

INTERNATIONAL MONETARY FUND

Scalable Suppliers in Global Trade Networks

Brandon Joel Tan

WP/26/183

IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate.

The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

**2026
AUG**



WORKING PAPER

IMF Working Paper

Western Hemisphere Department

Scalable Suppliers in Global Trade Networks**Prepared by Brandon Joel Tan**

Authorized for distribution by Anastasia Guscina

August 2026

IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate. The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

ABSTRACT: Whether exporters can take advantage of increases in foreign demand depends on the scalability of their input suppliers—that is, suppliers’ ability to expand production when demand rises. Using bilateral trade data linked to international input-output tables, I measure supplier scalability at the country-industry level and examine how it shapes downstream export growth. I find that supplier scalability varies sharply across industries within countries, that scalable suppliers tend to be connected to scalable suppliers themselves, and that downstream country-sectors exposed to more scalable suppliers respond more strongly to positive foreign demand shocks in sectors with relationship-sticky inputs. I rationalize these facts in a multicountry, multi-sector general-equilibrium trade model with input-output linkages, heterogeneous upward-sloping supplier supply curves, and gradually adjusting sourcing relationships. In the calibrated model, supplier bottlenecks substantially attenuate the export and welfare gains from a global demand expansion, while relationship stickiness determines where bottlenecks bind. Counterfactuals show that supplier upgrading and pre-arranged access to flexible sourcing networks are most valuable when targeted toward economically central, relationship-sticky, and bottleneck-exposed parts of the production network.

JEL Classification Numbers:	F12, F14, D57, L23
Keywords:	Scalability; trade; production networks
Author’s E-Mail Address:	btan2@imf.org

WORKING PAPERS

Scalable Suppliers in Global Trade Networks

Prepared by Brandon Joel Tan

1 Introduction

Foreign demand shocks create export opportunities, but they do not translate mechanically into export growth. When demand rises for a downstream sector, exporters must expand production, and expansion requires intermediate inputs.¹ This paper studies a supply-side margin in global trade networks: whether the upstream suppliers behind downstream exporters can scale when demand expands.

The mechanism is simple. A positive foreign demand shock raises downstream input demand. If inherited suppliers have scalable supply curves, input prices rise little and downstream exporters can expand more. If inherited suppliers are capacity constrained, specialized, or slow to adjust, input prices rise, downstream marginal costs increase, and the same demand shock generates a weaker export response. Relationship stickiness determines when inherited supplier exposure matters.² If buyers can quickly switch suppliers, they can reallocate away from constrained input sources. If buyer-supplier relationships are persistent, downstream producers remain exposed to the scalability of their inherited suppliers in the short run.

Recent demand booms make the mechanism concrete. The expansion of electric vehicles is not only a shock to final vehicle producers. It also requires scalable suppliers of machinery, electrical equipment, rubber and plastics, non-metallic minerals, metals, chemicals, and electronic components. Similarly, AI-related investment raises demand for semiconductors and servers, but also for electrical equipment, cooling systems, machinery, fabricated metals, chemicals, and construction-related inputs. These examples illustrate the central point: demand shocks are stress tests of entire upstream supply networks. Downstream output can expand only if the relevant input suppliers can scale.

The first part of the paper is empirical. I measure supplier scalability: the extent to which a supplier country-sector is able to expand exports when foreign demand for its upstream sector rises. I then ask whether downstream country-sectors connected to more scalable input suppliers respond more strongly to their own foreign demand shocks. The empirical challenge is that the same demand shocks that reveal supplier scalability may also reshape trade relationships. I therefore use a predetermined network design. Supplier destination shares, downstream input-sourcing shares, and downstream destination shares are all measured over 1995–1999, while responses are estimated from 2000 onward. This timing separates the network used to construct shocks and exposure from the period in which downstream export responses are studied. Leave-out market-size terms also remove the supplier’s or downstream exporter’s own sales from the relevant foreign demand shock.

The empirical evidence is organized around three facts. First, supplier scalability is country-sector specific. It varies sharply across sectors within countries. Second, scalable suppliers tend to have scalable suppliers. This recursive pattern suggests that scalability is a network property: the ability to expand is shaped not only by a supplier’s own production capacity, but also by whether its

¹Upstream sectors produce intermediate inputs used by downstream industries.

²Relationship stickiness refers to the persistence of buyer-supplier relationships and the difficulty of replacing existing suppliers quickly.

own upstream inputs can expand with it. Third, downstream export responses to demand shocks are stronger when country-sectors are more exposed to scalable suppliers, but only in sectors that rely on relationship-sticky inputs. Relationship stickiness refers to inputs for which buyer-supplier links are persistent and difficult to replace quickly, so downstream producers cannot easily switch to alternative suppliers when demand rises. In these sectors, country-sectors with greater exposure to scalable suppliers increase exports more in response to positive foreign demand shocks, with dynamic estimates showing no evidence of differential pretrends and effects that persist for several years before fading as production and sourcing adjust.

In the second part of the paper, I develop a quantitative trade model to rationalize these facts and quantify their importance.³ The model is a multi-country, multi-sector general-equilibrium framework with three key ingredients: input-output linkages across sectors, heterogeneous upward-sloping supply curves across supplier country-sectors, and gradually adjusting buyer-supplier relationships. Input-output linkages determine how a downstream demand shock translates into demand for upstream inputs. Heterogeneous supplier supply curves determine how much input prices rise when upstream demand expands. Sticky sourcing relationships determine how strongly downstream producers remain exposed to their inherited suppliers after the shock.

These ingredients generate the mechanism. When supplier supply is inelastic, an increase in input demand raises supplier prices. These price increases feed into downstream input price indices, raise marginal costs, and attenuate export growth. Because downstream producers source inputs through CES nests but inherited buyer-supplier relationships adjust only gradually, relationship stickiness governs the speed at which firms can reallocate away from constrained suppliers. In the short run, scalable-supplier exposure matters because firms cannot immediately reconfigure their input networks. Over time, as sourcing relationships adjust, the advantage of inherited exposure to scalable suppliers fades.

The calibrated model delivers three messages. First, supplier bottlenecks substantially attenuate the gains from a global demand expansion. Relative to benchmarks in which suppliers are highly or perfectly scalable, the baseline economy has lower export and welfare gains because higher intermediate input demand raises supplier prices and downstream marginal costs. In the perfectly elastic-supplier benchmark, the export response is about 17 percent larger and the welfare gain about 24 percent larger than in the baseline economy. Thus, a model that ignores finite supplier scalability would overstate the gains from demand expansions. Second, relationship adjustment has modest aggregate effects, but it plays a central role in determining where bottlenecks bind. High supplier-scalability-exposure sectors expand about 18 percent more in the short run, but this advantage fades as sourcing relationships adjust. Third, policy targeting matters. Supplier upgrading is most effective when bottleneck severity is combined with network centrality and downstream relationship stickiness. Likewise, pre-arranging access to flexible sourcing networks has the greatest option value in industries whose inherited supplier networks are both sticky and exposed to

³The model builds on the class of quantitative trade models developed in Eaton and Kortum (2002) and extended to input-output linkages by Caliendo and Parro (2015).

low-elasticity suppliers.

The paper builds on the literature on production networks and shock propagation, which shows that input-output linkages shape how shocks move across firms, sectors, and countries (Acemoglu et al., 2012; Carvalho, 2014; Carvalho and Tahbaz-Salehi, 2019). Much of this literature studies how the position of firms or sectors in the production network affects aggregate volatility and shock transmission. This paper shifts attention from network exposure alone to the scalability of the suppliers behind that exposure. Two downstream country-sectors may rely on similar upstream industries, but they can respond differently to the same foreign demand shock if one is connected to suppliers that can expand and the other is connected to suppliers with steep supply curves. The relevant object is therefore not only how much a downstream sector depends on an upstream input, but whether the inherited suppliers of that input can scale.

The paper also relates to work on supply-chain disruptions, bottlenecks, and resilience. Existing studies show that negative supplier shocks propagate downstream, especially when inputs are specific or difficult to replace (Barrot and Sauvagnat, 2016; Boehm et al., 2019; Carvalho et al., 2021). Recent work on global supply chains during the COVID-19 pandemic similarly emphasizes how production networks transmit disruptions across countries (Bonadio et al., 2021). Closely related, Ahn and Tan (2025) study how diversification of import sources can improve resilience to adverse trade shocks when supply chains cannot be immediately reconfigured. I study the complementary case of positive demand shocks. The constraint is not that an existing supplier is hit by an adverse shock, but that the supplier may be unable to scale when downstream demand rises. Bottlenecks therefore appear as attenuated export growth rather than lost production. This distinction leads to a different empirical object: supplier scalability, estimated from how supplier country-sectors respond to foreign demand for their own upstream sector, and a different quantitative object: the welfare and export attenuation generated by finite supplier supply elasticities.

Finally, the paper connects global sourcing models and evidence on persistent buyer-supplier relationships. Global sourcing models emphasize that firms choose suppliers to reduce costs and that sourcing decisions interact across markets through the production cost function (Antràs et al., 2017). Firm-network evidence shows that buyer-supplier relationships are shaped by search, geography, and relationship-specific frictions (Bernard et al., 2019). More directly, Martin et al. (2026) construct product-level measures of relationship stickiness from firm-to-firm relationship durations. I use this insight both empirically and quantitatively. Empirically, relationship stickiness identifies the sectors in which inherited supplier scalability should matter most for export adjustment. In the model, relationship persistence governs the speed at which downstream producers can reallocate away from inherited supplier bottlenecks. The contribution is therefore to measure a new supplier-side network object, show that it predicts downstream export adjustment under relationship stickiness, and quantify how supplier bottlenecks shape the aggregate and distributional gains from demand expansions.

