CHALMERS
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Establishing Strategic Technology Partnerships in Robotics

Navigating R&D Collaboration and Geopolitical Risk in High-Tech Innovation

Master's thesis in Management and Economics of Innovation

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ABSTRACT
As high-tech firms increasingly engage in external collaboration to accelerate R&D, they must navigate complex trade-offs between openness, control, and geopolitical risk. This thesis investigates how a high-tech firm adapts its R&D strategy and partner selection processes under geopolitical complexity, with two guiding research questions:

RQ1: How does the focal high-tech firm adapt its R&D strategy and external collaboration model, including partner selection, under geopolitical risk?

RQ2: What challenges and strategic trade-offs does the firm face when selecting external collaborators under geopolitical risk?

The study is based on a qualitative single-case study of a strategic collaboration project involving suppliers of advanced vision and processing technologies, with a focus on partnerships in China. The empirical foundation comprises nine semi-structured interviews with stakeholders across sourcing, R&D, and strategy functions, supported by internal documentation and informal interactions. Using an abductive approach and thematic analysis, the study captures how the firm's collaboration model evolved from closed innovation toward selective openness.

The findings reveal that partner selection is guided by a dynamic logic integrating technological competence, organizational alignment, and geopolitical foresight. However, the shift to external collaboration creates coordination complexity, capability gaps, and motivational challenges particularly in triadic collaboration settings. Geopolitical risk is not treated as a fixed constraint but as a structural input shaping design, governance, and substitution strategies.

The thesis contributes to open innovation literature by highlighting how geopolitical considerations are operationalized in partner selection and collaboration models. It proposes three managerial levers for increasing resilience: a cross-functional partner selection framework, modular product architectures with substitution options, and improve internal collaboration readiness. These insights inform how high-tech firms can structure externally oriented R&D strategies that remain robust in geopolitical risk.

Keywords: High-tech firm, R&D strategy, External collaboration, Partner selection, Geopolitical risk, Strategic trade-offs, Open innovation, Triadic collaboration.

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List of Terminology

Abductive Reasoning	A logical approach that moves back and forth between empirical data and theory to iteratively develop understanding, especially suited for exploratory research.
Closed Innovation	An R&D strategy where innovation is conducted internally within the firm, emphasizing control over proprietary technologies and intellectual property.
Open Innovation	A model where firms use external ideas, technologies, or partners to complement internal R&D efforts. It involves inbound (outside-in) and outbound (inside-out) knowledge flows.
Hybrid Innovation Strategy	A balanced approach combining both internal and external innovation efforts, selectively opening up certain parts of the R&D process while maintaining control over core capabilities.
External Collaboration	Strategic cooperation with external firms, suppliers, or research institutions to develop new technologies, products, or systems.
Partner Selection	The process of evaluating and choosing external collaborators based on technical, strategic, and increasingly geopolitical criteria.
Governance Mechanisms	Structures and tools used to coordinate and manage partnerships, including formal contracts (e.g. GSAs, FDAs, external collaboration agreements) and informal trust-based arrangements.
General Supply Agreement (GSA)	A contract governing the delivery of hardware or components under predefined commercial and legal terms.
Frame Development Agreement (FDA)	A contractual framework that structures collaboration in early-stage development and integration, often covering prototypes or technical alignment.
Geopolitical Risk	Uncertainty and potential disruptions arising from international politics, including trade restrictions, export bans, and regulatory volatility.
Scenario Planning	A strategic method used to forecast and prepare for multiple plausible future developments, particularly under geopolitical uncertainty.

Black Box Integration	A governance approach in which sensitive internal technologies (e.g. AI algorithms) are protected by defining limited interfaces for integration with externally developed components.
Strategic Trade-Off	The balancing act between conflicting priorities, such as speed vs. control or cost-efficiency vs. resilience, especially when managing innovation across firm boundaries.
Specification Writing	The process of creating detailed technical documentation that defines product or component requirements, essential for effective external collaboration.
Collaboration Readiness	An organization's internal ability to effectively engage in and manage external partnerships, including capabilities in communication, documentation, and cross-functional coordination.
Core Competence	A firm's central technological or organizational capability that provides long-term competitive advantage and is typically retained in-house.
Plug-and-Play Component	A system-ready module or subassembly that can be easily integrated into the final product without major adaptation or redesign.
Resilience	A firm's ability to withstand and adapt to disruptions, particularly those arising from geopolitical volatility or supply chain instability.
Fallback Production Capacity	An alternative manufacturing arrangement used to mitigate the risks associated with geopolitical exposure, especially when primary suppliers are based in sensitive regions.

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1. Introduction

1.1 Background

Industries across the global manufacturing landscape are undergoing rapid transformation driven by technological advancements, shifting consumer expectations, and regulatory pressures (World Manufacturing Forum, 2024). High-tech firms operating in these environments are increasingly integrating automation, electrification, and sustainability into their production and R&D strategies. The rise of autonomous systems, artificial intelligence (AI), and digital connectivity is reshaping competition, influencing how firms develop, source, and deliver their products (Akhtar, 2024).

As high-tech firms integrate automation, electrification, and digital connectivity into their R&D strategies, they face growing pressure to adapt how they structure innovation. A central dilemma is whether to rely on closed innovation developing proprietary technologies internally or to pursue open innovation through external collaboration. Closed innovation emphasizes internal R&D to protect intellectual property and maintain technological control (Teece, 1986), but it has become increasingly difficult to sustain in industries experiencing rapid technological change and disruption from new entrants. In contrast, open innovation allows firms to leverage external collaboration to integrate emerging technologies, reduce development costs, and accelerate innovation cycles (Chesbrough, 2003; West & Bogers, 2014). This approach offers access to specialized expertise and greater responsiveness but also introduces challenges related to partner selection, coordination, and strategic trade-offs particularly when collaboration must occur across organizational and geopolitical boundaries (Tidd & Bessant, 2021).

1.2 Problematization

As former sources of competitive advantage become obsolete, high-tech firms are increasingly forced to reconsider how they structure their R&D strategies particularly in relation to external collaboration. For firms that historically relied on proprietary systems and internally managed innovation, shifting to collaborative R&D models introduces new challenges involving intellectual property protection, long-term technological dependence, and coordination across internal functions (Chesbrough, 2003; Hagedoorn, 1993).

These decisions become even more complex when they involve partners in geopolitical risk. Geopolitical risk refers to the uncertainty and disruptions that firms face due to political tensions, regulatory changes, trade restrictions, export controls, and national security concerns. For high-tech firms, such risks can directly impact R&D strategies by limiting access to key technologies, constraining collaboration opportunities, and increasing the cost and complexity of managing cross-border innovation. Geopolitical risk has been shown to negatively affect firms' ability to select and sustain international collaboration, particularly in industries dependent on cross-border R&D (Guo, 2024). When regulatory constraints, national security concerns, and technology-related export restrictions overlap, the process of partner selection becomes strategically sensitive and increasingly difficult to manage (Rasshyvalova et al., 2024).

Although the literature on open innovation and R&D collaboration outlines the benefits of engaging with external partners (Chesbrough, 2003; Hagedoorn, 1993), it offers

limited guidance on how to evaluate and manage such collaboration under geopolitical risk Zahoor et al. (2022). The shift from internally governed innovation processes to more distributed forms of collaboration, such as joint development or licensing, further complicates the issue, as firms lack structured frameworks for partner assessment in these contexts. Moreover, many selection processes still rely on trust-based, informal mechanisms such as existing networks or prior experience (Solesvik & Gulbrandsen, 2013), which may not be sufficient in high-stakes, geopolitical risk.

This study addresses the need to better understand how firms adapt their R&D strategies particularly the transition from closed to more open innovation models when collaborating externally under geopolitical risk. The aim is to investigate how high-tech firms navigate strategic trade-offs, evaluate potential partners, and manage internal coordination across functions such as sourcing, R&D, and product management in light of these challenges.

1.3 Purpose and Research Questions

The purpose of this study is to explore how geopolitical risk influences the R&D strategy of high-tech firms, with particular attention to how firms adapt their R&D strategy and external collaboration structures, including partner-related decisions, in response to geopolitical risk. As global collaboration becomes increasingly shaped by export controls, regulatory restrictions, and intellectual property concerns, firms must reconsider how to balance internal development with external partnerships, particularly when engaging with suppliers and innovation partners based in geopolitical risk.

This study investigates how a focal high-tech firm responds to these challenges by analysing its evolving R&D strategy, how it evaluates and collaborates with external partners, and how it manages strategic trade-offs and internal coordination across functions such as sourcing, product management, and legal. The research focuses on how the firm moves from traditional sourcing of components toward more integrated forms of external collaboration, and how these decisions are shaped by geopolitical risk, technological complexity, and internal capabilities.

By identifying the key factors influencing these strategic decisions and analysing how the firm manages the associated challenges, the study aims to contribute to academic discussions on R&D strategy, open innovation, and partner collaboration in geopolitically complex environments. The findings also provide practical insights for firms seeking to structure external innovation partnerships that balance speed, control, and resilience.

Based on this purpose, the following research questions have been formulated:

RQ1: *How does the focal high-tech firm adapt its R&D strategy and external collaboration model, including partner selection, under geopolitical risk?*

RQ2: *What organizational challenges and strategic trade-offs arise in the focal high-tech firm's external R&D collaboration under geopolitical and structural complexity?*

2. Theory

This chapter presents the theoretical framework used to analyse how high-tech firms manage external R&D collaboration under geopolitical risk. It is organized around three core areas aligned with the study's research questions. First, it outlines strategic choices in R&D design, particularly the shift between closed and open innovation. Second, it reviews literature on partner selection and governance in external collaboration. Third, it introduces geopolitical risk and explores its implications for international partnerships and risk mitigation. Together, these lenses support the analysis of how the focal firm adapts its innovation and collaboration practices in a complex geopolitical environment.

2.1 R&D Strategy: Closed, Open and Hybrid Innovation

The closed innovation model describes an approach where firms rely on internal processes to develop and control technologies. According to Bogers, Chesbrough, and Moedas (2018), this involves leveraging ideas generated within the organization and managing innovation activities internally. Companies adopting this model typically benefit from temporary market exclusivity through strong intellectual property rights and high barriers to entry (Appleyard & Chesbrough, 2017). This approach allows firms to safeguard proprietary technologies and maintain control over pricing and quality. However, the closed innovation approach limits access to external ideas and resources, which can disadvantage firms in fast-moving, competitive industries facing rapid technological change (Appleyard & Chesbrough, 2017).

In contrast, open innovation represents a strategic R&D approach characterized by the purposeful integration and leveraging of external knowledge, technologies, and ideas across organizational boundaries. Chesbrough introduced this model to highlight how firms strategically utilize external sources of innovation alongside internal capabilities to pursue multiple paths to market (Bogers, Chesbrough, & Moedas, 2018). Open innovation is explicitly defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Bogers, Chesbrough, & Moedas, 2018, p. 6).

Open innovation involves two primary dimensions: outside-in (inbound) and inside-out innovation (Bogers et al., 2018). Outside-in open innovation involves integrating external knowledge, technologies, and ideas into the firm's innovation processes, a dimension that has received considerable attention in academia and industry. Inside-out open innovation, allowing underutilized internal knowledge to flow out to external entities, is less commonly addressed in the literature.

Firms that choose open innovation strategies can improve their competition by reducing production costs, improving product quality through different external inputs, shortening innovation cycles, and enabling faster dissemination of results (Appleyard & Chesbrough, 2017). Moreover, open innovation can quickly establish and coordinate a critical mass of players around a new technology platform, exemplified by Google's initial open approach to the Android operating system (Appleyard & Chesbrough, 2017).

However, firms employing open innovation must balance value creation and value capture. While openness may strengthen a firm's competitive position by lowering entry barriers and leveraging user innovation, it also requires new business models to capture value often by shifting profit to complementary offerings or downstream channels (Appleyard & Chesbrough, 2017).

Both closed and open innovation strategies provide distinct rationales and practical approaches for firms' strategic innovation decisions. These models directly inform and frame the strategic analysis of how firms, such as the focal company of this thesis, navigate R&D strategy and partner selection under conditions of rapid technological disruption and geopolitical uncertainties.

In practice, high-tech firms do not always strictly adhere to closed innovation or open innovation models. Instead, their R&D strategy frequently involves strategic shifts along a spectrum between openness and proprietary control, depending on evolving market conditions, internal capabilities, and strategic objectives (Appleyard & Chesbrough, 2017). For instance, a high-tech firm may selectively reduce intellectual property ownership or partially engage in external collaboration, while still maintaining control over critical technological assets. Such strategic trade-offs enable firms to access key capabilities, accelerate innovation, and manage geopolitical risk more effectively. Ultimately, the degree of openness a firm chooses is closely aligned with its innovation priorities, market maturity, and the broader geopolitical and competitive landscape.

2.2 Partner Selection in External Collaboration

2.2.1. Criteria for selecting R&D partners

Selecting the right external collaborators is a critical aspect of R&D strategy, as it directly shapes both innovation outcomes and the firm's ability to manage uncertainty. Gulati (1998) highlights three key factors in partner selection: technological compatibility, prior collaboration experience, and trust. Technological fit ensures that external capabilities align with the firm's internal R&D efforts, enabling smoother integration and faster progress. Trust reduces concerns related to knowledge leakage and coordination difficulties especially important in cross-border collaboration, where legal enforcement may be weaker or more complex.

