Goods Trade and Capital Investments in the Global Economy

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This Paper

• How do goods trade and international capital investments interact?
  – How much larger / smaller are costs of Brexit / Sanctions / US - China decoupling with both goods and capital market disintegration?

• Developed a tractable many-country model for analyzing this interaction that rationalizes key features of the observed data
  – Open-economy Ramsey model with differentiated goods trade, imperfect substitutability of capital investments, and growth on transition path
  – Within-period trade in goods consistent with the observed gravity equation for bilateral trade
  – Within-period capital allocation consistent with observed gravity equation for bilateral capital holdings
  – Across-period capital accumulation through consumption-saving decisions, consistent with observed current account imbalances

• Integrated framework featuring trade, capital / flows and growth that can be taken directly to the data and used for a range of applications
  – Sufficient statistics for comparative statics in terms of observed trade and investment shares and structural parameters
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Main Results

1. Real wage gains from trade differ from conventional ACR sufficient statistics of domestic trade share and trade elasticity
   - Endogenous changes in capital-labor ratio
   - Dynamic welfare gains and transition dynamics
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3. Capital market integration acts like an improvement in the efficiency of the investment technology
   - Stimulates capital accumulation and increases steady-state capital stock

4. Real wage gains from trade integration are larger for higher levels of capital market integration
   - For example, Brexit leads to a conventional static welfare loss from higher trade frictions via cross-substitution in goods markets
   - Brexit makes Britain a less attractive investment destination, because of reduced market access to the European Union
   - Welfare impact differs from comparative steady-state impact
Related Literature

• Quantitative international trade and sufficient statistics
  – Arkolakis et al. (2012), Adão et al. (2019), Baqae & Farhi (2019), Huo et al. (2019), Barthelme et al. (2019), Kleinman et al. (2020, 2021)

• International finance and international transmission of shocks

• Gravity equation in international trade

• Home bias and the gravity equation in capital investments

• Financial crises and the Great Recession
Outline

• Empirical Motivation
• Theoretical Framework
• New Implications for Trade and Welfare
• Quantitative Evidence
• Conclusions
• International Trade
  – United Nations COMTRADE
  – Bilateral international trade in goods

• International Capital Investments
  – Coordinated Portfolio Investment Survey (CPIS): equity and investment fund shares, long-term debt securities, and short-term debt securities
  – Global Debt Database (GDD): private and public debt of non-financial sector

• Country characteristics and distance
  – CEPII GEODIST database
  – Population-weighted distance between countries’ major cities
Gravity

• Fixed effects gravity equation estimation

\[ \ln X_{ni} = \eta_n + \mu_i + \delta \ln \text{dist}_{ni} + u_{ni}, \]

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• Gravity equation provides a good fit to observed data on bilateral international trade and capital investments
Correlation between bilateral capital investments and bilateral distance after conditioning on origin and destination fixed effects.
Outline

- Empirical Motivation
- Theoretical Framework
- New Implications for Trade and Welfare
- Quantitative Evidence
- Conclusions
Model Setup

- Economy consists of many countries $n, i \in \{1, \ldots, N\}$
- Time is discrete and indexed by $t \in \{0, \ldots, \infty\}$
- Each country supplies a differentiated good that is produced using labor and capital under constant returns to scale
- Markets are perfectly competitive
- Representative agent in each country endowed with labor $\ell_n$
- At the beginning period $t$, representative agent in each country inherits a stock of wealth $k_{nt}$ that is measured (and can be accumulated) in terms of its own consumption bundle
- Wealth is an aggregation of investments across countries
- Investments in each country are subject to idiosyncratic productivities and financial frictions
- Beginning period $t$: choose investment allocation across countries
- Beginning period $t + 1$: returns are realized and depreciation occurs, and investment again allocated across countries
Intertemporal Preferences

• Each country $n$ is endowed with mass $\ell_n$ of representative consumers with preferences

$$\max_{\{c_{nt}, k_{nit}\}} \sum_{s=0}^{\infty} \beta^{t+s} \left( \prod_{u=0}^{s} \phi_{nt+u} \right) \frac{c_{nt+s}^{1-1/\psi}}{1 - 1/\psi}$$

$$p_{nt} c_{nt} + p_{nt} \sum_{i=1}^{N} k_{nit+1} = (p_{nt} (1 - \delta) + \nu_{nt}) \sum_{i=1}^{N} k_{nit} + \omega_{nt}\ell_{n}$$

• Consumers in country $n$ choose how much to consume and how to allocate savings $\{k_{nit+1}\}$ across host countries $i$

