	–.72	–1.35•	–1.35•	–.67	–.59
	(.57)	(.63)	(.65)	(.64)	(.63)	(.66)	(.76)
Direct feedback (–) (0/1)			.05			.04	.03
			(.06)			(.06)	(.07)
Direct (–) × No. of engine users							–.09
							(.06)
Direct (–) × Distance to engine maker							.11•
							(.05)
Vicarious performance below historic level		2.61••		2.89••	2.74••		
		(.92)		(1.05)	(.72)		
Vicarious performance above historic level		–1.04		–1.36	–.74		
		(1.05)		(1.81)	(2.81)		
Vicarious performance below historic level × Direct (–)			3.61••			3.81••	2.14•
			(1.01)			(.97)	(1.03)
Vicarious performance above historic level × Direct (–)			–.62			–1.81	1.26
			(.94)			(2.68)	(2.35)
Vicarious performance below historic level × Direct (+)			–3.16			–2.35	–2.60
			(1.98)			(2.28)	(2.01)
Vicarious performance above historic level × Direct (+)			–3.24•			–4.75	–4.87
			(1.48)			(3.78)	(4.03)
VPF below historic level × No. of engine users				5.19••		5.03••	
				(1.20)		(1.31)	
VPF above historic level × No. of engine users				–1.38		–2.35	
				(8.49)		(8.55)	
VPF below historic level × Distance to engine maker					2.16•	1.85+	
					(.97)	(.95)	

(continued)

Table 3. (continued)

	Model 1 Baseline	Model 2 Test H1	Model 3 Test H2	Model 4 Test H3	Model 5 Test H4	Model 6 Full	Model 7 Three-way interactions
VPF above historic level × Distance to engine maker					.92 (10.46)	−2.89 (10.74)	
VPF below historic level × Direct (−) × No. of engine users							6.01•• (1.87)
VPF above historic level × Direct (−) × No. of engine users							3.37 (6.27)
VPF below historic level × Direct (+) × No. of engine users							8.48 (7.96)
VPF above historic level × Direct (+) × No. of engine users							−7.07 (10.07)
VPF below historic level × Direct (−) × Distance to engine maker							3.34•• (1.05)
VPF above historic level × Direct (−) × Distance to engine maker							−4.00 (4.22)
VPF below historic level × Direct (+) × Distance to engine maker							−3.01 (3.93)
VPF above historic level × Direct (+) × Distance to engine maker							−1.57 (6.12)
Observations	432	432	432	432	432	432	432
Number of constructors	57	57	57	57	57	57	57
Adjusted R-squared (within constructor)	.125	.141	.165	.154	.141	.176	.201
Constructor fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

+ $p < .10$; •$p < .05$; ••$p < .01$.

* Robust standard errors, in parentheses, are clustered by constructor and engine supplier.

constructor's recent level of *supplier churn* is negatively related to the risk of subsequent supplier tie dissolution. This coefficient might reflect strategic deceleration of supplier tie dissolution (Beck, Brüderl, and Woywode, 2008), or it may be picking up ''regression to the mean'' in the panel data. The number of other constructors using an engine is negatively related to tie dissolution in the baseline model, though this coefficient is nonsignificant in the other models.

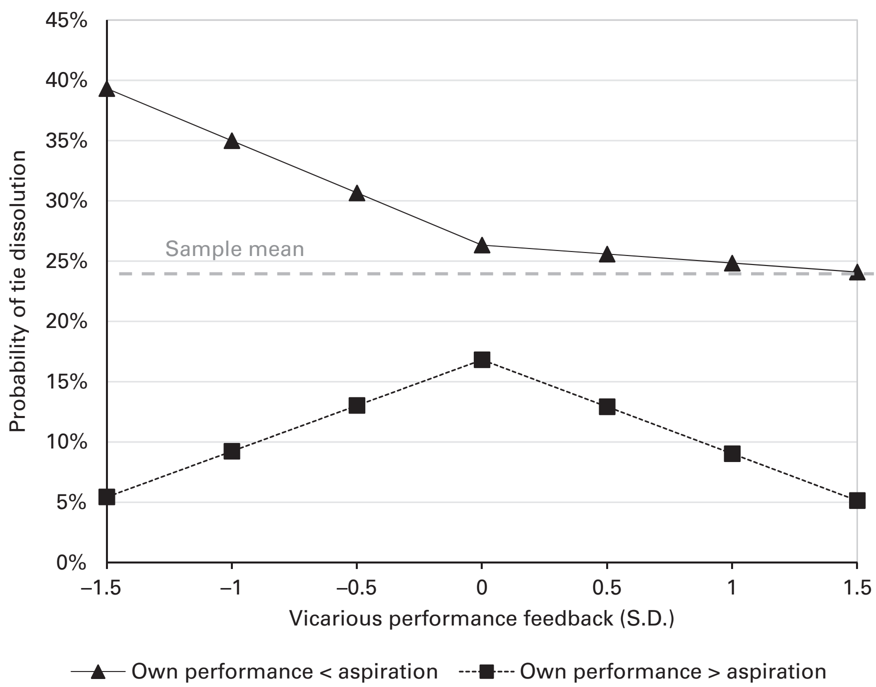
The coefficient on the variable for direct performance feedback when performance is below aspirations is in line with our baseline hypothesis: the further a constructor's performance drops below its aspirations, the more likely it is to dissolve its supplier tie. The effect is economically significant, with a one-standard-deviation drop in performance below the aspiration level associated with a 7.1-percentage-point increase in the likelihood of a supplier tie dissolving.

