Trade Wars with FDI Diversion

Spillover Conference, Basel

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Motivation

What are the impacts of trade policies on trade and welfare?

The Economist

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Accounting for the *responses* of **F**oreign **D**irect **I**nvestment & the *patterns* significantly change the quantitative implications of the Trump Tariffs.

This Paper

1. **Empirical evidence** connecting tariffs, trade and FDI;
2. A multi-country GE quantitative trade **model** incorporating FDI diversion;
   - FDI as producers choosing export-platform locations:
     Welfare effects of tariff changes: terms-of-trade, profit-shifting, relocation effects;
   - A tractable and flexible method to generate heterogeneous bilateral FDI diversion elasticities;
     Important for the *patterns* of FDI diversion, e.g., Vietnam;
3. **Calibrate** to world economy before the China-US trade war;
   Quantitative evaluations of the Trump Tariffs.

Summary of Results

- **Empirical** results:
  - Countries more exposed to trade diversion from the Trump Tariffs: higher inward FDI stocks;
  - Document country characteristics correlated with magnitude of bilateral FDI responsiveness;

    E.g., China and Vietnam;
- **Quantitative** results:
  - FDI diversion greatly changes aggregate welfare implications;

    E.g., China's losses tripled, the US flips from losses to gains;
  - Distributional implications: mechanisms and numbers;

    E.g., China's losses are borne by "consumers", not "producers", while US consumers gain;
  - FDI diversion leads to larger tariff incentives;
  - Pattern of FDI diversion especially important for certain cases, e.g. Chinese FDI in Vietnam.

Literature

- Trade Policies & Trade Diversion:

  Waugh'19WP; Flaaen, Hortacsu & Tintelnot'20AER; Amiti, Redding & Weinstein'19JEP,'20AER; Amiti, Kong & Weinstein'20WP; Fajgelbaum, Goldberg, Kennedy, Khandelwal & Taglioni'21WP; McCaig, Pavcnik & Wong'22WP; IMF World Economic Outlook, 2023 Apr; Ma & Meng'23CanadianJE; Chor & Li'24JIE;

  Optimal Tariff: Dixit'85HB; Ossa'14AER; Caliendo & Parro'22HB; Ju, Ma, Wang & Zhu'24JME;

- Multinational Production & FDI:

  Helpman'84JPE; Helpman, Melitz & Yeaple'04AER; Ramondo & Rodríguez-Clare'13JPE; Irarrazabal, Moxnes & Opromolla'13JPE; Tintelnot'17JPE; Arkolakis, Ramondo, Rodriguez-Clare & Yeaple'18AER; Alfaro & Chor'23WP;

  Heterogeneous Elasticity: Lind & Ramondo'23AER;

- International Capital Allocations:

  Portes & Rey'05JIE; Eaton, Kortum, Neiman & Romalis'16AER; Alessandria, Choi, and Lu'17IMF; Reyes-Heroles'17WP; Ravikumar, Santacreu & Sposi'19JIE; Anderson, Larch & Yotov'19EER; Li, Nie & Wang'20JIMF; Kleinman, Liu, Redding & Yogo'22WP; Hu'23WP; Correa, di Giovanni, Goldberg & Minoui'23.

Roadmap

1. **FDI Responses to the Trump Tariffs**
2. **Model with FDI Diversion**
3. **Calibration & Quantitative Evaluations**

FDI Responses to the Trump Tariffs

The Trump Tariffs: Who Gets Diverted Trade

- Logic: Tariffs $\rightarrow$ trade diversion $\rightarrow$ production capacity adjustment: FDI;
- The US increased tariffs on China that covered about \$350b in trade flows over 2018-2019;
  - Shift: tariff increase across goods ν, $\Delta\tau_{\text{US,CN}}(\nu)$;
  - Share: country i's and China's 2017 trade shares;

Construct a country's **exposure to trade diversion** from the Trump Tariffs;

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  - Share: country i's and China's 2017 trade shares;

  Construct a country's **exposure to trade diversion** from the Trump Tariffs;
- When does a big $\Delta\tau_{\mathrm{US,CN}}(\nu)$ create large trade diversion "opportunities" for country i?
  - i specializes in ν;
  - The US is a large market for i on ν;
  - China accounts for a large fraction of US imports on ν;

$$\textbf{Trade Diversion Index: } \mathbf{DI_i} = \sum_{\nu} \underbrace{r_{\mathrm{i}}(\nu)}_{\substack{\text{i's revenue share}\\ \text{for good } \nu}} \cdot \overbrace{r_{\mathrm{US,i}}(\nu)}^{\substack{\text{i's revenue share}\\ \text{from US for good } \nu}} \cdot \underbrace{\pi_{\mathrm{US,CN}}(\nu)}_{\substack{\text{US's import share}\\ \text{from China for good } \nu}} \cdot \Delta\tau_{\mathrm{US,CN}}(\nu).$$

Event Study Design: Treat the 2018-2019 Trade War as an Event

- Denote the inward FDI stocks as **FDK**;
- **Country** level regression:

$$\ln \mathrm{FDK}_{it} = \mathrm{FE}_i + \mathrm{FE}_t + \sum_{t'=2013, t' \neq 2017}^{2021} \vartheta_{t'} \mathbb{1}_{\{t'\}} \times \mathrm{DI}_i + u_{it};$$

Data: OECD Int'l direct investment database + IMF Coordinated Direct Investment Survry;

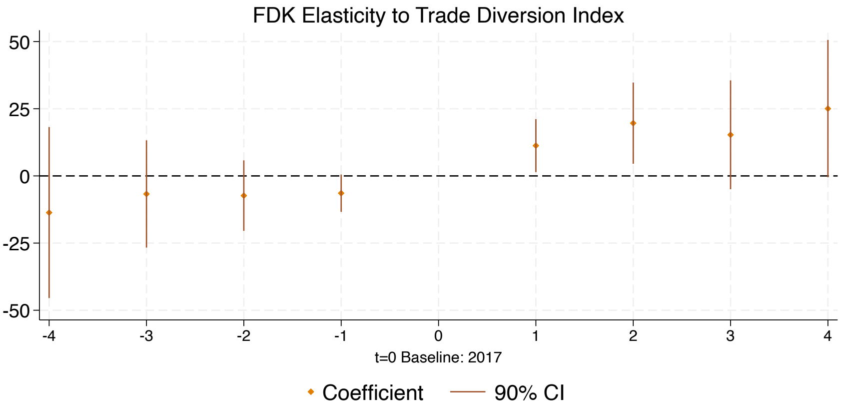
- **Sector** (NAICS 3-digit) level:

$$\ln J_{sit} = \mathrm{FE}_{it} + \mathrm{FE}_{st} + \mathrm{FE}_{si} + \sum_{t'=2013, t' \neq 2017}^{2021} \vartheta_{t'} \mathbb{1}_{\{t'\}} \times \mathrm{DI}_{si} + u_{sit},$$

where J_{sit} is the cumulative estimated jobs created from FDI;

Data: fDi Markets – project-level database since 2003, with source country, receiver, sector.

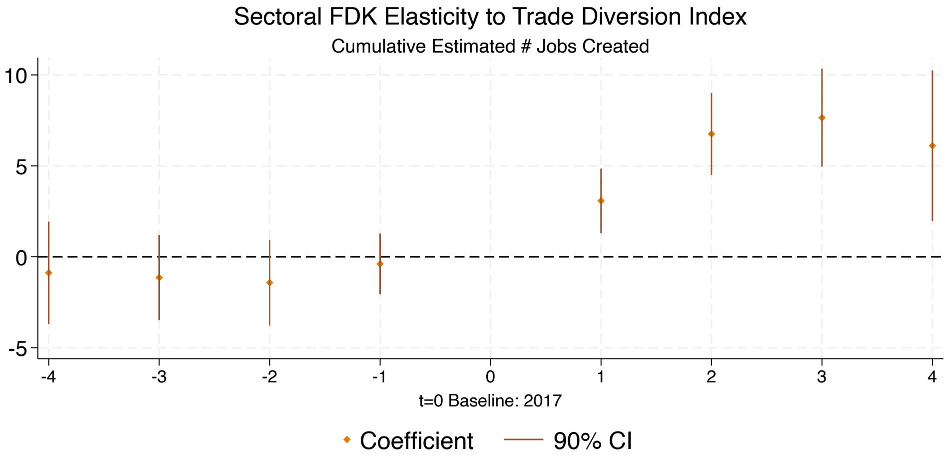
Country Level Result



Point estimate $\vartheta \approx 20$, 95th percentile DI ≈ 0.004 (which is Vietnam) $\Rightarrow$ 8% relative growth.

▸ XR adj. ▸ Sector Tariff ▸ Bilateral Stock ▸ EX. Growth

Sector Level Result: Cumulative Estimated Jobs Created



▸ # Projects ▸ Est. Capital Inv. ▸ Flow (ppml) ▸ Official vs. fDi

Systematic Factors for Responsiveness Heterogeneity

- $\mathbf{Z}_{ij}$: Bilateral country characteristics;
- $$\mathrm{d}\ln \mathrm{FDK}_{ij} = \mathrm{FE}_i + \mathrm{FE}_j + \mathbf{Z}_{ij}\tilde{\psi} + \left(\underbrace{\mathrm{d}\ln \mathrm{FDK}_i}_{\text{Proxy for change of receiver's overall FDI attractiveness;}} \cdot \mathbf{Z}_{ij}\right)\psi + u_{ij}$$

	ψ
$\mathrm{d}\ln \mathrm{FDK}_i \times \ln(\mathrm{Dist}_{ij})$	-0.284**
	(0.122)
$\mathrm{d}\ln \mathrm{FDK}_i \times \ln(\mathrm{GDPpc}_j)$	0.156**
	(0.065)
$\mathrm{d}\ln \mathrm{FDK}_i \times \mathrm{ComparaAdv}_{ij}$	0.599**
	(0.283)
R^2	0.105
# of Obs.	2735

Notes: The dependent variable is the bilateral FDI growth from 2017 to 2019. The sample includes 34 source countries and 199 receiver countries. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

- Geographic distance;
- Source country GDP per capita;
- Comparative advantage similarity (correlation of two countries' export portfolio over sectors): e.g. China & Vietnam.

VNM-UK Example | Other Factors | Sector Level

Model with FDI Diversion

Model Overview

- Static;
- N countries: exogenous efficiency units of labor $\{L_j\}$ and aggregate firm productivity $\{z_j\}$;
- S sectors;
- Representative **household**: consume aggregate goods;
- A fixed unit mass of **producers** indexed by ω in each **source country j** and sector s;
  - Each ω produces a differentiated tradable variety with monopolistic competition;
  - Simplifying assumption: Each ω operates in one **production country i** as an export platform;
- Key model mechanisms:
  - Producer's location choice $\rightarrow$ Trade shocks lead to trade and FDI diversion;
  - "FDI with Correlation" $\rightarrow$ Heterogeneous FDI diversion elasticities.

CES Demand

- For each **importing country h** and sector s:
  - Sectoral non-tradable composite goods aggregated by purchasing all varieties, supplied at cost:

$$Q_h^s = \left(\sum_{j=1}^{N} \sum_{i=1}^{N} \int_{M_{ij}^s} \left(q_{hij}^s(\omega) \right)^{\frac{\epsilon^s - 1}{\epsilon^s}} d\omega \right)^{\frac{\epsilon^s}{\epsilon^s - 1}} ;$$

  - M_{ij}^s: the endogenous set of varieties by producers from source country **j** produced in **i** in sector s;
  - Two frictions between **i** and **h**: iceberg trade costs $\{d_{hi}^s\}$, and one plus ad-valorem tariffs $\{\tau_{hi}^s\}$;
- Sectoral composites aggregate into final goods for consumption:

$$Q_h = \prod_{s=1}^{S} \left(Q_h^s \right)^{\phi_h^s}, \text{ s.t. } \sum_s \phi_h^s = 1.$$

Household Consumption

- The household consumes the final good, and the expenditure $X_h \equiv P_h C_h$ equals

$$w_h L_h + D_h + T_h - \Gamma_h;$$

- Total **income**:
  - labor wage income $w_h L_h$;
  - the aggregate rebated profits from domestic producers D_h;
  - the rebated tariff revenues from the government T_h;
  - an exogenous transfer term Γ_h.

Production

- Each ω draws a random vector of productivities across production locations i: $\mathbf{a}_j^s = \left\{a_{ij}^s\right\}_{i=1}^N$, which follows a max-stable Fréchet with shape θ, scale z_j and a correlation function G^j:

$$\mathbb{F}_{ij}^s(\mathbf{a}_j^s) \equiv \mathbb{P}\left(a_{1j}^s \leq a_1, a_{2j}^s \leq a_2, \ldots, a_{Nj}^s \leq a_N\right) = e^{-z_j G^j\left(a_1^{-\theta}, a_2^{-\theta}, \ldots, a_N^{-\theta}\right)};$$

- Given location choice i, and productivity a, ω from j in sector s:
    - Hires labor in i, produces output:

$$q_{ij}^s(a) = \frac{a^{\frac{1}{\sigma^s - 1}}}{\kappa_{ij}^s} l_{ij}^s(a),$$

    where κ_{ij}^s is the bilateral foreign operation friction (normalized to one when $i = j$);
    - Sets prices p_{hij}^s for sales to each country h, subject to

$$q_{hij}^s = \left(\frac{p_{hij}^s}{P_h^s}\right)^{-\epsilon^s} Q_h^s, \ \forall h, \quad \sum_{h=1}^N \tau_{hi}^s q_{hij}^s = q_{ij}^s.$$

Equilibrium

An equilibrium is

- a set of prices (good prices, wages) and allocations (consumptions, producer allocations)
- given a set of fundamentals (productivities, labor endowments, trade costs, tariffs, foreign operation frictions, idiosyncratic productivity draw distributions)

such that producers optimize, the distributions are consistent with these decisions, and

- goods markets clear: $Y_i = \sum_h \sum_s \frac{\pi^s_{hi}}{\tau^s_{hi}} X^s_h$, and
- country budget constraints hold: $\text{Current Account}_j + \text{Capital Account}_j + \text{Transfer}_j = 0$.

