Trade Wars with FDI Diversion

Spillover Conference, Basel

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April 30, 2024

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 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.

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, $\Delta\tau_{\mathsf{US,CN}}(\nu)$;
    - 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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  Construct a country's **exposure to trade diversion** from the Trump Tariffs;

- When does a big $\Delta\tau_{US,CN}(\nu)$ create large trade diversion "opportunities" for country i?
    - China accounts for a large fraction of US imports on ν;
    - i specializes in ν;
    - The US is a large market for i on ν;

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

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

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

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

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

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

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

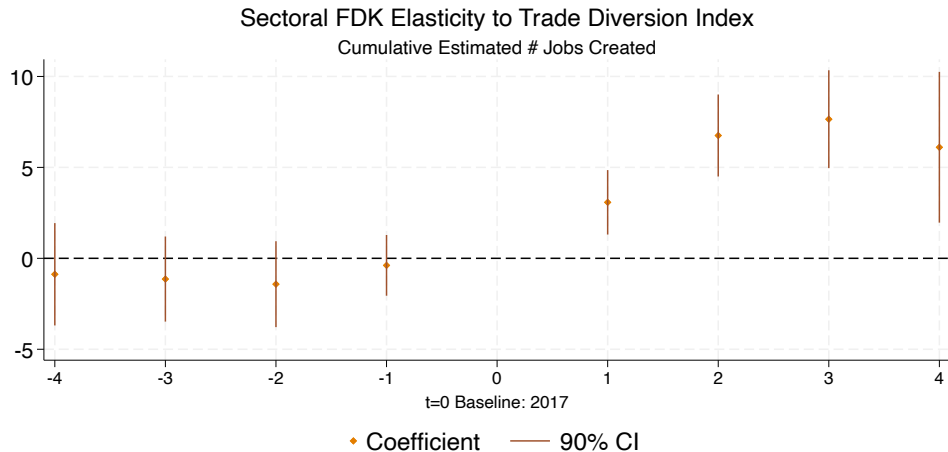where J_{sit} is the cumulative estimated jobs created from FDI;

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

Country Level Result

FDK Elasticity to Trade Diversion Index

t=0 Baseline: 2017

• Coefficient   —— 90% CI
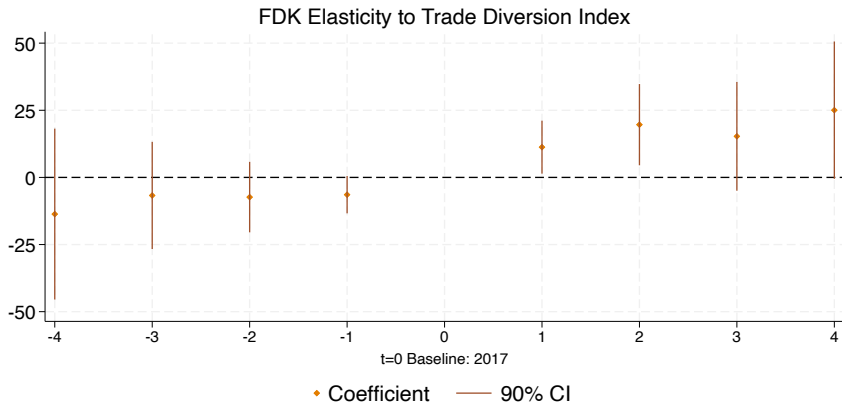
Point estimate $\vartheta \approx 20$, 95th percentile DI ≈ 0.004 (which is Vietnam) $\Rightarrow$ 8% relative growth.

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

Sector Level Result: Cumulative Estimated Jobs Created

Sectoral FDK Elasticity to Trade Diversion Index

Cumulative Estimated # Jobs Created

t=0 Baseline: 2017

♦ Coefficient   — 90% CI

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

Heterogeneous Bilateral FDK Responsiveness

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

Bilateral FDK in Vietnam and the UK
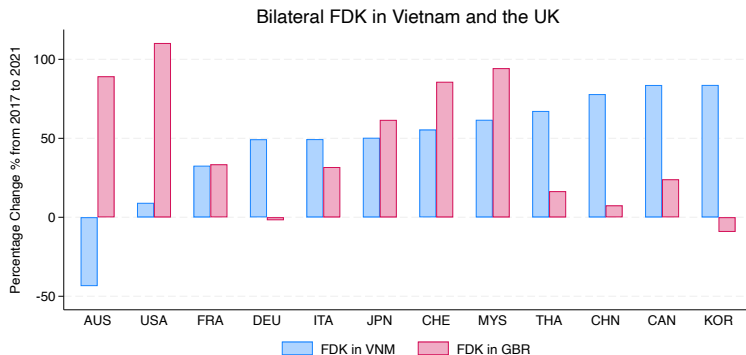
- Are such deviations purely due to bilateral idiosyncratic shocks?

Systematic Factors for Responsiveness Heterogeneity

- $\mathbf{Z}_{ij}$: Bilateral country characteristics;

- $d \ln \mathrm{FDK}_{ij} = \mathrm{FE}_i + \mathrm{FE}_j + \mathbf{Z}_{ij}\tilde{\psi} + \left(\underbrace{d \ln \mathrm{FDK}_i \cdot \mathbf{Z}_{ij}}_{} \right) \psi + u_{ij}$

  Proxy for change of receiver's overall FDI attractiveness;

ψ	
$d \ln \mathrm{FDK}_i \times \ln \left(\mathrm{Dist}_{ij}\right)$	-0.284**
	(0.122)
$d \ln \mathrm{FDK}_i \times \ln \left(\mathrm{GDPpc}_j\right)$	0.156**
	(0.065)
$d \ln \mathrm{FDK}_i \times \mathrm{ComparaAdv}_{ij}$	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.

▶ 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: $Y_i = \sum_h \sum_s \frac{\pi_{hi}^s}{\tau_{hi}^s} X_h^s$, and
- country budget constraints hold: Current Account$_j$ + Capital Account$_j$ + Transfer$_j$ = 0.

Solution to the Producer's Problem

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

$$p_{hij}^s(a) = \frac{\epsilon^s}{\epsilon^s - 1} \frac{d_{hi}^s \tau_{hi}^s w_i}{a^{\frac{1}{\epsilon^s-1}}/\kappa_{ij}^s} \quad \& \quad v_{ij}^s(a) \equiv \frac{1}{\epsilon^s - 1} \overbrace{A_i^s w_i^{1-\epsilon^s}}^{\equiv \tilde{A}_i^s} \frac{a}{\kappa_{ij}^{s\ \epsilon^s-1}};$$

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

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

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

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

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

Decomposition: Welfare Change Induced by Tariff Changes

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

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

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

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$$+ \sum_i \sum_s \frac{1}{\epsilon^s - 1} \frac{\tau_{ji}^s \mathcal{T}_{ji}^s}{X_j} \sum_{j'} \omega_{ij'}^s \, d \ln \tilde{M}_{ij'}^s \qquad \text{Relocation}$$

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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$$+ \underbrace{\sum_i \sum_s \frac{\left(\tau_{ji}^s - 1 \right) \mathcal{T}_{ji}^s}{X_j} \left(d \ln \mathcal{T}_{ji}^s - d \ln w_i \right)}_{\text{Tariff Revenues}} - \underbrace{\frac{\Gamma_j}{X_j} d \ln \Gamma_j}_{\text{Value of Transfers}} \quad,$$

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. $\tilde{v}_{ij}^s$:
    1. Independence of draws across locations;
    2. Uniform correlation to productivity draws across locations;
    3. Bilateral correlations.

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 $0 < \rho < 1$:

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

- 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):

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

- 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:

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

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

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.

Trade Elasticity ϵ^s

- Trade gravity: $\frac{X_{hi}^s}{X_{hh}^s} = \frac{\Phi_i^s (d_{hi}^s)^{1-\epsilon^s} (\tau_{hi}^s)^{-\epsilon^s}}{\Phi_h^s}$;

- For s = Agriculture, Manufacturing, gravity regression with fixed effects and tariff shifters:

$$\ln EX_{hit}^s = FE_{ht}^s + FE_{it}^s - \epsilon^s \ln \tau_{hit}^s + u_{hit}^s;$$

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

$$\ln EX_{hit}^3 = FE_h^3 + FE_i^3 + FE_t - \epsilon_{RER}^3 \ln RER_{hit} + u_{hit}^3;$$

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

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

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 $\theta, \rho, \boldsymbol{\zeta}$ to match empirical and model regression coefficients $\vartheta, \boldsymbol{\psi}$:

    $$d \ln K_i = \vartheta \text{DI}_i + u_i,$$
    $$d \ln K_{ij} = \text{FE}_i + \text{FE}_j + \mathbf{Z}_{ij}\tilde{\boldsymbol{\psi}} + \left(d \ln K_i \cdot \mathbf{Z}_{ij}\right) \boldsymbol{\psi} + u_{ij},$$

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

- 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.

