International Trade and Macroeconomic Dynamics with Sanctions

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Introduction

- Russia began its full-scale invasion of Ukraine on February 24, 2022.
- This prompted governments of many countries to impose sanctions.
- Russia was the 11th country in the world by nominal GDP before this war.
- Not since the 1930s has an economy of this size been placed under such restrictions.
- Different from the 1930s,
  - Russia is a major exporter of gas and oil,
  - the global economy is a lot more integrated.
- **Goal of this paper:** Understanding transmission and effects of sanctions with interdependence between large economies.

The Questions We Are Interested In

- What are the effects of sanctions in the short, medium, and long term?
  - Prices, exchange rate, economic activity.
- Who is most affected—the sanctioned country or the sanctioning one(s)?
  - Welfare.
- What are the effects of third-country decisions?

What We Do

- We start with a two-country model of international trade and macroeconomic dynamics.
- In each country:
  - Identical households consume, supply labor, and hold financial assets.
  - Upstream perfectly competitive gas production.
  - Downstream monopolistically competitive differentiated consumption good production.
    - Endogenous firm entry subject to initial sunk cost.
    - Firms produce with heterogeneous productivities.
    - Fixed trade costs imply only more productive firms export.
- Incomplete international financial markets.
- Ghironi and Melitz (2005) with a gas production sector.

What We Do, Continued

- Study sanctions in the form of exclusion from the international market.
- Consumption good trade sanctions:
  - Prohibition of international trade of outputs of firms with productivity above a certain threshold.
- Gas trade sanctions:
  - Prohibition of gas imports from the sanctioned country.
- Financial sanctions:
  - A fraction of agents in the sanctioned country is excluded from international bond trading.
- Analytical results (focusing on gas price and exchange rate) and numerical illustrations.

Preview of Results

- **Assumption:** Home imposes sanctions on Foreign.
- **Home export sanctions** $\Rightarrow$ Most productive (largest) Home firms no longer export to Foreign.
  - $\Rightarrow$ Home exports become more expensive.
  - $\Rightarrow$ Home real exchange rate (RER) depreciation.
- Foreign households substitute previously imported Home products with higher consumption of domestic goods.
  - $\Rightarrow$ Foreign demand of inputs in production of Foreign consumption goods rises.
  - $\Rightarrow$ Higher gas price and wages in Foreign.

Preview of Results, Continued

- **Gas sanctions** $\Rightarrow$ Foreign shifts resources toward production of consumption goods to replace lost export revenue.
  - $\Rightarrow$ Less productive Foreign producers start exporting to Home.
  - $\Rightarrow$ Foreign exports become more expensive $\Rightarrow$ Home RER appreciation.

Preview of Results, Continued

- **Financial sanctions** generate larger drop in Foreign consumption if larger proportion of Foreign households is sanctioned.
- There is incentive to front-load producer entry in Foreign.
  - $\Rightarrow$ Borrowing by non-sanctioned Foreign households rises.
    - Borrowing also on behalf of sanctioned households.
- Foreign households consume more domestic goods $\Rightarrow$ Input demand rises $\Rightarrow$ Higher gas price and wages in Foreign.

In All Scenarios

- Extensive margins (entry and exit by firms into and from markets) play important role.

Policy Bottom Line

- Exchange rate not a good metric to evaluate success or failure of sanctions (echoes Eichengreen et al., 2022).

Related Literature

Sanctions

- Albrizio et al. (2022), Bachmann et al. (2022), Bianchi and Sosa-Padilla (2023a,b), Darvas and Martins (2022), de Souza et al. (2022), Eichengreen et al. (2022), Imbs and Pauwels (2022), Itskhoki and Mukhin (2022), Lorenzoni and Werning (2023), Sonnenfeld et al. (2022), and Strum (2022).
  - Before Russia's 2022 invasion of Ukraine: Korhonen (2019), Van Bergeijk (2021), and references therein.

International Trade and Macro

- Alessandria and Choi (2007), Auray and Eyquem (2011), Barattieri et al. (2021), Bergin and Corsetti (2020), Bergin et al. (2021), Cacciatore (2014), Cacciatore and Ghironi (2021), Contessi (2010), Corsetti et al. (2007, 2013), Dekle et al. (2010), Hamano (2013, 2015), Kim (2021), Ozhan and Schembri (2021), Patureau and Poilly (2019), Rodriguez-Lopez (2011), Zlate (2010), and many more.
  - Most related to Ghironi and Melitz (2005).

The Model: Household Preferences

- Households choose consumption, labor effort, and asset holdings to maximize:

$$E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}\left(\ln C_s-\frac{\kappa}{2}L_s^2-\frac{\kappa_G}{2}L_{G,s}^2\right)\right],\quad 0<\beta<1,\ \kappa>0,\ \kappa_G>0.$$

- Consumption basket:

$$C_t=\left(\int_{\omega\in\Omega}c_t\left(\omega\right)^{\frac{\theta-1}{\theta}}d\omega\right)^{\frac{\theta}{\theta-1}},\quad \theta>1.$$

- At any time t, only a subset $\Omega_t\subset\Omega$ is actually available for consumption.

- Consumed goods can be produced by domestic firms or imported.

- Set of goods available to Foreign consumers, $\Omega_t^*\subset\Omega$, can differ from that available in Home.