Model 2 tests hypothesis 1 using the coefficient on the variable *vicarious performance below historic level*. The positive and significant coefficient on this variable supports hypothesis 1. The farther that firms using the same engine component as the focal firm drop below their historic performance levels, the more likely the focal firm is to dissolve its supplier tie. A one-standard-deviation drop below historic levels is associated with a 1.9-percentage-point increase in the likelihood of tie dissolution, an economically significant effect size roughly one quarter the magnitude of direct performance feedback.

Hypothesis 2 predicts that vicarious performance feedback is stronger when a firm's own performance is below its aspiration than when it is above its aspiration. Model 3 tests this by interacting the vicarious performance feedback term with a pair of dummy variables: *direct* (–) captures own performance below aspiration, and *direct* (+) captures own performance above aspiration. The interaction term with own performance below aspiration is significant and positive, while the interaction term with own performance above aspiration is nonsignificant. A Wald test finds that the difference between the two coefficients is significant ($p < .01$), providing support for hypothesis 2. Moreover, the nonsignificant coefficient on the interaction term with own performance above aspiration places a boundary condition on vicarious performance feedback, suggesting that managers respond to vicarious performance feedback only when their own experience is below aspirations. Figure 3 displays the effect size associated with vicarious performance feedback. It plots predicted probabilities of tie dissolution for constructors whose own performance is above or below aspirations for a range of values of vicarious performance feedback. The main finding in support of hypothesis 2 is represented by the solid line rising as vicarious performance declines below zero.

Hypothesis 3 predicts that vicarious performance feedback is stronger when more other constructors are using the same engine as the focal constructor. Model 4 tests this using an interaction term between vicarious performance feedback and (standardized) number of engine users. The positive and significant coefficient on this interaction term supports hypothesis 3. This coefficient

Figure 3. Estimated effects of vicarious performance feedback with own performance above and below aspirations.



size indicates that when the number of engine users is one standard deviation above the mean level (i.e., six firms use the engine), the constructor is roughly 2.8 times as sensitive to vicarious performance feedback as when the number of engine users is at the mean level of three.

Hypothesis 4 predicts that vicarious performance feedback is weaker for constructors that are geographically proximate to their supplier. Model 5 tests this using an interaction term between vicarious performance feedback and (standardized) geographic distance. The positive and significant coefficient on this interaction term supports hypothesis 4. It suggests that if a constructor is one standard deviation above the mean distance from its supplier, the constructor is roughly 1.8 times as sensitive to vicarious performance feedback, compared with a constructor at the mean distance.

Models 6 and 7 test the three moderating hypotheses simultaneously. Model 6 uses two-way interaction terms; it tests the number of engine users and geographic proximity as moderators of the main effect of vicarious performance feedback. Model 7 provides an interacted model that tests the moderating effect of number of engine users and geographic proximity in the context of the finding that vicarious performance feedback is contingent on direct performance feedback being negative. This is our preferred model, as it is both flexible—in the sense of imposing few constraints on how variables interact—and comprehensive—in the sense that it includes all three moderators of vicarious performance feedback. Model 7 provides support for hypotheses 2, 3, and 4 and supports the contingent nature of vicarious performance feedback. Model 7 has the highest explanatory power of our models, with an adjusted R^2 of 20.1 percent, compared with a value of 12.5 percent in the baseline model.

Figures 4a and 4b display the moderating effects measured in model 7. Figure 4a depicts the interaction between vicarious performance feedback and the number of engine users; figure 4b depicts the interaction between vicarious

Figure 4a. Estimated effects of vicarious performance feedback at varying numbers of other component users and own performance below aspiration.

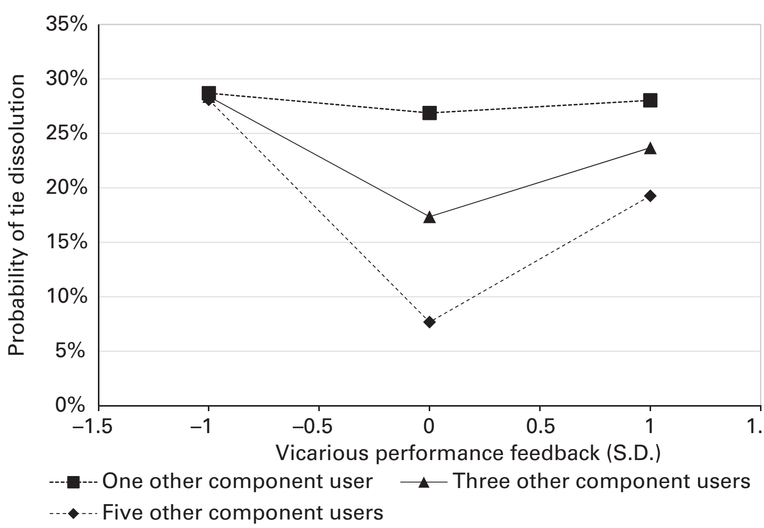
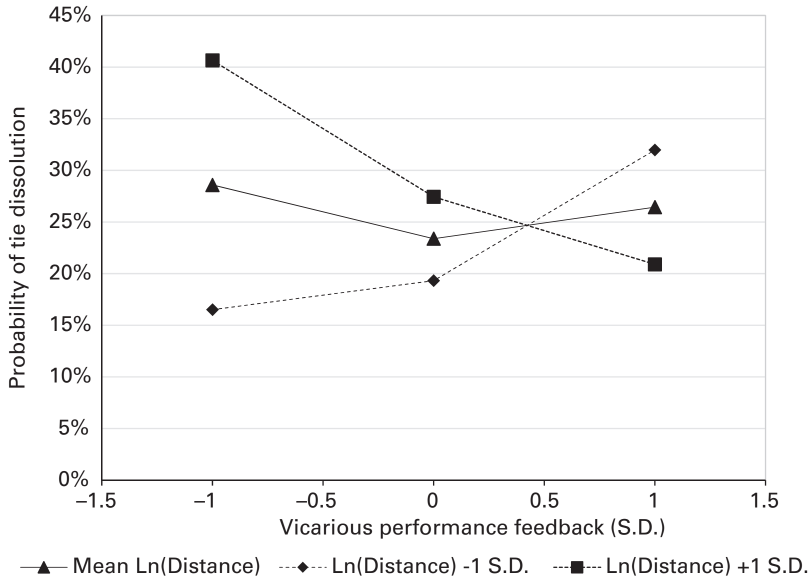