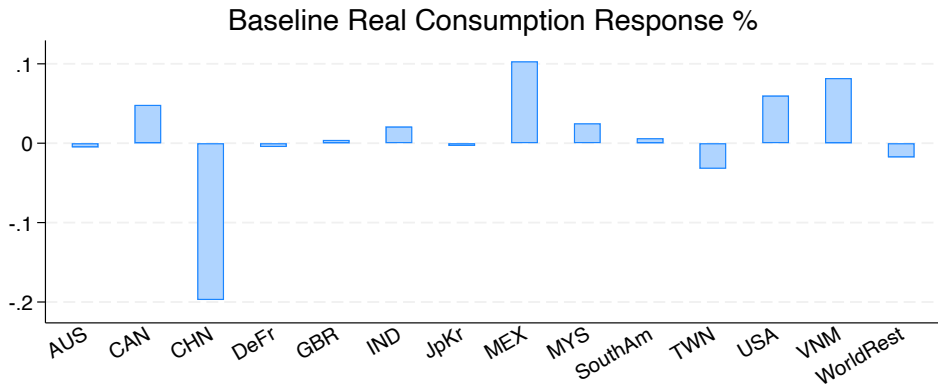# FDI Elasticities θ, ρ and $\left\{\eta_{ij}\right\}_{i \neq j}^{N,N}$: Indirect Inference, Cont.

	Outcome: $d \ln K_{ij}$		Calibration	
	Data	Model	Parameter	Value
$d \ln K_i \times \ln\left(Dist_{ij}\right)$	-0.169*	-0.176	ζ_1	-7
	(0.090)			
$d \ln K_i \times \ln\left(GDPpc_j\right)$	0.117**	0.116	ζ_2	5
	(0.059)			
$d \ln K_i \times ComparaAdv_{ij}$	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 ψ. 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 $\{\eta_{ij}\}_{i \neq j}^{N,N}$

$\eta_{\mathbf{ij}}$
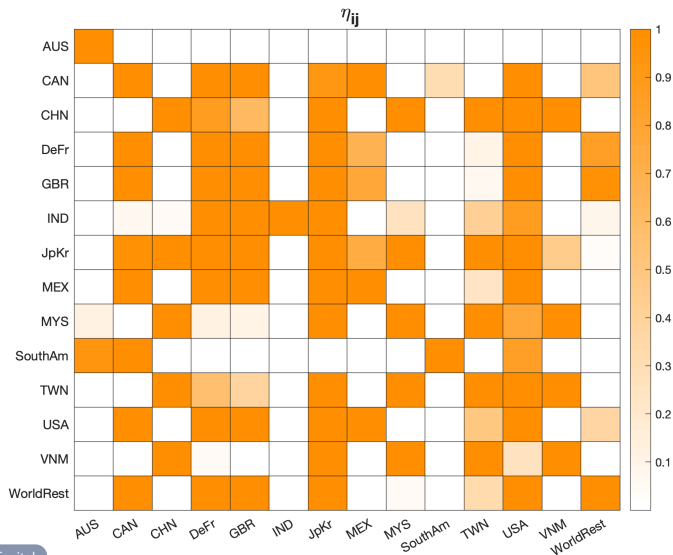
Quantitative Evaluations: The Trump Tariffs

- 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" for the US;

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

FDI Diversion on Aggregate Welfare

Baseline Real Consumption Response %

FDI Diversion on Aggregate Welfare

Real Consumption Response %

Legend: Baseline, Fixed FDI

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

30 / 44

Decomposition of Real Consumption Response % (Baseline)

Profit | ToT | Tariff Revenue | Transfer | Relocation
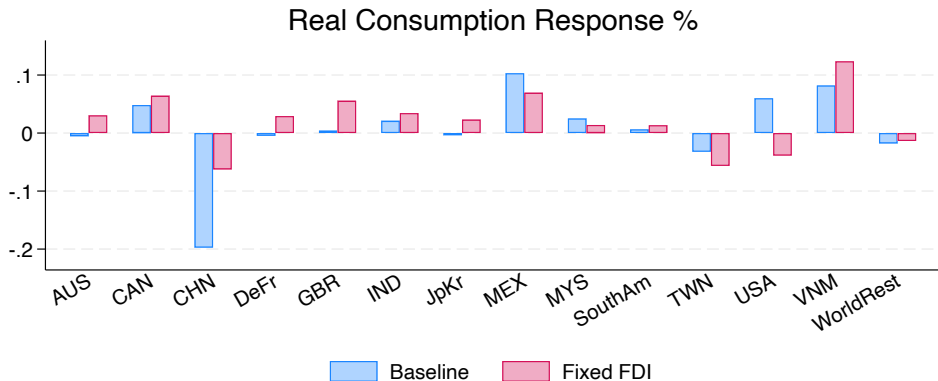
Welfare Response Decomposition: Fixed FDI

Decomposition of Real Consumption Response % (Fixed FDI)
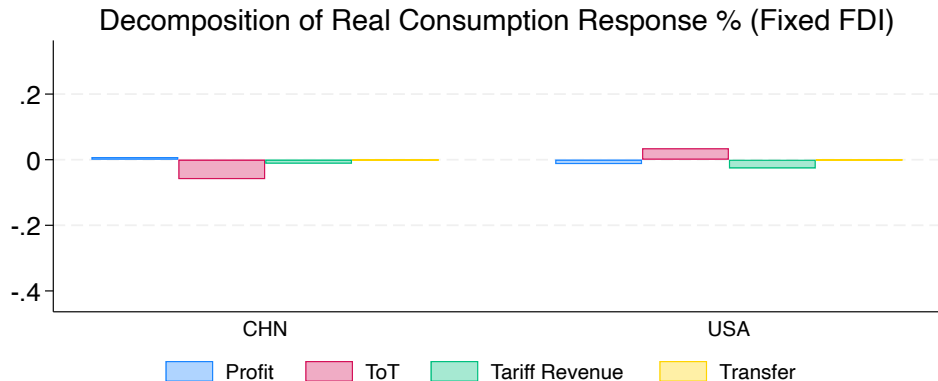
Numerical "Optimal Tariff" (Uniform and Unilateral)
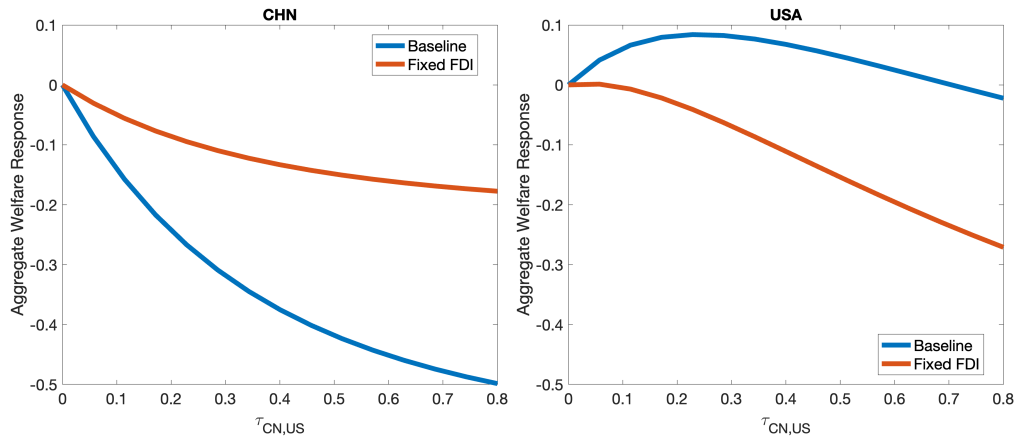
"Optimal Tariff": Nash (Baseline)
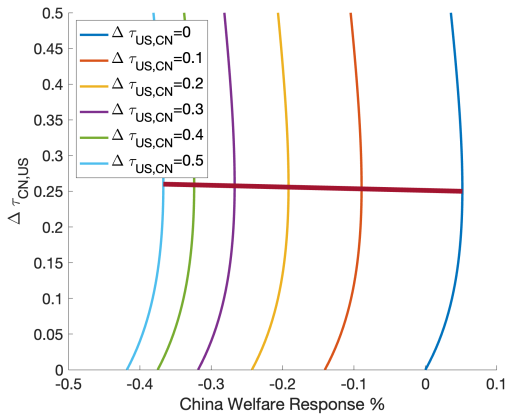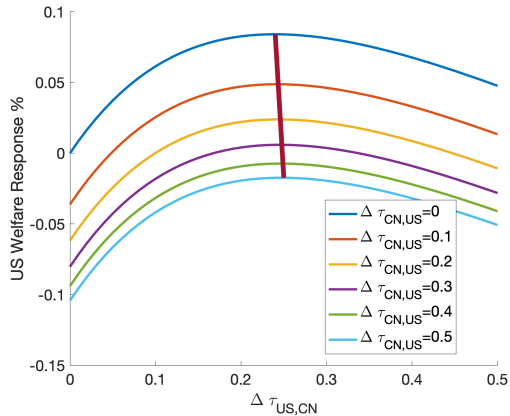
"Optimal Tariff": Nash (Fixed FDI)
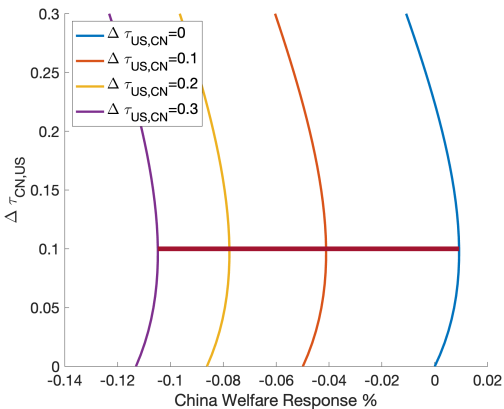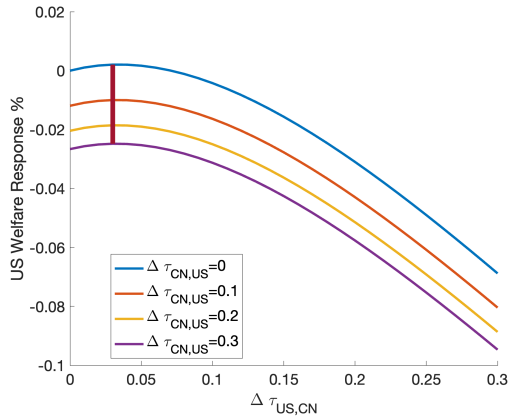
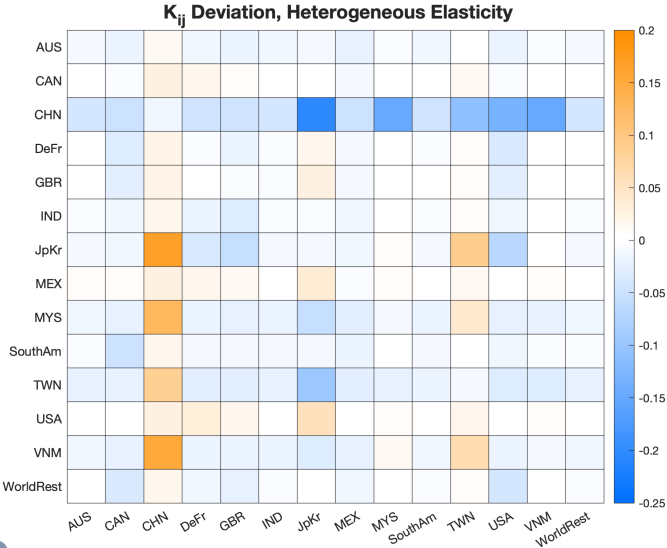# "Optimal Tariff": Nash Equilibrium Tariffs
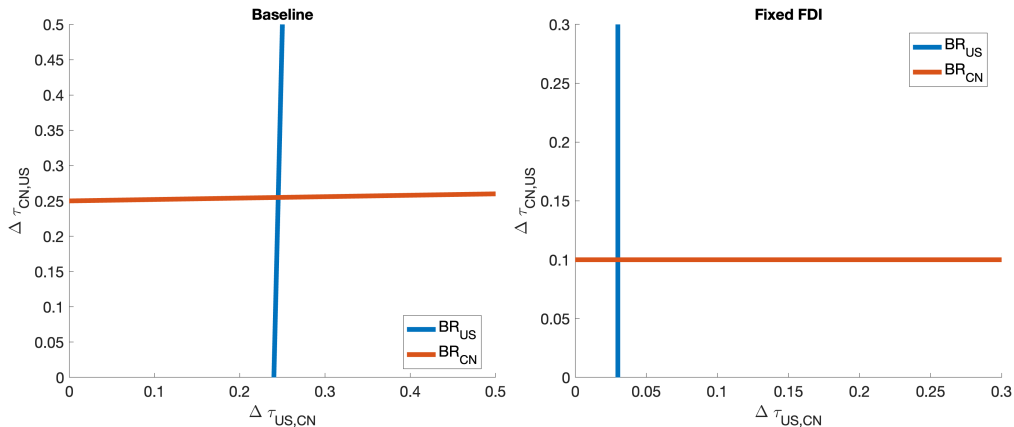
Export Value Responses

