

International Trade of Essential Goods During a Pandemic

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International Trade of Essential Medical Goods

Some goods have proved **critical** to combat **COVID-19**:

- **Personal protective equipment (PPE)**: Gloves, medical masks, face shields, ...
- **Medical equipment**: Respirators, equipment for ICU units, ...
- **COVID-19 tests, now also vaccines!**

Key role of trade to consume these goods **in normal times**

- Production of these goods is highly concentrated in a few locations
 - ▶ Only 20% of countries are net exporters of these goods
- Some countries are highly dependent on imports
 - ▶ e.g., US: $\approx 36\%$ of total absorption of these goods is imported

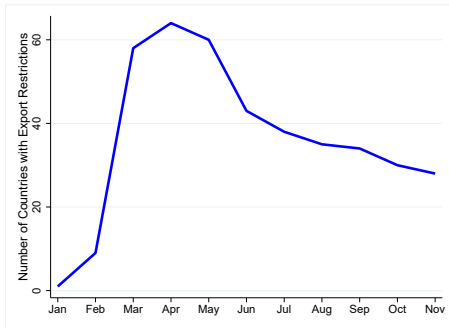
Yet, in a global pandemic:

- Increasing unease about relying so much on other countries for these goods
- If trade breaks down, importers may end up with very limited access to them

⇒ **To what extent does trade of these goods affect impact of a pandemic?**

Trade Policy on Essential Medical Goods During COVID-19

Widespread trade policy changes during COVID-19 across countries:



Higher export controls



Lower import barriers

(Data from Global Trade Alert, 1/1/2020–11/23/2020)

⇒ **Trade policy as important lever to address pandemic?**

⇒ **Key role of international trade of essential medical goods during a pandemic?**

Centerpiece of Biden's trade platform during the campaign...



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THE BIDEN PLAN TO REBUILD U.S. SUPPLY CHAINS AND ENSURE THE U.S. DOES NOT FACE FUTURE SHORTAGES OF CRITICAL EQUIPMENT

Joe Biden will work to ensure that the U.S. does not face shortages of the critical products America needs in times of crisis and to protect our national security. To combat the COVID-19 pandemic, Biden will immediately marshal all of the tools of the Federal government to secure sufficient supplies, treatments, and, as soon as possible, a vaccine to combat the pandemic. At the same time, he will implement fundamental reforms that shift production of a range of critical products back to U.S. soil, creating new jobs and protecting U.S. supply chains against national security threats.

This Paper

We ask:

- ① What is the role of international trade on the impact of a pandemic?
- ② To what extent should countries adjust trade policy in response to the pandemic?

How we answer these questions:

- Quantitative dynamic trade model with **essential goods**
 - ▶ **Complementarities:** Hard to substitute essential goods intra- and inter-temporally
 - ▶ **Myopic firms:** Do not internalize high mg. utility of essential goods during pandemic
 - ▶ **Sectoral adjustment costs** on capital and labor
- Study impact of a pandemic in economy open to trade in essential goods
- Study optimal trade policy in response to the pandemic
- Examine cross-sectional differences across countries and contrast with data

This Paper: Preview of the Results

A pandemic in our model consists of. . .

- Higher domestic demand for essential goods
- Higher global price of essential goods

1. Role of trade on the impact of a pandemic

- Trade makes domestic prices a function of export prices
- Domestic consumption and imports of essentials grow slower than output and exports due to higher prices

2. Optimal trade policy during the pandemic

- Export taxes: Lower domestic prices, increasing domestic consumption
 - Import subsidies: Reduce price of imported goods, increasing import consumption
- ⇒ Consistent with trade policy changes during COVID-19

3. Role of trade and optimal policy depend on comparative advantage

- Net importers: Larger optimal policy changes, worse off from pandemic
- Net exporters: Smaller optimal policy changes, not as hurt by pandemic

This Paper: Implications

Important implications beyond COVID-19 and essential medical goods. . .

