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Network rivalry, Competition and Innovation

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ABSTRACT

Strategy, structure and rivalry across an industry has an impact upon innovation outcomes at the industry level. However, when patterns of rivalry are altered through the presence of strategic networks (sets of firms that cooperate closely on the basis of their web of strategic alliances) it is not clear what impact this has upon product market (price) competition and in factor markets (patents). Using data from the motor vehicle industry, we find only limited support for the notion that competitive responses vary with changes in network-level rivalry most likely due to co-opetition and a lack of stability across the networks. The results suggest that firms are likely to engage in co-opetition, thus changes in innovation outcomes can only be observed at the network level. When the presence of strong strategic networks leads to lower levels of rivalry on the basis of at least some cooperative behavior within the network (and competitive actions being focused on firms in other networks) we see a reduction in innovation at the network level. However, as the strategic networks changed consistently over time, the change in patenting behavior was limited.

1. Introduction

Innovation is often positioned as the backbone for both firm competitiveness as well as regional economic growth (e.g. Bristow & Healy, 2018; Hashi & Stojčić, 2013 Hauser et al., 2018; Walker, Chen & Aravind, 2015). Given this critical role of innovation in the modern economy, considerable research across multiple levels of analysis has investigated how and when innovation occurs. For example, when looking at the economy as a totality, institutional economics highlights the role of institutions in determining economic choices. Thus, the regulatory environment, political systems and social structures impact investment in innovation across an economy (Coase, 1998; North, 1990; Williamson, 2000). At the more micro end of the spectrum, dynamic capabilities with its grounding in Schumpeterian economics considers how different positions, paths and processes may help firms build new capabilities to adapt to rapidly changing environments (Teece, Pisano & Schuen, 1997, Teece, 2007; Winter, 2003). These dynamic capabilities form a foundation for innovation within firms as they adapt to new or altered environments.

Between these economy-level and firm-level perspectives sits the role of industry – sets of firms that provide similar products or services to a set of customers. Industry structures (e.g. number of players) and industry dynamics (e.g. the manner in which these firms compete for customers) may also impact upon the speed and scope of innovation across these sets of firms. Porter (1990) for example, recognized that vigorous domestic rivalry within an industry is critical in improving internal efficiencies and also fosters the research that underpins future innovation. Without a minimum level of rivalry, both innovation and growth may be hampered (Carlin, Schaffer & Seabright, 2004) and hence most countries have some form of anti-trust or anti-monopoly legislation to ensure that industries are not dominated by oligopolies or monopolies that may dampen the drive for innovation. This paper considers innovation through this industry-level lens and how changing patterns of rivalry on the basis of strategic networks within industries may impact innovation.

Strategic networks are sets of firms within an industry that exhibit

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denser strategic linkages among themselves relative to the links that they may have to other firms within the same industry. These alliances may form for a variety of reasons. From a supply-side perspective, firms seek to build their resources – especially those that may enhance their capacity to innovate such as joint R&D efforts, sharing technology, patenting agreements, sharing critical technology and/or knowledge (Contractor & Lorange, 1988). Firms may also pursue strategic networks that can be explained via a demand-side logic whereby firms avoid head-to-head competition with all players and instead move to a more directed form of competition whereby rivalrous actions are directed towards members of other strategic networks and not towards firms within their own focal network (Gimeno, 2004).

The presence of strategic networks coordinating the behavior of groups of firms within an industry runs counter to the neoclassical economics assumptions that firms compete in a relatively homogeneous manner for the same (rare) resources or for the same markets/customers (McPherson, 1983). Prior research concerning industry dynamics already recognizes that an individual firm may compete more with some firms and less with other firms on the basis of market overlap, resource homogeneity or mutual dependence between firms (Chuang *et al.*, 2018, Guedri & McGuire, 2011). The development of various strategic networks of firms across an industry where these firms may collaborate and limit their engagement in direct head-to-head competition presents an additional logic for non-homogeneous patterns of competition. One of the outcomes of this potentially reduced level of rivalry may be a reduced level of investment in innovation as one form of competitive response to potentially reduced rivalry. Certainly, the emergence of identifiable strategic networks suggests that '[t]he image of atomistic actors competing for profits against each other in an impersonal marketplace is increasingly inadequate in a world in which firms are embedded in networks … with other individual and organizational actors' (Gulati, Nohria & Zaheer, 2000: 205). Thus, if firm-based competition is somewhat superseded by competition at the network level (ie networks of firms within an industry compete against other networks), it is not clear how this phenomena may impact the intensity of rivalry in an industry and the competitive actions undertaken by firms within the industry.

Rivalry within an industry may take a number of forms. Competitive rivalry may occur in product markets where firms compete for customers and the economic surplus that sales of goods and services to these customers may produce. Firms may also compete in factor markets for resources (such as skilled labor) which may allow the firm to subsequently produce superior goods and services or achieve greater levels of efficiency. In terms of Porter's (1980) generic strategies, inter-firm competition may play out in terms of cost structure and the subsequent pricing of goods or services (ie firms seek to compete on the basis of price), or firms may compete on the basis of non-price attributes to create a position of differentiation through such means as brand recognition, innovation associated with the product, warranty or availability. More intense rivalry results in firms seeking to more clearly define their competitive response such as become a clear price-oriented competitor, or further differentiate through increased innovation.

Overall, we are witnessing a growth in strategic alliances to the point where in some industries, we observe strategic networks acting as a coordination mechanism for competitive behavior. As firm versus firm competition starts to become superseded by network versus network competition, we are interested in how changes in rivalry at the network level impacts firms' competitive behaviour. Specifically do changes in rivalry between networks impact the extent to which a firm prioritizes innovation (as measured through lagged patent data) and competitive pricing in the form of price discounting, thereby providing insight for policy makers? To consider how rivalry between strategic networks impacts these competitive behaviors we draw upon data from the motor vehicle industry as one that features strategic networks and extensive use of patenting and price discounting.