▸ Producer's Problem Solution

Decomposition: Welfare Change Induced by Tariff Changes

$$d \ln C_j \approx \frac{w_j L_j}{X_j} d \ln w_j + \sum_i \sum_s \frac{D_{ij}^s}{X_j} d \ln w_i - \sum_i \sum_s \frac{\mathcal{T}_{ji}^s}{X_j} d \ln w_i$$

Terms-of-trade

where $\mathcal{T}_{ji}^s \equiv \frac{\pi_{ji}^s}{\tau_{ji}^s} X_j^s$ is the factual trade value exported from i to j in sector s, and

Decomposition: Welfare Change Induced by Tariff Changes

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Terms-of-trade

$$+ \sum_i \sum_s \frac{D_{ij}^s}{X_j}\left(\mathrm{d}\ln D_{ij}^s - \mathrm{d}\ln w_i\right)$$

Profit-shifting

where $\mathcal{T}_{ji}^s \equiv \frac{\pi_{ji}^s}{\tau_{ji}^s} X_j^s$ is the factual trade value exported from i to j in sector s, and

Decomposition: Welfare Change Induced by Tariff Changes

$$\begin{aligned}
d\ln C_j \approx\ & \frac{w_j L_j}{X_j} d\ln w_j + \sum_i \sum_s \frac{D_{ij}^s}{X_j} d\ln w_i - \sum_i \sum_s \frac{\mathcal{T}_{ji}^s}{X_j} d\ln w_i && \text{Terms-of-trade} \\
& + \sum_i \sum_s \frac{D_{ij}^s}{X_j} \left(d\ln D_{ij}^s - d\ln w_i \right) && \text{Profit-shifting} \\
& + \sum_i \sum_s \frac{1}{\epsilon^s - 1} \frac{\tau_{ji}^s \mathcal{T}_{ji}^s}{X_j} \sum_{j'} \omega_{ij'}^s \, d\ln \tilde{M}_{ij'}^s && \text{Relocation}
\end{aligned}$$

where $\mathcal{T}_{ji}^s \equiv \frac{\pi_{ji}^s}{\tau_{ji}^s} X_j^s$ is the factual trade value exported from i to j in sector s, and $\omega_{ij}^s \equiv \frac{D_{ij}^s}{\sum_{j'} D_{ij'}^s}$ is the share of FDI stocks in i and sector s owned by producers from j.

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$$\begin{aligned}
d\ln C_j \approx\ & \frac{w_j L_j}{X_j} d\ln w_j + \sum_i \sum_s \frac{D_{ij}^s}{X_j} d\ln w_i - \sum_i \sum_s \frac{\mathcal{T}_{ji}^s}{X_j} d\ln w_i && \text{Terms-of-trade} \\
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& + \underbrace{\sum_i \sum_s \frac{\left(\tau_{ji}^s - 1\right) \mathcal{T}_{ji}^s}{X_j} \left(d\ln \mathcal{T}_{ji}^s - d\ln w_i \right)}_{\text{Tariff Revenues}} - \underbrace{\frac{\Gamma_j}{X_j} d\ln \Gamma_j}_{\text{Value of Transfers}} \quad ,
\end{aligned}$$

where $\mathcal{T}_{ji}^s \equiv \frac{\pi_{ji}^s}{\tau_{ji}^s} X_j^s$ is the factual trade value exported from i to j in sector s, and $\omega_{ij}^s \equiv \frac{D_{ij}^s}{\sum_{j'} D_{ij'}^s}$ is the share of FDI stocks in i and sector s owned by producers from j.

FDI Diversion & Elasticity

- Model counterpart of FDK: D_{ij}^{s};
- The aggregate profits that producers from j in sector s get from operating in i

$$D_{ij}^{s} = \frac{\left(\tilde{v}_{ij}^{s}\right)^{\theta} G_{i}^{j}}{G^{j}} D_{j}^{s};$$

- The magnitude and heterogeneity of the elasticities of D_{ij}^{s} w.r.t. $\tilde{v}_{ij}^{s}$:
  - depends on the correlation structure captured by G^{j};
  - and is calibrated to match systematic correlations in the data.

Details

Calibration & Quantitative Evaluations

Calibration to the World Economy in 2017

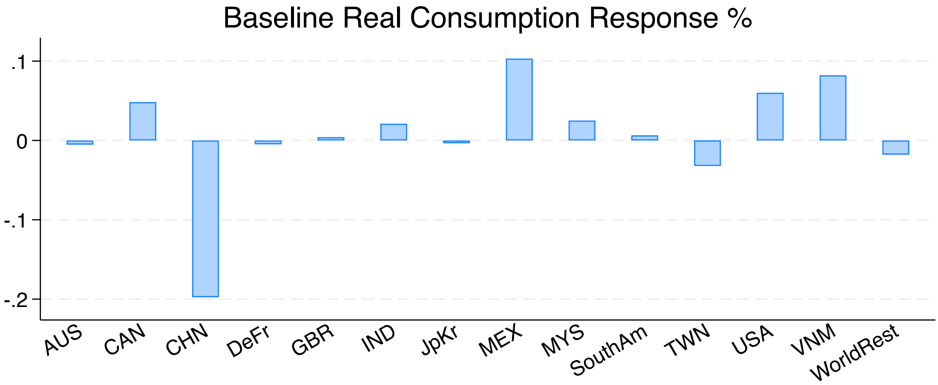
- 13 economies + World Rest;
- 3 sectors: Agriculture and mining, Manufacturing, Service;
- 3 sets of parameters:
  1. Direct measurement;
     - $\{L_i\}_{i=1}^{N}$: product of employees and human capital index (PWT);
     - $\{\phi_h^s\}_{h=1,s=1}^{N,S}$: 2017 Inter-Country Input-Output (ICIO) Tables sectoral expenditure;
     - $\{\tau_{ij}^s\}_{i\neq j,s=1}^{N,N,S}$: MFNAVE from WITS TRAINS + BACI;
  2. Fundamentals recovered by solving the model;
     - $\{z_j\}_{j=1}^{N}$ chosen to match expenditure $\{X_j\}_{j=1}^{N}$ (ICIO);
     - $\{d_{ij}^s\}_{i\neq j,s=1}^{N,N,S}$ chosen to match trade shares $\left\{\pi_{ij}^s\right\}_{i\neq j,s}^{N,N,S}$ (ICIO);
     - $\{\kappa_{ij}^s\}_{i\neq j,s=1}^{N,N,S}$ chosen to match FDI positions: $\{K_{ij}^s\}_{i\neq j,s=1}^{N,N,S}$ (OECD + CDIS + fDi Markets);
  3. Parameters that govern trade and FDI elasticities.

▸ Economy List ▸ Calibration Details

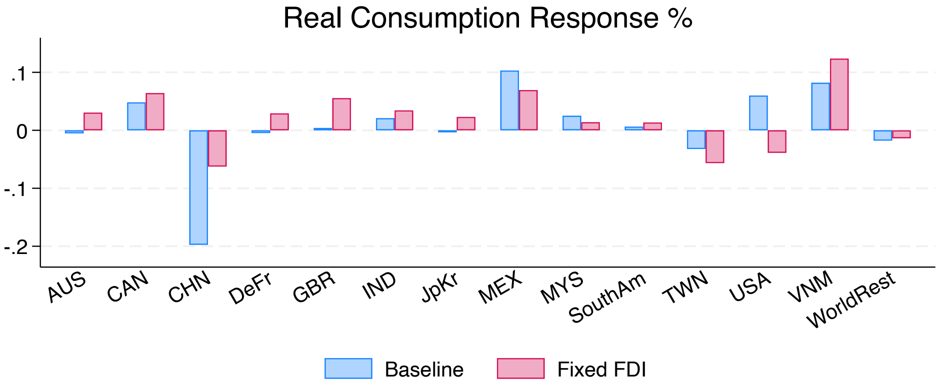
Quantitative Evaluations: The Trump Tariffs

- The Trump Tariffs:
  - 16.3% for the agriculture and mining sector, and
  - 19.7% for the manufacturing sector;
- The importance of FDI diversion for welfare:
  - Compare the Baseline with an "Fixed FDI" exercise where producers' locations are held fixed;
  - Decomposition;
  - Numerical "optimal tariff";

FDI Diversion on Aggregate Welfare

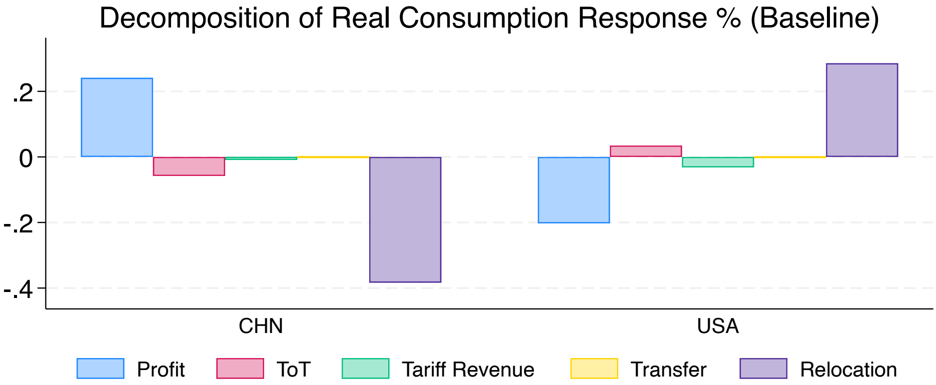


FDI Diversion on Aggregate Welfare

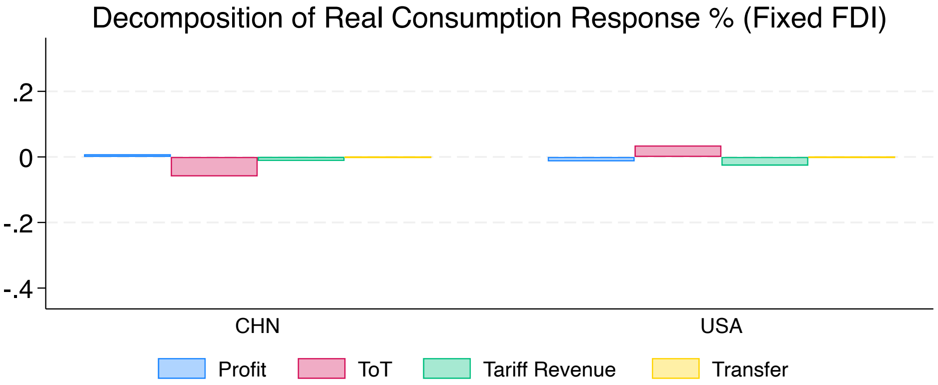


Sensitivity: $\theta = 14$ | FDI Diversion: China vs. Others

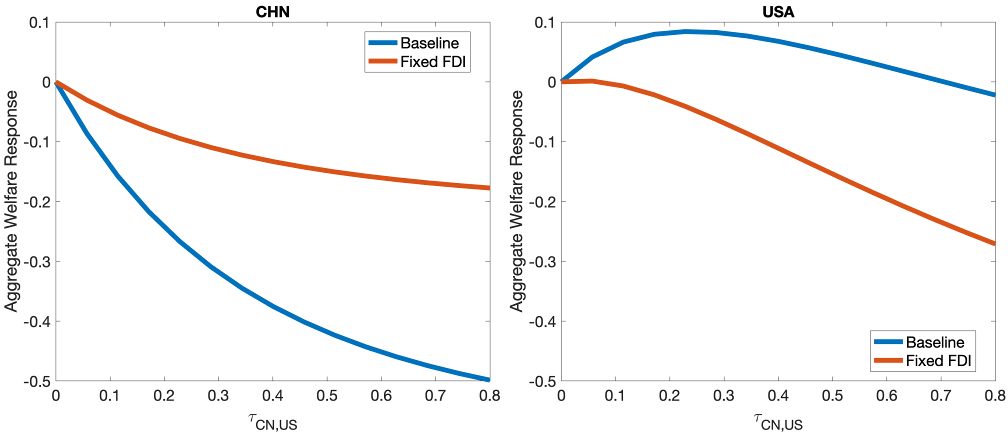
Welfare Response Decomposition: Baseline