Figure 4b. Estimated effects of vicarious performance feedback at varying distances between constructor and supplier and own performance below aspiration.



performance feedback and the geographic distance between constructor and supplier.

Robustness to Alternate Explanations

To further support our reasoning, we would like to rule out—or control for—a number of possible alternate explanations.

Imitation. This factor is a well-known cause of correlations in organizations' behavior. Interorganizational imitation has been studied both in institutional theory, under the label of mimetic isomorphism (DiMaggio and Powell, 1983), and in competitive strategy as a strategic move that laggard firms can employ to catch up to leaders (Lieberman and Asaba, 2006). If the dissolution of supplier ties is subject to imitation, we might erroneously attribute to vicarious performance feedback what is, in fact, the result of a combination of direct performance feedback and imitation. For example, assume firms A and B share a supplier S and that B's performance drops below its historic level. Direct performance feedback would make B more likely to dissolve its tie to S. If firm A imitates the tie dissolution, we would observe a pattern of data that resembles vicarious performance feedback but is not driven by our proposed mechanism.

To help rule out imitation as a possible explanation for our results, we exploited a feature of our empirical setting: engine supply decisions are negotiated separately by constructors during the preceding F1 season. This negotiation process takes place confidentially, with the outcomes gradually becoming public knowledge toward the end of the season. Imitation is therefore unlikely to be a major factor midway through a season, although it could plausibly happen at the end. We therefore re-ran our regression models using the constructor's performance at the end of the eighth race in the season, roughly halfway through, to construct the performance feedback variables. Model 1 in table 4 displays the results of this model and still finds significant support for vicarious performance feedback.

Another approach to ruling out imitation as an alternate explanation is to directly control for other firms' behavior. We created a variable counting the number of firms with the same supplier that dissolve that tie after a given year.[15] This is a particularly stringent specification as it controls for any correlation in behavior between customers of the same supplier, whether the correlation is ultimately caused by imitation or by vicarious performance feedback. Results with this additional control variable are reported in model 2 in table 4. Hypotheses 2 and 4 are supported at the 10-percent and 1-percent significance levels, respectively. The coefficient testing hypothesis 3 is nonsignificant, likely because the *number of engine users* moderator is correlated with *count of other component users that terminate supplier relationship*. The coefficient on the new variable is not statistically significant. Vicarious performance feedback thus has stronger explanatory power than imitation in accounting for constructors' tie dissolution decisions.

Underlying engine quality. A second possible alternate explanation is what we might call a ''mere quality'' effect. We have argued that managers' quality inferences are based on their observations of competitors' performance, which they then compare with the same firms' historic track records. One premise of our theory is that an engine component's quality is hard to assess directly because it functions within a complex product system. If managers were able to assess quality more directly, however, we would still expect dissolution of supplier ties to be correlated with poor performance. Ideally, we would therefore like to control for the absolute level of underlying component quality when testing our hypotheses. Engine quality is multidimensional with some unobservable aspects to it. In the absence of a single, unified measure of engine quality, our next best approach is to develop multiple proxies for engine quality from observable data.

We developed proxies for engine quality based on championship performances, engine reliability, and vehicle speeds. To operationalize the (absolute) championship performance of an engine supplier, we took the World Championship points share of the best-performing team that the engine maker supplies (similar results are found if we take the average). To operationalize engine reliability, we analyzed records published by the *Fédération Internationale de l'Automobile* (FIA), which specify the reasons why a driver fails to finish a Grand Prix. From these records we coded the instances when drivers withdrew from a race due to engine failure. We counted the engine failures attributed to each supplier in a given year and divided this by the total number of engine failures that year to account for the broad trend of increasing reliability over time. To operationalize vehicle speed, we used records of lap times from the practice and qualifying sessions that

[15] Results are robust to controlling for the proportion of joint component users who dissolve a supplier tie instead of the count of such users.

Table 4. Robustness Tests: Linear Regression Models for *Change of Engine Supplier* (Models 1–6) and *Change of Driver Lineup* (Model 7), 1981–2013*