2. Strategic networks, Rivalry and Innovation

Innovation has often been held up as the holy grail of economic development (Fagerberg & Srholec, 2008). At the level of a regional economy, it tends to be dependent upon a range of contextual variables including institutional factors and the political system (Kashani & Roshani, 2019). However, at the industry level, competition and rivalry have been linked with higher levels of innovation across an industry (Athreye, 2001; Carlin *et al.*, 2004). In this paper, we shift our attention to how changing patterns in rivalrous behavior between firms on the basis of strategic alliances may impact innovation outcomes.

Starting with inter-firm rivalry, the field of competitive dynamics considers when and how firms engage in specific competitive actions and reactions (Andrevski, *et al.*, 2016; Baum & Korn, 1996). In essence, how do firms alter their behaviour in response to competitors' actions and what form do these responses take? The focus of much of the research to date has been on the likelihood of response, the number and speed of responses and the extent or severity of the response (Chen & Miller, 2012). Empirically, the competitive responses that have been considered have focused on a firm's entry into new markets, or at least new market segments, or major price initiatives (e.g. Ferrier & Lee, 2002; Chen & Miller, 1994).

To date, the competitive dynamics literature has generally not accounted for close relationships between particular firms through strategic alliances and how these relationships may impact the action and reaction of firms that forms the central theme within competitive dynamics. Rather, literature pertaining to competitive dynamics relies upon neoclassical economics assumptions of firms as atomistic entities that act in their own self-interest. Thus, how strong strategic alliances (and thus strategic networks) may affect firm-level competitive responses is an understudied concern within this research stream (Chen & Miller, 2012).

Research that has considered strategic networks has primarily focused upon the structure and nature of these networks (Jacob & Duysters, 2017). Initial work at the network level (as opposed to the dyadic level) considered the structure of the industry in which networks occur, the shape or structure of the networks and the role or importance of central players in these networks (Arino-Martin & Garcia-Pont, 1998; Nohria & Garcia-Pont, 1991; Skilton & Bernardes, 2015). The other key theme has centered on the formation of networks and how the alliance choices of one firm impacted the alliances choices of others. For example, in the airline industry firms may respond to rivals' alliance networks by establishing alliances with their rivals' partners or establishing countervailing alliances (Gimeno, 2004).

Looking specifically at rivalry between strategic networks and the potential for firms to alter their behaviour on the basis of this network level rivalry, Boyd (2004) found that the strategic networks identified in the airline industry offered some limited predictive ability to account for patterns of rivalry, and Zhang and Zhang (2006) found that complementary alliances between members of the major strategic alliance blocks in the industry helped to explain certain competitive behaviors such as expanding output. Vanhaverbeke & Noorderhaven (2001) suggested that rivalry occurs between blocks of firms fighting for market acceptance in respect of technical standards.

To appreciate why rivalry may occur at a network level, firms may seek collaborative advantage (Contractor & Lorange, 1988; Dyer & Singh, 1998; Lavie, 2006) through collaborative activity that reduces rivalry and minimizes the application of market power by upstream or downstream industries. On this basis, firms within strategic networks may move away from rivalry being enacted by individual firms according to the traditional mechanisms of direct confrontation in factor and product markets, and instead manage rivalry via the collaborative orchestration between a number of participants or network members (Chung, 1993; Gomes-Casseres, 1996; Haugland and Gronhaug, 1996; Vanherbeke and Noorderhaven, 2001). Of course, this notion of coordinated actions occurring across a network assumes that individual

firms within each network are able to effectively align their actions. This is certainly possible in cases where there is some form of overarching governance structure for the network. However, in cases where this does not exist, the loosely coupled nature of such a network means firm behavior within the network will be impacted by the level of (structural, relational and cognitive) embeddedness (Uzzi, 1997). Firms then engage in a process of sensemaking on the basis of other firms actions and signalling to other firms in the network themselves (Simsek, Lubatkin & Floyd, 2003). In addition, direct communication may occur as part of alliance negotiation or through the informal personal networks of people engaging with partner firms through the alliances in place.

3. Rivalry and competitive actions

Competition sits at the heart of business strategy and draws upon the notion of contested goals (Porter, 1979). Where two or more firms seek a single goal (such as the sale of a product to a customer) these firms are engaged in competition (Medlin & Ellegard, 2015). Thus, the nature of rivalry within an industry in terms of who competes with who and the manner by which they compete is a central concern for both strategy theorists and practitioners alike given that competition tends to be a powerful motivator and significant driver of behaviour (Ford & Håkansson, 2013).

Theoretical conceptualizations of rivalry and how it may play out across an industry have emerged from a variety of perspectives including oligopoly theory (Shapiro, 1989), game theory (Camerer, 1991), competitive dynamics or 'warfare' models (Chen & Miller, 2012) and industrial organization economics (Porter, 1980). All of these approaches recognize that inter-firm rivalry is based upon specific competitive actions and reactions. The precise actions and reactions may vary considerably and involve competition in both product and factor markets, though empirically, most studies have tended to focus their attention on the product market side of the equation in terms of changes in pricing of goods and services, or entry (or exit) into new markets (Chen & Miller, 2012). Consistent choices of this nature represent a firm's strategy.

Any changes in strategy are underpinned by the existing stock of resources and capabilities, along with the firm's capacity to reconfigure these capabilities. This capacity to evolve and adapt to changing environments is driven by a firm's dynamic capabilities (Arndt & Pierce, 2018). Whether these dynamic capabilities emerge through the process of learning (Zollo & Winter, 2002) or via managerial or entrepreneurial capacity (Zahra, Sapienza & Davidsson, 2006), they allow firms to reconfigure their resources and capabilities to create heterogeneous positions within product markets (Burton and Galvin, 2020). This transformational process (Rice et al., 2015) allows firms to alter their competitive responses to changing rivalry between firms. For example, becoming more price competitive via increasing efficiencies or other factors that may help firms reduce their cost structure requires changes in their operating routines through learning or experimenting with new processes. Similarly, innovation as a basis for differentiation is driven by organizational learning whereby the accumulation of experience and knowledge from existing processes provides a basis for the creation of new knowledge on the basis of both individual and organizational learning (Nonaka, 1994).