Building on this, Hoang and Rothaermel (2005) emphasize the importance of prior alliance experience. Firms with a history of successful collaborations tend to have established routines that lower transaction costs, facilitate knowledge exchange, and improve the predictability of outcomes. These routines enhance both operational compatibility and strategic alignment.

Increasingly, geopolitical risk also shapes how firms assess and select external collaborators. As Arranz and Arroyabe (2007) note, partner evaluation now often includes criteria such as political stability, regulatory alignment, and exposure to national security concerns especially when dealing with partners from geopolitical risk. These factors are particularly salient for high-tech firms, which may face export controls, data sovereignty requirements, or public scrutiny. As a result, partner selection must integrate both technological considerations and geopolitical risk assessment as part of a structured and strategic decision-making process.

In addition to prior experience and technological alignment, the literature emphasizes the role of relational capital which is the trust, shared norms, and interpersonal alignment built over time between partners (Dyer & Singh, 1998; Kale, Singh, & Perlmutter, 2000). Relational capital improve collaboration quality, reduces transaction costs, and increases the likelihood of long-term strategic fit, especially in high-uncertainty environments. For high-tech firms navigating selective openness in R&D, evaluating relational capital has become an essential but often informal criterion in partner selection.

2.2.2. Governance Mechanisms for Collaboration

Once external collaborators are selected, firms must determine how to govern these relationships in ways that balance control, flexibility, and risk. Oxley and Sampson (2004) distinguish between formal mechanisms such as contracts and legal safeguards and informal governance, which relies on trust and mutual understanding. Formal agreements can clarify responsibilities, protect intellectual property, and reduce uncertainty. However, in rapidly evolving technological fields, excessive reliance on rigid contracts may hinder responsiveness and innovation.

By contrast, trust-based governance enables more adaptive and fluid collaboration. According to Arranz and Arroyabe (2007), such informal mechanisms can enhance knowledge sharing and problem-solving, especially in uncertain or exploratory projects. Still, trust is not easily built particularly in cross-border or high-stakes collaborations and often depends on past relationships or network familiarity.

For high-tech firms engaging in external collaboration under geopolitical risk, governance becomes not just an operational issue, but a strategic one. The choice between formal and informal mechanisms must account for partner location, legal enforceability, and political exposure. In such settings, firms must strike a balance: ensuring sufficient safeguards while preserving the flexibility needed for innovation and adaptation.

Recent scholarship has further extended the concept of governance in international R&D partnerships by emphasizing the role of proactive risk management and institutionalized foresight. Zahoor et al. (2022) argue that effective governance under geopolitical uncertainty increasingly relies on the formal integration of scenario planning, geopolitical risk scanning, and anticipatory decision-making into partnership routines. Rather than treating political or regulatory disruptions as isolated threats, high-tech firms are encouraged to embed systematic foresight capabilities into their governance structures evaluating not only the partner's technical and relational fit but also their adaptability to shifting geopolitical conditions. This perspective frames governance as a dynamic, cross-functional process that involves legal, compliance, risk management, and strategic planning functions, and positions geopolitical adaptability as a core criterion for both partner selection and ongoing relationship management.

2.3 Geopolitical Risk and Its Impact on Collaboration

2.3.1. Types and dimensions of geopolitical Risks

Geopolitical risk increasingly shapes how high-tech firms engage in external collaboration, particularly when partnerships involve cross-border technological exchange. Key dimensions of this risk include trade restrictions, regulatory unpredictability, intellectual property (IP) security concerns, and broader national security considerations. Trade restrictions often arise from diverging national interests, limiting access to critical technologies or key markets (Charpin, London, & Vincent, 2024). In parallel, frequent and unpredictable shifts in regulatory policy complicate long-term collaboration and investment planning (Rasshyvalova et al., 2024).

For firms engaged in international R&D strategy, these uncertainties are especially problematic. Heightened geopolitical tensions can lead to stricter intellectual property regulations and export controls, increasing the difficulty of managing knowledge flows across borders (Guo, 2024). This is particularly salient for high-tech firms operating in strategically sensitive domains, where collaboration with foreign partners may be subject to political scrutiny or sudden legal barriers. As a result, geopolitical risk introduces a layer of volatility into partner selection and demands new criteria for assessing the viability and stability of external collaboration

2.3.2. Strategic Approaches to Mitigate Geopolitical Risks

To safeguard their R&D strategy and external collaboration efforts, high-tech firms are increasingly adopting proactive measures to mitigate geopolitical risk. One common approach is diversification, where firms distribute their partnerships and sourcing activities across multiple regions. This reduces dependency on any single country or partner and increases resilience against disruptions stemming from political tensions or export restrictions (Rasshyvalova et al., 2024).

Another strategy is regionalization, which involves concentrating collaborations within politically stable and economically aligned regions. By operating within shared regulatory frameworks and cultural norms, firms can reduce the uncertainty associated with global collaboration. This approach also enables more predictable governance and lowers exposure to abrupt policy shifts or trade disputes (Guo, 2024; Rasshyvalova et al., 2024).

Finally, many firms employ scenario planning as a structured method for managing geopolitical uncertainty. This involves developing multiple plausible futures and preparing tailored responses for each. Scenario planning enhances strategic agility, allowing firms to adjust their R&D collaboration strategies quickly when faced with changing political or regulatory landscapes. By integrating this approach, firms can support long-term innovation goals while maintaining competitiveness in an increasingly volatile global environment (Rasshyvalova et al., 2024).

3. Method

3.1 Research Design

This study adopts a qualitative, exploratory research design based on an abductive approach. The aim is to understand how a high-tech firm navigates partner selection in R&D strategy under geopolitical risk. Since the topic involves complex decision-making across functions such as sourcing, R&D, and strategy and unfolds in a real-world, strategic project a qualitative approach is well suited to capture depth and context.

Abductive reasoning was chosen because it allows continuous iteration between theory and empirical insights. Rather than testing a predefined hypothesis (deductive) or generating theory entirely from data (inductive), the abductive logic enables the refinement of theoretical understanding as new insights emerge throughout the research process (Bell et al., 2022; Ganesha & Aithal, 2022). This was especially important in this case, where strategic decisions around collaboration and partner selection evolve as the project develops.

The research is based on a single-case study design (Yin, 2014), which allows for an in-depth examination of how a high-tech firm navigates external collaboration and partner selection within a geopolitically complex setting. The selected case involves a strategic partnership project in which the focal company, for the first time, integrates an externally co-developed subsystem into a core product platform. This initiative focuses on an AI-enabled Vision module developed in partnership with two Chinese technology suppliers, raising important concerns related to geopolitical risk, including export controls, data security, and the sustainability of international technology partnerships. The collaboration spans multiple internal functions, including R&D, sourcing, and legal, and highlights strategic trade-offs between innovation speed, specification control, and organizational coordination. A more detailed overview of the case company and the strategic project is provided in Chapter 4

The project is ongoing at a leading high-tech firm, anonymized in this thesis as “the focal company.” Access to the case was granted through one of the authors’ part-time employment at the company, which enabled close contact with key departments and participants. The research design is guided by a theoretical framework developed in Chapter 2, focusing on three core areas: R&D strategy (internal vs. external), partner selection in external collaboration, and the influence of geopolitical risk. This framework informed both the interview guide and the overall analysis, ensuring a consistent connection between the empirical data and the study’s research questions.

3.2 Case study Approach

This thesis applies a qualitative single-case study design to explore how a high-tech firm responds to strategic challenges in external collaboration and R&D strategy under geopolitical risk. The case study approach enables a focused examination of decision-making processes within the specific organizational and geopolitical context described in Section 3.1 (Yin, 2014).

The case was selected as an instrumental case (Stake, 1995), providing analytical depth rather than aiming for broad generalization. It offers insight into how geopolitical considerations influence partner selection, coordination across internal functions, and strategic adaptation in a real-world innovation project. The approach allows the researchers to trace how theoretical concepts unfold in practice and supports the study's overall aim to connect empirical observations with the underlying research questions.

3.3 Data collection

3.3.1. Interviews

Semi-structured interviews were chosen as the primary method of data collection in this study due to their ability to capture both structured insights and unstructured reflections. This method allowed for flexibility in exploring participants' experiences while maintaining alignment with the study's focus on R&D strategy, partner selection, and geopolitical risk (Easterby-Smith et al., 2015).

A total of nine interviews were conducted with employees across key functions within the focal company, including R&D, Advanced Development, Sourcing, and Risk/Legal. Participants represented multiple levels of seniority from category managers to senior functional leads ensuring a diverse set of perspectives relevant to the decision-making processes being investigated.

The interviews followed a semi-structured format. While a common set of guiding topics was used, questions were adapted based on the interviewee's role, function, and level of involvement in the strategic project. For instance, individuals in sourcing were asked about supplier assessment criteria and geopolitical exposure, while those in R&D and strategy were asked more about technology evaluation and internal-external alignment. This ensured depth and relevance across departments without compromising comparability.

To ensure alignment with the study's research questions, the interviews were guided by role-specific question sets. While a common thematic structure was maintained, the questions were tailored to the participant's function and proximity to the strategic partnership project. Participants in sourcing were asked about partner evaluation, supplier governance, and risk mitigation, while R&D personnel were asked about internal capabilities, collaboration trade-offs, and specification practices. The following examples illustrate the types of questions used across the interviews:

- What factors influenced the decision to move from internal development toward external collaboration for this project?
- How were external partners evaluated in terms of technical competence, cost, and strategic fit?
- What internal challenges have emerged when coordinating external collaboration across R&D, sourcing, and legal functions?

- How do geopolitical risks influence decisions about which suppliers to collaborate with?
- What governance mechanisms or contractual structures have been used to manage collaboration and intellectual property boundaries?
- In what ways has the firm adapted its R&D strategy or internal structure to support this new mode of working with external technology partners?

A summary of the interview participants is presented in the table below Quotes referenced in Chapter 5 (Findings) are attributed to anonymized informants using numerical identifiers.

Table 1. Overview of Interview Participants and Strategic Project Roles.

Informant ID	**Function**	**Strategic Project Involvement**
[1]	Sourcing	Leads innovation sourcing and strategic direction
[2]	Sourcing	Manages key supplier relationship and hardware strategy
[3]	Sourcing	Senior sourcing leader overseeing global collaboration
[4]	Sourcing	Manages collaboration with optical system supplier
[5]	Project Management	Coordinates development milestones and cross-unit tasks
[6]	R&D	Defines system-level specs and product architecture
[7]	R&D	Oversees technical roadmap and platform strategy
[8]	R&D	Heads robotics R&D, initiates strategic partner approach
[9]	R&D	Responsible for global R&D vision and capability shifts

Each interview lasted approximately 30 minutes. Due to confidentiality constraints and a signed non-disclosure agreement (NDA), the interviews were not audio-recorded. Instead, detailed notes were taken manually during each session. Because of the strategic complexity of the case, one participant with a central role in the project was consulted informally on multiple occasions, approximately every other week throughout the data collection period. These follow-ups served to clarify organizational boundaries, validate evolving interpretations, and ensure the accuracy of context-specific insights. Additional clarifications were sought from two other interviewees on a one-time basis to confirm technical or procedural details.

3.3.2. Sampling and Access

The interview sampling followed a hybrid of purposive and snowball techniques. Initial participants were identified based on their relevance to the ongoing project, focusing on individuals from sourcing and R&D. As interviews progressed, additional participants were recommended by interviewees, allowing the researchers to follow internal knowledge flows and organizational networks. This approach ensured inclusion of relevant stakeholders while adapting to the structure of the firm.

All participants were internal to the focal company and directly involved in or knowledgeable about the strategic collaboration project. Access to participants was facilitated through one of the authors' part-time employment at the company, which enabled close collaboration with key departments and simplified scheduling.

Participation in the study was voluntary, with all interviewees informed about the research objectives. Access to participants and internal materials was governed by pre-agreed confidentiality terms, which also supported the responsible handling of sensitive data and the integration of internal documentation alongside interview insights for triangulation purposes.

3.3.3. Internal Documents and Informal Discussions

In addition to the primary interview data, internal documents and informal discussions were used as complementary sources to support the empirical understanding of the case. These materials provided contextual insight into the strategic and operational challenges faced by the focal company in the ongoing partnership project

Internal documents included relevant PowerPoint presentations, project timelines, and briefing materials shared during internal alignment meetings. These materials were not part of a formal document archive but were made available through the authors' access within the organization. Although not comprehensive, they offered valuable input on how the project was framed internally, the milestones involved, and the high-level coordination required across departments.

Informal discussions, particularly with one of the authors' direct manager, were also used to gain a more nuanced understanding of the company's internal logic, strategic priorities, and organizational sensitivities. These conversations were not formally transcribed but helped clarify aspects of the project that were either implicit or not fully articulated in the formal interviews.

These supplementary sources were used to triangulate and validate findings from the semi-structured interviews. They did not replace primary data collection but enhanced the interpretation of themes related to strategic alignment, coordination challenges, and the role of geopolitical considerations in partner selection. All uses of internal materials respected the confidentiality obligations defined in the company's non-disclosure agreement.