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

- $\tilde{M}_{ij}^s$: the mass of producers, adjusted for the productivity distribution;

- $\omega_h^s \equiv \dfrac{\sum_{j \neq i} \tilde{M}_{ij}^s \left(P_{hij}^s\right)^{1-\epsilon^s}}{\sum_j \tilde{M}_{ij}^s \left(P_{hij}^s\right)^{1-\epsilon^s}}$: the share of foreign production capacity in country i for sector s.
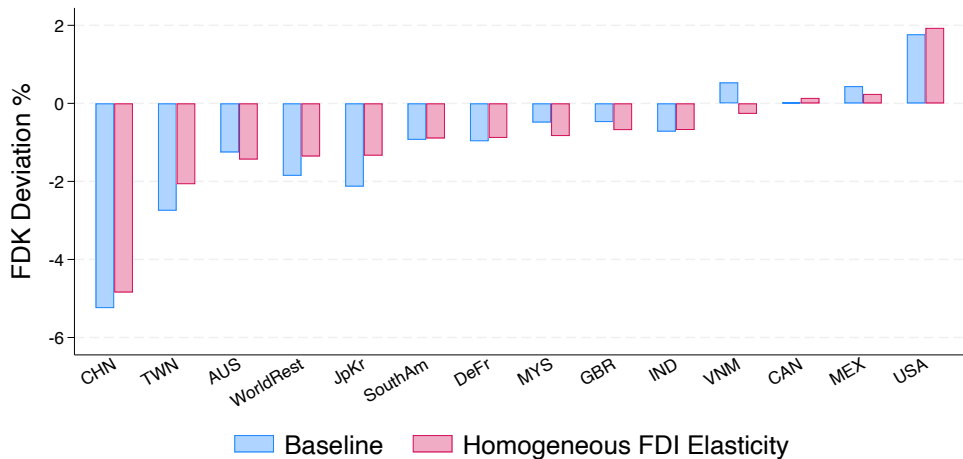
Export Value Responses

Decomposition of Export to US Response %
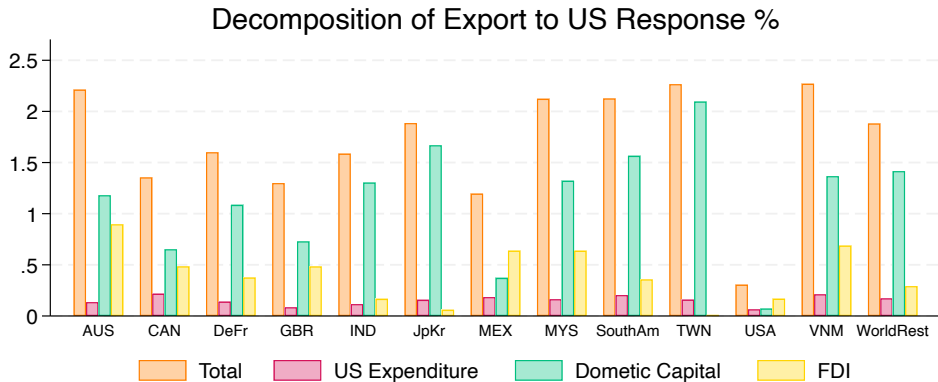
FDI Diversion: Bilateral

K$_{ij}$ Deviation, Heterogeneous Elasticity

▶ Comparison: Homogeneous Elasticities
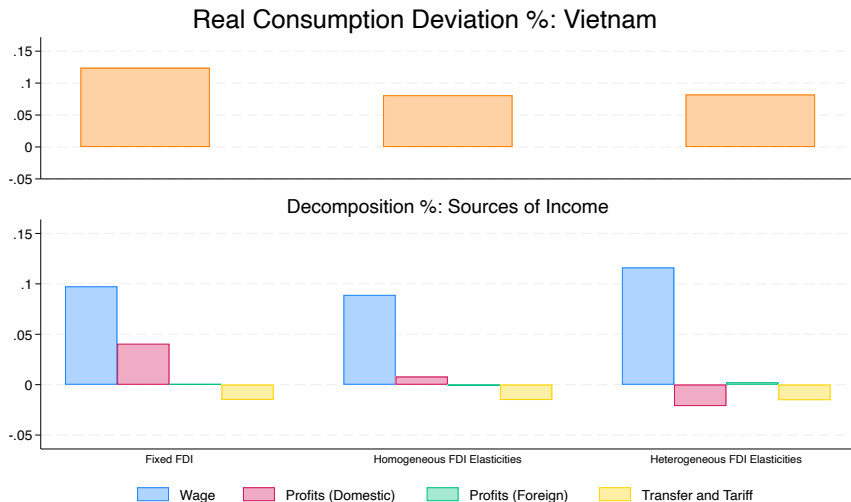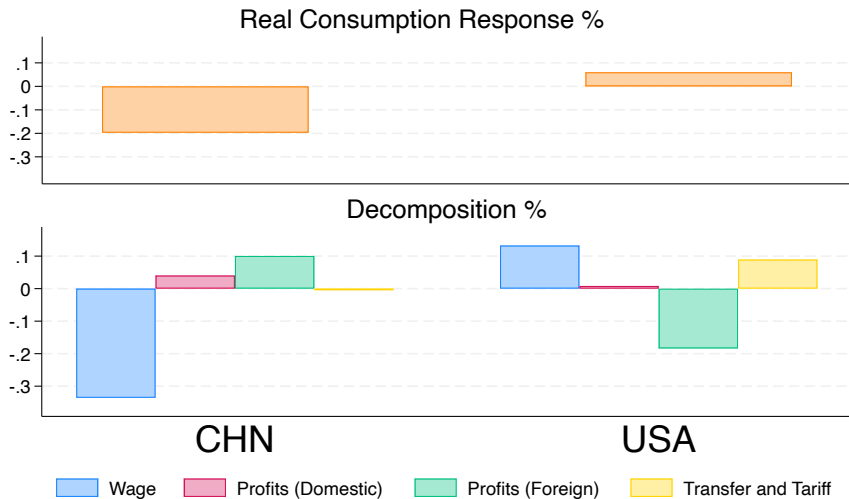
FDI Diversion: FDK, Homogeneous vs. Heterogeneous Elasticities