• $\delta$ is the depreciation rate, $\nu_{nt}$ is return to capital in terms of the numeraire, $\phi_{nt+u}$ is a discount factor shock

• $p_{nt}$ is the price of country $n$’s consumption and investment bundle

• Gross nominal and real returns to investment are

$$R_{nt}^{\text{Nom}} = \frac{p_{nt} (1 - \delta) + \nu_{nt}}{p_{nt-1}}$$

$$R_{nt} = \frac{R_{nt}^{\text{Nom}}}{p_{nt} / p_{nt-1}} = 1 - \delta + \frac{\nu_{nt}}{p_{nt}}$$
Consumption-Saving Decisions

- Let $k_{nt} \equiv \sum_{i=1}^{N} k_{nit}$ denote country $n$'s total capital wealth.
- We can rewrite the budget constraint as:

$$c_{nt} + k_{nt+1} = R_{nt}k_{nt} + \frac{w_{nt}\ell_{nt}}{p_{nt}}$$

- Let $h_{nt} \equiv \sum_{s=1}^{\infty} \frac{w_{nt+s}\ell_{nt+s}/p_{nt+s}}{\prod_{u=1}^{s}R_{nt+u}}$ denote the PDV of labor income measured in consumption units.
- From Angeletos (2007), optimal consumption-saving decisions are linear in current-period wealth:

$$c_{nt} = \varsigma_{nt} \left( R_{nt}k_{nt} + \frac{w_{nt}\ell_{nt}}{p_{nt}} + h_{nt} \right)$$

- Where $\varsigma_{nt}$ is defined recursively as:

$$\varsigma_{nt}^{-1} = 1 + \beta^\psi \phi_{nt+1}^\psi R_{nt+1}^\psi \varsigma_{nt+1}$$
Capital Allocation Within Each Period

- Imperfect substitutability in capital investments
- Model with idiosyncratic productivity shocks \((\alpha_{nit})\)
- Iceberg financial frictions: \(\kappa_{nit} > 1\) for \(i \neq n\) and \(\kappa_{nnt} = 1\)
- Return to a unit of capital invested from source \(n\) in host \(i\) \((v_{nit})\)
  \[
  v_{nit} = \frac{\alpha_{nit} r_{it}}{\kappa_{nit}}, \quad \alpha \sim e^{-\alpha^e}, \quad e > 1
  \]
- Bilateral capital investments satisfy a gravity equation
  \[
  b_{nit} = \frac{k_{nit}}{k_{nt}} = \frac{(r_{it}/\kappa_{nit})^e}{\sum_{h=1}^{N} (r_{ht}/\kappa_{nht})^e}, \quad e > 1
  \]
- Expected return to capital is equalized across alternative hosts \(i\)
  \[
  v_{nit} = v_{nt} = \gamma \left[ \sum_{h=1}^{N} (r_{ht}/\kappa_{nht})^e \right]^{\frac{1}{e}}, \quad \gamma \equiv \Gamma \left( \frac{\epsilon - 1}{\epsilon} \right)
  \]
Keynesian Marginal Efficiency of Capital

\[ \ln \bar{\alpha}_{nit} \]

\[ \ln b_{nit} \]

Slope \(-1/\varepsilon\)
Production and Trade

- Consumption and investment bundles follow CES (Armington):

\[ c_{nt} = \left[ \sum_{i=1}^{N} \left( c_{nit} \right)^{\theta+1} \right]^{\frac{\theta+1}{\theta}} \]

\[ \theta = \sigma - 1, \quad \sigma > 1 \]

- Country n’s expenditure share on good i:

\[ s_{nit} = \frac{\tau_{nit}p_{it}^{-\theta}}{\sum_{h=1}^{N} \tau_{nht}p_{ht}^{-\theta}} \]

- Prices

\[ p_{nit} = \frac{\tau_{nit}w_{it}^{\lambda}r_{it}^{1-\lambda}}{z_{it}} \]

\[ p_{nt} = \left[ \sum_{i=1}^{N} p_{nit}^{-\theta} \right]^{-1/\theta} \]

- Total payments for capital used in country i are proportional to payments for labor:

\[ \sum_{n=1}^{N} v_{nt}k_{nit} = r_{it}\tilde{k}_{it} = \frac{1-\lambda}{\lambda} w_{it}\ell_{i}, \quad \tilde{k}_{it} = \sum_{n=1}^{N} \gamma b_{nit}^{-\frac{1}{\epsilon}} k_{nit} \]
Market Clearing and Numeraire