The remainder of the paper proceeds as follows. Section 2 describe the data and establish the empirical facts. Section 3 presents the model. Section 4 presents the model results. Section 5

concludes.

2 Stylized Facts

2.1 Data and Measurement

The starting point is Base pour l'Analyse du Commerce International (BACI) bilateral trade at the HS6 exporter-importer-year level for 1995–2024 and 230 countries.⁴ HS6 products are mapped into Organisation for Economic Co-operation and Development Inter-Country Input-Output database (OECD ICIO)⁵ sectors and aggregated to bilateral country-sector-year exports, X_{ijut} , where i is the exporter, j is the importer, u is the upstream sector, and t is year.⁶ The HS6-to-ICIO concordance retains 89.7 percent of trade value and covers 17 manufacturing upstream sectors. Unmapped products are dropped rather than imputed, so the supplier-side object is tied to sectors that can be linked to the input-output structure.

The measurement design uses 1995–1999 as the baseline network window. Baseline shares enter three objects: supplier destination shares for supplier demand shocks, downstream import shares for scalable-supplier exposure, and downstream destination shares for foreign demand shocks. The estimation sample begins in 2000. This timing makes the network weights predetermined relative to the downstream response period while preserving a long post-baseline panel.

2.1.1 Measuring supplier scalability

For supplier country i , upstream sector u , and year t , the supplier demand shifter is

$$Shock_{iut} = \sum_k s_{iuk,95-99} \Delta \log M_{kut}^{ROW,-i},$$

where $s_{iuk,95-99}$ is supplier i 's 1995–1999 export share to destination k in sector u . $M_{kut}^{ROW,-i}$ is destination k 's total imports in sector u from all suppliers other than i , so supplier i 's own exports are excluded from the market-size term. Supplier scalability is then estimated from 2000 onward:

$$\Delta \log X_{iut} = a_{iu} + S_{iu} Shock_{iut} + e_{iut}.$$

The coefficient S_{iu} is the estimate of scalability for supplier country i in upstream sector u . It

⁴BACI is a harmonized bilateral trade database produced by Centre d'Etudes Prospectives et d'Informations Internationales using United Nations Comtrade data

⁵The OECD ICIO provide an international statistical infrastructure that maps flows of production, consumption, investment within countries and flows of international trade in goods and services between countries, broken down by economic activity and by country, globally and in a consistent manner and for a time period that makes such data fit for analytical purposes. The tables show how much each downstream industry relies on inputs from different upstream industries, including both domestically produced and imported inputs. The main ICIO-based objects used in the analysis are input-output coefficients, which measure the importance of each upstream industry in downstream production, and intermediate input shares, which measure the overall role of intermediate inputs in sectoral production.

⁶HS6 is the six-digit level of the Harmonized System product classification.

measures how strongly that supplier country-sector expands exports when foreign demand for that upstream sector rises.⁷

Our preferred specification uses an empirical Bayes measure that is less sensitive to noisy first-stage elasticities. We consider two variants:

$$S_{iu}^{EB0} = \rho_{iu} S_{iu}, \quad S_{iu}^{EB\mu} = \bar{S}_u + \rho_{iu} (S_{iu} - \bar{S}_u),$$

where

$$\rho_{iu} = \frac{\hat{\sigma}_u^2}{\hat{\sigma}_u^2 + \widehat{se}(S_{iu})^2}.$$

Here, $\hat{\sigma}_u^2$ is the within-upstream-sector variance of raw scalability, and $\bar{S}_u$ is the upstream-sector mean. The first measure, S_{iu}^{EB0} , shrinks noisier supplier-sector estimates toward zero while preserving the raw scale. The second, $S_{iu}^{EB\mu}$, instead shrinks noisy estimates toward the upstream-sector mean.

2.1.2 From supplier scalability to downstream exposure

Downstream scalable-supplier exposure aggregates supplier scalability through the input network:

$$SIE_{jd,95-99} = \sum_u \theta_{du} \sum_i s_{jiu,95-99} S_{iu},$$

where $s_{jiu,95-99}$ is downstream country j 's 1995–1999 import share from supplier i in upstream sector u , and θ_{du} is the ICIO input weight of upstream sector u in downstream sector d .⁸

The downstream demand shock is constructed analogously from predetermined destination shares:

$$DemandShock_{jdt} = \sum_k s_{jdk,95-99} \Delta \log M_{kdt}^{ROW,-j},$$

where $M_{kdt}^{ROW,-j}$ excludes downstream exporter j 's own exports to destination k in sector d . The main response sample uses positive demand shocks from 2000 onward.

2.2 Fact 1: Supplier Scalability Is Country-Sector Specific

The first fact is that supplier scalability is not simply a country characteristic. A country can be highly scalable in one upstream sector and weakly scalable in another. This matters because the relevant downstream exposure depends on which suppliers provide which inputs, not only on whether a downstream country sources from generally large or advanced economies.

Table 1 presents a variance decomposition. Country fixed effects explain only part of supplier scalability, and sector fixed effects explain even less. Even after absorbing both supplier-country

⁷Table A1 presents summary statistics by sector.

⁸To reduce the influence of noisy first-stage elasticities, the unadjusted supplier-scalability estimates are winsorized at the 1st and 99th percentiles before constructing downstream exposure.

and upstream-sector fixed effects, 60–72 percent of the variation remains at the supplier-country-sector level across the unadjusted and empirical-Bayes measures. The empirical object is therefore not a country’s average export capacity, nor a sector’s average scalability, but the scalability of specific country-sectors within upstream industries.

Table 1: Supplier scalability is country-sector specific

Outcome	Country FE R^2	Sector FE R^2	Country + sector FE R^2	Residual share
Unadjusted	0.231	0.043	0.278	0.722
Mean-centered Empirical Bayes	0.164	0.110	0.277	0.723
Zero-centered Empirical Bayes	0.315	0.069	0.400	0.600

Notes: Entries report the share of variation in the indicated supplier-scalability measure explained by supplier-country fixed effects, upstream-sector fixed effects, or both. The residual share equals one minus the R^2 from the specification with supplier-country and sector fixed effects.

The correlates in Table 2 help interpret what this country-sector object captures. Conditional on supplier-country and sector fixed effects, supplier-sector size is positively related to scalability across all measures. The destination-reach variables also point in the expected direction, especially for the empirical-Bayes measures: supplier country-sectors that serve more destinations and have more diversified destination portfolios tend to be more scalable. Baseline export growth is robustly positive, while baseline growth volatility is robustly negative. Overall, the pattern suggests that scalable supplier country-sectors are larger, broader-based, faster-growing, and relatively stable exporters.

Table 2: Correlates of supplier scalability

Variable	Unadjusted	Mean-centered Empirical Bayes	Zero-centered Empirical Bayes	N
Supplier-sector size	0.076*** (0.012)	0.047*** (0.007)	0.098*** (0.007)	1813
Log destinations served	0.126 (0.079)	0.109** (0.043)	0.245*** (0.046)	1813
Destination diversification	0.135 (0.107)	0.098* (0.059)	0.152** (0.063)	1813
Baseline export growth	0.533*** (0.151)	0.178** (0.083)	0.248*** (0.089)	1813
Baseline growth volatility	-0.212*** (0.045)	-0.080*** (0.025)	-0.215*** (0.026)	1813

Notes: Each cell reports the coefficient from a separate regression of the indicated supplier-scalability measure on the row variable. All regressions include supplier-country and sector fixed effects. Standard errors are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.3 Fact 2: Scalable Suppliers Tend to Have Scalable Suppliers

The second fact is recursive. Supplier country-sectors that are connected to more scalable input suppliers tend to be more scalable themselves. This turns supplier scalability from a stand-alone country-sector attribute into a network property.

Figure 1 shows a strongly positive relationship between a supplier country-sector’s own scalability and the scalability of its input network. This is consistent with a supply-chain capacity

interpretation. A supplier's ability to expand exports depends not only on its own technology, size, or market reach, but also on whether its upstream inputs can expand with it. Scalable suppliers therefore appear to be embedded in scalable parts of the production network.

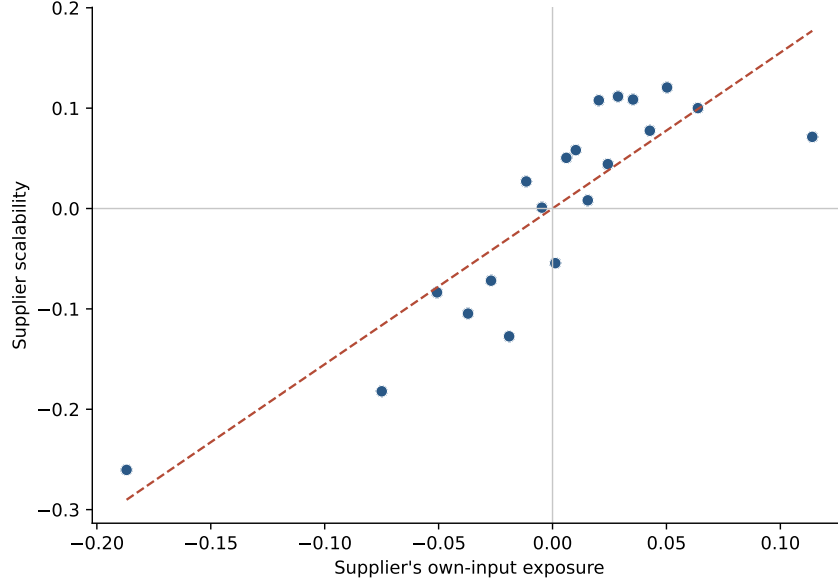


Figure 1: Scalable suppliers have more scalable suppliers

Notes: The figure residualizes supplier scalability and the supplier's own scalable-input exposure by upstream-sector fixed effects, then plots binned means of the residualized variables. The dashed line is a linear fit through the bin means.