Welfare Response Decomposition: Fixed FDI

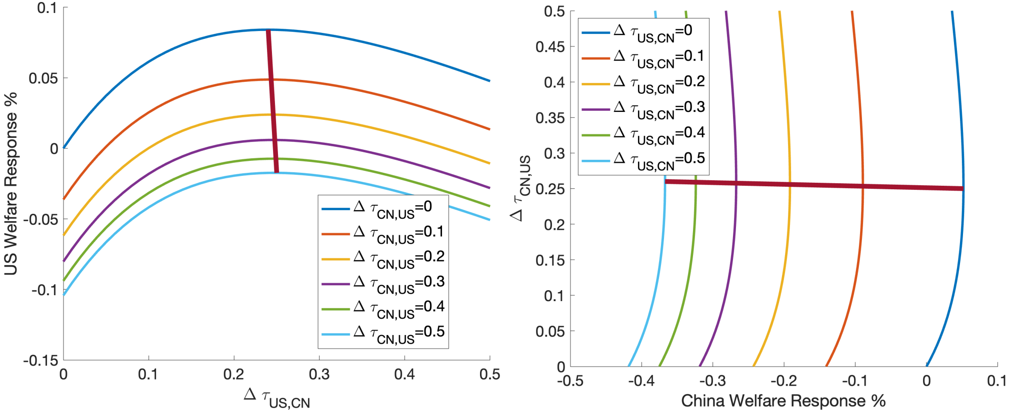


Numerical "Optimal Tariff" (Uniform and Unilateral)

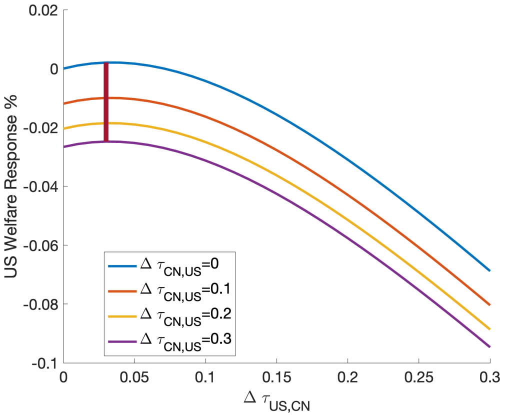


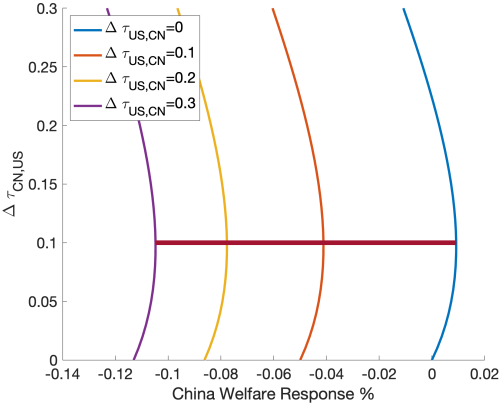
▸ Impacts on MEX, VNM

“Optimal Tariff”: Nash (Baseline)

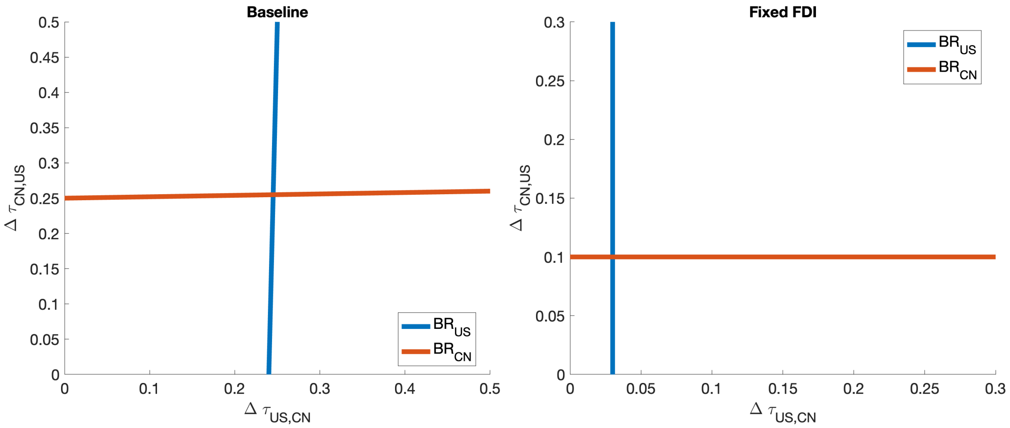


“Optimal Tariff”: Nash (Fixed FDI)





"Optimal Tariff": Nash Equilibrium Tariffs



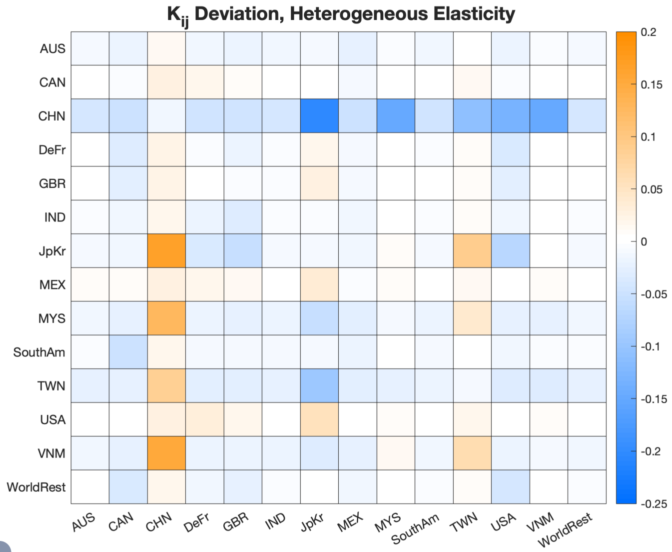
Other Implications

- Other model implications:
  1. FDI diversion patterns: heterogeneity and its effects;
  2. FDI's contributions in driving export value responses;

     E.g., much more important for VNM, MEX, etc.;
  3. Distributional implications from income-based (wages vs. profits) decomposition.

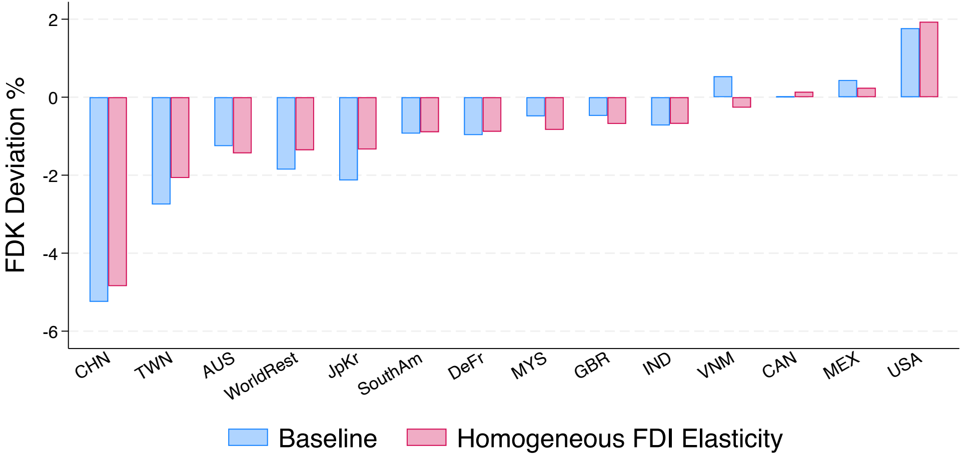
▸ Export Reponses ▸ Income-based Decomposition

FDI Diversion: Bilateral

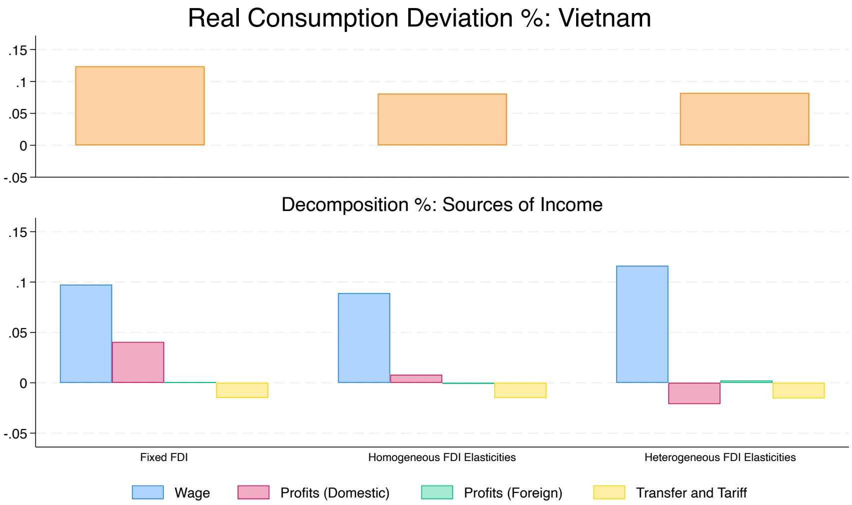


Comparison: Homogeneous Elasticities

FDI Diversion: FDK, Homogeneous vs. Heterogeneous Elasticities



Heterogeneous FDI Elasticities on Vietnam Welfare Implications



Conclusion

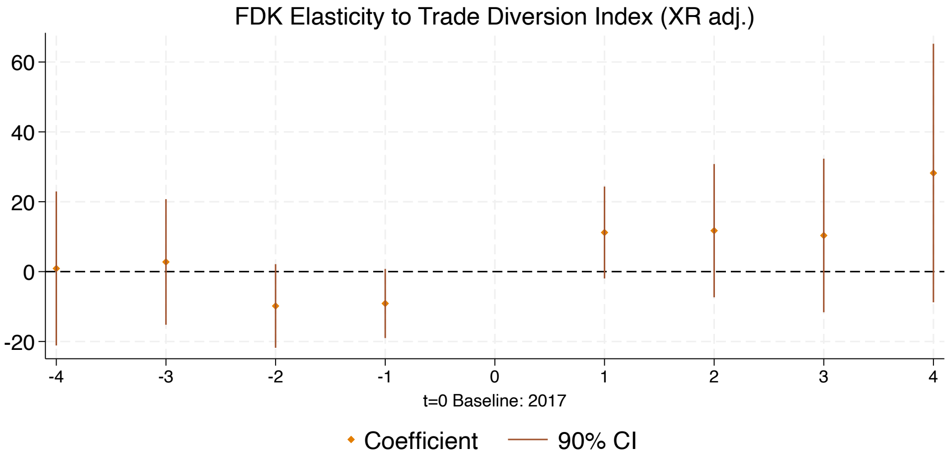
Trump pledges to get tough with tariffs again if elected

Biden raises tariffs on $18 billion of Chinese imports: EVs, solar panels, batteries and more

- Ignores many interesting elements:
  - Correlated other shocks and policies; Uncertainty; Other effects of FDI, etc.
- Should not ignore FDI when studying trade policies:
  - Recent case: the China-US trade war;
  - Numbers, mechanisms, distributions;
  - Heterogeneous FDI elasticities important for FDI diversion patterns.

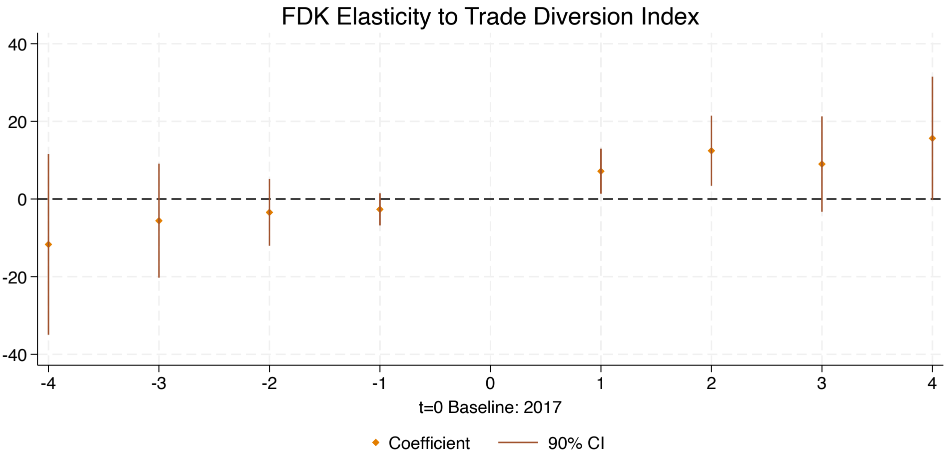
Appendix

Country Level Result: Exchange Rate Adjusted



Return

Country Level Result: Use ISIC 2-digit Tariffs



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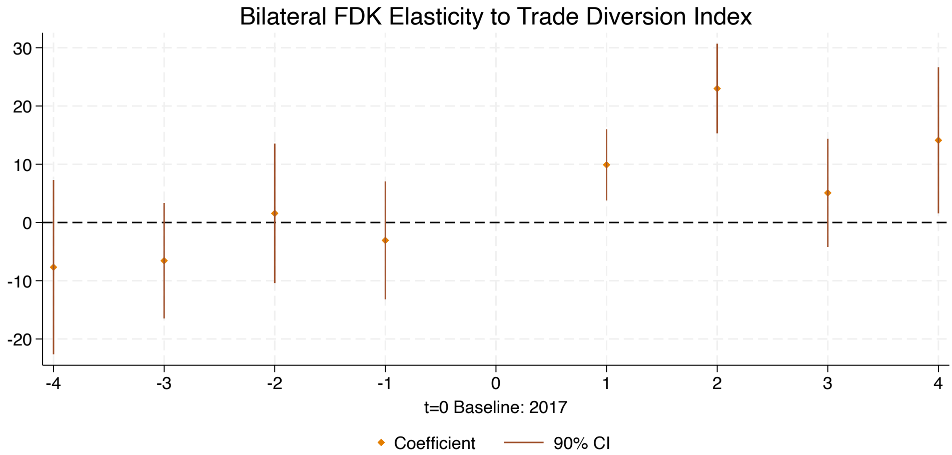
Country Level Result: Bilateral FDI Stocks



