Collaborative innovation among cross-border supply chain partners in a context of geopolitical conflicts

Fernando Greve
fgreve@gmail.com

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1. Introduction

Global supply chains are highly interconnected as a result of the well-established globalization of manufacturing in many industries. In this regard, a large number of businesses offshore their operations to Asia, resulting in intricate worldwide supply chains for consumer and industrial goods and forming cross-border buyer-supplier relationships (BSR). The literature has studied BSR extensively, enhancing that companies can enhance commercial prospects and improve the efficiency of physical resources through these cross-border transactions, as well as lower costs and gain expertise (Pitelis & Teece, 2010). However, cultural differences (Ribbink & Grimm, 2014), institutional contexts (Ho et al., 2018), and geographic distance (Kaufmann & Carter, 2006) make maintaining these connections particularly difficult.

The globalization of manufacturing has also impacted the process of innovation. Innovation is an activity developed to achieve competitive advantages by reducing cost, improving processes and developing new products to finally maximize profits. International suppliers allowed buyers to extend their innovation capabilities by changing the way suppliers pursue innovation from a more "internal" model, in which a company creates, develops, and markets its own innovations, to a more "external" model, in which a company substantially depends on a range of external sources for its technology and ideas (Chesbrough, 2003). Research has shown that innovation collaboration within this cross-border BSR is crucial to develop its capacity to create new goods and services as well as cut costs through process innovation (Lee and Schmidt, 2016). Apple and Amazon are good examples. Apple has consistently been at the top of Bloomberg's list of innovative firms and among the world's most valuable corporations (PWC, 2015). On the other hand, Apple is one of two companies in Gartner's (2015) inaugural “masters” category for supply chain management, demonstrating its innovation and leadership. The same occurs with Amazon, winner of Gartner's (2015) “Supply Chain Top 25,” and 11th in Bloomberg (2010) innovativeness rankings, leads in innovation and supply chain management. Both organizations use supply networks to make and transport their products, thus their success depends in part on strong supply chain management.

Recently, trade war has been a profound change in global manufacturing. Since 2018, the first wave of 25% tariff increases has affected over 1,300 product categories and $50 billion in imports from China. Later, the scope expanded to $300 billion in 3,805 categories. In retaliation, China raised tariffs on $75 billion in US products. These impact the primary benefits of cross-border buyer–supplier relationships: cost-reduction. The American Chamber of Commerce notices that 42% of its members had greater production expenses, and more than half of its members expected their product sales to fall (Bray, 2019). The trade war between the U.S. and China has significantly undermined the cost advantages typically associated with international suppliers, especially due to the imposition of tariffs. As detailed by Fan, Zhou, et al. (2022), this geopolitical conflict has increased transaction costs, indicated by prolonged inventory days and undermined cost efficiencies, for U.S. firms sourcing from China.

In the context of geopolitical conflicts, the question that emerges is how tariffs impact collaborative innovation among cross-border supply chain partners. Current literature studying tariffs impact on innovation has the impact only on Chinese suppliers (Chen et al, 2023); the relationship between tariffs, innovation and managerial characteristics (Kong et al., 2024); and the divergence in Chinese and US innovation after the tariff war (Ma et al., 2024). None work has linked tariffs and innovation in this collaborative perspective.

This work aims to address this research gap by investigating the impact of economic geopolitical conflicts on cross-border buyer–supplier innovation. The aim of this work is to analyze the effects of the 2018 U.S.-China trade war on the innovation relationships between Chinese suppliers and their U.S. buyers. In order to do this, we <u>first</u> define cross-border buyer supplier relationship (BSR) as the unit of analysis. <u>Second</u>, we specify a theoretical framework combining perspectives of resource dependence theory and transaction cost economics. And <u>third</u>, we define hypotheses to analyze the trade war impact on buyer-supplier innovation level, integration and radicality in the context of the theoretical framework.