Correlates reinforce this network interpretation (Table A2). Supplier-side scalability is positively associated with destination diversification, suggesting that scalable suppliers tend to have broad sales networks as well as scalable sourcing networks. The remaining downstream correlates are small or not as robust across measures.

2.4 Fact 3: Export Responses Rise with Scalable-Supplier Exposure

The third fact is the central result that exposure matters for export adjustment. Country-sectors connected to more scalable input suppliers respond more strongly to positive foreign demand shocks, but only in sectors that rely on relationship-sticky inputs. This is intuitive because, when inputs are relationship-sticky, downstream producers cannot easily replace constrained suppliers in response to a shock. Their ability to expand therefore depends more directly on whether their existing suppliers can scale with them.

The main estimating equation is

$$\begin{aligned} \Delta \log X_{jd,t+1} = & \alpha DemandShock_{jdt} + \delta SIE_{jd,95-99} \\ & + \beta (DemandShock_{jdt} \times SIE_{jd,95-99}) + \Gamma_{jdt} + \varepsilon_{jdt}, \end{aligned}$$

estimated on country-sector-year observations with positive demand shocks from 2000 onward. The outcome is cumulative one-year export growth for downstream country j and sector d . The shock is the leave-out foreign demand shock constructed from predetermined destination shares. The exposure term is scalable-supplier exposure from the 1995–1999 input-sourcing network.⁹ Γ_{jdt} represents fixed effects. β compares how the response to a demand shock differs with predetermined exposure to scalable suppliers. Standard errors are clustered by country-sector.

Table 3 shows that the interaction between demand shocks and scalable-supplier exposure is small and insignificant in the full sample, but becomes large and significant among downstream sectors that rely more heavily on relationship-sticky inputs, as defined following Martin et al. (2026).¹⁰ Relationship stickiness captures inputs for which buyer-supplier links are harder to replace, so adjustment is more likely to occur through existing supplier relationships rather than rapid supplier switching. The full-sample null is therefore informative: scalable suppliers do not matter equally across all input networks, but matter most where supplier relationships are difficult to reallocate quickly. The pattern is robust across the unadjusted scalable-supplier measure and the two Empirical Bayes adjustments, supporting the interpretation that scalable input networks are especially important when downstream producers depend on sticky input relationships.

Figure 2 restricts attention to country-sectors with high relationship-sticky inputs and plots binned country-sector demand elasticities against scalable-supplier exposure. The fitted line through the bin means is positive.¹¹ The figure shows that the same positive demand shock generates a larger export response when the downstream country-sector is more exposed to scalable suppliers, where input relationships are harder to reallocate.

Figure 3 shows the dynamic response for high input relationship-stickiness sectors from $t - 3$ to $t + 4$ using country-sector and country-year fixed effects. Each point is the estimated coefficient on the interaction between the foreign demand shock and scalable-supplier exposure, where the outcome is cumulative export growth relative to the shock year. The interaction coefficients are close to zero and statistically insignificant before the shock, providing no evidence of differential pretrends. The response turns positive on impact, peaks around the one-year horizon, and remains positive over subsequent years before gradually fading by $t + 4$. This pattern suggests that exposure to scalable suppliers shapes the export adjustment path after a demand shock. The effect is strongest around the first year, when downstream exporters in relationship-sticky sectors are espe-

⁹Appendix Table A3 provides an additional check on possible mechanical overlap between the demand variation used to estimate supplier scalability and the downstream demand shock in the main estimating equation. This overlap is already limited by the design: supplier scalability, input-sourcing exposure, and downstream demand shocks are constructed using predetermined 1995–1999 network shares, and the demand shocks use leave-out market-size terms that exclude the exporter’s own sales. For further robustness, we reconstruct scalable-supplier exposure using supplier-scalability estimates that leave out demand variation associated with the same downstream country-sector whose response is being studied. The estimates are similar to the baseline, confirming that the results are not driven by mechanical overlap between the first-stage scalability measure and the downstream demand shock.

¹⁰Relationship stickiness is constructed from HS6 product-level relationship stickiness scores from Martin et al. (2026) aggregated to ICIO upstream sectors using 2000-onward trade weights, then aggregated to downstream sectors using ICIO input weights. We define downstream sectors that rely more heavily on relationship-sticky inputs as those above the median of the resulting sticky-input measure.

¹¹Country-sector demand elasticities are winsorized at the 1st and 99th percentiles to drop noisy cell-level estimates.

Table 3: Export Responses and Relationship-Sticky Inputs

SIE measure	All		High input relationship stickiness	
	(1)	(2)	(3)	(4)
Unadjusted	0.022 (0.046)	0.019 (0.043)	0.291** (0.138)	0.348*** (0.134)
Mean-centered Empirical Bayes	0.032 (0.045)	0.023 (0.042)	0.377** (0.148)	0.401*** (0.141)
Zero-centered Empirical Bayes	0.033 (0.045)	0.029 (0.042)	0.353*** (0.132)	0.432*** (0.128)
N	58,440	58,440	31,699	31,699
Year FEs	X		X	
Country-Sector FEs	X	X	X	X
Country-Year FEs		X		X

Notes: Outcome is one-year cumulative log export growth winsorized at the overall 5th and 95th percentiles. The sample uses positive demand shocks from 2000 onward. Relationship stickiness is constructed from HS6 product-level relationship-stickiness scores aggregated to ICIO upstream sectors using 2000-onward world-trade weights, then aggregated to downstream sectors using ICIO input weights. The high-input-relationship-stickiness column restricts the sample to downstream sectors above the median of the resulting sticky-input measure across observed country-sector cells. All regressions include the demand-shock main effect and the interaction between the demand shock and standardized SIE. SIE levels are absorbed by country-sector fixed effects. Standard errors are clustered by country-sector.

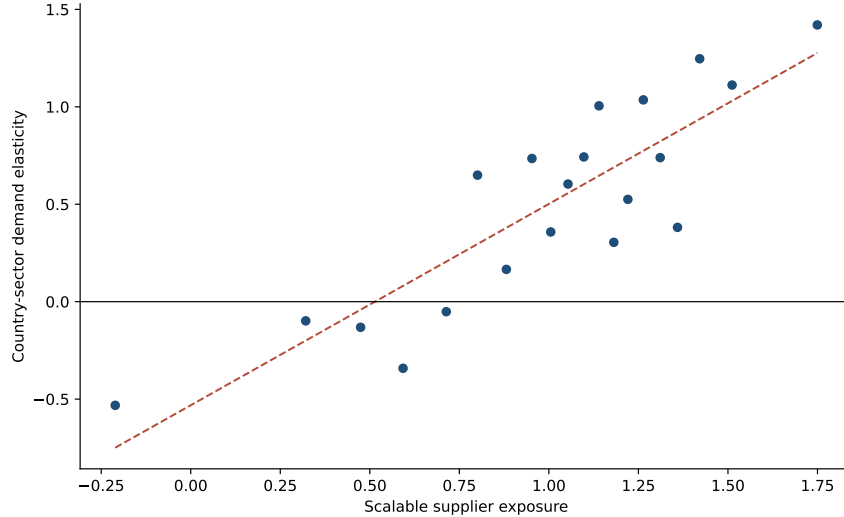


Figure 2: Export response rises with scalable-supplier exposure: High input relationship stickiness

Notes: The sample is restricted to downstream country-sectors in sectors above the median input relationship-stickiness measure. For each country-sector, the demand elasticity is estimated from residualized one-year cumulative export growth and residualized demand shocks after absorbing country-sector and year fixed effects. Points plot binned means of the cell-level elasticities against the indicated scalable-supplier exposure measure. Cell-level elasticities are winsorized at the 1st and 99th percentiles; the dashed line is a linear fit through the bin means.

cially dependent on the capacity of existing input suppliers to expand, and then fades as production and sourcing adjust over time.

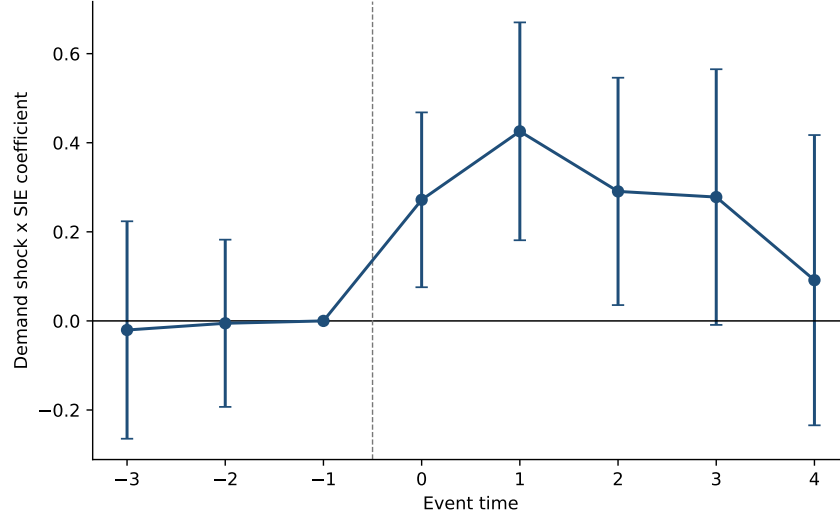


Figure 3: Dynamic cumulative export response: High input relationship stickiness

Notes: The sample is restricted to downstream country-sectors in sectors above the median input relationship-stickiness measure. Each point is the coefficient on the interaction between the demand shock and the scalable-supplier exposure measure at event horizons from $t - 3$ to $t + 4$. Outcomes are cumulative export growth relative to the shock year and are winsorized at the 5th and 95th percentiles within each horizon. Regressions include country-sector and country-year fixed effects; standard errors are clustered by country-sector. The omitted pre-period is normalized to zero at $t - 1$.