3.4 Data Analysis

3.4.1. Thematic Analysis

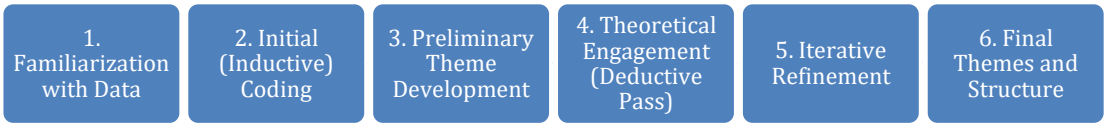
The interview data was analysed using abductive thematic analysis, a flexible yet rigorous method suited for qualitative case studies that seek to explore both emergent patterns and theoretical meaning (Braun & Clarke, 2006). Abductive thematic analysis blends inductive (data-driven) coding with deductive (theory-informed) refinement, allowing the researcher to move iteratively between empirical insights and conceptual frameworks. This approach was well aligned with the abductive research logic of this study, which aimed to generate theoretically grounded insights from qualitative data on external collaboration and partner selection under geopolitical risk.

No formal coding software was used. Instead, interview notes were manually reviewed and organized using Excel. This choice reflected the manageable scale of the dataset and allowed for transparent documentation of the coding process. The analysis began with an initial familiarization phase and open coding of the interview notes, identifying data segments that reflected repeated ideas, key phrases, or insights (Braun & Clarke, 2006). These initial codes, grounded in the participants' own language, were grouped inductively into first-order themes, staying close to the empirical material.

In a second phase, the researchers engaged with the theoretical framework to interpret and refine these first-order themes. This deductive iteration involved organizing and, when necessary, relabelling themes based on their alignment with concepts from the open innovation, governance, and geopolitical risk literature. This process mirrors abductive best practices described in recent methodological work, which emphasizes the cyclical movement between data and theory to ensure analytic depth (Linneberg & Korsgaard, 2019).

Through this iterative coding process, the first-order codes and theory-informed refinements were consolidated into a set of second-order themes, which were then further refined into six final themes that structure the findings chapter. These final themes are shown in Figure 5.1, which provides a transparent coding map linking data excerpts to their respective analytical categories. This structure is also informed by the Gioia methodology (Gioia, Corley, & Hamilton, 2013), which distinguishes between informant-centric codes and researcher-derived themes to enhance clarity and theoretical contribution.

Figure below illustrates the six-step process followed in the abductive thematic analysis. It outlines how the researchers moved from initial familiarization with the data through inductive coding, theoretical engagement, and iterative refinement to arrive at the final thematic structure presented in the findings chapter.



3.5 Research Quality and Trustworthiness

To ensure the quality of the research process and findings, this study was evaluated based on the trustworthiness framework which includes the criteria of credibility, transferability, dependability, and confirmability.

3.5.1. Credibility

Credibility concerns the accuracy and plausibility of the findings. To strengthen credibility, this study applied methodological triangulation by using interviews as the primary data source and supporting these with internal documents and informal discussions. Moreover, the iterative nature of the data collection allowed for clarification and follow-up conversations when necessary, increasing the robustness of interpretations. As interviews progressed, early insights informed subsequent questions, helping the researchers refine their understanding and build a richer empirical picture. Although the interviews were not audio-recorded due to confidentiality, detailed notes were taken and cross-checked after each session.

3.5.2. Transferability

Transferability relates to the extent to which findings can be applied to other contexts. This research focuses on a single high-tech firm undergoing a geopolitically sensitive R&D collaboration, which limits broad generalization. However, the study provides detailed contextual information about the firm's organizational setup, its innovation challenges, and the nature of the project. These rich descriptions may support analytical generalization, allowing readers to assess the relevance of the findings to similar contexts particularly within innovation-driven, globally active firms facing geopolitical complexity.

3.5.3. Dependability

Dependability refers to the consistency and traceability of the research process. To support dependability, this chapter outlines the full research design in detail, including the abductive reasoning process, the interview approach, sampling logic, and the thematic analysis technique. All steps taken from interview preparation and note-taking to data sorting and theme development have been clearly documented to allow others to understand how conclusions were reached. Interview guides, research notes, and internal files were managed systematically to maintain data integrity throughout the process.

3.5.4. Confirmability

Confirmability addresses the extent to which the findings are shaped by the participants rather than researcher bias. To support confirmability, the researchers relied on triangulation across data sources and maintained a reflexive approach throughout the project. Themes were grounded in the interview data and validated through cross-checking with internal documents and informal discussions. Anonymized reporting of interview content and the use of theoretical constructs as sensitizing concepts helped reduce subjectivity and ensure that interpretations remained anchored in the empirical material.

3.6 Ethical Consideration

This study adhered to established ethical guidelines for qualitative research. All participants were informed about the study's aims and consented to participation. Given the strategic sensitivity of the project, particularly in relation to external partnerships in geopolitically exposed contexts, confidentiality was strictly maintained throughout. Interview data and internal documents were handled in accordance with pre-agreed confidentiality terms, and all interviews were documented through detailed note-taking rather than audio recordings.

From a societal perspective, the study touches on the implications of cross-border technological collaboration in a time of rising geopolitical tensions. Strategic decisions regarding partner selection can affect long-term competitiveness, data security, and innovation sovereignty, particularly when dealing with suppliers in politically sensitive regions.

Although ecological aspects were not the primary focus, the study acknowledges that partner selection may indirectly influence environmental sustainability through differences in regulatory compliance, production standards, and supply chain transparency. These broader implications are important considerations in the company's long-term strategic positioning.

3.7 Researcher Positioning and Access

One of the authors held a part-time position in the sourcing function at the focal company during the research period. This insider role provided a contextual understanding of the firm's operations and facilitated access to relevant departments and participants involved in the strategic partnership project. While not formally part of the project team, the author was able to follow the collaboration process closely, observe internal coordination efforts, and identify interviewees with relevant insights. This position helped the researchers interpret organizational dynamics and strategic concerns from an informed, yet analytically grounded perspective.

4. The Case Company and Strategic Partnership Project

This chapter introduces the focal company an anonymized high-tech manufacturer of robotic solutions and outlines the strategic partnership project examined in the study. The case provides a real-world context for exploring how the firm navigates partner selection and collaboration under conditions of geopolitical risk. Due to confidentiality, the company's name and its external partners have been anonymized throughout the chapter.

4.1 The Focal Company

4.1.1. R&D Structure and Innovation Model

The company's R&D strategy is primarily internal, supported by two specialized divisions: one for residential robotics and another for professional robotics. These units are organized into cross-functional teams comprising system test engineers, embedded software developers, electrical and mechanical engineers, and systems engineers. Collaborative input is also provided through in-house verification labs.

Although internal development remains a core strength, the company increasingly applies a hybrid innovation model. This approach integrates elements of open innovation, such as research collaborations with universities, while preserving control over core technologies. The company's R&D strategy balances internal control with selective external collaboration to access emerging technologies and scale development.

4.1.2. Industry and Global Presence

The focal company is a leading high-tech firm in the outdoor power equipment industry, with a strong track record in autonomous technologies. It operates globally, with a presence in over 100 countries and thousands of employees across Europe, North America, and Asia. Headquartered in Northern Europe, the firm distributes its products through a vast network of dealers and manages multiple production sites worldwide. Its offerings span both consumer and professional segments, including various types of connected and automated outdoor solutions.

4.1.3. Strategic Priorities

The company's long-term strategy is structured around three core pillars: growth, efficiency, and sustainability.

Growth: The company aims for organic sales growth through expansion in strategic areas such as consumer robotics, electrified equipment, and digitally connected products..

Efficiency: Operational efficiency is pursued through cost reduction programs, modular product architectures, and increased use of artificial intelligence. These efforts support faster time-to-market and optimized manufacturing and sourcing practices.

Sustainability: Sustainability is integrated into the company's product development and supply chain strategy. Key initiatives include a transition to low-carbon and battery-powered products, science-based carbon reduction targets, circular economy

innovations, and biodiversity initiatives. These objectives are intended to align environmental responsibility with long-term commercial viability.

4.2 The Strategic Partnership Project

4.2.1. Technology Focus and Strategic Objectives

The strategic partnership project examined in this thesis represents a pivotal shift in the focal company's approach to innovation and sourcing. Historically, the company has maintained a leading position in the consumer robotics segment, built on proprietary in-house development and physical perimeter guidance systems However, this position is now being challenged by shifts in market A new wave of competitors particularly those leveraging AI-driven vision systems has rendered traditional wire-based navigation less attractive, prompting an urgent need for technological renewal.

In response to this disruption, the company initiated a transition toward fully virtual navigation, based on a proprietary satellite-based positioning system. This system enables users to define virtual operating zones through a mobile interface, removing the need for physical boundary infrastructure and allowing for greater flexibility and customization. Building on this platform, the company is developing an AI-powered vision system that incorporates onboard cameras for object detection, environmental awareness, and enhanced functionality in low-light conditions. The system is intended for integration into future autonomous platforms across key market segments.

The decision to pursue this innovation trajectory is not only driven by competitive pressure, but also by cost considerations. As price competition intensifies in the consumer robotics market, the company has recognized the need to reduce development costs and accelerate time-to-market. These pressures have contributed to a strategic revaluation of its internal R&D capacity, highlighting the limits of a purely internal model in addressing the speed and scope of required innovation.

While the company remains committed to retaining ownership of certain core technologies, it has become increasingly open to external collaboration in areas where internal capabilities are either insufficient or too costly to scale rapidly. This includes software architecture integration and specialized component development, particularly for vision and processing functions. The shift reflects a broader strategic aim: to sustain product leadership while recalibrating the boundary between internal innovation and external collaboration. This approach underscores the company's effort to navigate strategic trade-offs between innovation responsiveness and control over core technology assets.

4.2.2. External Collaboration

A central feature of the project is the ongoing external collaboration with two Chinese technology suppliers: Supplier X, a leading developer of camera modules, and Supplier Y, which specializes in high-performance processors. These suppliers are engaged not merely as providers of off-the-shelf components but as external collaboration partners, involving them early in system design and integration. This marks a significant strategic shift from the focal company's traditionally transactional supplier relationships, historically centred around Western partners.

The collaboration is jointly managed by sourcing and R&D teams, with additional support from advanced development and legal/risk functions, reflecting the complexity inherent in managing partner selection and collaboration. Current internal discussions focus explicitly on identifying and clarifying which subsystems should remain under internal control and which can be co-developed externally, with a critical emphasis on maintaining technological autonomy and safeguarding intellectual property.
Supplier X and Supplier Y offer access to advanced technologies at competitive cost levels, strategically important within an innovation-driven and cost-sensitive market.

However, the Chinese base of both suppliers introduces specific considerations around geopolitical risk concern highlighted by several internal stakeholders and external consultants involved in scenario planning. These include potential impacts of evolving export controls, regulatory unpredictability, and increasing scrutiny of technology transfers involving Chinese firms. Compared to suppliers in Europe or North America, the geopolitical exposure was perceived as significantly higher, particularly in light of rising trade tensions and national security policies in key markets.

These external factors directly influence the company's evolving partner selection criteria and governance frameworks, highlighting strategic trade-offs such as balancing speed with control, cost efficiency with technological sovereignty, and innovation capacity with risk mitigation. This multifaceted and deliberately structured approach is central to the company's strategic R&D initiative under conditions of geopolitical uncertainty.

Figure below: summarizes the roles and relationships within the focal company's external collaboration model. It illustrates the bilateral external collaboration arrangements with Supplier X and Supplier Y, and highlights the integration of Supplier Y's processor into Supplier X's Vision module reflecting the tiered, specification-driven collaboration structure now adopted by the company.

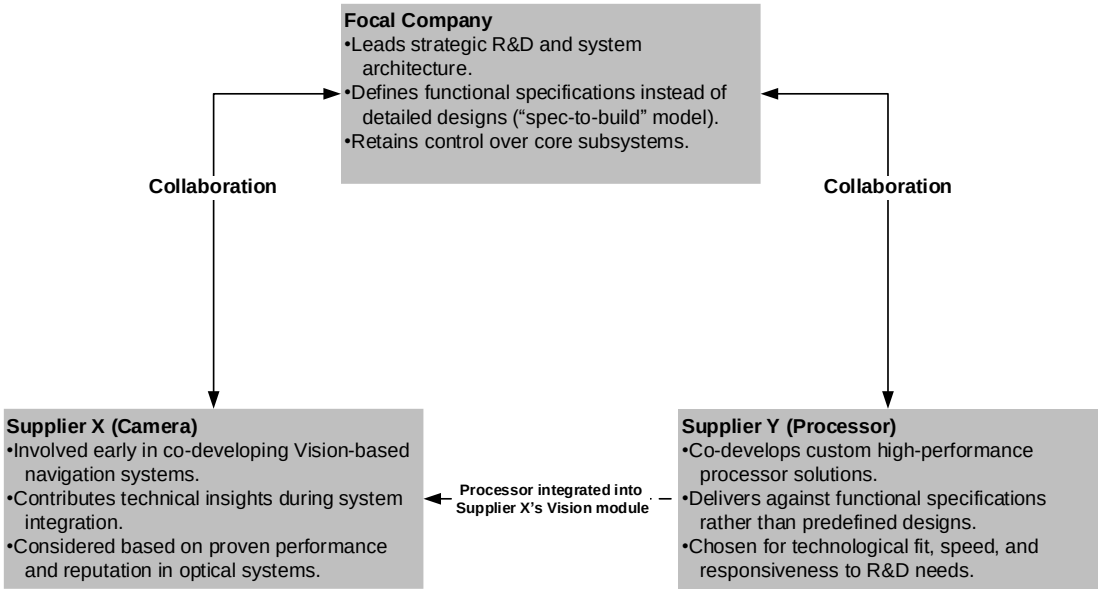


Figure 1 - Strategic collaboration model overview

5. Findings

To ensure transparency and traceability, all quotes in this chapter are attributed to anonymized informants using numerical identifiers e.g. ([1], [2] as introduced in the Methods chapter (Section 3.3.1). These references correspond to interviewees across functions such as Sourcing, R&D, and Project Management who were directly involved in the strategic R&D collaboration analysed in this study. The findings are presented according to the two research questions and reflect insights developed through abductive thematic analysis.