- Goods market clearing:

\[ w_{it} \ell_i + \sum_{n=1}^{N} \nu_{nit} k_{nit} = \sum_{n=1}^{N} s_{nit} \left( p_{nt} c_{nt} + p_{nt} k_{nt+1} - p_{nt} \left(1 - \delta \right) k_{nt} \right) \]

\[ \iff w_{it} \ell_i = \lambda \sum_{n=1}^{N} s_{nit} \left( \nu_{nt} k_{nt} + w_{nt} \ell_n \right) \]

- We use world GDP as the numeraire, so

\[ 1 = \sum_{i=1}^{N} \left( w_{it} \ell_i + \sum_{n=1}^{N} \nu_{nit} k_{nit} \right) \]

\[ = \frac{1}{\lambda} \sum_{i=1}^{N} w_{it} \ell_i \]
General Equilibrium

- Given state variables \( \{ k_{nt} \}_{n=1}^{N} \), equilibrium endogenous variables \( \{ w_{nt}, r_{nt}, s_{nit}, v_{nt}, b_{nit} \}_{n=1}^{N} \) satisfy

\[
\begin{align*}
    s_{nit} &= \frac{\left( \frac{\tau_{nit} w_{it}^{\lambda} r_{it}^{1-\lambda}}{z_{it}} \right)^{-\theta}}{\sum_{h=1}^{N} \left( \frac{\tau_{nht} w_{ht}^{\lambda} r_{ht}^{1-\lambda}}{z_{ht}} \right)^{-\theta}} \\
    w_{it} \ell_i &= \lambda \sum_{n=1}^{N} s_{nit} (v_{nt} k_{nt} + w_{nt} \ell_n) \\
    b_{nit} &= \frac{(r_{it} / \kappa_{nit})^{\epsilon}}{\sum_{h=1}^{N} (r_{ht} / \kappa_{nht})^{\epsilon}} \\
    v_{nt} &= \gamma \left[ \sum_{h=1}^{N} (r_{ht} / \kappa_{nht})^{\epsilon} \right]^{1/\epsilon} \\
    \sum_{n=1}^{N} v_{nt} b_{nit} k_{nt} &= \frac{1 - \lambda}{\lambda} w_{it} \ell_i, \quad \frac{1}{\lambda} \sum_{i=1}^{N} w_{it} \ell_i = 1
\end{align*}
\]
General Equilibrium

- Evolution of state variables \( \{k_{nt}\}_{n=1}^{N} \) follows

\[
k_{nt+1} = (1 - \zeta_{nt}) \left( R_{nt} k_{nt} + \frac{w_{nt} \ell_{n}}{p_{nt}} + h_{nt} \right) - h_{nt}
\]

\[
h_{nt} \equiv \sum_{s=1}^{\infty} \frac{w_{nt+s} \ell_{nt+s} / p_{nt+s}}{\prod_{u=1}^{s} R_{nt+u}}
\]

\[
p_{nt} \equiv \left[ \sum_{i=1}^{N} \left( \tau_{nit} w_{it}^{\lambda} r_{it}^{1-\lambda} / z_{it} \right)^{-\theta} \right]^{-1/\theta}
\]

- where \( \zeta_{nt} \) is defined recursively as

\[
\zeta_{nt}^{-1} = 1 + \beta^{\psi} \phi_{nt+1}^{\psi} R_{nt+1}^{\psi-1} \zeta_{nt+1}^{-1}
\]
Steady-State Equilibrium

• Steady-state equilibrium of the model:
  - Time-invariant values of the state variables \( \{k_n^*\}_{n=1}^N \) and the other endogenous variables of the model \( \{w_n^*, r_n^*, s_{ni}^*, v_{nt}^*, b_{ni}^*\}_{n=1}^N \)
  - Given time-invariant values of country fundamentals \( \{\ell_n, z_n\}_{n=1}^N \) and \( \{\tau_{ni}, \kappa_{ni}\}_{n,i=1}^N \) (set \( \phi_{nt} = 1 \) for all \( n, t \))
  - Denote the steady-state values of variables by an asterisk

• Steady-state gross real return to capital \( (R_n^*) \) and the steady-state saving rate \( (\varsigma_n^*) \) are inversely related to discount factor \( (\beta) \):
  \[
  R_n^* = \frac{1}{\beta}, \quad \varsigma_n^* = 1 - \beta
  \]

• Common steady-state realized real return to capital \( (v_n^*/p_n^*) \):
  \[
  \frac{v_n^*}{p_n^*} = \beta^{-1} - 1 + \delta
  \]

