# Shortages of Critical Goods in a Global Economy: Optimal Trade and Industrial Policy

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Trade, Value Chains, and Financial Linkages in the Global Economy
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## Pros and Cons of Specialization and Trade

**Renewed popularity of protectionist trade and industrial policies in response to recent shocks**

- Recent shocks: Geopolitical conflict with China, COVID-19, Ukraine war,...
- Policies: Export controls, industrial policy, sanctions, ...
- e.g., US: Defense Production Act, CHIPS Act, curbs on exports of advanced technologies, ...

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- Specialization based on comparative advantage $\Rightarrow$ Increased efficiency
- Broad consensus on positive impact, debate about size and timing of the gains

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**Growing unease about the costs of international trade**

- High reliance on other countries to access **critical goods**
  - e.g., medical goods, food, semiconductors, advanced technologies, military equipment, etc.
- Potentially very costly in the face of large **global shocks** that limit access to these goods

  $\Rightarrow$ **Tension between efficiency and resiliency**

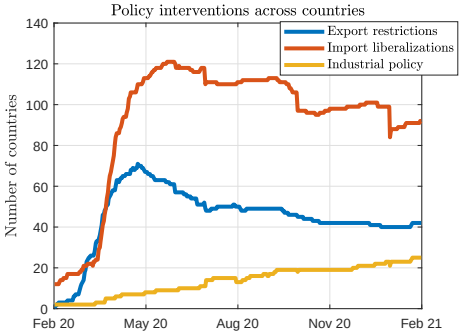
# Application: Trade of Essential Medical Goods During COVID-19

**Essential medical goods to combat COVID-19:**

- e.g., PPE, medical equipment, tests, vaccines, etc.
- High concentration of production, trade key to access these goods
- Global pandemic, increased demand $\Rightarrow$ Shortages + Rationing across countries + Higher prices

**Sharp policy response:**

[Source: Global Trade Alert]




$\Rightarrow$ Protectionism?

$\Rightarrow$ Optimal?

## Why Role for Policy? Private Incentives to Increase Access to Essential Goods?

**Basic idea...**

**1. Consider a firm that produces goods critical to combat COVID-19:**

- Higher prices provide incentives to scale up production
- Face standard intertemporal investment tradeoff:
  - Today: Pay investment costs today, lower returns
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**2. Tradeoff can be mediated by two salient features:**

1. Frictions in financial markets
   (Dinlersoz et al. 2019; Leibovici and Wiczer 2023; Buera et al. 2011; Midrigan and Xu 2014)
2. Prevalence of privately owned firms / imperfect diversification of firm ownership across households
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**3. Firms' intertemporal tradeoff $\neq$ Social tradeoff**

$\Rightarrow$ **Underinvestment relative to first-best**
(Caballero and Lorenzoni 2014; Itskhoki and Moll 2019)

$\Rightarrow$ **Critical goods: Underinvestment is very costly**

$\Rightarrow$ **Role for trade and/or industrial policies?**

## This Paper

**This paper: How to respond once shocks are realized?**

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**What we do:**

- Set up dynamic trade model with the following key ingredients:
  - **Critical goods modeled via complementarities:** Hard to substitute critical goods intra- and inter-temporally
  - **Heterogeneous households:** Heterogeneous ownership of critical and non-critical producers
  - **Incomplete financial markets:** Bond economy + bond-holding costs
- Quantify impact of critical goods shortages in economy open to trade: Application to COVID-19
- Investigate role for trade and industrial policy interventions
- Contrast with evidence on trade and industrial policy changes during COVID-19

## Model

- Small open economy
- Two sectors: Non-essential ($n$), essential ($e$)
  - In each sector: Firm that produces **domestic varieties**
  - In each sector: **Sectoral good** = aggregate of domestic and imported varieties
- International trade
  - Goods: Domestic varieties in each sector are exported, foreign varieties imported
  - Financial assets: 1-period bond
- Heterogeneous households, 2 types $i = \{n, e\}$:
  - Agent $n$: Owns producer of non-essential varieties, endowed with $\kappa_n$ units of labor
  - Agent $e$: Owns producer of essential varieties, endowed with $\kappa_e$ units of labor