3 Model

This section presents a multi-country, multi-sector general-equilibrium model in which downstream export responses depend on the scalability of inherited upstream supplier networks. The central mechanism is simple. A foreign demand expansion raises downstream production. Higher production increases demand for intermediate inputs. If a downstream producer sources from suppliers with steep supply curves, upstream input prices rise, downstream marginal costs increase, and the export response is attenuated. If the inherited supplier network is more scalable, the same foreign demand shock generates a larger downstream export expansion.

The model combines four ingredients. First, sectors are linked through input-output production. Second, downstream producers source intermediate inputs across foreign and domestic suppliers through constant elasticity of substitution (CES) sourcing nests. Third, supplier country-sectors face upward-sloping supply curves, with supply elasticities that differ across suppliers within the same upstream sector. Fourth, upstream sectors differ in relationship stickiness: in sticky input markets, existing buyer-supplier links are harder to replace quickly, so downstream producers are more exposed to the scalability of their inherited suppliers.

3.1 Environment

There are countries indexed by i, j, n and sectors indexed by d, u . A country-sector jd produces a sectoral good using value added and intermediate inputs. Value added is supplied by labor in country j . Intermediate inputs are composites of goods from upstream sectors u , and each upstream input is sourced from supplier countries i .

Country j 's representative household owns labor and receives income from production. Labor is mobile across sectors within a country. The household consumes a Cobb-Douglas bundle of sectoral goods with expenditure shares β_{jd} .

3.2 Production

Gross output in downstream country-sector jd is produced with value added V_{jd} and an aggregate intermediate bundle M_{jd} :

$$Y_{jd} = A_{jd} V_{jd}^{1-\alpha_d} M_{jd}^{\alpha_d}, \quad (1)$$

where $\alpha_d \in [0, 1]$ is the intermediate input share of sector d . The intermediate bundle is Cobb-Douglas across upstream sectors:

$$M_{jd} = \prod_u M_{jdu}^{\theta_{du}}, \quad \sum_u \theta_{du} = 1. \quad (2)$$

The weights θ_{du} encode the input-output structure: they determine how much downstream sector d relies on each upstream sector u .

For each upstream sector u , the input aggregate M_{jdu} is a CES composite across supplier countries:

$$M_{jdu} = \left[\sum_i \omega_{jiu}^{1/\sigma} q_{jiu}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}, \quad (3)$$

where q_{jiu} is the quantity of input u purchased by country j from supplier country i , ω_{jiu} are sourcing weights, and $\sigma > 1$ is the elasticity of substitution across suppliers.

Let p_{jiu} be the delivered price of input u from supplier i to buyer j . The CES price index for input u used by country j is

$$P_{ju} = \left[\sum_i \omega_{jiu} p_{jiu}^{1-\sigma} \right]^{1/(1-\sigma)}. \quad (4)$$

The downstream intermediate input price index is

$$P_{jd}^M = \prod_u P_{ju}^{\theta_{du}}. \quad (5)$$

The unit cost of producing the downstream good is

$$c_{jd} = \frac{1}{A_{jd}} \left(\frac{w_j}{1 - \alpha_d} \right)^{1-\alpha_d} \left(\frac{P_{jd}^M}{\alpha_d} \right)^{\alpha_d}. \quad (6)$$

Equivalently, in proportional changes, the marginal cost hat is

$$\hat{c}_{jd} = \hat{w}_j^{1-\alpha_d} \prod_u \hat{P}_{ju}^{\alpha_d \theta_{du}} \hat{A}_{jd}^{-1}. \quad (7)$$

3.3 Supplier Supply Curves

Each supplier country-sector iu produces upstream good u with an upward-sloping supply curve:

$$p_{iu} = \kappa_{iu} C_{iu} Q_{iu}^{1/\eta_{iu}}, \quad (8)$$

where Q_{iu} is total quantity supplied by iu , C_{iu} is the producer cost component, κ_{iu} is a supply shifter, and $\eta_{iu} > 0$ is the supplier supply elasticity. A high η_{iu} means the supplier can expand output with little price pressure. A low η_{iu} means output expansion is costly and creates bottlenecks.

Delivered prices are

$$p_{jiu} = \tau_{jiu} p_{iu}, \quad (9)$$

where $\tau_{jiu} \geq 1$ is a bilateral sourcing cost. In hat notation,

$$\hat{p}_{jiu} = \hat{\tau}_{jiu} \hat{C}_{iu} \hat{Q}_{iu}^{1/\eta_{iu}} \hat{\kappa}_{iu}. \quad (10)$$

If supplier iu is itself a country-sector in the production network, its producer cost satisfies the same input-output cost equation:

$$\hat{C}_{iu} = \hat{w}_i^{1-\alpha_u} \prod_v \hat{P}_{iv}^{\alpha_u \theta_{uv}} \hat{A}_{iu}^{-1}. \quad (11)$$

Thus the model allows supplier bottlenecks to interact with input-output linkages. A supplier's price can rise because its own output expands, because its wage rises, or because its own upstream inputs become more expensive.

The inverse supply curve is interpreted as a marginal-cost schedule. Conditional on the producer cost component C_{iu} , total operating cost and supply-curve rents are

$$VC_{iu} = \int_0^{Q_{iu}} \kappa_{iu} C_{iu} q^{1/\eta_{iu}} dq = \frac{\eta_{iu}}{1 + \eta_{iu}} p_{iu} Q_{iu}, \quad (12)$$

$$\Pi_{iu} = p_{iu} Q_{iu} - VC_{iu} = \frac{1}{1 + \eta_{iu}} p_{iu} Q_{iu}. \quad (13)$$

Low- η_{iu} suppliers therefore generate larger scarcity rents when their output is demanded. Supplier rents are owned domestically and rebated lump-sum to the representative household in supplier country i .

3.4 Relationship Stickiness

Let $\omega_{jiu,t}$ denote the sourcing weight inherited from past relationships, and let $\omega_{jiu,t+1}^*$ denote the frictionless desired sourcing weight implied by current prices and fundamentals

$$\omega_{jiu,t+1}^* = \frac{\omega_{jiu,t} p_{jiu,t+1}^{1-\sigma}}{\sum_{\ell} \omega_{j\ell u,t} p_{j\ell u,t+1}^{1-\sigma}}. \quad (14)$$

A simple law of motion is

$$\log \omega_{jiu,t+1} = \rho_u \log \omega_{jiu,t} + (1 - \rho_u) \log \omega_{jiu,t+1}^*, \quad (15)$$

where $\rho_u \in [0, 1]$ measures relationship persistence. High ρ_u means sourcing relationships adjust slowly. In a short-run counterfactual, this corresponds to holding ω_{jiu} close to its baseline value. In a longer-run counterfactual, buyers gradually reorient toward cheaper or more scalable suppliers. When $\rho_u = 0$, sourcing is fully frictionless and $\omega_{jiu,t+1} = \omega_{jiu,t+1}^*$. When $\rho_u = 1$, sourcing remains at the inherited baseline allocation.

Similarly, there is persistence in the input price aggregator. Let $P_{ju,t}^*$ be the CES price index associated with $\omega_{jiu,t}^*$. The upstream input price index is

$$P_{ju,t+1} = (P_{ju,t+1}^*)^{1-\rho_u} (P_{ju,t})^{\rho_u}. \quad (16)$$

This nests the frictionless CES price index when $\rho_u = 0$ and the inherited fixed-relationship cost index when $\rho_u = 1$.

3.5 Demand

Each country-sector sells to domestic and foreign destinations. Let X_{jdn} denote sales from producer jd to destination n . Destination demand is isoelastic:

$$X_{jdn} = B_{jdn} \left(\frac{p_{jdn}}{P_{dn}} \right)^{1-\varepsilon_d} E_{dn}, \quad (17)$$

where B_{jdn} is a demand shifter, p_{jdn} is the delivered price, P_{dn} is the destination-sector price index, E_{dn} is destination expenditure on sector d , and $\varepsilon_d > 1$ is the elasticity of demand across source countries.

For the mechanism emphasized here, the key demand shock is an outward shift in foreign demand for downstream country-sector jd . In reduced form, this can be represented as an increase in B_{jdn} . In hat notation, holding destination expenditure fixed,

$$\hat{X}_{jdn} = \hat{B}_{jdn} \hat{p}_{jdn}^{1-\varepsilon_d} \hat{P}_{dn}^{\varepsilon_d-1}. \quad (18)$$

Aggregating across destinations gives total sales $X_{jd} = \sum_n X_{jdn}$.

3.6 Input Demand and Market Clearing

Cost minimization implies that downstream country-sector jd 's expenditure on upstream input u is

$$E_{jdu}^M = \alpha_d \theta_{du} R_{jd}, \quad (19)$$

where R_{jd} is gross revenue. Within the CES sourcing nest, the share of spending on supplier i is

$$\pi_{jiu} = \frac{\omega_{jiu} p_{jiu}^{1-\sigma}}{\sum_h \omega_{jhu} p_{jhu}^{1-\sigma}}. \quad (20)$$

Quantity demanded from supplier iu by buyer j is therefore

$$q_{jiu} = \frac{\pi_{jiu} E_{jdu}^M}{p_{jiu}}. \quad (21)$$

Supplier country-sector output clears the market:

$$Q_{iu} = \sum_{j,d} q_{jiu} + F_{iu}, \quad (22)$$

where F_{iu} denotes final demand for supplier iu 's sectoral good. The first term captures intermediate demand from downstream producers. The second term captures final consumption, investment, government demand, and export demand not explicitly assigned to intermediate use.