Heterogeneous FDI Elasticities on Vietnam Welfare Implications

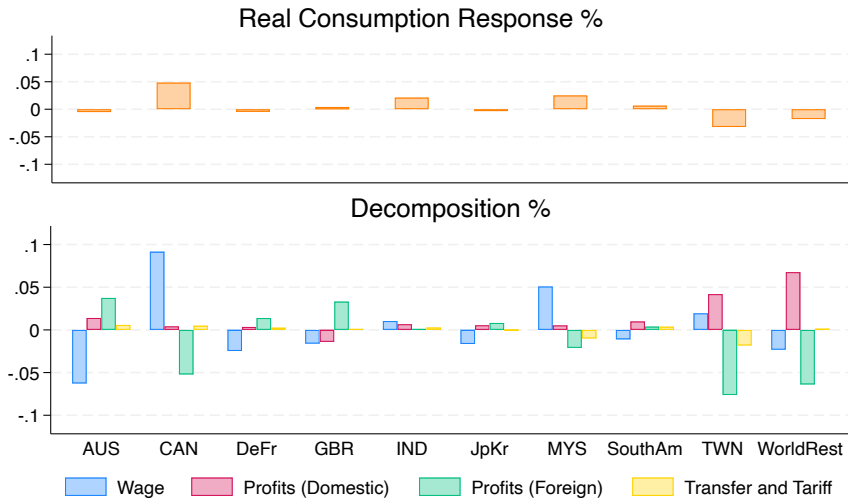Real Consumption Deviation %: Vietnam

Decomposition %: Sources of Income

Wage ▪ Profits (Domestic) ▪ Profits (Foreign) ▪ Transfer and Tariff

Distributional Implications: China and the US

Real Consumption Response %

Decomposition %

CHN   USA

Wage   Profits (Domestic)   Profits (Foreign)   Transfer and Tariff

Distributional Implications: Mexico and Vietnam

Real Consumption Response %

Decomposition %

MEX   VNM

Wage   Profits (Domestic)   Profits (Foreign)   Transfer and Tariff
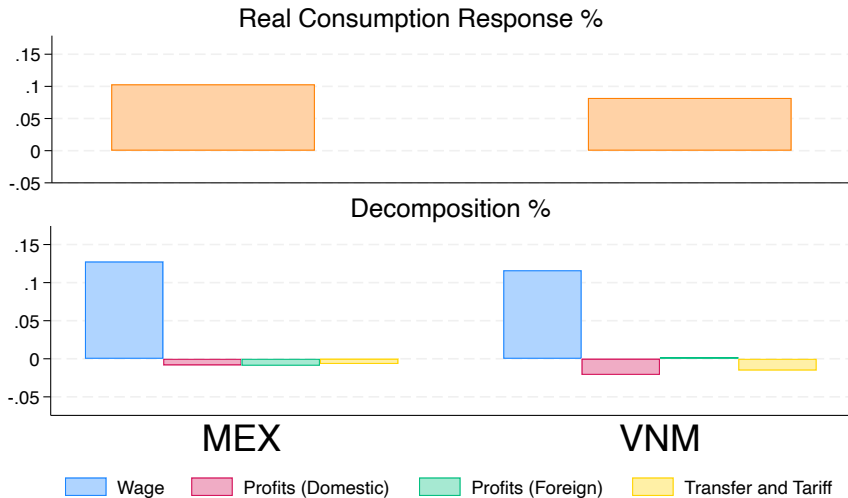
Distributional Implications: Others

Real Consumption Response %

Decomposition %

Wage | Profits (Domestic) | Profits (Foreign) | Transfer and Tariff

Conclusion

Trump pledges to get tough with tariffs again if elected
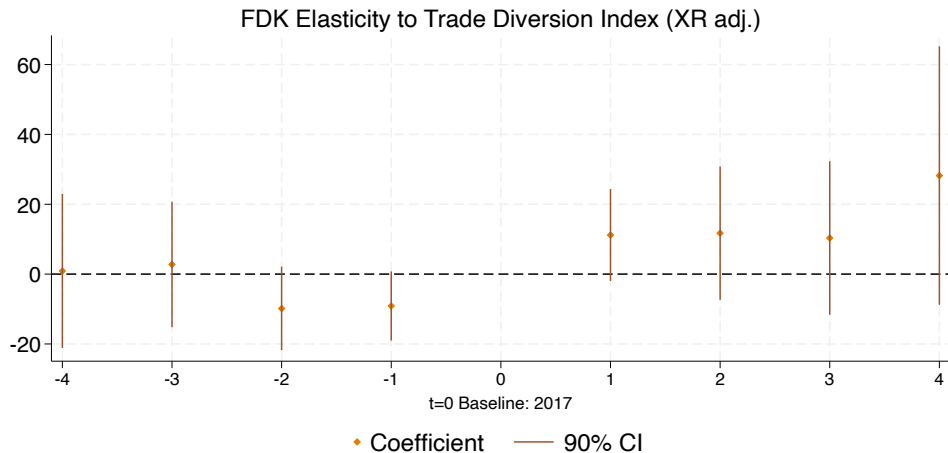
Conclusion

Trump pledges to get tough with tariffs again if elected
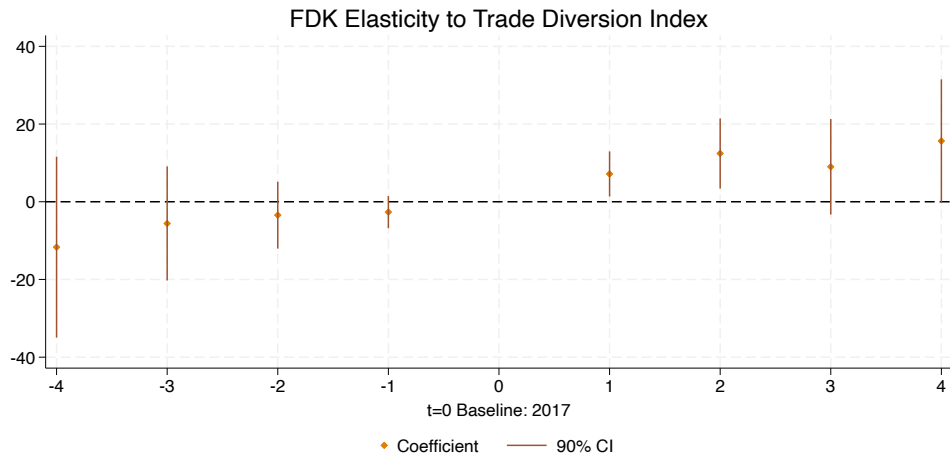
- Should not ignore FDI when studying trade policies:
    - Recent case: the China-US trade war;
    - Numbers, mechanisms, distributions;
    - Heterogeneous FDI elasticities important for FDI diversion patterns.
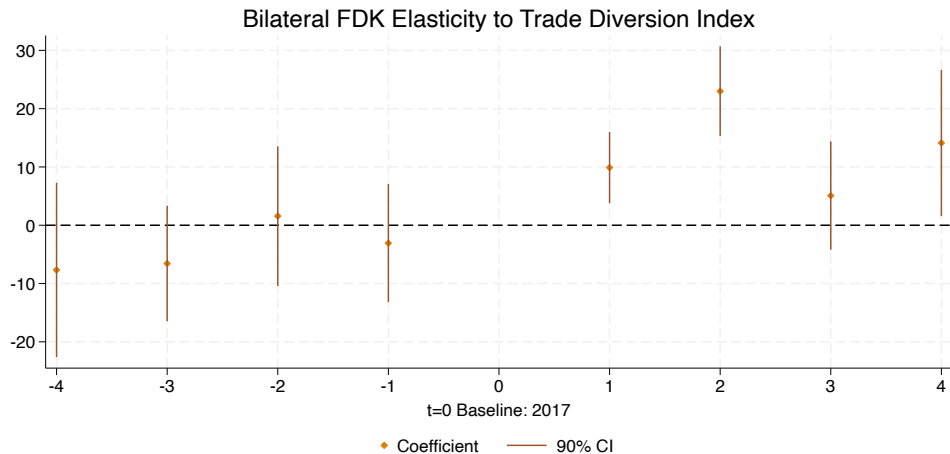
Appendix