Figures below illustrates the process used for thematic analysis, following the Gioia methodology. The figure demonstrates how raw interview quotes were coded into first-order concepts, then clustered into second-order themes, and ultimately into aggregate dimensions aligned with the study's research questions. Due to space constraints, only a representative selection of quotes is shown in the figure

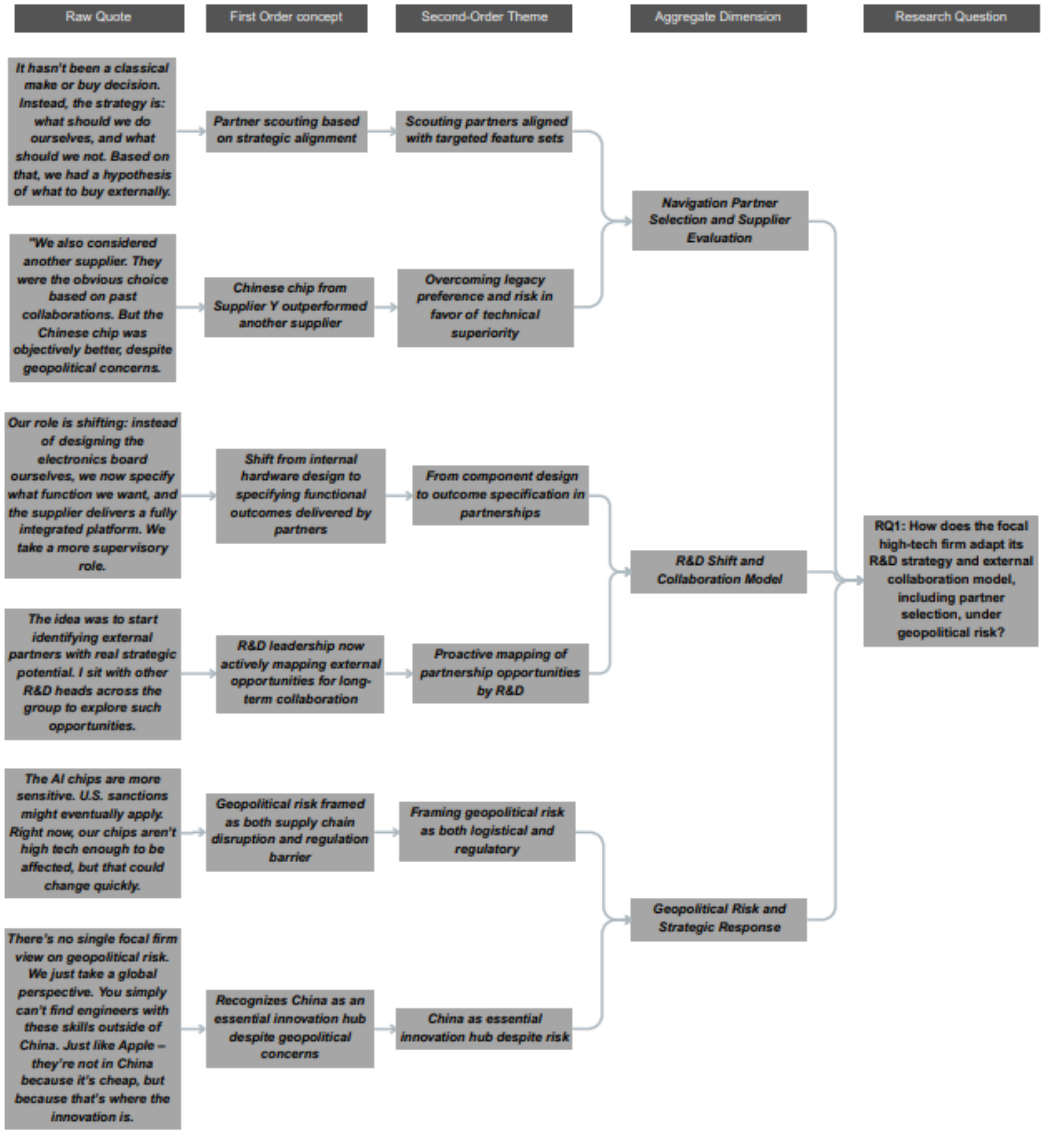


Figure 2 - Thematic coding structure for RQ1: Partner Selection and R&D Adaptation under Geopolitical Risk.

Figure 3 -Thematic Coding Structure for RQ2: Organizational Challenges and Strategic Trade-Offs in External R&D Collaboration.

5.1 How does the focal high-tech firm adapt its R&D strategy and external collaboration model, including partner selection, under geopolitical risk?

5.1.1. Navigation Partner Selection and Supplier Evaluation

Partner selection within the focal high-tech firm has not followed a conventional make-or-buy framework. Instead, decisions have been driven by an evolving R&D strategy that prioritizes customer value, internal capability mapping, and external constraints. As one sourcing manager explained, *"It hasn't been a classical make or buy decision. Instead, the strategy is: what should we do ourselves, and what should we not. Based on that, we had a hypothesis of what to buy externally"* [1]. This logic was supported across functions, where participants emphasized the need to identify which capabilities generate value internally and which are more efficiently accessed through external collaboration*: "From a sourcing perspective, the key question is which capabilities we want internally and which we can buy"* [1].

The evaluation of external partners began with this strategic plan and moved toward identifying suppliers with compatible technology, responsiveness, and integration readiness. As one engineer explained: *"We don't just want a camera, we want the whole thing to work in our product. It needs to be plug-and-play,"*[7]. Performance and system fit were repeatedly cited as critical dimensions. *"Supplier Y had a very competent system on chip for video processing and strong capabilities in interpreting video streams"* [5], while another participant noted*, "What drove this external shift? Primarily cost and the need for new functionality. Our current solutions are twice as expensive. Chinese competitors are ahead in robotics and offer competitive solutions"* [3].

Speed of execution and supplier engagement emerged as additional criteria. *"China isn't the answer to everything. But they're fast, really fast. That gives them a competitive edge in getting products to market quickly"* [2]. Several interviewees contrasted Chinese suppliers' responsiveness with slower reactions from Western alternatives. *"We did a technical evaluation. We started wide, then narrowed it down to about five options. One was clearly the most powerful. But it was from a Chinese supplier, so sourcing still pushed for a Western alternative"* [6]. However, internal evaluation teams emphasized capability over country of origin. *"We also considered a long-standing Western partner. They were the obvious choice based on past collaborations. But the alternative had a better overall offering, despite geopolitical concerns" [5].*

Beyond technical and commercial fit, several participants emphasized the importance of relational chemistry. *"There were several reasons why we chose Supplier X, but what stood out most was the interpersonal chemistry. They asked the right questions and felt like the right match for us"* [9]. This was described as a shift toward partnership-based external collaboration, rather than transactional supplier management: *"I don't think of Supplier X as a traditional supplier. We want a partnership – not just a buyer-seller relationship"* [8]. Others characterized the process as ongoing and flexible. *"It's a lot like dating. You don't just marry someone right away. You ask questions, get a feel, and take it day by day" [9].*

Multiple interviewees described how the firm benchmarked potential collaborators through site visits and reference checks. The evaluation process itself was conducted entirely in-house, with no external support involved in assessing supplier performance or conducting site visits. *"The final choice of partner was based on general competence and follow-up site visits in China. No consultants were used, we did the evaluation ourselves" [5]*. Peer credibility also influenced perceptions*: "I wasn't involved in the early evaluations, but yes, we checked whether they were also working with our competitors. That matters for credibility and trust"* [4]. Internal documents confirm that the evaluation process included structured tools such as comparison matrices and supplier scoring sheets. *"We had an Excel sheet with all the criteria – segmentation models, hardware demands, etc. We marked a red cross for one of the a Western supplier items and asked them to comment. But they said nothing. It felt like they didn't care"* [6]. Other participants highlighted how evaluation logic included assessing long-term adaptability. *"Component decisions often depend on pragmatic factors, if Supplier X has better prices or quicker access, we go with them. It's case by case"* [9].

The firm also integrated geopolitical risk into its partner selection process. Evaluation criteria included suppliers' ability to manufacture outside of China and flexibility to respond to regulatory shifts. However, in parallel to technical evaluation, the firm engaged external consultants to support geopolitical scenario planning and risk analysis, particularly to assess future regulatory uncertainties. *"We've had help from the risk team and consultants to scout scenarios, it's too complex to navigate alone"* [2]. One interviewee summarized, *"It's not just about price or intellectual property, it's whether we can even use the component in future markets"* [2]. Still, the geopolitical context was viewed through a balanced lens*. "As for risks with China – it's hard to say. These suppliers are eager to enter non Chinese markets, so they're taking it seriously. But historically, there have been concerns"* [4].

Participants also pointed to strategic trade-offs between short-term agility and long-term control. *"We need to identify where we lack internal capabilities and what Supplier X can add, and at the same time, show what we offer them. It has to be meaningful on both sides"* [9]. This dual value logic was often described as central to securing commitment from high-performing suppliers. *"It has to be a win-win and a strategic fit. Otherwise it will fall apart" [3].*

5.1.2. R&D Shift and Collaboration Model

The focal high-tech firm has undergone a shift in its R&D strategy, moving from a predominantly closed model toward more selective external collaboration. This shift has been driven by intensified competition, the need for cost-efficiency, and the pace of technological advancement. As one sourcing stakeholder noted, *"The main reason we've shifted toward external collaboration is cost and innovation. We've realized the market isn't in here anymore, it's probably in China, where the next big things for our products are happening"* [1].

Rather than outsourcing entire product platforms, the firm now targets specific subsystems and competencies where internal development is no longer seen as efficient or strategically necessary. *"Initially, the plan was to buy a lot. Now, we're just acquiring targeted competence and a subsystem from a Chinese supplier"* [5]. Another participant added, *"If a supplier makes millions of similar products, maybe they should do it, not us"* [4].This indicates a strategic decision to focus internal efforts on core areas where the firm can add the most value, while outsourcing non-core components.

A recurring theme across interviews was the firm's evolving approach to functional specification. Historically, internal development allowed for continuous iteration and close collaboration across teams. As one respondent put it, *"Internal development allows more iteration and informal collaboration. You can just walk over and ask someone what they think. That's not possible when working externally"* [1]. The shift toward external collaboration has also reshaped how internal teams think about system-level responsibility. As one R&D representative explained, *"Our role is shifting: instead of designing the electronics board ourselves, we now specify what function we want, and the supplier delivers a fully integrated platform"* [7]. This reflects a shift toward modularization and a focus on specifying functional outcomes rather than detailed design execution.

This transition has been particularly evident in the Vision module project, where suppliers are now responsible for hardware design, embedded software, and system calibration. As one participant explained, *"Normally we send detailed technical specifications and suppliers just manufacture. Now, the Chinese engineers are responsible for the design, including software"* [5]. Several interviewees noted that this represents a shift away from the traditional build-to-print model and toward external collaboration. One stakeholder reflected, *"The company is used to designing everything internally, a build-to-print model, where suppliers simply manufacture from a spec sheet. But outsourcing design changes everything"* [4].

This change has also triggered internal discussions about capability boundaries. As one R&D stakeholder described, *"We've been scouting for partners that align with our strategy. The strategy isn't that we should design a camera, it's that we should specify what kind of camera we want to enable our features"* [1]. Rather than trying to replicate external advancements, the firm now focuses on defining functional outcomes and identifying where external partners add the most value. *"Previously, we developed everything in house because others couldn't contribute much. But now, with camera and AI tech from automotive and vacuum robots, it's different"* [7].

Speed has also been cited as a major driver of the shift. *"The strategic partnership project took off way faster than expected. We were caught off guard and ended up*

behind the market" [6]. Another sourcing representative commented, *"Time is another key driver. We have a reputation for being slow. We're getting outpaced. Outsourcing can help us move faster"* [2].

Yet, the transition is still ongoing and viewed with cautious optimism. *"Right now, we are clearly moving toward more external collaboration, driven by cost and speed. But whether that holds two years from now? I don't know. We'll learn by doing"* [2]. Another participant highlighted the longer-term ambition: *"Strategic partnerships like this make future partnerships easier. Ideally, we want a few partners with broad capabilities, we want to learn from them"* [8].