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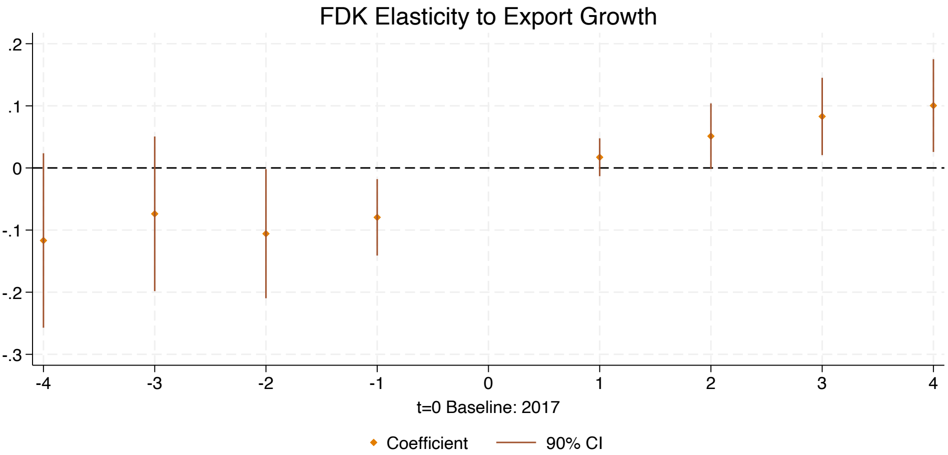
Using Export Directly: Export Growth as Independent Variable



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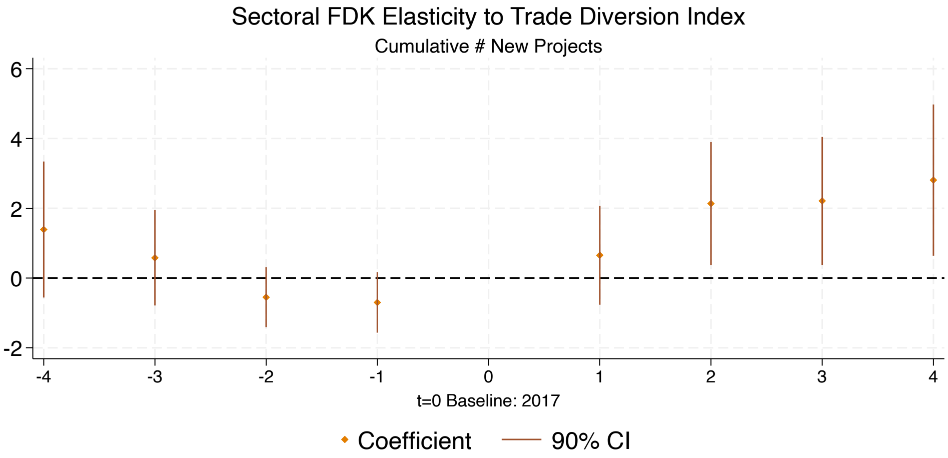
Sector Level Result: Cumulative # Projects



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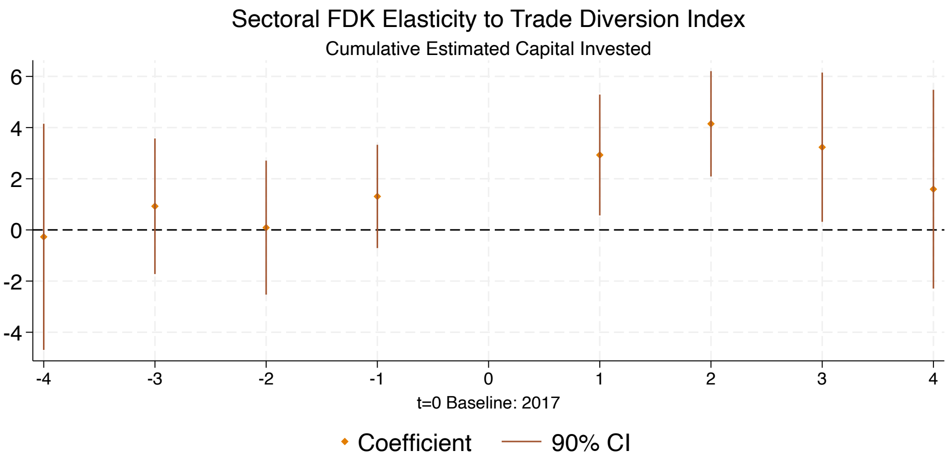
Sector Level Result: Cumulative Estimated Capital Invested



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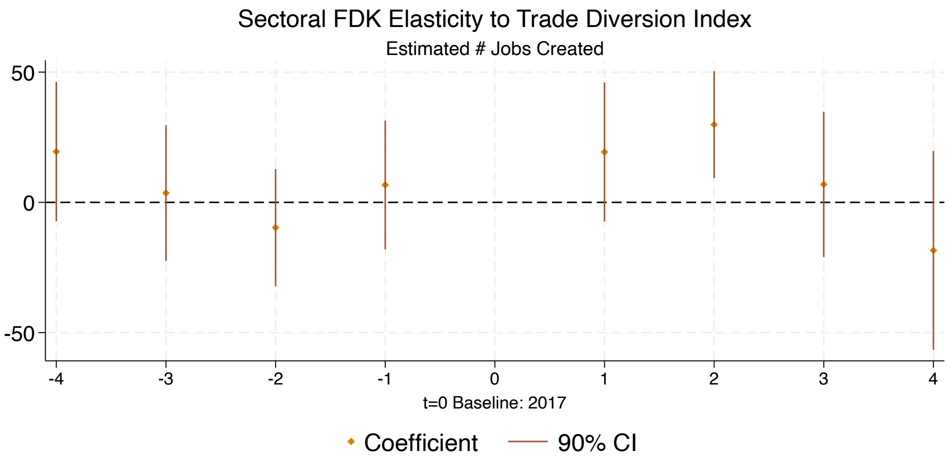
Sector Level Result: Estimated Jobs Created



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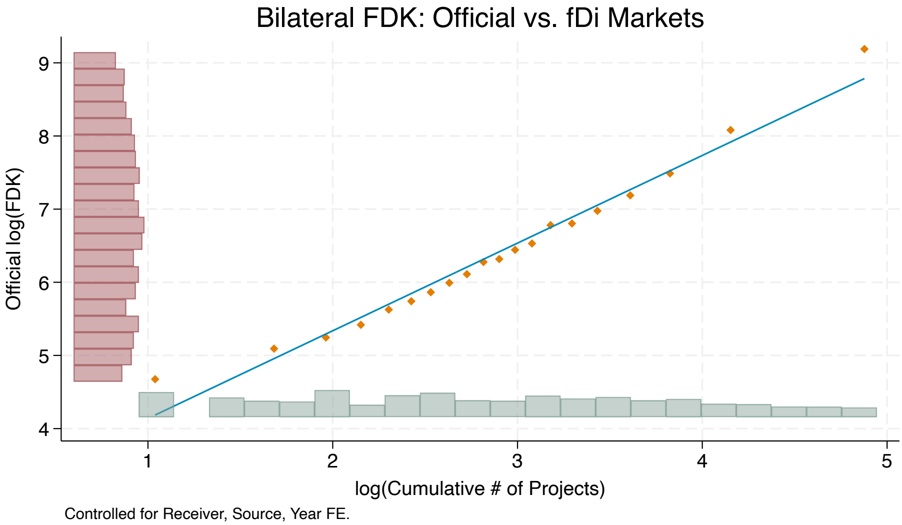
FDI Data: Official vs. fDi Markets



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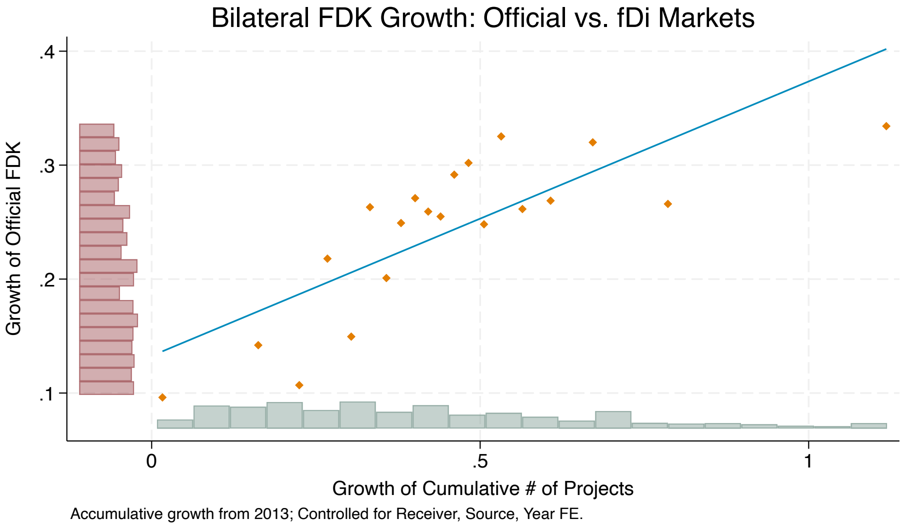
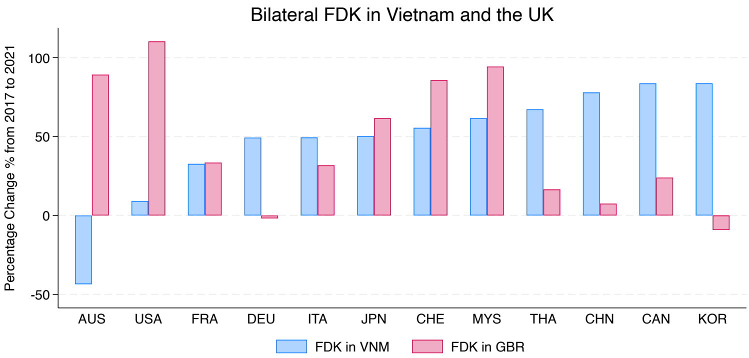


Return

Heterogeneous Bilateral FDK Responsiveness

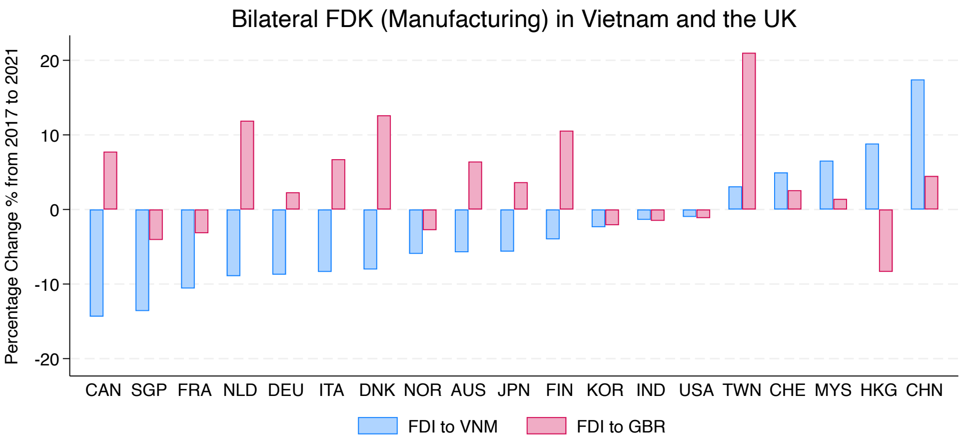
- Bilateral FDK with a gravity structure: $d \ln \text{FDK}_{ij} = \underbrace{d \ln \text{FE}_i}_{\text{Receiver}} + \underbrace{d \ln \text{FE}_j}_{\text{Source}} + \underbrace{d \ln \kappa_{ij}}_{\text{E.g., FDI efficiency cost}}$;



- Are such deviations purely due to bilateral idiosyncratic shocks?

▸ Manufacturing (fDi) ▸ Service (fDi)

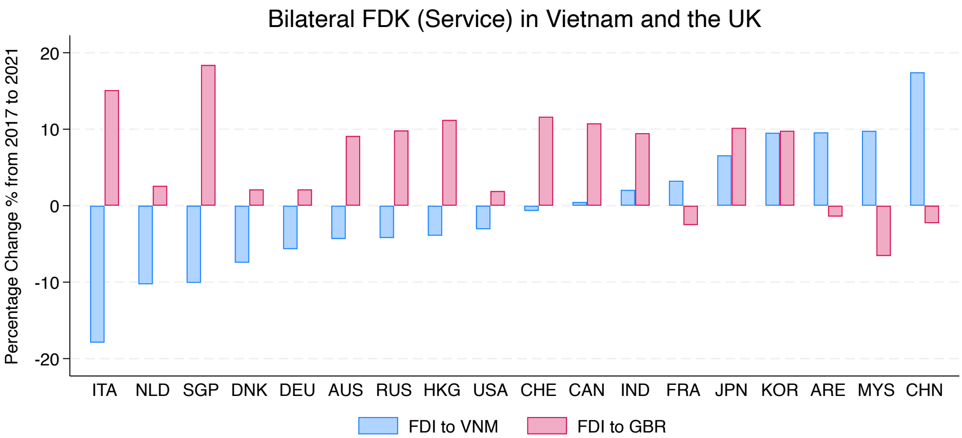
Heterogeneous Bilateral FDK Responsiveness (Manufacturing)



FDK measured using Cumulative # of FDI projects from fDi Markets, residualized by investor FE.