We propose a theoretical framework based on the relational view (RV) and transactional cost economics (TCE) (See Fan et al, 2024). We, <u>first</u>, consider the unit of analysis as the cross-border buyer–supplier relationship (BSR) and the collaboration in innovation within the BSR as a decision to develop complementary capability that requires relation-specific assets (from the supplier) and substantial knowledge exchange (from the buyer) and allows relational rents (Dyer and Singh, 1998). <u>Second</u>, we interpret the trade war as an increase of transference cost that affects essential resource flows within BSRs (Casciaro & Piskorski, 2005; Darby et al., 2020) and leads to increased transaction costs in terms of trade costs and risks (Fan, Zhou, et al., 2022; Handley & Limao, 2022). Having a negative impact on the expected rent of the innovation. Therefore, there is a question that buyer might ask: is it still a strategic decision to continue developing relation-specific assets and exchanging substantial knowledge exchange by innovation collaboration? In particular, buyers may find the increased transaction costs of continuing business within the BSR, when combined with the uncertainty introduced by the trade war, outweigh the costs of seeking alternative suppliers and the relation-specific assets developed in the past, and will have a negative impact on the expected returns of the innovation.

We explore the impact of the U.S.-China tariff war on 3 dimensions of cross-border buyer-supplier innovation collaboration. First, we analyze how tariffs imposed on US importers impact the number of patents of the cross-border BSR. Second, it examines how tariffs imposed on US importers impact the buyer' outsource decision regarding the degree to which suppliers are involved in the innovation cycle. Third, the buyer's decision regarding the strategic bucket of the innovation on the basis of whether it involves new technology, and/or a new customer market. The identification strategy relies on the exogenous nature of the trade war, instigated by a sudden and largely unanticipated shift in U.S. trade policy that was not driven by the individual characteristics or performance of firms. This unpredictable environment provides a unique opportunity to analyze the strategic adaptations firms make in response to external pressures, particularly regarding their governance strategies and engagement in emissions reduction initiatives. To empirically assess these impacts, I employ a difference-in-differences (DID) analysis following the methodology outlined by Ho et al. (2017).

We collected data from Compustat, Bloomberg SPLC, FactSet Revere, CSMAR Supply Chain Database and U.S. patent and Trademark Office USPTO. The identification strategy relies on the exogenous nature of the trade war, instigated by a sudden and largely unanticipated shift in U.S. trade policy that was not driven by the individual characteristics or performance of firms. To empirically assess these impacts, we employ an event study design and treats the US-China trade war as a quasi-natural experiment to empirically analyze its impact on Chinese firms' patenting in the United States. To test our hypotheses, we employed matched samples of buyer–supplier dyads in a long horizon event study. The treatment group comprised dyads of listed Chinese suppliers and their U.S. buyers affected by the tariff increase, while the control group was matched with suppliers unaffected by the trade war (See Fan et al, 2024).

This research, first, makes significant contributions to the OM literature on cross-border BSRs (e.g., Carter, 2000) by shedding light on the influence of geopolitics or a new era of geopolitical tensions that become more prevalent and contentious. Particularly, we advance the knowledge of collaborative innovation among cross-border supply chain partners. Second, this work contributes to the understanding of the economic impact of the tariffs under a supply chain perspective. Particularly, this work establishes a new scope by bringing the cross-border buyer supplier dyads innovation activities to discussion.

2. Literature Review

2.1. Prior trade wars

The tendency toward decreased cross-border economic interchange, known as deglobalization, is a response to globalization and the liberal economic policies that go along with it (Witt et al., 2023). Major economic powers reacting to one other's military and economic growth frequently drive this shift, which is propelled by growing geopolitical concerns, especially in the late 2010s and early 2020s (Witt, 2019; Witt et al., 2021). The effects of the recent return to protectionism (Fajgelbaum et al., 2020) and trade de-liberalization (Blank et al., 2022) are beginning to draw the attention of economists. Geopolitical events have been demonstrated to cause major disruptions in OM (Fan et al., 2022). As a result, firms have been forced to adapt through strategies like increased collaboration (Azadegan & Dooley, 2021), vertical integration (Fan & Xiao, 2023), buffer inventory building (Darby et al., 2020), and decreased innovation investment (Chen et al., 2024). Furthermore, buyers may need to reevaluate the risks of an offshore strategy when trade restrictions are used as a weapon to defend domestic industries. This could result in them adjusting, reconfiguring, or even abandoning their cross-border business strategy (Dong & Kouvelis, 2020).

