Beyond Trade Balances: Technology-Trade Resilience under Supply-Chain and Policy Uncertainty

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Technology trade is highly exposed to uncertainty because it combines specialization, cross-border production networks and long investment horizons. This article examines how operational supply-chain pressure and trade-policy uncertainty shape technology-trade resilience across the US, China and European economies. We conceptualize technology-trade resilience in a bounded, trade-based sense, as an observable dual-margin outcome reflected in the export-to-import ratio, capturing short-run trade-flow adjustment, and revealed comparative advantage, capturing structural export specialization. The results show that uncertainty does not operate through a single resilience channel. Operational pressure is associated mainly with export-import adjustment, while specialization responses are selective and strongest in semiconductors. Trade-policy uncertainty produces more polarized patterns, combining flow deterioration, specialization vulnerability and adaptive specialization. The findings show that technology-trade resilience cannot be inferred from trade balances alone and that strategic component sectors are internally heterogeneous rather than uniformly vulnerable or resilient.

Keywords: technology trade; trade-policy uncertainty; global supply-chain pressure; resilience

JEL codes: C23; F13; F14; O33; L63

Declarations

The authors declare no conflict of interests.

1. Introduction

Technology trade is especially exposed to uncertainty because it combines high specialization, long investment horizons, and strong dependence on cross-border production networks. In such sectors, trade outcomes depend not only on tariffs and final demand, but also on supplier coordination, access to intermediate inputs, and the stability of globally fragmented production systems. As a result, uncertainty may affect technology trade not only by weakening current trade performance, but also by altering the structure of specialization itself (Lall, 2000; Bloom, 2009; Antràs, 2020).

Existing research, however, remains fragmented. Many studies examine a single source of uncertainty, such as trade-policy uncertainty or geopolitical risk, and trace its effects on export participation, firm entry, or aggregate trade flows (Handley & Limão, 2015, 2017; Matzner et al., 2023; Ozdemir et al., 2022; Gupta et al., 2022). Other contributions emphasize global value chain (GVC) restructuring under rising trade tensions and policy volatility, suggesting that firms may reconfigure sourcing and supplier networks rather than simply reduce cross-border activity (Freund et al., 2024; Charoenwong et al., 2023). Recent work further shows that uncertainty propagates through export-market penetration, transportation costs and broader macroeconomic spillover channels, rather than only through aggregate trade values (Antonakakis et al., 2014; Melas et al., 2025; Yildirim et al., 2026). This broader literature motivates the article's focus on how uncertainty is transmitted across distinct technology-trade margins, rather than through a single trade outcome. What is still less developed is an integrated framework that jointly distinguishes between multiple uncertainty dimensions and multiple trade outcomes in technology sectors.

This article addresses that gap by conceptualizing technology-trade resilience in two complementary dimensions. Technology-trade resilience is defined as the capacity of a country-sector pair to absorb or adapt to uncertainty shocks, as reflected in limited deterioration, recovery, or adaptive reallocation in two complementary margins: trade-balance performance (EI) and export specialization (RCA). Both indicators are formally defined in Section 3. The key country-level exposure variable is lagged PPTRD, defined as the share of intermediate goods in total trade, expressed as a percentage. PPTRD is used as a pre-shock proxy for exposure to intermediate-input trade, production fragmentation, and GVC embeddedness. It captures whether a country was integrated into intermediate-goods trade before the annual uncertainty shock occurred.

We use two theoretically grounded adjustment channels as interpretive lenses for analysing technology-trade responses to uncertainty. The first is postponement, whereby firms may defer trade-, sourcing-, and investment-related commitments when

uncertainty raises the value of waiting under irreversibility and sunk costs (e.g., Bernanke, 1983; Bloom, 2009; Handley & Limão, 2015, 2017; Feng et al., 2017; Caldara et al., 2020). The second is reconfiguration, whereby firms and economies may reorganize sourcing, production, and specialization when uncertainty disrupts GVC-dependent production or reshapes the geography of technologically sensitive trade (e.g., Freund et al., 2024; Charoenwong et al., 2023; Braun et al., 2023). Because the empirical analysis is based on aggregate country-sector-year data, these channels are treated as theoretically informed interpretations of EI-RCA response patterns rather than as directly identified firm-level mechanisms. Against this backdrop, the article asks how two uncertainty dimensions affect technology-trade resilience: operational uncertainty, proxied by the Global Supply Chain Pressure Index (GSCPI) (Federal Reserve Bank of New York, 2025), and trade-policy uncertainty, proxied by the Trade Policy Uncertainty index (TPU) (Caldara et al., 2020). GSCPI captures global supply-chain pressure associated with logistics stress, delivery delays, input bottlenecks and supplier-coordination problems, while TPU captures uncertainty surrounding trade-policy regimes, tariffs, trade rules and market-access conditions. Technology-trade resilience is conceptualized as a joint outcome observed across two complementary margins: the short-term trade-flow margin captured by EI and the more structural export-specialization margin captured by RCA. The key objective is not to assign each uncertainty dimension to a single outcome indicator or mechanism, but to examine whether the uncertainty pressures captured by GSCPI and TPU are associated with EI-RCA response patterns that can be interpreted in relation to postponement and reconfiguration. The article further asks whether these response patterns differ across technology sectors, especially between electronics parts-and-components and non-parts electronics, and within the component group itself.

The framework yields two testable expectations. First, uncertainty should not affect technology-trade resilience through a single, uniform margin. Instead, its effects should be observable through EI-RCA response patterns that distinguish short-run trade-flow adjustment from more structural changes in revealed specialization. GSCPI and TPU are used to capture different sources of uncertainty pressure but the corresponding adjustment channel is inferred from the joint behaviour of EI and RCA rather than imposed ex ante. Second, these response patterns are expected to be conditioned by sectoral exposure, with stronger and potentially more heterogeneous responses in electronics parts-and-components than in non-parts electronics, especially within strategically salient component sectors such as semiconductors.

The main empirical findings are threefold. First, exposure to operational supply-chain pressure is associated primarily with adjustment in the export-import margin, while responses in revealed specialization are more selective. Second, trade-policy uncertainty produces more polarized sectoral patterns, including flow deterioration, specialization vulnerability and adaptive specialization. Third, semiconductors and related electronic components are the only sector displaying joint positive EI and RCA responses under both

uncertainty dimensions, whereas telecommunications shows no statistically detectable response. These results indicate that technology-trade resilience cannot be inferred from a single trade indicator and that electronics component sectors are internally heterogeneous.

The empirical analysis is based on country-sector-year observations for the US, China and EU economies and the UK. The underlying data cover 1998-2024. The EU is not estimated as a single aggregate actor in the panel regressions; instead, the European dimension is represented by country-level observations. Aggregate EU technology-trade statistics are used only to motivate the systemic relevance of the European block within the US-China-Europe technology-trade triangle. The choice of the economies is empirically grounded in their dominant role in advanced-technology trade. The sample captures the dominant poles of the global technology economy. The group jointly account for nearly 60% of world technology exports, around two thirds of global ICT services exports, at least three quarters of global R&D expenditure, and more than two thirds of international patenting activity measured through PCT applications and major patent-office filings. The coverage is therefore not only geographically broad, but also structurally concentrated in the main centres of technology production, digital services trade, innovation investment and codified technological knowledge (Table A1 in the Appendix). Moreover, these trade actors represent distinct institutional and structural configurations, making them a suitable setting for examining whether technology-trade responses to uncertainty are broadly general or contingent on market structure and international production exposure. We study eight selected SITC Rev. 3 technology-goods sectors. The term “technology trade” is therefore used in a bounded empirical sense: it refers to the analysed goods sectors listed in Section 2.5, not to the full universe of technology-intensive industries or activities.

The article contributes to the literature in four ways. First, it moves beyond aggregate treatments of uncertainty by separating operational supply-chain pressure from trade-policy uncertainty. Second, it develops a mechanism-informed interpretive framework that links uncertainty pressures and EI-RCA response patterns to two theoretically grounded adjustment channels: reconfiguration in GVC-dependent production and postponement under sunk costs and irreversibility. The framework is not intended to provide direct causal identification of these mechanisms; rather, it offers a structured way to interpret reduced-form, exposure-conditioned empirical patterns. Third, it advances a two-dimensional view of technology-trade resilience, distinguishing between EI as a short-run trade-balance margin and RCA as a structural specialization margin. This distinction allows uncertainty to weaken current trade performance without necessarily altering specialization, or to reshape specialization without an immediate deterioration in the export-import balance. Fourth, it embeds this framework in sectoral heterogeneity by comparing electronics parts-and-components with non-parts electronics, while allowing

the strength and sign of the responses to differ within the component group itself, especially in strategically salient sectors such as semiconductors.

By linking uncertainty shocks to technology-trade resilience, the article speaks to debates on technological dependence, supply-chain resilience, economic security and the governance of interdependence. The EI-RCA distinction is important for these debates because resilience cannot be inferred from trade balances alone: a sector may preserve export coverage while losing revealed specialization, or strengthen specialization despite short-run trade-flow pressure.

Empirically, the article relies on sector-specific linear panel-data models with country and year fixed effects and uncertainty-exposure interaction terms, estimated separately for EI and RCA, to assess how operational and trade-policy uncertainty shape technology-trade resilience across different sectoral exposure conditions.

The remainder of the article is structured as follows. Section 2 develops the conceptual framework and hypotheses. Section 3 describes the data sources, measurement strategy, and the empirical model specification. Section 4 presents the empirical results and discusses them in the context of the existing literature. Section 5 concludes with key findings and strategic implications.

2. Conceptual framework and hypotheses

2.1. Why uncertainty affects technology trade differently?

Technology trade is likely to respond to uncertainty differently from trade in less knowledge-intensive sectors because it combines three features that amplify adjustment frictions: high sunk costs, strong dependence on cumulative capabilities, and extensive reliance on internationally fragmented production. As emphasized by Lall (2000), technology export structures are path-dependent and difficult to transform quickly, which makes them especially sensitive to shocks that affect investment, learning, and market access. In turn, the uncertainty literature supports that when decisions are at least partly irreversible, firms may delay action in response to volatility because the value of waiting increases under uncertain conditions (Bernanke, 1983; Bloom, 2009; Handley et al., 2020). In technology sectors, this logic is particularly relevant because export expansion often requires prior investments in supplier relationships, production capabilities, certification, and foreign-market presence.

A further reason why uncertainty may matter more in technology trade is that many technology goods are produced within complex cross-border production systems. In these sectors, trade outcomes depend not only on final demand and border measures, but also on the smooth coordination of suppliers, access to specialized intermediate inputs, and the stability of production networks spanning multiple jurisdictions. This makes technology trade especially vulnerable to shocks that interrupt logistics, delay

contracting, or alter the expected profitability of foreign-market engagement (Manova & Yu, 2016). Existing evidence is consistent with both channels. Policy uncertainty can reduce firms' incentives to incur sunk export-entry and investment costs, thereby depressing market entry and cross-border expansion (Handley & Limão, 2015, 2017; Guenzel, 2025). At the same time, rising trade tensions need not simply compress trade flows; they can also induce firms to reroute sourcing, shift supplier networks, and reallocate trade toward countries with a stronger revealed comparative advantage in the affected product space (Freund et al., 2024; Charoenwong et al., 2023).

For these reasons, uncertainty in technology trade should not be expected to generate a uniform response across sectors or outcomes. Some sectors may react primarily through delayed investment, entry, and contracting, while others may respond through production-network adjustment, trade rerouting, and changes in relative specialization. More generally, the magnitude and even the sign of the trade response may depend on how uncertainty interacts with product position, supplier dependence, and exposure to cross-border production linkages. This is consistent with evidence that the trade effects of uncertainty are heterogeneous rather than uniform, varying across countries, sectors, and the source of the shock (Matzner et al., 2023). In the context of technology trade, this heterogeneity suggests the need to move beyond one-shock, one-outcome approaches and instead examine how different uncertainty dimensions translate into distinct adjustment mechanisms.

Against this background, the next subsection distinguishes the two main adjustment channels through which uncertainty is expected to affect technology trade: postponement and reconfiguration.

2.2. Two adjustment channels: postponement and reconfiguration

2.2.1. Postponement under irreversibility and sunk costs

A first channel through which uncertainty can affect technology trade is postponement. The core intuition is well supported in the literature on irreversible investment and real options: when firms face partly irreversible decisions and uncertainty is at least partly reducible over time, the value of waiting increases, making immediate action less attractive (Bernanke, 1983; Bloom, 2009; Dixit & Pindyck, 1994). In such conditions, firms may adopt a wait-and-see approach, postponing market entry, investment, contracting, and sourcing decisions until the expected policy or market environment becomes clearer (McGrath, 1997; Lukas & Welling, 2014). This logic is particularly relevant in technology sectors, where trade expansion often requires prior commitments in production capability, supplier relationships, certification, market development, and technology upgrading. Because these commitments are costly to reverse, higher uncertainty may induce firms to delay export entry, postpone scale-up, or

suspend investment and sourcing decisions (Handley, 2014; Handley et al., 2020; Feng et al., 2017; Ahmad & Mahmood, 2020).

The importance of postponement is reinforced when international trade involves substantial sunk costs. The trade-policy uncertainty literature suggests that when export entry and market participation require sunk costs, policy uncertainty depresses firms' incentives to invest in foreign-market access even if current tariff conditions remain unchanged (Handley & Limão, 2015, 2017). In this setting, uncertainty affects trade not only through contemporaneous policy levels, but also through expectations about future policy regimes and the credibility of market access. For technology trade, this is especially important because firms frequently commit resources before exports materialize, including investments in product adaptation, imported-input sourcing, distribution channels, and complementary technologies. Uncertainty can therefore reduce trade by delaying the decisions that make cross-border exchange possible (Fryges, 2009; Graziano et al., 2024; Hossain et al., 2025).

In technology sectors, this mechanism can also have dynamic implications. If postponement persists, delayed investment and delayed foreign-market engagement may slow capability accumulation, weaken learning processes, and reduce firms' ability to consolidate positions in technologically demanding markets. Thus, postponement is not only a short-run response to uncertainty; it may also shape subsequent trade performance by affecting the timing and scale of capability-building decisions. This provides the first theoretical channel through which uncertainty can translate into weaker technology-trade resilience.

2.2.2. Reconfiguration under GVC-dependent production

A second channel through which uncertainty can affect technology trade is reconfiguration. This mechanism is particularly relevant in sectors organized through GVCs, where production is fragmented across countries and depends on the coordination of specialized suppliers, intermediate inputs, and sequential production stages (Antràs, 2020; Alfaro & Chor, 2023). In such settings, uncertainty need not simply reduce trade. It may instead induce firms to reorganize sourcing, reroute trade, reallocate production across locations, or shift specialization toward activities and partners perceived as more reliable under changing conditions (e.g., Moradlou et al., 2025; Cerqueti et al., 2026). Because these adjustments operate through the structure of production networks rather than only through contemporaneous trade volumes, they may alter trade patterns even when aggregate trade does not collapse (Li et al., 2024). Recent studies on geoeconomic fragmentation reinforce this point. Alfaro and Chor (2026) show that supply-chain trade is being reallocated across partners rather than simply withdrawn from global sourcing. Gopinath et al. (2025) emphasize that trade and investment linkages are increasingly shaped by geopolitical alignment and connector-country roles,

while Conteduca et al. (2025a) show that fragmentation can reorganize GVCs across countries and sectors, increasing regionalization and the role of neutral connectors.

Recent evidence is consistent with this interpretation. Freund et al. (2024) indicate that the decline in US imports from China during the trade war was partly offset by rising imports from other developing economies with revealed comparative advantage in the affected products, pointing to trade redirection rather than simple withdrawal from cross-border exchange. Charoenwong et al. (2023), in turn, suggest that trade and foreign economic policy uncertainty can reshape firms' supply-chain networks, with firms adjusting the composition of their domestic and foreign suppliers rather than merely reducing activity. More broadly, the literature on GVC restructuring emphasizes that production networks are interdependent but adaptable: shocks can trigger costly but non-negligible reorganization of value chains, especially where supplier relationships and imported inputs are central to production.

Taken together, the postponement and reconfiguration channels suggest that uncertainty may affect different dimensions of technology-trade resilience in different ways, which motivates the separate treatment of EI and RCA in the empirical analysis.

2.3. Two-dimensional resilience: EI and RCA

The two adjustment channels discussed above imply that technology-trade resilience cannot be treated as a one-dimensional outcome.

If uncertainty affects trade through postponement, its effects are likely to appear first in current trade-balance performance, as firms delay export entry, scale-up, contracting, or imported-input adoption. Because technology exports may depend on imported intermediate inputs, EI responses are interpreted as changes in the export-import balance margin rather than as an unambiguous welfare or performance ranking.

If uncertainty affects trade through reconfiguration, its effects may appear more strongly in changes in relative specialization, as firms and economies redirect sourcing, shift market shares, or reorient production across product segments and trade partners. For this reason, the present article conceptualizes technology-trade resilience in two complementary dimensions: trade-balance resilience and specialization resilience.