1. Broader range of essential goods

- Consumption: Food and agriculture, medical
- Production: Key raw materials, key intermediates, proprietary technologies
- Strategic: Defense-related goods, technology

2. Broader range of disruptions

- Global shocks to demand, supply, or trade technology
- e.g. Pests, wars, political regime change, climate change

⇒ **Our work connects with theoretical literature on trade policy under uncertainty**

- National defense argument for trade protection: Mayer (1977)
- Trade protection as insurance: Eaton and Grossman (1985)
- Broader trade policy under uncertainty: Helpman and Razin (1978), Pomery (1984)

This paper: Novel mechanism + Quantification + Evidence

Model

- Small open economy
- Two sectors: Essential (e), non-essential (c)
- Agents:
 - ▶ Household
 - ▶ Producer of a **domestic variety** in each sector
 - ▶ Producer of **bundles of domestic and imported varieties** in each sector
 - ▶ Essential and non-essential bundles are used for consumption and investment
- International trade
 - ▶ Goods: Domestic varieties in each sector are exported, foreign varieties imported
 - ▶ Financial assets: 1-period bond

Household: Preferences

Preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{x_t^{1-\xi}}{1-\xi}$$

where...

$$x_t = \left[(1-\gamma)c_t^{\frac{\rho-1}{\rho}} + \gamma \left(\frac{e_t}{\bar{e}_t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

and...

- x_t : aggregate consumption bundle
- c_t : non-essential goods
- e_t : essential goods
- \bar{e}_t : "reference level" of essential good consumption (exogenous)
- ρ : Intra-temporal elasticity between essential and non-essential goods
- $1/\xi$: Intertemporal elasticity of the aggregate consumption bundle

Household: Preferences

Preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{x_t^{1-\xi}}{1-\xi}$$

where . . .

$$x_t = \left[(1-\gamma)c_t^{\frac{\rho-1}{\rho}} + \gamma \left(\frac{e_t}{\bar{e}_t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

Essential goods (1/2)

- Low ρ : Essential and non-essential goods as complements
⇒ Need essential goods to enjoy utility from non-essential goods
- High ξ : Hard to substitute aggregate consumption bundle over time
⇒ Hard to compensate periods of low utility with periods of high utility in the future
⇒ e.g. Hard to offset current shortages of essential goods with future surpluses

Household: Preferences

Preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{x_t^{1-\xi}}{1-\xi}$$

where . . .

$$x_t = \left[(1-\gamma)c_t^{\frac{\rho-1}{\rho}} + \gamma \left(\frac{e_t}{\bar{e}_t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

Essential goods (2/2)

- Consumption of essential goods is high or low **relative to some reference level \bar{e}_t**
- e.g. Health services compared to medical needs; \approx Stone-Geary's subsistence level
- Tight mapping between e_t/\bar{e}_t and data used to discipline pandemic shock

Household: Income, Financial Markets, and Household's Problem

Income

- One unit of labor supplied inelastically at wage w_t
- Own domestic producers of essential and non-essential varieties, earn $\pi_{c,t}$ and $\pi_{e,t}$

Financial markets

- Can save or borrow internationally with 1-period bond at interest r
- Bond-holding cost: Penalizes deviations from steady-state holdings

Household's problem:

$$\max_{\{c_t, e_t, b_{t+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{x_t^{1-\xi}}{1-\xi}$$

subject to

$$p_{c,t}c_t + p_{e,t}e_t + b_t + p_{c,t} \frac{\Omega_b}{2} (b_{t+1} - \bar{b})^2 = w_t + \pi_{c,t} + \pi_{e,t} + \frac{b_{t+1}}{1+r} \quad \forall t = 0, \dots, \infty$$

Producers of Domestic Varieties in Sector $j \in \{c, e\}$

Technologies

- 1 Produce varieties: $Y_{j,t} = A_j N_{j,t}^\alpha K_{j,t}^{1-\alpha}$
- 2 Accumulate capital: $K_{j,t+1} = (1 - \delta)K_{j,t} + I_{j,t}$

Sectoral adjustment costs

- Capital: $\phi_k(K_{j,t+1}, K_{j,t}) = \frac{\Omega_k}{2} \left(\frac{K_{j,t+1}}{K_{j,t}} - 1 \right)^2$
- Labor: $\phi_n(N_{j,t}, N_{j,t-1}) = \frac{\Omega_n}{2} \left(\frac{N_{j,t}}{N_{j,t-1}} - 1 \right)^2$
- Denominated in units of non-essential goods

Firms are myopic:

- They discount profits with β , not with household's SDF
- Producers don't internalize value of production and profits made during pandemic
 \Rightarrow e.g., Motivates use of Defense Production Act in U.S. during COVID-19?