The capacity of trade conflicts to impede resource flows at borders sets them apart from other exogenous occurrences, especially the recent U.S.-China conflict that began in 2018. As one of the biggest changes in U.S. trade policy, the U.S.-China trade war stands in stark contrast to the country's longstanding role in lowering tariffs around the world (Fajgelbaum & Khandelwal, 2022). In comparison to other trade disputes, including the Smoot-Hawley tariffs of the 1930s, its scope is more significant in terms of the percentage of products targeted by tariffs (67% vs. 27%) and the U.S. GDP impacted (3.6% vs. 1.4%). The globalized supply chain is undergoing an unprecedented transformation and disruption as a result of this conflict, which has an impact on businesses' values (Rogers et al., 2024) and operational expenses worldwide (Fan, Zhou, et al., 2022). A significant amount of uncertainty over future international trade situations is also created by the trade war, which represents a significant geopolitical confrontation between the two biggest economies in the world (Handley & Limao, 2022).

Cross-border BSRs face additional challenges as a result of growing geopolitical tensions between large countries (Moradlou et al., 2021). This is especially troubling because most supply chain management literature from the 2000s and 2010s assumes a low-tariff, stable environment (Dong and Kouvelis, 2020). Many of these conflicts have been triggered by the demand for reshoring and a reduction in cross-border BSRs brought about by the "America First" policy and other anti-globalization economic policies. According to the literature, exogenous shocks are growing increasingly frequent and severe (Witt, 2019), but little is known about how they impact BSRs (Fan, Zhou, et al., 2022). Therefore, there is an urgent need for study findings that could help management and policymakers make decisions about how to anticipate and mitigate these negative effects.

Fan, et al. (2024) is one of the only works that investigates the impact of economic geopolitical conflicts, particularly using the 2018 trade war, on cross-border buyer–supplier transactions. By focusing specifically on the attributes of international suppliers that enable them to maintain their cross-border buyer–supplier transactions during such conflicts. The main result reveals that the trade war generally adversely affected these buyer–supplier transactional relationships, leading to a negative abnormal transaction value in the affected dyads. Finally, the authors find that this adverse impact can be attenuated when Chinese suppliers demonstrate superior innovation capabilities, higher corporate social responsibility performance, or fewer local political ties.

2.2. Cross-border buyer-supplier relationships

Numerous studies on cross-border buyer-supplier relationships (BSR) have been conducted in the fields of international business (IB), economics, and management. Researchers in economics concentrate on how importers benefit from the tariff reduction in terms of improving product quality (Fan et al., 2015), broadening the scope of products (Fan, Luong, et al., 2022), enabling offshoring (Pierce & Schott, 2016), and preserving stable cross-border buyer-supplier transactions (Monarch, 2022). In the meantime, IB researchers concentrate on how tariff reduction alters the cross-border competitive environment that businesses in impacted nations must contend with (e.g., Baggs & Brander, 2006; Flammer, 2015; Seyoum, 2007). In a liberalized trade environment, they also address how multinational corporations might leverage global resources to strengthen their competitive edge (e.g., Kotabe & Murray, 2004; Lewin et al., 2009).

The management of cross-border BSRs in a stable, low-tariff environment as well as in a liberalized trade environment is another topic that OM scholars in global supply chain management extensively debate (Dong & Kouvelis, 2020). The international framework in which cross-border BSRs operate results in increased volatility, uncertainty, complexity, and ambiguity due to cultural, institutional, and economic disparities (Kaufmann & Carter, 2006). International BSRs are consequently subject to heightened hazards and necessitate significant management efforts (Choi & Krause, 2006). Prior studies have concentrated on the relational and operational elements that contribute to these difficulties, such as trust (Rungsithong & Meyer, 2020), governance systems (Li et al., 2010), cultural distance (Kaufmann & Carter, 2006), and ethical concerns (Carter, 2000). On the other hand, nothing is known about how exogenous events, particularly transactions, affect cross-border BSRs. Specifically, supply chain management studies have mostly overlooked geopolitical conflicts, despite the fact that they still have a significant impact on global trade (Cheng & Chiu, 2018; Duanmu, 2014) (Fan, Zhou, et al., 2022). We now move onto the discussion of how geopolitical disputes may lead to a scaling back or even dissolution of the cross-border BSR, in keeping with the research on BSR dissolution (e.g., Chen et al., 2013).