- Demand of individual good ω:

$$c_t\left(\omega\right)=\rho_t\left(\omega\right)^{-\theta}C_t.$$

The Model: Gas Production and Trade

- Home and Foreign are endowed with natural gas G_N and G_N^*, respectively, where $G_N^* > G_N$.
- Production of usable gas by Home is:

$$G_t = G_N L_{G,t}.$$

- This gas can be used domestically ($G_{H,t}$) or exported to Foreign ($G_{F,t}$):

$$G_N L_{G,t} = G_{H,t} + G_{F,t}.$$

- Our assumptions will imply that, absent sanctions, Foreign does not import gas from Home, which instead imports gas from Foreign:

$$G_{F,t} = 0 \quad \text{and} \quad G_{H,t}^* > 0.$$

- Optimal labor demand by Home gas producer:

$$w_{G,t} = \rho_{G,t} G_N.$$

- Gas trade is subject to iceberg cost $\tau_{G,t} \geq 1$.
- Absent sanctions,

$$\rho_{G,t} = \tau_{G,t} Q_t \rho_{G,t}^*,$$

where Q_t is the RER (units of C_t per unit of C_t^*).

The Model: Consumption Goods Production, Pricing, and Trade

- Home firm ω produces output $y_t(\omega)$ of good ω with production function:

$$y_t(\omega) = zZ_t \left(G_{H,t}(\omega) + \frac{G^*_{H,t}(\omega)}{\tau_{G,t}} \right)^{\alpha} L_t(\omega)^{1-\alpha}.$$

- Firms produce until they are hit by an exogenous exit shock, which happens at the end of each period with probability δ.

- The firm's marginal cost is:

$$\frac{\rho^{\alpha}_{G,t} w_t^{1-\alpha}}{zZ_t},$$

  where w_t is the real wage paid in the consumption goods production sector.

The Model: Consumption Goods Production, Pricing, and Trade, Continued

- Switch from the firm identifier ω to z, the firm's heterogeneous productivity.
- Firm z's total profits, which will be distributed to share-holders as dividends, are:

$$\begin{aligned} d_t(z) &= \rho_{H,t}(z)\, c_{H,t}(z) + Q_t \rho_{F,t}(z)\, c_{F,t}(z) \\ &\quad -\rho_{G,t}\left(G_{H,t}(z) + G^*_{H,t}(z)\right) - w_t L_t(z) - I_t(z)\, w_t \frac{f_{X,t}}{Z_t}. \end{aligned}$$

  - $f_{X,t}$ is a fixed trade cost in units of effective final-sector labor.
  - $I_t(z)$ is a function that takes the value 1 if the firm exports (and hence $c_{F,t}(z) > 0$) or 0 if the firm does not export (and hence $c_{F,t}(z) = 0$).
- Fixed cost of exporting implies only firms whose export profits are positive will export.
- Only firms with productivity above a cutoff level $z_{X,t}$ export.

The Model: Consumption Goods Production, Pricing, and Trade, Continued

- Optimal price setting implies prices:

$$\begin{aligned}\rho_{H,t}(z) &= \left(\frac{\theta}{\theta-1}\right)\frac{\rho_{G,t}^{\alpha}w_t^{1-\alpha}}{zZ_t},\\ \rho_{F,t}(z) &= \left(\frac{\theta}{\theta-1}\right)\frac{\tau_t\rho_{G,t}^{\alpha}w_t^{1-\alpha}}{Q_tzZ_t}.\end{aligned}$$

  - Note: $\rho_{F,t}(z)=\frac{\tau_t}{Q_t}\rho_{H,t}(z)$.

- Optimal input demands are such that:

$$\alpha w_tL_t(z)=(1-\alpha)\rho_{G,t}\left(G_{H,t}(z)+\frac{G_{H,t}^*(z)}{\tau_{G,t}}\right).$$

The Model: Firm Averages

- As in Melitz (2003), it is possible to define the productivity averages:

$\tilde{z}_D \equiv$ market-share weighted productivity average for all producing Home (or Foreign) firms,

$\tilde{z}_{X,t} \equiv$ market-share weighted productivity average for Home exporters,

$\tilde{z}^*_{X,t} \equiv$ market-share weighted productivity average for Foreign exporters.

- These productivity averages are such that the model behaves like one in which $N_{D,t}$ Home firms with productivity $\tilde{z}_D$ produce and sell output domestically, and $N_{X,t}$ Home firms with productivity $\tilde{z}_{X,t}$ export to Foreign.

- $N_{X,t}/N_{D,t}$ is the proportion of Home firms that export.

The Model: Firm Entry

- Prior to domestic entry, firms are identical and face a sunk entry cost of $f_{E,t}$ units of effective final-sector labor, or $w_t f_{E,t}/Z_t$ units of consumption.
- Firms that enter in each period only start producing in the following period.
- Since the exit shock happens at the end of each period, some unlucky entrants will never get to produce.
- Prospective entrants are forward-looking and compute the expectation of the stream of total profits that, on average, they will generate post-entry:

$$\tilde{v}_t \equiv E_t \left\{ \sum_{s=t+1}^{\infty} \left[\beta \left(1-\delta\right)\right]^{s-t} \left(\frac{C_s}{C_t}\right)^{-1} \tilde{d}_s \right\},$$

  where $\tilde{d}_s$ is the average amount of a firm's profits in period s.