Producers of Domestic Varieties in Sector $j \in \{c, e\}$ (cont.)

Market structure

- Domestic sales: Monopolistic competition
- Exports: Price taken as given from rest of the world

Producers' problem:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[q_{j,t}^d y_{j,t}^d + q_{j,t}^x y_{j,t}^x - w_t N_{j,t} - p_{c,t} l_{j,t} - p_{c,t} \phi_k(K_{j,t+1}, K_{j,t}) - p_{c,t} \phi_n(N_{j,t}, N_{j,t-1}) \right]$$

subject to

$$K_{j,t+1} = (1 - \delta)K_{j,t} + I_{j,t} \quad \forall t = 0, \dots, \infty$$

$$y_{j,t}^d + y_{j,t}^x = A_j N_{j,t}^\alpha K_{j,t}^{1-\alpha} \quad \forall t = 0, \dots, \infty$$

$$y_{j,t}^d = \omega_j \left(\frac{q_{j,t}^d}{p_{j,t}} \right)^{-\sigma} Y_{j,t} \quad \forall t = 0, \dots, \infty$$

$$y_{j,t}^x \geq 0 \quad \forall t = 0, \dots, \infty$$

Producers of Composite Good $j \in \{c, e\}$

Technology

$$Y_{j,t} = \left[\omega_j y_{j,t}^d \frac{\sigma-1}{\sigma} + (1 - \omega_j) y_{j,t}^m \frac{\sigma-1}{\sigma} \right]^{\frac{\sigma}{\sigma-1}}$$

where...

- $y_{j,t}^d$: Domestic variety
- $y_{j,t}^m$: Imported variety
- $\omega_j \in (0, 1)$: Weight across varieties

Imported varieties

- Price taken as given from the rest of the world
- Subject to sector-specific iceberg trade cost τ_j

Uses of composite goods

- Non-essential goods: Consumption, investment, adj. costs
- Essential goods: Consumption

Competitive Equilibrium

Equilibrium definition:

- 1 Given prices, allocations solve the household's problem
- 2 Given prices, allocations solve problem of domestic producers in each sector
- 3 Given prices, allocations solve problem of composite good producers in each sector
- 4 Labor market clears: $N_{c,t} + N_{e,t} = 1 \forall t$
- 5 Essential composite market clearing: $e_t = Y_{e,t} \forall t$
- 6 Non-essential composite market clearing:

$$c_t + \sum_{j \in \{c,e\}} \left[l_{j,t} + \frac{\Omega_k}{2} \left(\frac{K_{j,t+1}}{K_{j,t}} - 1 \right)^2 + \frac{\Omega_n}{2} \left(\frac{N_{j,t}}{N_{j,t-1}} - 1 \right)^2 + \frac{\Omega_b}{2} (b_{t+1} - \bar{b})^2 \right] = Y_{c,t} \forall t$$

A Pandemic in Our Model

We model a global pandemic as...

- Domestic shock: **Increase of \bar{e}_t** (reference level of essential goods)
- Foreign shock: **Increase of $q_{e,t}^x$ and $q_{e,t}^m$** (world price of essential goods)

Goal is to capture:

- Higher global need for essential medical goods (e.g., PPE, COVID-19 tests, etc.)
- Domestically: Lower utility if increased needs not satisfied (e.g., disease, death)
- Abroad: Higher need + hard to scale up production \Rightarrow Higher prices

Does not capture other important features of a pandemic:

- Lockdown policies and their economic consequences
- Endogeneity between increased needs and the level of economic activity

\Rightarrow We take these shocks as exogenous, study role the of international trade

What is the Impact of a Pandemic in Our Model?

Consider a shock to the reference level...

1. Increased demand for essential medical goods if $\rho < 1$

$$\frac{e}{c} = \left(\frac{p_e}{p_c} \right)^{-\rho} \left(\frac{\gamma}{1-\gamma} \right)^{\rho} \bar{e}^{1-\rho}$$

2. Reallocation from exports to domestic sales

- If exports > 0 , no incentive to increase scale \Rightarrow Intl. price in both markets
- If exports become zero, incentive to increase scale (but hard to do in short-run)

3. Increase imports of foreign variety of essential goods

What is the Impact of a Pandemic in Our Model?

Consider a shock to world prices of essential goods. . .