Overall, changes in rivalry across an industry will drive some form of competitive response. Exactly what this response will in part be determined by the dominant competitive actions and reactions within the industry, but the options for change are path dependent (Teece, Pisano & Schuen, 1997) as firms are not only constrained by their stock of resources and capabilities, but by their capabilities to change and adapt in different ways. Thus some firms may continually adapt their market presence through innovation to deliver a combination of new product and service releases (substantive and tangible changes in the market offerings of firms) or they may seek to transform their internal operations or their supply chains to achieve lower cost structures (Galvin, Rice & Liao, 2014; 2015).

Linking these adaptions on the part of firms back to the industry level and changing industry conditions, Porter's (1980) Five Forces model suggests that high levels of rivalry will result in aggressively targeting competitor's markets, often through price-based competition. Competing on the basis of price is not positioned as an attractive option, but in cases of low levels of differentiation, low diversity of competitors, high exit costs, a high proportion of fixed costs and numerous competitors, firms revert to price-based competition. In the longer-term, price-based competition will be detrimental to a firm's profitability (Shapiro, 1989), however, in terms of actions and reactions, price discounting remains a common feature of increasing rivalry – especially where firms lack the capacity to change their competitive response on the basis of existing capabilities and where opportunities for differentiation are limited.

At the strategic network level, extrapolating the concept that increased rivalry between firms will lead to increases in competitive actions by firms, we apply this logic to strategic networks of firms. As the level of rivalry between different strategic networks increases (ie firm versus firm competition is superseded by network versus network competition) we expect that individual firms will react with price reductions across products that compete with the products of those firms that make up other strategic networks. That is, competitive actions (such as increasing production) that lead to increased rivalry will lead to a reaction in the form of price discounting. Specifically, we hypothesise:

H1. There is a positive association between strategic network rivalry and price discounting of products that compete directly with products from other strategic networks.

If price discounting is a competitive response of rivalry in respect of product markets, then seeking to outperform competitors in factor markets as a basis for pursuing a differentiation strategy – as per Porter's (1980) generic strategies – represents an alternative response to another firm's competitive action. Avoiding head-to-head competition on the basis of price, and instead building a competitive position around differentiation through superior resources such as brand equity, distribution channels, product design, superior performance or the like is perhaps a longer-term, but more sustainable approach to competition. Thus whilst differentiation as a generic strategy may be achieved via a number of means, of these various potential reactions that will address a firm's competitive position, building superior innovative products on the basis of patents is relatively easily quantified and is therefore the specific reaction we consider in respect of increasing rivalry between strategic networks. We hypothesize:

H2. There is a positive association between the measure of rivalry between strategic networks and (lagged) patenting activities.

Pricing decisions pertain to specific market segments and must be made by specific firms. For example, a strategic network featuring firms selling products into four market segments A, B, C and D may find itself subject to increased rivalry courtesy of a another strategic network where the firms reduce prices or increase production levels across some market segments. The responding strategic network itself does not decrease prices, but rather individual firms in the network may drop some prices where their products go head-to-head in specific market segments. For example, one firm may drop its prices for products in market segments A and B, whereas another firm may drop its prices for product being sold in market segments C and D to specifically target the actions of the firm from the opposing strategic network.

Similarly, patenting behaviour is measured at the firm level. However, while patents may be registered at the firm-level, they may benefit multiple firms (or even all firms) within a strategic network. Strategic networks are defined by the multiple, strong relationships between firms within the network. Many of the strategic alliances in a network are built around R&D sharing and technology sharing

alliances. Others may see R&D sharing in return for other benefits such as market access. As such, we proposed a further hypothesis that considers patenting as a reaction, but at the network level rather than the firm level. That is, not all firms need to increase their patenting activity as long as the total patenting activity increases across the strategic network as a totality as a reaction to increases in network rivalry.

H3. There is a positive association between the measure of rivalry between strategic networks and the (lagged) patenting activities by each strategic network.

4. Methods

To test the hypotheses, data was collected from the automotive industry for the period 1993–2007. Known for its extensive use of strategic alliances (Rosenkopf & Schilling, 2007), the auto industry also features high levels of rivalry across many segments of the industry and the high level of fixed costs incurred by manufacturers has led to a number of instances of price discounting by many players–particularly during periods of reduced demand. These difficult competitive conditions have led to some consolidation of the industry through M&A activity, though profitability remains variable (as overtly seen through the 'bail-out' of the three largest US-based manufacturers in 2009).

For analysis purposes, data was collected for 13 market segments comprising the light vehicle automotive industry in the USA for the period 1993 to 2007 from the *Ward's Automotive Yearbooks* with the data being collected biannually (e.g. 1993, 1995, 1997 etc.). We accepted the definition of the industry that *Wards* have presented, including those firms that they deem to be included versus those that have been excluded. Information was also collated on inter-firm relationships from *How the World's Automakers are Related* for the same timeframe. The sample included 19 firms. Whilst our theory discussion and the subsequent hypotheses discuss firms, these firms compete via vehicle models designed for different segments within the market. Thus to investigate with whom Ford competes most vigorously, it is necessary to look at the different models produced by Ford for different market segments and ascertain the competitive rivalry in each of these segments (via the particular model in question) relative to the models being produced by competitors in each market segment.

4.1. Classifying Strategic Networks

Current strategic network literature suggests the strategic network concept bears close association with what has been referred to in the literature as 'strategic blocks' (Nohria & Garcia-Pont, 1991), and 'alliance blocks' (Vanhaverbeke & Noorderhaven, 2001). However, underlying these apparent similarities are significant methodological differences which distinguish the concepts of strategic blocks from strategic networks. The core difference lies in the *structure* of the resulting collective of firms; while strategic blocks associate firms together who share positional equivalence (firms who share in same relative position and relationships within the context of a network to other firms who may or may not be in the same relational network within an industry), strategic networks conversely are firms that are either directly or indirectly related to each other based on the presence of direct or indirect strategic relationships (Jussila, Mainela & Nätti, 2016; Nohria & Garcia-Pont, 1991).