Return

Heterogeneous Bilateral FDK Responsiveness (Service)



FDK measured using Cumulative # of FDI projects from fDi Markets, residualized by investor FE.

Return

Share of FDK Investment

- $\omega_{ij} = \frac{FDK_{ij}}{\sum_{j' \neq i} FDK_{ij'}}$;

	(1)	(2)
$d \ln FDK_i \times \ln(Dist_{ij})$	-0.284**	-0.204*
	(0.122)	(0.121)
$d \ln FDK_i \times \ln(GDPpc_j)$	0.156**	0.115*
	(0.065)	(0.065)
$d \ln FDK_i \times ComparaAdv_{ij}$	0.599**	0.580**
	(0.283)	(0.280)
$d \ln FDK_i \times \omega_{ij}$		1.342***
		(0.240)
R^2 adj.	.005	.03
# of Obs.	2735	2735

Notes: The dependent variable is the bilateral FDI growth from 2017 to 2019. The sample includes 34 source countries and 199 receiver countries.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Return

Within Sector: NAICS 2-digit (fDi Markets)

- Outcome: $d \ln N_{ij,t} = \ln\left(N_{ij,t+1}/N_{ij,t}\right), t = 2017, \ldots, 2020$;

  $N_{i,t}$: Cumulative # of Projects;

  FE: Investor-year-sector & Receiver-year-sector;

	(1)	(2)	(3)
$d \ln N_{i,t} \times \omega_{ij,t}$	0.429***		0.413***
	(0.011)		(0.011)
$d \ln N_{i,t} \times \ln\left(Dist_{ij}\right)$		-0.048***	-0.046***
		(0.006)	(0.006)
$d \ln N_{i,t} \times GDPpc_j$		0.060***	0.044***
		(0.006)	(0.006)
R^2 adj.	.087	.086	.108
# of Obs.	24211	24211	24211

Notes: The dependent variable is the next-year bilateral FDK growth measured by the number of projects from fDi Markets at the NAICS 2-digit sector level, for years from 2017 to 2020. The dependent variable is winsorized at the 90_{th} percentile. The sample includes 30 source countries, 92 receiver countries, and 14 sectors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Return

From Trade Policy to FDI Diversion: Details

- Trade policy change (i.e. τ^s_{hi}) $\Rightarrow$ a new steady state;
- Without capital adjustment: Prices & Trade diversion;
- For production location i of sector s, producers from j, the following also change:

Market access $$A^s_i = \text{constant} \cdot \sum_h \left(d^s_{hi}\right)^{-\epsilon^s} \left(\tau^s_{hi}\right)^{1-\epsilon^s} \overbrace{\left(P^s_h\right)^{\epsilon^s} Q^s_t}^{\text{h market size}};$$

Optimal capital value $$P_i k^{s*}_{ij}(a) = \underbrace{\Lambda^s_i}_{\text{constant}} \frac{\tilde{A}^s_i}{\kappa^{s\ \epsilon^s-1}_{ij}}, \text{ where } \tilde{A}^s_i \equiv P_i^{-(\epsilon^s-1)\alpha^s_i} \left(\frac{w_i}{1-\alpha^s_i}\right)^{-(\epsilon^s-1)\left(1-\alpha^s_i\right)} A^s_i;$$

Value of operation $$\tilde{v}^s_{ij} = \underbrace{\tilde{\Lambda}^s_i}_{\text{constant}} \frac{\tilde{A}^s_i}{\kappa^{s\ \epsilon^s-1}_{ij}};$$

$\Rightarrow$ FDI diversion: intensive ($k^{s*}_{ij}(a)$) and extensive ($\tilde{\mathbb{F}}^s_{ij}(a)$).

Return

Binscatter: EX $\sim$ DI + FDI

	To All (ex. CN)		To US	
	(1)	(2)	(3)	(4)
Diversion Index	26.692	14.536	88.429**	74.273*
	(19.479)	(19.445)	(41.371)	(39.604)
FDK Growth		0.591***		0.791**
		(0.185)		(0.383)
Controls	✓	✓	✓	✓
R2 adj.	.02	.06	.07	.09
# of Obs.	140	140	141	141

Notes: Data uses official inward FDI stocks from OECD, IMF CDIS, and UNCTAD, export value from BACI. The export growth is from 2017 to 2020, while FDI growth is from 2017 to 2019. The diversion index is constructed using equation (**??**), with ν at HS 6-digit level, and trade value from BACI for year 2017, Trump tariff increase from **?**, all at at HS 6-digit level. I constraint the country to be those with the largest inward FDI stocks in 2017, and excluding those that are usually regarded as tax heavens, which results in about 140 countries. All regressions control for the log export, inward FDI stock, and GDP per capita levels in 2017. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Return

Solution to the Producer's Problem

1. Given the choice of production location i, optimal prices & profits:

$$p^s_{hij}(a) = \frac{\epsilon^s}{\epsilon^s - 1} \frac{d^s_{hi} \tau^s_{hi} w_i}{a^{\frac{1}{\epsilon^s - 1}} / \kappa^s_{ij}} \quad \& \quad v^s_{ij}(a) \equiv \frac{1}{\epsilon^s - 1} \overbrace{A^s_i w_i^{1-\epsilon^s}}^{\equiv \tilde{A}^s_i} \frac{a}{\kappa^{s\ \epsilon^s - 1}_{ij}};$$

where A^s_i captures the market access of country i as a production location for sector s;

2. Denote $\tilde{v}^s_{ij} = v^s_{ij}(1)$, the probability that the location i is chosen:

$$\mathbb{P}\left(v^s_{ij}\left(a^s_{ij}\right) = \max_{i'} v^s_{i'j}\left(a^s_{i'j}\right)\right) = \frac{\tilde{v}^{s\theta}_{ij} G^j_i(\tilde{v}^{s\theta}_{1j}, \tilde{v}^{s\theta}_{2j}, \ldots, \tilde{v}^{s\theta}_{Nj})}{G^j(\tilde{v}^{s\theta}_{1j}, \tilde{v}^{s\theta}_{2j}, \ldots, \tilde{v}^{s\theta}_{Nj})}, \text{ where } G^j_i \equiv \frac{\partial G^j\left(x_1, x_2, \ldots, x_N\right)}{\partial x_i};$$

Denote $\tilde{M}^s_{ij} \equiv \left(\left(\tilde{v}^s_{ij}\right)^\theta G^j_i / G^j\right)^{\frac{\theta - 1}{\theta}} \left(G^j_i\right)^{\frac{1}{\theta}}$,

which captures the mass of producers, adjusted for the producers productivity distributions.

▸ Return

Example 1: No Correlation

- Suppressing s, suppose $G^j\left(a_1^{-\theta}, a_2^{-\theta}, \ldots, a_N^{-\theta}\right) \equiv \sum_{i=1}^N a_i^{-\theta}$ (i.i.d. Fréchet):

$$\mathbb{P}\left(a_{1j} \leq a_1, a_{2j} \leq a_2, \ldots, a_{Nj} \leq a_N\right) = e^{-z_j \sum_{i=1}^N a_i^{-\theta}};$$

- FDI gravity, and bilateral FDI responses across equilibria:

$$D_{ij} = \frac{\left(\tilde{v}_{ij}\right)^\theta}{\sum_{i'}\left(\tilde{v}_{i'j}\right)^\theta} D_j \quad \Rightarrow d\ln D_{ij} = \theta\left[d\ln \tilde{A}_i - (\epsilon - 1)\, d\ln \kappa_{ij}\right] + \underbrace{d\ln \frac{D_j}{\sum_{i'}\left(\tilde{v}_{i'j}\right)^\theta}}_{FE_j};$$

- Suppose $d\ln \tilde{A}_i > 0$ due to tariff shocks;
    - Larger θ: smaller draw dispersion, and larger elasticity;
    - Conditional on FE_j, elasticity $d\ln D_{ij} \,/\, d\ln \tilde{A}_i = \theta$ is the same across country pairs.

Example 2: Uniform Correlation

- Suppose $G^j\left(a_1^{-\theta}, a_2^{-\theta}, \ldots, a_N^{-\theta}\right) = \left(\sum_{i=1}^N a_i^{-\frac{\theta}{1-\rho}}\right)^{1-\rho}$ with $0 < \rho < 1$:

$$\mathbb{P}\left(a_{1j} \leq a_1, a_{2j} \leq a_2, \ldots, a_{Nj} \leq a_N\right) = e^{-z_j \left(\sum_{i=1}^N a_i^{-\frac{\theta}{1-\rho}}\right)^{1-\rho}};$$

- The corresponding bilateral FDI deviation across equilibria:

$$d \ln D_{ij} = \frac{\theta}{1-\rho}\left[d \ln \tilde{A}_i - (\epsilon - 1)\, d \ln \kappa_{ij}\right] + d \ln \frac{D_j}{\left(G^j\right)^{\frac{\rho}{1-\rho}}};$$

- As if dispersion is smaller and FDI elasticity is larger, but still the same across country pairs.

Example 3: Bilateral Correlations

- A cross-nested CES correlation function G^j (from Lind and Ramondo, 2023):

$$G^j\left(a_1^{-\theta}, a_2^{-\theta}, \dots, a_N^{-\theta}\right) = \underbrace{\sum_{i=1}^{N} \left(1 - \eta_{ij}\right) a_i^{-\theta}}_{\text{First nest i.i.d. across i}} + \underbrace{\left(\sum_{i=1}^{N} \left(\eta_{ij} a_i^{-\theta}\right)^{\frac{1}{1-\rho}}\right)^{1-\rho}}_{\text{Second nest with correlation } \rho>0} ;$$

- Interpretation: two *latent technology types* for operation;
- Building in the idea of the "fit" of technologies to locations:
    - Nest 1: no *predictability* in terms how good a_{ij}^s is tells how good $\left\{a_{i'j}^s\right\}_{i'\neq i}$ are;
    - Nest 2: operation using some technologies have such correlation and predictability;
- Certain $\mathbf{Z}_{ij}$ informative of *the relative importance* of the two nests for i and j: η_{ij};

Example 3: Bilateral Correlations, Cont.

- When fundamentals change, larger responsiveness if the second type more important:
  - λ_{ij}^{W*}: within-type profit shares from i for j for the second technology type;
  - The corresponding bilateral FDK responses across equilibria:

$$d \ln D_{ij} = \theta \left(1 + \frac{\rho}{1-\rho} \frac{\eta_{ij} \left(\lambda_{ij}^{W*}\right)^{\rho}}{(1-\eta_{ij}) + \eta_{ij} \left(\lambda_{ij}^{W*}\right)^{\rho}} \right) \left[d \ln \tilde{A}_i - (\epsilon - 1) \, d \ln \kappa_{ij} \right] + u_{ij};$$

  - A change for $\tilde{A}_i$ leads to heterogeneous responses of FDK for different source countries j.

Return

Country List

Code	Name	Economies
AUS	Australia	Australia
CAN	Canada	Canada
CHN	China	China
DeFr	Germany & France	Germany, France
GBR	United Kingdom	United Kingdom
JpKr	Japan & Korea	Japan, Korea
MEX	Mexico	Mexico
MYS	Malaysia	Malaysia
SouthAm	South America	
TWN	Taiwan	Taiwan
USA	United States of America	United States of America
VNM	Viet Nam	Viet Nam
WorldRest	Rest of the World	

Return

Trade Elasticity ϵ^s

- Trade gravity: $\frac{X^s_{hi}}{X^s_{hh}} = \frac{\Phi^s_i (d^s_{hi})^{1-\epsilon^s} (\tau^s_{hi})^{-\epsilon^s}}{\Phi^s_h}$;
- For s = Agriculture, Manufacturing, gravity regression with fixed effects and tariff shifters:

$$\ln EX^s_{hit} = FE^s_{ht} + FE^s_{it} - \epsilon^s \ln \tau^s_{hit} + u^s_{hit};$$

- Not applicable to the service sector; Instead, use real exchange rate (RER) as cost shifters:

$$\ln EX^3_{hit} = FE^3_h + FE^3_i + FE_t - \epsilon^3_{RER} \ln RER_{hit} + u^3_{hit};$$

- Trade elasticities inferred from RER are much lower than those inferred from tariff shifters:

$$\hat{\epsilon}^3 = \hat{\epsilon}^3_{RER} \times \frac{\hat{\epsilon}^2}{\hat{\epsilon}^2_{RER}},$$

  assuming the same pass-throughs difference between RER and tariff shifters across sectors;
  $\Rightarrow \hat{\epsilon}^1 = 5.34, \hat{\epsilon}^2 = 3.29, \hat{\epsilon}^3 = 2.84.$

FDI Elasticities θ, ρ and $\{\eta_{ij}\}_{i \neq j}^{N,N}$: Indirect Inference

- FDI diversion elasticities:
  - Magnitude: θ, ρ;
  - Heterogeneity: η_{ij};

    Paramatrize η_{ij} to be systematically correlated with observable bilateral variables $\mathbf{Z}_{ij}$:

    $$\eta_{ij} = \frac{e^{\mathbf{Z}_{ij}\boldsymbol{\zeta}}}{1 + e^{\mathbf{Z}_{ij}\boldsymbol{\zeta}}}, \text{ where } \mathbf{Z}_{ij}\boldsymbol{\zeta} = \zeta_0 + \zeta_1 \ln\left(\text{Dist}_{ij}\right) + \zeta_2 \ln\left(\text{GDPpc}_j\right) + \zeta_3 \text{CA}_{ij};$$

    Set $\eta_{ij} = 1$ when $i = j$;
- Pick θ, ρ, $\boldsymbol{\zeta}$ to match empirical and model regression coefficients $\vartheta, \boldsymbol{\psi}$:

$$d \ln K_i = \vartheta DI_i + u_i,$$

$$d \ln K_{ij} = FE_i + FE_j + \mathbf{Z}_{ij}\tilde{\boldsymbol{\psi}} + \left(d \ln K_i \cdot \mathbf{Z}_{ij}\right)\boldsymbol{\psi} + u_{ij},$$

where K_i, K_{ij} are replaced by corresponding profits in the model.