1. Negative income effect for net importers of essential goods like the U.S.

2. Reallocation from domestic sales to exports

- Lower domestic demand due to higher prices + negative income effect
- But returns to exporting are higher, incentive to scale up (but hard in short-run)

3. Decrease imports of foreign variety of essential goods

A global pandemic: Higher reference level + Higher world prices

- Tension between higher domestic needs and higher prices, which make it harder to sell good domestically increasing attractiveness of foreign sales
- ⇒ Which dominates? Role for policy? Study these questions quantitatively. . .

Quantitative Analysis

We now ask:

- ① What is the impact of a pandemic in our economy?
- ② To what extent should countries adjust trade policy in response to the pandemic?

To do so, parametrize model:

- One period = One month
- Estimate model to match salient features of U.S. data during COVID-19
- Partition parameter space into:
 - ① Predetermined parameters
 - ② Parameters chosen to match moments prior to COVID-19 (steady-state)
 - ③ Parameters chosen to match dynamics during COVID-19
- Essential goods \equiv PPE and other medical goods, non-essential \equiv all other goods

Parametrization: Predetermined + Prior to COVID-19

Predetermined parameters		
Parameter	Value	Description
β	0.99	Discount factor
ρ	0.20	Elasticity between essential and non-essential goods
$1/\xi$	0.10	Intertemporal elasticity of substitution
σ	4	Elasticity of substitution
α	0.66	Labor share
δ	0.01	Capital depreciation rate ($\approx 11\%$ annual depreciation)
$\omega_e = \omega_c$	0.50	Weight on home goods
A_e	1	Productivity of essential good sector

Parameters estimated to match targets prior to COVID-19		
Parameter	Value	Description
A_c	1.39	Sectoral productivities
γ	0.006	CES weight on essential goods
τ_e	0.14	Trade costs on essential goods
τ_c	0.37	Trade costs on non-essential goods
\bar{e}	0.39	Reference level of essential goods
Moment	Target value	Model
NX_e / GDP_e	-0.25	-0.25
GDP_e / GDP	0.10	0.10
$M_e / p_e e$	0.36	0.36
$M_c / p_c c$	0.21	0.21
e / \bar{e}	1.00	1.00

Parameterization: Dynamics Following COVID-19 Pandemic

1. Shock to \bar{e}

- Focus on needs (\bar{e}) vs. availability (e) of N95 masks, Jan to May 2020
- White House COVID-19 Supply Chain Task Force: $\Delta \ln(e/\bar{e}) \approx -1.22$
 \Rightarrow Domestic shock: $\Delta \ln \bar{e} = 1.00$ for first 12 months

2. Shock to export and import prices of essential goods

- 429% increase in price of masks imported from China, Jan to Apr 2020
 \Rightarrow Foreign shock: $\Delta \ln q_e^x = \Delta \ln q_e^m = 2.00$ for first 12 months

3. Sectoral adjustment costs $\Omega_n = \Omega_k = 150$

- Target domestic production increase of N95 masks, Jan to May 2020
- 3M (major producer): 59% increase, from 22m to 35m per month

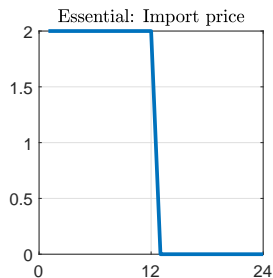
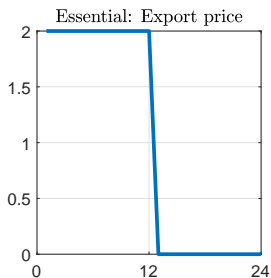
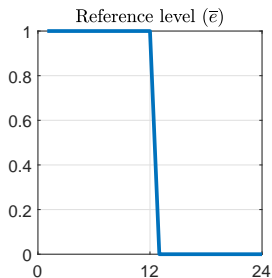
4. Bond-holding costs $\Omega_b = 0.10$