As the presence (or absence) of strategic relationships between firms is of central importance in the formation of strategic networks, the nature and strength of relations (ties) between actors or agents (nodes) is pivotal to defining meaningful strategic networks. The spectrum of strategic relationships that can exist between firms is extensive and ranges from distribution and marketing arrangements to cross-equity holdings. As the degree to which different alliance types impacts upon the strategic decision making of the firm, differentiating between different alliance types and weighting them appropriately is critical. For the purposes of determining the interdependencies that may exist between otherwise atomistic firms, non-directional relationships were valued according to the scoring system used by Nohria and Garcia-Pont (1991) – which itself was adapted from the prior work of Contractor and Lorange (1988). In instances where firms exhibited more than a single relationship between partners, the highest scoring relationship was used. Inter-reliability tests were performed on the classifications generated for each strategic relationship as reported qualitatively in *Ward's Interrelationship Guide* on a random sample of relationship descriptions, resulting in a 79.23% mean result. While production and price data was only available for the US market, our alliance database covered provided global coverage of alliances and thus our networks feature firms (such as Chinese manufacturers) that do not compete in the US market.

The valued relationship data of all firms was entered into a n x n matrix configuration for each period of analysis. Each cell *Sij* indicated the strength of the relationship between nodes i and j, with the value of '10' ascribed Firm A x Firm A to indicate that the strongest relationship held by any firm was that of the firm to itself. Each matrix S was symmetrical ($Sij = Sji$) due to the non-directionality of the valued relations, aside from the diagonal values of '10' assigned Firm A x Firm A (Scott, 2005; Wasserman & Faust, 1999).

A number of alternative methods exist by which to identify cohesive subsets in data, however, many of these approaches elicit restrictive limitations to the ultimate identification of groupings that can negatively impact on meaningful results and later analysis. It is important to note that no definitive methodological approach exists by which to analyze *valued non-directional* network data, therefore it was necessary to run a range of procedures (clique, n-clique, n-clan, cluster, factions, components, K-Plex and K-Core) to determine the most appropriate method to employ. After running a range of possible alternatives, the use of Johnson's Hierarchical Clustering Procedure (1967) was ultimately determined to provide the most representative outcomes and finds precedent in the previous work on networks completed by Lazzarini (2007). To overcome the limitations associated with both the use of single link and complete link methods, the criteria of average linkage was employed (Hanneman & Riddle, 2005). All modeling was performed via UCInet (Borgatti, Everett & Freeman, 2002). The resulting strategic networks are shown in Table 1.

4.2. The Measurement of Rivalry

Whilst rivalry forms a central concern within strategy research, there are not well accepted measures for the construct. The Herfindahl Index, a measure of concentration ratios, has in some instances provided an effective measure of inferred rivalry in the context of particular studies. Within this study, a modified version of the Herfindahl Index was employed to capture variances in sales of vehicles in the United States at the level of the product market segment. Drawing on the work of Cool and Dierickx (1993), the use of this modified version of the Herfindahl Index finds precedent in measuring the differences observed in rivalry by excluding a firm's own market share from the overall industry market segment Herfindahl. This measure was also successfully employed by Durisin and Von Krogh (2005) to study group level effects in investment banking. Using this approach, 'a negative correlation between this rivalry index and return suggests that firms adversely affect each other's profits; conversely, a positive correlation indicates the absence of rivalry' (Cool and Dierickx, 1993: 50).

To create an aggregate rivalry measure, the level of rivalry can be assessed between networks in each market segment, to determine if network structures facilitate competitive outcomes. To determine the level of rivalry a firm faced in a given market segment the Herfindahl score was subtracted from the overall market segment Herfindahl. Specifically, the aggregate measure of rivalry, RIVj, was computed for each firm j as:

Table 1
Strategic Networks in the Motor Vehicle Industry (1993-2007)