• Recover steady-state capital and labor income \( (q_n^* = w_n^*\ell_n \text{ and } \zeta_n^* = v_n^*k_n^*) \) from one of trade share matrices \( (S^*, T^*) \) and one of capital share matrices \( (B^*, X^*) \)
Transition Dynamics

• Observe the economy somewhere on the transition path to an unobserved steady-state with time-invariant fundamentals

• Suppose we observe labor and capital income \((q, \zeta)\) and the trade and capital share matrices \((S, T, B, X)\) for this initial equilibrium

• Linearize the model around initial unobserved steady-state equilibrium \((\tilde{x} \equiv \ln x_t - \ln x^*)\) and define

\[
\tilde{\tau}_{nt}^{in} \equiv \sum_{i=1}^{N} S_{nit} \tilde{\tau}_{nit}, \quad \tilde{\tau}_{it}^{out} \equiv \sum_{n=1}^{N} T_{int} \tilde{\tau}_{nit},
\]

\[
\tilde{\kappa}_{nt}^{out} \equiv \sum_{i=1}^{N} B_{nit} \tilde{\kappa}_{nit}, \quad \tilde{\kappa}_{it}^{in} \equiv \sum_{n=1}^{N} X_{int} \tilde{\kappa}_{nit}
\]

\[
\tilde{f}_t = \begin{bmatrix} \tilde{z}_t \quad \tilde{\kappa}_t^{in} \quad \tilde{\kappa}_t^{out} \quad \tilde{\tau}_t^{in} \quad \tilde{\tau}_t^{out} \end{bmatrix}^\prime
\]

• Solve in closed-form for the transition path of the endogenous variables in response to a future sequence of shocks \(\tilde{f}_t\)
Outline

• Empirical Motivation

• Theoretical Framework

• New Implications for Trade and Welfare

• Quantitative Evidence

• Conclusions
(1) Welfare Gains from Trade

- Exogenous \( \tilde{k}_i \rightarrow \) ACR class of models in which domestic trade share \( s_{nt}^T \) and trade elasticity \( (\theta) \) are sufficient statistics for real wage

\[
s_{nit} = \frac{\left( \tau_{nit} w_{it} \left( \frac{1-\lambda \ell_i}{\lambda \tilde{k}_{it}} \right)^{1-\lambda} / z_{it} \right)^{-\theta}}{\sum_{h=1}^{N} \left( \tau_{nht} w_{ht} \left( \frac{1-\lambda \ell_h}{\lambda \tilde{k}_{ht}} \right)^{1-\lambda} / z_{ht} \right)^{-\theta}}
\]

\[
p_{nt} \equiv \left[ \sum_{i=1}^{N} \left( \tau_{nit} w_{it} \left( \frac{1-\lambda \ell_i}{\lambda \tilde{k}_{it}} \right)^{1-\lambda} / z_{it} \right)^{-\theta} \right]^{-1/\theta}
\]

\[
\frac{w_{nt}^T / p_{nt}^T}{w_{nt}^A / p_{nt}^A} = \left( \frac{\tilde{k}_{nt}^T}{\tilde{k}_{nt}^A} \right)^{1-\lambda} \left( \frac{1}{s_{nnt}^T} \right)^{1/\theta}
\]

- More generally, welfare gains from trade differ from ACR
  1. Both capital and labor income
  2. Endogenous response of \( \tilde{k}_{it} \) to trade liberalization
  3. Dynamic welfare gains and transition dynamics
     \( \Rightarrow \) welfare impact \( \neq \) comparative steady-state impact
(2) Trade Integration and Investment

- Goods trade integration induces capital accumulation and raises the steady-state capital-labor ratio
- Steady-state

\[ v_n^* = \gamma \left[ \sum_{h=1}^{N} \left( \frac{r_h^*}{\kappa_{hn}} \right)^{\frac{1}{\epsilon}} \right]^{\frac{1}{\epsilon}} = \gamma \frac{r_n^* / \kappa_{nn}}{(b_{nn}^*)^{\frac{1}{\epsilon}}}, \quad v_n^* = [\beta^{-1} - 1 + \delta] \ p_n^* \]

\[ r_n^* = \frac{[\beta^{-1} - 1 + \delta] \ p_n^*}{\gamma / \kappa_{nn}} (b_{nn}^*)^{\frac{1}{\epsilon}}, \quad \tilde{k}_n^* = \frac{1 - \lambda}{\lambda} \ \frac{w_n^*}{r_n^*} \]

\[ \Rightarrow \quad \frac{\tilde{k}_n^*}{\ell_n} = \frac{1 - \lambda}{\lambda} \ \frac{\gamma / \kappa_{nn}}{[\beta^{-1} - 1 + \delta] (b_{nn}^*)^{\frac{1}{\epsilon}}} \ p_n^* \]