  – We are assuming that firms are owned by domestic households.
  – Since entrants and incumbents face same risk of exit, $\tilde{v}_t$ is also the average value of an incumbent firm.

The Model: Firm Entry, Continued

- Entry occurs until:

$$\tilde{v}_t = w_t \frac{f_{E,t}}{Z_t}.$$

- Entry and the exit shock imply:

$$N_{D,t+1} = (1-\delta)\left(N_{D,t} + N_{E,t}\right),$$

  where $N_{E,t}$ is the number of entrants.

- We assume that firm creation is easier in Home (higher Z), which implies that there is a larger number of firms in Home than in Foreign.

The Model: Household Budget Constraint

- The household begins period t with holdings of Home bonds $B_{H,t}$, holdings of Foreign bonds $B^*_{H,t}$, and shares x_t in a portfolio of $N_{D,t}$ Home firms that produce and sell output in period t.
- Budget constraint:

$$\begin{aligned} & C_t + B_{H,t+1} + Q_t B^*_{H,t+1} + \tilde{v}_t \left(N_{D,t} + N_{E,t}\right) x_{t+1} + \eta \left(B^*_{H,t+1}\right)^2 /2 \\ = \; & \left(1 + r_t\right) B_{H,t} + Q_t \left(1 + r^*_t\right) B^*_{H,t} + \left(\tilde{d}_t + \tilde{v}_t\right) N_{D,t} x_t + w_{G,t} L_{G,t} + w_t L_t + T^f_t . \end{aligned}$$

- The household chooses C_s, $B_{H,s+1}$, $B^*_{H,s+1}$, x_{s+1}, $L_{G,s}$, and L_s for every s from t to ∞ to maximize its intertemporal utility.
- This yields standard Euler equations and labor supply conditions.

The Model: Trade Balance, Current Account, and Net Foreign Assets

- Home GDP:

$$Y_t = w_{G,t} L_{G,t} + w_t L_t + N_{D,t} \tilde{d}_t.$$

- Home trade balance:

$$TB_t \equiv \frac{1}{2}\left(Y_t - Q_t Y_t^*\right) - \frac{1}{2}\left(C_t - Q_t C_t^*\right) - \frac{1}{2}\left(\tilde{v}_t N_{E,t} - Q_t \tilde{v}_t^* N_{E,t}^*\right).$$

- Home current account:

$$CA_t \equiv r_t B_{H,t} + Q_t r_t^* B_{H,t}^* + TB_t,$$

- Home net foreign assets:

$$B_{H,t+1} + Q_t B_{H,t+1}^* = B_{H,t} + Q_t B_{H,t}^* + CA_t.$$

- Starting position in our exercises: $TB_t = 0$ as result of importing gas from Foreign and exporting consumption goods to Foreign.

Gas Price Determination

- Imposing equilibrium conditions and log-linearizing around the initial steady-state position yields:

$$\tilde{\rho}_{G,t} = (1 + \Gamma_1 - \Gamma_2)\,\mathsf{C}_t - (\Gamma_1 - \Gamma_2)\,(\mathsf{Q}_t + \mathsf{C}^*_t) - \frac{1}{\theta - 1}\mathsf{N}_t.$$

  - Γ_1 and Γ_2 are positive constants that are functions of model parameters.
    - We assume parameter values such that $\Gamma_1 > \Gamma_2$.
  - We are holding $\tau_{G,t}$ constant.
  - $\mathsf{N}_t \equiv$ percentage change in the total number of products (domestic and imported) available to Home consumers.
    - The term $-\frac{1}{\theta-1}\mathsf{N}_t$ removes the pure welfare effect of product variety from the welfare-consistent price $\rho_{G,t}$.

Gas Price Determination, Continued

$$\tilde{\rho}_{G,t} = (1 + \Gamma_1 - \Gamma_2)\,\mathsf{C}_t - (\Gamma_1 - \Gamma_2)\,(\mathsf{Q}_t + \mathsf{C}_t^*) - \frac{1}{\theta - 1}\mathsf{N}_t.$$

- Higher C_t causes higher demand of gas for production by Home firms, hence higher $\tilde{\rho}_{G,t}$.
- Higher $\mathsf{Q}_t + \mathsf{C}_t^*$ implies increase in gas demand by Foreign firms relative to Home (given share of non-traded final goods larger than $1/2$).
  - Gas demand shifts toward Foreign, causing lower $\tilde{\rho}_{G,t}$.
- Less product variety in Home cause $\tilde{\rho}_{G,t}$ to increase.
  - Holding product prices constant, Home price level increases if product variety contracts, implying consumers can buy less consumption (and hence obtain less welfare) by spending a given amount.
  - Data-consistent $\tilde{\rho}_{G,t}$ removes this effect.

Bottom Line

- Policy actions that cause C_t to fall imply lower $\tilde{\rho}_{G,t}$, policy actions that cause $\mathsf{Q}_t + \mathsf{C}_t^*$ and/or N_t to fall imply higher $\tilde{\rho}_{G,t}$.