	Model 1 Mid-season	Model 2 Imitation	Model 3 Quality	Model 4 Quality	Model 5 Quality	Model 6 Quality	Model 7 Drivers
Supplier relationship length (years, max. 5)	.13•	.12+	.12•	.15••	.13•	.13•	
	(.05)	(.06)	(.05)	(.06)	(.06)	(.06)	
Supplier relationship length^2	–.03••	–.03•	–.03••	–.04••	–.03•	–.03•	
	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	
Engine supplied by competitor	–.18	–.18	–.26•	–.24•	–.21+	–.20	
	(.14)	(.12)	(.13)	(.12)	(.13)	(.13)	
Vertically integrated team (0/1)	.10	.01	.02	–.01	.01	–.06	
	(.14)	(.19)	(.14)	(.15)	(.19)	(.20)	
Exclusive third-party supplier	.02	–.00	–.07	–.04	–.03	–.05	
	(.15)	(.16)	(.14)	(.13)	(.16)	(.16)	
Status difference	.04	.02	.05	.04	.01	.00	
	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	
Distance to engine maker	.01	–.03	.01	.01	–.03	–.02	
	(.02)	(.03)	(.02)	(.02)	(.03)	(.03)	
Supplier churn (5 years)	–.11+	–.14••	–.13••	–.12•	–.14••	–.13•	
	(.06)	(.05)	(.04)	(.05)	(.05)	(.05)	
Number of engine makers	.02	.01	.01	.01	.01	.00	
	(.02)	(.02)	(.02)	(.02)	(.03)	(.02)	
Number of constructors using engine	–.02	–.02	–.02+	–.02	–.02	–.02	
	(.01)	(.03)	(.01)	(.01)	(.03)	(.03)	
Constructor decision-maker exits	.03	.02	.02	.04	.02	.02	
	(.04)	(.06)	(.04)	(.04)	(.06)	(.06)	
No data on constructor decision maker	.03	–.02	–.01	.01	–.01	–.04	
(0/1)	(.09)	(.07)	(.07)	(.07)	(.07)	(.08)	
Performance below aspirations	.86	1.45		2.04•	1.54	1.57+	2.74••
	(.77)	(.90)		(.90)	(.94)	(.88)	(.59)
Performance above aspirations	–.80	–.51		–.87+	–.57	–.71	–2.14••
	(.64)	(.66)		(.51)	(.91)	(.90)	(.27)
Direct feedback (–) (0/1)	.03	.04			.03	.03	–.20•
	(.09)	(.06)			(.07)	(.07)	(.08)
Direct (–) × No. of engine users		–.11•			–.09	–.09	
		(.05)			(.06)	(.06)	
Direct (–) × Distance to engine maker		.11•			.11•	.10+	
		(.05)			(.05)	(.05)	
Vicarious performance below historic	3.41••	1.47+			2.14+	1.97+	–2.59•
level × Direct (–)	(.73)	(.82)			(1.09)	(1.01)	(1.04)
Vicarious performance above historic	–.29	2.07			1.30	1.02	–1.26
level × Direct (–)	(.67)	(2.24)			(2.36)	(2.34)	(1.19)
Vicarious performance below historic	–.54	–3.07			–2.59	–2.77	–.63
level × Direct (+)	(1.28)	(2.03)			(1.95)	(1.84)	(2.70)
Vicarious performance above historic	–1.51	–4.63			–4.81	–5.13	1.46
level × Direct (+)	(1.08)	(3.92)			(4.13)	(4.01)	(1.53)
VPF below historic level × Direct (–) ×		3.03			5.97••	5.55••	
No. of engine users		(2.31)			(1.71)	(1.61)	
VPF above historic level × Direct (–) ×		5.62			3.34	2.87	
No. of engine users		(5.80)			(6.28)	(6.48)	
VPF below historic level × Direct (+) ×		5.91			8.42	8.77	
No. of engine users		(7.44)			(8.33)	(8.12)	
VPF above historic level × Direct (+) ×		–6.34			–7.03	–7.68	
No. of engine users		(9.55)			(10.15)	(10.06)	

(continued)

Table 4. (continued)

	Model 1 Mid-season	Model 2 Imitation	Model 3 Quality	Model 4 Quality	Model 5 Quality	Model 6 Quality	Model 7 Drivers
VPF below historic level × Direct (–) ×		3.34••			3.35••	3.88••	
Distance to engine maker		(1.05)			(1.02)	(.82)	
VPF above historic level × Direct (–) ×		–4.30			–3.98	–3.93	
Distance to engine maker		(4.15)			(4.31)	(4.26)	
VPF below historic level × Direct (+) ×		–2.66			–3.02	–2.75	
Distance to engine maker		(3.87)			(3.94)	(3.80)	
VPF above historic level × Direct (+) ×		–1.04			–1.53	–.84	
Distance to engine maker		(6.11)			(6.05)	(5.79)	
Count of other component users that		.05					
terminate supplier relationship		(.03)					
Engine maker: best customer performance			–.81•	–.39	–.03	.16	
(points share)			(.40)	(.35)	(.42)	(.43)	
Engine failures (this supplier as % of						.56+	
year's total)						(.31)	
Engine maker: best average speed in year						–.03	
						(.03)	
Observations	432	432	432	432	432	432	432
Number of constructors	57	57	57	57	57	57	57
Adjusted R-squared (within constructor)	.113	.205	.097	.128	.199	.207	.052
Constructor fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

+ $p < .10$; •$p < .05$; ••$p < .01$.

* Robust standard errors, in parentheses, are clustered by constructor and engine supplier.

take place on the first and second days of each Grand Prix weekend, and we calculated the average speed of each driver's fastest qualifying lap. Among these we found, for each year, the best average speed achieved by any driver using a given engine.

Model 3 in table 4 enters the championship performance variable alongside the control variables; model 4 adds the direct performance feedback variable; and model 5 adds the vicarious performance feedback variables. In the absence of our performance feedback variables, there is a significant negative correlation between absolute performance and tie dissolution, as expected. When the performance feedback variables are added, the coefficient on absolute quality drops below significance and adjusted R^2 increases, indicating that the performance feedback variables better capture managerial tendencies to dissolve the supplier tie than the ''mere quality'' measure. A similar pattern of results is obtained for the other two proxies of engine quality (reported in table C1 in Online Appendix C). Model 6 enters all three proxies of engine quality alongside our theoretical variables. Hypotheses 2, 3, and 4 remain supported even with this multidimensional approach to controlling for absolute engine quality.