FDI Elasticities θ, ρ and $\{\eta_{ij}\}_{i \neq j}^{N,N}$: Indirect Inference, Cont.

- u_{ij} is correlated with regressors; Need to specify the shock process from 2017 to 2019;
  - Shocks to $L_j, z_j, \phi_h^s, d_{ij}^s, \tau_{ij}^s, \kappa_{ij}^s$: directly measured or recovered by matching 2019;
  - Decompose $d \ln \kappa_{ij}^s = d \ln \kappa_i^{s,in} + d \ln \kappa_j^{s,out} + d \ln \tilde{\kappa}_{ij}^s$;
  - Simulate $d \ln \tilde{\kappa}_{ij}^s$, assuming i.i.d. $\sim$ recovered distribution, while other shocks are deterministic;

	Outcome: $d \ln K_i$		Calibration	
	Data	Model	Parameter	Value
DI_i	18.67 **	18.29	ρ	0.82
	(7.83)	(7.60)	θ	5.79
R^2	0.471			
# of Obs.	117			

Notes: The first column reports empirical regression coefficient for ϑ. I constrain the sample to include the largest FDI receivers, while excluding those typically considered tax havens, which results in 117 receiver countries. The second column reports the median and standard error of regression coefficients from 10 model simulation runs. Finally, the last column reports the corresponding parameter values. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

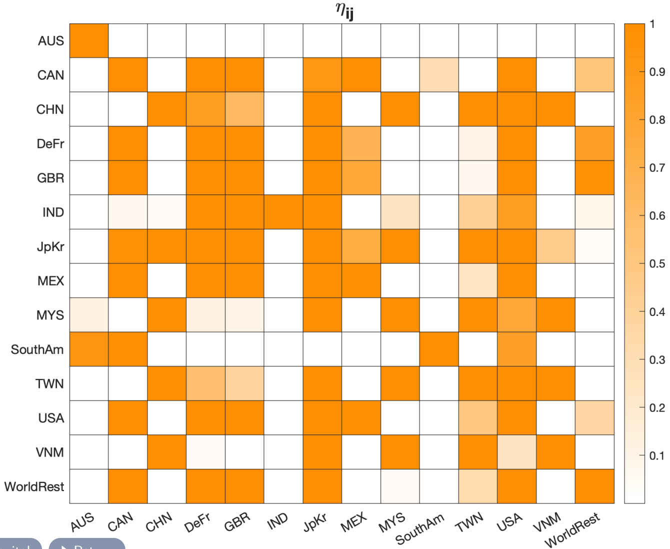
Back Out Shocks

FDI Elasticities θ, ρ and $\{\eta_{ij}\}_{i \neq j}^{N,N}$: Indirect Inference, Cont.

	Outcome: $d \ln K_{ij}$		Calibration	
	Data	Model	Parameter	Value
$d \ln K_i \times \ln(\text{Dist}_{ij})$	-0.169*	-0.176	ζ_1	-7
	(0.090)			
$d \ln K_i \times \ln(\text{GDPpc}_j)$	0.117**	0.116	ζ_2	5
	(0.059)			
$d \ln K_i \times \text{ComparaAdv}_{ij}$	0.576***	0.521	ζ_3	19
	(0.219)			
			ζ_0	-9.5
R^2	0.111			
# of Obs.	2621			

Notes: The first column reports empirical regression estimates of the interaction coefficients $\boldsymbol{\psi}$. I constrain the sample to include investors with sufficient large number of receivers, while excluding those typically considered tax havens, which results in 36 investor and 193 receiver countries. The second column reports the median of regression coefficients from 10 model simulation runs. Finally, the last column reports the corresponding parameter values. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

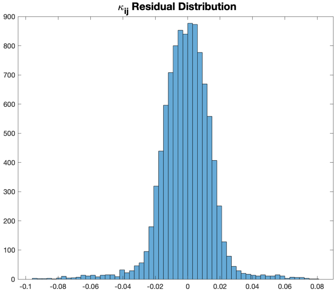
Calibrated $\{\eta_{ij}\}_{i \neq j}^{N,N}$



▸ Given θ ▸ Validation: Domestic Capital ▸ Return

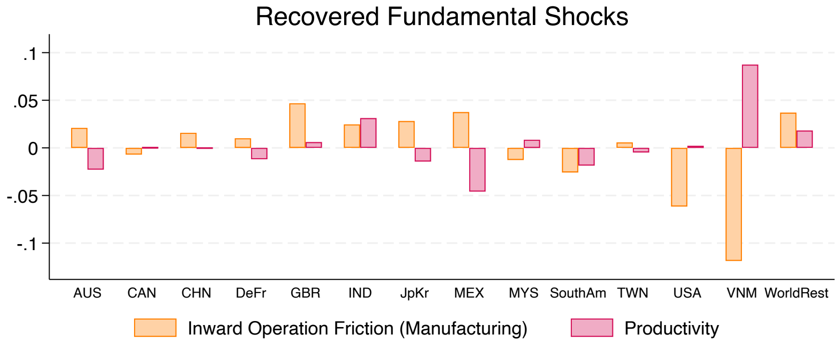
Back Out Shocks

- Shocks in the model:
  - $d \ln L_j$, $d \ln \phi_h^s$, $d \ln \tau_{ij}^s$ directly measured;
  - $d \ln z_j$, $d \ln d_{ij}^s$ account for deviation in total expenditure and trade shares;
  - $d \ln \kappa_{ij}^s = d \ln \kappa_j^{s,out} + d \ln \kappa_i^{s,in} + d \ln \tilde{\kappa}_{ij}^s$ account for deviation in bilateral FDI positions;
- Recover shocks by matching 2019 data; get distribution for $d \ln \tilde{\kappa}_{ij}^s$; Data is one realization; In principle, can add i.i.d. shocks to all other fundamentals;



Back Out Shocks

- Recovered $d \ln \kappa_i^{2,in}$ and $d \ln z_i^{1/\epsilon^2}$



Return

Indirect Inference: Given $\theta = 14$

	Outcome: $d \ln K_i$		Calibration	
	Data	Model	Parameter	Value
DI_i	18.67 **	18.90	ρ	0.84
	(7.83)	(7.02)	θ	14
R^2	0.471			
# of Obs.	117			

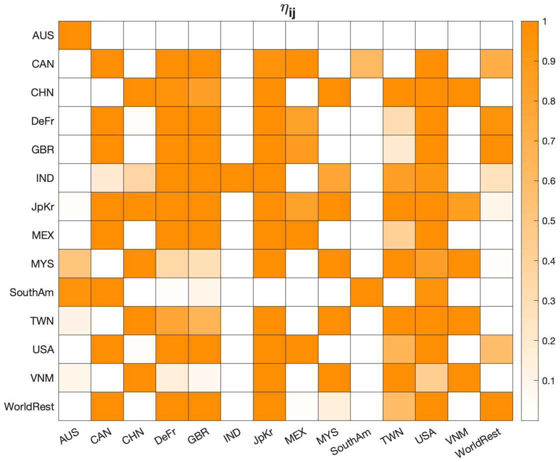
Notes: The first column reports empirical regression coefficient for ϑ. I constrain the sample to include the largest FDI receivers, while excluding those typically considered tax havens, which results in 117 receiver countries. The second column reports the median and standard error of regression coefficients from 10 model simulation runs. Finally, the last column reports the corresponding parameter values. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Indirect Inference: Given $\theta = 14$, Cont.

	Outcome: $d \ln K_{ij}$		Calibration	
	Data	Model	Parameter	Value
$d \ln K_i \times \ln(Dist_{ij})$	-0.169*	-0.181	ζ_1	-7
	(0.090)			
$d \ln K_i \times \ln(GDPpc_j)$	0.117**	0.122	ζ_2	4.5
	(0.059)			
$d \ln K_i \times ComparaAdv_{ij}$	0.576***	0.634	ζ_3	16.5
	(0.219)			
			ζ_0	-7
R^2	0.111			
# of Obs.	2621			

Notes: The first column reports empirical regression estimates of the interaction coefficients $\boldsymbol{\psi}$. I constrain the sample to include investors with sufficient large number of receivers, while excluding those typically considered tax havens, which results in 36 investor and 193 receiver countries. The second column reports the median of regression coefficients from 10 model simulation runs. Finally, the last column reports the corresponding parameter values. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Calibrated $\{\eta_{ij}\}_{i \neq j}^{N,N}$: Given $\theta = 14$



Return

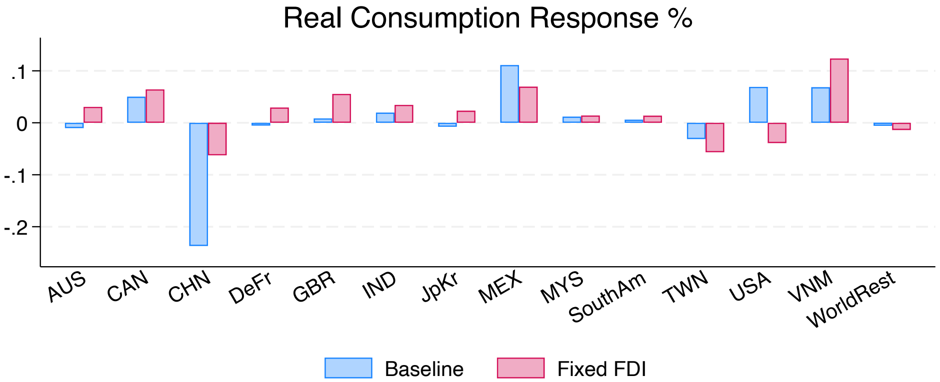
Untargeted Moments: Domestic Capital $\sim$ DI

	FDK		Domestic Capital	
	Data	Model	Data	Model
	(1)	(2)	(3)	(4)
DI	18.281**	18.291**	-5.621	-4.279
	(8.180)	(7.600)	(3.766)	(4.469)
R2 adj.	.04		.01	
# of Obs.	100		96	

Notes: Columns (1) and (3) reports empirical regression estimates of the coefficients on the Trade Diverion Index. I constrain the sample to include investors with sufficient large number of receivers, while excluding those typically considered tax havens. The data for domestic capital use IMF domestic capital from 2017, and GDP growth to infer the 2019 value. Columns (2) and (4) report the median of regression coefficients from 10 model simulation runs. Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

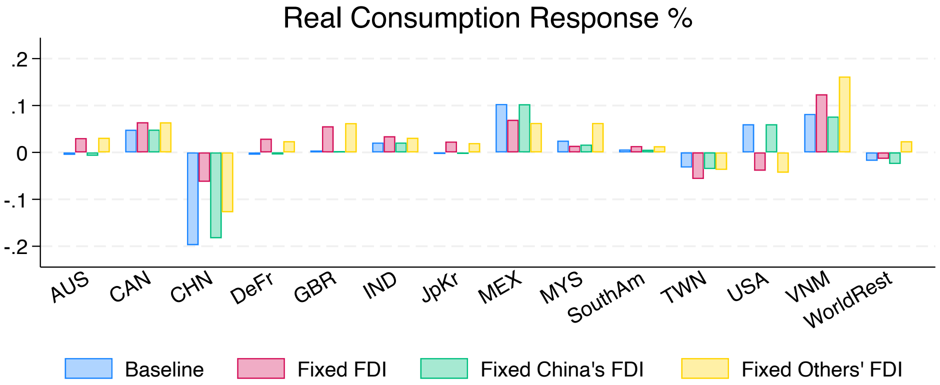
Return

FDI Diversion on Aggregate Welfare: Given $\theta = 14$



Return

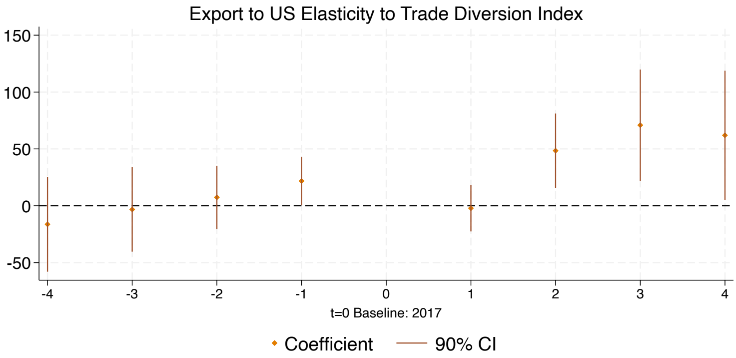
Chinese and Others' FDI Diversion



▸ Return

Contribution of FDI Diversion to Relative Export Growth

- DI_i also predicts relative export growth to the US:



- Production capacity responses: Domestic capital + FDI; How large is FDI's contribution?