Real Exchange Rate Determination

- Imposing equilibrium conditions, log-linearizing around the initial steady-state position, and assuming constant τ_t, Z_t, and Z_t^* yields:

$$\begin{aligned}\tilde{\mathsf{Q}}_t \;\propto\; & (\theta-1)(\Phi_1-\Phi_2)(1-\alpha)\mathsf{TOL}_t + (\theta-1)(\Phi_2+\Phi_4)\tilde{\mathsf{z}}^*_{X,t} - (\Phi_2+\Phi_3)\tilde{\mathsf{z}}_{X,t} \\ & -\Phi_1[\mathsf{N}_{D,t} - \mathsf{N}_t - (\mathsf{N}^*_{D,t} - \mathsf{N}^*_t)] + \Phi_2[\mathsf{N}^*_{X,t} - \mathsf{N}_t - (\mathsf{N}_{X,t} - \mathsf{N}^*_t)] \\ & -\Phi_3[\mathsf{N}_{X,t} - \mathsf{N}^*_t - (\mathsf{N}_{D,t} - \mathsf{N}_t)] + \Phi_4[\mathsf{N}^*_{X,t} - \mathsf{N}_t - (\mathsf{N}^*_{D,t} - \mathsf{N}^*_t)],\end{aligned}$$

  where:
  - Φs are positive constants that are functions of model parameters,
  - we assume parameter values are such $\Phi_1 > \Phi_2$ (share of non-traded final goods $> 1/2$)
  - and $TOL_t \equiv \varepsilon_t(W_t^*/Z_t^*)/(W_t/Z_t) =$ relative cost of effective final-sector labor.
- All the terms in the equation above have intuitive interpretations.

Real Exchange Rate Determination, Continued

$$\tilde{\mathsf{Q}}_t \propto (\theta-1)(\Phi_1-\Phi_2)(1-\alpha)\mathsf{TOL}_t + (\theta-1)(\Phi_2+\Phi_4)\tilde{\mathsf{z}}^*_{X,t} - (\Phi_2+\Phi_3)\tilde{\mathsf{z}}_{X,t} + ...$$

- $\mathsf{TOL}_t \downarrow \Rightarrow \tilde{\mathsf{Q}}_t \downarrow$ because higher relative cost of effective labor implies relatively higher $\tilde{P}_t$.
- $\tilde{\mathsf{z}}^*_{X,t} \uparrow \Rightarrow \tilde{\mathsf{Q}}_t \uparrow$ because exporters charge on average lower prices, which causes lower $\tilde{P}_t$.
- $\tilde{\mathsf{z}}_{X,t} \uparrow \Rightarrow \tilde{\mathsf{Q}}_t \downarrow$because, in this case, it is $\tilde{P}^*_t$ that becomes lower.

Real Exchange Rate Determination, Continued

$$\tilde{\mathsf{Q}}_t \propto ... - \Phi_1[\mathsf{N}_{D,t} - \mathsf{N}_t - (\mathsf{N}^*_{D,t} - \mathsf{N}^*_t)] + \Phi_2[\mathsf{N}^*_{X,t} - \mathsf{N}_t - (\mathsf{N}_{X,t} - \mathsf{N}^*_t)] + ...$$

- $\mathsf{N}_{D,t} - \mathsf{N}_t - (\mathsf{N}^*_{D,t} - \mathsf{N}^*_t) =$ relative share of domestic goods in total product variety.
  - $\mathsf{N}_{D,t} - \mathsf{N}_t - (\mathsf{N}^*_{D,t} - \mathsf{N}^*_t) \uparrow \Rightarrow \tilde{\mathsf{Q}}_t \downarrow$ because domestic goods (which include non-traded goods) have on average higher prices, implying $\tilde{P}_t \uparrow$ relative to $\tilde{P}^*_t$.
- $\mathsf{N}^*_{X,t} - \mathsf{N}_t - (\mathsf{N}_{X,t} - \mathsf{N}^*_t) =$ relative share of imported goods in total product variety.
  - $\mathsf{N}^*_{X,t} - \mathsf{N}_t - (\mathsf{N}_{X,t} - \mathsf{N}^*_t)] \uparrow \Rightarrow \tilde{\mathsf{Q}}_t \uparrow$ because exporters charging on average lower prices causes $\tilde{P}^*_t \uparrow$ relative to $\tilde{P}_t$.

Real Exchange Rate Determination, Continued

$$\tilde{\mathsf{Q}}_t \propto ... - \Phi_3[\mathsf{N}_{X,t} - \mathsf{N}_t^* - (\mathsf{N}_{D,t} - \mathsf{N}_t)] + \Phi_4[\mathsf{N}_{X,t}^* - \mathsf{N}_t - (\mathsf{N}_{D,t}^* - \mathsf{N}_t^*)].$$

- Relative shares of imported goods in total variety versus domestic goods in total variety abroad.
  - If this share rises for Home, the RER depreciates; if it rises for Foreign, the RER appreciates.
  - Consider, for example, the third term:
    - If imported products representation in total variety available in Foreign rises relative to domestic products representation in total variety available in Home, $\tilde{P}_t^*$ falls and $\tilde{P}_t$ rise because, on average, exporters charge lower prices than non-exporters.
    - Similarly, but with opposite effects on $\tilde{Q}_t$ for the fourth term.

Policy Bottom Line

- The RER effects of policies that cause the relative cost of effective final-sector labor, average exporter productivity, and/or relative shares of different types of products to move can be interpreted using the mechanisms above.