- Sufficient statistics for impact opening of closed economy on real wage

\[ \frac{w_n^{T*}}{p_n^{T*}} / \frac{w_n^{A*}}{p_n^{A*}} = \left( \frac{1}{b_{nn}^{T*}} \right)^{\frac{1}{\lambda \epsilon}} \left( \frac{1}{s_{nn}^{T*}} \right)^{\frac{1}{\lambda \theta}} \]

- Goods and capital market integration interact with one another
(3) Capital Market Integration

• Recall the expected return to capital

\[ v_{ni} = v_n = \gamma \left[ \sum_{h=1}^{N} \left( \frac{r_h}{\kappa_{nh}} \right)^\epsilon \right]^\frac{1}{\epsilon} = \gamma \frac{r_n}{\kappa_{nn}} \left( \frac{b_{nn}}{\epsilon} \right)^\epsilon \]

• Steady-state expected return to capital

\[ \frac{v_n^*}{p_n^*} = \beta^{-1} - 1 + \delta \]

• Combining these two expressions

\[ \frac{v_n^*}{p_n^*} = \beta^{-1} - 1 + \delta = \gamma \frac{r_n^*/\kappa_{nn}}{p_n^*(b_{nn})^\epsilon} \]

• Capital market autarky: \( b_{nn}^* = 1 \)

• Capital market integration: \( 0 < b_{nn}^* < 1 \Rightarrow \) other things equal, \( r_n^* \downarrow \)

• Capital market integration increases expected return to investment and acts like an improvement in the investment technology, which stimulates capital accumulation, and reduces the rental rate
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• Empirical Motivation

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Quantitative Evidence

• Illustrate these theoretical predictions quantitatively using Brexit as a first empirical application
• Start with the observed data for 2015 before Brexit
• Shock trade cost, capital market frictions, or both, between the UK and EU countries
• UK experiences a welfare loss from higher trade frictions, as in a conventional trade model
  – Cross-substitution effects, as substitute towards trade with other nations and domestic trade
• UK welfare loss magnified as it becomes a less attractive investment destination, because of reduced market access to the European Union
  – Reduces steady-state capital-labor ratio in the United Kingdom
  – Slower rate of growth along the transition path to steady-state
• Examine impulse response functions for consumption
• Other applications to decoupling between China and USA and trade and capital market sanctions on Russia
Parameterization

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<td>Investment elasticity</td>
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• Observe $T$, $S$ and $B$ matrices in 2015
• Recover implied $X$ matrix and income vectors \{q, $\zeta$\}
• Consider a small shock to trade or capital frictions or both
• Solve for the consumption impulse response
GBR $S$ versus $B$ Matrix

Log Shares in Trade and Capital, GBR 2015
Brexit on consumption: dynamic model
shock bilateral capital flow cost
Brexit on consumption: dynamic model
shock both trade and capital flow costs
Brexit and DEU Consumption

Brexit on DEU consumption

dynamic model: trade cost shock
dynamic model: capital frictions
dynamic model: both shocks
static model: trade cost shock

caption
Brexit and UK Investment

UK business investment has underperformed the trend

£bn in 2019 value (taking into account an ONS error)

- Business investment
- 2009-2015 trend

Sources: ONS, FT calculation © FT
Foreign direct investment into the UK has fallen since the Brexit vote

4-year average foreign direct investment inflows as a share of GDP, 1973-2020

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• Empirical Motivation

• Theoretical Framework

• New Implications for Trade and Welfare

• Empirical Results

• Conclusions
Conclusions

• Do goods trade and international capital investments interact?
  – How much larger / smaller are costs of Brexit / Sanctions / US - China decoupling with both goods and capital market disintegration?

• Develop a tractable many-country model for analyzing this interaction that rationalizes key features of the observed data
  – Within-period trade in goods consistent with the observed gravity equation for bilateral trade
  – Within-period capital allocation consistent with observed gravity equation for bilateral capital holdings
  – Across-period capital accumulation through consumption-saving decisions, consistent with observed current account imbalances

• Integrated framework featuring trade, capital flows and growth that can be taken directly to the data and used for a range of applications
  1. Real wage gains from opening closed economy differ from ACR formula
  2. Goods trade integration stimulates capital accumulation and increases the steady-state capital-labor ratio
  3. Capital market integration like improvement investment productivity
  4. Real wage gains to trade integration are increasing in capital integration