3.7 Labor-Market Clearing and Income

Labor is mobile across sectors within a country. Let L_j be country j 's labor endowment. Labor-market clearing requires

$$L_j = \sum_d L_{jd}. \quad (23)$$

Aggregate labor supply responds to wages according to a constant-elasticity labor-supply schedule

$$\widehat{L}_j = \widehat{w}_j^\varphi, \quad (24)$$

where $\varphi \geq 0$ is the labor-supply elasticity.

With Cobb-Douglas production, labor payments are a fixed share of supplier operating cost, net of the supply-curve rents in equation (13). The equilibrium wage condition is

$$w_j L_j = W B_j = \sum_u (1 - \alpha_u) \frac{\eta_{ju}}{1 + \eta_{ju}} R_{ju}. \quad (25)$$

Combining (24) and (25), the wage hat satisfies

$$\widehat{w}_j = \left(\widehat{W B_j} \right)^{1/(1+\varphi)}, \quad (26)$$

where $\widehat{WB}_j$ is the proportional change in the country value-added wage bill implied by sectoral revenues.

Household income in country j is

$$Y_j^{inc} = w_j L_j + \Pi_j + T_j, \quad (27)$$

where $\Pi_j = \sum_u \Pi_{ju}$, denotes profits or rents rebated to households and T_j denotes net transfers. The representative household allocates expenditure across sectoral goods:

$$E_{jd} = \beta_{jd} Y_j^{inc}. \quad (28)$$

The country consumer price index is

$$P_j^C = \prod_d P_{jd}^{\beta_{jd}}, \quad (29)$$

and real income is Y_j^{inc} / P_j^C . In hat notation, the real wage is

$$\widehat{RW}_j = \frac{\widehat{w}_j}{\widehat{P}_j^C}. \quad (30)$$

3.8 Equilibrium

Given productivities $\{A_{jd}\}$, demand shifters $\{B_{jdn}\}$, bilateral sourcing costs $\{\tau_{jiu}\}$, sourcing shifters $\{\omega_{jiu}\}$, input-output weights $\{\theta_{du}\}$, intermediate shares $\{\alpha_d\}$, and supply elasticities $\{\eta_{iu}\}$, an equilibrium consists of wages, supplier quantities, supplier prices, delivered input prices, input price indices, sectoral marginal costs, bilateral sales, input demands, and final expenditures such that:

1. firms minimize costs, so equations (4)–(7) and (20) hold;
2. supplier prices satisfy the upward-sloping supply curves (8) or (10);
3. goods demand satisfies (17);
4. input demands satisfy (19)–(21);
5. supplier markets clear according to (22);
6. country labor markets clear according to (23)–(25);
7. household income and expenditure satisfy (27)–(28).

The model is solved in proportional changes around the baseline equilibrium.

The country-level welfare object is real income,

$$W_j = \frac{Y_j^{inc}}{P_j^C}.$$

Aggregate welfare is the income-weighted average of country real-income changes,

$$\Delta \log W^{World} = \sum_j \omega_j \Delta \log W_j, \quad \omega_j = \frac{Y_{j0}^{inc}}{\sum_n Y_{n0}^{inc}}.$$

3.9 Mechanism

The model clarifies why scalable supplier exposure changes downstream export responses. Consider a positive foreign demand shock for downstream country-sector jd . The direct effect is to increase desired sales X_{jd} . To produce more, jd increases expenditure on each upstream input u in proportion to $\alpha_d \theta_{du}$. The increase in input demand is allocated across inherited suppliers according to the CES sourcing shares π_{jiu} .

If the relevant suppliers have low η_{iu} , their supply curves are steep. The demand expansion raises Q_{iu} , which raises p_{iu} , and therefore raises delivered input prices p_{jiu} . These input price increases raise P_{ju} , then P_{jd}^M , then downstream marginal cost c_{jd} . Higher marginal cost offsets part of the original demand expansion. The downstream export response is attenuated.

Relationship stickiness amplifies this force through the persistence of sourcing relationships. The parameter $\rho_u \in [0, 1]$ governs how quickly buyers can move from inherited sourcing weights $\omega_{jiu,t}$ toward frictionless desired weights $\omega_{jiu,t}^*$. When ρ_u is high, the buyer remains tied to its inherited input suppliers after a shock, so the scalability of those suppliers matters more. When ρ_u is low, sourcing weights adjust more quickly, and the downstream producer can partially reallocate away from constrained suppliers.

If the same downstream country-sector instead sources from high- η_{iu} suppliers, the increase in supplier quantities causes smaller input price increases. The input price index rises less, marginal cost rises less, and the downstream sector expands exports more. The mechanism therefore operates through the interaction of four objects:

$$\begin{aligned} & \text{Demand shock} \times \text{input intensity and IO weights} \\ & \quad \times \text{supplier supply scalability} \times \text{relationship stickiness.} \end{aligned}$$

3.10 Calibration

This section calibrates the model for the counterfactual simulations. Network objects are taken directly from the data, supplier supply elasticities are disciplined by the empirical supplier-scalability moments, and the remaining elasticities are set to standard baseline values.

3.10.1 Baseline network and directly observed objects

The baseline network is constructed using the same trade data used in the empirical analysis. Baseline sourcing shares s_{jiu0} measure country j 's purchases of upstream input u from supplier country i . Input-output weights θ_{du} are taken from the ICIO tables and determine how much downstream sector d relies on upstream sector u . Sectoral intermediate input shares α_d are also

taken from the ICIO data. These objects determine how a downstream demand shock propagates into demand for upstream inputs.

3.10.2 Relationship stickiness and sourcing persistence

Relationship stickiness is calibrated through the sourcing-persistence parameter $\rho_u \in [0, 1]$, which governs how quickly buyers move from inherited sourcing relationships toward the frictionless desired allocation.

I discipline ρ_u using the duration-based interpretation of the relationship-stickiness measure from Martin et al. (2026). Their measure is constructed from firm-to-firm relationship durations and is motivated by a search model in which buyers switch suppliers only when a sufficiently attractive alternative arrives. This makes relationship duration a natural empirical moment for sourcing persistence. Let RS_u denote the relationship-stickiness index aggregated to upstream sector u . In line with its empirical construction in Martin et al. (2026), the index enters as a log shifter of relationship duration, so differences in RS_u imply proportional rather than additive differences in expected relationship length. The implied relationship duration is therefore $D_u = D_0 \exp(RS_u - \overline{RS})$, where D_u is measured in years and D_0 is the expected duration assigned to the mean-stickiness input sector. The calibration sets $D_0 = 2$, consistent with the mean duration of firm-to-firm relationships reported by Martin et al. (2026). Annual sourcing persistence is then $\rho_u = \exp\left(-\frac{1}{D_u}\right)$.

3.10.3 Other elasticities and normalizations

The calibration holds the supplier substitution elasticity fixed across sectors. This keeps static substitutability conceptually distinct from relationship stickiness: substitution across suppliers is governed by σ within the adjustable part of sourcing, while ρ_u governs the persistence of inherited buyer-supplier relationships. We set the destination demand elasticity to $\epsilon_d = 5$ and choose σ so that the mean one-year persistence-adjusted substitution margin satisfies $(1 - \rho_u)\sigma = 5$. The labor-supply elasticity is set to $\varphi = 3$. These values provide medium-elasticity benchmarks consistent with standard quantitative trade calibrations. Productivities, bilateral sourcing costs, and non-shocked demand shifters are normalized to one in the baseline equilibrium unless directly shocked in a counterfactual. Because the model is solved in proportional changes, the counterfactuals require baseline expenditure shares and elasticities rather than levels of all primitive shifters.

3.10.4 Supplier scalability and supply elasticities

Supplier country-sectors differ in their ability to expand production. In the model, this heterogeneity is governed by the supplier supply elasticity η_{iu} . A high η_{iu} means that supplier iu can expand output with little price pressure, while a low η_{iu} means that expansion is costly and creates bottlenecks.

I discipline η_{iu} using the empirical-Bayes supplier-scalability estimates from the first-stage supplier regressions. These estimates are reduced-form export responses, not structural supply elasticities. I therefore use them to discipline the relative ordering and dispersion of supplier elasticities, and choose the level and slope of the mapping by asking the model to reproduce the same first-stage moment in simulated data.

Let z_{iu} denote the standardized empirical-Bayes scalability estimate. Supplier elasticities are parameterized as

$$\eta_{iu} = \bar{\eta}_u \exp(\lambda_u z_{iu}).$$

$\bar{\eta}_u$ governs the elasticity assigned to a supplier with average scalability, while λ_u governs how strongly measured scalability maps into elasticity dispersion.

I choose $(\bar{\eta}_u, \lambda_u)$ by simulated method of moments. For each candidate vector, I simulate the model under sector-country demand shocks and estimate in the simulated data the same first-stage regression used in the empirical analysis:

$$\Delta \log X_{iu,t}^{model} = \alpha_{iu} + \hat{S}_{iu}^{model} Shock_{iut}^{model} + \varepsilon_{iu,t}^{model}.$$

The calibration compares $\hat{S}_{iu}^{model}$ with the empirical supplier-scalability estimate, minimizing export-weighted squared deviations.¹²

4 Quantitative Results

This section uses the calibrated model to quantify how supplier scalability shapes the response to a 10 percent global demand shock.

The results deliver two messages. First, supplier bottlenecks attenuate the aggregate gains from the shock. Relative to benchmarks in which suppliers are highly or perfectly scalable, the baseline economy has lower export and welfare gains because higher intermediate input demand raises supplier prices and downstream marginal costs. Second, relationship stickiness determines where these bottlenecks bind. High supplier-scalability-exposure sectors expand more in the short run, but this advantage fades as sourcing relationships adjust.

We then explore two sets of policies: supplier upgrading from a global policy perspective and pre-arranging relationships with scalable suppliers that can be activated when demand expands from a country policy perspective.