- Target change in agg. NX/GDP in US ≈ 0.01 , Jan to May 2020

A Pandemic in Our Model

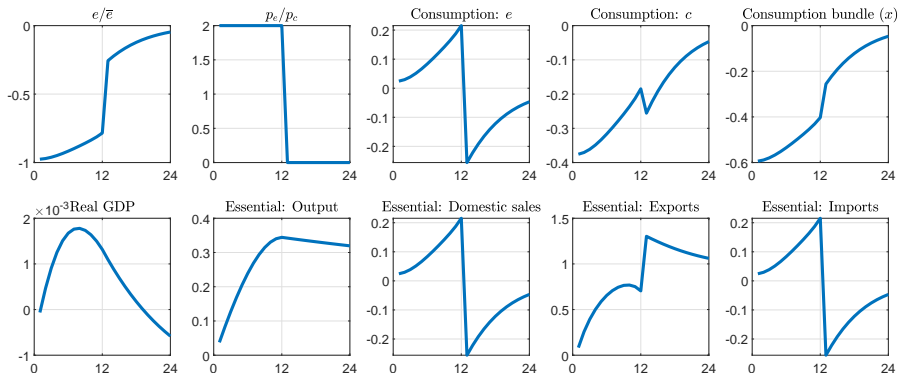
The experiment

- Economy is in steady-state before the pandemic hits
- Study impact of shock to \bar{e} , q_e^x , q_e^m
 - ▶ Unexpected
 - ▶ Transitory: Shocks last 12 months, back to steady-state thereafter
- Focus on perfect foresight path from shock back to initial steady-state



Dynamics Following a Pandemic

Q1: What is the impact of a pandemic in our economy?



1/3 — Consumption:

- Pandemic pushes $e \ll \bar{e} \Rightarrow$ Strong incentive to increase e and e/\bar{e}
- e increases gradually, but by end of pandemic it only cuts $\approx 1/4$ of the distance to \bar{e}
- Non-essentials fall due to negative income effect, grow gradually due to complement.

Optimal Trade Policy Following a Pandemic

Q2: To what extent should countries adjust trade policy during the pandemic?

How we answer this question:

- Set of instruments: (i) import tariffs/subsidies, (ii) export taxes/subsidies
- For now, consider one value per instrument for duration of the pandemic + only consider policies on trade of essential goods
- **Government's problem:** Choose these instruments to maximize household's lifetime utility starting from period in which pandemic hits

Remarks:

- ① Ex-post optimal policy: After pandemic realized
⇒ Coming soon: Role for ex-ante policies?
- ② Commitment: Government commits to trade policy path following pandemic

Optimal Trade Policy Following a Pandemic

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Two details:

- ① Throughout we consider model with domestic sales subsidy chosen to remove markup distortions from monopolistic competition
⇒ Government does not choose trade policy to overcome these distortions
- ② Taxes (subsidies) are reimbursed (collected) as lump-sum transfers to (from) HHs

Optimal Trade Policy Following a Pandemic

Q2: To what extent should countries adjust trade policy during the pandemic?

Optimal trade policy following a pandemic		
	Export tax	Import tariff
No pandemic (steady-state)	0.00%	0.00%
Baseline	22.51%	-21.85%

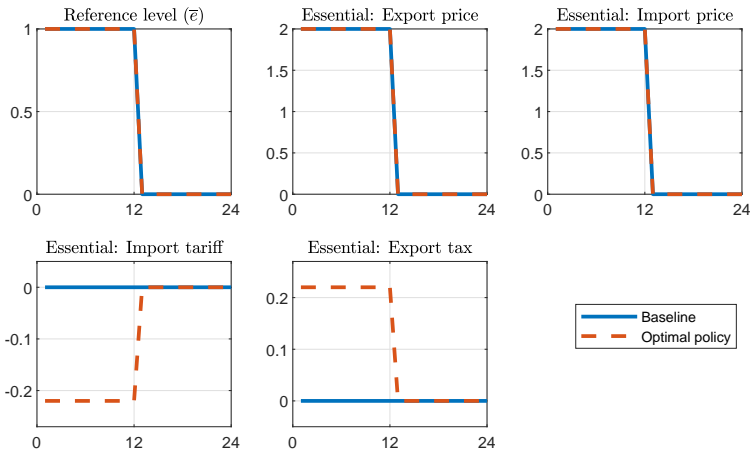
Welfare gains from optimal trade policy:

- Ask: What permanent % change of agg. consumption in the baseline economy would make households indifferent to economy under optimal policy?
- Consumption-equivalent gains from optimal policy: **0.94% per period**

