# International Trade in an Uncertain World

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# Motivation

- Growing concerns about *uncertainty* & *resilience* to shocks
  - Transportation disruptions in the aftermath of COVID-19
  - Uncertainty over national, regional and multilateral trade policies
  - National security concerns about access to critical goods
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- Key challenge: introducing general equilibrium uncertainty into nonlinear quantitative trade models
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- Key challenge: introducing general equilibrium uncertainty into nonlinear quantitative trade models
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  - However, most public debates about resilience involve decision-making under general eqm uncertainty
- We make three main contributions
  1. Develop a tractable approach to introducing *general equilibrium uncertainty* into the class of quantitative trade models with a constant trade elasticity
  2. Allow countries to make upfront investments in bilateral import and export capacities that determine *resilience* in the face of this general equilibrium uncertainty
  3. Show that a country's *risk profile* becomes a key determinant of bilateral patterns of international trade, the terms of trade and welfare

# Related Literature

- Quantitative trade models
  - Eaton and Kortum (2002), Arkolakis et al. (2012), Costinot & Rodriguez-Clare (2014), Caliendo & Parro (2015)
- Trade and uncertainty
  - Newberry & Stiglitz (1984), Koren & Tenreyro (2007, 2013), Caselli et al. (2020), Allen & Atkin (2022), Fitzgerald (2024), Caliendo et al. (2025), Castro-Vincenzi et al. (2025), Fan and Luo (2025)
- Reallocation in response to unanticipated trade policy
  - Alfaro and Chor (2023), Grossman et al. (2023), Fajgelbaum et al. (2024), Adão et al. (2025)
- International macroeconomics literature on international risk diversification
  - Cole and Obstfeld (1991), Backus et al. (1992), Backus & Smith (1993), Obstfeld and Rogoff (2000), Heathcote & Perri (2013), Coeurdacier & Gourinchas (2016), Baley et al. (2020), Aguiar et al. (2025), Fitzgerald (2025)
- Networks in macro and international economics
  - Acemoglu et al. (2012), Baqaee & Farhi (2019, 2024), Boehm et al. (2019), Liu (2019), Carvalho et al. (2021), Tascherau-Dumouchel (2022), Bachmann et al. (2024), Liu & Tsyvinski (2024), Nikolakoudis (2024), Elliott el. (2022), Elliot & Golub (2023), Grossman et al. (2024)
- Geoeconomics (international political economy of trade policy)
  - Hirschman (1945), Tinbergen (1962), Grossman & Helpman (1995), Broner et al. (2023), Clayton et al. (2023, 2024), Liu & Yang (2023), Thoenig (2023), Becko & Connor (2024), Kleinman et al. (2024)

# Outline

- Modeling Uncertainty and Resilience
- Data
- Quantitative Results
- Conclusions

# This Paper: Economic Environment

- Each country has a representative agent with labor endowment $\bar{\ell}_n$
- The representative agent is risk averse with constant relative risk aversion (CRRA) preferences
- Goods are differentiated by country of origin, subject to iceberg trade costs ($\tau_{ni} \geq 1$)
  - Trade gravity equation with a constant trade elasticity
- Consumption $c_{ni}$ by importer $n$ of the good produced by exporter $i$ requires:
  - *Ex ante* investments in import capacity by the importer ($\iota_{ni}$)
  - *Ex ante* investments in export capacity by the exporter ($h_{ni}$)
  - *Ex post* production labor by exporter ($\ell_{ni}$)

$$c_{ni} = \iota_{ni}^{\alpha} h_{ni}^{\beta} \left( z_i \ell_{ni} / \tau_{ni} \right)^{\delta}, \qquad \alpha + \beta + \delta = 1$$

- *Ex ante* investments chosen before observing random productivities $\{z_i\}$ and trade costs $\{\tau_{ni}\}$
  - Determine ability to trade with trade partners ("resilience")
- Labor market clearing

$$\bar{\ell}_n = \sum_{j=1}^{N} \iota_{nj} + \sum_{k=1}^{N} \left( \ell_{kn} + h_{kn} \right)$$