Alternate dependent variable. As a further test of our proposed mechanism, we examined an alternate dependent variable: whether a constructor changes its driver roster in the subsequent F1 season. We earlier reasoned that managers have difficulty attributing performance among underlying organizational resources. We argued that vicarious observation of declines in performance at other constructors using the same engine supplier allows managers to attribute their own performance to that supplier. A corollary of this is that the constructor's drivers are less likely to be blamed for any perceived underperformance of the overall organization. We would therefore expect that negative vicarious performance feedback would be associated with a lower likelihood that the driver roster will change after a given F1 season. We ran a linear regression model with *change of driver lineup* as the dependent variable and used our direct and vicarious performance feedback measures as independent variables. Results of this analysis are reported in model 7 in table 4. Consistent with standard behavioral theory, constructors are more likely to change their driver lineup the farther their own performance falls below aspirations. Also, consistent with our theory, constructors are less likely to change their driver lineup after negative vicarious performance feedback at the engine level.

Other robustness tests. Our qualitative evidence—described above and shown in table A2 in the Online Appendix—indicates that suppliers are not the decision makers behind tie dissolution in F1 and that the locus of decision making rests with the top managers of F1 constructors. To further validate our approach, we generated engine supplier-level performance feedback variables for supplier performance below and above aspiration. Table C1 in the Online Appendix adds these two variables to our regression model. Coefficients on these variables are nonsignificant, and our theoretical variables in support of hypotheses 2, 3, and 4 remain significant, providing some quantitative assurance that engine makers are not important decision makers in the dissolution of constructor–supplier ties.[16]

We also tested the robustness of our findings to alternate variable specifications, which we report in tables C2 and C3 in the Online Appendix. First, while our main analysis aggregates the vicarious performance feedback of multiple joint component users by taking the mean value, our findings are robust to taking the median. Also, similar results are obtained using simple count variables of the number of joint component users whose performance is above or below their historic performance. Second, the interaction between direct and vicarious performance feedback, tested in hypothesis 2, is robust to alternate specifications, including interacting two continuous variables or interacting two dummy variables. Third, the main effect of a firm's own performance feedback (the baseline hypothesis) is robust to alternate specifications, such as taking the median instead of mean performance to define the social aspiration level. We find strong support for the baseline hypothesis when a firm's own performance feedback is operationalized using a historically based social aspiration threshold (HiBSAT) as described in work by Moliterno et al. (2014); see table C3 in the Online Appendix for details. Additionally, we find support for our hypotheses when controlling for other engine makers' performance to capture the attractiveness of a firm's outside options.

[16] In Online Appendix D we report analyses of the performance trajectories for engine suppliers after ties with constructors dissolve. We find that these trajectories tend to be negative, implying that suppliers do not regularly break ties with weak constructors in order to form ties with better-performing constructors.

Qualitative Evidence

The qualitative data we collected corroborates and enriches our quantitative analyses. Across our interviews it became evident that, in line with our baseline hypothesis, a constructor's decision to dissolve the collaboration with its engine supplier depends on performance feedback. The chief operating officer of an F1 constructor told us, "The reason why we moved away from [engine supplier A] to [engine supplier B] was very simple: performance. I mean, [engine supplier A]'s engine was so bad that you were simply not competitive if you were running a [supplier A] engine."

Our interviews also provided strong evidence that managers assessed an engine by studying the performance of all constructors using it. When asked about the relative performance of the Mercedes and Ferrari engines, a vehicle modeling engineer said, "You should look not just at the Mercedes team and the Ferrari team but [also] at the customer teams." Another interviewee said, "You look at performance by engine, so obviously for [the] Mercedes [engine] that's all the teams they supply." When studying the performance across teams, our interviewees considered performance relative to historical performance. As a vehicle performance engineer explained, "If you look at a team that was using another engine manufacturer, and then when they switched to Mercedes with a new engine, you could all of a sudden see a jump in performance." It also became evident that managers draw conclusions about component quality based on vicarious performance feedback. Discussing the reasons his employer (a constructor) performed below its target level, one interviewee said, "Listen, [team C] is using the same engine and look at them, they're winning races. It's not the engine."

Our interviews also corroborated our quantitative evidence on hypothesis 2 that managers learn from vicarious performance feedback particularly when their organization performs below aspirations. The former CEO of an F1 constructor told us, "You monitor the competition all the time. . . . [W]hen you think about switching your engine supplier, which is a major decision you only make if your performance is not where you want it to be, you look at other teams using the same powertrain you already have and check whether they do better or worse than you would expect." A performance vehicle engineer revealed, "I collect data on all the teams all the time. What changes is to what degree that data is requested by the top management. For example, in 2017, the worse we did, the more data they requested on [team C] and [team D]," which were other constructors using the same engine as the interviewee's employer.

The qualitative evidence also confirms why managers pay more attention to vicarious performance feedback when more firms rely on the same component: because this situation increases the amount of data available and thus managers' ability to learn from vicarious performance feedback and to reduce causal ambiguity. A test engineer told us, "[T]he more cars use your engine, the more samples you have, the more accurate your data are, and the easier it is to assess what's the performance of your engine compared to your competitors." The chief designer on the power unit of an F1 constructor underscored how having more constructors using the same component has a positive effect: "Statistics increase significantly. This is the most important thing, statistics. If you have two cars [it's one thing], but if you have six cars, it's something different. It really makes a difference.'' The strong need for more information was noted by the technical head of an F1 constructor: ''Those are statistically shallow data sets, and so you have to do everything you can to try and improve the quality of the statistical significance of the information by looking at all teams.''