## Household $i \in \{n, e\}$

**Preferences**

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_{it}/\kappa_i\right)^{1-\xi}}{1-\xi}, \qquad \text{where} \qquad c_{it} = \left[(1-\gamma) n_{it}^{\frac{\rho-1}{\rho}} + \gamma \left(\frac{e_{it}}{\overline{e}_t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

- Essential goods $e_{it}$ evaluated relative to **reference level** $\overline{e}_{it}$
- **Complementarities**: Hard to substitute intra- and inter-temporally (low $1/\xi$ and $\rho$)

**Income**

- $\kappa_i$ units of labor supplied inelastically at wage $w_t$
- Owns firm that produces domestic varieties $i$, earns $\pi_{it}$

**Financial markets**

- Save or borrow domestically and internationally with 1-period bond at interest $r$
- Bond-holding cost: Control degree of financial market development

## Problem of Household $i \in \{n, e\}$

$$V_{i0} = \max_{\{c_{it}, n_{it}, e_{it}, b_{it+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_{it}/\kappa_i\right)^{1-\xi}}{1-\xi}$$

subject to

$$c_{it} = \left[ (1-\gamma) n_{it}^{\frac{\rho-1}{\rho}} + \gamma \left( \frac{e_{it}}{\bar{e}_t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \quad \forall t = 0, ..., \infty$$

$$p_{nt} n_{it} + p_{et} e_{it} + b_{it} + p_{nt} \frac{\Omega_b}{2} \left( b_{it+1} - \bar{b}_i \right)^2 = \kappa_i w_t + \pi_{it} + \frac{b_{it+1}}{1+r} + \mathcal{T}_{it} \quad \forall t = 0, ..., \infty$$

**Households are heteogeneous in:**

- Labor supply $\kappa_i$
- Firm ownership $\pi_i$

## Producers of Domestic Variety $i \in \{n, e\}$

**Technologies**

- Produce varieties: $Y_{it} = A_i \left( L_{it}^{\alpha} \; K_{it}^{1-\alpha} \right)^{\eta}$
- Accumulate capital: $K_{it+1} = (1 - \delta) K_{it} + I_{it}$
- Sectoral adjustment costs on capital and labor $\Rightarrow$ **Limit supply response to changes in demand**

**Market structure**

- Domestic: Monopolistic competition, but remove markup distortions
- Exports: Price taken as given from rest of the world

**Firm ownership and management**

- Owned by household $i$
- Firm operated on behalf of the owner $\Rightarrow$ **Discount profit streams with household $i$'s SDF**

## Problem of Producer of Domestic Variety $i \in \{n, e\}$

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} m_{it} \left[ q_{it}^d y_{it}^d + q_{it}^x y_{it}^x - w_t L_{it} - p_{nt} I_{it} - p_{nt} \phi_k(K_{it+1}, K_{it}) - p_{nt} \phi_\ell(L_{it}, L_{it-1}) \right]$$

subject to

$$K_{it+1} = (1 - \delta) K_{it} + I_{it} \qquad \forall t = 0, ..., \infty$$

$$y_{it}^d + y_{it}^x = A_i \left( L_{it}^\alpha K_{it}^{1-\alpha} \right)^\eta \qquad \forall t = 0, ..., \infty$$

$$y_{it}^d = \omega_i \left( \frac{q_{it}^d}{p_{it}} \right)^{-\sigma} Y_{it} \qquad \forall t = 0, ..., \infty$$

$$y_{it}^x \geq 0 \qquad \forall t = 0, ..., \infty$$

where $m_{it}$ is household $i$'s stochastic discount factor

## Closing the Model + Application

**Producers of composite good** $i \in \{n, e\}$

- CES technology to combine domestic and imported varieties
- Imports: Price given from the rest of the world, subject to iceberg trade cost $\tau_i$