- Without uncertainty, competitive equilibrium is isomorphic to Armington model

- In the *ex post* stage, agents take *ex ante* investments $\{\iota_{ni}, h_{ni}\}$ as given
- In general equilibrium, each country's income equals the expenditure of all countries on its goods $\Longrightarrow$ wages must satisfy

$$w_i \left( \bar{\ell}_i - \sum_{k=1}^{N} \iota_{ik} - \sum_{n=1}^{N} h_{ni} \right) = \sum_{n=1}^{N} \frac{\left( \iota_{ni}^{-\alpha/\delta} h_{ni}^{-\beta/\delta} \tau_{ni} w_i / z_i \right)^{1-\tilde{\omega}}}{\sum_{j=1}^{N} \left( \iota_{nj}^{-\alpha/\delta} h_{nj}^{-\beta/\delta} \tau_{nj} w_j / z_j \right)^{1-\tilde{\omega}}} w_n \left( \bar{\ell}_n - \sum_{k=1}^{N} \iota_{nk} - \sum_{m=1}^{N} h_{mn} \right)$$

  - Isomorphic to Armington model with trade elasticity $\tilde{\omega} \equiv \frac{\omega}{\omega - \delta(\omega - 1)}$
  - *Ex ante* investments are absorbed into bilateral iceberg trade costs: $\tilde{\tau}_{ni} \equiv \iota_{ni}^{-\alpha/\delta} h_{ni}^{-\beta/\delta} \tau_{ni}$

# Characterizing the *Ex Ante* Equilibrium

- *Ex ante* investments depend on expectations over distribution of prices around the world
- *Ex ante* investments determine resilience in response to productivity realizations
  - Focus investments on cheaper suppliers and bigger buyers in expectation
  - Or diversify: option to trade with countries with poor expectations but good realizations

**Proposition.** The *ex ante* labor allocation satisfies

$$\sum_{i=1}^{N} \iota_{ni} = \alpha \bar{\ell}_n, \quad \sum_{k=1}^{N} h_{ki} = \beta \bar{\ell}_i,$$

$$\iota_{ni} \propto_n \mathbb{E}\left[\frac{\mathcal{U}'(\mathcal{C}_n)}{\mathcal{P}_n} p^x_{ni} x_{ni}\right]$$

$$h_{ni} \propto_i \mathbb{E}\left[\frac{\mathcal{U}'(\mathcal{C}_i)}{\mathcal{P}_i} p^x_{ni} x_{ni}\right]$$

**Proposition.** As a second-order approximation,

$$\iota_{ni} \propto_n \mathbb{E}\left[\left(\iota_{ni}^{-\alpha/\delta}\ell_{ni}^{-\beta/\delta}\tau_{ni}w_i/z_i\right)^{1-\tilde{\omega}}\right]$$
$$\times \exp\left(Cov\left(\ln \mathcal{C}_n^{-\gamma}, \ln\left(\tau_{ni}w_i/z_i\right)^{1-\tilde{\omega}}\right)\right)$$
$$\times \exp\left(Cov\left(\ln w_n/\mathcal{P}_n, \ln\left(\tau_{ni}w_i/z_i\right)^{1-\tilde{\omega}}\right)\right)$$
$$\times \exp\left(-Cov\left(\ln \mathcal{Q}_n^{1-\tilde{\omega}}, \ln\left(\tau_{ni}w_i/z_i\right)^{1-\tilde{\omega}}\right)\right)$$

Importer $n$ invests more into import capacity if $i$'s goods are cheap

- In expectation
- When $n$'s marginal utility is high
- When $n$ has high purchasing power
- When other goods in $n$'s consumption bundle are expensive

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$$h_{ni} \propto_i \mathbb{E}\left[\left(\iota_{ni}^{-\alpha/\delta}\ell_{ni}^{-\beta/\delta}\tau_{ni}\right)^{1-\tilde{\omega}}\mathcal{Q}_n^{-(1-\tilde{\omega})}w_n\bar{\ell}_n\right]$$
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$$\times \exp\left(Cov\left(\ln\left(w_i/z_i\right)^{1-\tilde{\omega}}, \ln\left(\tau_{ni}/\mathcal{Q}_n\right)^{1-\tilde{\omega}} w_n\right)\right)$$

Exporter $i$ invests more into export capacity if importer $n$ has higher expenditure on $i$

- In expectation
- When $i$'s marginal utility is high
- When $i$'s CPI is low (i.e., when revenue is valuable in real terms)
- When $i$'s cost of production is low

- Holds regardless of the distribution for exogenous productivity
- We solve for the mean, variance and covariance of the endogenous variables using a second-order approximation of the general equilibrium income accounting condition