Country Level Result: Exchange Rate Adjusted
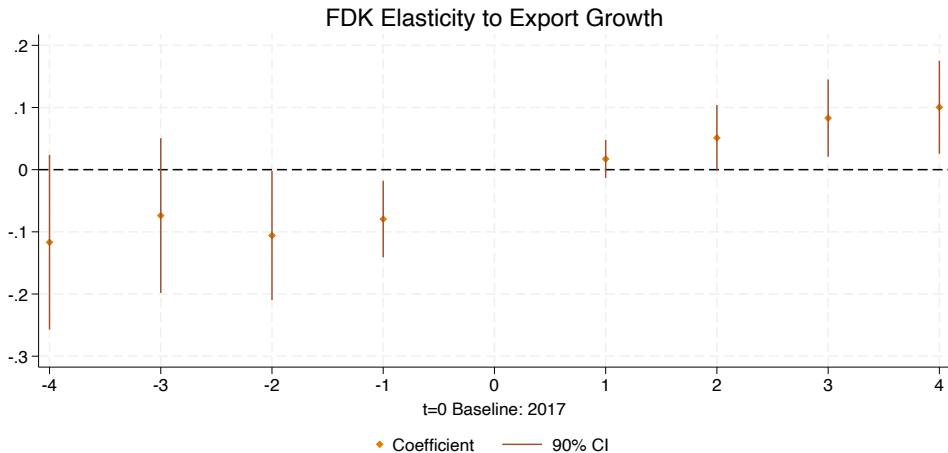

FDK Elasticity to Trade Diversion Index (XR adj.)

t=0 Baseline: 2017

♦ Coefficient —— 90% CI

Country Level Result: Use ISIC 2-digit Tariffs

FDK Elasticity to Trade Diversion Index

t=0 Baseline: 2017

♦ Coefficient —— 90% CI

Country Level Result: Bilateral FDI Stocks

Bilateral FDK Elasticity to Trade Diversion Index

t=0 Baseline: 2017

♦ Coefficient   —— 90% CI

Using Export Directly: Export Growth as Independent Variable

FDK Elasticity to Export Growth

t=0 Baseline: 2017

♦ Coefficient ——— 90% CI

Sector Level Result: Cumulative # Projects

Sectoral FDK Elasticity to Trade Diversion Index
Cumulative # New Projects

t=0 Baseline: 2017

♦ Coefficient — 90% CI
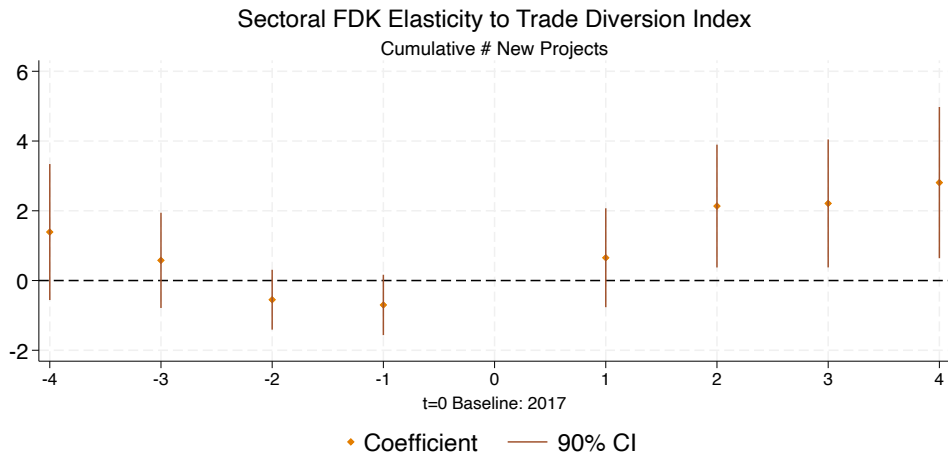
Sector Level Result: Cumulative Estimated Capital Invested

Sectoral FDK Elasticity to Trade Diversion Index

Cumulative Estimated Capital Invested

t=0 Baseline: 2017

♦ Coefficient　—— 90% CI

◄ Return
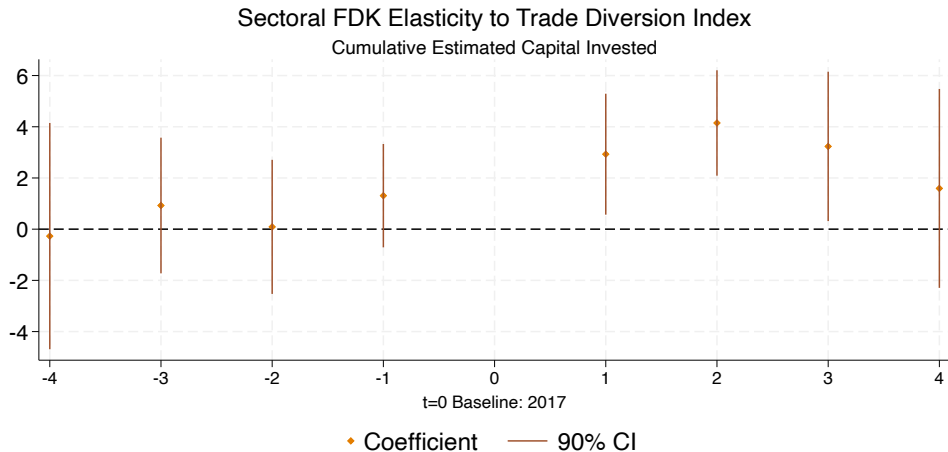
Sector Level Result: Estimated Jobs Created

Sectoral FDK Elasticity to Trade Diversion Index

Estimated # Jobs Created

t=0 Baseline: 2017

• Coefficient — 90% CI

FDI Data: Official vs. fDi Markets

Bilateral FDK: Official vs. fDi Markets
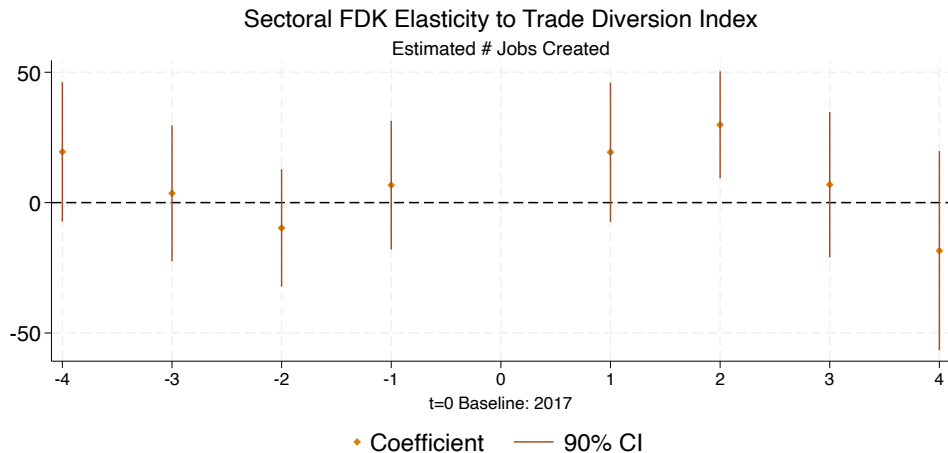
Official log(FDK) vs. log(Cumulative # of Projects)
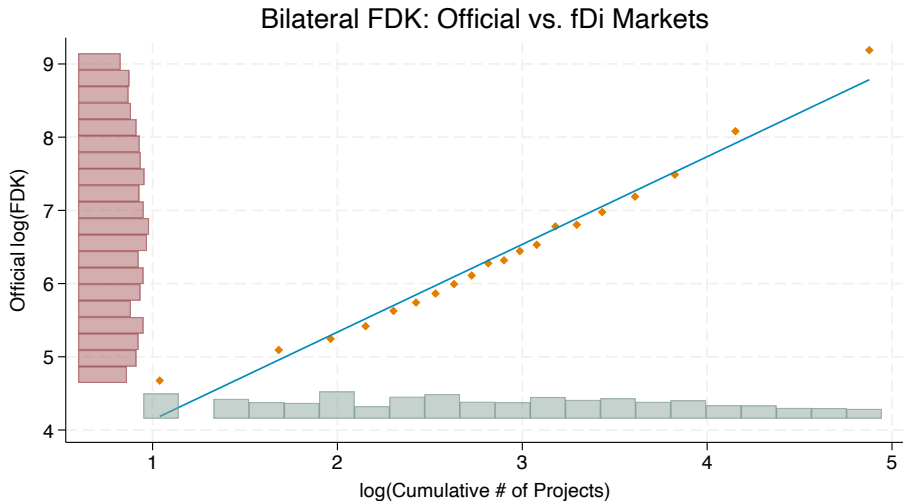
Controlled for Receiver, Source, Year FE.