**Market clearing conditions**: Labor, varieties, composite goods

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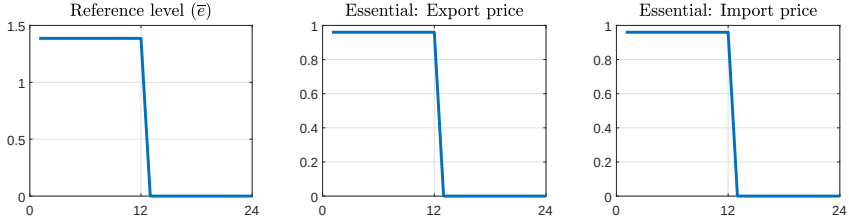
**Today's application: Global shortages of essential medical goods to combat COVID-19**

**Unexpected, transitory, one-time shocks:**



## Shortages of Critical Goods

**Demand: Households cannot substitute away from consuming these goods**

- Inter-temporal complementarity: Hard to substitute current consumption with future consumption
- Intra-temporal complementarity: Hard to substitute critical goods with consumption of non-critical goods

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

$\Rightarrow$ **Need to increase current consumption of these goods**

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**Supply: Output increase $<$ First-best**

- Firms' investment (and hiring decisions) determined by owners' SDF

$$\mathbb{E}\left\{ m_{it} \left[ q^{x}_{it+1} \eta (1-\alpha) L^{\alpha\eta}_{it+1} K^{\eta(1-\alpha)-1}_{it+1} + (1-\delta) p_{nt+1} \right] \right\} = p_{nt}$$

- Ownership heterogeneity + Incomplete mkts $\Rightarrow$ Heterogeneous SDF dynamics
- Agent $e$ better off, but needs to invest to realize gains, at expense of consumption $\Rightarrow$ Lower SDF

$\Rightarrow$ **But supply increases less than socially optimal**

## Predetermined Parameters

**Parametrization approach:**

- One period = One month
- Estimate model to match salient features of U.S. data during COVID-19
  1. Predetermined parameters
  2. Parameters chosen to match moments prior to COVID-19 (steady-state)
  3. Shocks + Parameters chosen to match dynamics during COVID-19

**Predetermined parameters**

| Parameter | Value | Description |
|---|---|---|
| $\beta$ | $0.96^{\frac{1}{12}}$ | Discount factor |
| $1/\xi$ | 0.50 | Intertemporal elasticity of substitution |
| $\sigma$ | 4 | Armington elasticity |
| $\alpha$ | 0.66 | Labor share |
| $\eta$ | 0.85 | Returns to scale |
| $\delta$ | 0.01 | Capital depreciation rate |

# Parametrization: Estimated Parameters

**Estimated parameters, pre-pandemic steady-state**

| Parameter | Value | Description |
|---|---|---|
| $A_n$ | 1.591 | Sectoral productivity |
| $\tau_e$ | 0.138 | Trade costs on essential goods |
| $\tau_n$ | 0.342 | Trade costs on non-essential goods |
| $\bar{e}$ | 0.326 | Reference level of essential goods |
| $\gamma$ | 0.001 | Utility weight on essential goods |
| $\kappa_n$ | 0.957 | Measure of agents of type $n$ |
| $\bar{b}_n$ | −147.89 | Steady-state level of debt: Agent $n$ |
| $\kappa_e$ | $1 - \kappa_n$ | Measure of agents of type $e$ |
| $\bar{b}_e$ | $\kappa_e \left( \bar{b}_n + \bar{b}_e \right)$ | Steady-state level of debt: Agent $e$ |

| Moment | Target value | Model |
|---|---|---|
| $NX_e / GDP_e$ | −0.188 | −0.188 |
| $GDP_e / GDP$ | 0.043 | 0.043 |
| $M_e / p_e e$ | 0.404 | 0.404 |
| $M_n / p_n n$ | 0.293 | 0.293 |
| $NX / GDP$ | −0.063 | −0.063 |
| Aggregate $e / \bar{e}$ | 1.000 | 1.000 |
| HH $n$ labor share | 0.957 | 0.957 |