5.1.3. Geopolitical Risk and Strategic Response

As part of its R&D strategy, the focal high-tech firm has integrated geopolitical risk considerations into its external collaboration and partner selection processes. Interviewees emphasized that this awareness is not driven by a fixed company-wide policy, but rather emerges through an adaptive, project-specific logic. One senior R&D stakeholder, responsible for the firm's global R&D vision and capability shifts, explained: "*There's no single focal firm view on geopolitical risk. We just take a global perspective. You simply can't find engineers with these skills outside of China. Just like Apple , they're not in China because it's cheap, but because that's where the innovation is"* [9].

This dual framing of China as both a source of innovation and a region associated with systemic risk underpins many of the firm's recent strategic choices. *"Now that the chip is from China, we might as well build more of the system there. Supplier X, for instance, supplies major global brands which is a strong indicator"* [5]. However, respondents consistently acknowledged that this engagement introduces new layers of uncertainty. *"Supplier Y is an emerging Chinese company operating within a complex international supply network. That places us right in the middle of heightened geopolitical tensions" [3].*

Several interviewees also reflected on the evolving structure of the firm's supply chain and its implications for long-term partner selection strategy. *"Our supply chain is very Europe centred. That will change. We're already evaluating Chinese components even though we mostly use Western ones today"* [1]. The stakeholder also raised the need to integrate geopolitical foresight into early sourcing decisions: *"We need to rethink how we design products, should Chinese components be part of the core design from the beginning?"* [1].

Geopolitical risk was not viewed solely as a constraint, but also as a strategic driver. *"There are risks with going to China, of course. But right now, all the competition is coming from there, and we need to respond to those conditions"* [4]. The firm's decision to collaborate with Chinese suppliers was consistently portrayed as intentional rather than a response to external pressure, driven by performance, responsiveness, and technological maturity. Still, the importance of critical awareness was repeatedly emphasized. *"I've been going to China for 35 years. I know how it works. We must not be naive"* [3].

Finally, some participants noted the competitive dynamics that shape supplier behaviour within China, and the need for the firm to account for that in its collaboration

model. *"In China, it's about survival. 20 companies might compete in a region and only the strongest survives"* [3]. Others mentioned broader concerns about overestimating geopolitical stability. "*Geopolitics matter. We chase cost savings in China, but I also hear from industry contacts that some firms are pulling out because they didn't get the returns they expected"* [2].

Participants described how the firm collaborates with internal risk management teams and external consultants to navigate this complexity. *"We're working with our risk department and external consultants to track geopolitics. It's too complex to just read the news and guess"* [1]. Scenario planning and supplier footprint analysis have become integrated into the R&D strategy, particularly when evaluating whether external components could become restricted in future markets. As one sourcing participant explained, *"The AI chips are more sensitive. U.S. sanctions might eventually apply. Right now, our chips aren't high tech enough to be affected, but that could change quickly"* [1].

Some interviewees reflected on the need to proactively restructure the firm's supply chain in anticipation of long-term shifts. *"Our supply chain is very Europe centred. That will change. We're already evaluating Chinese components even though we mostly use Western ones today"* [1]. The stakeholder also raised the importance of embedding geopolitical foresight early in the design phase: *"We need to rethink how we design products, should Chinese components be part of the core design from the beginning?"* [1].

In parallel, some interviewees emphasized the unpredictable and competitive nature of the supplier landscape in China, noting the implications for long-term collaboration. *"In China, it's about survival. 20 companies might compete in a region and only the strongest survives"* [3]. Others raised concerns about the risks of overestimating geopolitical stability. *"Geopolitics matter. We chase cost savings in China, but I also hear from industry contacts that some firms are pulling out because they didn't get the returns they expected"* [2].

5.2 What organizational challenges and strategic trade-offs arise in the focal high-tech firm's external R&D collaboration under geopolitical and structural complexity?

5.2.1. Governance and Coordination Challenges

The strategic partnership project has introduced a range of governance and coordination challenges, particularly related to the integration and management of multiple external suppliers. As outlined in the firm's collaboration structure, this complexity is especially pronounced in triadic arrangements, where the focal firm coordinates two suppliers with distinct yet interdependent roles. One sourcing representative explained: *"Supplier Y supplies the chip to Supplier X, and Supplier X delivers the full camera system to us. This three-way collaboration requires careful coordination"* [5]. These coordination challenges are not accidental, but arise from the strategic decision to engage two technically capable but interdependent suppliers, selected in part due to geopolitical constraints. The need to balance technological capability, responsiveness, and supply chain diversification has led to a deliberately complex supplier constellation that now requires new forms of governance.

Several participants pointed out that clarity in roles, responsibilities, and expectations becomes critical in these triadic structures. Ambiguities in interface responsibilities were cited as particularly challenging, especially during the integration and testing phases. Another sourcing participant described this operational uncertainty: *"Certifications and interfaces are tough. For example, if the video stream looks fine in the lab but fails in the final product, who's responsible?"* [5]. This highlights the difficulty of assigning accountability when technical failures occur at the intersection of two supplier contributions, particularly when responsibilities are not clearly defined across the organizations

To manage these challenges, the firm has expanded its governance framework through the introduction of layered contractual agreements. Interviewees noted the necessity of clearly defined scopes, including separate agreements for general supply, software external collaboration, and intellectual property ownership. One category manager detailed the contractual setup: *"We'll have three contract scopes with Supplier Y: a general supply agreement for the component, a frame development agreement for shared software work, and a separate development agreement for the AI algorithm, defining IP ownership"* [1].

While formal contracts provided a necessary foundation, participants emphasized that operational coordination and structured internal processes are equally essential. Cross-functional collaboration involving sourcing, legal, and R&D teams has become central. One sourcing respondent elaborated on their coordinating role: *"My role in the project is to coordinate the collaboration agreement together with Legal. I'm responsible for setting up the contract, not for the actual purchasing"* [4].

Further, internal stakeholders identified the absence of clear strategies for outsourcing and partner management as an underlying cause of reactive decision-making. This concern was clearly expressed by one participant: *"Some people internally are asking: what's our outsourcing strategy? Honestly, I don't think we have a clear one. It feels*

reactive, like we're trying to stand back up after being knocked down" [2]. In response, the firm has begun developing new collaborative governance routines such as regular steering group meetings, clearly defined project roles, and cross-functional category teams. One manager described the recent initiative: *"We're now defining structure: steering group, project structure, regular meetings, and processes"* [4].

Interviewees highlighted additional operational challenges related to lifecycle management, especially concerning after-sales support, spare parts, and ongoing software updates. These responsibilities, according to several respondents, are less clearly defined than initial project deliverables: *"The biggest challenges won't be during development; they'll come in the maintenance phase, especially with spare parts and keeping the chip's software updated"* [5]. Communication barriers also emerged as a critical coordination challenge, often made worse by differences in geographic location, culture, and language. A respondent highlighted this operational difficulty: *"Try explaining something complex in an email to an external supplier like Supplier X—it's not easy. Language can be a challenge too"* [9].

Moreover, the firm's shift from internal, informal decision-making to formal, externally-driven processes has required and will require adjustments in its operational practices. Interviewees underscored the increased importance of strong, structured documentation and explicit role assignments, contrasting this with their previous internal approach: *"Internally, it's easier to work in an agile way; you don't have to be so clear. But in external collaborations, you can't make decisions at the coffee machine anymore. It demands more structure"* [8]. Participants repeatedly noted the complexity of operationalizing these governance and coordination mechanisms, particularly given the rapid pace of technological change and evolving market conditions. As one stakeholder simply summarized: *"High level it's simple. Low level it's extremely complex. It's especially difficult with a three-party collaboration that adds another layer of complexity"* [8].

5.2.2. Capability Gaps and Role Misalignment

The focal high-tech firm's strategic shift towards external collaboration with suppliers based in China and specializing in complex technologies has highlighted key challenges related to internal capabilities, role alignment, and organizational readiness. These challenges have emerged on their own but are a direct consequence of the firm's partner selection. Respondents described a gap between the firm's existing technical capabilities and the competencies required to manage such partnerships effectively. One engineer noted the disparity clearly, stating: *"Advanced Development had been looking at cameras for ages. You'd think we'd have more capabilities in house by now. But when we went to China, we realized everything we're trying to invent already exists there"* [6]. This realization has raised questions about the firm's ability to handle to integrate externally sourced innovations into its core offerings, particularly when those technologies originate outside the company's established areas of expertise and control.

Interviewees underscored the necessity of strengthening technical competencies internally, particularly concerning specification writing and technical oversight. A sourcing representative emphasized this, noting*: "That raises the bar for R&D. Writing good specifications for complex products requires real competence. That's something we'll need to improve if we continue outsourcing"* [2]. Consequently, the focal firm has begun training initiatives, aiming specifically at improving technical knowledge among

sourcing personnel to ensure they can effectively manage these external relationships. As one respondent elaborated, *"We're training our organization, especially purchasers, to become more technically competent. To ensure the supplier relationship operates at an appropriate level"* [3].

Alongside capability building, the selection of external partners for critical innovation work has raised internal cultural and motivational challenges. As the firm chooses to outsource strategically important subsystems to maintain competitiveness under risk, internal R&D teams must adapt to a more selective innovation role. As articulated by a participant, *"One risk I see is around motivation. Engineers love working with new tech. If we outsource all the 'fun stuff,' we risk losing skilled people who want to stay engaged. That's a real concern"* [2]. Interviewees acknowledged that maintaining internal motivation while clearly defining roles and expectations is crucial, especially during the transformation phase where uncertainty prevails regarding core and non-core capabilities. One respondent highlighted this transitional complexity: *"We're in a transformation phase. What is core? What isn't? If we no longer care what components go on the board, sourcing changes dramatically. No more BOM scrutiny or price breakdowns"* [2].

Additionally, role alignment across functions such as R&D, sourcing, and advanced development has emerged as a crucial organizational challenge. Historically, the firm's pioneering status in in their field meant limited external collaboration, which has influenced current internal structures and expertise alignment. As described by one respondent, *"Because we pioneered in our filed, there simply weren't external experts in the beginning. That limited our ability to look outside"* [8]. This historical context partially explains the initial hesitation and ongoing struggle in aligning roles clearly across departments, as employees adapt from internally focused innovation to managing external technology partnerships.

Participants further emphasized the critical importance of co-locating internal teams to facilitate effective cross-functional collaboration. Current structural and physical distances between departments were noted as obstacles, with one senior R&D stakeholder saying: *"We'll need more resources in strategic sourcing and project management. Also, co-location matters. Departments are still too physically and structurally distant, although it's improving"* [8]. Ensuring closer collaboration and alignment of internal roles is perceived as essential for successfully integrating externally sourced technologies.

Despite these challenges, respondents expressed cautious optimism regarding the long-term outcomes of improved external collaboration. There was acknowledgment of internal resistance due to concerns about losing control over key competencies. As one respondent candidly noted, *"Some at focal firm fear that we're giving away core competencies. Change is always challenging, and people react differently. The hardest part is getting everyone onboard"* [8]. However, others highlighted positive expectations for the strategic partnerships underway, emphasizing the opportunity to leverage complementary capabilities. One participant remarked positively, *"Our strength lies in domain knowledge. We know what it takes to build a top-tier product. Supplier Y and Supplier X brings broader vision and AI knowledge"* [7].

5.2.3. Strategic Trade-Offs and Integration Complexity

The focal high-tech firm's increased reliance on external collaboration has highlighted strategic trade-offs and complexities, particularly related to dependency risks, intellectual property, and maintaining strategic autonomy. Respondents consistently acknowledged the underlying tension between retaining strategic control and leveraging external technological capabilities. A sourcing representative succinctly captured this challenge, stating: *"It comes down to understanding our core competence, what we should keep, and what can be outsourced to get better outcomes"* [2].

The focal high-tech firm's move toward external partnership has surfaced a number of strategic dilemmas that extend beyond initial partner selection. As collaboration deepens, new integration complexities arise around dependency risk, intellectual property boundaries, and the firm's ability to maintain long-term strategic autonomy. These are not simply commercial challenges but structural tensions that influence how the firm configures its innovation processes. One sourcing stakeholder described the foundational dilemma as follows: *"It comes down to understanding our core competence, what we should keep, and what can be outsourced to get better outcomes"* [2].

A recurring tension concerns the firm's reliance on external suppliers for fast access to emerging technologies, such as AI and vision systems. While this has enabled accelerated development, several interviewees noted the risk of long-term dependence, particularly in software-heavy subsystems. As one respondent put it, *"It's simply too expensive to do everything ourselves—especially when the market is moving this fast"* [3]. However, another noted that this agility introduces new forms of lock-in: *"When you're working with microcontrollers or processors, where 80% is software and only 20% hardware, the lock-in risk is even higher"* [2]. This reflects growing awareness that supplier dependencies are not only technical but also strategic, especially when critical software layers are controlled externally.

Intellectual property protection emerged as another critical area of complexity in strategic collaboration decisions. Respondents indicated that effectively managing intellectual property involves careful consideration of what knowledge to share. Excessive openness risks compromising valuable proprietary assets, whereas excessive secrecy may undermine effective collaboration. A respondent emphasized the strategic importance of selective openness: *"Intellectual property will be a major part of the contract. We'll need to decide what knowledge to share, too little openness makes collaboration difficult"* [7].