We capture these dimensions using EI and RCA. EI reflects asymmetry in the relative strength of exports vis-à-vis imports and is particularly informative when evaluating contemporaneous trade-balance adjustment aftershocks. RCA, following Balassa (1965), captures relative export specialization by comparing the weight of a sector in a country's export basket with the corresponding sectoral weight in world exports. RCA is therefore better suited to tracing shifts in revealed specialization and market shares following uncertainty-induced trade diversion, supplier substitution, or production-network adjustment. This interpretation is consistent with recent evidence

linking trade reallocation to revealed comparative advantage and changes in GVC configurations (Freund et al., 2024; Braun et al., 2023).

The use of EI and RCA as resilience indicators is therefore indirect and outcome-based. EI is relevant for resilience because it shows whether a country-sector pair maintains its export-coverage capacity when exposed to uncertainty. However, a higher EI value is not automatically interpreted as stronger resilience, since it may also reflect import compression or delayed imported-input adoption. RCA is relevant for resilience because it captures whether a country-sector pair retains or strengthens its revealed position in world export specialization. However, RCA does not measure domestic value added, technological capability, productivity, or innovation capacity directly. For this reason, the article treats EI and RCA as complementary observable margins of technology-trade resilience rather than as complete measures of resilience.

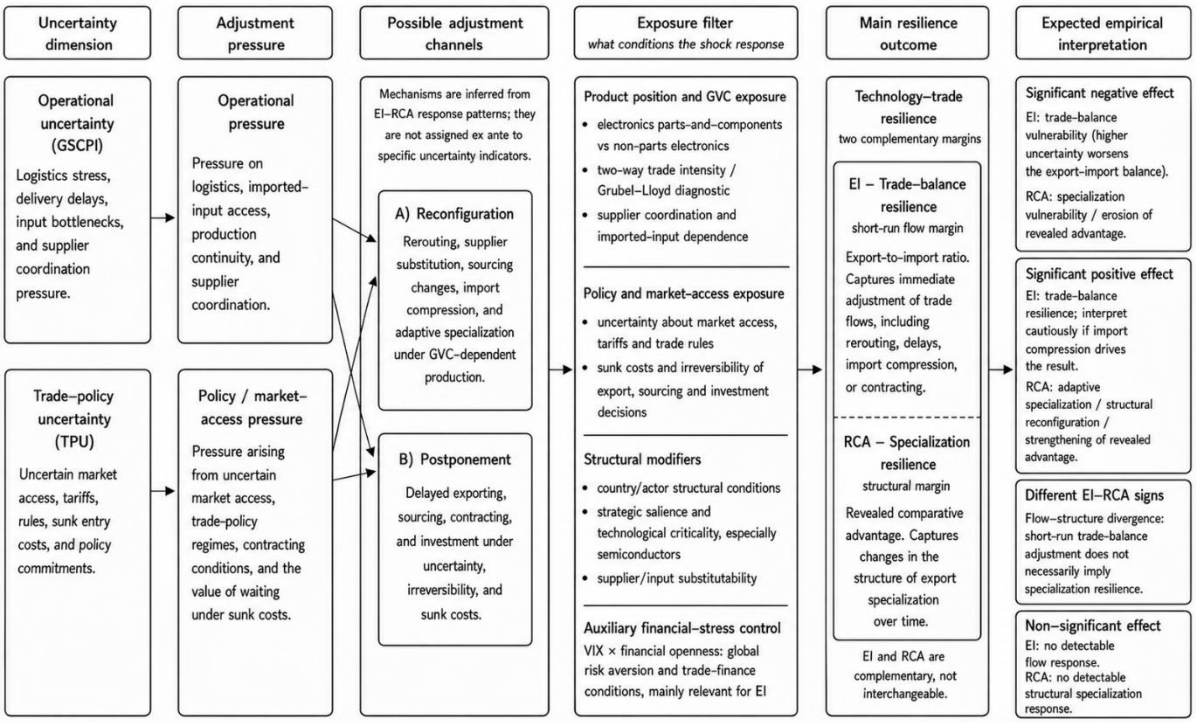
Treating EI and RCA separately is important because the two indicators need not move in the same direction or with the same timing. A deterioration in EI may coincide with relative stability in RCA if uncertainty weakens current trade performance without materially altering specialization. Conversely, RCA may change without a sharp contemporaneous decline in EI if uncertainty induces reallocation across suppliers, locations or product segments rather than uniform trade compression. EI is therefore expected to react more quickly because it reflects current export-import flows, whereas RCA may respond more slowly through market-share reallocation and sectoral repositioning. Their formal operationalization is presented in Section 3.

2.4. Uncertainty dimensions and expected mappings

The next step is to link these channels to the two uncertainty dimensions used in the empirical analysis. We distinguish between operational uncertainty and trade-policy uncertainty because each type of shock is expected to generate different adjustment pressures, which may materialize in different EI-RCA response patterns across sectors.

Figure 1 organizes the theoretical argument around a sequence from uncertainty pressure to exposure-conditioned adjustment and observable technology-trade outcomes. Operational and trade-policy uncertainty may be associated with postponement- or reconfiguration-type responses, whose form and strength depend on country- and sector-level exposure. The corresponding EI-RCA patterns provide observable implications of these adjustment channels, although aggregate trade data do not allow any single pattern to be attributed uniquely to one firm-level mechanism.

Figure 1. Conceptual framework of technology-trade resilience under uncertainty



Note: The final column reports possible mechanism-consistent interpretations, not one-to-one empirical classifications. The categories are heuristic and non-exclusive.

Source: own elaboration.

Rather than linking GSCPI and TPU ex ante to a single adjustment mechanism, the framework allows both uncertainty dimensions to be associated with postponement- or reconfiguration-type responses across the flow and specialization margins. The empirical interpretation therefore depends on the joint EI-RCA configuration and on the country- and sector-level exposure conditions specified in the framework.

The exposure filter should be interpreted as a set of conditioning factors rather than as a separate group of uncertainty indicators. It indicates where uncertainty-induced EI-RCA responses are expected to be more visible. For operational pressure, the relevant conditioning factors include product position, GVC embeddedness, supplier coordination and imported-input dependence. For trade-policy pressure, they include uncertainty about market access, trade rules and sunk-cost-intensive export, sourcing and investment commitments. In both cases, responses may also be shaped by country-specific structural conditions and by sectoral characteristics such as technological criticality, supplier substitutability and strategic salience.

Financial-market uncertainty is not treated as a third core uncertainty dimension; where included empirically, VIX interacted with financial openness serves only as an auxiliary control for exposure to global risk aversion and trade-finance conditions. Broader economic policy uncertainty is also relevant, but it is not treated as a third core uncertainty dimension in the baseline framework. EPU-type indicators combine several policy domains, including fiscal, monetary, regulatory and macroeconomic policy

uncertainty, and may overlap with trade-policy uncertainty while being less directly tied to the specific operational and market-access channels analysed here. In addition, country-level EPU series are not available as a fully balanced and consistently comparable panel for all economies in the sample. For these reasons, broader EPU measures are treated as relevant robustness and limitation considerations rather than as a baseline uncertainty dimension.

Empirically, the exposure logic is implemented in two layers: lagged PPTRD captures country-level exposure to intermediate-goods trade, while sector-specific estimations and the electronics parts-and-components/non-parts distinction capture sectoral exposure. Full variable definitions, transformations and sources are summarized in Appendix Table A3a.

2.5. Sectoral heterogeneity and classification

Sectoral heterogeneity is central to the framework because uncertainty is unlikely to affect all technology sectors with the same strength, sign or EI-RCA response pattern. The empirical analysis covers eight SITC Rev. 3 technology-goods sectors: office machines (SITC 751), automatic data-processing machines, n.e.s. (SITC 752; hereafter: computers), parts and accessories for machines of groups 751 and 752 (SITC 759; hereafter: parts and accessories), television receivers (SITC 761; hereafter: TV receivers), radio-broadcast receivers (SITC 762; hereafter: radio receivers), sound recorders or reproducers (SITC 763; hereafter: sound recorders), telecommunications equipment, n.e.s., and parts, n.e.s. (SITC 764; hereafter: telecommunications), and semiconductors and related electronic components (SITC 776). Sector-specific estimation preserves heterogeneity within technology-goods trade rather than imposing a common response across these product categories. Accordingly, the term “technology trade” is used here in a bounded empirical sense and does not refer to the full universe of technology-intensive activities, such as biotechnology, pharmaceuticals, medical technologies or aerospace.

To provide an externally grounded and more parsimonious product-position grouping, we follow UNCTAD’s classification of high-skill and technology-intensive manufactures. Within the sectors analysed here, non-parts electronics comprise SITC 751, 752, 761, 762 and 763, whereas electronics parts-and-components comprise SITC 759, 764 and 776. This classification is not constructed from the estimated results and is used to support comparison across product positions while retaining the full eight-sector structure of the empirical analysis.

Product position alone, however, may not fully capture sectoral exposure or the direction of adjustment. Responses may also depend on technological criticality,

concentration at important value-chain nodes, supplier substitutability and asymmetries in trade dependence. Strategic salience is therefore treated as an interpretive modifier of sectoral responses rather than as a separate binary classification that predetermines the empirical result. This approach is consistent with recent research showing that strategic dependence should be assessed at the product and input level, taking into account import concentration, substitutability, network bottlenecks and the potential costs of disruption (Arjona et al., 2023; Conteduca et al., 2025b; Panon et al., 2026; Consonni & Magerman, 2026).

Appendix Table A2 complements the UNCTAD classification with sector-level trade-structure diagnostics. The Grubel-Lloyd index is used as a descriptive measure of two-way trade intensity, not as a direct measure of GVC participation. Nevertheless, the GVC and intra-industry trade literature links two-way trade in intermediate goods and components to vertical specialization and internationally fragmented production (OECD, 2017; Yoshida, 2008; Pittiglio, 2014; Widodo, 2009). We therefore identify the core GVC-intensive component segment using two complementary criteria: membership in UNCTAD's electronics parts-and-components group and high two-way trade intensity in the analysed sample. This dual criterion avoids inferring GVC intensity either from product labels alone or from the Grubel-Lloyd index alone.

SITC 759, 764 and 776 meet both criteria. Together, these sectors account for 66.7% of the technology trade analysed and have a mean Grubel-Lloyd index of 0.730, compared with 0.484 for non-parts electronics. This pattern is consistent with UNCTAD's discussion of parts and components for electrical and electronic goods as products closely connected to vertical international production sharing (Mayer et al., 2003). It also explains why an economically important assembled final-goods sector such as SITC 752 is not included in the core component segment solely because it may participate in fragmented production, whereas the mixed SITC 764 category is retained because it satisfies both the product-position and two-way-trade criteria.

These diagnostics also provide an empirical basis for examining semiconductors more closely, rather than treating them as distinctive solely because of their geopolitical importance. SITC 776 is the largest individual sector in the analysed sample, accounting for 27.9% of analysed technology trade, and combines component-sector status with a high mean Grubel-Lloyd index of 0.749. Its trade-structure profile is comparable to, but not identical with, those of the remaining component sectors: SITC 759 displays an even higher mean Grubel-Lloyd index but a smaller trade share, while SITC 764 has a similarly large trade share but a lower mean Grubel-Lloyd index. These characteristics motivate closer examination of the semiconductor response but do not predetermine its sign or magnitude. Section 4.4 and Table 3 therefore compare its estimated EI-RCA response profile with those of SITC 759 and SITC 764, while formal coefficient-difference tests are reported in Appendix Table A9.

The UNCTAD grouping is thus used as a theoretically and empirically grounded layer for interpreting sectoral heterogeneity, not as a substitute for sector-specific estimation. In line with the exposure-filter logic of the framework, uncertainty-related responses are expected to be more visible where trade depends more strongly on component production, imported inputs and cross-border supplier coordination (Lall, 2000; Antràs, 2020; Alfaro & Chor, 2023).

2.6. Hypotheses

The hypotheses follow from the dual-margin conceptualization of technology-trade resilience and from the distinction between postponement-type and reconfiguration-type adjustment. Postponement and reconfiguration are not inferred mechanically from a single outcome variable. Instead, they are interpreted cautiously through joint EI-RCA response patterns. A postponement-type response should appear primarily in EI, because firms may delay exporting, sourcing, contracting or investment before the structure of revealed specialization changes. This logic follows the real-options and trade-policy uncertainty literature, which links uncertainty, irreversibility and sunk costs to delayed entry, investment and export commitments (Bernanke, 1983; Dixit & Pindyck, 1994; Bloom, 2009; Handley & Limão, 2015, 2017; Feng et al., 2017; Caldara et al., 2020). By contrast, a reconfiguration-type response should become visible where uncertainty is associated with rerouting, supplier substitution, production-network adjustment or changes in revealed specialization, especially in GVC-dependent sectors. This logic is consistent with the literature on fragmented production, supplier-network adjustment and trade reallocation under uncertainty and supply-chain stress (Antràs, 2020; Alfaro & Chor, 2023; Freund et al., 2024; Charoenwong et al., 2023; Braun et al., 2023).

H1. Operational and trade-policy uncertainty should generate distinguishable EI-RCA response patterns.

Operational supply-chain pressure is expected to be associated primarily with flow-margin adjustment and selective structural responses where disruptions become embedded in sourcing, production or revealed specialization. Trade-policy uncertainty is expected to generate postponement-type flow responses more directly, while RCA responses may arise where policy uncertainty becomes persistent or is associated with durable reallocation.

Sectoral exposure provides the second layer of the framework. If uncertainty operates through postponement and reconfiguration, its effects should be strongest where trade is most dependent on cross-border production linkages, imported intermediate inputs and supplier coordination. Electronics parts-and-components are therefore expected to display stronger responses than non-parts electronics. At the same

time, the component group itself is expected to be heterogeneous, with stronger and potentially distinct responses in strategically salient sectors, especially semiconductors and related electronic components.

H2. Uncertainty-related EI-RCA responses are expected to be more visible and more structurally differentiated in electronics parts-and-components than in non-parts electronics.

Table 1 provides a heuristic guide for interpreting EI-RCA response patterns. It is not an ex-post coding device and should not be read as a one-to-one empirical classification of outcomes. The table specifies non-exclusive, theoretically motivated readings of alternative EI-RCA combinations. These readings help structure the empirical discussion, but they do not imply that a given aggregate pattern uniquely identifies one underlying adjustment mechanism. Some EI-RCA combinations may be consistent with more than one process. For example, a positive EI response without RCA confirmation may reflect export resilience, import compression, temporary demand conditions or short-run sourcing adjustment rather than structural reconfiguration.

Table 1. Heuristic guide for interpreting EI-RCA response patterns

Observed EI-RCA response pattern	Non-exclusive interpretation	Mechanism-consistent reading and caveats
EI negative; RCA non-significant	Short-run deterioration in the export-import margin without detectable specialization change	Consistent with postponement-type flow deterioration, but not direct evidence of firm-level delay; may also reflect adverse demand, exchange-rate movements, or temporary trade-flow shocks
EI positive; RCA non-significant	Improved export-coverage margin without detectable specialization change; possible import compression	Flow-margin adjustment; not sufficient evidence of structural reconfiguration; may reflect export resilience, import compression, temporary demand shifts, or short-run sourcing adjustment
RCA positive; EI mixed or non-significant	Strengthening of revealed specialization without a uniform EI response	Consistent with adaptive specialization or reconfiguration-type adjustment when aligned with exposure logic; may also reflect market-share redistribution or sector-specific conditions
RCA negative; EI mixed or non-significant	Erosion of revealed specialization without contemporaneous EI collapse	Specialization vulnerability; may reflect competitiveness loss, adverse reallocation, policy exposure, or sector-specific demand conditions
EI positive; RCA positive	Improved export-import margin combined with strengthening of revealed specialization	Joint positive EI-RCA response, consistent with adaptive adjustment; not evidence that uncertainty is generally beneficial

EI negative; RCA negative	Deterioration in the export-import margin combined with erosion of revealed specialization	Joint vulnerability; consistent with adverse flow and specialization responses
EI positive; RCA negative	Improved export-coverage margin combined with erosion of revealed specialization	Flow-structure divergence; possible import compression or structural vulnerability
EI negative; RCA positive	Short-run deterioration in the export-import margin combined with strengthening of revealed specialization	Flow-structure divergence; specialization gain despite short-run EI deterioration; may reflect reallocation with short-run adjustment costs

Source: own elaboration.

Empirical support for the hypotheses is assessed at the level of EI-RCA response patterns rather than isolated coefficients. H1 will be considered supported only if the uncertainty pressures captured by GSCPI and TPU are associated with statistically detectable and theoretically distinguishable combinations of EI and RCA responses. The framework would not support H1 if uncertainty-exposure coefficients were statistically absent, unstable across specifications, concentrated only in isolated and theoretically unmotivated cases, or failed to generate distinguishable flow-margin and specialization-margin patterns. It would also be weakened if the observed EI-RCA combinations systematically contradicted the expected distinction between short-run flow adjustment and more structural revealed-specialization responses.