4.1 Supplier bottlenecks attenuate aggregate gains

The first result compares the baseline model to two supplier-scalability benchmarks. The sector-p90 benchmark assigns each supplier country-sector the within-sector 90th percentile supply elasticity. This is a data-bounded high-scalability benchmark: it asks how the economy would respond if low-scalability suppliers looked like high-scalability suppliers in the same upstream sector. The

¹²Figure A3 plots the fit between $\hat{S}_{iu}^{model}(\bar{\eta}_u, \lambda_u)$ and S_{iu} .

infinite-elasticity benchmark removes supplier bottlenecks entirely. It corresponds to a model in which upstream inputs can expand without raising supplier prices.

Table 4 shows the results. Under the baseline calibration, the 10 percent demand shock raises mean exports by 4.32 percent and real income by 3.17 percent. Input prices rise by 1.55 percent, and downstream marginal costs rise by 1.30 percent.

Under the sector-p90 benchmark, the export response rises to 5.11 percent and the real-income gain rises to 4.09 percent. Relative to this high-scalability benchmark, the baseline export response is 15.46 percent lower and the welfare gain is 22.65 percent lower. The attenuation is larger relative to the infinite-elasticity benchmark: with perfectly elastic suppliers, exports rise by 5.17 percent, so the baseline export response is 16.51 percent below the perfectly elastic benchmark. The corresponding welfare attenuation is 24.24 percent. This comparison shows that supplier bottlenecks matter both for trade quantities and for real income.

Table 4: Supplier bottlenecks and the response to a 10 percent global demand shock

Outcome	Baseline	Sector-p90 η	Infinite η
Export response (p.p.)	4.32	5.11	5.17
Real income gain (p.p.)	3.166	4.093	4.179
Marginal cost (p.p.)	1.30	1.11	1.09
Input price (p.p.)	1.55	0.89	0.83
Export attenuation (%)	–	15.46	16.51
Welfare attenuation (%)	–	22.65	24.24

Notes: Level outcomes are reported as percentage-point log changes. Attenuation columns are percentages: the percent by which the baseline response is below the benchmark response.

The table shows that supplier scalability is quantitatively important. Models that treat suppliers as highly or perfectly scalable predict larger gains from the same demand shock because they miss the upstream price-pressure channel. In the baseline economy, higher downstream production raises demand for intermediate inputs. Since supplier supply curves are upward sloping, this raises supplier prices. These price increases feed into downstream marginal costs, so part of the foreign demand expansion is absorbed by higher costs rather than higher export quantities.

4.2 Relationship stickiness determines where bottlenecks bind

The second result studies the transition as sourcing relationships become less sticky. Supplier supply elasticities are held fixed throughout the transition, so the exercise isolates the role of relationship adjustment.

In the aggregate, relaxing sourcing relationships has only a modest effect on export responses (Table 5). The export response rises from 4.32 percent on impact to 4.46 percent after one year, 4.51 percent after two years, and 4.56 percent in the long run. This is a 5.69 percent increase relative to the initial response. The associated real-income gains are reported in the same table.

The modest aggregate movement reinforces the interpretation that relationship stickiness is not primarily an aggregate amplification mechanism.

Table 5: Aggregate export and welfare response as sourcing relationships adjust

Outcome	$T = 0$	$T = 1$	$T = 2$	Long run
Export response (p.p.)	4.32	4.46	4.51	4.56
Export gain vs. $T = 0$ (%)	–	3.30	4.43	5.69
Real income gain (p.p.)	3.166	3.180	3.184	3.189
Welfare gain vs. $T = 0$ (%)	–	0.44	0.57	0.72

Notes: Level outcomes are reported as percentage-point log changes. Gain rows are percentages relative to $T = 0$.

The modest aggregate transition does not mean that relationship stickiness is unimportant. Instead, it means that relationship stickiness matters mainly for the distribution of adjustment across sectors. When relationships are fixed, sectors connected to scalable suppliers expand more because their suppliers can meet higher input demand with smaller price increases. As relationships adjust, downstream producers can reallocate toward more scalable suppliers, so inherited exposure becomes less important.

Table 6 shows that the scalable-supplier exposure premium is strongest on impact and fades as sourcing relationships adjust. Comparing country-sectors at the 90th and 10th percentiles of scalable-supplier exposure within downstream sectors, the high-exposure group increases exports by 18.19 percent more on impact. This premium falls to 9.56 percent after one year, 6.82 percent after two years, and 3.93 percent in the long run. Thus, most of the initial exposure premium disappears as relationship stickiness fades, indicating that scalable-supplier exposure matters primarily because firms cannot immediately reconfigure their inherited supplier networks.

The same table reports the corresponding gaps in marginal costs and input prices. These cost gaps provide the mechanism. High scalable-supplier exposure sectors have smaller increases in input prices and marginal costs than low scalable-supplier exposure sectors, especially on impact. These cost gaps shrink over time, together with the export-response gap. This pattern shows that the fading scalable-supplier exposure gradient is not mechanical. It reflects the weakening of upstream bottlenecks as downstream producers become less tied to inherited suppliers.

Taken together, the results show that supplier scalability matters in two ways. At the aggregate level, finite supplier supply elasticities attenuate the gains from a global demand shock. At the sectoral level, relationship stickiness determines where bottlenecks bind. High scalable-supplier exposure sectors expand more on impact because they face less upstream price pressure, but most of this advantage disappears as sourcing relationships adjust.

4.3 Global Policy: Fixed-budget supplier-upgrading

The next exercise asks where a global supplier-upgrading policy would have the largest effect. The exercise fixes a policy budget equal to 10 percent of supplier country-sectors. For each targeted

Table 6: Scalable-supplier exposure gradient over the adjustment horizon

Outcome	$T = 0$	$T = 1$	$T = 2$	Long run
p90/p10 export response (%)	18.19	9.56	6.82	3.93
p90/p10 marginal cost (%)	-12.54	-7.60	-5.69	-3.46
p90/p10 input price (%)	-23.97	-18.68	-16.71	-14.38
p10 export response (p.p.)	3.89	4.22	4.33	4.46
p90 export response (p.p.)	4.60	4.62	4.63	4.64

Notes: p90 and p10 compare country-sectors at the within-downstream-sector 90th and 10th percentiles of model-implied scalable-supplier exposure (SIE_{model}). Ratio rows are percentages. Export response rows are percentage-point log changes.

supplier country-sector, the model moves its supply elasticity up to the within-upstream-sector 90th percentile if it is below it. The shock considered is the same 10 percent global demand shock.

Table 7 compares five targeting rules. Random targeting is a placebo-style benchmark. Lowest- η targeting upgrades the most inelastic supplier country-sectors. Largest-sector targeting prioritizes supplier country-sectors with the largest baseline export value. Central-supplier targeting prioritizes supplier nodes with the largest baseline intermediate-input demand in the model network. Sticky-bottleneck targeting ranks supplier country-sectors by the product of inverse supply elasticity, baseline intermediate-input demand, and an upstream-sector stickiness weight.

Table 7: Fixed-budget supplier-upgrading exercise

Outcome	Baseline	Random	Low- η	Large	Central	Sticky
Export response (p.p.)	4.319	4.474	4.510	4.589	4.593	4.738
Real-income gain (p.p.)	3.166	3.370	3.403	3.650	3.653	3.794
Input-price change (p.p.)	1.545	1.407	1.379	1.304	1.305	1.186
Export gain vs. baseline (%)	—	3.59	4.43	6.27	6.36	9.72
Real-income gain vs. baseline (%)	—	0.20	0.23	0.47	0.47	0.61
Input-price change vs. baseline (%)	—	-8.95	-10.75	-15.61	-15.57	-23.26

Notes: The exercise upgrades 10 percent of supplier country-sectors under each rule, restricting targets to supplier cells below their within-upstream-sector p90 supply elasticity. Targeted cells are moved to the maximum of their baseline elasticity and the within-sector p90. Outcomes compare a 10 percent global demand shock.

The policy ranking is informative. Random targeting raises the aggregate export response by 3.59 percent relative to the no-upgrade baseline, while lowest- η targeting raises it by 4.43 percent. Pure bottleneck repair therefore helps, but not much, because many very inelastic suppliers are not central to downstream production. Targeting economic mass performs better: largest-sector and central-supplier targeting raise the export response by 6.27 and 6.36 percent, respectively. Sticky-bottleneck targeting performs best because it targets the constraints that are most likely to bind after a demand shock. It raises the export response by 9.72 percent relative to the baseline. This is 5.92 percentage points larger than random targeting and 5.06 percentage points larger than

lowest- η targeting. It also raises real income by 0.61 percent relative to the baseline and lowers input-price pressure by 23.26 percent. The lesson is that supplier upgrading is most valuable when it targets bottlenecks that are both economically central and hard for downstream producers to avoid in the short run.

4.4 Country Policy: Pre-arranging scalable supplier relationships

Next, we ask how much countries gain from pre-arranging supplier relationships before demand expands. These relationships remain dormant in normal times but can be activated when a demand shock arrives, allowing selected industries to scale more effectively with their flexible-sourcing network. In practice, this could reflect advance contracting, supplier qualification, reserved capacity, logistics arrangements, or other relationship-specific investments that make it possible to expand purchases from scalable suppliers quickly when demand rises.

When the global 10 percent demand shock arrives, selected country-industries can immediately source as they would in the long-run/no relationship stickiness equilibrium, while untreated industries remain tied to inherited supplier relationships. The exercise therefore measures gross option value rather than net welfare after relationship-building costs.

The all-industries benchmark reproduces the model’s existing fully flexible shock equilibrium. Relative to the sticky impact economy, full preparedness raises the global export response by 5.7 percent and real income by 0.7 percent. Table 8 asks how much of these gains can be captured when each country prepares only three industries.