1993	
Network 1	BMW, CARROZZERIA BERTONE, DAIHATSU, DONGFENG AUTO, FIAT spa, GUANGZHOU, INDUSTRIE PININFARINA, PEUGEOT CITROEN, TIANJIN
Network 2	AO AVTOVAZ, BEIJING AUTOMOBILE WORKS, CHINA MOTOR CO, CHRYSLER DAIMLER, HONDA, HYUNDAI, MITSUBISHI, PORSCHE, PROTON, SSANGYONG
Network 3	DAEWOO, FIRST AUTO WORKS, FORD, FUJI (SUBARU), GM, ISUZU, KIA, MARUTI, MAZDA, NISSAN, RENAULT, SUZUKI, TOYOTA, VOLKSWAGEN
1995	
Network 1	BEIJING AUTOMOBILE WORKS, CHINA MOTOR CO., CHRYSLER, HONDA, HYUNDAI GROUP, LOTUS, MITSUBISHI, PROTON
Network 2	BMW, CARROZZERIA BERTONE spa, DAIHATSU, GHANGZHOU, INDUSTRIE PININFARINA spa, KIA, TIANJIN
Network 3	DAEWOO, DONGFENG AUTO, FIAT spa, FORD, FUJI (SUBARU), GM, ISUZU, MARUTI, MAZDA, NISSAN, PEUGEOT CITROEN, RENAULT, SUZUKI, TOYOTA
Network 4	AO AVTOVAZ, DAIMLER, FIRST AUTO WORKS, PORSCHE, SHANGHAI AUTO, SSANGYONG, VOLKSWAGEN
1997	
Network 1	BMW, CHRYSLER, DAIMLER, FIAT spa, FORD, FUJI (SUBARU), GM, HONDA, ISUZU, MARUTI, MAZDA, MITSUBISHI, NISSAN, PEUGEOT CITROEN, RENAULT, SUZUKI, TOYOTA
Network 2	DAIHATSU, HYUNDAI, KIA, SSANGYONG, TIANJIN
Network 3	AO AVTOVAZ, CHINA MOTOR CO., DONGFENG AUTO, GHANGZHOU, INDUSTRIE PININFARINA spa GROUP, LOTUS, PROTON
Network 4	BEIJING AUTO, CARROZZERIA BERTONE spa, DAEWOO, FIRST AUTO WORKS, PORSCHE, SHANGHAI AUTO, VOLKSWAGEN
1999	
Network 1	HYUNDAI, KIA GROUP, LOTUS, PROTON, SAMSUNG
Network 2	CHINA MOTOR CO., DAIHATSU, GUANGZHOU, TIANJIN
Network 3	CHRYSLER, DAIMLER BENZ, FIAT spa, FORD, FUJI (SUBARU), GM, HONDA, ISUZU, MAZDA, MITSUBISHI, NISSAN, PEUGEOT CITROEN, RENAULT, SUZUKI, TOYOTA
Network 4	AO AVTOVAZ, BEIJING AUTOMOBILE WORKS, DONGFENG AUTO, INDUSTRIE PININFARINA spa MARUTI
Network 5	BMW, CARROZZERIA BERTONE spa, DAEWOO, FIRST AUTO WORKS, PORSCHE, SHANGHAI AUTO, SSANGYONG, VOLKSWAGEN
2001	
Network 1	FIAT spa, FORD, FUJI (SUBARU), GUANGZHOU, GM, HONDA, ISUZU, MARUTI, MAZDA, NISSAN, SUZUKI
Network 2	BMW, BEIJING AUTOMOBILE WORKS, CHRYSLER, DAIMLER BENZ, DAIHATSU, TINAJIN, TOYOTA
Network 3	CARROZZERIA BERTONE spa, DAEWOO, INDUSTRIE PININFARINA spa, SSANGYONG
Network 4	CHINA MOTOR CO. GROUP, LOTUS, MITSUBISHI, PROTON
Network 5	AO AVTOVAZ, FIRST AUTO WORKS, PORSCHE, SHANGHAI AUTO, VOLKSWAGEN
Network 6	Dongfeng Auto, Hyundai, Kia, Peugeot Citroen, Renault
2003	
Network 1	Bmw, Beijing Automobile Works, Chrysler, Daimler Benz, Fiat Spa, Ford, Fuji (Subaru), Gm, Hyundai, Mazda, Mitsubishi, Nissan, Peugeot Citroen, Renault, Suzuki, Toyota
Network 2	Ao Avtovaz, Carrozzeria Bertone Spa Group, Lotus, Maruti, Udyog Proton
Network 3	Daewoo, First Auto Works, Industrie Pininfarina Spa, Porsche, Shanghai Auto, Ssangyong, Tianjin, Volkswagen
Network 4	China motor co., daihatsu, dongfeng auto, guangzhou, honda, isuzu, kia
2005	
Network 1	AO AVTOVAZ, CHRYSLER, DAEWOO, DAIMLER BENZ, FIAT spa, FUJI (SUBARU), GM, INDUSTRIE PININFARINA spa, SHANGHAI AUTO, SUZUKI
Network 2	BEIJING AUTOMOBILE WORKS, CHINA MOTOR CO., HYUNDAI, KIA GROUP, LOTUS, PROTON
Network 3	BMW, CARROZZERIA BERTONE spa,PORSCHE, SSANGYONG, VOLKSWAGEN
Network 4	DONGFENG AUTO, GUANGZHOU, HONDA, ISUZU, MITSUBISHI, NISSAN, PEUGEOT CITROEN, RENAULT, TOYOTA
Network 5	DAIHATSU, FIRST AUTO WORKS, FORD, MARUTI, MAZDA, TIANJIN
2007	
Network 1	DONGFENG AUTO, FUJI (SUBARU), GUANGZHOU, HONDA, ISUZU, MITSUBISHI, NISSAN, PEUGEOT CITROEN, RENAULT, TOYOTA
Network 2	AO AVTOVAZ, CARROZZERIA BERTONE spa, DAEWOO, FIAT spa, FORD, GM, INDUSTRIE PININFARINA spa, MARUTI, SHANGHAI AUTO, SSANGYONG, SUZUKI
Network 3	BMW, BEIJING AUTOMOBILE WORKS, CHINA MOTOR CO., CHRYSLER, DAIMLER BENZ, HYUNDAI, KIA
Network 4	Daihatsu, First Auto Works Group, Lotus, Mazda, Porsche, Proton, Tianjin, Volkswagen

$RIV_j = \sum_i w_{ij} RIV_{ij};\ i = 1,\ \ 13\ segments$
with
w_{ij} = the ratio of the sales of firm j in segment i to its overall sales (segment weight)
RIVij = the rivalry index for firm j in segment i (segment rivalry), i.e., the overall segment Herfindahl from which the squared segment share of firm j has been subtracted.

RIVij measures the rivalry a firm faces from all other firms in segment i. This index can be disaggregated to distinguish rivalry from firms belonging to other strategic networks. This rivalry measure RIVjb (between network rivalry) was calculated as follows:

$RIV_j^w = \sum_i w_{ij} RIV_{ij}^w;\ i = 1,\ \ 13\ segments$
$RIV_j^b = \sum_i w_{ij} RIV_{ij}^b;\ i = 1,\ \ 13\ segments$
with
RIVijw = the within network rivalry index for firm j in segment i (i.e., summed over all members of firm j's strategic network, except firm j).
RIVijb = the between network rivalry index for firm j in segment i (i.e., summed over all firms not in the strategic network of firm j).

Based on this formula, the level of rivalry experienced by firms in the United States Light Vehicles Industry was determined. Based on the networks determined for each year covered by this study, a *between network* rivalry measure was computed. The rivalry index mean is 0.083

(std. dev. = 0.174).

As the hypotheses focus on 'increases' in rivalry we compare the rivalry measure at t_{+1} with the same measure at t via the formula t_{+1} / t such that a score of greater than 1.0 shows an increase in rivalry relative to the previous period and a score of less than 1.0 shows a decrease in rivalry.

4.3. Price and Patent Measures

Price data was collected for each different model within each different market segment. As vehicle models change, are added or dropped from a manufacturer's line-up, price data was not available for all models. Akin to the way we considered the change in rivalry, we used the same approach to compare the price in the more recent year relative to the previous list price (t_{+1} relative to t). As the data was biannual, there were price increases in almost all cases. For each manufacturer we averaged the price differentials for each vehicle model for which data was available.