H2 will be considered supported only if these response patterns are stronger or more structurally visible in electronics parts-and-components than in non-parts electronics, while allowing for heterogeneity within the component group. H2 would not be supported if electronics parts-and-components did not display stronger or more structurally differentiated responses than non-parts electronics, or if sectoral responses showed no relation to the exposure filters specified in the conceptual framework.

Alternative interpretations cannot be ruled out completely with aggregate country-sector-year data. For this reason, the categories in Table 1 are not used to assign a unique causal mechanism to each empirical result. Instead, the empirical discussion evaluates whether the observed patterns are statistically detectable, theoretically interpretable and consistent with sectoral exposure conditions. Where alternative readings are plausible - for example, import compression, temporary demand shifts, sector-specific policy support, exchange-rate movements, inventory adjustment or partner substitution - these are explicitly acknowledged in the interpretation.

3. Methodology

3.1. Empirical strategy and model specification

The empirical unit is a country-sector-year observation. The sample comprises the US, China, EU economies and the UK. The EU is therefore not estimated as a single

aggregate actor in the panel regressions; rather, the European dimension is represented by country-level observations. To examine how uncertainty is associated with technology-trade outcomes, we estimate static panel-data models using two complementary specifications: country fixed effects and Mundlak correlated random effects. The fixed-effects estimator controls for unobserved, time-invariant country characteristics, such as persistent trade structures, institutional differences, structural specialization, or long-term exposure to GVCs. This is consistent with standard panel-data econometrics, where fixed effects remove the time-invariant component of unobserved heterogeneity from the error term (Hsiao, 2014; Baltagi, 2021; Wooldridge, 2010).

The Mundlak specification, also referred to as the correlated random-effects approach, augments the random-effects model with country-specific means of the time-varying regressors. This relaxes the restrictive assumption that the unobserved country-specific component is uncorrelated with the explanatory variables and allows the random-effects framework to approximate the fixed-effects correction for correlated heterogeneity (Mundlak, 1978; Wooldridge, 2019). Recent econometric work also shows that Mundlak-type formulations can be extended to settings with time effects and are closely related to two-way fixed-effects estimators (Wooldridge, 2025).

The choice of a static panel-interaction design follows from the revised research objective. The aim of the empirical analysis is not to estimate a dynamic system of feedback between uncertainty and trade outcomes or to trace impulse-response paths over time. Rather, the objective is to examine whether common annual uncertainty shocks are associated with different EI and RCA outcomes across countries and sectors with different lagged intermediate-goods trade exposure and sectoral product positions. A dynamic system design is better suited to questions about temporal feedback among endogenous variables, whereas the present framework requires a design that conditions common uncertainty shocks on pre-existing exposure and compares response patterns across resilience margins and sectors. For this reason, we use sector-specific panel models with country and year effects, complemented by Mundlak correlated-random-effects specifications.

The empirical analysis is organised around four model families, estimated separately for each of the eight technology sectors: (i) RCA models with the Global Supply Chain Pressure Index (GSCPI), (ii) RCA models with the Trade Policy Uncertainty index (TPU), (iii) $\ln$EI models with GSCPI, and (iv) $\ln$EI models with TPU. Thus, GSCPI and TPU are not included simultaneously in the same equation. Instead, each uncertainty index is examined in a separate specification to avoid conflating supply-chain pressure with trade-policy uncertainty and to facilitate sector-by-sector comparison of the estimated coefficients. This structure is pre-specified by the conceptual framework rather than selected after inspecting the results. It follows a 2 × 2 design: two resilience margins, lnEI and RCA, are crossed with two uncertainty dimensions, GSCPI and TPU. Within each outcome family, the same country and year effects, lagged PPTRD exposure variable,

auxiliary VIX-financial-openness interaction, and control-variable logic are applied consistently across sectors. Sector-specific estimation is used to preserve heterogeneity across technology sectors, not to search for isolated significant results.

Estimating GSCPI and TPU separately does not imply that the two uncertainty dimensions are orthogonal. The purpose is to compare exposure-conditioned EI-RCA patterns associated with each source of uncertainty pressure without imposing a structural decomposition of correlated global shocks.

The empirical strategy is therefore reduced-form in nature. It is designed to estimate whether common uncertainty shocks are associated with different EI and RCA outcomes across country-sector pairs with different lagged intermediate-goods trade exposure. This design is therefore not a substitute for a structural dynamic model; it is a reduced-form design tailored to the revised question of exposure-conditioned heterogeneity across resilience margins and sectors. The models do not directly identify postponement or reconfiguration as causal mechanisms. Instead, the interaction coefficients document exposure-conditioned associations, which are subsequently interpreted through the theoretical framework. In this sense, postponement and reconfiguration are interpreted cautiously from EI-RCA response patterns and should be understood as mechanism-type interpretations rather than directly estimated structural channels.

To address potential endogeneity concerns, we additionally estimate dynamic-panel GMM specifications as robustness checks. The main concern is not the direct level of GSCPI or TPU, which are common annual shocks absorbed by time effects in the baseline design, but the possibility that lagged trade exposure and the uncertainty-exposure interaction may be correlated with unobserved trade dynamics. We therefore estimate difference-GMM models including the lagged dependent variable and treating $Y_{i,t-1}$, $PPTRD_{i,t-1}$, and $U_t \times PPTRD_{i,t-1}$ as potentially endogenous or predetermined. Collapsed internal instruments dated t-2 and t-3 are used to avoid instrument proliferation. The number of instruments is kept below the number of countries. The reported diagnostics include the Arellano-Bond AR(2) test and the Hansen test of overidentifying restrictions.

The main exposure variable is PPTRD, defined as the share of intermediate goods in total trade. In the empirical models, PPTRD enters with a one-year lag, so that exposure is measured before the contemporaneous annual uncertainty shock and before current EI and RCA outcomes are observed. Economically, PPTRD acts as a pre-shock exposure filter for intermediate-input trade and GVC embeddedness. Full variable definitions and transformations are summarized in Appendix Table A3a.

Let i denote country, t denote year, and k denote technology sector. Since the estimations are conducted sector by sector, k indexes the sector-specific equation rather than a pooled sector dimension. For each sector k and uncertainty indicator U_t, where $U_t \in \{\text{GSCPI}_t, \text{TPU}_t\}$, the interaction channels are defined as:

$$C_{it}^{(U)} = U_t \times \text{PPTRD}_{i,t-1}, \qquad F_{it} = \text{maxVIX}_t \times \text{OpenFin}_{i,t-1}.$$

The two-way fixed-effects model is then written as:

$$y_{ikt}^{(U)} = \alpha_i + \lambda_t + \mathrm{X}'_{ikt}\beta + \theta C_{it}^{(U)} + \delta F_{it} + \varepsilon_{ikt}. \qquad (1)$$

In equation (1), $y_{ikt}^{(U)}$ is the dependent variable and is defined either as RCA_{ikt} or as $\ln\text{EI}_{ikt}$. The term α_i denotes country fixed effects, λ_t denotes year fixed effects, X_{ikt} is a vector of observed control variables, and ε_{ikt} is the idiosyncratic error term. The coefficient θ is the main uncertainty-channel coefficient: it measures whether the association between a common uncertainty shock and technology-trade outcomes differs with lagged intermediate-goods trade exposure, measured by $\text{PPTRD}_{i,t-1}$. The coefficient δ captures the auxiliary financial-stress channel, measured by the interaction between maxVIX_t and lagged financial openness.

The use of interaction terms is required by the structure of the data and by the inclusion of time effects. GSCPI, TPU, and maxVIX vary only over time and are common to all countries in a given year. Their direct level effects are therefore perfectly collinear with the full set of year dummies in a two-way model and cannot be separately identified. For this reason, GSCPI and TPU enter the model through their interaction with lagged PPTRD, while maxVIX enters through its interaction with lagged financial openness. These interaction terms transform common time-varying shocks into regressors that differ across countries depending on their exposure to the relevant transmission channel.

The corresponding Mundlak correlated random-effects model is specified as:

$$y_{ikt}^{(U)} = \alpha + \lambda_t + \mathrm{X}'_{ikt}\beta + \theta C_{it}^{(U)} + \delta F_{it} + \overline{\mathrm{Z}}'_i\pi + u_i + \varepsilon_{ikt}. \qquad (2)$$

In equation (2), u_i is the country-specific random component and $\overline{\mathrm{Z}}_i$ contains country-specific means of the time-varying regressors, including the control variables and the relevant interaction terms. Including these means allows the unobserved country effect to be correlated with the regressors. The Mundlak estimates are therefore used as a robustness-oriented counterpart to the fixed-effects results and as a way to assess whether the fixed-effects conclusions are sensitive to the treatment of unobserved heterogeneity.

The set of controls differs across the two outcome variables, reflecting the different economic interpretations of RCA and $\ln$EI. In the RCA models, the control vector includes labour productivity, R&D intensity, the real effective exchange rate, lagged PPTRD, and lagged financial openness. In the $\ln$EI models, the control vector includes the terms-of-trade index, GDP growth, the real effective exchange-rate measure, lagged PPTRD, and lagged financial openness. In both sets of models, the uncertainty-channel interaction and the maxVIX financial-stress interaction are included. The estimations reported in the tables are based on all countries analysed; after the use of lagged variables, each sector-specific model contains 806 observations.

The coefficient on the uncertainty interaction has a different substantive interpretation depending on the dependent variable. In RCA models, it indicates whether the same uncertainty shock is associated with stronger or weaker revealed comparative advantage in countries with greater exposure through PPTRD. In lnEI models, the coefficient can be interpreted as a semi-elastic relationship with the export-to-import ratio: a positive coefficient implies that, conditional on the controls and fixed effects, uncertainty is associated with a higher export-to-import ratio in more exposed countries, whereas a negative coefficient implies a deterioration of the export-to-import relationship.

To assess economic significance, the interaction coefficients are evaluated over meaningful exposure differences rather than read only as coefficient signs. For the lnEI models, the estimated interaction coefficient can be translated into an approximate percentage difference in the export-to-import ratio as $100 \times [\exp(\beta \Delta U \Delta PPTRD) - 1]$, where ΔUdenotes a change in the uncertainty indicator and $\Delta PPTRD$denotes the difference in lagged intermediate-goods trade exposure. For RCA models, the corresponding calculation is $\beta \Delta U \Delta PPTRD$, which gives the implied change in the RCA index. In the discussion below, illustrative magnitudes are evaluated for a one-unit increase in the uncertainty indicator and a one-standard-deviation difference in lagged PPTRD exposure.

3.2. Dependent variables: export-to-import ratio and revealed comparative advantage

The empirical analysis uses two complementary trade-based indicators of technology-trade resilience: the export-to-import ratio (EI) and revealed comparative advantage (RCA). These indicators are not treated as complete measures of economic or technological resilience. Rather, they provide observable country-sector-year outcomes through which two resilience margins can be assessed: EI captures the short-run export-coverage or trade-balance margin, while RCA captures the more structural revealed-specialization margin.. The two outcomes are therefore analysed jointly, but they are not treated as mechanically equivalent. Uncertainty may affect the balance between exports and imports without necessarily changing revealed specialization, and conversely, changes in specialization may occur without a proportional change in the export-to-import ratio.

EI and RCA are constructed from sector-level trade data. The export-to-import ratio is defined as:

$$\mathrm{EI}_{ikt} = \frac{X_{ikt}}{M_{ikt}}. \qquad (3)$$

where X_{ikt} denotes exports of technology sector k by country i in year t, and M_{ikt} denotes imports of the same sector by the same country and year. An EI value equal to one means

that exports equal imports; values above one indicate that exports exceed imports, whereas values below one indicate that imports exceed exports. In the resilience interpretation, EI is used to capture the export-coverage margin under uncertainty. A deterioration in EI indicates weaker export coverage relative to imports, while an improvement in EI may indicate stronger export performance, import compression, or temporary sourcing adjustment. For this reason, EI is interpreted together with RCA rather than as a standalone measure of resilience. In the estimated models, EI enters as a natural logarithm:

$$\ln \mathrm{EI}_{ikt} = \ln\left(\frac{X_{ikt}}{M_{ikt}}\right). \qquad (4)$$

This transformation is appropriate because the EI distribution is highly skewed across sectors and contains extreme values, as shown by the descriptive statistics. The logarithmic form reduces the influence of outliers, improves comparability across sectors, and allows coefficients to be interpreted in relative terms.

RCA is calculated following Balassa (1965):

$$\mathrm{RCA}_{ikt} = \frac{X_{ikt}/X_{it}}{X_{wkt}/X_{wt}}. \qquad (5)$$

where X_{ikt} is exports of technology sector k by country i in year t, X_{it} is total exports of country i in year t, X_{wkt} is world exports of technology sector k in year t, and X_{wt} is total world exports in year t. An RCA value above one indicates that a country has a revealed comparative advantage in a given sector, while a value below one indicates the absence of such an advantage. In the resilience interpretation, RCA is used to capture whether revealed specialization is retained, weakened, or strengthened under uncertainty. RCA is especially relevant for technology-trade resilience because specialization in technology sectors is path-dependent and linked to cumulative capabilities. However, RCA remains a revealed trade indicator: it does not directly measure domestic technological capability, innovation capacity, productivity, or domestic value added. In contrast to EI, RCA is used in levels in the reported models. This distinction is important: the study estimates RCA models and $\ln$EI models, rather than log-transforming both dependent variables.

3.3. Uncertainty indices and interaction channels

The study uses two core annual uncertainty indicators: GSCPI, which captures operational supply-chain pressure, and TPU, which captures trade-policy and market-access uncertainty. The two indicators are examined separately because they represent conceptually different uncertainty dimensions and because the empirical objective is to compare their exposure-conditioned EI-RCA response patterns rather than to impose a structural decomposition of correlated global shocks. The trade-uncertainty literature shows that uncertainty can reduce trade flows, discourage export-market entry, delay

investment and contracting decisions, and amplify the responsiveness of trade to global shocks (Handley & Limão, 2017; Novy & Taylor, 2020).

Because GSCPI is reported in standard-deviation units, TPU is standardised to improve comparability of scale. The 1997-2021 reference period was retained because the TPU transformation was originally performed when this was the estimation window used in the initial GSCPI methodology (Benigno et al., 2022). The transformation is a simple z-score standardisation intended to express TPU in units comparable to GSCPI and was not selected ex post based on the regression results. TPU is therefore transformed as follows:

$$\text{ZTPU}_m = \frac{\text{TPU}_m - \overline{\text{TPU}}_{1997-2021}}{s(\text{TPU})_{1997-2021}}. \qquad (6)$$

Monthly uncertainty data are then aggregated to annual frequency by taking the maximum value within each year. Monthly uncertainty data are then aggregated to annual frequency by taking the maximum value within each year. This annual maximum approach is used to capture episodes of peak uncertainty, which are likely to be particularly relevant for firms and countries exposed to GVCs. Annual maxima should therefore be interpreted as measures of peak annual uncertainty exposure rather than the average intensity of uncertainty throughout the year. Annual averages and medians would smooth such short but salient episodes, whereas end-of-year values could miss major uncertainty shocks occurring earlier in the year. Because this aggregation rule may place greater weight on short-lived spikes, Appendix Table A8 re-estimates the baseline fixed-effects interaction models using annual averages of monthly GSCPI and TPU.

In addition to GSCPI and TPU, the models include maxVIX as a financial-stress control. maxVIX captures annual peaks in global financial-market uncertainty and risk aversion. It is not treated as a third core uncertainty dimension in the conceptual framework. Instead, it controls for the possibility that financial stress affects technology trade through financing conditions and exposure to international financial markets. Since maxVIX is also common to all countries in a given year, its direct effect is absorbed by year fixed effects. Therefore, the model includes maxVIX only through the interaction $\text{maxVIX}_t \times \text{OpenFin}_{i,t-1}$. Broader EPU-type indicators are not included as additional controls because they capture a wider range of policy uncertainty and the available country-level series do not provide a fully balanced and consistently comparable panel for all sample economies over 1998-2024. Their inclusion is therefore treated as an avenue for future robustness analysis.

The two interaction channels therefore have distinct roles. The main uncertainty-exposure interaction estimates whether the association between supply-chain pressure or trade-policy uncertainty and technology-trade outcomes varies with lagged intermediate-goods trade exposure ($U_t \times \text{PPTRD}_{i,t-1}$). The auxiliary maxVIX-financial-openness interaction ($\text{maxVIX}_t \times \text{OpenFin}_{i,t-1}$) controls for heterogeneous exposure to global financial stress through financial openness. This specification makes the identifying assumptions transparent: the empirical models do not estimate the average

direct effect of common uncertainty shocks; instead, they estimate whether countries with different exposure characteristics display different technology-trade outcomes under the same global shock.

3.4. Preliminary data diagnostics

Descriptive statistics and unit-root tests are reported in Tables A3b and A4 in the Appendix. Appendix Table A4 also reports the distribution of PPTRD, defined as the share of intermediate goods in total trade. In the sample, PPTRD has a mean of 21.92 and a standard deviation of 5.47 percentage points, with values ranging from 8.04 to 43.16. This indicates substantial cross-country and over-time variation in pre-existing intermediate-goods trade exposure. The annual uncertainty indicators cover the period 1998-2024. TPU displays the highest variability among the core uncertainty measures, with a standard deviation of 2.07 and pronounced right-skewness. GSCPI has a lower standard deviation of 1.24 but is also right-skewed, reflecting the episodic nature of supply-chain disruptions. The maxVIX, included as a financial-stress control, has a mean of 14.00 and a standard deviation of 7.79.