Table 8: Gross option value of preparing three industries per country

Outcome	3 Random	3 Largest	3 Lowest SIE	3 Highest Stickiness
Full export gain captured (%)	28.6	65.5	41.6	29.8
Full welfare gain captured (%)	31.0	73.3	45.9	39.8
Treated export coverage (%)	17.5	53.7	18.1	15.3
Targeting efficiency	1.64	1.22	2.30	1.95

Notes: All targeting rules preprepare three industries per country. Selected country-industries can immediately activate flexible/no-stickiness sourcing when the 10 percent global demand shock arrives. Untreated industries retain sticky relationships. Random reports the average across predetermined draws. SIE is measured as weighted exposure to inverse supplier supply elasticities. Efficiency is the share of the full export gain captured divided by treated export coverage.

Targeting the three largest industries in each country captures the most aggregate benefit. It delivers 65.5 percent of the full export gain and 73.3 percent of the full welfare gain, while covering 53.7 percent of global exports. This reflects the large economic mass of the treated industries. However, its targeting-efficiency ratio is 1.22, below the random targeting benchmark of 1.64.

Targeting industries with the lowest model-based scalable-supplier exposure is more selective. We construct exposure to scalable-suppliers (SIE) from calibrated supplier supply elasticities: in-

dustries have low exposure when their inherited input bundles are heavily exposed to suppliers with low η_{iu} . Preparing the three lowest-SIE industries in each country captures 41.6 percent of the full export gain and 45.9 percent of the full welfare gain while covering only 18.1 percent of global exports. Its targeting-efficiency ratio is 2.30, the highest among the rules considered. By comparison, random targeting captures 28.6 percent of the full export gain with 17.5 percent export coverage.

Targeting the three highest-stickiness industries in each country also performs well. It captures 29.8 percent of the full export gain and 39.8 percent of the full welfare gain while covering only 15.3 percent of global exports, yielding a targeting-efficiency ratio of 1.95. This is substantially more efficient than random or largest-industry targeting because preparedness directly relaxes the relationship friction where it binds most strongly. However, high-stickiness targeting remains less efficient than low-SIE targeting. Stickiness identifies industries that have difficulty adjusting suppliers, but it does not by itself identify whether their inherited suppliers have low supply elasticities. The largest option values arise when sticky relationships coincide with exposure to upstream bottlenecks.

These results separate scale from targeting efficiency. Preparing large industries captures the largest share of aggregate gains, while preparing industries exposed to low-elasticity suppliers generates the largest gain per unit of treated export activity. Stickiness determines how difficult it is to escape an inherited network, while exposure to scalable-suppliers determines how costly that inherited network becomes when demand expands. Relationship preparedness is therefore especially valuable where both forces are present.

5 Conclusion

This paper studies a simple but important question: when foreign demand rises, how much does an economy’s ability to expand exports depend on the capacity of its suppliers to increase production? Using bilateral trade data linked to international input-output tables, I estimate supplier scalability at the country-industry level from export responses to foreign demand shocks and construct measures of downstream exposure to scalable suppliers based on pre-existing sourcing relationships. The empirical results show that supplier scalability varies sharply across industries within countries, that scalable suppliers tend to be connected to other scalable suppliers, and that downstream sectors exposed to more scalable suppliers respond more strongly to increases in foreign demand in sectors where firms cannot quickly replace existing suppliers.

To interpret and quantify these findings, I develop a multi-country, multi-sector general-equilibrium trade model with input-output linkages, heterogeneous supplier supply curves, and sourcing relationships that adjust gradually over time. The calibrated model shows that supplier bottlenecks substantially attenuate the export and welfare gains from a global demand expansion. Difficulties in switching suppliers shape where bottlenecks bind and how strongly they propagate through production networks. As a result, two sectors facing similar increases in demand can

experience very different outcomes depending on the scalability of their suppliers and their ability to access alternative sources of inputs.

These findings have implications for policies aimed at strengthening supply-chain resilience and supporting export growth. Policies that expand supplier capacity can generate larger benefits when directed toward economically central parts of the production network where limited scalability constrains production in downstream sectors. At the same time, capacity expansion is only one way to reduce these constraints. Pre-arranging relationships with alternative suppliers in advance can allow firms to respond more quickly when demand rises, particularly in sectors where sourcing relationships are otherwise slow to adjust. The counterfactual results therefore suggest that supplier upgrading and pre-arranged access to flexible sourcing networks are most valuable when targeted toward parts of the production network that are economically central, exposed to supply bottlenecks, and difficult to reconfigure.

The policy counterfactuals should be interpreted as measuring the potential gross benefits of relaxing supplier constraints rather than the full cost-effectiveness of specific interventions. Expanding capacity or developing alternative supplier relationships can be costly, and the model does not quantify these costs. Future work could incorporate endogenous investment in supplier capacity and sourcing relationships to study when such interventions are privately or socially optimal. Richer modeling of heterogeneity among domestic suppliers could also help identify more precisely where bottlenecks arise within countries and how firm-level adjustment affects their propagation. More broadly, the results suggest that understanding an economy's ability to respond to new export opportunities requires looking beyond downstream exporters themselves to the production networks and supplier constraints that support their expansion.

References

- Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi**, “The Network Origins of Aggregate Fluctuations,” *Econometrica*, 2012, 80 (5), 1977–2016.
- Ahn, JaeBin and Brandon Joel Tan**, “Supply Chain Diversification and Resilience,” IMF Working Paper 2025/102, International Monetary Fund 2025.
- Antràs, Pol, Teresa C. Fort, and Felix Tintelnot**, “The Margins of Global Sourcing: Theory and Evidence from US Firms,” *American Economic Review*, 2017, 107 (9), 2514–2564.
- Barrot, Jean-Noël and Julien Sauvagnat**, “Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks,” *The Quarterly Journal of Economics*, 2016, 131 (3), 1543–1592.
- Bernard, Andrew B., Andreas Moxnes, and Yukiko U. Saito**, “Production Networks, Geography, and Firm Performance,” *Journal of Political Economy*, 2019, 127 (2), 639–688.
- Boehm, Christoph E., Aaron Flaaen, and Nitya Pandalai-Nayar**, “Input Linkages and the Transmission of Shocks: Firm-Level Evidence from the 2011 Tohoku Earthquake,” *The Review of Economics and Statistics*, 2019, 101 (1), 60–75.
- Bonadio, Barthélemy, Zhen Huo, Andrei A. Levchenko, and Nitya Pandalai-Nayar**, “Global Supply Chains in the Pandemic,” *Journal of International Economics*, 2021, 133, 103534.
- Caliendo, Lorenzo and Fernando Parro**, “Estimates of the Trade and Welfare Effects of NAFTA,” *The Review of Economic Studies*, 2015, 82 (1), 1–44.
- Carvalho, Vasco M.**, “From Micro to Macro via Production Networks,” *Journal of Economic Perspectives*, 2014, 28 (4), 23–48.
- **and Alireza Tahbaz-Salehi**, “Production Networks: A Primer,” *Annual Review of Economics*, 2019, 11, 635–663.
- **, Makoto Nirei, Yukiko U. Saito, and Alireza Tahbaz-Salehi**, “Supply Chain Disruptions: Evidence from the Great East Japan Earthquake,” *The Quarterly Journal of Economics*, 2021, 136 (2), 1255–1321.
- Eaton, Jonathan and Samuel Kortum**, “Technology, Geography, and Trade,” *Econometrica*, 2002, 70 (5), 1741–1779.
- Martin, Julien, Isabelle Mejean, and Mathieu Parenti**, “Relationship Stickiness, International Trade, and Economic Uncertainty,” *The Review of Economics and Statistics*, 2026, 108 (1), 179–193.

A Appendix Figures and Tables

Table A1: Supplier scalability by upstream sector, 1995–1999 baseline

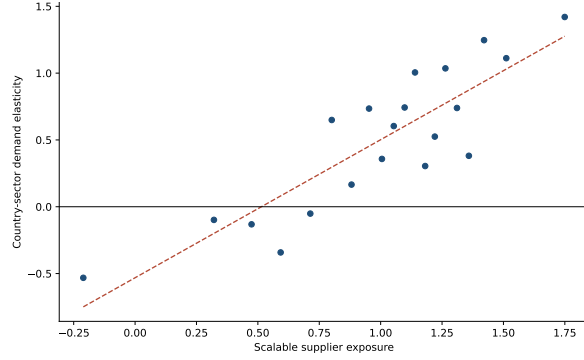
Sector	Industry	Mean S	SD	P25	P75	Suppliers
D28	Machinery	1.015	0.541	0.679	1.138	101
D10T12	Food, beverages, tobacco	0.985	0.604	0.545	1.026	177
D29	Motor vehicles	0.977	0.541	0.608	1.101	78
D22	Rubber and plastics	0.960	0.391	0.809	1.057	85
D23	Non-metallic minerals	0.958	0.879	0.737	1.214	103
D27	Electrical equipment	0.957	0.496	0.756	1.179	93
D13T15	Textiles, apparel, leather	0.956	0.906	0.805	1.331	144
D16	Wood products	0.947	0.656	0.661	1.127	96
D31T33	Furniture and other manufacturing	0.944	0.734	0.598	1.116	114
D25	Fabricated metals	0.938	0.475	0.846	1.234	100
D17T18	Paper and printing	0.935	0.446	0.683	1.080	82
D19	Coke and refined petroleum	0.934	0.545	0.739	1.054	111
D26	Computer and electronics	0.929	0.608	0.564	1.191	93
D24	Basic metals	0.927	0.798	0.573	1.147	125
D20	Chemicals	0.921	0.556	0.780	1.484	128
D21	Pharmaceuticals	0.846	0.561	0.370	0.993	79
D30	Other transport equipment	0.773	1.428	0.162	1.215	104

Notes: Mean S is the baseline-export-weighted mean of supplier-scalability estimates within each upstream sector. SD, P25, and P75 summarize the unweighted cross-supplier-country distribution of supplier scalability within the sector. Suppliers counts distinct supplier countries with non-missing scalability estimates.