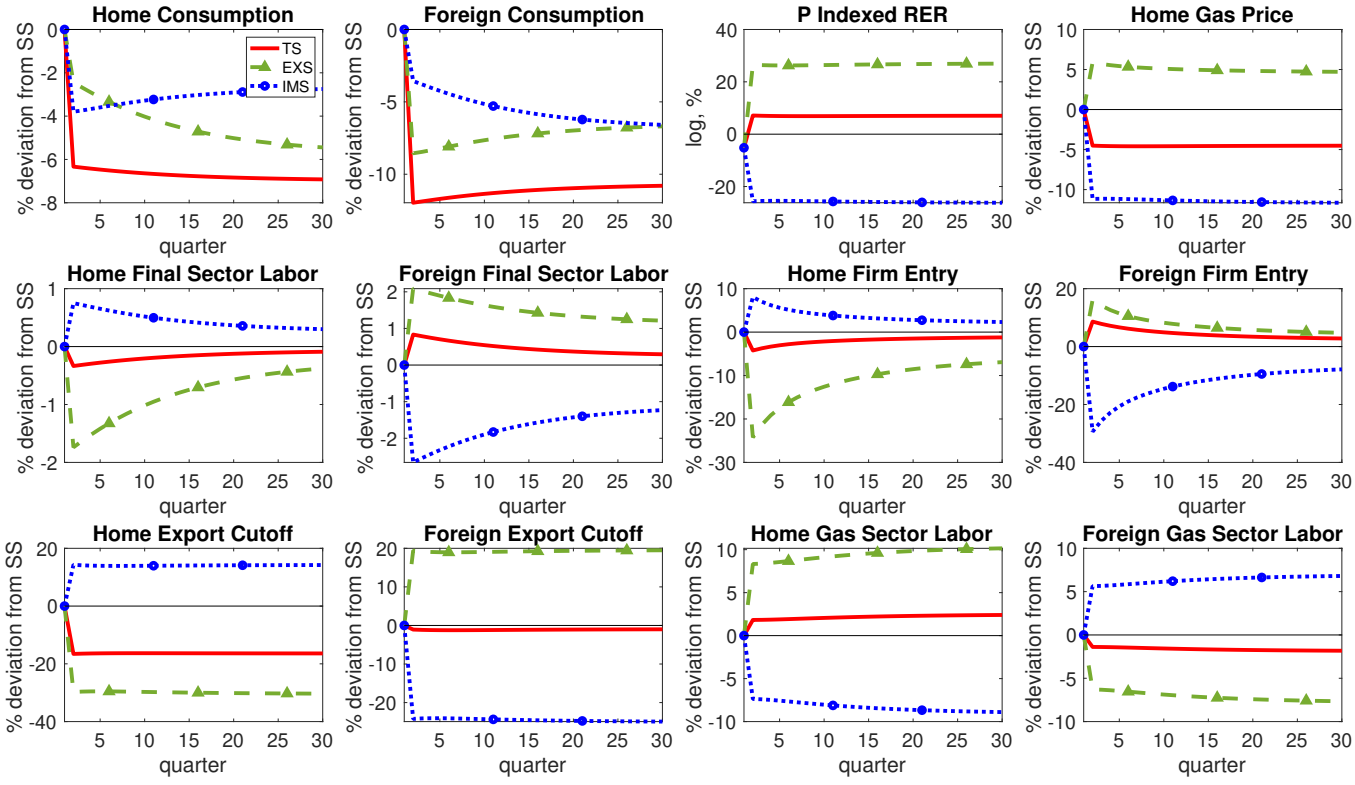
Numerical Illustrations

- We calibrate the model using conventional parameter values and simulate:

1. Home export sanctions: A fraction of Home exporters (the relatively larger ones) are excluded from exporting to Foreign.
2. Home import sanctions: A fraction of Foreign exporters (the relatively larger ones) are excluded from exporting to Home.
3. A gas trade ban: Home stops importing Foreign gas.
4. Financial sanctions: A fraction of Foreign households is excluded from the international financial market.

- We assume the economies are in the initial steady state until time $t = 0$, then sanctions are imposed permanently at time $t = 1$.
- This makes it possible to solve the non-linear system numerically under assumption of perfect foresight.