2.3. Cross-border supply chain innovation

Phases of the Product Innovation Cycle

Studies indicate that great ideas typically emerge from a meticulous process encompassing several critical steps. The innovation cycle commences with the ideation stage (phase 1), where brainstorming produces a multitude of potential thoughts or opportunities. In phase 2, the concepts undergo evaluation, commencing with a screening process where they are assessed across various dimensions, including strategic alignment with the organization, financial viability, and the capacity of the value chain to implement the idea. Feasible concepts that successfully pass this second evaluation phase, known as the concept phase, are anticipated to progress to phase 3, the design and development stage. Currently, a stage-gate (sometimes referred to as a phase-gate) product development process is frequently employed, wherein the product must successfully navigate multiple 'gates' that serve as go/no-go decision evaluations. Upon the conclusion of phase 4 (testing and validation), the product is prepared for launch, and production escalates to full capacity in phase 5. Even when the product attains full production, design concerns may persist that require resolution during the 'maintenance' phase (phase 6). The last phase is that of ‘end of life,’ phase 7. Even at this stage there may be design issues. For example, maybe a low-volume, lower-end component can be discontinued and a higher-end version approved as a substitute to be used across all models, or maybe the supplier can produce a lifetime supply of product (Cattani, 2005, Cattani and Souza, 2003).

Historically, supplier engagement has generally been increasingly direct and specific as one advances along the funnel. Value chains differ in the degree to which distinct stages of the product innovation cycle are incorporated into product design and development phases. In nearly all cases, it is advisable to engage a component supplier in design-for-manufacturing (DFM) efforts during the design and development phase. The level of engagement may be significantly deeper, potentially encompassing the total outsourcing of certain operations to the supplier, a distinct external design firm like IDEO, or to entrepreneurs.

Inclusion of value chain partners in one or more phases

In the 1980s, it was acknowledged that the 'over the wall' method of new product development (NPD) was inadequate. The design of the product followed by the transfer of specification drawings (blueprints) to production necessitated extensive debugging of the manufacturing process throughout the pilot production run and the subsequent ramp-up to full production (Whitney, 1988). The disparity between the actual design criteria and the readily manufacturable elements could be particularly obvious when manufacturing was outsourced. Consequently, the principle of design for manufacturability (DFM) gained prominence, leading to a closer integration of manufacturing departments (and suppliers, in cases of outsourced components) into the new product development (NPD) process to offer insights on optimizing product design for enhanced ease and reduced production costs.

Numerous suppliers advanced further by engaging in upward vertical integration. This involves cultivating their own design ability. Previously, an OEM such as Ford would design the majority of car components internally and subsequently provide design drawings to suppliers like Johnson Controls, which manufactures seats and other interior components, requesting them to produce the components. Now, Ford can provide Johnson Controls with general specifications, such as interior dimensions, allowing the supplier to finalize the design. The major responsibility for the overarching system design, architecture and integration of the supplier-designed components will rest with the OEM; however, the supplier will finalize the component design specifics to minimize manufacturing costs. Numerous suppliers evolved from contract manufacturers (CMs), tasked solely with constructing products according to provided specifications, to contract design manufacturers (CDMs), who assumed the supplementary responsibility of product design. Some vendors have advanced their skills to produce general design specifications and complete products autonomously, without direct input from OEM clients. These vendors, known as ODMs (original design manufacturers), produce a catalog of 'off-the-shelf' products from which the OEM can choose.

The strategic decision regarding outsourcing

The buyer must make a strategic decision on the extent of supplier involvement in the innovation process. The buyer should consider whether the product's design is outsourced and if it is produced internally. We analyze a succinct representation of the phases of the product innovation cycle (see Lee and Schmidt, 2016) and categorize the cycle into two primary stages, designated as "design" and "production." Outsourcing the production phase may be perceived as delegating stages five, six, and possibly seven, whereas outsourcing the design phase could be regarded as delegating steps one through four, or phases two through four with the OEM retaining responsibility for step one.

Figure 1 demonstrates that the corporation has four alternatives based on the two phases of "design" and "production." The "x" axis presents the choice of either designing the product internally or outsourcing the design, while the "y" axis reflects the option of manufacturing the product internally or outsourcing the production. Vertical integration (VI) is depicted in the lower-left quadrant, where the company manages both design and production; OEM outsourcing to a contract manufacturer (CM) is illustrated in the upper-left quadrant; and the services of a contract design manufacturer (CDM) — if the OEM retains responsibility for phase one — or an original design manufacturer (ODM) — if the OEM delegates that responsibility to the supplier — are represented in the upper-right quadrant. An OEM will engage a design firm to autonomously create products for its manufacturing in the lower-right quadrant, a scenario never observed in practice. This does not imply that an OEM does not outsource one or more of phases one through four; further details will follow.