▸ Trade Diversion (ex. CN) ▸ Bin-Scatter: EX ∼ FDI

Contribution of FDI Diversion to Relative Export Growth

- Assume identical contributions to export of per unit increase in domestic capital and FDK;

1. The elasticities of FDK / domestic capital to the trade diversion index:

	FDK	Domestic Capital
DI	26.029**	19.567*
	(11.536)	(11.265)
R2 adj.	.04	.02
# of Obs.	99	94

Notes: The dependent variables are FDK growth and domestic capital stocks growth from 2017 to 2019 at the country level. I drop countries with measured FDK larger than the domestic capital stocks. I further winsorize the growth of domestic capitals at the 2.5th and 97.5th percentiles and drop Mexico and Canada. I exclude Mexico and Canada because they have the largest trade diversion indexes. If I include these two countries, the estimates and standard errors for both columns become 17.96 (8.13) and 8.95 (7.92). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

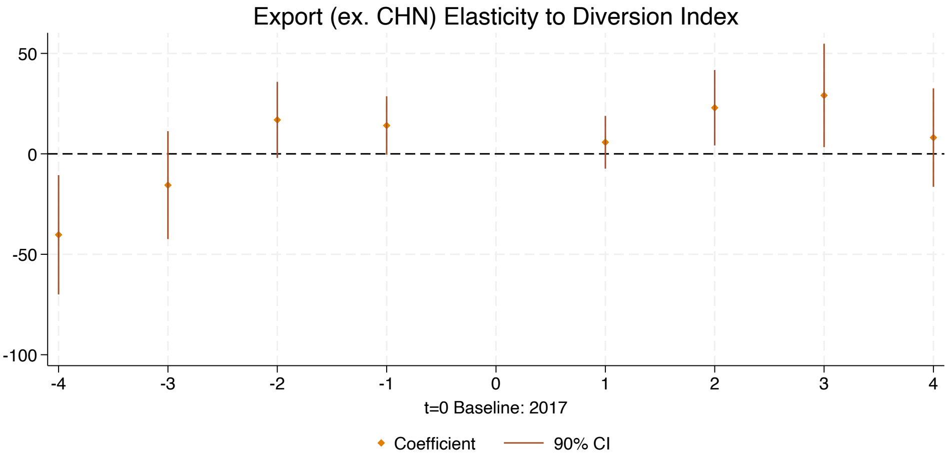
2. Average FDK share: 23.6%;

- Relative export growth to the US for a given country associated with FDI diversion:

$$\frac{26.03 \times 23.6\%}{26.03 \times 23.6\% + 19.57 \times (1 - 23.6\%)} \approx 29.1\%.$$

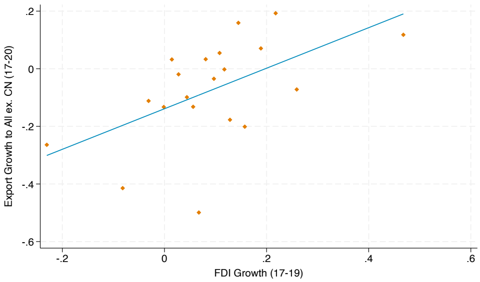
Importance of Levels Return

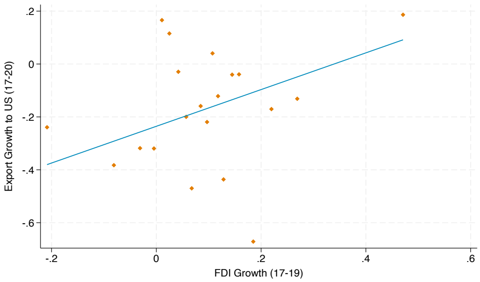
Total Export Growth (ex CN)



Return

Bin-scatters: EX $\sim$ FDI





Return

Contribution of FDI Diversion to Export Growth: Example

- Consider two countries, where country 1 is more exposed, e.g., 1 vs. 0;
- Before the Trump Tariffs:

	FDK	Domestic Capital	Export
Country 1	50	100	150
Country 2	50	100	150

- After the Trump Tariffs:

	FDK	Domestic Capital	Export
Country 1	70	130	200
Country 2	60	120	180

- Contribution of FDK is

$$\frac{(40-20)\% \times 1/3}{(40-20)\% \times 1/3 + (30-20)\% \times 2/3} = 50\%.$$

▸ Return

Contribution of FDI Diversion to Export Growth: Example 2

- Consider two countries, where country 1 is more exposed, e.g., 1 vs. 0;
- Before the Trump Tariffs:

	FDK	Domestic Capital	Export
Country 1	10	20	30
Country 2	50	100	150

- After the Trump Tariffs:

	FDK	Domestic Capital	Export
Country 1	15	21	36
Country 2	55	110	165

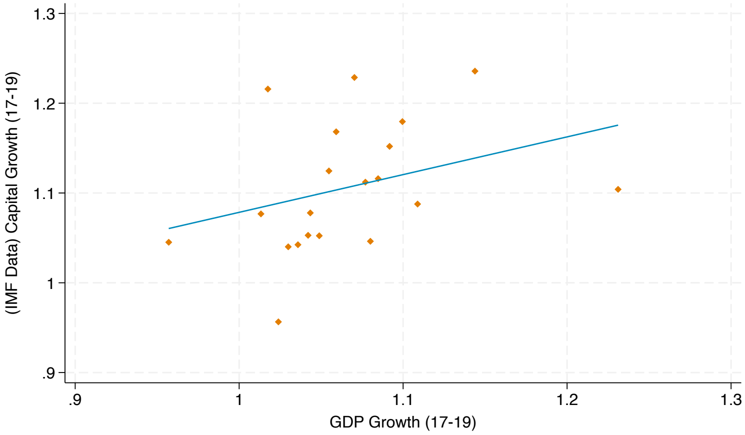
- Contribution of FDK is

$$\frac{(50-10)\% \times 1/3}{(50-10)\% \times 1/3 + (5-10)\% \times 2/3} = 133\%.$$

▸ Return

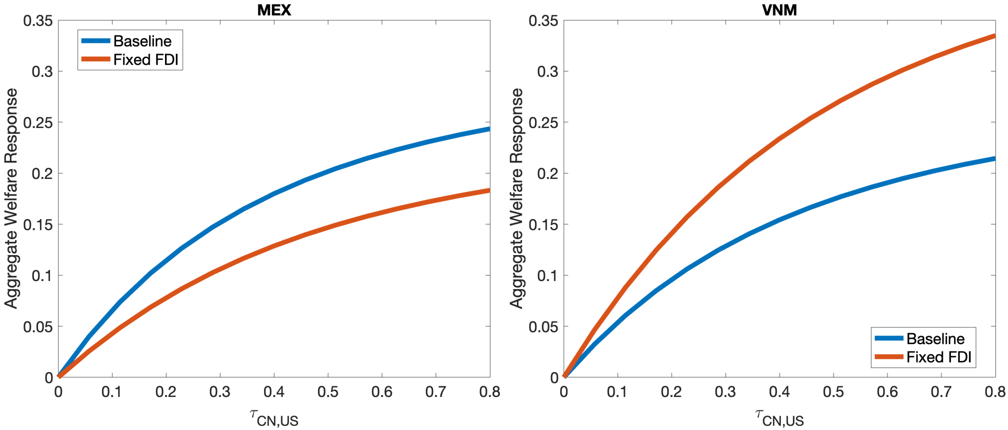
Data: FDI Growth

- Current results use IMF domestic capital measure: not very realistic across years (2017-2019);



- Calibration uses GDP growth implied total capital growth from 17 to 19;

Numerical “Optimal Tariff”: MEX, VNM



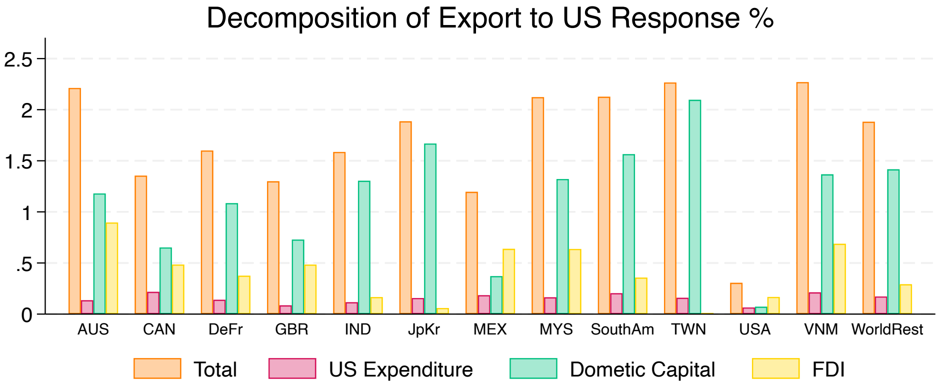
Return

Export Value Responses

$$d\ln\frac{X_{hi}^{s}}{\tau_{hi}^{s}} = \underbrace{d\ln\frac{X_{h}^{s}}{\tau_{hi}^{s}}\frac{1}{\left(P_{h}^{s}\right)^{1-\epsilon^{s}}}}_{\text{Importer's sectoral expenditure}} + \underbrace{\left(1-\omega_{h}^{s}\right) d\ln\tilde{M}_{ii}^{s}\left(P_{hii}^{s}\right)^{1-\epsilon^{s}}}_{\text{Dometic capital}} + \underbrace{\omega_{h}^{s}\, d\ln\sum_{j\neq i}\tilde{M}_{ij}^{s}\left(P_{hij}^{s}\right)^{1-\epsilon^{s}}}_{\text{FDI}}.$$

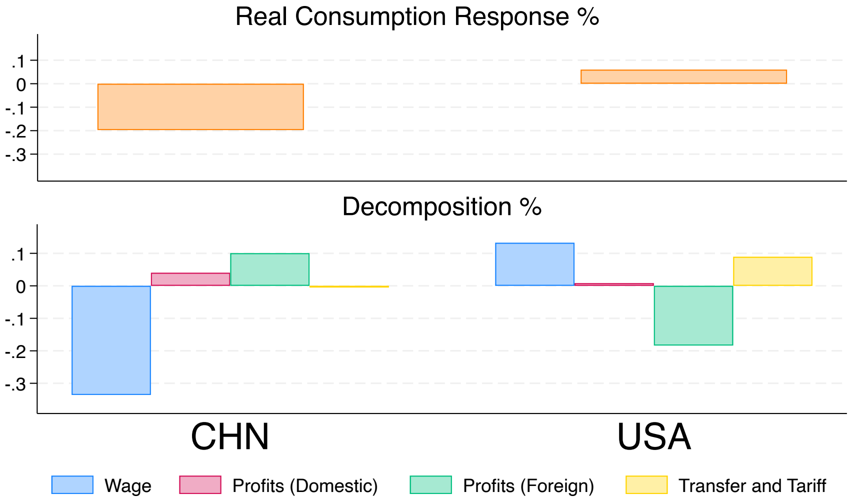
- $\tilde{M}_{ij}^{s}$: the mass of producers, adjusted for the productivity distribution;
- $\omega_{h}^{s} \equiv \frac{\sum_{j\neq i}\tilde{M}_{ij}^{s}\left(P_{hij}^{s}\right)^{1-\epsilon^{s}}}{\sum_{j}\tilde{M}_{ij}^{s}\left(P_{hij}^{s}\right)^{1-\epsilon^{s}}}$: the share of foreign production capacity in country i for sector s.