Home Export Sanctions

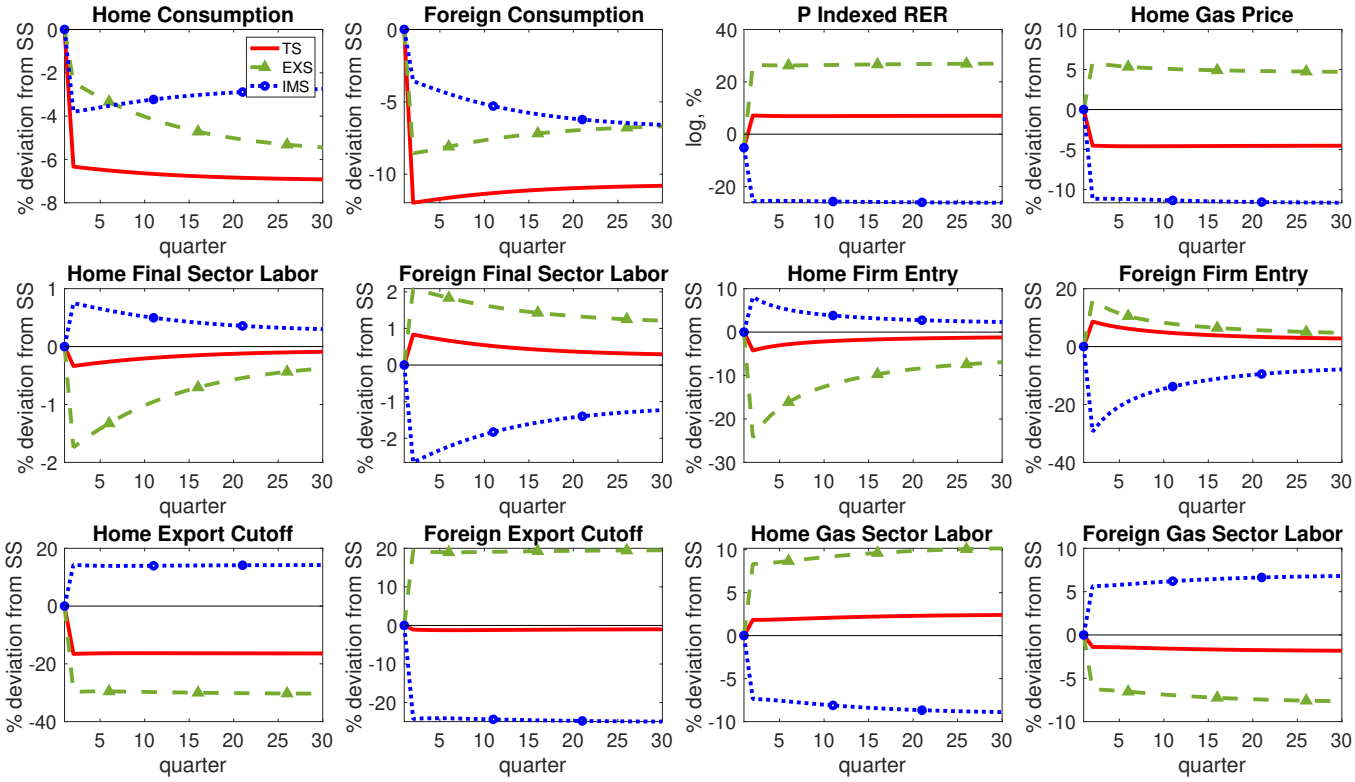


Top 10% most productive Home exporters drop from trade.