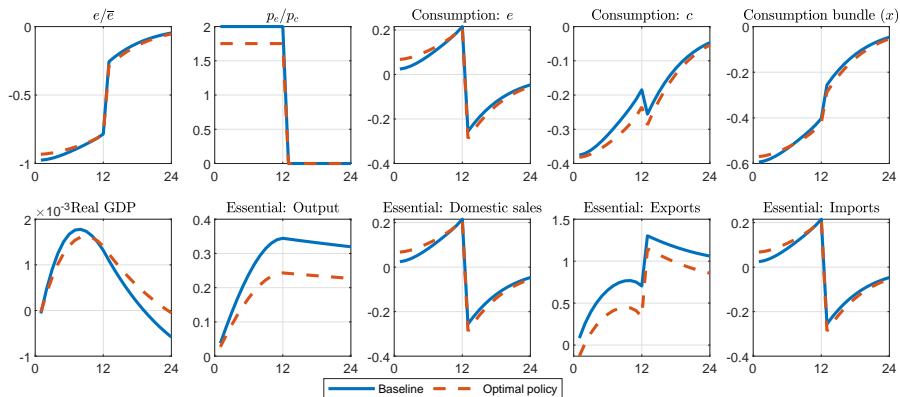
⇒ **What is optimal policy achieving? Let's have a look at the IRFs...**

Pandemic under Optimal Trade Policy

Shocks and trade policy instruments:



Pandemic under Optimal Trade Policy (cont.)



1/2 — Export tax:

- Lowers domestic price of essential goods \Rightarrow Higher domestic sales, lower exports
- Marginal unit produced is exported, so lower return to production \Rightarrow Lower output

Optimal Trade Policy Following a Pandemic

Q3: Which features of the model account for the optimal policies?

Optimal trade policy following a pandemic

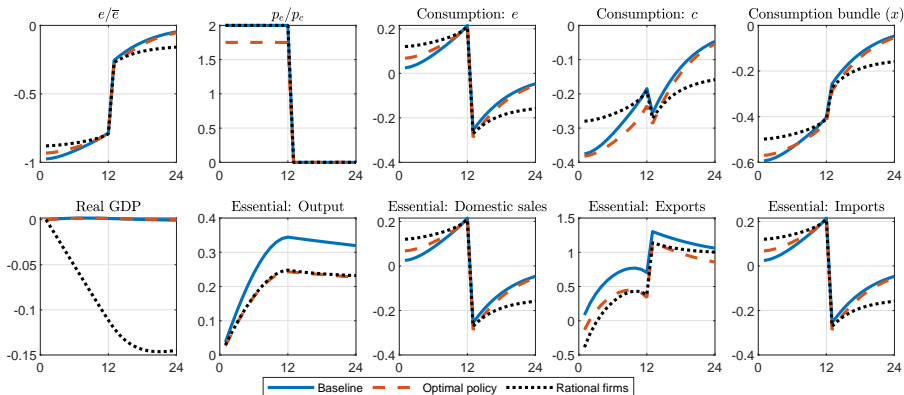
	Export tax	Import tariff
No pandemic (steady-state)	0.00%	0.00%
Baseline	22.51%	-21.85%
Rational firms (non-myopic)	0.00%	0.00%
Weaker inter-temporal complementarities ($\xi = 0.50$ vs. $\xi = 10$)	0.00%	0.00%
Weaker intra-temporal complementarities ($\rho = 1.50$ vs. $\rho = 0.10$)	7.43%	-17.66%
Smaller global shock (change log price = 0.50 vs. 2.00)	- 4.64%	- 2.66%

Role of myopic firms:

- Marginal utility of consumption increases substantially during pandemic
- But firms do not discount profits using household's SDF
- This prevents HHs from obtaining higher profits to pay for essential goods
⇒ Optimal policy attempts to realign incentives of firm and household

Pandemic Dynamics under Rational Firms

IRFs under rational firms...