Our interviews also clarified what kind of alternative information managers gain when they are geographically close to a supplier. Being geographically close allows managers to engage in forward-looking reasoning by learning about the supplier's development efforts for future components. One high-ranking manager told us, ''[Y]ou literally need to go and talk to them. See what sort of pathway they're on for the future, because you're not really buying an engine for this season.'' Site visits allow for learning about the progress the supplier is making on those future components. When asked how he would use the state of development on a future component to assess a supplier, one interviewee said, ''Do they already have a prototype on the dyno?[17] I think that would be a very clear indicator that they will do better.''

DISCUSSION

In this paper, we developed the theory of vicarious performance feedback to explain how organizations evaluate an exchange partner in the presence of causal ambiguity. We found that when evaluating an exchange partner—and deciding whether to renew or dissolve that interorganizational tie—a firm reacts not only to its own performance relative to aspirations but also to that of other organizations that share the same exchange partner. Our paper contributes to three areas of organizational scholarship.

Contributions to Research on Vicarious Learning

At the core of the literature on vicarious learning is the idea that when managers make strategically important decisions, they incorporate inferences derived from observation of other firms (Terlaak and Gong, 2008; Greve, 2013). Work on vicarious learning has identified a hierarchy of inferential mechanisms of increasing sophistication (Haunschild and Miner, 1997; Baum, Li, and Usher, 2000). At the base of the hierarchy is frequency-based inference, in which a focal firm's adoption or abandonment of a practice, strategy, or technology depends on the count of prior adoptions or abandonments in the population (e.g., Fligstein, 1985; Greve, 2011). A more sophisticated form of learning underlies trait-based inference, in which organizations give more weight to learning from organizations that are large or successful (e.g., Haveman, 1993; Haunschild and Miner, 1997) or that are similar to themselves (e.g., Greve, 1998b; Baum, Li, and Usher, 2000). More sophisticated still is outcome-based inference, in which managers assess the value of a practice by observing its impact on other firms' performance (Haunschild and Miner, 1997). Although frequency-based and trait-based mechanisms are well researched, surprisingly little work has directly addressed outcome-based vicarious learning. By showing that firms evaluate their suppliers by examining how other organizations that rely on the same suppliers perform relative to their

[17] An engine dyno is a testing rig used to measure engine performance while in development.

aspirations—that is, based on vicarious performance feedback—we provide one of the first empirical tests of outcome-based vicarious learning (cf. Strang and Patterson, 2014). Our confidence that outcome-based learning is occurring is strengthened by our robustness tests, which find that vicarious performance feedback remains significant when we control for frequency-based imitation.

We also add to the vicarious learning literature by examining how vicarious learning depends on the organization's structural position (Beckman and Haunschild, 2002). Prior studies on vicarious learning in the diffusion of practices and innovations have shown that network proximity to prior adopters is an important factor in a focal firm's adoption decision (Haunschild, 1993; Davis and Greve, 1997). A related literature on reputation shows that locally cohesive networks can spread secondhand information about the quality or reliability of a prospective exchange partner (Coleman, 1988; Greif, 1993; Zhelyazkov and Gulati, 2016). These findings are consistent with network ties acting as pipes through which information about a practice or a prospective partner flows (Haunschild and Beckman, 1998; Podolny, 2001).

We depart from work on social ties as conduits of information to instead depict competitive relationships as attention-focusing devices. Prior work has argued that actors in networks direct attention toward structurally equivalent actors—those with whom they share direct ties—and imitate adoption decisions due to social comparison (Burt, 1987). Prior interorganizational research, such as Bothner's (2003) study of the sixth-generation Intel Pentium chip and Greve's (2009) study of shipbuilding innovations, has found that structurally equivalent buyers in a buyer–supplier network appear to influence each other's technology adoption decisions. However, these studies do not discern whether the underlying mechanism is the attention being paid to structurally equivalent competitors or the flows of information through the network ties from a common supplier. The use of tie dissolution as the dependent variable in our study makes the latter mechanism less likely, as we can assume that the supplier does not act as a conduit for negative opinions about itself. We thus show that managers are paying attention to the performance trajectories of structurally equivalent competitors and that structural equivalence—not just network proximity—is an important basis for vicarious learning.

Another area to which we contribute is the question of how vicarious and experiential learning interact (Haunschild and Beckman, 1998; Tuschke, Sanders, and Hernandez, 2014). Work on this question has put forward various mechanisms by which vicarious and experiential learning may be substitutes for one another (e.g., Schwab, 2007; Simon and Lieberman, 2010; Yue, 2012) and other mechanisms by which they are complements (e.g., Madsen and Desai, 2010; Posen and Chen, 2013). We find that managers react to negative vicarious performance feedback when their firm's own performance is below aspiration. This suggests vicarious performance feedback might operate through a two-stage process in which managers initially attend to internal information sources and then look externally for validation.[18] Our findings are consistent with Baum and Dahlin's (2007) argument that sub-aspiration performance leads firms to increase their locus of search for information, generating a complementarity between vicarious and experiential forms of learning.

[18] We are grateful to an anonymous reviewer for suggesting this possibility.

Contributions to Research on Network Dynamics

A major project in organization theory is to understand the dynamics of social networks, which entails untangling the microdynamics that apply when actors form, maintain, or dissolve a tie (Ahuja, Soda, and Zaheer, 2012). Prior work has shown that network changes depend on the current network structure, so that network evolution is, at least partially, an endogenous process (e.g., Gulati and Gargiulo, 1999; Beckman, Haunschild, and Phillips, 2004). We build on and complement this work by pointing to a thus-far neglected mechanism.