Home export cutoff ↓ → Home export prices ↑ → RER ↑

Foreign demand of Foreign goods ↑ → Factor input demand ↑

Home Import Sanctions

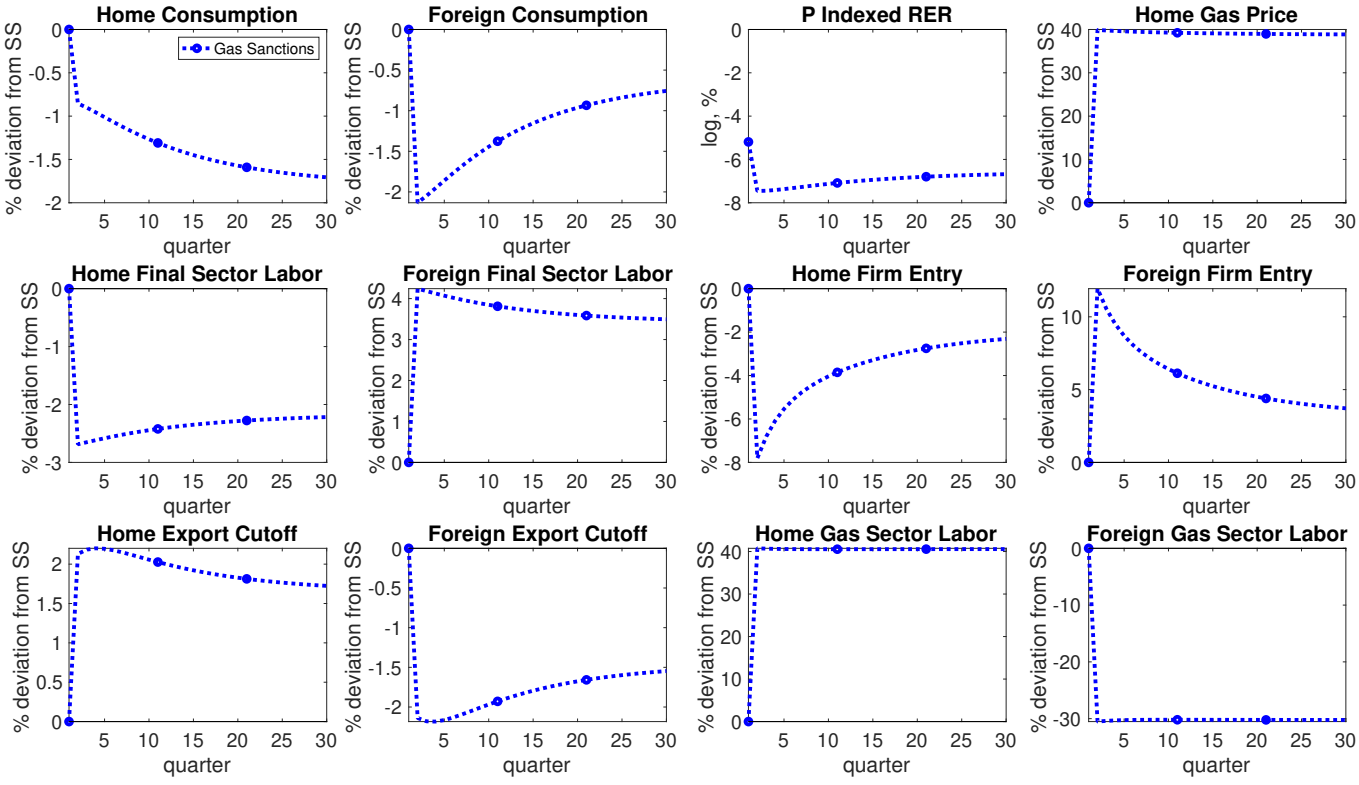


Top 10% most productive Foreign exporters drop from trade.

Foreign export cutoff ↓ → Foreign export prices ↑ → RER ↓

Number of producers ↓ → Labor supply shifts towards gas sector

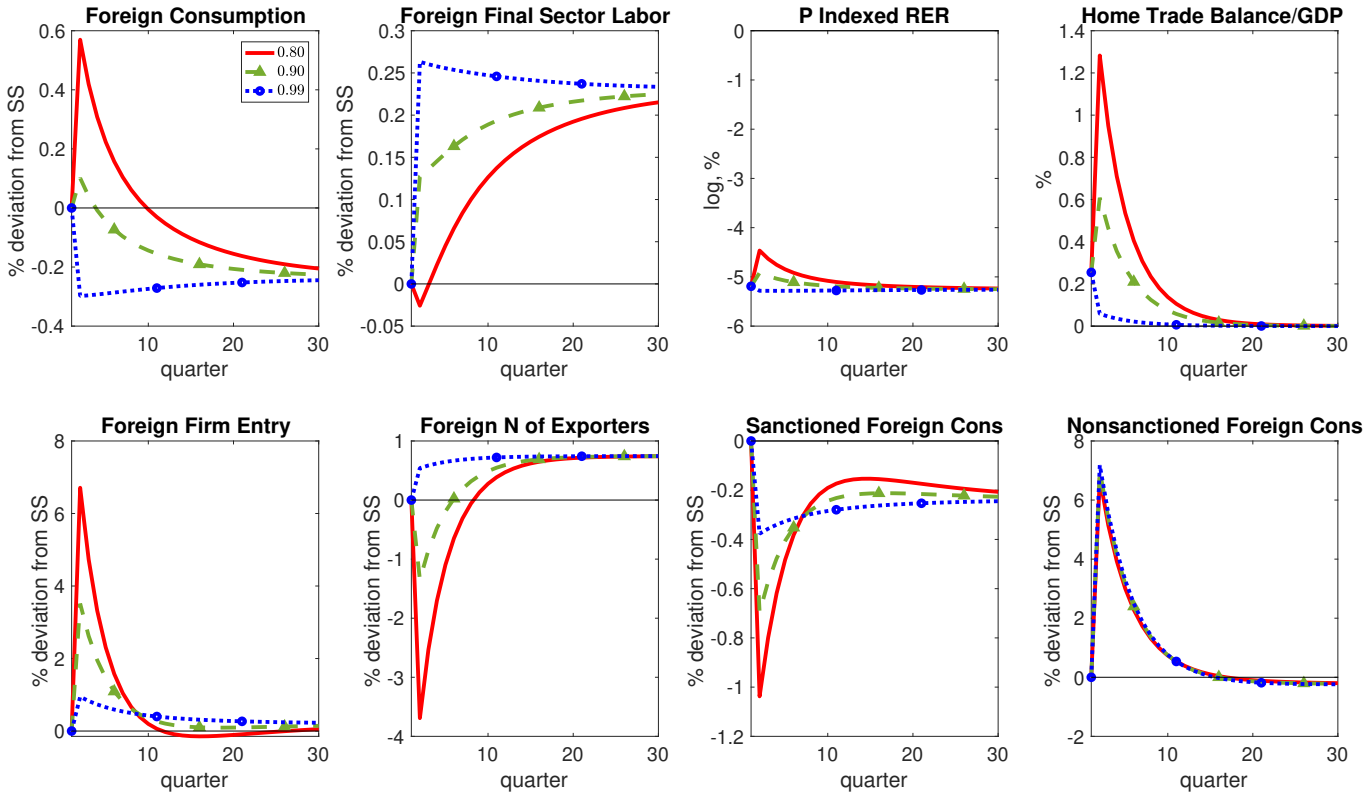
Gas Trade Ban



Demand for Home gas ↑ → Home gas price ↑ → Marginal costs ↑ → Home entrants ↓

Foreign entry in export ↑ → Foreign average export price ↑ → Home RER appreciates.