To address this challenge, the firm adopted a strategy of selective openness. Core intellectual property, such as proprietary AI algorithms, is internally protected, while complementary technologies like hardware integration are collaboratively developed externally. One interviewee clarified this strategy explicitly: *"We won't share our AI model with either Supplier X or Supplier Y. Supplier Y is the brain, but we gave everything else to Supplier X and a few selected external collaborators"* This approach reflects a deliberate effort to retain control over high-value innovation while still enabling efficient external collaboration of supporting subsystems.

Maintaining strategic autonomy was also highlighted as a significant area of complexity. Respondents expressed concern regarding overly integrated external solutions potentially reducing internal control. Interviewees specifically warned against scenarios involving highly integrated or unclear supplier solutions, emphasizing the importance of transparency and control. One respondent explicitly expressed this concern: *"The most complex thing now is integrating everything. We don't want an automotive-style black box where we lose all control"* [3]. The term "black box" here refers to a solution delivered by a supplier that functions as intended but offers limited visibility into its internal workings, making it difficult for the firm to troubleshoot issues, adapt the system, or fully understand how key functions are performed.

Furthermore, participants emphasized that successful strategic partnerships require clear and mutually beneficial arrangements, where the firm retains focus on core competencies while leveraging complementary external expertise from Supplier X and Y. One interviewee clearly explained this approach: *"For us, a true partnership needs to be win-win. We're not trying to learn how to build vision systems we're focused on what the camera can do to improve our products"* [9]. Strategic clarity regarding internal versus external technology responsibilities was viewed as important to supporting this model. Interviewees stressed the importance of clearly defining strategic roles clearly and explicitly between internal development and external collaboration. One respondent simply summarized the firm's strategic approach: *"We want to develop AI algorithms and application software ourselves, but buy the hardware and embedded software, the part that makes the chip run. Basically, we want to buy the computer"* [1].

5.3 Summary of Findings

To synthesize the empirical findings and provide a clear overview of the focal firm's approach to external collaboration under geopolitical risk, Table below summarizes the key themes identified in relation to each research question. The table links the empirical insights to their strategic implications for R&D strategy, partner selection, and governance. This summary serves as a foundation for the analytical discussion presented in Chapter 6.

Table 1. Summary of Key Empirical Themes and Observed Challenges across RQ1 and RQ2.

THEME (SUBCHAPTER)	KEY EMPIRICAL INSIGHT	OBSERVED CHALLENGE
5.1.1 PARTNER SELECTION AND SUPPLIER EVALUATION	Partner selection is driven by technology fit, supplier responsiveness, and interpersonal chemistry, not just cost.	Balancing high performance requirements with geopolitical risk and few Western alternatives.
5.1.2 R&D SHIFT AND COLLABORATION MODEL	The firm has shifted from internal build-to-print to modular external collaboration, outsourcing key subsystems to suppliers.	Moving away from build-to-print has raised challenges in capability boundaries, speed, and redefining internal roles in partnership
5.1.3 GEOPOLITICAL RISK AND STRATEGIC RESPONSE	Scenario planning and supplier diversification are now embedded early in R&D and sourcing decisions.	Anticipating future regulations and embedding geopolitical foresight into design and sourcing remains complex and uncertain.
5.2.1 GOVERNANCE AND COORDINATION CHALLENGES	Triadic coordination with dual suppliers requires formal contracts, clear roles, and structured governance routines.	Preventing coordination breakdowns and managing operational complexity at supplier-supplier and supplier-firm interfaces.
5.2.2 CAPABILITY GAPS AND ROLE MISALIGNMENT	Effective external collaboration depends on mature specifications and stronger internal technical competence.	Addressing skill gaps while sustaining motivation and clarifying evolving role boundaries across R&D, sourcing, and AD.
5.2.3 STRATEGIC TRADE-OFFS AND INTEGRATION COMPLEXITY	Selective openness and modular partnerships enable agility while protecting core IP and system integration control.	Avoiding long-term supplier lock-in and retaining transparency and adaptability across critical subsystems.

6. Discussion

6.1 How does the focal high-tech firm adapt its R&D strategy and external collaboration model, including partner selection, under geopolitical risk?

6.1.1. Navigation Partner Selection and Supplier Evaluation

The focal high-tech firm's approach to partner selection is not rooted in a classical make-or-buy framework, but instead emerges from a strategically driven capability-mapping process. Rather than treating partner selection as a discrete procurement activity, the firm approaches it as a continuation of internal capability mapping, identifying which innovation-critical functions should be retained and which can be sourced externally. This reflects a hybrid R&D strategy where openness is selectively applied to accelerate innovation while preserving proprietary control over core technological domains, consistent with Appleyard and Chesbrough's (2017) model of bounded openness.

The selection process is based on an internally developed strategic hypothesis, what the firm needs to acquire, why, and from whom. This departs from the linear flow of classical make-or-buy frameworks and instead embraces a iterative decision logic that integrates technological fit, responsiveness, and system integration readiness. These dimensions align with Gulati's (1998) criteria for partner evaluation, where compatibility and trust are central, but are now further nuanced by current challenges such as global supply chain instability and geopolitical exposure.

What distinguishes this case is the dual attention to both technical attributes and relational qualities in supplier evaluation. Beyond performance benchmarks, the firm's evaluation process increasingly emphasize interpersonal alignment and collaborative purpose, signalling a shift from transactional supplier management to strategic partnership formation. This approach resonates with the broader open innovation literature, particularly the emphasis on knowledge co-creation and long-term value exchange (Bogers et al., 2018). It also reflects an effort to address the practical challenges that arise when incorporating externally developed technologies into the firm's broader product systems, particularly in areas that are closely linked to hardware components.

The firm's selection logic is also shaped by strategic trade-offs between short-term innovation speed and long-term control. These trade-offs are not abstract dilemmas but built in realities within the evaluation process itself. For instance, the prioritization of "plug-and-play" integration reflects a need to accelerate time-to-market, yet introduces new dependencies on external system architectures. Here, the firm engages in active boundary-setting, limiting openness to areas where internal capabilities are lacking or less differentiated, while retaining control over intellectual property and high-value domains. This balancing act exemplifies the tension between value creation and value capture in open innovation models (Appleyard & Chesbrough, 2017).

Geopolitical risk further conditions how openness is operationalized. The firm does not assess partners in isolation from political realities Instead, selection criteria include fallback production capabilities, responsiveness to regulatory instability, and exposure to export restrictions. These considerations extend the theoretical frameworks of

partner selection (Hoang & Rothaermel, 2005; Zahoor et al., 2022) by treating geopolitical foresight not merely as a risk mitigation function but as a structuring input into selection logic. Rather than excluding suppliers based on geography alone, the firm applies a nuanced evaluation of geopolitical adaptability, favouring partners who demonstrate scenario-readiness and jurisdictional flexibility.

Finally, the firm formalizes this multidimensional evaluation logic through internal benchmarking tools and scoring frameworks. These mechanisms enable systematic comparison across both technical and relational dimensions, improving transparency and cross-functional alignment. However, the process remains adaptable, allowing teams to weigh criteria contextually based on project goals, partner configurations, and geopolitical signals. This reflects an embedded governance model in which evaluation is not only standardized but also strategically responsive.

6.1.2. R&D Shift and Collaboration Model

The focal high-tech firm's R&D strategy reflects a practical adjustment of internal and external innovation roles in response to shifting technological, economic, and geopolitical conditions. Rather than a strict either or shift from closed to open innovation, the firm demonstrates an increasingly hybrid R&D model, characterized by selective openness structured around functional boundaries and system-level priorities. This is consistent with Appleyard and Chesbrough's (2017) assertion that high-tech firms often operate along a spectrum of openness, guided less by ideological commitment and more by adaptive strategic logic.

In practice, the firm's openness is not applied in the same way across all area but directed at subsystems and technologies where internal development is no longer seen as strategically differentiating. This approach reflects what Bogers et al. (2018) describe as outside-in open innovation, where external capabilities are integrated into the firm's product architecture to increase speed, reduce cost, and capture external technological advancement. The shift from developing entire systems internally to specifying modular functional outcomes shows a significant departure from traditional, vertically integrated models of R&D. It reflects a intentional effort to refocus internal resources on core competencies, while leveraging partners for complementary capabilities that offer cost or time-to-market advantages.

A central implication of this shift is the changing role of specification and system-level responsibility. As the firm moves toward external collaboration, it no longer controls all aspects of product design but instead coordinates innovation across organizational boundaries. The growing reliance on functional rather than technical specifications is a clear sign of modularization, a strategy that enables architectural separation between core and non-core components. This decoupling reflects the logics of platform-based innovation, where integration is achieved through interface standards rather than internal co-location. Theoretical accounts of open innovation often underscore the need for firms to give up some design control in exchange for innovation speed and variety, yet the case here illustrates how that loss of control is bounded and conditional.

This transition also highlights an important strategic trade-off between speed and control. By allowing external partners to take over design and system adjustments, the firm speeds up product development but also risks becoming dependent on others and losing some in-house skills. Appleyard and Chesbrough (2017) warn that open

innovation, while enabling faster progress and broader reach, can make it harder for firms to protect key knowledge and stay competitive in the long run. In this case, the firm's mixed approach seems to reduce these risks by outsourcing only those parts seen as less essential to its competitive edge, essentially keeping control over core innovations while opening up less central subsystems to joint development.

The firm's collaboration model is shifting from a traditional build-to-print paradigm, where suppliers execute tightly defined specifications, toward more integrated external collaboration. This represents a structural transformation in how innovation responsibilities are distributed, with external partners increasingly engaged in design and systems integration tasks. Such a shift reflects the logic of open innovation as described by Bogers, Chesbrough, and Moedas (2018), wherein external actors are not merely sources of cost advantage but contributors to knowledge creation and technological advancement. At the same time, this evolution remains bounded by the firm's hybrid R&D strategy, which seeks to preserve architectural control over core domains while selectively opening up non-core components to external collaboration (Appleyard & Chesbrough, 2017).

Notably, this shift is not static but ongoing, characterized by organizational learning and strategic recalibration. While current decisions emphasize cost, speed, and capability access, the firm remains cautious about long-term commitments. This cautious stance aligns with the idea that open innovation strategies must be contextually responsive—continuously reassessed as markets, technologies, and geopolitical environments evolve. In this respect, the firm's approach reflects a form of "learning-by-doing" in R&D governance, where early collaborations serve as templates for future strategic configurations.

6.1.3. Geopolitical Risk and Strategic Response

While the focal high-tech firm's R&D strategy reflects a practical move toward external collaboration, its approach to partner selection under geopolitical risk is characterized by situational awareness rather than rigid policy. Instead of applying uniform risk thresholds, the firm engages in a project-specific logic that embeds geopolitical foresight into sourcing, supplier evaluation, and technology road mapping. This decentralized and adaptive stance reflects what Rasshyvalova et al. (2024) describe as a "strategic scanning approach," where scenario planning and regional sensitivity are integrated early in the innovation process to mitigate uncertainty without ruling out access to high-performing suppliers.

In contrast to either or geographic risk filters, the firm's evaluation logic considers geopolitical exposure in relation to supplier competence and strategic necessity. China, in particular, emerges as both an essential source of frontier technologies and a centre of regulatory uncertainty. This dual framing highlights a tension not often captured in conventional partner selection models (e.g., Gulati, 1998), which typically emphasize technological fit and trust. Here, geopolitical adaptability becomes an additional axis of partner evaluation, one that requires balancing performance potential against future market viability. Rather than excluding suppliers based on origin, the firm evaluates their capacity to operate across jurisdictions, respond to regulatory shocks, and align with evolving global trade regimes. This aligns with Guo's (2024) argument that managing innovation risk increasingly depends on understanding not just where a partner is today, but where they can deliver from tomorrow.

Importantly, geopolitical risk is not only treated as a constraint, but also as a strategic stimulus. The firm's decision to collaborate with Chinese suppliers is not just reactive but reflects a calculated response to shifting competitive conditions particularly the speed and specialization emerging from China In this sense, geopolitical exposure is accepted as the "cost of access" to leading-edge technologies, and the firm seeks to manage rather than eliminate it. As Appleyard and Chesbrough (2017) note, firms pursuing hybrid R&D strategies must continuously navigate the trade-off between control and access, an insight that proves especially relevant in cross-border collaboration under changing regulations.

This framing introduces an additional layer of strategic complexity: partner selection decisions now intersect with long-term questions of supply chain architecture and platform integration. Scenario planning becomes not just a defensive tool but an input into design thinking which leads to shaping decisions about whether potentially sensitive components should be embedded in the core architecture or modularized for future substitution. Such anticipatory governance aligns with Rasshyvalova et al.'s (2024) view of geopolitical risk as a system-level concern that must be addressed through both supplier diversification and architectural separation.

Notably, the firm's response is not purely internal. Risk intelligence is developed jointly with both internal risk teams and external consultants, reflecting the growing challenge of understanding geopolitical signals through informal networks or past experience alone. This also illustrates how governance processes around partner selection are expanding beyond sourcing and R&D to include legal, compliance, and strategic foresight functions, what Zahoor et al. (2022) describe as an "institutionalization of foresight." that is, the embedding of scenario planning and geopolitical awareness into formal decision-making routines. Still, the firm avoids rigid planning. Instead, it maintains flexibility by assessing suppliers not only for current fit but also for future adaptability, ensuring that short-term innovation gains do not block long-term resilience.