Patent data was acquired through a German government patent office with the data covering the global patenting activities of each firm. We considered only patents submitted and not those granted and the process of granting a patent may take a number of years. As a greater investment in R&D to react to increased rivalry will not be immediate, we used lagged data. Patent data is often problematic on a number of fronts. Often patents are submitted by subsidiary organizations under different names (thereby reducing the visible patent count), or firms that are diversified (e.g. Suzuki also manufacture motorcycles and outboard marine engines) may overstate the relevant patent count. For some organizations, the motor vehicles operations are clearly distinct (eg Mitsubishi Motors is separate from Mitsubishi Electric, Mitsubishi Heavy Industries etc.) but this is not always the case. By looking at sequential time periods to assess the change in patenting activity (ie the patent count at t_{+1} relative to t) we look at relative growth or decline in this variable and thus potentially limit the impact of over- and understated patent counts by firms as the entity is likely to file patents in a consistent manner over time.

5. Results

The unit of analysis for the purpose of analysing the data is the firm and for the period of the study data we ran data on 16 firms. We removed Kia, Peugeot and Daewoo from the sample as each firm controlled less than one percent of the market in any select year and thus had the potential to throw the rivalry measure given we use a concentration derived measure.

Analysis for each hypothesis was undertaken using a Pearson correlation that considered the correlation between average changes in vehicle model prices per manufacturer and changes in the between network rivalry measure from the perspective of each manufacturer (hypothesis one) and changes in patent application counts across sequential time periods and the same rivalry measure (hypothesis two). For the third hypothesis, it was not possible to look at changes in rivalry and changes in patenting as the analysis required correlating a cumulative between network rivalry score (one score for each network) with the cumulative patent count for the same network. As the networks varied, it was not appropriate to consider changes in network rivalry as the size and composition varied each time period. The same applies to patent count. All results are shown below in Tables 2 to 4.

Table 2
Results of Bivariate Correlations: Change in Patents and Change in Rivalry

	1	2
1. Change in Patents	1.000	
2. Change in Rivalry	-.004	1.00

Table 3
Results of Bivariate Correlations: Change in Rivalry and Change in Price

	1	2
1. Change in Rivalry	1.000	
2. Change in Price	-.235	1.00

Table 4
Results of Bivariate Correlations: Change in Rivalry Between Networks and Total Patents for the Entire Network

	1	2
1. Change in Rivalry Between Networks	1.000	
2. Total Patents for the Entire Network	.394*	1.00

* $p < .05$

The results for Hypothesis 1 and Hypothesis 2 were not significant. Hypothesis 3 was supported as there was a positive and statistically significant correlations between rivalry between strategic networks and increases in subsequent patenting activities ($\rho = .39$, $p < .05$).

6. Discussion

The lack of significant results for two of the three hypotheses have a number of potential explanations. One explanation centers on the measures used, particularly the rivalry measure. Slightly adapted from prior studies, the rivalry measure is built on the notion of concentration as a driver of rivalry. At a firm level, this is appropriate. However, we identified that there was very little stability in the structure of the networks. In some instances more than half of the firms in our sample concerning the US market were deemed to be part of a single network (with there being as few as three networks in place), whereas in other years, firms were distributed across a greater number of networks and in a more equal fashion. In this industry, many alliances were relatively short-term as they covered technology transfer, outsourcing production or joint component development. This rapid shifting of alliance partners sits in contrast to other industries where the strategic networks are very stable such as those where networks of firms coalesce around particular technology standards such as mobile phone network systems (Galvin & Rice, 2008).

The result of this instability was that the rivalry measure varied enormously due to the large changes in concentration as the strategic network composition altered. The rivalry measure considered market share of the total market within a particular market segment, but even though individual manufacturer's sales did not vary enormously, when assessed relative to the total sales in a particular market segment, this relative number was very inconsistent. A graph of total sales (see Fig. 1 below) across all manufacturers relative to total patents across the industry for each year of the study shows a much higher degree of stability than the network rivalry measure was able to produce.

In coding each alliance in the industry, it became clear that firms entered alliances for a variety of reasons and that there were significant differences in the alliance relationships across the industry both in terms of relationship strength and in respect of the strategic logic for the alliance. Firms thus differed in the degree to which they became embedded in an 'opportunity structure' that delivered greater access to strategic resources. For example, firms may engage in joint R&D efforts, share particular technology, pursue second source agreements, know-how and patenting agreements or even simple distribution agreements. Many of these alliances may be relatively short-term in nature before a new set of alliances are pursued to meet different strategic imperatives that are relevant at the time.

When Gomes-Casseres (1994) suggested that firm versus firm competition may be superseded by group versus group (or in the terms of this research, strategic network versus strategic network), he made

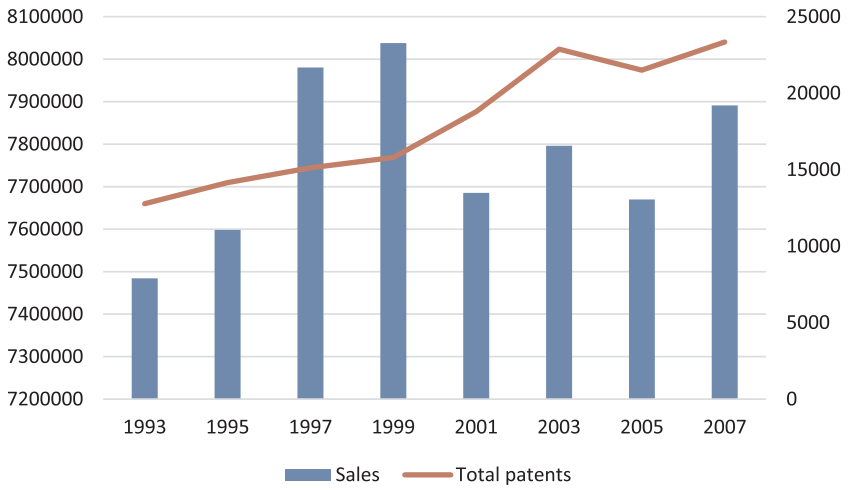

Fig. 1. Total Sales and Total Patents by Year

reference to fairly stable alliance networks – formal airline alliance structures. The core players of OneWorld, Star Alliance and Sky Team have changed little in more than two decades. In such an environment, it may make sense to direct competitive moves towards direct rivals and seek to limit the impact of such moves on alliance partners. However, in the case of the motor vehicle industry, this instability in respect of alliances means all firms are likely to seek alliance partners that help them achieve short-term goals, but that these cooperative relationships that will improve their position with regard to specific firm needs, do not affect their choices concerning competitive actions – a classic case of co-opetition.