The Augmented Dickey-Fuller tests indicate that GSCPI is stationary in levels in both the constant-only and constant-plus-trend specifications. TPU does not reject the unit-root null in these tests, which is consistent with its episodic and persistent spikes during major trade-policy tensions. In the empirical models, TPU is nevertheless retained in levels because it is treated as an exogenous uncertainty indicator and enters the two-way specification through an interaction term rather than as an independently identified time-series effect. maxVIX is stationary according to both ADF specifications.

The descriptive statistics for the dependent variables support the adopted transformations. EI is highly dispersed and strongly skewed across sectors. Sectoral means range from 0.61 to 17.73, and the maximum values are particularly large in some sectors, reaching 8,177.27. This provides a clear statistical motivation for using $\ln$EI in the regression models. RCA is also heterogeneous across sectors, with mean values ranging from 0.55 to 1.35 and maximum values reaching 23.90, but it is retained in levels because it is interpreted as an index of revealed specialization rather than as an export-coverage ratio.

Stationarity of EI, RCA, and the control variables is assessed using the Im-Pesaran-Shin panel unit-root test. For both EI and RCA, the level tests allow rejection of the unit-root null in all sectors at conventional significance levels, and the first-difference tests strongly reject the unit-root null. These results support the use of the variables in the subsequent panel estimations, although the diagnostic tests are interpreted together with the fixed effects and robustness specifications reported below.

The reported regression tables also include diagnostic information for each sector-specific model. Year effects are included in all specifications and are jointly tested. Additional diagnostics cover heteroskedasticity, cross-sectional dependence,

and serial correlation where relevant. The comparison between fixed-effects and Mundlak estimates provides a check on the robustness of the estimated uncertainty-channel coefficients to alternative treatment of unobserved country heterogeneity.

4. Discussion

Table 1 provides heuristic shorthand for interpreting statistically detectable patterns across the two trade-based resilience margins, EI and RCA. Because the models condition common annual shocks on lagged PPTRD and estimate sectors separately, the interaction coefficients are interpreted as exposure-conditioned associations rather than average global effects. References to postponement, reconfiguration, vulnerability and adaptive specialization therefore denote mechanism-consistent patterns, not directly identified firm-level causal processes.

The year fixed effects reported in Figure A1 provide a background diagnostic of common temporal shifts, including the global financial crisis, the post-2018 trade-tension period, the COVID-19 shock and the post-2022 geopolitical and energy-shock environment. They are not interpreted as separate uncertainty mechanisms; they contextualize the exposure-conditioned estimates by absorbing time-specific shocks common to the sample.

Table 2 summarizes the main statistically detectable EI-RCA patterns using the heuristic framework introduced in Table 1, without treating them as direct evidence of specific mechanisms.

Table 2. Heuristic synthesis of statistically detectable EI-RCA response patterns by uncertainty dimension and sector

EI-RCA response pattern	Main sectoral evidence	Interpretation
Positive EI without RCA confirmation	GSCPI exposure: office machines, computers, TV receivers; TPU exposure: TV receivers; weakly sound recorders	Flow-margin adjustment without structural specialization confirmation.
Negative EI without RCA response	TPU exposure: office machines	Postponement-type flow deterioration.
Negative RCA with weak, insignificant, or divergent EI	TPU exposure: computers, parts and accessories; GSCPI exposure: parts and accessories	Specialization vulnerability or flow-structure divergence.
Negative EI and negative RCA	TPU exposure: radio receivers	Joint vulnerability: trade-balance deterioration combined with erosion of revealed specialization.
Positive EI and positive RCA	GSCPI and TPU exposure: semiconductors and related electronic components	Adaptive specialization in a strategically salient component sector.
No detectable EI-RCA response	GSCPI and TPU exposure: telecommunications	Weak component-sector sensitivity; evidence against a uniform parts-and-components gradient.

Notes: The table condenses the sector-level interaction effects discussed in the text. EI denotes the export-import margin; RCA denotes revealed export specialization. The detailed coefficient estimates are reported in Appendix Tables

A5a-A5d. Descriptive statistics used for the economic-magnitude benchmarks, including the standard deviation of PPTRD and sectoral mean RCA values, are reported in Appendix Table A4. Selected economic-magnitude calculations are summarized in Appendix Table A6. Because EI and RCA are measured on different margins, coefficients are not directly interchangeable across outcomes. For this reason, the economic significance of the main interaction effects is discussed separately below for lnEI and RCA.

The statistically detectable coefficients are economically meaningful when evaluated over realistic differences in exposure. The interaction term means that the effect of uncertainty is conditional on lagged PPTRD. The magnitude calculations use the fixed-effects estimates as the baseline coefficients; the Mundlak estimates are used as robustness-oriented counterparts and are substantively similar for the main interaction effects. In the sample, the standard deviation of PPTRD is 5.47, so a one-standard-deviation difference in lagged intermediate-goods trade exposure provides a useful benchmark for interpreting the magnitude of the estimated effects.

For the lnEI models, a one-unit increase in the relevant uncertainty indicator combined with a one-standard-deviation difference in lagged PPTRD implies economically visible changes in the export-to-import ratio, generally of approximately 3-10%. The largest GSCPI-related differences are observed in TV receivers (9.7%) and office machines (8.0%), while TPU exposure is associated with effects ranging from a 4.8% deterioration in radio receivers to a 6.8% improvement in TV receivers. The full set of sector-specific magnitudes is reported in Appendix Table A6.

RCA effects should be interpreted differently because RCA is retained in levels and captures revealed specialization rather than a proportional trade-balance margin. Evaluated at a one-standard-deviation difference in PPTRD, the GSCPI-related RCA coefficient for semiconductors and related electronic components implies an increase of approximately 0.049 RCA points, which corresponds to about 7.7% of the sector's mean RCA. The TPU-related semiconductor coefficient implies a similar RCA increase. By contrast, negative RCA effects in computers, parts and accessories, and radio receivers are smaller in absolute terms, approximately 0.016 to 0.033 RCA points, or around 3% of the corresponding sectoral mean RCA. These effects are more modest than the largest EI effects, but they remain substantively relevant because RCA is a slower-moving specialization indicator. Even relatively small RCA changes may indicate meaningful shifts in revealed specialization when they occur in strategically important or GVC-intensive sectors.

Overall, the magnitude calculations support the substantive interpretation of the results. The strongest EI responses indicate economically visible short-run flow-margin adjustment, while the semiconductor RCA effects indicate a non-trivial strengthening of revealed specialization. At the same time, the smaller RCA effects in some vulnerable sectors suggest that the evidence should be interpreted as specialization erosion at the margin rather than as abrupt structural collapse.

4.1. Flow-margin adjustment: positive EI without RCA confirmation

The first empirical pattern is positive EI without positive RCA confirmation. This pattern is observed most clearly in office machines, computers, and TV receivers under the GSCPI-exposure interaction, and in TV receivers under the TPU-exposure interaction. In these cases, the export-import margin improves, but the RCA margin does not provide evidence of strengthened revealed specialization. Using the terminology of Table 1, this pattern can be read as short-run flow-margin adjustment rather than as generalized structural reconfiguration. However, it should not be treated as uniquely identifying one adjustment process, since positive EI without RCA confirmation may also reflect import compression, temporary demand conditions, or short-run sourcing adjustment. Parts and accessories and semiconductors also display positive EI responses under GSCPI exposure, but they are treated separately below because their RCA margins point to different patterns: flow-structure divergence in the former case and adaptive specialization in the latter. In economic terms, these flow-margin effects are not negligible. Evaluated at a one-standard-deviation difference in PPTRD, the GSCPI-related EI effects imply approximately 4.5-9.7% differences in the export-to-import ratio across the main positive-EI sectors.

Consistent with the interpretation of GSCPI as operational supply-chain pressure, these results suggest that disruptions in logistics, input access and supplier coordination are first reflected in the export-import margin before translating into more durable changes in revealed specialization (Manova & Yu, 2016; Antràs, 2020; Alfaro & Chor, 2023).

TV receivers provide a clear example of this pattern: the sector displays positive EI responses under both GSCPI and TPU exposure, but without statistically significant RCA effects. A similar interpretation applies to computers under GSCPI exposure, where positive EI indicates export-coverage adjustment without durable specialization gain.

4.2. Postponement-type deterioration: when TPU weakens EI before RCA changes

The second empirical pattern corresponds more closely to postponement-type adjustment: negative EI without a statistically significant RCA response. This pattern is most clearly visible in office machines under the TPU-exposure interaction. TPU exposure is associated with a negative EI response in Office machines, while RCA remains statistically insignificant. This indicates deterioration in the export-import margin without detectable erosion of revealed specialization. The magnitude is also economically visible: the TPU-exposure coefficient implies an approximately 3.8% lower export-to-import ratio for a one-standard-deviation difference in PPTRD under a one-unit increase in TPU.

This pattern is consistent with real-options and trade-policy uncertainty arguments, according to which market-access uncertainty may delay sunk-cost trade

commitments before it affects revealed specialization (Bernanke, 1983; Dixit & Pindyck, 1994; Bloom, 2009; Handley & Limão, 2015, 2017; Caldara et al., 2020).

Office machines therefore provide the clearest postponement-type case in the sample. Under GSCPI exposure, the sector displays a positive EI response, while under TPU exposure it displays a negative EI response without RCA adjustment. This contrast suggests that operational and policy uncertainty do not operate identically. Operational pressure may be associated with short-run export-coverage adjustment, whereas trade-policy uncertainty is more closely associated with weaker current trade-flow performance, consistent with delayed or reduced trade-related commitments. The office machines case is therefore consistent with postponement-type adjustment, but only as a specific EI-RCA response pattern rather than as a directly identified mechanism or a universal effect of TPU.

4.3. Specialization vulnerability: negative RCA without contemporaneous EI collapse

The third pattern is specialization vulnerability: negative RCA responses with weak, insignificant or divergent EI effects. It appears under TPU exposure in computers and parts and accessories, and as joint EI-RCA deterioration in radio receivers. These cases indicate that revealed specialization may weaken even when the contemporaneous export-import margin remains stable or moves differently.

Computers and parts and accessories illustrate this pattern under TPU exposure. In both sectors, the TPU-exposure interaction is associated with negative RCA responses without corresponding EI deterioration. This indicates that TPU exposure is associated with erosion of revealed specialization even when the contemporaneous export-import margin remains relatively stable. Such a result is consistent with studies documenting supplier-network adjustment and substitution across foreign sourcing locations under trade and foreign economic policy uncertainty, rather than simple reductions in trade volumes (Charoenwong et al., 2023). It is also consistent with evidence that trade reallocation after policy shocks is conditioned by pre-existing revealed comparative advantage and product-network position (Freund et al., 2024; Braun et al., 2023).

The case of parts and accessories is particularly important because the sector belongs to the electronics parts-and-components group and displays high two-way trade intensity. Yet the results do not point to adaptive reconfiguration. Under GSCPI exposure, the sector displays positive EI but negative RCA at the margin of statistical significance. Under TPU exposure, it displays negative RCA without a significant EI response. This is a clear flow-structure divergence. The positive EI response under operational pressure should therefore be interpreted cautiously, as it may reflect import compression, temporary export-coverage improvement, or short-run adjustment in a sector deeply embedded in cross-border component trade. The negative RCA response, however, suggests erosion of revealed specialization. Parts and accessories therefore show that

component sectors may be exposed not only to adaptive reconfiguration but also to specialization vulnerability.

The implied RCA magnitudes are moderate but substantively meaningful. For computers and parts and accessories, the TPU-related effects correspond to approximately 0.022 and 0.016 RCA points, respectively, when evaluated at a one-standard-deviation difference in PPTRD. These values represent roughly 3% of the corresponding sectoral mean RCA values, suggesting specialization erosion at the margin rather than abrupt structural collapse.

Radio receivers provide the clearest case of joint vulnerability under TPU exposure. The sector displays both negative EI and negative RCA responses to the TPU-exposure interaction. Within the heuristic logic of Table 1, this joint negative EI-RCA pattern is consistent with deterioration in the export-import margin combined with erosion of revealed specialization. Unlike office machines, where TPU exposure affects EI without RCA, radio receivers show a more adverse and structurally consequential response. This suggests that trade-policy uncertainty may be associated not only with postponement-type flow deterioration, but also with broader vulnerability when the flow and specialization margins deteriorate together.

4.4. Adaptive specialization in strategic components: the semiconductor case

The most distinctive adaptive-specialization pattern appears in semiconductors and related electronic components. This sector displays positive EI and positive RCA responses under both the GSCPI-exposure and TPU-exposure interactions. This joint positive EI-RCA response differs from simple flow-margin adjustment because the improvement in the export-import margin is accompanied by strengthening of revealed specialization. In the interpretive terms of Table 1, this is the strongest pattern consistent with adaptive adjustment in the sample.

The economic magnitude reinforces this interpretation. On the EI margin, the semiconductor coefficients imply approximately 3.3-3.9% higher export-to-import ratios when evaluated at a one-standard-deviation difference in PPTRD. On the RCA margin, the GSCPI and TPU coefficients imply an increase of about 0.049 RCA points, equivalent to approximately 7.7% of the sector's mean RCA. The semiconductor result is therefore not only statistically detectable but also economically meaningful, especially because RCA captures a slower-moving specialization margin.

The semiconductors and related electronic components interpretation builds on the trade-structure diagnostics reported in Section 2.5 and Appendix Table A2. Table 3 compares the estimated EI-RCA response profile of semiconductors with those of the remaining component sectors. Formal within-component coefficient-equality tests indicate that the semiconductor-versus-remaining-components contrasts are jointly

significant, although the differences are concentrated in the TPU-related EI response and the RCA specifications rather than being uniform across all four model families (Table A9). Taken together, these results show that the semiconductor finding is not a mechanical consequence of component-sector classification. Parts and accessories display specialization vulnerability or flow-structure divergence, while telecommunications shows no statistically detectable EI-RCA response. Semiconductors and related electronic components therefore stand out because their trade-structure profile is accompanied by a distinctive joint positive EI-RCA response under both uncertainty dimensions.

Table 3. Component-sector comparison: trade-structure position and EI-RCA response profiles

Component sector	Component-sector position	EI-RCA response profile	Implication for interpretation
SITC 759 Parts and accessories	Parts-and-components sector with high two-way trade intensity	GSCPI exposure: positive EI with negative RCA at the margin; TPU exposure: negative RCA without significant EI response	High two-way trade intensity does not automatically imply adaptive specialization; the sector displays specialization vulnerability or flow-structure divergence
SITC 764 Telecommunications	Parts-and-components sector with substantial trade share and high two-way trade intensity	No statistically detectable EI-RCA response under either uncertainty dimension	Component classification and substantial trade share do not mechanically generate uncertainty sensitivity
SITC 776 Semiconductors and related electronic components	Largest component sector in the analysed sample and high two-way trade intensity	Positive EI and positive RCA responses under both GSCPI and TPU exposure	Distinctive joint flow-and-specialization response; consistent with adaptive specialization within a strategically salient component sector

Notes: Component-sector positions summarize the trade-structure diagnostics reported in Section 2.5 and Appendix Table A2. EI-RCA response profiles summarize the statistically detectable patterns discussed in Sections 4.3-4.5. The table is descriptive and interpretive; it does not introduce additional econometric estimates.

This result should not be interpreted as evidence that uncertainty is generally beneficial. Rather, it suggests that uncertainty may be associated with a redistribution of revealed specialization toward countries or sectoral positions that are better placed to benefit from reallocation. The empirical distinctiveness of semiconductors and related electronic components is reinforced by, but not reducible to, the strategic position of semiconductors in technology-intensive GVCs. The semiconductor-related component segment is directly connected to debates on technological dependence, supply-chain resilience, economic security, and strategic autonomy, but the interpretation advanced here rests on the conjunction of trade-structure diagnostics, within-component comparison, and observed EI-RCA response patterns. In such sectors, uncertainty may coincide not only with vulnerability but also with selective adaptive reallocation,

particularly where existing capabilities, market position, or policy priorities allow some economies to gain from shifts in sourcing and specialization.

This interpretation is consistent with recent evidence on trade reallocation and supply-chain adjustment. Freund et al. (2024) show that the decline in US imports from China during the US-China tariff episode was partly offset by imports from other economies with revealed comparative advantage in the affected products. Charoenwong et al. (2023) similarly show that trade and foreign economic policy uncertainty can reshape supply-chain networks, with firms adjusting the composition of domestic and foreign suppliers rather than merely reducing activity. In the semiconductor context, Bown (2020) shows how the sector became deeply entangled in the US-China trade conflict and how semiconductor trade was shaped by both tariff measures and export-control dynamics.