6.1.4. Summary of Thematic Insights:

To synthesize the findings related to RQ1, the table below outlines the key themes that characterize how the focal high-tech firm adapts its R&D strategy and external collaboration model, including partner selection, under geopolitical risk. Each theme capture a core empirical insight and links it to relevant theoretical perspectives.

Table 2. Theoretical Interpretation of Empirical Themes Related to RQ1.

Theme	Empirical Insight	Theoretical Interpretation
Partner Selection and Evaluation Logic	Partner selection is driven by strategic capability mapping, not conventional procurement logic. Evaluation emphasizes both technical fit and relational alignment, using internal scoring tools that remain adaptable to project needs.	Reflects *bounded openness* (Appleyard & Chesbrough, 2017). Extended by Gulati's (1998) trust-based partner selection and Zahoor et al.'s (2022) notion of geopolitical adaptability. Aligns with open innovation literature on strategic partnerships (Bogers et al., 2018).
Shifting R&D Strategy and Collaboration Model	The firm adopts a hybrid R&D model with modular, function-level outsourcing. It opens non-core domains to accelerate innovation while retaining architectural control. Specification maturity emerges as a key collaboration interface.	Matches Bogers et al.'s (2018) "outside-in" open innovation and modular platform theory. Reflects the management of speed–control trade-offs (Appleyard & Chesbrough, 2017) through ongoing learning-by-doing.
Strategic Response to Geopolitical Risk	Geopolitical foresight is embedded into supplier evaluation and technology road mapping. Suppliers are assessed based on adaptability, jurisdictional flexibility, and scenario resilience. China is viewed as both a strategic opportunity and a geopolitical risk.	Aligns with *strategic scanning* and anticipatory governance (Rasshyvalova et al., 2024). Builds on Guo's (2024) framing of geopolitical adaptability and Zahoor et al.'s (2022) institutionalization of foresight. Repositions open innovation in the context of global uncertainty.

6.2 What organizational challenges and strategic trade-offs arise in the focal high-tech firm's external R&D collaboration under geopolitical and structural complexity?

6.2.1. Governance and Coordination Challenges

The governance challenges faced in the firm's triadic collaboration model underscore a tension between strategic goals and operational execution. While the decision to engage multiple interdependent suppliers was rooted in a careful response to geopolitical and technological constraints, it introduced a layered coordination burden that exceeds conventional one-to-one governance frameworks. This complexity is not just procedural; it is structural, shaped by the firm's selective openness and system-level outsourcing logic.

From a theoretical standpoint, the firm's experience illustrates the limits of relying solely on formal contractual mechanisms. As Oxley and Sampson (2004) suggest, contracts can clarify responsibilities and protect proprietary knowledge, but their efficacy declines when interface ambiguity and rapid innovation cycles dominate. In this project, formal governance has been necessary but insufficient. The addition of layered contract scopes and legal frameworks has provided a foundational structure, yet has not resolved uncertainties in operational accountability particularly in cross-supplier integration tasks.

This highlights a core strategic trade-off: the more the firm decentralizes design and development activities to external partners, the more coordination costs and ambiguity it incurs. These are not minor coordination issues, but embedded tensions in the shift from internally integrated R&D toward external R&D collaboration. This aligns with Arranz and Arroyabe's (2007) observation that informal governance mechanisms based on trust and relational familiarity are crucial in high-uncertainty contexts. Yet in this project, such mechanisms are underdeveloped, limited by geographical spread, limited prior collaboration history, and cultural differences.

Compounding this challenge is the organization's own readiness. The absence of a formalized approach to external collaboration has left internal teams operating reactively, without clear protocols for partner selection or cross-functional execution. What results is not just a governance gap but also a capability misalignment. The firm's internal routines and structures have not fully adapted to the complexity of triadic supplier arrangements and a hybrid R&D strategy. This reinforces the need for embedded governance mechanisms that go beyond contractual safeguards to include shared routines, cross-functional integration, and structured coordination across organizational boundaries.

Moreover, looking at the full product lifecycle adds more complexity. Governance structures that work well during early development may weaken after the product is launched, especially when responsibilities for software updates, spare parts, or ongoing support are not clearly defined or formally built into the organization. This built-in weakness in governance over time is often overlooked, but becomes important as the firm shifts toward modular R&D and outsourcing larger parts of the system.

6.2.2. Capability Gaps and Role Misalignment

The focal firm's transition toward an open R&D strategy has not only redefined its external interface but exposed significant internal capability gaps. These gaps are not minor but strategic: they limit the organization's ability to manage and integrate external innovation effectively, particularly under geopolitical and technological complexity. The firm's attempt to take in and coordinate high-end subsystems, especially from Chinese suppliers operating in advanced domains, has highlighted a mismatch between the complexity of the sourced technologies and the firm's own readiness to specify, oversee, and embed them into its product architecture.

From a theoretical standpoint, this reflects the structural tension identified in hybrid R&D models, where open innovation is selectively applied to accelerate development while preserving architectural control (Appleyard & Chesbrough, 2017). In such models, integration capabilities become a requirement. Yet the findings suggest that key internal functions, notably specification writing, cross-functional governance, and technical communication, have not kept pace with the demands of system-level outsourcing. As a result, value creation through external collaboration risks being undermined by weak ability to take in and use new knowledge and insufficient operational maturity.

This misalignment extends beyond technical capabilities. It includes a redefinition of roles across R&D, sourcing, and advanced development, a redefinition that remains uncertain. Historically, the firm's pioneering position enabled an internally based innovation model, which minimized the need for boundary-spanning roles. The current strategic shift makes such models outdated but leaves internal teams without a shared understanding of their evolving responsibilities. This role ambiguity, especially in triadic and distributed external collaboration, adds friction to collaboration and blurs accountability. It also reflects the broader organizational challenge of transitioning from vertically integrated development to externally coordinated innovation networks.

Also, the challenge is not just functional but motivational. The findings indicate that selectively outsourcing "strategic subsystems" to external partners introduces a perceived loss of purpose among internal engineering teams. This aligns with open innovation literature that warns of unintended consequences for internal talent when firms outsource the most technologically stimulating tasks (Bogers et al., 2018). Without careful role reframing and internal capability signalling, the firm risks disengagement among its technical workforce which is a threat not to immediate performance, but to long-term innovation identity and employee loyalty.

This situation reinforces the importance of alignment not just across technical interfaces but across organizational purpose. As the firm shifts toward a modular innovation architecture, role clarity and internal collaboration routines must change in parallel. The findings illustrate that physical and structural distances between departments have become bottlenecks for effective knowledge integration. This is particularly problematic when high-context coordination is required to bridge externally sourced systems and internally controlled platforms.

Taken together, the firm's experience underscores that external collaboration under geopolitical risk is not simply a matter of choosing capable partners, but of preparing the internal organization to receive and operationalize that collaboration. Strategic

trade-offs between specialization and integration, between openness and motivation—must be actively managed not only through governance mechanisms but through deliberate capability building and role realignment. Without this, even the most promising partnerships risk being structurally misaligned with the firm's internal fabric.

6.2.3. Strategic Trade-Offs and Integration Complexity

The focal firm's engagement in external collaboration has surfaced not only coordination and capability challenges, but also structural trade-offs at the intersection of innovation control, dependency, and long-term strategic independence. These tensions are particularly clear in the context of increasingly software-defined products and high geopolitical exposure, where integration complexity and supplier relationships increasingly shape architectural control, long-term dependency risk, and the firm's ability to respond to geopolitical shifts, making them core strategic variables.
Although previously addressed in the context of partner selection and collaboration models (6.1.2, 6.1.3), these themes remerge here as deeper organizational trade-offs that constrain or enable the firm's pursuit of long-term strategic autonomy

From a theoretical perspective, these patterns align with the core dilemmas of hybrid R&D strategies (Appleyard & Chesbrough, 2017). In such models, firms seek to benefit from external knowledge flows (Bogers et al., 2018) while preserving control over key architectural and intellectual property domains. However, this balance proves delicate when subsystems such as AI modules or embedded vision platforms are co-developed with external suppliers. The findings show that while external collaboration accelerates development cycles and improves access to frontier technologies, it also introduces risks of lock-in and black-box dependency, particularly when critical software or hardware is not transparently shared.

A key trade-off emerges between short-term innovation gains and long-term strategic control. The firm's decision to retain proprietary ownership of AI algorithms while outsourcing embedded software and hardware illustrates a bounded openness approach. This enables it to access supplier capabilities while safeguarding core competencies. Yet even this selectively open position requires careful coordination and architectural planning, particularly to avoid chain-reaction dependencies or integration lock-in. As Bogers et al. (2018) warn, open innovation without enough boundary management can shift value capture away from the focal firm.

The complexity intensifies when intellectual property and system integration responsibilities are distributed across multiple external actors. The firm's strategic response, keeping intellectual property-sensitive elements separate from collaborative development, is both careful and limiting. It reduces the risk of intellectual property leakage but also constrains the depth of co-development. This trade-off reflects the tension between innovation speed and knowledge protection, a recurring theme in open innovation theory (Appleyard & Chesbrough, 2017).

Finally, integration complexity is not limited to technical systems. It extends to strategic autonomy. When supplier solutions become overly integrated or unclear—what respondents termed "black box" arrangements—the firm risks losing visibility and flexibility in its own product development. This concern is especially pronounced in high-risk geopolitical contexts, where regulatory changes or supplier disruptions could suddenly compromise entire subsystems. As a result, architectural separation and

modularization become not just design preferences, but strategic safeguards. This supports Teece's (1986) argument that firms must align appropriability regimes with architectural control to retain competitive advantage.

6.2.4. Summary of Thematic Insight

To consolidate the discussion of RQ2, Table 3 summarizes how the focal high-tech firm's challenges in external collaboration reflect systemic tensions in governance, internal capability, and geopolitical coordination. Each empirical dimension is linked to its theoretical interpretation, illustrating how the firm's hybrid R&D strategy gives rise to strategic trade-offs when navigating external collaboration under geopolitical risk. These insights extend existing theory on open innovation by emphasizing the importance of internal alignment, collaboration readiness, and triadic governance capabilities in politically sensitive environments.

Table 3. Theoretical Interpretation of Empirical Themes Related to RQ2.

Theme	Empirical Insight	Theoretical Interpretation
Governance and Coordination Challenges	Triadic collaboration introduces structural coordination burdens that exceed traditional governance models. Formal contracts provide a baseline but are insufficient in managing interface ambiguity, unclear operational accountability, and lifecycle continuity. Informal mechanisms and internal integration routines remain underdeveloped.	Reflects Oxley & Sampson's (2004) view on the limitations of contractual governance under high uncertainty. Aligns with Arranz & Arroyabe (2007) on the need for relational governance. Highlights the importance of embedded governance in Hybrid R&D strategies.
Capability Gaps and Role Misalignment	Internal capability gaps, especially in specification writing, cross-functional coordination, and partner integration, constrain the firm's ability to absorb and operationalize external innovation. Ambiguity in internal roles and reduced motivation among engineering teams further undermine collaboration readiness.	Extends Appleyard & Chesbrough's (2017) hybrid R&D model to emphasize internal capability development. Supports Bogers et al. (2018) on motivational risks in open innovation. Underscores the importance of organizational alignment in managing external partnerships.
Strategic Trade-Offs and Integration Complexity	External collaboration accelerates innovation but increases the risk of supplier dependency, black-box systems, and loss of architectural control. The firm seeks to retain ownership of core IP while outsourcing subsystems, but integration complexity raises long-term risks under geopolitical volatility.	Reaffirms open innovation trade-offs between access and control (Appleyard & Chesbrough, 2017). Reflects Bogers et al.'s (2018) concerns about value leakage. Aligns with Teece (1986) on the need to align IP protection with architectural control to retain strategic autonomy.

7. Recommendation

7.1.1. Implement a cross-Functional partner selection framework

The findings of this study reveal that partner selection within the focal high-tech firm is currently guided by a combination of strategic intuition, technical fit, responsiveness, and personal connection. While this approach has led to promising outcomes in recent collaborations, it remains largely informal and lacks a standardized structure that could ensure repeatability, transparency, and integration of geopolitical awareness. This is particularly relevant as the firm expands its hybrid R&D strategy and increasingly sources critical subsystems from suppliers operating in complex geopolitical contexts.

As illustrated in Section 5.1.1, the firm relies heavily on internal evaluations, including scoring sheets and technical site visits, to assess supplier performance. Factors such as capability alignment, integration readiness, and responsiveness are given substantial weight. Geopolitical risk, in contrast, is addressed in parallel through collaboration with internal risk teams and external consultants, particularly for scenario planning and regulatory awareness, as noted in Section 5.1.3. While this project-specific approach has been effective, it remains loosely integrated into the firm's standard evaluation routines, which limits its consistency and influence during early-stage partner selection.