What we find:

- Higher domestic and imported consumption of essential goods than optimal policy
- Optimal policy closes $\approx 1/2$ gap between baseline and economy with rational firms
- Key channel: Non-essential sector shrinks, resources used to boost consumption

Cross-Country Heterogeneity in Pandemic Experience

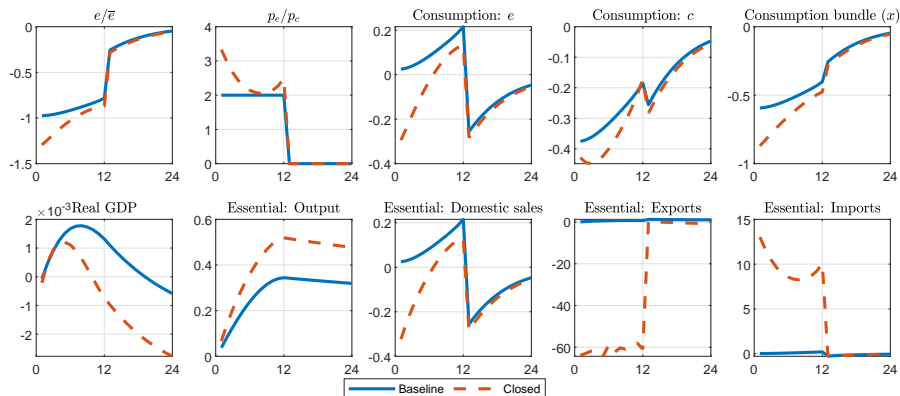
**Q4: How different is the experience of a pandemic across countries?
Differences in optimal trade policy?**

How we answer this question:

- Study one dimension: Net exporters of essential goods vs. net importers (like U.S.)
- We consider economy calibrated to match $NX_e/Y_e = 0.65$ vs. -0.25 in baseline
⇒ Think China vs. U.S.
- Analysis:
 - ① Contrast IRFs vs. baseline economy
 - ② Optimal trade policy
 - ③ Contrast differences in optimal policy vs. data

Pandemic Dynamics by Sectoral Trade Balance in Essential Goods

How different is the experience of a pandemic across countries?



Sectoral trade balances and the impact of a pandemic:

- Trade deficit: Spend more in essentials than produce, worse off from higher price
- Trade surplus: Sell more than consume, better off from higher price

Optimal Trade Policy Heterogeneity

Differences in optimal policy?

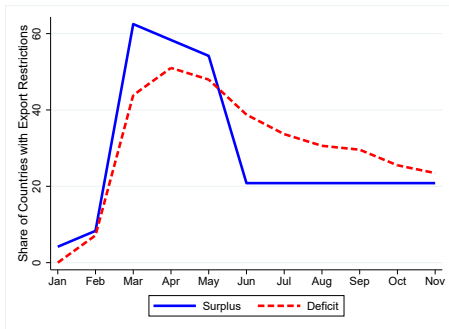
Optimal trade policy following a pandemic

	NX_e/Y_e	Export tax	Import tariff
Baseline	-0.25	22.51%	-21.85%
Sectoral trade surplus in essential goods	0.65	12.99%	-11.84%

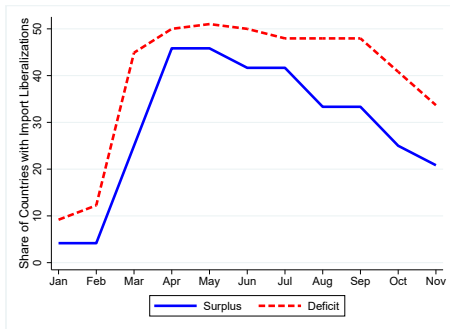
⇒ Differences in policy along this dimension also in the data?

Trade Policy Response Heterogeneity

Differences in policy along this dimension also in the data?



Higher export controls



Lower import barriers

As in the model...

- ⇒ Both types of countries introduce export barriers and liberalize imports
- ⇒ More trade policy changes in countries with deficits in essentials

Concluding Remarks

Q: What is the role of intl. trade of essential medical goods during a pandemic?

We find:

- Higher prices during global pandemic increase attractiveness of exporting, while making it harder to access imports of goods in high demand
- If firms do not internalize value of consumption during pandemic, exports are inefficiently high while domestic consumption and imports are inefficiently low
- Optimal policy changes on essentials: Tax exports, subsidize imports
- Larger policy changes across net importers of essentials; consistent with the data

Our findings raise several questions. . .

- ① Are there other more useful policies to address shortages of essential goods?
 - ▶ e.g., Production subsidies, domestic sales subsidies, stockpiling, etc.
- ② Optimal policies ex-ante? Tension between comp. adv. and resilience to shocks
- ③ Strategic policies in a multi-country world? Cooperative solutions?