We contribute to the literature on the dynamics of market networks (Baker, Faulkner, and Fisher, 1998; Broschak, 2004; Rogan, 2014). Market networks typically consist of distinct sets of buyers and suppliers, i.e., they are two-mode networks (Vernet, Kilduff, and Salter, 2014), meaning some mechanisms of tie stability well established in the broader networks literature may be less relevant to market networks. For example, it is not clear whether or how the mechanism of structural embeddedness, which stabilizes closed triads in one-mode networks, would apply to buyer–supplier networks (Shipilov and Li, 2012). In this paper, we document vicarious performance feedback as a mechanism that most naturally applies to two-mode networks such as buyer–supplier networks. We extend the literature on tie stability to better understand the dynamics of triadic and portfolio-level structures at the interorganizational level of analysis (see, e.g., Ozcan and Eisenhardt, 2009; Sytch and Tatarynowicz, 2014; Davis, 2016; Zhelyazkov, 2018; Zhang and Guler, 2020).

Our theory also advances network dynamics research by incorporating firm performance as an antecedent factor in network change (see also Baum et al., 2005; Shipilov, Li, and Greve, 2011; Zhelyazkov, 2018). This perspective complements prior work that links network structure to performance outcomes (Gulati, Lavie, and Madhavan, 2011). By going beyond endogenous network evolution to consider how structure interacts with the performance or "fitness" of network actors, we get closer to a picture of the market network as a complex evolutionary system characterized by variation, selection, and retention (Anderson, 1999; Hodgson and Knudsen, 2010). We validate the basic notion that strong performance makes an agent more likely to retain network ties, with the caveat that the agent's perception of performance is relative to its aspiration level. Moreover, we find that performance outside the focal dyad can impact that dyad's stability, which paints a more complicated picture and suggests that network evolution studies that focus narrowly on dyads may miss important interactions between the dyad and elements of its network neighborhood (see also, e.g., Hallen, Katila, and Rosenberger, 2014; Hernandez, Sanders, and Tuschke, 2015; Li and Piezunka, 2019).

Contributions to Research on Performance Feedback

We also contribute to the literature on the relationship of performance feedback to social structure. The existing performance feedback literature depicts managers as social comparators, benchmarking their firm's performance against a set of social referents that may or may not have network ties to their own firm (Greve, 2003a). Beyond this, however, "the interface [between network research and] the Behavioral Theory of the Firm is not well explored" (Gavetti et al., 2012: 24). We address that gap by theorizing a variant of performance feedback that can occur when two organizations both have ties to a common exchange partner. Our findings suggest that managers keep in mind not only their own organization's aspiration level but also a vicarious analogue corresponding to the performance expectations of their competitors. We thus depict performance feedback as a more deliberative, cognitively sophisticated process than traditional portrayals suggest (see also Joseph, Klingebiel, and Wilson, 2016; Posen et al., 2018). This forges a link between performance feedback behavior and the epistemic perspective on social networks, which is gaining increasing attention in organization theory (Moldoveanu and Baum, 2014). The managers in our study appear to be ''putting themselves in the shoes'' of the managers of competitor firms, using someone else's evaluation of an exchange partner to inform their own judgment.

Adding to this perspective on performance feedback as a cognitive process, we find evidence that vicarious performance feedback guides managers' causal attributions about performance. This, in turn, addresses another issue that performance feedback theory faces: it predicts that firms make changes when performance is below aspirations, but it does not predict what those changes will be. Prior work has linked performance feedback to a wide range of dependent variables, such as research and development (R&D) expenditure (Greve, 2003b), market position (Greve, 1998a), product portfolio decisions (Gaba and Joseph, 2013; Joseph, Klingebiel, and Wilson, 2016), and technology sourcing strategy (Gaba and Bhattacharya, 2012; Lungeanu, Stern, and Zajac, 2016; Eggers and Kaul, 2018). When multiple things could be changed, however, it is not clear which one managers will focus on (Greve, 2018). Our vicarious performance feedback theory shows one way to resolve this. When multiple factors—such as the firm's supplier and its employees—could have caused sub-aspiration performance, vicarious observation of poor performance at the supplier's other customers allows managers to narrow down their causal attribution. We show for F1 constructors that when their supplier's other customers underperform with respect to their historic track records, the constructors are more likely to dissolve their tie to the supplier and less likely to change their driver roster.

While vicarious performance feedback has a cognitive component, it retains a central behavioral feature of performance feedback theory: managers respond to relative performance (i.e., performance relative to an aspiration level) rather than to absolute performance. The importance of the direct and vicarious aspiration thresholds is evident in figure 2, which makes visible a discontinuous change in the rate of tie dissolution at these thresholds. The robustness tests that control for an array of observable measures of engine quality further illustrate the importance of relative rather than absolute performance in managers' decision making. Vicarious performance feedback thus has both a cognitive aspect (i.e., managers observe competitors' performance and try to understand what factors contribute to that performance) and a behavioral aspect (i.e., managers change the firm's strategy when firm performance and vicarious performances fall below aspirations).