The semiconductor case therefore refines the article's reconfiguration argument. Operational uncertainty does not produce a broad RCA response across all technology sectors. Its structural effect becomes visible mainly in semiconductors and related electronic components. Similarly, TPU does not operate only through postponement. In semiconductors and related electronic components, trade-policy uncertainty is associated with joint positive EI-RCA adjustment. This suggests that in strategically salient component sectors, uncertainty may coincide with adaptive specialization rather than simple deterioration.

At the same time, the semiconductor result requires caution. The semiconductors and related electronic components group is broader than advanced microchips and does not isolate the most technologically advanced semiconductor segments. It does not distinguish frontier chips, legacy chips, semiconductor manufacturing equipment, design activities, or downstream electronics in the way a more granular product classification would allow. Moreover, the current country set does not include Taiwan or South Korea, which are central to the global semiconductor value chain. Since the present discussion focuses on sector-level response patterns, the semiconductor result should be read as evidence of revealed specialization adjustment within the US-China-EU economies triangle rather than as identification of the specific actor driving this adjustment.

Nevertheless, the semiconductors and related electronic components result is central to the article's contribution. It shows that strategic component sectors may respond to uncertainty differently from both non-parts electronics and other component sectors. The sector is not simply more vulnerable because it is GVC-intensive; it may also display adaptive specialization when uncertainty is associated with shifts in sourcing, market access, or production-network positioning. This supports the argument that strategic salience and technological criticality should be treated as important interpretive modifiers of GVC exposure.

4.5. The limits of the parts-and-components distinction: the weak response of telecommunications

The sectoral results also show that the distinction between electronics parts-and-components and non-parts electronics is useful but insufficient. The strongest structural RCA responses are concentrated in selected component sectors, especially parts and accessories and semiconductors and related electronic components. However, telecommunications does not display statistically significant EI or RCA responses under either uncertainty dimension. This weak sensitivity is important because telecommunications belongs to the electronics parts-and-components group and displays relatively high two-way trade intensity, yet it does not behave like parts and accessories or semiconductors and related electronic components. This contrast is particularly important for the interpretation of the semiconductor result. If semiconductor distinctiveness were merely a consequence of being classified as an electronics component sector, telecommunications would be expected to show a similarly strong response. Its absence of statistically detectable EI-RCA sensitivity therefore reinforces the conclusion that the semiconductor pattern is not exceptional by construction, but reflects a sector-specific combination of trade position, two-way trade intensity, strategic salience, and observed response profile.

Telecommunications therefore functions as a non-confirming component case that refines the exposure-filter logic of the article. Product position and GVC embeddedness matter, but they do not fully determine uncertainty responses. If the parts-and-components classification alone were sufficient, Telecommunications would be expected to display stronger responses. Instead, the results suggest that uncertainty effects depend on a broader set of conditioning factors, including strategic salience, technological criticality, supplier substitutability, country-specific positioning, and the degree to which a sector is directly affected by shifts in policy priorities or sourcing strategies. The evidence therefore supports a layered interpretation of sectoral heterogeneity rather than a simple parts-versus-non-parts gradient.

4.6. Comparing operational and trade-policy uncertainty

The comparison reveals a clear difference in the distribution of responses across the two resilience margins. GSCPI exposure is associated mainly with EI adjustment, while its RCA responses are selective and confined to component sectors. TPU exposure produces a more polarized pattern across both margins, ranging from flow deterioration and specialization vulnerability to joint vulnerability and adaptive specialization. Operational pressure is therefore associated primarily with the trade-flow margin, whereas trade-policy uncertainty is more frequently associated with differentiated combinations of flow and specialization adjustment (Table 2; Appendix Tables A5a-A5d).

These results do not support a one-to-one mapping between GSCPI and reconfiguration or between TPU and postponement. Both uncertainty dimensions may be associated with postponement- or reconfiguration-type patterns, depending on country- and sector-level exposure. The difference is therefore one of the relative prevalence of particular response patterns rather than the exclusive operation of a single mechanism. This interpretation is consistent with the real-options literature on delayed trade and investment commitments under uncertainty (Bernanke, 1983; Dixit & Pindyck, 1994; Bloom, 2009; Handley & Limão, 2015, 2017; Caldara et al., 2020) and with research on trade rerouting, supplier substitution and production-network reorganization (Antràs, 2020; Alfaro & Chor, 2023; Freund et al., 2024; Charoenwong et al., 2023; Braun et al., 2023).

4.7. Assessment of the hypotheses

Taken together, the results provide qualified support for H1. Operational and trade-policy uncertainty generate distinct EI-RCA response patterns, but not as clean one-shock-one-mechanism effects. GSCPI exposure is associated mainly with flow-margin adjustment, with structural RCA effects concentrated in semiconductors and related electronic components and signs of specialization vulnerability in parts and accessories. TPU exposure produces a more polarized pattern, ranging from postponement-type EI deterioration in office machines to specialization vulnerability in computers and parts and accessories, joint vulnerability in radio receivers, and adaptive specialization in semiconductors and related electronic components. Thus, the evidence supports the more limited premise that EI-RCA patterns provide a useful basis for cautious mechanism-type interpretation, rather than for assigning specific uncertainty indicators to mechanisms ex ante or directly identifying firm-level adjustment channels. This support is therefore not based on assigning every EI-RCA combination to a successful mechanism, but on the fact that the statistically detectable patterns are differentiated across the flow and specialization margins and are broadly aligned with the exposure logic specified before the empirical results are discussed.

The economic-magnitude calculations strengthen this assessment. The main EI effects imply changes in the export-to-import ratio of roughly 3-10% for a one-standard-deviation difference in PPTRD, while the largest RCA effects, concentrated in semiconductors, amount to approximately 7-8% of the sectoral mean RCA. The hypotheses are therefore supported not only by statistical detectability but also by economically interpretable effect sizes.

The dynamic-panel GMM checks do not indicate a systematic endogeneity-related misspecification (Table A7). Across the 32 sector-specific robustness models, the Hansen test does not reject the overidentifying restrictions in 31 cases at the 5% level, and the AR(2) test does not indicate second-order serial correlation in 27 cases. For the

main statistically detectable baseline effects summarized in Appendix Table A6, 14 out of 16 specifications pass both diagnostics at the 5% level. The GMM diagnostics are generally acceptable, although coefficient-level robustness is mixed: 13 of the 16 highlighted effects preserve their signs and five remain statistically detectable. The GMM exercise therefore does not eliminate endogeneity concerns, but supports treating the baseline findings as exposure-conditioned associations whose robustness varies across sectors.

The results are also robust to the annual aggregation procedure. When annual averages of monthly GSCPI and TPU are used instead of annual maxima, all 16 main interaction effects preserve their signs and 14 remain statistically detectable. The main EI-RCA patterns are therefore not driven solely by isolated within-year spikes, although the weaker significance of two effects indicates that some responses are more closely associated with peak than with average annual uncertainty (Appendix Table A8).

H2 is also supported in a qualified way. The strongest structural RCA responses are concentrated in selected component sectors, especially parts and accessories and semiconductors and related electronic components. However, the evidence does not support a simple claim that all electronics parts-and-components are more sensitive to uncertainty than non-parts electronics. Telecommunications remains weakly responsive despite its component classification, while several non-parts sectors display significant EI or RCA responses. The results therefore support a structural-response gradient and within-component heterogeneity rather than a simple parts-versus-non-parts gradient.

These findings refine the conceptual framework in three ways. First, the results support treating EI and RCA as complementary but non-interchangeable margins of technology-trade resilience. EI captures short-run flow adjustment, but it does not necessarily indicate stronger structural specialisation. RCA captures revealed specialization, but it may change even when the export-import margin remains stable. Second, postponement and reconfiguration should be interpreted cautiously from response patterns rather than assigned ex ante to specific uncertainty indicators or treated as directly identified causal mechanisms. Third, product-position categories should be complemented by strategic salience, technological criticality, supplier substitutability, and country-specific positioning.

The policy implication is that technology-resilience strategies should not rely on trade-balance indicators alone. A higher export-to-import ratio may indicate stronger export performance, but it may also reflect import compression or temporary sourcing adjustment. Conversely, RCA deterioration may signal erosion of revealed specialization even when the export-import balance appears stable. Policymakers should therefore monitor both flow resilience and specialization resilience. In sectors showing positive EI but weak or negative RCA responses, policy should not assume that resilience has improved. The more relevant question is whether the observed flow adjustment is

accompanied by capability retention, supplier diversification, and sustained specialization.

The Figure A1 evidence on year fixed effects further supports this interpretation by showing that common temporal shocks were substantial but sectorally uneven. This reinforces the need to distinguish uncertainty-exposure responses from broader time-specific shifts in technology trade. The main empirical contribution is therefore not that uncertainty affects all technology sectors uniformly, but that different sectors translate common uncertainty conditions into different EI-RCA response patterns.

5. Conclusions

This article examined how operational and trade-policy uncertainty shape technology-trade resilience across the US, China and the EU economies. It argued that resilience in technology trade should not be inferred from a single trade-performance indicator. Instead, it should be conceptualized as a two-margin outcome observed through the export-to-import ratio (EI), which captures the short-run trade-flow or export-coverage margin, and revealed comparative advantage (RCA), which captures the more structural margin of revealed export specialization. This distinction is central to the article's contribution: a sector may improve its export coverage without strengthening specialization, or lose revealed specialization without an immediate deterioration in the export-import relationship.

The empirical results support this two-dimensional interpretation. Operational uncertainty, proxied by GSCPI, is associated mainly with EI responses, suggesting that supply-chain pressure is first absorbed through the trade-flow margin. These positive EI responses should be interpreted cautiously, as they may reflect import compression, delayed imported-input adoption, trade rerouting or temporary export-coverage improvement rather than stronger structural specialisation. RCA responses to GSCPI are much more selective, with the clearest positive effect appearing in semiconductors and related electronic components and signs of specialization vulnerability in parts and accessories. Trade-policy uncertainty, proxied by TPU, produces a more polarized EI-RCA pattern. Some sectors show postponement-type deterioration in EI, while others display specialization losses without contemporaneous EI deterioration. Semiconductors and related electronic components again stand out, showing positive responses in both EI and RCA. This does not imply that uncertainty is beneficial in general; rather, it suggests that in strategically salient sectors uncertainty may coincide with selective adaptive reallocation toward actors or sectoral positions with stronger revealed specialization.

The estimated magnitudes are also economically meaningful: using the fixed-effects estimates and the one-standard-deviation PPTRD benchmark reported in Appendix Table A4, the main statistically detectable lnEI effects correspond to

approximately 3-10% differences in export-to-import ratios, while the largest RCA effects, observed in semiconductors and related electronic components, correspond to roughly 7-8% of the sector's mean RCA, as summarized in Appendix Table A6.

The hypotheses are therefore supported in a qualified rather than mechanical way. H1 is partially supported: operational and trade-policy uncertainty generate distinct EI-RCA response patterns, but not as simple one-shock-one-mechanism effects. GSCPI is mainly associated with flow-margin adjustment, whereas TPU combines postponement-type deterioration, specialization vulnerability and selective adaptive specialization. H2 is also partially supported. The strongest structural responses are concentrated in the electronics parts-and-components segment, especially parts and accessories and semiconductors and related electronic components, but the results do not support a simple parts-versus-non-parts gradient. Telecommunications is comparatively weak, while several non-parts sectors display significant EI responses. The evidence therefore points to layered heterogeneity: product position matters, but so do strategic salience, technological criticality and supplier substitutability.

Theoretically, the article contributes to the uncertainty-trade literature in three ways. First, it shows that technology-trade resilience should be treated as a dual-margin phenomenon rather than a single trade-performance outcome. EI and RCA are complementary, not interchangeable. Second, the empirical strategy remains reduced form. Country and year effects, lagged exposure variables, Mundlak specifications and dynamic-panel GMM robustness checks help address persistent country heterogeneity, common temporal shocks, dynamic persistence and potential feedback from current trade outcomes to lagged exposure. The GMM diagnostics do not indicate systematic endogeneity-related misspecification. Nevertheless, these checks do not transform the analysis into a structural causal design. The results should therefore be interpreted as robust exposure-conditioned associations rather than structural causal estimates. Future research could use event-study designs, quasi-experimental policy variation, external instrumental-variable strategies, or more granular firm-, transaction- or product-level data to establish stronger causal identification. Third, it refines the sectoral interpretation of technology trade by showing that electronics parts-and-components are not internally homogeneous. Semiconductors and related electronic components behave differently from other component sectors, but this conclusion is not based on strategic salience alone. It is supported by trade-structure diagnostics, within-component comparison, and the fact that SITC 776 is the only analysed sector displaying joint positive EI and RCA responses under both uncertainty dimensions. Strategic salience and technological criticality should therefore be treated as interpretive modifiers of GVC-related exposure rather than as assumptions that mechanically define the semiconductor result.

The practical implication is that technology-resilience policy should not rely on trade-balance indicators alone. A higher export-to-import ratio may indicate stronger export performance, but it may also reflect import compression or temporary sourcing adjustments. Conversely, RCA deterioration may signal erosion of revealed specialization even when the export-import balance appears stable. Policymakers should therefore monitor both flow resilience and specialization resilience. In sectors showing positive EI but weak or negative RCA responses, policy should not assume that resilience has improved; the more relevant question is whether the observed trade-flow adjustment is accompanied by capability retention, supplier diversification and sustained specialization. In sectors showing negative RCA responses, policy attention should focus on preventing erosion of sectoral capabilities, supporting upgrading and facilitating supplier substitution.

The findings also speak directly to the broader technology-and-society agenda. Technology-trade resilience is not only a matter of export performance or sectoral specialisation. It affects how societies manage technological dependence, supply-chain vulnerability, economic security and strategic autonomy. The results suggest that uncertainty may be associated with a redistribution of revealed specialization across technology sectors and may therefore reshape the technological capacities available to economies over time. This connects trade adjustment to broader societal choices about openness, technological sovereignty, industrial policy and the governance of interdependence. The social and strategic consequences of technology trade therefore cannot be understood from aggregate trade flows alone; they require attention to the structural specialization patterns through which technological capabilities are retained, weakened or reallocated.

Several limitations should be acknowledged, and each points to avenues for future research. First, the analysis is based on aggregate country-sector-year trade indicators and does not directly observe firm-level postponement, supplier switching, contractual delays, inventory adjustment, production relocation or partner substitution. Alternative processes such as import compression, temporary demand shifts, exchange-rate movements or sector-specific policy support may therefore generate similar aggregate EI-RCA patterns. The mechanism labels and EI-RCA categories used in the article should be read as theoretically grounded, non-exclusive interpretations rather than as definitive causal attribution. Future research using firm-level, transaction-level, customs-level or partner-level data could more directly distinguish among these alternative mechanisms.

Second, the empirical strategy is reduced-form. Country and year effects, lagged exposure variables and Mundlak specifications help control for persistent country heterogeneity and common temporal shocks, but they do not eliminate all endogeneity concerns. The results should therefore be interpreted as exposure-conditioned associations rather than structural causal estimates. Future research could use event-

study designs, quasi-experimental policy variation, instrumental-variable strategies or dynamic panel approaches to examine whether the EI-RCA patterns documented here persist under stronger causal-identification designs.

Third, the timing of uncertainty transmission is modelled only indirectly. EI is expected to respond more quickly through the export-import margin, while RCA may adjust more slowly through revealed specialization. The annual specification captures this distinction through EI-RCA response patterns, but it does not estimate separate short-, medium- and long-run lag structures. Future work could use distributed lags, quarterly or monthly trade data where available, or separate lag structures for EI and RCA. Relatedly, the use of annual maxima for GSCPI, TPU and maxVIX is intended to capture peak uncertainty exposure, but may overweight short-lived spikes. The annual-average robustness checks reported in Appendix Table A8 preserve the signs of the main interaction effects, although two estimates become statistically weaker. The baseline results should therefore be interpreted primarily as responses to peak annual uncertainty exposure rather than as effects of the average level of uncertainty throughout the year.

Fourth, the exposure measures are informative but imperfect. PPTRD captures country-level exposure to intermediate-goods trade, not sector-specific GVC participation, while the Grubel-Lloyd index is used as a descriptive measure of two-way trade intensity rather than a direct GVC indicator. Future research could combine the EI-RCA framework with input-output data, TiVA indicators, firm-level sourcing data or product-level network measures to capture GVC embeddedness more directly.

Fifth, the sectoral and country scope is necessarily bounded. The sectoral classification is constrained by SITC Rev. 3 and by the eight technology-goods sectors analysed in the article. The findings should not be generalized mechanically to all technology-intensive domains, such as biotechnology, pharmaceuticals, medical technologies, aerospace or clean technologies, where uncertainty may operate through different regulatory, innovation and supply-chain channels. Future research should use more disaggregated product classifications, including finer semiconductor categories such as frontier chips, legacy chips, semiconductor equipment and downstream electronics, and should include a broader set of semiconductor-intensive economies, especially Taiwan and South Korea.

Sixth, the uncertainty indicators are proxies for broader and partly overlapping dimensions of uncertainty. GSCPI captures global supply-chain pressure, while TPU captures trade-policy uncertainty, but neither is technology-specific and both may overlap with geopolitical, regulatory and macroeconomic risks. Although the models include VIX as an auxiliary financial-stress control, consistently comparable country-level indicators covering other uncertainty dimensions are not available for all economies and years in the sample. Future research should therefore examine robustness to

alternative measures, including economic policy uncertainty, geopolitical risk and broader macro-financial uncertainty indicators.