Export Value Responses



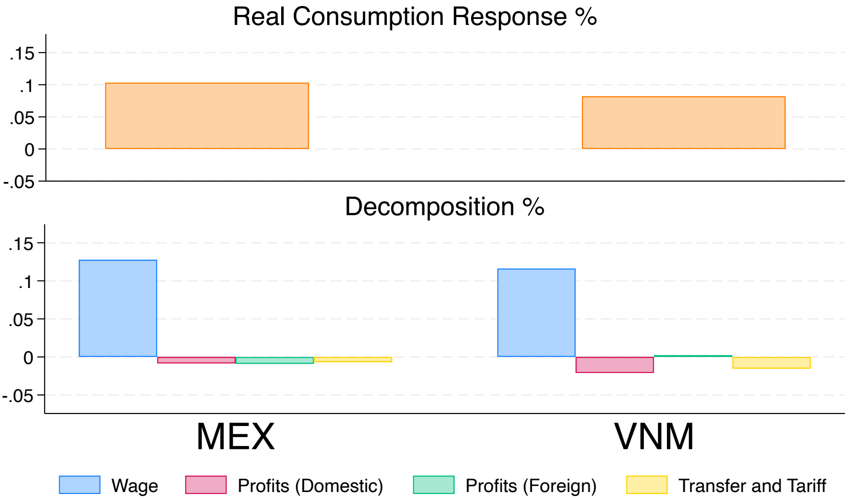
▸ Export to All ▸ Empirics ▸ Return

Distributional Implications: China and the US



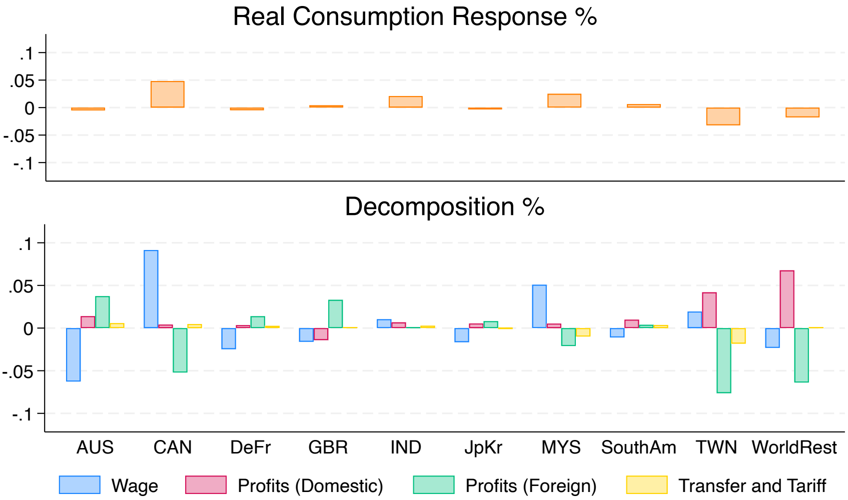
▸ Model Comparison

Distributional Implications: Mexico and Vietnam



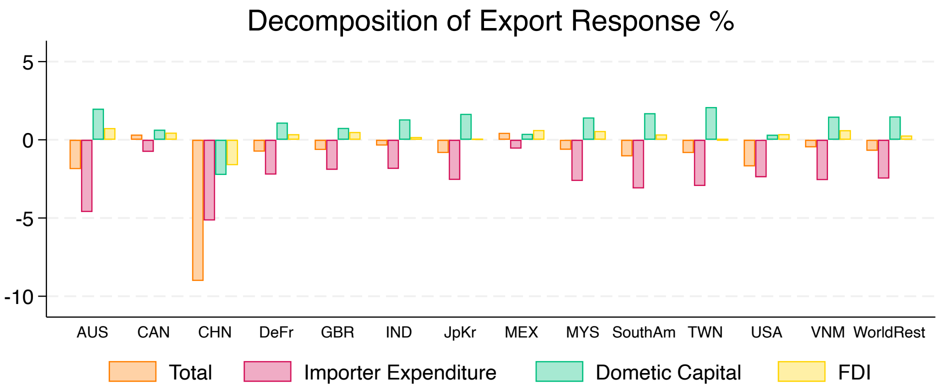
▸ Model Comparison

Distributional Implications: Others



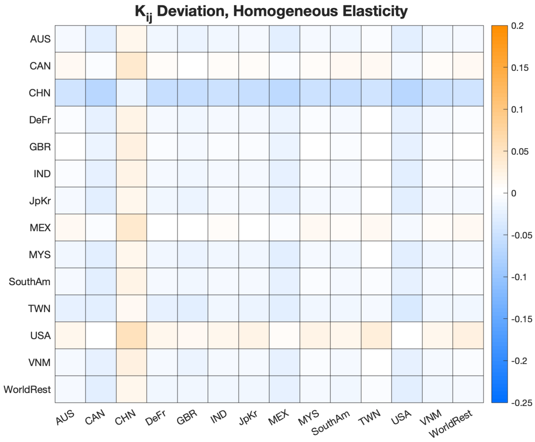
▸ Model Comparison ▸ Sensitivity: $\theta = 14$ ▸ Return

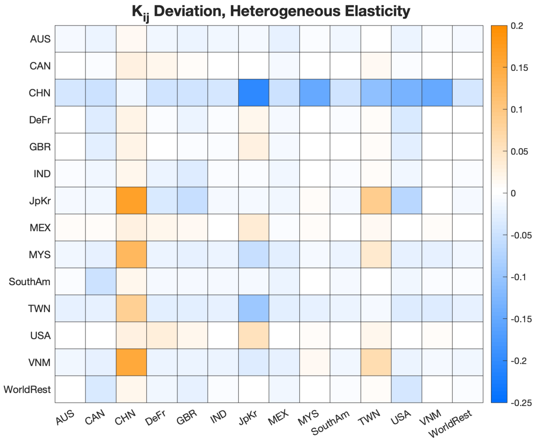
Total Export Value Responses



Return

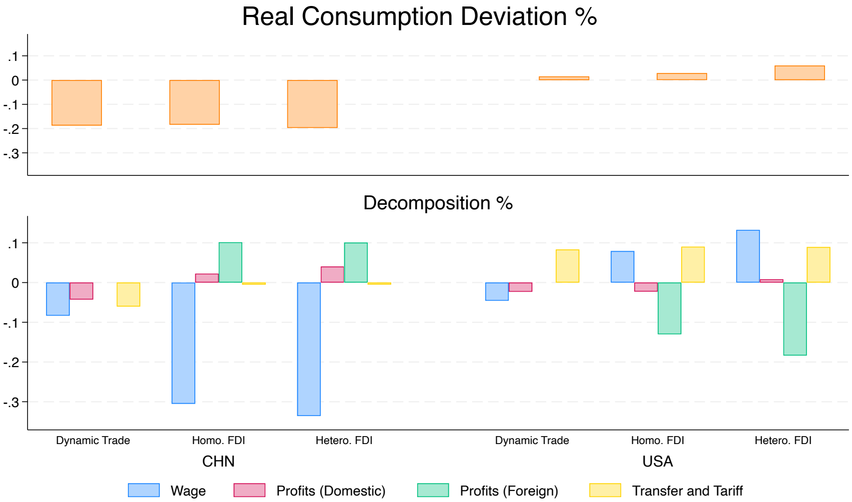
Bilateral FDI Diversion: Homogeneous vs. Heterogeneous Elasticity





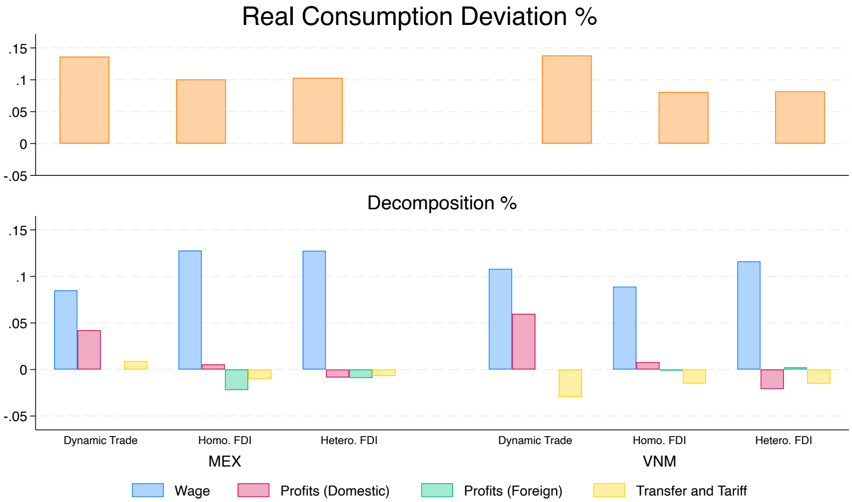
Return

Model Comparison for China and the US



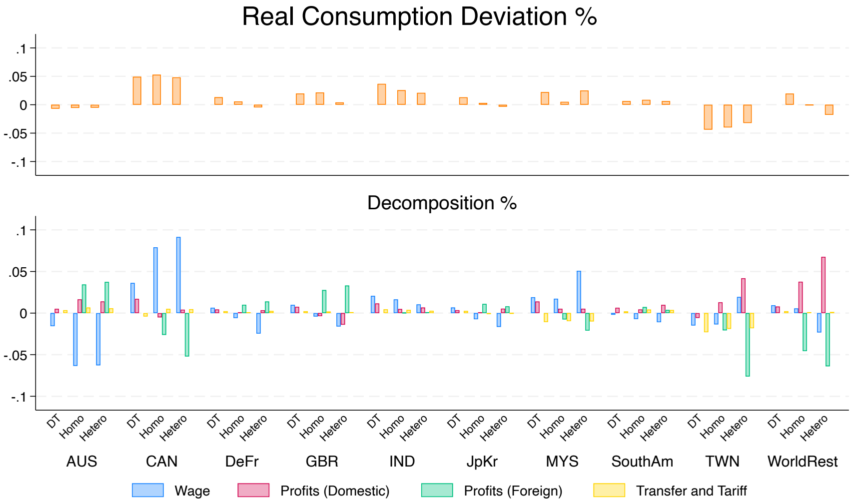
Return

Model Comparison for Mexico and Vietnam



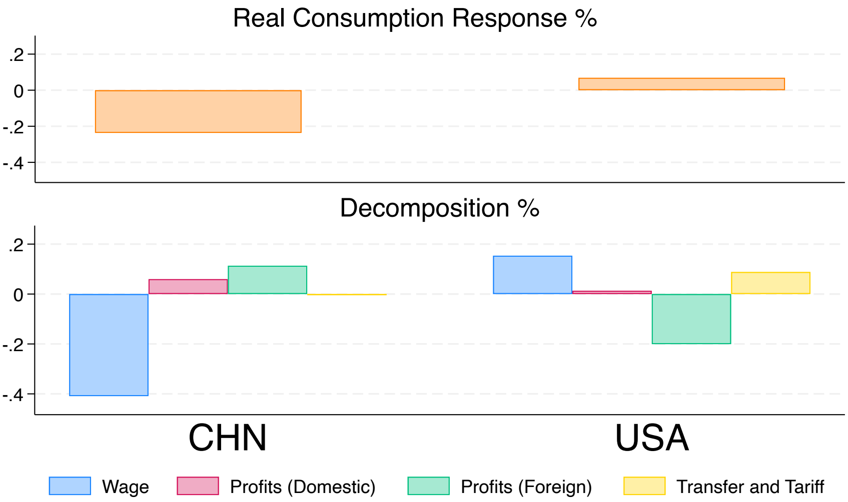
Return

Model Comparison for Others

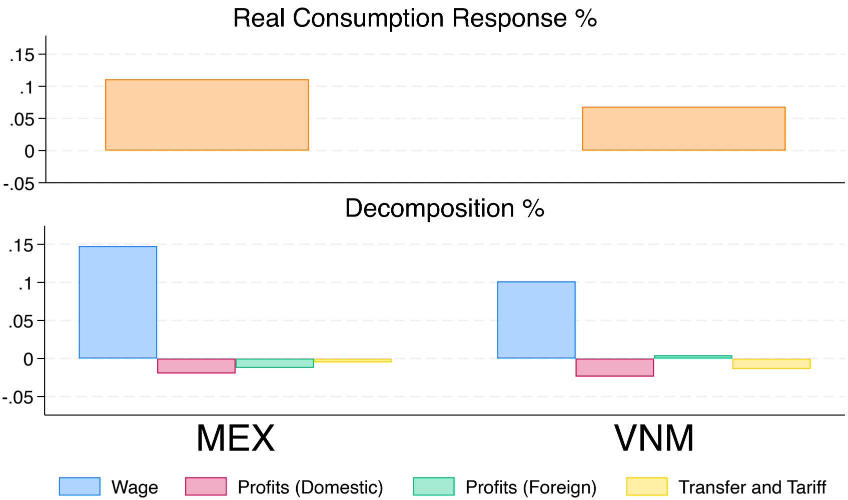


Return

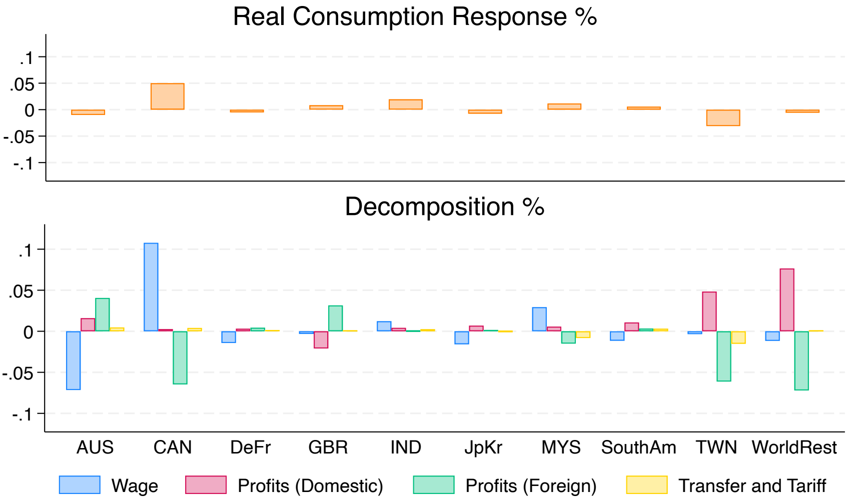
Sensitivity Quantitative Results: $\theta = 14$



Sensitivity Quantitative Results: $\theta = 14$, Cont.



Sensitivity Quantitative Results: $\theta = 14$, Cont.



Return