The outsourcing decision as a function of the strategic bucket and innovation type

Another factor to consider in the innovation decision is to evaluate it within the framework of the 'strategic bucket' illustrated in Figure 2. The strategic bucket framework classifies innovations based on their incorporation of new technology and/or the targeting of new client markets. The more recent the product, the greater the associated risk, the longer the timeline for its launch and market expansion, and therefore, the higher the anticipated return; if the projected return does not align with the risk, the innovation will not be considered feasible.

Chao and Kavadias (2008) shows that the pursuit of radical innovations is especially pertinent in contexts where numerous product qualities interact, which they refer to as an environment of complexity. Moreover, radical developments utilizing new technology may necessitate the participation of universities or other research institutions to validate the technique. In certain instances, the company may predominantly abandon the pursuit of internal radical innovation in favor of acquiring technologies or even entire enterprises established by outsiders. Conversely, incremental innovations, often referred to as 'derivative' products due to their basis in current items, may necessitate minimal external engagement, but a CDM or ODM supplier could be a crucial catalyst in the innovation process. We assert that external involvement is likely to be most pronounced at the extremes of the spectrum; radical innovations may depend significantly on the value chain for idea generation and technological advancements, whereas derivative products, being more price-sensitive, are best developed by suppliers with in-depth knowledge of production processes. Confirming or disproving this idea could present a prospect for future research.

2.4. Theoretical foundation

The relational view (RV) suggests that cross-border BSR generates competitive advantages if there is (1) investments in relation-specific assets; (2) substantial knowledge exchange, including the exchange of knowledge that results in joint learning; (3) the combining of complementary, but scarce, resources or capabilities (typically through multiple functional interfaces), which results in the joint creation of unique new products, services, or technologies; and (4) lower transaction costs than competitor alliances, owing to more effective governance mechanisms. By these mechanisms, collaboration generates relational rent. In the context of the NPD in the BSR, collaboration in innovation activities for new product development is, in fact, a complementary capability which results in the joint creation of unique new product. In particular, collaboration in innovation requires substantial knowledge exchange from the buyer (market knowledge) and, on the other hand, suppliers must develop capabilities to generate the general design specifications and create finished products.

Integrating transaction cost economics (TCE) into our research improves our comprehension of how trade wars, as interruptions to resource flow, increase transaction costs, especially for U.S. buyers and Chinese suppliers. Recent literature indicates that trade wars have elevated transaction costs for buyers engaged in global sourcing (Fan, Zhou, et al., 2022). Initially, these conflicts impose trade costs on both exporters and importers (Antras et al., 2017). Moreover, geopolitical conflicts can foster national hatred (Arikan & Shenkar, 2013), hence undermining confidence between buyers and suppliers from the opposing nations (Korovkin & Makarin, 2023). Furthermore, the geopolitical characteristics of trade conflicts differentiate them from other forms of supply chain interruptions, such natural disasters or pandemics. Trade wars, reflecting persistent geopolitical tensions between nations like the U.S. and China, are not isolated incidents but may resurface or escalate (Handley & Limao, 2022). The persistent uncertainty and risk increase transaction costs (Langlois, 2003a) and diminish transaction value by challenging forecasts of partner behavior in adverse future scenarios (Foss & Foss, 2022).

Regarding the collaboration innovation and in the context of the increased trade cost and uncertainty, a question that buyer might ask: is it a strategic decision to continue developing relation-specific assets and exchanging substantial knowledge exchange? In particular, buyers may find the increased transaction costs of continuing business with a specific supplier, when combined with the uncertainty introduced by the trade war, outweigh the costs of seeking alternative suppliers and the relation-specific assets developed in the past. This evaluation process, emphasized by TCE, involves assessing whether the benefits of collaboration are eroded to the extent that switching suppliers becomes a more attractive option.