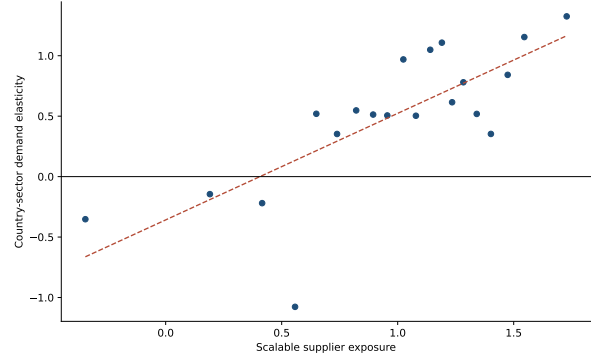
Table A2: Country-sector correlates of scalable supplier exposure

Variable	Unadjusted	Mean-centered Empirical Bayes	Zero-centered Empirical Bayes	N
Country-sector export size	0.001 (0.001)	0.001* (0.001)	0.002** (0.001)	3570
Log destinations served	0.003 (0.004)	0.004 (0.003)	0.001 (0.003)	3570
Destination diversification	0.020*** (0.007)	0.015*** (0.005)	0.009* (0.005)	3553
Baseline export growth	0.000 (0.003)	-0.000 (0.002)	-0.001 (0.002)	3505
Baseline growth volatility	-0.002 (0.002)	-0.003** (0.001)	-0.002 (0.001)	3463

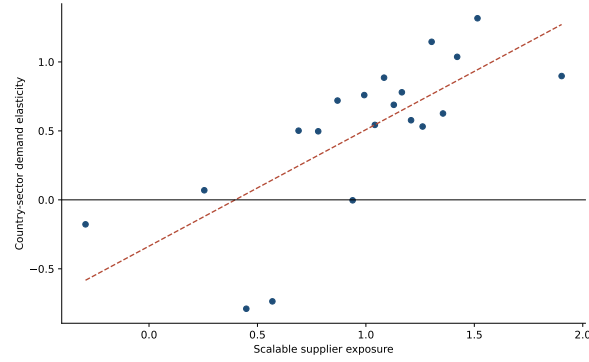
Notes: Each cell reports the coefficient from a separate regression of the indicated scalable-supplier exposure measure on the row variable. All regressions include country and sector fixed effects. Standard errors are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.



(a) Mean-centered Empirical Bayes



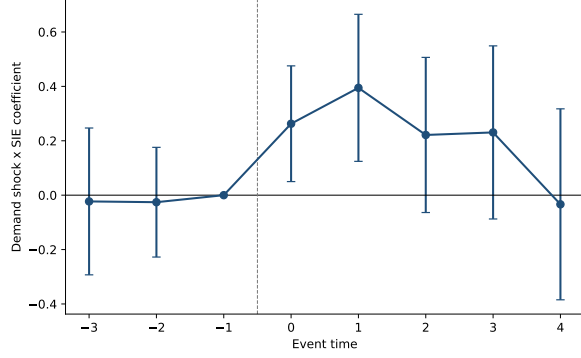
(b) Zero-centered Empirical Bayes



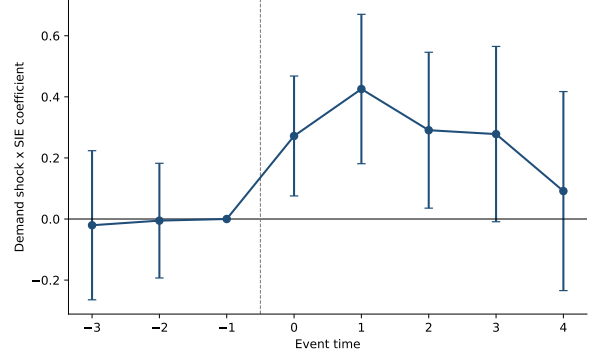
(c) Unadjusted

Figure A1: Export response rises with scalable-supplier exposure: High input relationship stickiness – Robustness to Measure

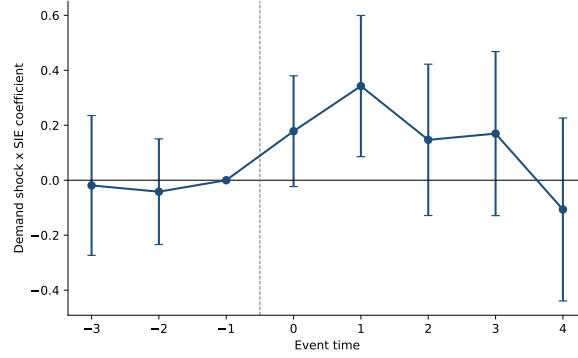
Notes: The sample is restricted to downstream country-sectors in sectors above the median input relationship-stickiness measure. For each country-sector, the demand elasticity is estimated from residualized one-year cumulative export growth and residualized demand shocks after absorbing country-sector and year fixed effects. Points plot binned means of the cell-level elasticities against the indicated scalable-supplier exposure measure. Cell-level elasticities are winsorized at the 1st and 99th percentiles; the dashed line is a linear fit through the bin means.



(a) Mean-centered Empirical Bayes



(b) Zero-centered Empirical Bayes



(c) Unadjusted

Figure A2: Dynamic cumulative export response: High input relationship stickiness – Robustness to Measure

Notes: The sample is restricted to downstream country-sectors in sectors above the median input relationship-stickiness measure. Each point is the coefficient on the interaction between the demand shock and the indicated scalable-supplier exposure measure at event horizons from $t - 3$ to $t + 4$. Outcomes are cumulative export growth relative to the shock year and are winsorized at the 5th and 95th percentiles within each horizon. Regressions include country-sector and country-year fixed effects; standard errors are clustered by country-sector. The omitted pre-period is normalized to zero at $t - 1$.

Table A3: Robustness to downstream country-sector leave-out supplier scalability

SIE measure	All		High input relationship stickiness	
	(1)	(2)	(3)	(4)
Unadjusted	0.031 (0.044)	0.021 (0.043)	0.280** (0.113)	0.335*** (0.122)
Mean-centered EB	0.039 (0.044)	0.026 (0.042)	0.348*** (0.128)	0.402*** (0.133)
Zero-centered EB	0.040 (0.044)	0.033 (0.042)	0.322*** (0.116)	0.429*** (0.120)
N	58,440	58,440	31,699	31,699
Year FEs	X		X	
Country-Sector FEs	X	X	X	X
Country-Year FEs		X		X

Notes: Outcome is one-year cumulative log export growth winsorized at the overall 5th and 95th percentiles. The sample uses positive demand shocks from 2000 onward. Relationship stickiness is constructed from HS6 product-level relationship-stickiness scores aggregated to ICIO upstream sectors using 2000-onward world-trade weights, then aggregated to downstream sectors using ICIO input weights. The high-input-relationship-stickiness column restricts the sample to downstream sectors above the median of the resulting sticky-input measure across observed country-sector cells. The scalable-supplier exposure is rebuilt after re-estimating supplier scalability for each downstream country-sector with the downstream country left out of the destination-sector demand component in the supplier demand shock. All regressions include the demand-shock main effect and the interaction between the demand shock and standardized SIE. SIE levels are absorbed by country-sector fixed effects. Standard errors are clustered by country-sector.

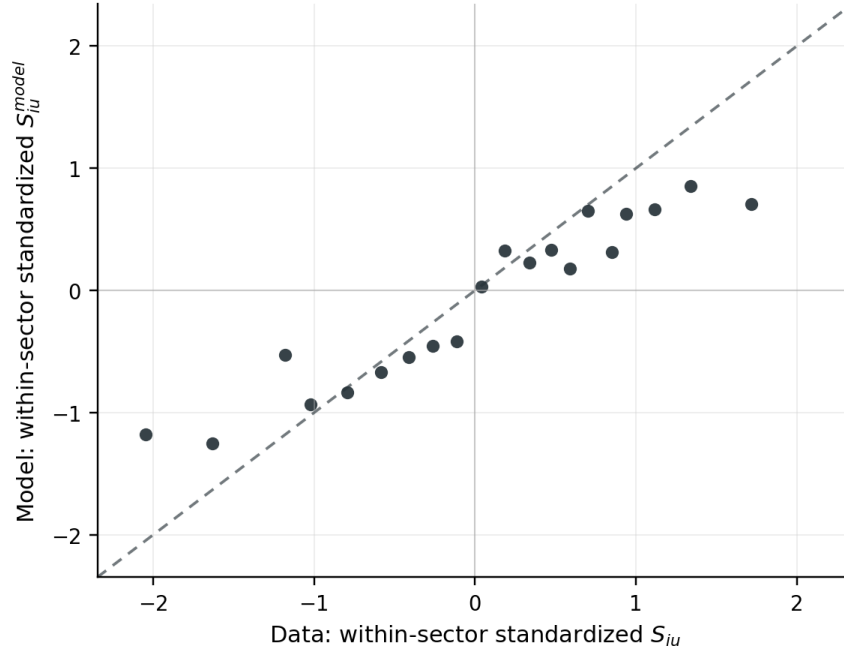


Figure A3: Supplier Scalability Calibration Fit

Notes: The binscatter shows the fit between $S_{iu}^{model}(\bar{\eta}_u, \lambda_u)$ and S_{iu} from the model calibration.



PUBLICATIONS

Scalable Suppliers in Global Trade Networks
Working Paper No. WP/2026/183