Seventh, the annual panel specification cannot identify within-year differences between uncertainty occurring one, six, or twelve months before the annual trade outcome. A more granular distinction between short-term monthly uncertainty and medium-term annual adjustment would require a mixed-frequency framework, such as MIDAS-VAR, and is therefore left for future research.

Finally, EI and RCA are informative but imperfect measures of technology-trade resilience. EI may improve because exports expand, but also because imports contract or imported-input adoption is delayed. RCA captures revealed specialization rather than domestic value added, technological capability, welfare, productivity or innovation capacity. Future work could connect trade-based resilience margins to domestic capability indicators, value-added measures, productivity data and innovation outcomes.

Overall, the article shows that uncertainty does not affect technology trade through a single, uniform resilience channel. Its effects depend on the resilience margin observed, the exposure conditions of the sector and the strategic position of the product category. Technology-trade resilience should therefore be understood as a joint flow-and-specialization outcome, with direct relevance for debates on technological dependence, economic security and the societal governance of global technology interdependence.

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Appendix

Table A1. Global technology-economy coverage of the sample (%)

Technology dimension	Indicator	Year	China	United States	European economies	Combined sample
Technology goods trade	Share of world technology exports	2023	24.1	6.1	29.4	59.6
Digital services trade	Share of world ICT services exports	2024	5.1	7.2	53.3	65.6
R&D capacity	Share of global gross domestic expenditure on R&D	2022	27.0	30.0	≥18.0	≥75.0
Corporate technology investment	Share of global private R&D investment	2023	17.1	42.3	≥18.7	≥78.1
Semiconductor industry	Share of global semiconductor market by major producing economies/firms	2023	7.2	50.2	≥12.7	≥70.1
International patenting	Share of PCT international patent applications	2023	25.5	20.4	21.8*	67.7*
Patent-system scale	Share of patent applications received by major patent offices	2023	47.2 CNIPA	16.8 USPTO	5.6 EPO	69.6
ICT-goods intensity	ICT goods exports as % of total goods exports	2022	22.6	7.8	4.9*	35.3*
Technology orientation of research output	Engineering + computer/information sciences as % of S&E publications	2022	36.8	18.1	22.5*	77.4*

* For PCT applications, the European figure is the EU, without the UK.

Source: World Bank (2026); NCSES (2026); SIA (2024); WIPO (2026).

Source: own elaboration based on Eurostat (2026) and UNCTAD (2025).

Table A2. Sector-level support for identifying the core GVC-intensive component segment, 1998-2024

SITC	Sector	UNCTAD product-position group	Share in analysed technology trade (%)	Mean Grubel-Lloyd index	Indicative GVC-intensity profile
751	Office machines	Non-parts electronics	1.8	0.511	Intermediate
752	Computers	Non-parts electronics	22.7	0.573	Intermediate
759	Parts and accessories	Parts-and-components	12.0	0.792	Higher
761	Television receivers	Non-parts electronics	4.9	0.412	Intermediate

762	Radio receivers	Non-parts electronics	1.0	0.446	Intermediate
763	Sound recorders	Non-parts electronics	3.0	0.479	Intermediate
764	Telecommunications	Parts-and-components	26.9	0.650	Higher
776	Semiconductors and related electronic components	Parts-and-components	27.9	0.749	Higher

The Grubel-Lloyd index is used as a measure of two-way trade intensity, not as a direct measure of GVC participation. A sector is interpreted as part of the core GVC-intensive component segment only when it belongs to UNCTAD's electronics parts-and-components group and displays high two-way trade intensity in the sample.

Source: own elaboration based on Eurostat (2026) and UNCTAD (2025).

Table A3a. Variable definitions, transformations and empirical role

Variable / construct	Role in analysis	Definition / construction	Transformation / timing	Source / remarks
EI (export-to-import ratio)	Dependent variable; trade-flow or export-coverage margin	Sector-level exports divided by sector-level imports for country i, sector s and year t: $EI_{i,s,t} = X_{i,s,t} / M_{i,s,t}$.	Used in logarithmic form in regressions: lnEI. Values above one indicate exports exceed imports; values below one indicate imports exceed exports.	Constructed from sector-level goods trade data used in the article.
lnEI	Dependent variable in EI models	Natural logarithm of EI.	Used to reduce skewness and limit the influence of extreme EI values; coefficients are interpreted in relative terms.	Descriptive motivation reported in Appendix Table A4.
RCA (revealed comparative advantage)	Dependent variable; revealed-specialization margin	Balassa index: $RCA_{i,s,t} = (X_{i,s,t} / X_{i,total,t}) / (X_{world,s,t} / X_{world,total,t})$.	Used in levels. Values above one indicate revealed comparative advantage; values below one indicate absence of revealed comparative advantage.	Constructed from export data; sectoral means reported in Appendix Table A4.
GSCPI	Core uncertainty indicator; operational supply-chain pressure	Global Supply Chain Pressure Index capturing global logistics, delivery-time, backlog and production-bottleneck pressures.	Monthly series aggregated to annual maxima. Used as common annual uncertainty shock and interacted with lagged PPTRD.	Federal Reserve Bank of New York; see Benigno et al. (2022).
TPU	Core uncertainty indicator; trade-policy / market-access uncertainty	Trade Policy Uncertainty index capturing uncertainty related to trade-policy regimes, tariffs, trade restrictions and policy commitments.	Standardized using z-score transformation over the stated baseline period; monthly series aggregated to annual maxima. Used as common annual shock and interacted with lagged PPTRD.	Caldara et al. (2020).
maxVIX	Auxiliary financial-stress control	Annual maximum of the VIX financial-market uncertainty / risk-aversion indicator.	Included only through interaction with lagged financial openness because direct annual level effects are absorbed by year effects.	Used as auxiliary control, not as a third core uncertainty dimension.

PPTRD	Main country-level exposure variable	Share of intermediate goods in total trade, expressed as a percentage.	Enters with a one-year lag, PPTRD(t-1), so exposure is measured before contemporaneous uncertainty shocks and outcomes.	WITS country-profile data. Descriptive statistics reported in Appendix Table A4.
GSCPI x PPTRD(t-1)	Main uncertainty-exposure interaction	Interaction between annual GSCPI and lagged PPTRD.	Estimates whether the association between operational supply-chain pressure and technology-trade outcomes differs with pre-existing intermediate-goods trade exposure.	Main interaction in GSCPI models.
TPU x PPTRD(t-1)	Main uncertainty-exposure interaction	Interaction between annual standardized TPU and lagged PPTRD.	Estimates whether the association between trade-policy uncertainty and technology-trade outcomes differs with pre-existing intermediate-goods trade exposure.	Main interaction in TPU models.
openfin	Country-level financial openness variable	Financial-openness measure used to condition exposure to global financial stress.	Enters with one-year lag in the control set and through the maxVIX x openfin interaction.	Included to control for heterogeneous exposure to global risk aversion and trade-finance conditions.
maxVIX x openfin(t-1)	Auxiliary financial-stress interaction	Interaction between annual maxVIX and lagged financial openness.	Controls for heterogeneous exposure to global financial-market stress.	Auxiliary control in all model families.
REER / lnREER	Control variable	Real effective exchange-rate measure.	Included as a control; lnEI fixed-effects specifications use lnREER where reported in the estimation log, while Mundlak specifications report REER.	See notes to Appendix Tables A5c-A5d.
TOT	Control variable in lnEI models	Terms-of-trade index.	Included in lnEI models to control for trade-price conditions affecting export-import ratios.	Descriptive statistics reported in Appendix Table A4.
GDP growth	Control variable in lnEI models	Annual GDP growth.	Included in lnEI models to control for macroeconomic performance and demand conditions.	Descriptive statistics reported in Appendix Table A4.
GDP per worker	Control variable in RCA models	Labour productivity proxy.	Included in RCA models to control for productivity differences that may shape revealed specialization.	Reported as ln GDP per worker in the model tables.
R&D/GDP	Control variable in RCA models	Research and development expenditure as a share of GDP.	Included in RCA models to control for innovation effort and technology-capability conditions.	Descriptive statistics reported in Appendix Table A4.
SITC sector indicators	Sectoral unit of analysis	Eight SITC Rev. 3 technology-goods sectors analysed separately.	Sector-specific estimation preserves heterogeneity rather than pooling all sectors into one coefficient.	Sectors listed in Section 2.5 and Appendix Table A2.
Electronics parts-and-components vs non-parts electronics	Sectoral exposure classification	UNCTAD/UNCTADStat product-position grouping used to distinguish electronics parts-and-components from non-parts electronics.	Used as a sectoral exposure layer and interpretive grouping, not as a replacement for sector-specific estimation.	External product classification; sector support shown in Appendix Table A2.
Grubel-Lloyd index	Descriptive sector-level diagnostic	Measure of two-way trade intensity.	Used descriptively to support identification of core GVC-intensive component sectors; not treated as a direct GVC participation measure.	Reported in Appendix Table A2.
Country fixed effects	Model component	Country-specific intercepts controlling for time-invariant unobserved country heterogeneity.	Included in fixed-effects specifications.	Used with year effects in the baseline panel design.

Year fixed effects	Model component	Year-specific intercepts absorbing common annual shocks.	Included in all fixed-effects specifications; common annual levels of GSCPI, TPU and maxVIX are absorbed by year effects.	Year-effect diagnostics summarized in Figure A1.
Mundlak correlated random effects	Robustness-oriented specification	Random-effects model augmented with country-specific means of time-varying regressors.	Used as a counterpart to fixed effects to assess sensitivity to the treatment of unobserved country heterogeneity.	Model estimates reported alongside fixed effects in Appendix Tables A5a-A5d.

Table A3b. Summary statistics and panel unit root test for annual uncertainty indices (1998-2024)

Index	Mean	SD	Skewness	Min	Max	ADF_c	p-value	ADF_{ct}	p-value
GSCPI	0.70	1.24	2.01	-0.55	4.45	-2.87	0.049	-4.03	0.008
TPU	0.88	2.07	2.23	-0.40	7.80	2.93	1.000	0.38	0.999
VIX	14.00	7.79	0.00	1.00	27.00	-3.41	0.037	-3.04	0.032

SD - standard deviation, ADF_c - ADF unit root test's statistics only constant version, ADF_{ct} - ADF unit root test's statistics constant and trend version.

source: own calculation

Table A4. Summary statistics and panel unit root test for EI and RCA

Statistics	Sector							
	1	2	3	4	5	6	7	8
Export/Import ratio								
Mean	1.16	0.85	0.61	3.34	17.73	2.32	0.83	0.83
SD	6.24	2.76	0.72	14.13	305.04	18.47	1.63	1.33
Skewness	19.50	18.82	13.15	7.76	25.06	14.37	10.56	8.75
Minimum	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Maximum	151.66	68.35	16.36	187.24	8177.27	301.84	30.40	21.77
Test unit root Im-Pesaran-Shin								
Levels (with trend, panel means and 1 lags in ADF regressions)								
IPS test	-2.88	-5.60	-2.81	-8.73	-4.03	-4.53	-2.26	-3.96
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
First differences (with panel means and 1 lags in ADF regressions)								
IPS test	-17.22	-15.07	-13.75	-20.23	-21.63	-16.51	-16.62	-16.48

p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCA ratio								
Mean	0.75	0.75	0.55	1.35	1.12	0.70	0.96	0.64
SD	1.03	0.92	0.58	2.47	2.89	0.87	1.06	1.57
Skewness	4.47	2.28	3.06	4.45	5.13	3.88	2.60	6.16
Minimum	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Maximum	10.00	4.60	4.70	20.80	23.90	8.70	7.10	13.80
Test unit root Im-Pesaran-Shin								
Levels (with trend, panel means and 1 lags in ADF regressions)								
IPS test	-1.91	-2.35	-1.65	-8.98	-1.72	-2.59	-1.75	-3.71
p-value	0.03	0.01	0.05	0.00	0.04	0.01	0.04	0.00
First differences (with panel means and 1 lags in ADF regressions)								
IPS test	-14.85	-16.36	-17.13	-17.54	-18.69	-14.78	-16.98	-15.51
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exogenous variables								
	pptrd	**openfin**	**REER**	**gdp_grow**	**lp_gdp_worker**	**tot**	**RD/gdp**	
Mean	21.92	15.04	98.51	2.70	99689	99.62	.0019	
SD	5.47	48.34	11.52	3.84	46745	6.96	.003	
Minimum	8.04	0.57	52.28	-16.04	6535	67.5	0.00	
Maximum	43.16	405.66	156.98	24.62	320323	134.17	0.03	
Test unit root Im-Pesaran-Shin								
Levels (with trend, panel means and 1 lags in ADF regressions)								
IPS test	-6.22	-3.41	-1.73	-8.07	-9.84	-4.41	-1.85	
p-value	0.00	0.00	0.04	0.00	0.04	0.00	0.03	
First differences (with panel means and 1 lags in ADF regressions)								
IPS test	-5.36	-2.32	-3.56	-9.76	-12.84	-0.32	-2.29	
p-value	0.00	0.01	0.00	0.00	0.00	0.38	0.00	

SD - standard deviation, IPS - Im, Pesharan, Shin panel unit root test's statistics.

PPTRD denotes the share of intermediate goods in total trade, expressed as a percentage.

source: own calculation

Table A5a. Fixed-effects and Mundlak estimates for RCA models with GSCPI

Variable	Sector							
	1	2	3	4	5	6	7	8
Fixed-effects estimator								
ln GDP per worker	7.20e-8 [0.892]	-2.53e-7 [0.446]	-1.64e-7 [0.436]	-1.95e-6 [0.038]	1.08e-7 [0.894]	-4.25e-7 [0.278]	2.25e-7 [0.671]	4.07e-7 [0.390]
RD/GDP	383.73 [0.826]	-753.26 [0.491]	-2288.73 [0.001]	-4280.57 [0.168]	3219.00 [0.229]	324.08 [0.802]	968.07 [0.579]	3546.15 [0.023]
REER	-3.56e-4 [0.916]	-2.48e-3 [0.243]	-6.03e-3 [<0.001]	0.03 [<0.001]	-4.16e-3 [0.423]	-3.42e-3 [0.172]	0.02 [<0.001]	5.47e-3 [0.071]
PPTRD(t-1)	5.21e-3 [0.672]	-0.07 [<0.001]	-0.07 [<0.001]	-0.07 [0.002]	4.28e-3 [0.820]	-0.01 [0.175]	-0.02 [0.195]	-0.02 [0.119]
ln open finance(t-1)	-0.03 [0.759]	-0.17 [0.004]	-0.10 [0.005]	-0.18 [0.252]	-0.36 [0.011]	-0.07 [0.287]	-0.02 [0.806]	-0.81 [<0.001]
GSCPI x PPTRD(t-1)	-1.02e-3 [0.775]	-2.51e-3 [0.261]	-2.58e-3 [0.069]	9.18e-3 [0.146]	-7.60e-3 [0.164]	2.29e-3 [0.385]	-1.51e-3 [0.672]	9.10e-3 [0.004]
VIX x open finance	-7.86e-4 [0.767]	-2.33e-4 [0.889]	-1.61e-5 [0.988]	-1.81e-3 [0.701]	3.83e-4 [0.925]	-2.55e-3 [0.196]	-3.07e-4 [0.908]	3.17e-3 [0.182]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.040	0.174	0.290	0.153	0.049	0.040	0.115	0.237
Overall R-squared	0.010	0.019	0.026	0.053	0.005	0.061	0.049	0.019
Model p-value	0.516	<0.001	<0.001	<0.001	0.225	0.529	<0.001	<0.001
Time effects p-value	0.572	0.178	0.001	0.143	0.262	0.458	0.305	0.006
Modified Wald p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Correlated random-effects estimator (Mundlak)								
ln GDP per worker	6.52e-8 [0.902]	-2.56e-7 [0.442]	-1.66e-7 [0.432]	-1.95e-6 [0.038]	1.05e-7 [0.897]	-4.32e-7 [0.273]	2.21e-7 [0.677]	4.06e-7 [0.389]
RD/GDP	379.90 [0.828]	-754.10 [0.493]	-2288.49 [0.001]	-4286.97 [0.168]	3221.52 [0.228]	321.79 [0.805]	966.08 [0.580]	3548.82 [0.023]
REER	-3.22e-4 [0.924]	-2.45e-3 [0.250]	-6.01e-3 [<0.001]	0.03 [<0.001]	-4.14e-3 [0.424]	-3.38e-3 [0.180]	0.02 [<0.001]	5.47e-3 [0.070]
PPTRD(t-1)	5.26e-3 [0.669]	-0.07 [<0.001]	-0.07 [<0.001]	-0.07 [0.002]	4.29e-3 [0.820]	-0.01 [0.179]	-0.02 [0.193]	-0.02 [0.118]
ln open finance(t-1)	-0.03 [0.759]	-0.17 [0.004]	-0.10 [0.005]	-0.18 [0.253]	-0.36 [0.010]	-0.07 [0.290]	-0.02 [0.806]	-0.81 [<0.001]
GSCPI x PPTRD(t-1)	-1.02e-3 [0.776]	-2.51e-3 [0.263]	-2.58e-3 [0.070]	9.18e-3 [0.147]	-7.60e-3 [0.164]	2.29e-3 [0.387]	-1.51e-3 [0.673]	9.10e-3 [0.004]
VIX x open finance	-7.86e-4 [0.768]	-2.32e-4 [0.889]	-1.56e-5 [0.988]	-1.80e-3 [0.703]	3.83e-4 [0.925]	-2.55e-3 [0.198]	-3.09e-4 [0.908]	3.17e-3 [0.182]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.040	0.174	0.290	0.153	0.049	0.040	0.115	0.237
Overall R-squared	0.136	0.139	0.283	0.299	0.034	0.136	0.098	0.424
Mundlak test p-value	0.787	0.419	0.042	0.044	0.991	0.919	0.940	<0.001
Time effects p-value	0.580	0.182	<0.001	0.142	0.259	0.475	0.305	0.004
Pesaran CD p-value	<0.001	<0.001	0.751	<0.001	<0.001	0.085	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Notes: Coefficients are reported with p-values in square brackets. Coefficients below 0.01 in absolute value are shown in scientific notation with a two-decimal mantissa. Year effects are included but not reported. Mundlak mean terms are included in the correlated random-effects specifications but not reported; the Mundlak test is the joint test of the mean terms as reported in the Stata log. The base year for time effects is 1999.