3. Hypothesis Development

3.1. Impacts of U.S.–China trade war on buyer–supplier amount of patents

The trade war between the U.S. and China has significantly undermined the cost advantages typically associated with international suppliers, especially due to the imposition of tariffs. As detailed by Fan, Zhou, et al. (2022), this geopolitical conflict has increased transaction costs, indicated by prolonged inventory days and undermined cost efficiencies, for U.S. firms sourcing from China. These impacts negate one of the primary benefits of maintaining cross-border buyer–supplier transactions: cost-reduction. And this could stimulate business innovation. In the operational activities of enterprises, the primary objective is typically profit maximization. Consequently, the foremost consideration is to enhance product sales volume and minimize input costs. Only when influenced by external factors or policies do they contemplate improving and innovating their operational or production methods (Reymen et al., 2015; Chen et al., 2021). The onset of the trade war between the US and China deteriorated the export trade conditions for ICT companies, prompting these firms to enhance resource allocation efficiency and advance production technology, thereby yielding an innovation compensation effect (Jaffe and Palmer, 1997). Therefore, the baseline hypothesis (H1) is as follows:

H1. The 2018 U.S.–China trade war event had a negative impact on the buyer–supplier transaction value of the treated dyads (U.S. buyer and Chinese supplier).

3.2. Impacts of U.S.–China trade war on make-or-buy decision

In addition to the present increase in transactional costs, the trade war introduces a significant layer of political risk in these transactions and, with them, uncertainty regarding future higher tariffs. Buyers amid political risks face difficulty in operational planning (Darby et al., 2020). This uncertainty exacerbates the transaction costs (Fan, Zhou, et al., 2022) as firms struggle to predict future trade policies and their impacts, thereby complicating sourcing decisions. As we argued before, collaboration in innovation activities for new product development is, in fact, a complementary capability which results in the joint creation of unique new product. Collaboration in innovation requires substantial knowledge exchange that results in joint learning. And finally, in order to increase their participation in the innovation project, suppliers develop even further capabilities to generate the general design specifications and create finished products.

We hypothesis that future uncertainty regarding higher tariffs in the future decreases the incentives of the buyer for developing relation-specific assets and exchanging substantial knowledge exchange with the supplier.

H2. The 2018 U.S.–China trade war event had a negative impact on the buyer–supplier innovation integration of the treated dyads (U.S. buyer and Chinese supplier).

3.3. Impacts of U.S.–China trade war on strategic bucket of innovation

The concept of the strategic bucket categorizes an innovation on the basis of whether it involves new technology, and/or a new customer market (Lee and Schmidt, 2016). The 'newer' the product the riskier it is, the longer the time horizon for launching the product and/or growing the market, and presumably, the higher the expected return (if the expected return is not commensurate with the risk, the innovation will not be deemed viable). The optimal involvement of different value chain partners in the various phases of the innovation process will, to some extent, be highly related with which strategic bucket the innovation lies. The identification of more-radical innovations (the upper-right corner of Figure 2) may be more likely if outside influences are involved early, in the ideation phase, start-ups and external intermediary networks may be potential sources of radical ideas. We hypothesis that uncertainty regarding higher tariffs in the future decreases the incentives of the buyer for developing newer and riskier products.

H3. The 2018 U.S.–China trade war event had a negative impact on the buyer–supplier radical level of innovation of the treated dyads (U.S. buyer and Chinese supplier).

4. Methodology

4.1. Data and sample

To examine the hypotheses, we construct the sample from these datasets: Compustat database for the initial firm list and financial data of U.S. buyers; Bloomberg SPLC and FactSet Revere databases for suppliers' information of the U.S. buyers; CSMAR database for the financial and innovation data for Chinese suppliers; and U.S. patent and Trademark Office USPTO (Chen et al., 2023 POMS). We defined the 2 years (2016 and 2017) prior to the 2018 trade war as the base years or pre-trade war period. The buyer–supplier dyads had not yet been affected by the pre-event time window. Moreover, we defined the years 2018 and 2019 as the post-trade war period. The research window stopped in 2019 because the major disruption caused by COVID-19 in 2020 may have confounded our analysis. In contrast to the previous literature, which is commonly focused on the buyer's view (Narayanan et al., 2015), we used the buyer–supplier dyad as the analytical unit. We defined the treated dyad as the buyer–supplier pairing involving a U.S. buyer and a Chinese supplier.