FDI Data: Official vs. fDi Markets

Bilateral FDK Growth: Official vs. fDi Markets
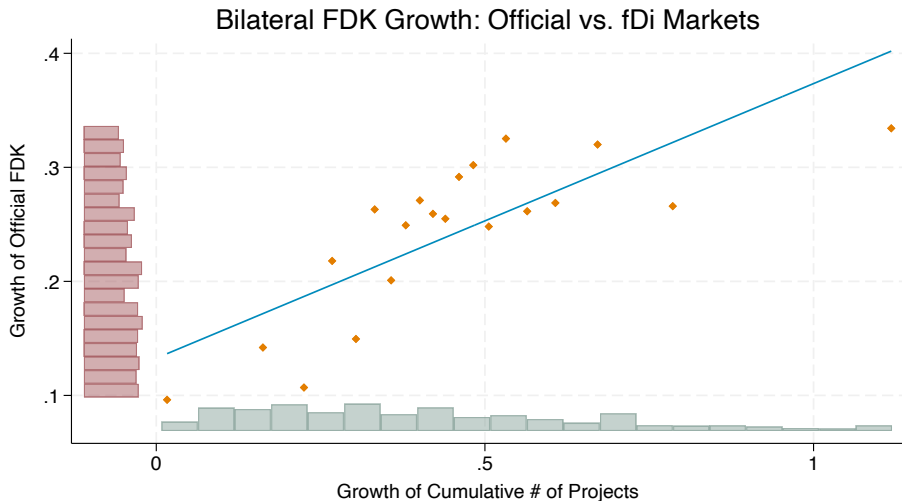
Accumulative growth from 2013; Controlled for Receiver, Source, Year FE.

Heterogeneous Bilateral FDK Responsiveness (Manufacturing)
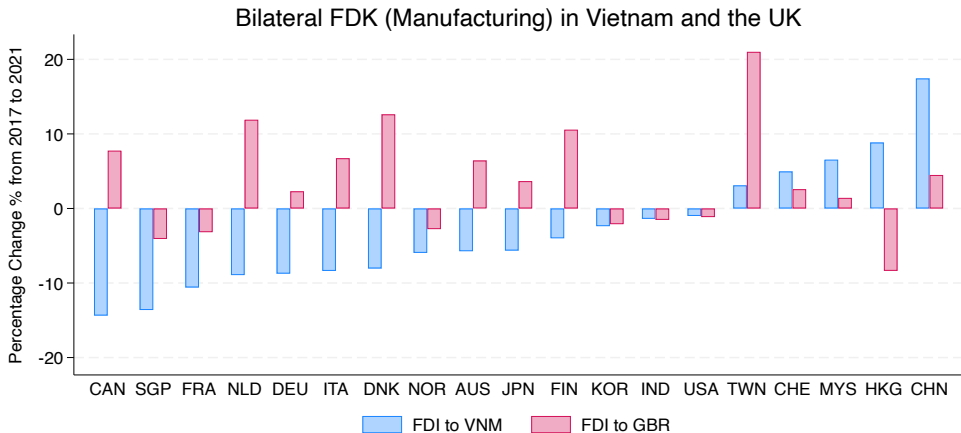
Bilateral FDK (Manufacturing) in Vietnam and the UK

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

Heterogeneous Bilateral FDK Responsiveness (Service)
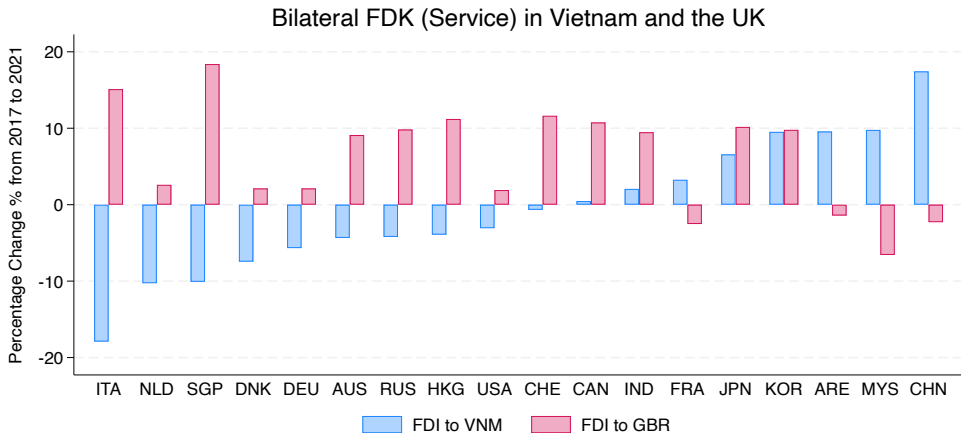
Bilateral FDK (Service) in Vietnam and the UK

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

Share of FDK Investment

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

	(1)	(2)
d ln FDK$_i$ × ln (Dist$_{ij}$)	-0.284**	-0.204*
	(0.122)	(0.121)
d ln FDK$_i$ × ln (GDPpc$_j$)	0.156**	0.115*
	(0.065)	(0.065)
d ln FDK$_i$ × ComparaAdv$_{ij}$	0.599**	0.580**
	(0.283)	(0.280)
d ln FDK$_i$ × ω_{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: $d \ln N_{ij,t} = \ln(N_{ij,t+1}/N_{ij,t}), t = 2017, \ldots, 2020;$

  $N_{i,t}$: 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)
$d \ln N_{i,t} \times \ln(\text{Dist}_{ij})$		-0.048***	-0.046***
		(0.006)	(0.006)
$d \ln N_{i,t} \times \text{GDPpc}_j$		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_{hi}^s) $\Rightarrow$ a new steady state;

- Without capital adjustment: Prices & Trade diversion;

- For production location i of sector s, producers from j, the following also change:

$$\textbf{Market access} \qquad A_i^s = \text{constant} \cdot \sum_h \left(d_{hi}^s\right)^{-\epsilon^s} \left(\tau_{hi}^s\right)^{1-\epsilon^s} \overbrace{\left(P_h^s\right)^{\epsilon^s} Q_t^s}^{\text{h market size}};$$

$$\textbf{Optimal capital value} \qquad P_i k_{ij}^{s*}(a) = \underbrace{\Lambda_i^s}_{\text{constant}} \frac{\tilde{A}_i^s}{\kappa_{ij}^s \; \epsilon^s - 1}, \text{ where } \tilde{A}_i^s \equiv P_i^{-(\epsilon^s-1)\alpha_i^s} \left(\frac{w_i}{1-\alpha_i^s}\right)^{-(\epsilon^s-1)\left(1-\alpha_i^s\right)} A_i^s;$$

$$\textbf{Value of operation} \qquad \tilde{v}_{ij}^s = \underbrace{\tilde{\Lambda}_i^s}_{\text{constant}} \frac{\tilde{A}_i^s}{\kappa_{ij}^s \; \epsilon^s - 1};$$

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

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, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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	

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;

κ_{ij} **Residual Distribution**
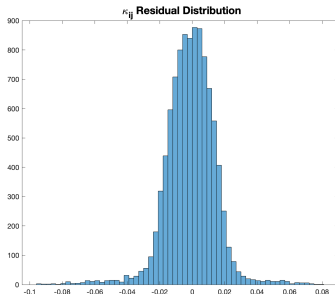
Back Out Shocks

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

Recovered Fundamental Shocks
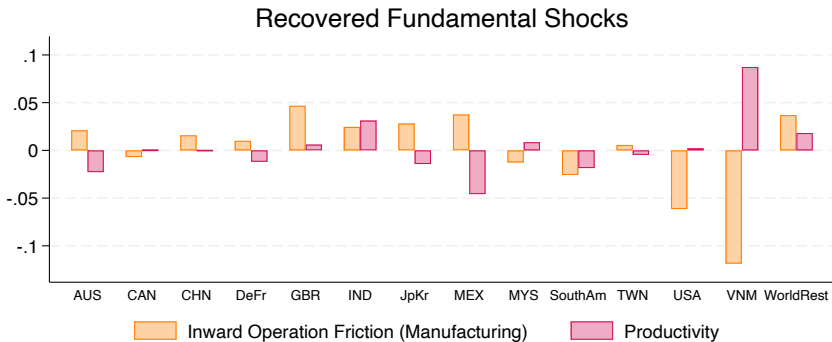
Indirect Inference: Given $\theta = 14$