There were examples of firms being in the same strategic network throughout the study, but this tended to occur in the case of very strong relationships such as the case of Ford owning 33.4% of Mazda during the period for which data was collected. In these cases, the specific market segments being targeted and the positioning of the product may have accounted for the long-term strong strategic alliances in place, but such relationships were very much in the minority across the industry and thus this phenomena could not be demonstrated empirically.

However, beyond the measurement issues and the instability of the networks, the results may have a more simple theoretical explanation. The first two hypotheses drew upon industrial organization (IO) economics arguments aligned with the 'structure, conduct, performance' paradigm whereby the structure of the industry (e.g. number of players) will impact the conduct of the business (e.g. their competitive actions). Drawing upon this work, our hypotheses are extensions of the basic principle that increased rivalry in an industry will drive increased levels of competition.

What IO economics does not consider is the potential for cooperation in the form of alliances and competition to occur simultaneously. Best addressed through the concept of co-opetition, it has been suggested that cooperation and competition are not necessarily at opposite ends of the same continuum and may actually constitute different axes of models concerning competitive behaviour (Chin, Chan & Lam, 2007; Dorn, Schweiger & Albers, 2016; Lado *et al.*, 1997). Thus extensive alliances between various firms within a strategic network may not actually reduce the degree to which these firms compete with each other head to head. The difference between firms' competitive actions with respect of their network partners may not differ to their competitive actions relative to players in other networks. Just because firms have a strategic alliance in place does not mean that they will alter their competitive actions. Within the co-opetition literature cases are often presented where cooperation occurs in early stages of the value chain (e.g. research and development, sourcing of components, sharing technology) but firms continue to engage in highly competitive behavior in product markets against their alliance partners (Gnyawali *et al.*, 2006; Osarenkhoe, 2010; Peng *et al.*, 2012). Thus, we suggest that an explanation for the findings may centre around the fact that while cooperation was clearly visible through a multitude of alliances, firms remained independent actors who pursued their competitive strategies with minimal regard for their alliance partners.

The third hypothesis was supported suggesting that even if the instability of individual members of a strategic network limits the potential relationship between rivalry and competitive reactions, when considered at an aggregate level, there is some correlation between competitive actions at the network level and patenting activity. While the strategic networks were not stable with many of the smaller players moving into and out of the strategic networks, the reality is that the networks tended to center around the largest players who featured in the bulk of the alliances. These larger players (with higher levels of patenting activity) were more stable in their strategic network membership such that they tended to operate as central players in a network and not join the networks of other very large players. The innovation did not need to occur in all members of the strategic network as rivalry increased and in fact, small players may join the network to access the R&D of the larger players. Thus, at an aggregate level, as rivalry increased for the network as a whole, there was a corresponding increase of patenting (using lagged data) when considered at the network level. Co-opetition is still likely as all firms may compete vigorously in product markets, but longer term investments in R&D (as measured via patents) may alter across the network as the central network players (who contribute the majority of the patents) adjust their R&D efforts according to the structure and make-up of the different networks and the resultant network rivalry.

Given the limited results, it is worth questioning the utility of the strategic network concept. Work to date has largely concerned the structure (ie centrality, structural holes) of strategic networks and subsequent behaviour of firms. In terms of the field of competitive dynamics, without a relatively high degree of network stability, the impact of strategic networks on firms' actions and reactions may be limited. Certainly, presuming that the competitive characteristics that define singular inter-firm relationships would spill-over to encompass the entire horizontal network to the point that strategic networks may compete as collective competitive units against other networks within industry environments is not currently empirically supported. Furthermore, the cooperative dimension may actually have limited impact upon the direction and strength of competitive actions as suggested by co-opetition scholars. Nevertheless, there were some notable effects when considering the data in aggregated (ie. Hypothesis three) and thus, in the same way that strategic groups provide with an additional level of insight concerning otherwise heterogeneous patterns of firms behaviour (Tywoniak, Galvin & Davies, 2007), so too may

strategic networks under the right conditions.

Perhaps the other significant challenge in suggesting strategic networks may orchestrate their competitive behaviors against members of other strategic networks is that without some form of overarching governance structure, firms are left to engage in sensemaking of other firms behaviors to determine how they may react (Simsek, Lubatkin & Floyd, 2003). The effectiveness of firm signalling and sensemaking is a likely constraint to significant coordination of competitive behaviors.

Overall, our results attained in this research further extends our understanding of the competitive dynamics associated with collaboration and its impact upon innovation levels. Much of existing knowledge is grounded in industrial economics and operates at the industry level (Park & Zhou, 2005). With relatively few studies occurring at the firm level (Ang, 2008), the role that other firms play in determining the focal firm's behaviour is often under-emphasized (Chuang *et al.*, 2018; Park & Zhou, 2005). Alliances play a major role in allowing firms to overcome resource constraints, however, with whom these alliances and formed and the pattern of these alliances across an industry would seem to have relatively little impact upon the competitive actions pursued by aligned firms. To this extent, any shift from firm versus firm level rivalry to network versus network rivalry would seem to have limited impact upon innovation outcomes. Thus, while some authors have suggested rivalry may help to drive innovation (e.g. Athreye, 2001; Carlin *et al.*, 2004) the presence or otherwise of this rivalry at a network level is unlikely to form a major consideration in respect of innovation policy.