# Certainty-equivalent Welfare and Gains from Trade

- Certainty-equivalent welfare:

$$\mathcal{W}_n \equiv \mathcal{U}^{-1}\left(\mathbb{E}\left[\mathcal{U}\left(\mathcal{C}_n\right)\right]\right) = \mathbb{E}\left[\mathcal{C}_n^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$

- To second-order,

$$\ln \mathcal{W}_n \quad \approx \quad \mathbb{E}\left[\ln \mathcal{C}_n\right] + \frac{1-\gamma}{2}\mathbb{V}\left[\ln \mathcal{C}_n\right]$$

- Gains from trade:

$$\begin{aligned} \ln \mathcal{W}_n/\mathcal{W}_n^{aut} \quad &\approx \quad \mathbb{E}\left[\alpha \ln\left(\frac{\iota_{nn}}{\alpha\bar{\ell}_n}\right) + \beta \ln\left(\frac{h_{nn}}{\beta\bar{\ell}_n}\right) + \delta \ln S_{nn}^{\frac{1}{1-\tilde{\omega}}}\right] \\ &= \quad + \frac{1-\gamma}{2}\left(\mathbb{V}\left[\ln \mathcal{C}\right] - \mathbb{V}\left[\ln \mathcal{C}^{aut}\right]\right) \end{aligned}$$

# Data

- Balanced panel of 106 countries over 1993-2017
- IMF Direction of Trade Statistics
  - Bilateral value of trade
- Global Macro Database (GMD)
  - Country GDP, price indexes and population
- World Input-Output Database (WIOD)
  - Country gross output for a sample of countries and years
  - Predict gross-output to GDP ratio out-of-sample using WIOD sample

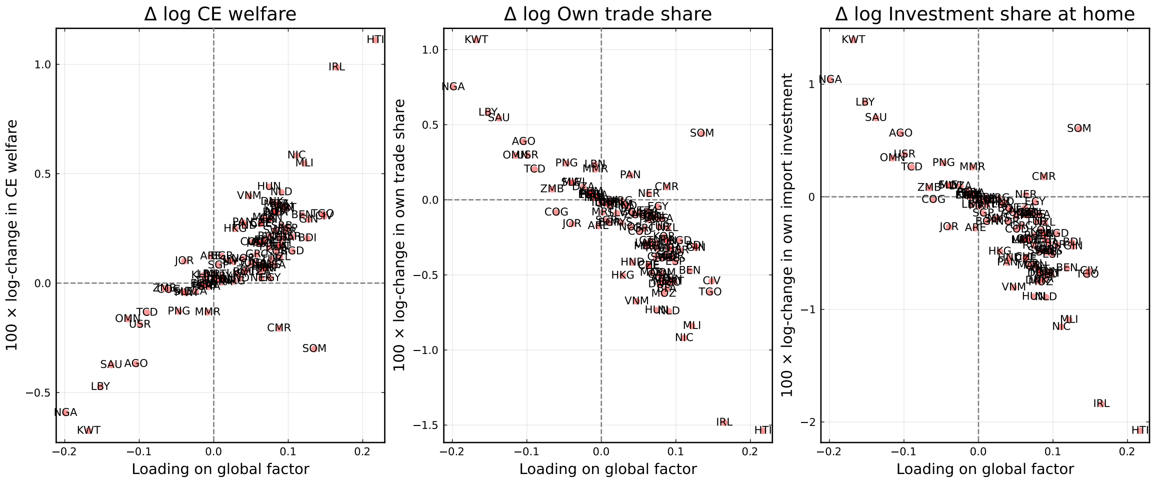
# Quantitative exercises

- Set baseline expected log-productivities ($\mu_z$) and trade frictions based on inverted values in 2017
  - Covariance matrix $\Sigma_z$ based on the full-sample
  - Inversion is based on the deterministic Armington model
- Parameters
  - $\beta = 0$ (no exporter ex-ante investments)
  - $\alpha = 0.5$, and $\omega = 9$: match short-run and long-run trade elasticities of $\theta^{SR} = \frac{\delta(\omega-1)}{(1-\delta)\omega+\delta} = 0.8$ and $\theta^{LR} = \alpha + \beta + \delta\omega - 1 = 4.0$
  - Risk aversion: $\gamma = 10$ (Collin-Dufresne et al. 2016)
- Undertake principle components decomposition of the variance-variance matrix