Although the firm already performs both technical evaluations and risk assessments, these processes remain decoupled and reactive rather than integrated and proactive. To address these challenges, we propose the gradual formalization of a cross-functional partner selection framework that is modular and context-sensitive, adaptable to different project needs and evolving strategic priorities. The framework builds on insights from the focal firm's ongoing partnerships and is structured around three core evaluation dimensions below:

Capability mapping ensures alignment between supplier offerings and the firm's platform architecture. For instance, with Supplier Y, the firm evaluated not only chip performance but also how the processor would integrate with internal systems, an increasingly important concern as supplier technologies become embedded within broader solution stacks.

Relational capital captures qualitative attributes such as trust, responsiveness, and shared strategic ambition. Collaboration with Supplier X demonstrated that strong interpersonal alignment was a key factor in navigating integration challenges, particularly under time pressure and cultural distance. These relational factors were repeatedly cited by interviewees as critical for project success.

Geopolitical foresight involves assessing jurisdictional exposure, fallback production capabilities, and export control sensitivity. Although such analyses were conducted for Supplier X and Y, they occurred alongside technical evaluations rather than within them. As Section 5.1.3 illustrates, this siloed treatment of geopolitical risk limited its strategic influence during partner selection.

Taken together, these dimensions offer a structured but flexible approach to evaluating external partners that balances technical competence, relational dynamics, and systemic risk awareness. Empirical evidence suggests that such a framework would benefit from shared ownership across R&D, Sourcing, Legal, and Risk functions. Interviewees emphasized the current lack of coordination in evaluation routines and governance

responsibilities, which contributes to uncertainty and slows decision-making (5.2.1). A unified approach could mitigate these frictions and improve cross-functional alignment. This recommendation also responds to request from internal stakeholders for more structured, forward looking sourcing practices. As noted in 5.1.3, there is an emerging recognition that geopolitical exposure must be factored into partner decisions not only at the point of crisis but as a standard element of upstream evaluation. While current efforts are project-specific, codifying lessons learned from on going collaboration into reusable templates could support organizational learning and reduce reliance on tacit knowledge.

However, it is important to acknowledge that increased formalization may also constrain the very collaboration readiness and responsiveness that have enabled successful external collaboration to date. Several interviewees emphasized that informal mechanisms such as personal relationships and ad hoc problem solving have historically supported fast decision-making and creative integration under pressure. A strong framework risks overlooking these relational factors. Therefore, the proposed structure is deliberately designed to be modular and context-sensitive, supporting strategic alignment without imposing a one-size-fits-all process. The goal is to codify learning and improve cross-functional coordination and not only replacing judgment or innovation.

Importantly, the framework should remain context-sensitive and non-deterministic. The intention is not to exclude suppliers based on geography alone, but to assess their adaptability and strategic fit through a broader lens. Scenario planning, for instance, could be treated as a strategic input that informs, rather than dictates, supplier choices. By making geopolitical foresight a visible and structured element of the evaluation process, the firm can improve its long-term resilience without compromising access to frontier technologies.

7.1.2. Establish Modular Product Architecture with Built-In Substitution Options

The firm's ongoing shift toward a hybrid R&D strategy has introduced new dependencies on externally developed subsystems. While this approach expanded access to frontier technologies, it has also created architectural vulnerabilities for external modules are deeply integrated or sourced from geopolitical risk. To address these risks, this recommendation proposes that the firm incrementally strengthen its modular product architecture by embedding design-for-substitution principles. This does not imply decoupling or standardization at the expense of innovation, but rather treating architectural flexibility as a strategic safeguard aligned with the firm's evolving collaboration model.

As identified in Sections 5.1.2 and 5.2.3, the firm has already begun outsourcing subsystems with embedded software and hardware integration responsibilities. While these collaborations enable access to specialized capabilities, they also raise concerns about architectural transparency. Interviewees expressed a clear desire to avoid so-called "black box" arrangements supplier-delivered modules that function as intended but offer limited visibility into internal workings. Such configurations can limit the firm's ability to switch suppliers or modify components without significant reengineering. As discussed in Section 6.2.3, this is not just a technical concern but a

strategic one, as reduced transparency may undermine long-term autonomy and adaptability.

To address these risks, the firm could implement design-for-substitution principles within its modular product architecture. This involves defining robust and compatible interfaces between internal platforms and externally sourced subsystems, thereby enabling the integration of alternative components without requiring full system redesign. In addition, externally developed modules such as vision technologies or processing units should be structured to ensure that internal teams retain control over application logic, intellectual property sensitive layers, and system-level coordination. For subsystems exposed to regulatory or geopolitical uncertainty, the architecture should incorporate parallel integration pathways or designate workable secondary sourcing alternatives. Collectively, these architectural safeguards would improve the firm's strategic resilience and preserve system adaptability under external instability.

The empirical material shows that modularity is not yet a consistent design principle across projects but is increasingly seen as necessary for managing uncertainty. Interviewees acknowledged that tightly integrated external solutions offer speed and functionality but may constrain future decisions. As such, treating substitution readiness as a cross-functional requirement, co-owned by R&D, sourcing, and systems engineering, could improve both innovation agility and strategic resilience. This recommendation should not be viewed as a design mandate. Rather, it advocates for a gradual and context-sensitive strengthening of architectural modularity, aligned with the firm's hybrid R&D strategy. Where substitution is not feasible due to performance or integration constraints, the principle can still guide evaluation. In this way, modularity becomes a structural enabler of selective openness: it keeps the ability to collaborate externally without locking the firm into permanent dependencies.

7.1.3. Strengthen Internal Readiness through Role Clarity and Capability Building

Despite progress in building external collaborations, the firm's internal readiness remains uneven. In particular, capability gaps in specification writing, unclear role boundaries across functions, and declining motivation among engineers present meaningful constraints to sustaining the current R&D strategy. These are not minor issues but structural challenges that come directly from the firm's evolving external collaboration model and hybrid R&D approach. Addressing them is critical not only for realizing value from partnerships but also for protecting long-term innovation identity and integration capability.

Rather than prescribing a fixed transformation path, this recommendation proposes a set of capacity-building actions that can be phased and adapted based on organizational maturity and project-specific needs. The aim is to align internal roles and technical skills with the firm's hybrid R&D model, thereby improving its ability to manage complex external collaborations without undermining internal unity or morale.

To strengthen internal collaboration readiness, we suggest a set of phased capacity-building actions that can be tailored to project maturity and strategic priority as follow:

Improve Specification Capability
As the firm increasingly outsources functionally integrated subsystems, the ability to formulate clear and robust specifications becomes critical. Several interviewees highlighted that vague or insufficient specifications have led to supplier misunderstandings and integration delays. Rather than treating this as a training issue alone, improving specification maturity should be understood as a cross-functional coordination challenge, where communication standards, ownership clarity, and early-stage technical framing require joint reinforcement between engineering and sourcing.

Clarify Role Interfaces Across Functions
As noted in Section 5.2.2, confusion over who governs what across the external collaboration impedes coordination. Simple, project-specific role mapping, co-developed by involved teams, could offer a practical way to identify and resolve interface frictions without requiring full organizational restructuring. The aim is not to redesign functional ownership, but to improve operational clarity through collaborative boundary-setting.

Clarify Role Interfaces Across Functions and Suppliers
As noted in Section 5.2.2, confusion over who governs what across the external collaboration lifecycle has hindered coordination, not only within the firm which is between R&D, sourcing, and advanced development but also in interactions with external partners. This ambiguity becomes especially challenging in triadic collaborations involving interdependent suppliers. To address these frictions, we recommend piloting lightweight, project-specific role mapping practices co-developed by internal and external stakeholders to clarify task ownership and interface responsibilities. The goal is not to redesign organizational structures but to improve operational clarity through joint boundary-setting, both within the firm and across supplier relationships.

Reinforce Integration Ownership Across Functions
Interviewees pointed to uncertainty about who internally should own and coordinate the integration of externally developed subsystems into the broader platform. As noted in Sections 5.2.2 and 5.2.3, this lack of integration ownership risks misalignment across R&D, sourcing, and project management. Rather than assigning this responsibility to a single function, the firm could pilot shared ownership models that align integration tasks with those closest to architectural decision-making. Embedding this into project governance could enhance platform consistency without duplicating oversight efforts.

These actions do not aim to reverse the shift toward external collaboration, but rather to support it. As discussed in Section 6.2.2, open innovation strategies require complementary internal capabilities and motivational alignment. Without these, even well-governed external partnerships may struggle to deliver full value. The proposed initiatives can be introduced gradually, piloted in current strategic partnerships, and iteratively refined based on feedback and observed outcomes. Ultimately, strengthening collaboration readiness is not about creating new layers of process but about aligning skills, expectations, and organizational identity with the demands of hybrid innovation.

8. Conclusion

This study set out to examine how a high-tech firm adapts its R&D strategy and external collaboration model under geopolitical risk, with particular attention to partner selection, internal coordination, and the strategic trade-offs that arise in this process. Through a qualitative single-case study involving live R&D collaborations with camera and processor suppliers based in China, the research contributes both empirical insight and theoretical advancement in understanding how hybrid R&D strategies are operationalized in structurally and geopolitically complex environments.

In response to Research Question 1, the focal firm does not adopt a strictly closed or open innovation model, but instead pursues a selectively open R&D strategy, but instead adopts a hybrid R&D strategy. This hybrid model is driven by practical considerations such as innovation speed, subsystem complexity, and capability boundaries, while simultaneously constrained by geopolitical exposure and the need to retain architectural control. Partner selection has evolved from transactional evaluation to a multidimensional process incorporating technical fit, integration readiness, relational alignment, and geopolitical foresight. Importantly, adaptability and system-level compatibility are prioritized over geographic origin, reflecting a nuanced partner evaluation logic. The firm has also begun to embed scenario planning and modular design into upstream collaboration decisions, indicating a growing emphasis on architectural flexibility and geopolitical resilience.

Addressing Research Question 2, the study identifies several organizational challenges that accompany this shift in R&D collaboration. The firm's governance structures have struggled to manage the triadic complexity introduced by interdependent external partners, with role ambiguity and coordination breakdowns frequently cited. Capability gaps as in specification writing, integration management, and cross-functional alignment have constrained collaboration readiness. In the same time, the outsourcing of strategically important tasks has raised internal concerns about long-term motivation, innovation identity, and control over core technologies. These challenges underscore the organizational tensions of bounded openness, where strategic autonomy must be balanced against innovation speed and external dependency. Furthermore, geopolitical risk is no longer treated as a purely external constraint, but is actively integrated into supplier selection, regulatory planning, and supply chain design.

Taken together, this thesis contributes to research on R&D strategy, open innovation, and external collaboration by clarifying how firms navigate the intersection of internal capability, external technology access, and systemic geopolitical risk. It extends existing theory by demonstrating how triadic collaboration structures, modular product architectures, and cross-functional foresight routines can serve as strategic enablers in hybrid R&D strategies. Notably, it illustrates that managing external collaboration under geopolitical risk is not only about choosing the right partners, but also about preparing the internal organization to absorb, govern, and adapt these relationships over time.

In practical terms, the study offers a framework for implementing hybrid R&D strategies through three interrelated levers: structured partner evaluation that

incorporates geopolitical foresight, modular product architecture that enables substitution and transparency, and internal capability building to support cross-functional collaboration readiness. These insights are especially relevant for high-tech, innovation-driven firms seeking to balance speed, adaptability, and strategic autonomy while engaging with emerging global technologies under increasing political fragmentation.

The following chapter outlines concrete strategic recommendations derived from these findings. Each recommendation is grounded in empirical insights and aligned with the thesis's theoretical contributions, offering actionable guidance for firms navigating the complexities of external R&D collaboration under geopolitical risk. Together, they provide a foundation for building resilient and future-ready innovation systems in structurally uncertain environments.

8.1 Limitations and Future Research

While this study offers meaningful insights into how a high-tech firm navigates external R&D collaboration and partner selection under geopolitical risk, it is not without limitations.

First, the findings are taken from a single-case study focused on one focal firm and a specific set of strategic supplier collaborations. While this design enabled deep, context-rich insights, it also limits the results. The firm’s hybrid R&D strategy, organizational maturity, and suppliers are likely to differ from those of other high-tech firms, especially in different industry segments or geopolitical contexts. Future research could extend this work through comparative multi-case studies that explore how different firms structure external collaboration models under varying levels of geopolitical exposure, technological complexity, or regulatory environments.

Second, the study relied on semi-structured interviews with internal stakeholders, with data captured through detailed written notes due to confidentiality constraints that prevented audio recordings. Future research could benefit from audio-recorded interviews to improve data richness and transparency. Additionally, incorporating the perspectives of external stakeholders such as supplier representatives would allow for a more comprehensive understanding of the collaboration dynamics, trust-building processes, and perceptions of strategic alignment across firm boundaries.

Third, the study’s temporal scope was bounded by an ongoing project, capturing a snapshot of an collaboration process. As such, the longer-term consequences of partner selection decisions such as performance outcomes, supplier lock-in, or adaptation to regulatory changes remain beyond the scope of this thesis. Longitudinal research could offer valuable insights into how hybrid R&D strategies mature over time and how governance mechanisms evolve in response to shifting geopolitical or technological conditions.

Finally, while the thesis highlight the role of geopolitical risk, it treats it as a contextual factor influencing partner selection and collaboration design. Future research could explore the inverse relationship how firms in geopolitically exposed industries actively shape their innovation ecosystems, supplier networks, or lobbying strategies in response to political risk.

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