source: own calculation

Table A5b. Fixed-effects and Mundlak estimates for RCA models with TPU

Variable	Sector							
	1	2	3	4	5	6	7	8
Fixed-effects estimator								
ln GDP per worker	6.46e-8 [0.903]	-2.72e-7 [0.409]	-1.84e-7 [0.379]	-1.87e-6 [0.046]	4.69e-8 [0.954]	-4.07e-7 [0.298]	2.13e-7 [0.687]	4.79e-7 [0.307]
RD/GDP	260.56 [0.882]	-958.59 [0.381]	-2447.16 [<0.001]	-4139.95 [0.183]	2989.06 [0.265]	352.97 [0.785]	899.84 [0.607]	3933.07 [0.011]
REER	-2.63e-4 [0.938]	-2.31e-3 [0.275]	-5.89e-3 [<0.001]	0.03 [<0.001]	-3.89e-3 [0.453]	-3.47e-3 [0.166]	0.02 [<0.001]	5.08e-3 [0.091]
PPTRD(t-1)	6.74e-3 [0.574]	-0.07 [<0.001]	-0.07 [<0.001]	-0.06 [0.002]	4.24e-3 [0.817]	-0.01 [0.189]	-0.02 [0.194]	-0.02 [0.075]
ln open finance(t-1)	-0.04 [0.634]	-0.19 [0.001]	-0.12 [0.001]	-0.17 [0.284]	-0.38 [0.007]	-0.07 [0.304]	-0.03 [0.742]	-0.77 [<0.001]
TPU x PPTRD(t-1)	-1.91e-3 [0.385]	-3.56e-3 [0.010]	-3.05e-3 [<0.001]	5.90e-3 [0.131]	-6.21e-3 [0.065]	1.40e-3 [0.390]	-1.50e-3 [0.496]	8.74e-3 [<0.001]
VIX x open finance	-7.97e-4 [0.764]	-2.60e-4 [0.875]	-4.45e-5 [0.966]	-1.71e-3 [0.717]	2.98e-4 [0.941]	-2.52e-3 [0.200]	-3.23e-4 [0.903]	3.27e-3 [0.166]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.041	0.180	0.298	0.154	0.050	0.040	0.115	0.249
Overall R-squared	0.011	0.018	0.025	0.052	0.006	0.061	0.051	0.015
Model p-value	0.481	<0.001	<0.001	<0.001	0.178	0.530	<0.001	<0.001
Time effects p-value	0.917	0.195	0.074	0.248	0.120	0.534	0.465	<0.001
Modified Wald p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Correlated random-effects estimator (Mundlak)								
ln GDP per worker	5.71e-8 [0.914]	-2.75e-7 [0.406]	-1.86e-7 [0.375]	-1.87e-6 [0.046]	4.41e-8 [0.957]	-4.14e-7 [0.293]	2.09e-7 [0.693]	4.78e-7 [0.306]
RD/GDP	254.80 [0.885]	-960.08 [0.382]	-2447.32 [<0.001]	-4147.21 [0.183]	2991.21 [0.264]	349.48 [0.789]	898.16 [0.608]	3935.51 [0.011]
REER	-2.23e-4 [0.948]	-2.28e-3 [0.284]	-5.87e-3 [<0.001]	0.03 [<0.001]	-3.88e-3 [0.454]	-3.43e-3 [0.174]	0.02 [<0.001]	5.08e-3 [0.090]
PPTRD(t-1)	6.80e-3 [0.572]	-0.07 [<0.001]	-0.07 [<0.001]	-0.06 [0.003]	4.26e-3 [0.816]	-0.01 [0.194]	-0.02 [0.192]	-0.02 [0.074]
ln open finance(t-1)	-0.04 [0.635]	-0.19 [0.001]	-0.12 [0.001]	-0.17 [0.286]	-0.38 [0.007]	-0.07 [0.307]	-0.03 [0.742]	-0.77 [<0.001]
TPU x PPTRD(t-1)	-1.91e-3 [0.385]	-3.56e-3 [0.010]	-3.05e-3 [<0.001]	5.90e-3 [0.132]	-6.21e-3 [0.065]	1.40e-3 [0.393]	-1.50e-3 [0.497]	8.74e-3 [<0.001]
VIX x open finance	-7.97e-4 [0.765]	-2.60e-4 [0.876]	-4.40e-5 [0.967]	-1.70e-3 [0.719]	2.98e-4 [0.941]	-2.52e-3 [0.203]	-3.25e-4 [0.903]	3.27e-3 [0.165]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.041	0.180	0.298	0.154	0.050	0.040	0.115	0.249
Overall R-squared	0.146	0.161	0.328	0.281	0.041	0.128	0.100	0.428
Mundlak test p-value	0.748	0.310	0.082	0.119	0.982	0.917	0.930	<0.001
Time effects p-value	0.922	0.202	0.075	0.250	0.116	0.555	0.467	<0.001
Pesaran CD p-value	<0.001	<0.001	0.931	<0.001	<0.001	0.089	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Notes: Coefficients are reported with p-values in square brackets. Coefficients below 0.01 in absolute value are shown in scientific notation with a two-decimal mantissa. Year effects are included but not reported. Mundlak mean terms are included in the correlated random-effects specifications but not reported; the Mundlak test is the joint test of the mean terms as reported in the Stata log. The base year for time effects is 1999.

source: own calculation

Table A5c. Fixed-effects and Mundlak estimates for lnEI models with GSCPI

Variable	Sector							
	1	2	3	4	5	6	7	8
Fixed-effects estimator								
TOT	-2.69e-3 [0.637]	0.01 [0.010]	0.02 [<0.001]	0.04 [<0.001]	0.03 [<0.001]	3.29e-3 [0.562]	-3.31e-3 [0.396]	-1.77e-4 [0.967]
GDP growth	1.16e-13 [0.689]	4.12e-13 [0.065]	1.69e-15 [0.992]	2.54e-13 [0.421]	5.87e-14 [0.865]	1.24e-13 [0.667]	6.72e-14 [0.734]	-4.55e-13 [0.034]
lnREER	0.62 [0.117]	0.60 [0.052]	-0.04 [0.869]	0.56 [0.200]	1.78 [<0.001]	0.18 [0.652]	1.77 [<0.001]	-0.06 [0.846]
PPTRD(t-1)	-0.04 [0.009]	-0.07 [<0.001]	-0.02 [0.005]	-0.05 [0.002]	2.07e-3 [0.908]	6.06e-3 [0.687]	-0.04 [<0.001]	0.02 [0.098]
ln open finance(t-1)	-0.54 [<0.001]	-0.16 [0.063]	0.13 [0.040]	-0.09 [0.471]	-0.03 [0.842]	0.21 [0.058]	0.27 [<0.001]	-0.03 [0.687]
GSCPI x PPTRD(t-1)	0.01 [0.002]	8.43e-3 [0.013]	8.38e-3 [0.001]	0.02 [<0.001]	-4.76e-3 [0.364]	4.81e-3 [0.274]	4.59e-3 [0.129]	6.48e-3 [0.048]
VIX x open finance	-1.03e-3 [0.754]	-1.99e-3 [0.432]	-2.54e-3 [0.165]	1.40e-3 [0.696]	5.62e-3 [0.151]	-6.48e-3 [0.048]	3.28e-4 [0.884]	2.17e-3 [0.375]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.169	0.135	0.099	0.098	0.187	0.101	0.153	0.074
Overall R-squared	0.034	0.031	0.011	0.024	0.016	0.017	0.017	0.003
Model p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Time effects p-value	<0.001	0.181	0.140	0.581	0.001	0.099	0.083	0.004
Modified Wald p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001
Correlated random-effects estimator (Mundlak)								
TOT	-2.21e-3 [0.698]	0.01 [0.008]	0.02 [<0.001]	0.04 [<0.001]	0.04 [<0.001]	3.75e-3 [0.508]	-3.31e-3 [0.397]	-2.25e-4 [0.958]
GDP growth	1.16e-13 [0.690]	4.12e-13 [0.066]	1.83e-15 [0.991]	2.53e-13 [0.423]	5.78e-14 [0.867]	1.24e-13 [0.667]	6.57e-14 [0.740]	-4.55e-13 [0.034]
REER	3.89e-3 [0.357]	4.23e-3 [0.193]	-1.45e-3 [0.534]	4.66e-3 [0.310]	0.01 [0.011]	-8.81e-4 [0.833]	0.02 [<0.001]	-2.88e-4 [0.926]
PPTRD(t-1)	-0.04 [0.004]	-0.07 [<0.001]	-0.03 [0.003]	-0.05 [0.001]	-6.82e-3 [0.707]	1.81e-3 [0.904]	-0.04 [<0.001]	0.02 [0.090]
ln open finance(t-1)	-0.55 [<0.001]	-0.16 [0.060]	0.13 [0.042]	-0.09 [0.466]	-0.03 [0.802]	0.21 [0.064]	0.28 [<0.001]	-0.03 [0.691]
GSCPI x PPTRD(t-1)	0.01 [0.002]	8.55e-3 [0.012]	8.42e-3 [0.001]	0.02 [<0.001]	-4.43e-3 [0.402]	4.92e-3 [0.263]	4.70e-3 [0.120]	6.47e-3 [0.048]
VIX x open finance	-1.17e-3 [0.722]	-2.10e-3 [0.409]	-2.59e-3 [0.157]	1.33e-3 [0.710]	5.30e-3 [0.178]	-6.61e-3 [0.044]	2.68e-4 [0.905]	2.18e-3 [0.371]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.167	0.132	0.099	0.097	0.178	0.101	0.152	0.074
Overall R-squared	0.185	0.198	0.353	0.330	0.216	0.264	0.301	0.306
Mundlak test p-value	0.225	0.218	0.016	0.013	0.302	0.122	0.005	0.043
Time effects p-value	<0.001	0.145	0.110	0.560	<0.001	0.080	0.103	0.003
Pesaran CD p-value	0.026	0.002	0.002	0.132	0.011	0.012	0.006	0.080
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001

Notes: Coefficients are reported with p-values in square brackets. Coefficients below 0.01 in absolute value are shown in scientific notation with a two-decimal mantissa. Year effects are included but not reported. Mundlak mean terms are included in the correlated random-effects specifications but not reported; the Mundlak test is the joint test of the mean terms as reported in the Stata log. The base year for time effects is 1999.

For lnEI models, the FE specifications in the log use lnREER, while the Mundlak specifications use REER; the table follows the variable names in the log.

Source: own calculation,

Table A5d. Fixed-effects and Mundlak estimates for lnEI models with TPU

Variable	Sector							
	1	2	3	4	5	6	7	8
Fixed-effects estimator								
TOT	-8.52e-3 [0.140]	9.67e-3 [0.030]	0.02 [<0.001]	0.04 [<0.001]	0.03 [<0.001]	4.60e-3 [0.421]	-3.66e-3 [0.353]	1.68e-3 [0.693]
GDP growth	1.19e-13 [0.682]	4.09e-13 [0.068]	-3.78e-15 [0.981]	2.31e-13 [0.463]	7.15e-14 [0.835]	1.15e-13 [0.688]	6.36e-14 [0.748]	-4.67e-13 [0.029]
lnREER	0.75 [0.061]	0.63 [0.041]	-0.02 [0.937]	0.50 [0.245]	1.84 [<0.001]	0.15 [0.710]	1.78 [<0.001]	-0.10 [0.731]
PPTRD(t-1)	-0.01 [0.335]	-0.06 [<0.001]	-0.02 [0.056]	-0.05 [0.002]	8.03e-3 [0.645]	4.65e-3 [0.750]	-0.04 [<0.001]	0.02 [0.131]
ln open finance(t-1)	-0.71 [<0.001]	-0.22 [0.014]	0.09 [0.146]	-0.05 [0.666]	-0.09 [0.479]	0.24 [0.032]	0.26 [0.001]	8.50e-3 [0.919]
TPU x PPTRD(t-1)	-7.40e-3 [0.008]	-2.46e-4 [0.908]	1.37e-3 [0.374]	0.01 [<0.001]	-8.55e-3 [0.009]	5.17e-3 [0.059]	1.22e-3 [0.519]	7.17e-3 [<0.001]
VIX x open finance	-6.87e-4 [0.835]	-1.85e-3 [0.468]	-2.43e-3 [0.188]	1.48e-3 [0.678]	5.68e-3 [0.145]	-6.48e-3 [0.047]	3.84e-4 [0.865]	2.16e-3 [0.374]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.166	0.128	0.085	0.103	0.193	0.104	0.151	0.085
Overall R-squared	0.024	0.025	0.011	0.018	0.017	0.018	0.017	0.024
Model p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Time effects p-value	<0.001	0.263	0.264	0.231	<0.001	0.159	0.172	0.001
Modified Wald p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Correlated random-effects estimator (Mundlak)								
TOT	-8.04e-3 [0.165]	0.01 [0.025]	0.02 [<0.001]	0.04 [<0.001]	0.03 [<0.001]	5.11e-3 [0.372]	-3.70e-3 [0.349]	1.66e-3 [0.696]
GDP growth	1.18e-13 [0.684]	4.08e-13 [0.069]	-3.74e-15 [0.982]	2.30e-13 [0.465]	7.02e-14 [0.839]	1.15e-13 [0.689]	6.22e-14 [0.754]	-4.67e-13 [0.029]
REER	5.18e-3 [0.221]	4.55e-3 [0.164]	-1.31e-3 [0.577]	3.91e-3 [0.394]	0.01 [0.007]	-1.28e-3 [0.759]	0.02 [<0.001]	-8.44e-4 [0.786]
PPTRD(t-1)	-0.02 [0.219]	-0.06 [<0.001]	-0.02 [0.034]	-0.05 [0.001]	-5.86e-4 [0.973]	2.65e-4 [0.986]	-0.04 [<0.001]	0.02 [0.125]
ln open finance(t-1)	-0.72 [<0.001]	-0.22 [0.013]	0.09 [0.152]	-0.05 [0.658]	-0.10 [0.452]	0.24 [0.035]	0.26 [0.001]	8.74e-3 [0.916]
TPU x PPTRD(t-1)	-7.31e-3 [0.008]	-1.74e-4 [0.935]	1.43e-3 [0.355]	0.01 [<0.001]	-8.35e-3 [0.011]	5.30e-3 [0.053]	1.16e-3 [0.539]	7.17e-3 [<0.001]
VIX x open finance	-8.29e-4 [0.802]	-1.96e-3 [0.443]	-2.48e-3 [0.178]	1.41e-3 [0.694]	5.37e-3 [0.171]	-6.61e-3 [0.043]	3.24e-4 [0.886]	2.17e-3 [0.371]
Observations	806	806	806	806	806	806	806	806
Countries	31	31	31	31	31	31	31	31
Within R-squared	0.163	0.125	0.086	0.102	0.185	0.104	0.149	0.085
Overall R-squared	0.201	0.215	0.355	0.323	0.236	0.265	0.300	0.334
Mundlak test p-value	0.049	0.125	0.017	0.014	0.225	0.126	0.005	0.032
Time effects p-value	<0.001	0.205	0.210	0.210	<0.001	0.128	0.212	0.001
Pesaran CD p-value	0.056	0.003	0.003	0.172	0.010	0.013	0.007	0.090
Wooldridge AR(1) p-value	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001

Notes: Coefficients are reported with p-values in square brackets. Coefficients below 0.01 in absolute value are shown in scientific notation with a two-decimal mantissa. Year effects are included but not reported. Mundlak mean terms are included in the correlated random-effects specifications but not reported; the Mundlak test is the joint test of the mean terms as reported in the Stata log. The base year for time effects is 1999.