# Global Factor

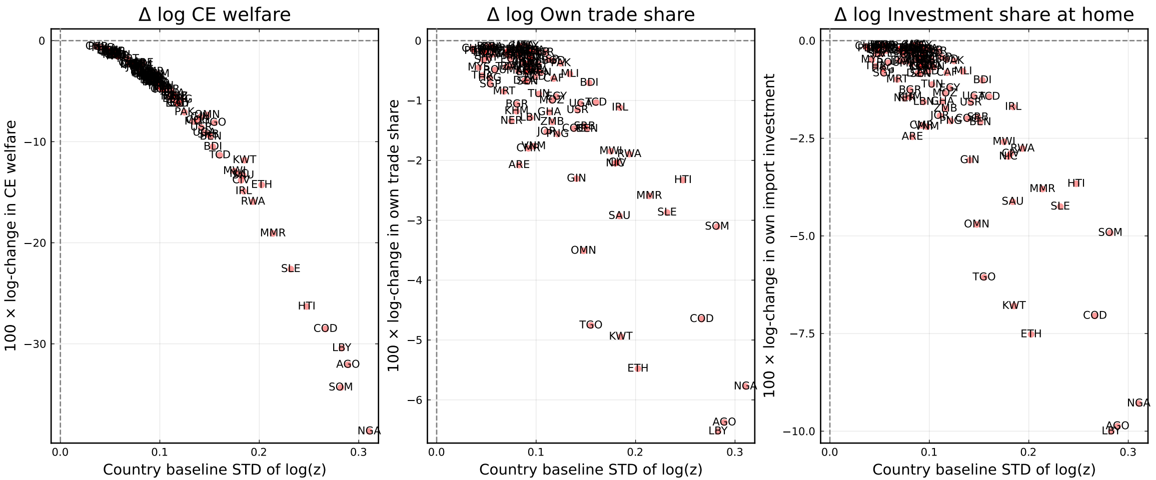

- Global factor (1st principal component) accounts for 43% of productivity variance
- First 5 factors account for 80%

# Counterfactual 1: Eliminating Correlations in Productivity (Holding Variance Constant)



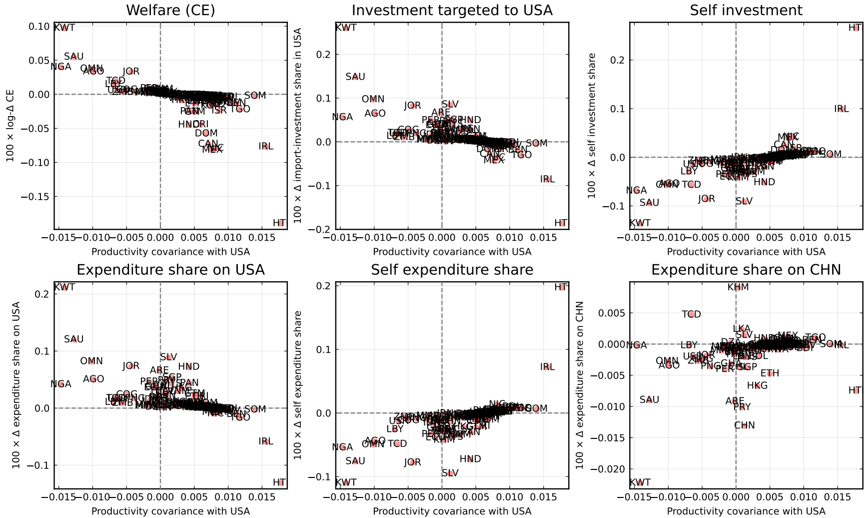

- Welfare ↑ in countries with positive loadings and ↓ in countries with negative loadings
- Removing correlation raises hedging opportunities through trade for countries with positive loadings
- Removing correlation reduces hedging opportunities through trade for countries with negative loadings

# Counterfactual 2: Doubling Global Uncertainty (Holding Constant Expected Productivity)




- Welfare goes down in all countries because of risk aversion
- Countries trade off domestic goods (with zero trade costs) against foreign goods (with positive trade costs but imperfectly correlated productivity)
- As global uncertainty ↑ ⇒ domestic investments ↓ and domestic trade shares ↓

# Counterfactual 3: Mean Preserving Spread for USA Productivity




- Holding constant mean U.S. productivity and cross-country correlations of productivity
- Countries with +ve covariance with U.S.: welfare ↓, US investment ↓, domestic investment ↑
- Countries with -ve covariance with U.S.: welfare ↑, US investment ↑, domestic investment ↓

# Conclusions

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Thank You