7. Conclusion

In this paper we consider issues pertinent to innovation policy, not at the level of national innovation systems, but rather at the level of inter-firm dynamics and how rivalry and competition may impact the economic system. Positioning our focus on competitive dynamics (Chen & Miller, 2015) we recognize that firms engage in competitive behaviour whereby an action by one firm elicits a reaction from other firms. The manner in which competitive dynamics plays out in different industries and under different conditions (e.g. multi-market competition, oligopolistic industries) has received considerable attention (e.g. Chen & Miller, 2015; Ferrier & Lee, 2002; Kim & Parke, 2009). In this paper, we continue this theme, recognizing that patterns of competition are not homogeneous and thus firms will pursue competitive actions and respond in different ways according to the prevailing alliances in the industry. However, we take an alternative approach and introduce the concept of strategic networks to investigate whether the locus of competition may shift from firm-level interaction to network-level interactions. Specifically, we consider whether the level of between network rivalry impacts the competitive responses of different firms. We also take a different approach to considering possible reactions by investigating more than just a product market variable (changes in price) but also a factor market variable (patenting activities).

The results were non-significant in respect of two of the three hypotheses, though we did find that the lagged patent data for an entire network correlated with the between network rivalry measure. In essence, not all firms may alter their patenting activity in response to the rivalry they face from firms in other networks, but as a totality, the strategic network does respond. Through the network and the multitude of strategic alliances that are in place, firms are able to leverage R&D generated by some firms.

However, what became clear given the dynamism of the networks when assessed at two-yearly intervals was that the strategic alliances were often relatively short-term, and in many cases, quite operational rather than strategic. Market access, distribution agreements, second sourcing agreements all featured frequently. As the networks changed significantly over the course of the study, the results are suggestive of a high level of co-opetition. Firms cooperate in the early stages of the value chain, but in many cases continue to compete with their alliance partners. Observing the make-up of the strategic networks over 15 years shows that some firms continued to work together over the entire period, and it is these firms that are more likely to account for their alliance partners in respect of their competitive actions and reactions.

The theoretical contribution of this research is that changes in the level of rivalry between different strategic networks does not correlate with changes if firm behavior in respect of pricing or innovation; however, changes in the level of rivalry are associated with changes in innovation at the network level. Whilst theoretically, strategic networks should impact the degree of rivalry within an industry and the subsequent actions and reactions that this rivalry creates, overall, our results suggest that at least in terms of the motor vehicle industry, strategic networks tend not to operate in a collective manner when it comes to competitive actions and reactions, or at best this effect is very weak. Inter-network rivalry will theoretically be strongest if all participant members of a network are aware of their affiliation as the potential for social control and incentive alignment will be most effective if firms understand the make-up of their network and thus who to target via such behavior (Sonenshein, Nault & Obodaru, 2017). With the alliances varying in strength and with the composition of the networks changing rapidly, it is possible that firms were not clear as to whom they were most closely aligned and whether they were strategically committed to their network partners. The presence of multiple low-level interdependency alliances (for example distribution or marketing alliances) may somewhat muddy our ability to discern the strong (and potentially competitive action inducing) relationships (Zhang & Zhang, 2006).

From a policy perspective, the logic that extensive alliances across the industry would lessen rivalry and thereby reduce pressures to innovate does not seem to have occurred. While some firms do not seem to alter their patenting behavior in the face of increased rivalry, at the entire network level, there is a competitive response and thus innovation is not compromised by the presence of the strategic networks. In essence, policy-makers should not view a multitude of strategic alliances in an industry as a threat to competition and there does not seem to be evidence of such alliances compromising innovation outcomes at an industry level.

Beyond the challenges of distinguishing between different forms of alliances, a further limitation relates to the measure of rivalry employed and the method of network formation. In regard to the rivalry measure, the use of the modified Herfindahl index elicited both benefits and weaknesses in application. The benefits of this measure include the capacity to use the real production figures of each firm in conjunction with specific product market participation of each firm. In this respect, this measure provides for a sound representation of what level of rivalry one firm faces from other firms participating in the same product market segment. The principal weakness associated with this measure is that as a concentration derived measure that considers the market share of one strategic network in a market segment relative to the market share of participants from other strategic networks (less the focal firm's own market share), the rapid changing of strategic network membership resulted in rapidly changing between network rivalry measures. At a more macro level, such a measure also brings with it weaknesses in the form of the inability to incorporate dynamic elements such as tit-for-tat rivalry, marketing strategies and competitive attacks in terms of instigating price competition between firms.

Moving forward, there are certainly opportunities to consider the impact of strategic networks on competitive dynamics in industries where the networks are far more stable such as airlines and technology products where competitors tend to coalesce around particular technological standards. Alternatively, rather than being restricted to specific alliance networks, given the convergence of technology in this and other industries, it may be appropriate to adopt a wider conceptualization of the relationships in-play and apply an ecosystems lens to better understand firm behaviors in respect of actions and reactions. Irrespective of how groups of firms are considered, a potentially fruitful path forward in better understanding firm's competitive behaviors may be through the way that we approach firm actions and reactions.

Competitive dynamics studies to date have tended to concern themselves with actions and reactions concerning product market factors. The focus has been almost exclusively upon price and market entry/presence (Chen & Miller, 2012). But competition also occurs in factor markets and while reactions to competitors' actions may not be as immediately noticeable, extending the principle of action and reaction would do well to consider reactions such as acquiring new strategic resources or even major investments in brand development. That is linking network rivalry to the acquisition and development of new resources or investment in learning to build dynamic capabilities may present significant opportunities. Quite possibly, the consideration of factor market responses would provide a clearer picture concerning the manner in which competitive dynamics plays out across industries and the impact upon innovation.

CRediT authorship contribution statement

Peter Galvin: Conceptualization, Investigation, Writing - original draft, Writing - review & editing. **Nicholas Burton:** Conceptualization, Writing - original draft. **Prakash J. Singh:** Methodology, Formal analysis. **David Sarpong:** Writing - original draft. **Norbert Bach:** Investigation. **Stephen Teo:** Formal analysis.

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