For lnEI models, the FE specifications in the log use lnREER, while the Mundlak specifications use REER; the table follows the variable names in the log.

source: own calculation.

Table A6. Illustrative economic magnitudes of selected statistically detectable interaction effects

Outcome	Uncertainty-exposure channel	Sector	Baseline FE interaction coefficient	Implied magnitude for one SD PPTRD difference
lnEI	GSCPI × PPTRD(t-1)	Office machines	0.01 [0.002]	+8.0% in EI
lnEI	GSCPI × PPTRD(t-1)	Computers	8.43e-3 [0.013]	+4.5% in EI
lnEI	GSCPI × PPTRD(t-1)	Parts and accessories	8.38e-3 [0.001]	+4.5% in EI
lnEI	GSCPI × PPTRD(t-1)	TV receivers	0.02 [<0.001]	+9.7% in EI
lnEI	GSCPI × PPTRD(t-1)	Semiconductors and related electronic components	6.48e-3 [0.048]	+3.3% in EI
lnEI	TPU × PPTRD(t-1)	Office machines	-7.40e-3 [0.008]	-3.8% in EI
lnEI	TPU × PPTRD(t-1)	TV receivers	0.01 [<0.001]	+6.8% in EI
lnEI	TPU × PPTRD(t-1)	Radio receivers	-8.55e-3 [0.009]	-4.8% in EI
lnEI	TPU × PPTRD(t-1)	Sound recorders	5.17e-3 [0.059]	+2.8% in EI
lnEI	TPU × PPTRD(t-1)	Semiconductors and related electronic components	7.17e-3 [<0.001]	+3.9% in EI
RCA	GSCPI × PPTRD(t-1)	Parts and accessories	-2.58e-3 [0.069]	-0.016 RCA points; about -3.0% of sector mean RCA
RCA	GSCPI × PPTRD(t-1)	Semiconductors and related electronic components	9.10e-3 [0.004]	+0.049 RCA points; about +7.7% of sector mean RCA
RCA	TPU × PPTRD(t-1)	Computers	-3.56e-3 [0.010]	-0.022 RCA points; about -2.9% of sector mean RCA
RCA	TPU × PPTRD(t-1)	Parts and accessories	-3.05e-3 [<0.001]	-0.016 RCA points; about -3.0% of sector mean RCA
RCA	TPU × PPTRD(t-1)	Radio receivers	-6.21e-3 [0.065]	-0.033 RCA points; about -2.9% of sector mean RCA
RCA	TPU × PPTRD(t-1)	Semiconductors and related electronic components	8.74e-3 [<0.001]	+0.049 RCA points; about +7.7% of sector mean RCA

Notes: Coefficients are reported with exact p-values in square brackets and correspond to the fixed-effects interaction estimates in Tables A5a-A5d. Magnitudes are evaluated for a one-unit increase in the uncertainty indicator and a one-standard-deviation difference in lagged PPTRD exposure. The standard deviation of PPTRD is 5.47. For lnEI models, percentage magnitudes are calculated as $100 \times [\exp(\beta \times 5.47) - 1]$. For RCA models, magnitudes are calculated as $\beta \times 5.47$ and, where useful, compared with the sectoral mean RCA reported in Table A4. The table reports selected interaction effects with $p<0.10$ and is intended to illustrate economic magnitude rather than replace the full coefficient tables.

Source: own calculations based on Appendix Tables A4 and A5a-A5d.

Table A7. Dynamic panel GMM robustness checks for the uncertainty-exposure interactions

Outcome	Uncertainty-exposure channel	Sector	Baseline FE coefficient [p-value]	Dynamic GMM coefficient [p-value]	AR(2) p-value	Hansen p-value	Instruments	Observations	Diagnostic conclusion
lnEI	GSCPI x PPTRD(t-1)	Office machines	0.01 [0.002]	0.01 [0.004]	0.744	0.763	11	712	Acceptable
lnEI	GSCPI x PPTRD(t-1)	Computers	8.43e-3 [0.013]	6.20e-3 [0.065]	0.459	0.826	11	713	Acceptable
lnEI	GSCPI x PPTRD(t-1)	Parts and accessories	8.38e-3 [0.001]	2.80e-3 [0.179]	0.436	0.353	11	713	Acceptable
lnEI	GSCPI x PPTRD(t-1)	TV receivers	0.02 [<0.001]	-7.00e-4 [0.732]	0.413	0.079	11	713	Pass at 5%; borderline at 10%
lnEI	GSCPI x PPTRD(t-1)	Semiconductors and related electronic components	6.48e-3 [0.048]	5.30e-3 [0.055]	0.273	0.306	11	713	Acceptable
lnEI	TPU x PPTRD(t-1)	Office machines	-7.40e-3 [0.008]	-4.50e-3 [0.471]	0.229	0.067	11	712	Pass at 5%; borderline at 10%
lnEI	TPU x PPTRD(t-1)	TV receivers	0.01 [<0.001]	0.02 [<0.001]	0.494	0.172	11	713	Acceptable
lnEI	TPU x PPTRD(t-1)	Radio receivers	-8.55e-3 [0.009]	-8.00e-4 [0.869]	0.044	0.238	11	705	AR(2) rejects at 5%; interpret cautiously
lnEI	TPU x PPTRD(t-1)	Sound recorders	5.17e-3 [0.059]	1.20e-3 [0.680]	0.051	0.748	11	713	Pass at 5%; borderline at 10%
lnEI	TPU x PPTRD(t-1)	Semiconductors and related electronic components	7.17e-3 [<0.001]	1.70e-3 [0.573]	0.138	0.426	11	713	Acceptable
RCA	GSCPI x PPTRD(t-1)	Parts and accessories	-2.58e-3 [0.069]	-2.00e-4 [0.837]	0.465	0.349	11	713	Acceptable
RCA	GSCPI x PPTRD(t-1)	Semiconductors and related electronic components	9.10e-3 [0.004]	6.00e-4 [0.566]	0.257	0.047	11	713	Hansen rejects at 5%; interpret cautiously
RCA	TPU x PPTRD(t-1)	Computers	-3.56e-3 [0.010]	1.50e-3 [0.182]	0.198	0.431	11	713	Acceptable
RCA	TPU x PPTRD(t-1)	Parts and accessories	-3.05e-3 [<0.001]	-1.60e-3 [0.081]	0.595	0.666	11	713	Acceptable
RCA	TPU x PPTRD(t-1)	Radio receivers	-6.21e-3 [0.065]	3.30e-3 [0.573]	0.543	0.203	11	713	Acceptable

RCA	TPU x PPTRD(t-1)	Semiconductors and related electronic components	8.74e-3 [<0.001]	1.00e-4 [0.860]	0.237	0.549	11	713	Acceptable

Notes: The table reports dynamic-panel difference-GMM robustness checks for the main statistically detectable baseline uncertainty-exposure interactions. Baseline FE and dynamic-GMM coefficients are reported with p-values in square brackets. The dependent variable is either lnEI or RCA. The lagged dependent variable, lagged PPTRD, and the uncertainty-exposure interaction are treated as potentially endogenous or predetermined. Collapsed internal instruments dated t-2 and t-3 are used to limit instrument proliferation. AR(2) denotes the Arellano-Bond test for second-order serial correlation in the differenced residuals. Hansen denotes the test of overidentifying restrictions. Across all 32 GMM models estimated, the Hansen test does not reject the overidentifying restrictions in 31 cases at the 5% level, and the AR(2) test does not indicate second-order serial correlation in 27 cases. Among the 16 baseline effects summarized here, 14 pass both diagnostics at the 5% level.

Source: Own calculations based on dynamic-panel GMM estimates and Appendix Tables A5a-A5d and A6.

Table A8. Robustness to alternative annual aggregation of uncertainty indicators

Outcome	Uncertainty-exposure channel	Sector	Annual maximum coefficient [p-value]	Annual average coefficient [p-value]	Robustness reading
lnEI	GSCPI × PPTRD(t-1)	Office machines	0.01 [0.001]	0.01 [0.020]	Sign preserved; annual-average effect statistically detectable
lnEI	GSCPI × PPTRD(t-1)	Computers	9.00e-3 [0.011]	7.00e-3 [0.162]	Sign preserved; annual-average effect weaker / not statistically detectable
lnEI	GSCPI × PPTRD(t-1)	Parts and accessories	9.00e-3 [<0.001]	9.00e-3 [0.003]	Sign preserved; annual-average effect statistically detectable
lnEI	GSCPI × PPTRD(t-1)	TV receivers	0.02 [<0.001]	0.02 [0.003]	Sign preserved; annual-average effect statistically detectable
lnEI	GSCPI × PPTRD(t-1)	Semiconductors and related electronic components	7.00e-3 [0.024]	9.00e-3 [0.025]	Sign preserved; annual-average effect statistically detectable
lnEI	TPU × PPTRD(t-1)	Office machines	-0.01 [0.005]	-0.02 [0.006]	Sign preserved; annual-average effect statistically detectable
lnEI	TPU × PPTRD(t-1)	TV receivers	0.01 [<0.001]	0.03 [<0.001]	Sign preserved; annual-average effect statistically detectable
lnEI	TPU × PPTRD(t-1)	Radio receivers	-0.01 [0.018]	-0.02 [0.018]	Sign preserved; annual-average effect statistically detectable
lnEI	TPU × PPTRD(t-1)	Sound recorders	7.00e-3 [0.075]	0.01 [0.122]	Sign preserved; annual-average effect weaker / not statistically detectable

lnEI	TPU × PPTRD(t-1)	Semiconductors and related electronic components	0.01 [<0.001]	0.02 [<0.001]	Sign preserved; annual-average effect statistically detectable
RCA	GSCPI × PPTRD(t-1)	Parts and accessories	-2.00e-3 [0.154]	-3.00e-3 [0.077]	Sign preserved; annual-average effect statistically detectable
RCA	GSCPI × PPTRD(t-1)	Semiconductors and related electronic components	9.00e-3 [0.003]	0.01 [0.001]	Sign preserved; annual-average effect statistically detectable
RCA	TPU × PPTRD(t-1)	Computers	-3.00e-3 [0.077]	-6.00e-3 [0.067]	Sign preserved; annual-average effect statistically detectable
RCA	TPU × PPTRD(t-1)	Parts and accessories	-4.00e-3 [<0.001]	-6.00e-3 [0.002]	Sign preserved; annual-average effect statistically detectable
RCA	TPU × PPTRD(t-1)	Radio receivers	-0.01 [0.037]	-0.02 [0.025]	Sign preserved; annual-average effect statistically detectable
RCA	TPU × PPTRD(t-1)	Semiconductors and related electronic components	0.01 [<0.001]	0.02 [<0.001]	Sign preserved; annual-average effect statistically detectable

Notes: All specifications include country and year fixed effects and the same control-variable structure as the baseline models. Rows correspond to the main baseline interaction effects highlighted in Appendix Table A6. For comparability with the annual-average specification, the annual-maximum column is re-estimated on the same common sample. The annual-average specification uses annual means of monthly GSCPI and TPU instead of within-year maxima; TPU averages are reported on the same normalized scale as the annual maximum TPU variable. Because the supplied monthly uncertainty sheet contains complete monthly observations for 1998-2023 and only two observations for 2024, this robustness check is estimated for 1999-2023 after applying one-year lags. Across all 32 estimated interaction models, the sign is preserved in 31 cases; among the 16 main baseline effects summarized here, all signs are preserved and 14 remain statistically detectable at $p<0.10$ under annual averages.

Source: own calculations.

Table A9. Formal within-component tests of semiconductors and related electronic components coefficient differentials

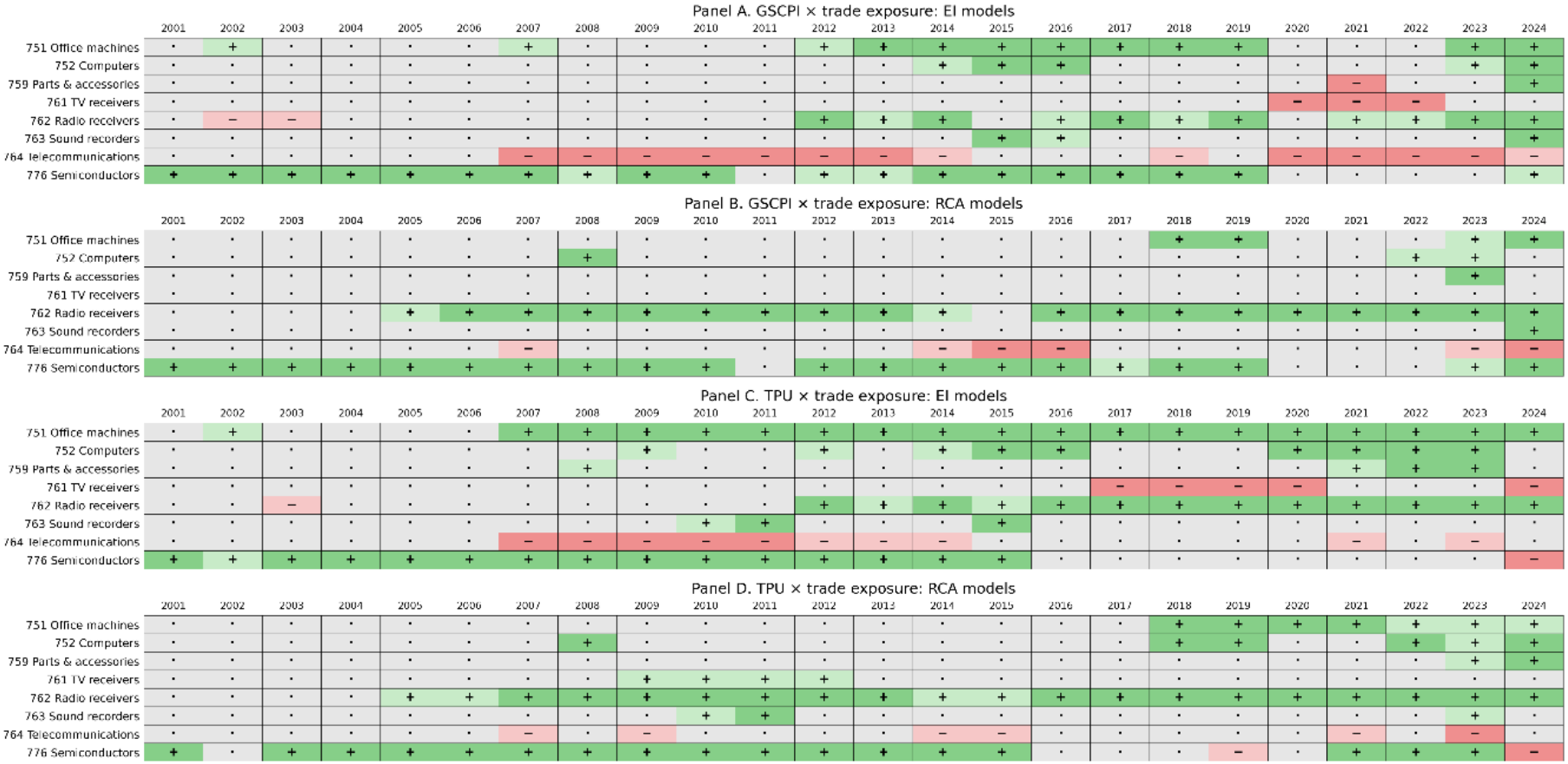
Outcome	Uncertainty	β759	β764	β776	β776 - mean(β759, β764)	Clustered SE	p-value	p: β776=β759	p: β776=β764
lnEI	GSCPI	0.0083	0.0046	0.0065	0.0001	0.0049	0.9861	0.6034	0.7872
lnEI	TPU	0.0012	0.0011	0.0070	0.0058	0.0020	0.0079	0.0029	0.0737
RCA	GSCPI	-0.0020	-0.0009	0.0086	0.0100	0.0050	0.0563	0.0311	0.1595
RCA	TPU	-0.0024	-0.0005	0.0084	0.0098	0.0057	0.0963	0.0441	0.2071

Joint Wald test across all four outcomes semiconductor-versus-mean contrasts: $F(4,30) = 4.728$; $p = 0.00445$

Notes: The comparison benchmark is the mean response of the two remaining component sectors (SITC 759 and SITC 764). Each equation uses the same country and year fixed-effects structure and control set as the corresponding baseline model. Standard errors and p-values are clustered by country (31 clusters); N = 806 country-year observations per equation. The results support a systematic joint difference, but not a uniformly stronger semiconductor response in every margin.

Source: own calculations.

Figure A1. Traffic-light matrix of year fixed effects by sector



Notes: Only years with the densest concentration of significant year effects are shown (at least 25 significant sector-model coefficients at $p < 0.10$ across the four panels). Dark green/red cells denote $p < 0.05$; light green/red cells denote $0.05 \leq p < 0.10$; gray cells denote non-significant effects. "+" indicates a positive year effect relative to the omitted base year; "--" indicates a negative year effect. The four panels report year fixed effects separately for the GSCPI and TPU specifications and for EI and RCA.

Source: own elaboration.