Financial Sanctions

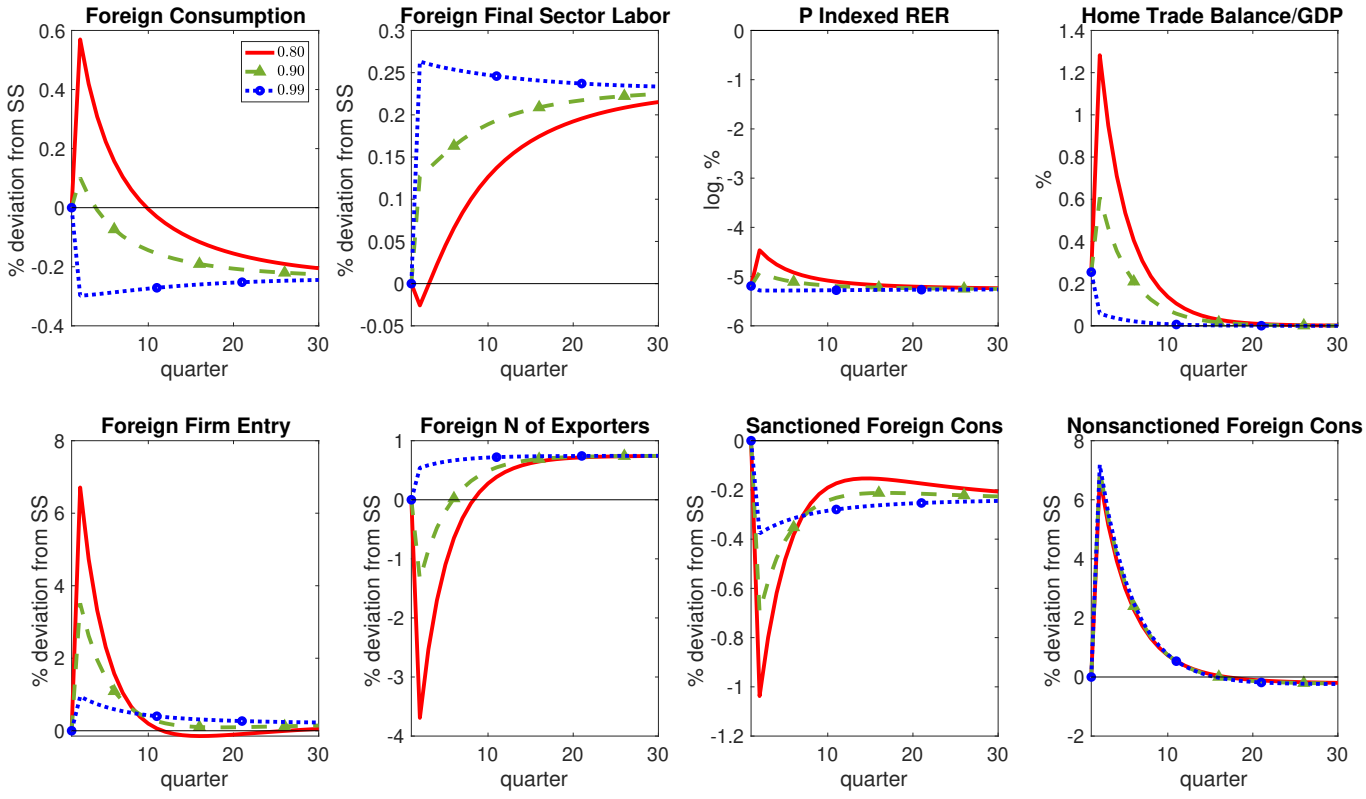


Foreign $\underline{N}$FA → 0 & fraction of households cannot trade bonds internationally.

Foreign incentive to front-load entry during transition ↑ → Nonsanctioned borrowing ↑

Number of entrants ↑→ Labor demand ↑ → TOL ↑ → RER ↑

Financial Sanctions, Continued



Larger share of sanctioned households → Less borrowing from Home → Less entry → More labor used to produce existing consumption goods.

Home RER depreciates, trade balance/GDP rises.

Welfare

- Goods trade sanctions are more costly for Foreign than Home, but the opposite is true for a gas ban.
  - A gas trade ban forces Home to reallocate resources toward the sector in which it has a disadvantage.
  - The results show it is better to sanction the sector in which Foreign has a disadvantage while pushing it to reallocate resources toward that sector.
- In the exercise we perform, financial sanctions cause loss of welfare in Foreign, but a small welfare gain in Home, because Home households are no longer debtors in the global financial market.
- Notice: Welfare results are based on infinite horizon; they may differ if welfare were evaluated over a shorter horizon.

Summary of Key Results from Three-Country Model

- Banning gas imports from Foreign has a much smaller impact on Home welfare if Home can substitute imports from Foreign with imports from another country (RoW).
- Similarly, sanctions on goods trade or financial sanctions have a smaller impact on Foreign if Foreign can trade with another country.
- It is important to coordinate sanctions between Home and RoW for them to have a large impact on Foreign.

Conclusions and Plan for Future Work

- We developed a framework for understanding the effects of sanctions in a world of interdependent countries.
- The model sheds light on mechanisms through which sanctions are transmitted and affect welfare.
- The three-country version of the model highlights the importance of internationally coordinated sanctions.
- Our plan for the future includes studying more scenarios within the current setup (for instance, price caps), studying optimal determination of sanctions, and studying the interaction of sanctions with macroeconomic policy (for instance, how should the central banks of sanctioned and sanctioning countries respond to sanctions?).