We follow a similar process for data collection than the one done by Fan et al. (2024). The data collection process began with obtaining the firms' names of U.S. buyers from the Compustat database. We used each company's name to search for the ticker code in the Bloomberg SPLC and FactSet Revere databases to obtain the supplier data, including the supplier's name, ticker, and location. As for the CSMAR database, it includes information on Chinese listed firms' five biggest buyers. We used the buyers' names, which are provided in the CSMAR database, to identify their other information in the Compustat database. We also required the dyads to have available transaction data during the pre- (2016–2017) and post trade war periods (2018–2019). In other words, we need dyads to have at least one transaction data both in the pre- and post-trade war periods. We then identified the influenced industries based on the official documents of trade action industry lists one and two from USTR. Considering that the USTR adapts the Harmonized Tariff Schedule of the United States (HTSUS) code for industry classification, we transformed HTSUS to the North American Industry Classification System (NAICS) code (six-digit) based on the translation table supplied by the United States International Trade Commission (2020) and used by Compustat to identify the affected industries as per NAICS corresponding to those on lists one and two of the USTR.

We define relevant variables as follows. First, referring to the methods of Wang et al. (2013) and Zhao et al. (2021), this paper selects patent data to measure innovation. Unlike other indicators, patents, as output indicators of enterprise innovation inputs, demonstrate innovation information such as research personnel, research funding, and research capability of enterprises (Chen et al., 2018). In order to identify cross-border innovations, we only consider patents that established location of inventors from both China and the US (see Chen et al., 2023). Given the lag in the patent application process, we define the number of invention patent applications (Patents) as a measure of the innovation level. Second, according to the patent law, patents can be divided into invention patents, utility model patents, and design patents. We define innovation radicality as the number of invention patents, as these innovations can best reflect the technological innovation level of enterprises. Third, we define innovation integration as follows: if a dyad has invention patents, we say that the dyad is highly integrated. If a dyad has only design patents, we say the dyad has a lower integration.

4.2. Event study design

To examine our hypotheses, we adhered to prior research and developed a long-horizon event study (Corbett et al., 2005; Lo et al., 2014), a quasi-natural experiment methodology. The experiment's treatment involved the commencement of the U.S.-China trade war in 2018, applied to buyer-supplier dyads. Consequently, we sought to compare the variation in patent value of the treated dyads before (2016 and 2017) and after (2018 and 2019) the trade war event.

The absence of the counterfactual outcome renders a direct comparison of the treated dyad's transaction value pre- and post-treatment somewhat problematic for evaluation. We employed a matching methodology to establish a benchmark counterfactual result (i.e., a control group) for assessing the treatment effect, utilizing U.S. buyer and non-Chinese supplier dyads. The treated and control dyads needed to be sufficiently comparable for the control group to function as an effective benchmark. Previous long-horizon event researchers have employed several criteria to build controls, such as company size and performance (Barber & Lyon, 1996; Huang et al., 2021).

The treatment buyer-supplier dyad was specifically matched to a control buyer-supplier dyad based on the following criteria. The matched dyads shared the same U.S. buyer and the same industry for the suppliers. We employed the SIC criterion to delineate the identical industry (four-digit SIC code) between the treated and control groups. Secondly, the matched dyads comprised suppliers of comparable size, with the total assets of each supplier falling within 50%-200% of the other's total assets, as determined by their natural logarithm values. Third, the matched dyads consisted of suppliers with comparable performance, wherein a supplier's return on assets (ROA) was required to fall within 20%-500% of another supplier's ROA.

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6. Figures

Figure 1: Possible outcomes of the make-buy decision involving design and production.

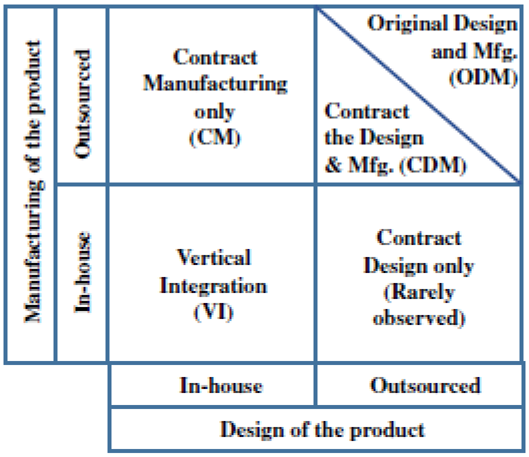

Figure 2: Strategic buckets