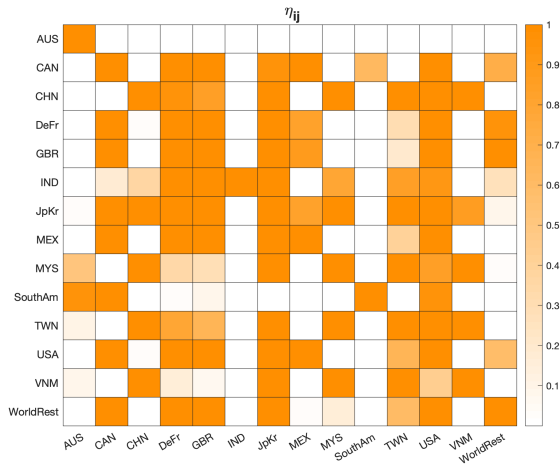|	Outcome: $d \ln K_i$		Calibration	
	Data	Model	Parameter	Value
DI_i	18.67 **	18.90	ρ	0.84
	(7.83)	(7.02)	θ	14
R^2	0.471			
# of Obs.	117			

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
$d \ln K_i \times \ln \left(\text{Dist}_{ij}\right)$	-0.169* (0.090)	-0.181	ζ_1	-7
$d \ln K_i \times \ln \left(\text{GDPpc}_j\right)$	0.117** (0.059)	0.122	ζ_2	4.5
$d \ln K_i \times \text{ComparaAdv}_{ij}$	0.576*** (0.219)	0.634	ζ_3	16.5
			ζ_0	-7
R^2	0.111			
# of Obs.	2621			

Notes: The first column reports empirical regression estimates of the interaction coefficients ψ. 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, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

η_{ij}

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 $\theta = 14$

Real Consumption Response %
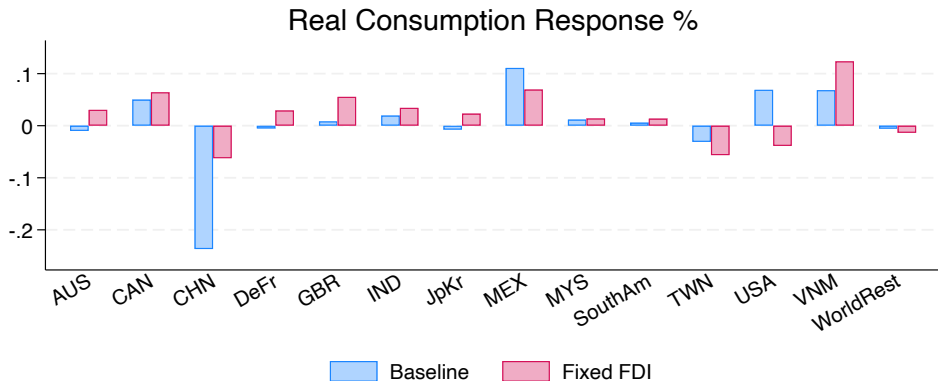
Chinese and Others' FDI Diversion

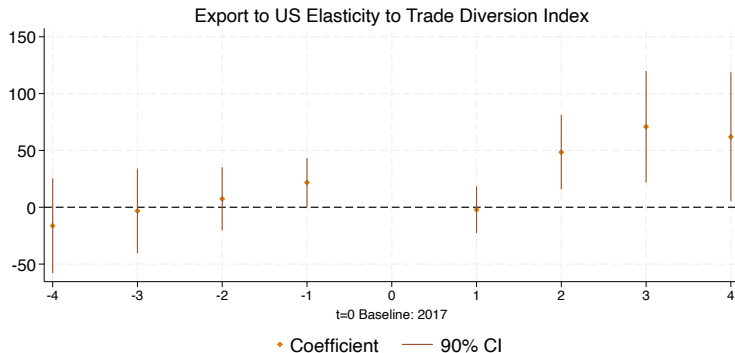Real Consumption Response %

Legend: Baseline, Fixed FDI, Fixed China's FDI, Fixed Others' FDI
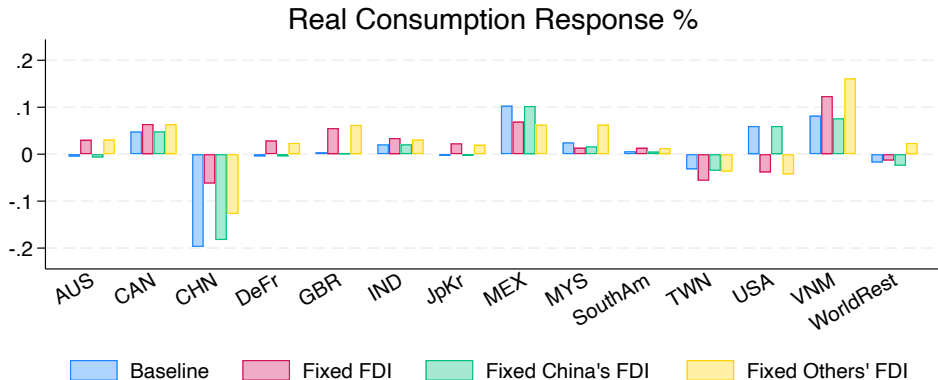
Contribution of FDI Diversion to Relative Export Growth

- DI_i also predicts relative export growth to the US:

Export to US Elasticity to Trade Diversion Index

t=0 Baseline: 2017

♦ Coefficient —— 90% CI

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

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:

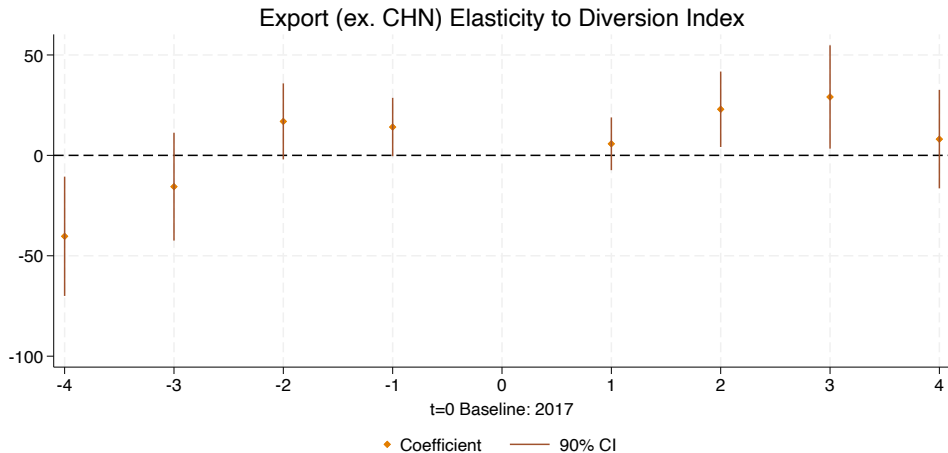|	FDK	Domestic Capital
DI	26.029**	19.567*
	(11.536)	(11.265)
R2 adj.	.04	.02
# of Obs.	99	94

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). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
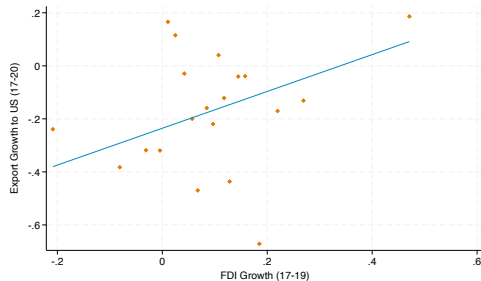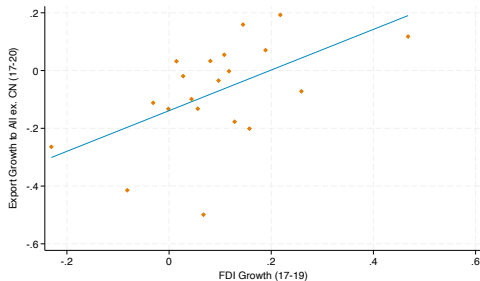
2. Average FDK share: 23.6%;

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

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

Total Export Growth (ex CN)

Export (ex. CHN) Elasticity to Diversion Index

t=0 Baseline: 2017

● Coefficient   —— 90% CI

Bin-scatters: EX ~ FDI

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

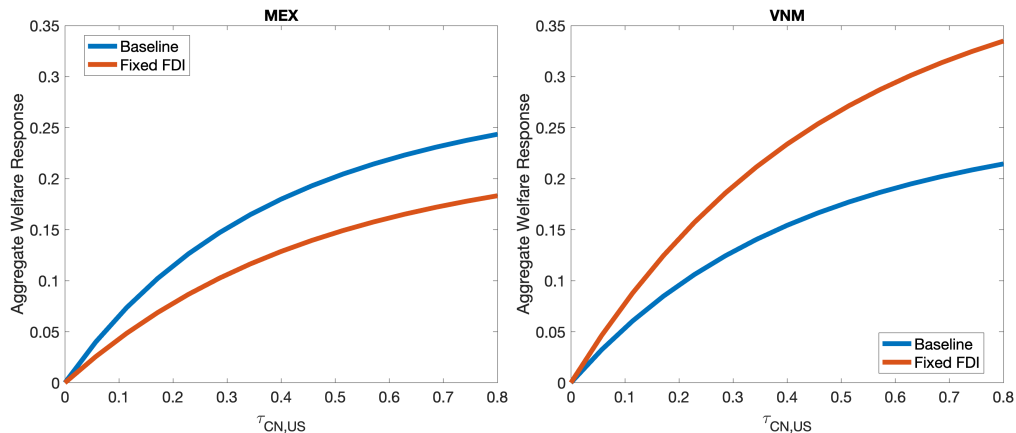$$\frac{(50 - 10)\% \times 1/3}{(50 - 10)\% \times 1/3 + (5 - 10)\% \times 2/3} = 133\%.$$