Boundary Conditions for Vicarious Performance Feedback

A number of boundary conditions apply to our theory of vicarious performance feedback, which narrow the settings to which we expect the theory to generalize. First, the component or input provided by the shared partner must have a substantial impact on the customer's performance. A shared supplier of a standardized, mass-produced component is therefore unlikely to be a subject of vicarious performance feedback. Second, the firm's environment should be dynamic; otherwise, the relative attractiveness of each exchange partner will become known and a stable hierarchy of assortative matches between partners is likely to result. Third, competitors' historical performances must be documented and salient. In sports settings this is clearly the case, as fans, pundits, and employees maintain a collective memory of producers' trajectories (Day, Gordon, and Fink, 2012). Many other organizational fields have analogous systems of institutional memory, such as public firms' trajectories tracked by stock analysts (Zuckerman, 2000), professional service firms and universities tracked in annual rankings (Askin and Bothner, 2016), or transportation companies tracked by regulators (Madsen and Desai, 2018). Vicarious performance feedback is unlikely to be found in settings that lack shared, observable performance measures or settings in which participants focus only on how organizations perform in the moment.

A fourth condition limits the circumstances under which observing a structurally equivalent competitor helps managers evaluate a shared partner: the system-level complexity governing organizational performance—conceptualized as the extent of interdependencies between components—should be in an intermediate range (Schilling, 2000; Rivkin, 2001). Vicarious observation is not informative if system-level complexity is either low or very high. At low complexity, managers can accurately evaluate a partner based on their own experience with the partner; causal ambiguity is low, and so vicarious observations hold no additional information. At very high complexity, vicarious performance feedback is uninformative because meaningful attribution of the competitors' performance to its contributing factors is impossible; the ''landscape'' is so rugged—the interdependencies so dense—that it is impossible to reduce system-level behavior to its separate constituent factors (Rivkin, 2000). While this reasoning places a bound on the conditions under which vicarious performance feedback *should* (normatively) be undertaken, it does not necessarily describe how managers in fact behave. In practice, managers may react to vicarious performance feedback even when system-level complexity is high, despite the fact that competitors' performances would be uninformative. This would constitute a form of superstitious inferential learning (cf. Denrell, 2003). The goal of this study is descriptive rather than normative, and future research might tease out whether managers' reactions to vicarious performance feedback are functional or superstitious.

While we developed our theory of vicarious performance feedback at the interorganizational level of analysis, the theory might have implications for interpersonal tie dissolution (Burt, 2000; Schwab and Miner, 2008; Kleinbaum, 2018). When a mentor or manager supervises multiple subordinates, those subordinates—who are structurally equivalent with respect to the mentor—likely monitor one another's performance (i.e., career) trajectories. To the extent a subordinate can choose to switch mentors, they may be inclined to do so after one or more other subordinates have a negative career shock. Future work might investigate whether the mechanisms extend to one-mode collaboration networks, in which a person monitors the productivity (e.g., patenting rate) of their collaborator's other collaborators and questions whether to renew a collaboration tie if a structurally equivalent individual's productivity declines.

Future work could also investigate whether the mechanisms extend to cross-level person–organization networks, in which ‘‘crowd’’ complementors might monitor how organizations engage with other contributors when deciding whether to contribute in the future (Boudreau, Lacetera, and Lakhani, 2011; Zhu and Liu, 2018; Pan Fang, Clough, and Wu, 2019; Piezunka and Dahlander, 2019).

Implications

The main managerial implication we draw from this work relates to the supplier rather than to the customers. Our work highlights how customers of the same supplier pay close attention to one another, which negatively impacts the supplier if the inferences drawn from this observation are unfavorable (Sa Vinhas, Heide, and Jap, 2012). The supplier may be able to mitigate these negative comparisons through strategic communication. First, if a customer suffers an episode of poor performance after a string of successes, it is in the supplier’s interest to carefully frame this occurrence as a result of external factors when communicating with other stakeholders. Second, and more subtly, the supplier can attempt to downplay the customer’s historic record of success, so that the comparison against this record looks less surprising. In either case, the supplier should be aware of the heightened risk of losing multiple customers after one of them has a failure and should increase its client retention efforts for all customers, not just the focal one.

Our empirical setting provides an appropriate first test of our theory but brings with it several limitations. We measured and controlled for a variety of factors that can impact tie dissolution, but several dyadic factors that may be theoretically relevant—such as the prices at which various transactions take place, the contractual terms governing the engine supply arrangements, the extent of partner-specific investments, and the level of trust between the two partners—lack visibility (Williamson, 1985; Mayer and Argyres, 2004). For example, firms in our empirical context sometimes sign multi-year supply agreements but are also known to terminate these contracts before expiration. Because we do not have access to the original supply agreements, we cannot control for contractual penalties for breaking off a long-term arrangement. Future empirical work in settings in which prices and contractual terms are measurable would help to strengthen the foundations of our theory.

Managers face a daunting challenge in attributing organizational performance to the numerous factors that contribute to it. We have shown that managers may use the performance trajectory of their exchange partners’ other partners when evaluating whether to continue or terminate an exchange tie. By developing theory at the intersection of behavioral theory and social networks, our study moves two of the most established strands of organization theory toward closer integration. We hope the questions we raise here inspire research that paints a more nuanced picture of how vicarious learning and performance feedback influence network evolution.

Acknowledgments

We are grateful to the (anonymous) Formula 1 professionals whom we interviewed in the course of this research. We thank Philip Anderson, Rodolphe Durand, Vibha Gaba, Martin Gargiulo, Javier Gimeno, Henrich Greve, Steve Mezias, and audiences at the 2016 Academy of Management Annual Meeting in Anaheim, the 2016 Strategic Management Society Special Conference in Rome, and Cass Business School for helpful comments. We also thank associate editor Christine Beckman and the three anonymous reviewers who provided extremely valuable feedback. Philipp Reineke provided exemplary research assistance. All errors are our own.

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Supplemental Material

Supplemental material for this article can be found in the Online Appendix at http://journals.sagepub.com/doi/suppl/10.1177/0001839219899606.

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