Data: FDI Growth

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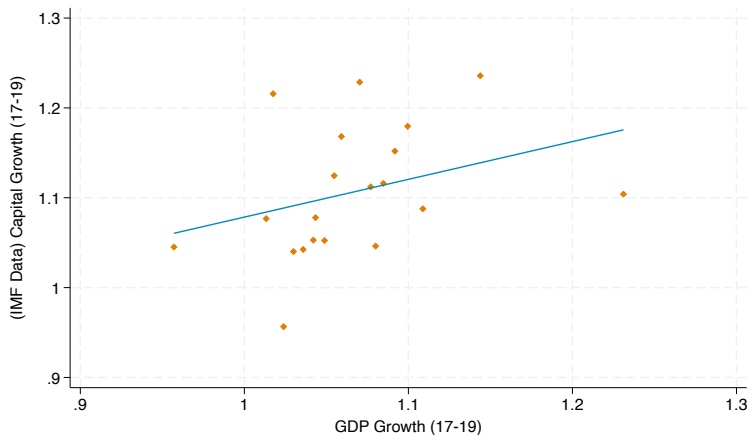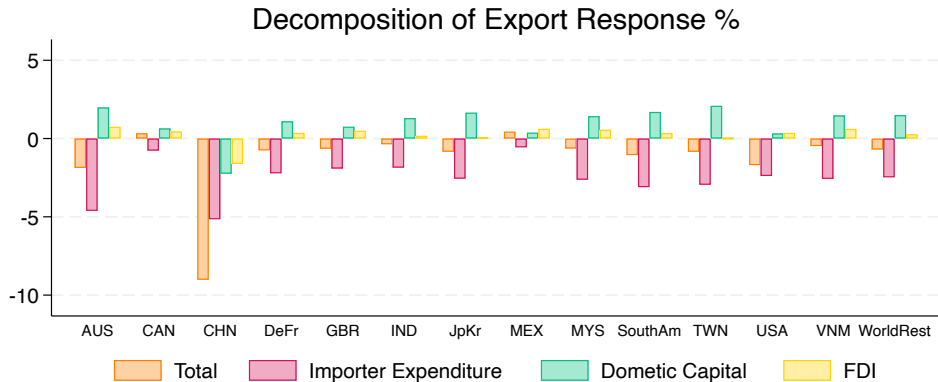

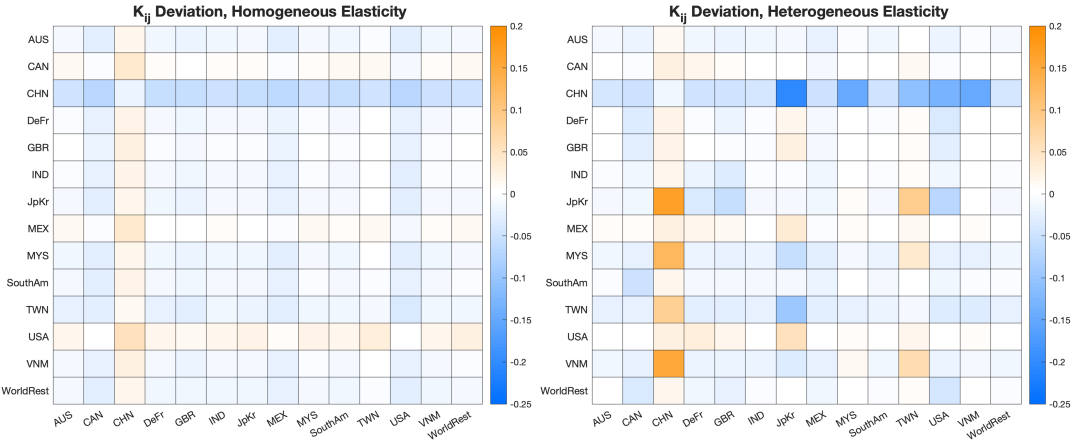- Calibration uses GDP growth implied total capital growth from 17 to 19;

Numerical "Optimal Tariff": MEX, VNM
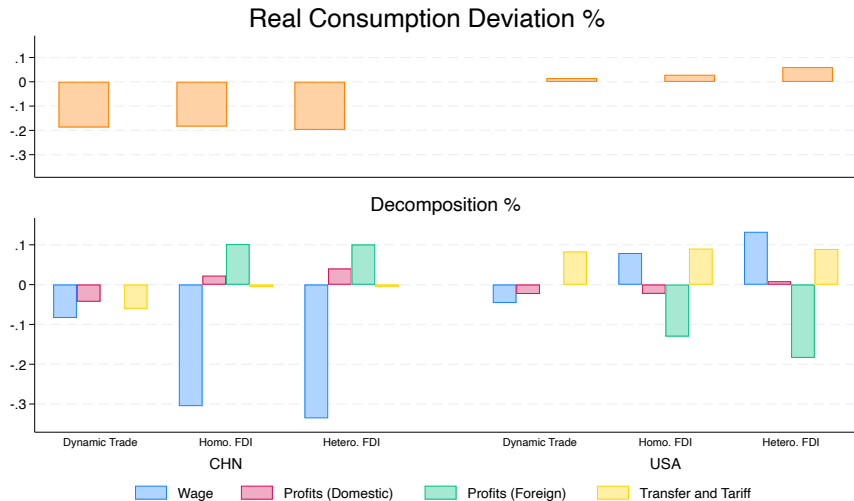
Total Export Value Responses

Decomposition of Export Response %

Bilateral FDI Diversion: Homogeneous vs. Heterogeneous Elasticity

K_{ij} Deviation, Homogeneous Elasticity

K_{ij} Deviation, Heterogeneous Elasticity

Model Comparison for China and the US

Real Consumption Deviation %

Decomposition %

CHN — USA

Dynamic Trade | Homo. FDI | Hetero. FDI | Dynamic Trade | Homo. FDI | Hetero. FDI

Legend: Wage | Profits (Domestic) | Profits (Foreign) | Transfer and Tariff

Model Comparison for Mexico and Vietnam

Real Consumption Deviation %

Decomposition %

MEX — Dynamic Trade, Homo. FDI, Hetero. FDI

VNM — Dynamic Trade, Homo. FDI, Hetero. FDI

Wage | Profits (Domestic) | Profits (Foreign) | Transfer and Tariff

▶ Return
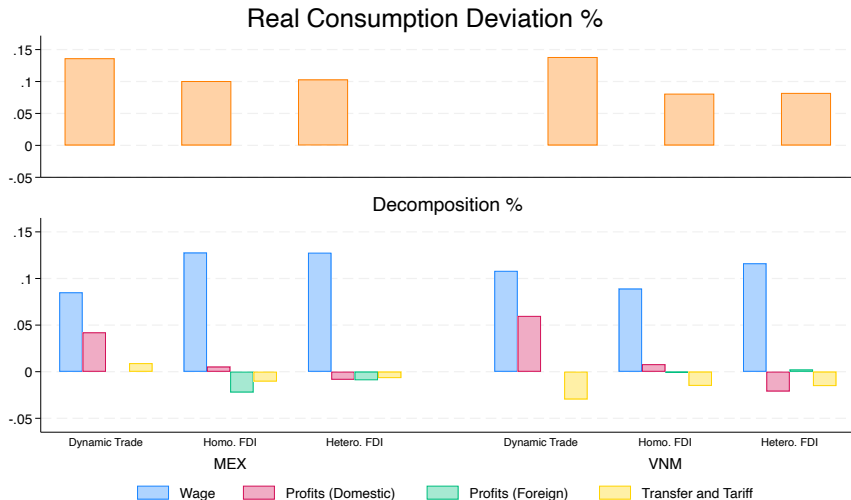
Model Comparison for Others

Real Consumption Deviation %

Decomposition %

Wage   Profits (Domestic)   Profits (Foreign)   Transfer and Tariff

▶ Return

Sensitivity Quantitative Results: $\theta = 14$

Real Consumption Response %

Decomposition %

CHN · USA

Wage · Profits (Domestic) · Profits (Foreign) · Transfer and Tariff

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

Real Consumption Response %

Decomposition %

MEX   VNM

Wage   Profits (Domestic)   Profits (Foreign)   Transfer and Tariff

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

Real Consumption Response %

Decomposition %

AUS CAN DeFr GBR IND JpKr MYS SouthAm TWN WorldRest

Wage   Profits (Domestic)   Profits (Foreign)   Transfer and Tariff

▶ Return