**Estimated parameters, pandemic dynamics**

| Parameter | Value | Description |
|---|---|---|
| $\rho$ | 0.269 | Elasticity essential and non-essential |
| $\phi_{k,n} = \phi_{\ell,n}$ | 46.087 | Adjustment costs: Non-essential |
| $\phi_{k,e} = \phi_{\ell,e}$ | 4.201 | Adjustment costs: Essential |
| $\Omega_b$ | 0.024 | Bond-holding cost |

| Moment | Target value | Model |
|---|---|---|
| $e_t$ : log(Avg. Q2-Q3 '20 / Pre-pandemic) | 0.619 | 0.663 |
| $n_t$ : log(Avg. Q2-Q3 '20 / Pre-pandemic) | −0.062 | −0.062 |
| $y_{nt}$: log(Avg. Q2-Q3 '20 / Pre-pandemic) | −0.070 | −0.070 |
| $NX / GDP$: Avg. Q2-Q3 '20 — Pre-pandemic | −0.009 | −0.009 |

## Dynamics Following a Pandemic

**Q: What is the impact of a pandemic in an open economy?**

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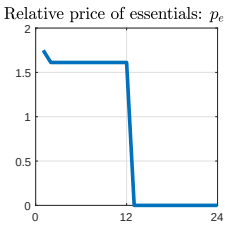
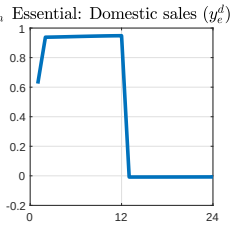
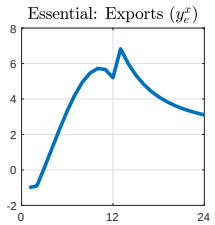
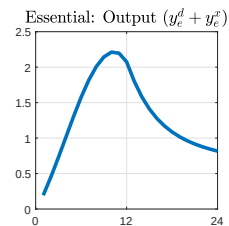
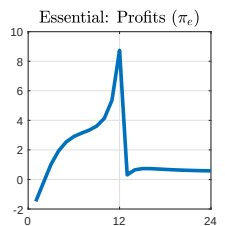
**Production and trade of essential goods...**

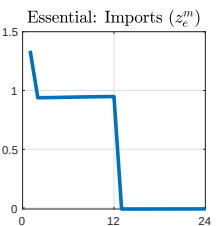


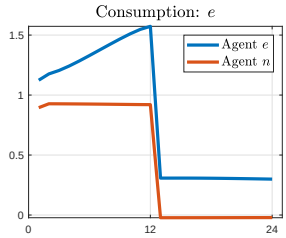



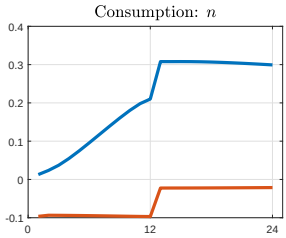

- Higher price $\Rightarrow$ Incentive to scale up production
- Export price determines domestic price, pinning down domestic sales. The rest is exported
- Domestic sales and imports increase given demand shock, despite large price increase
- **Yet, exports increase more than domestic; essentials shipped out!**

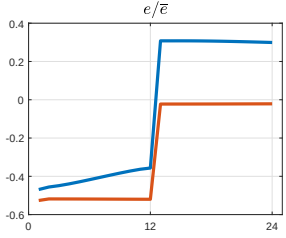
# Dynamics Following a Pandemic

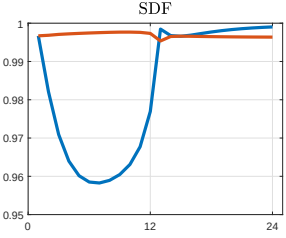
**Q: What is the impact of a pandemic in an open economy?**

**Consumption. . .**




**Both households:**

- Pandemic pushes $e << \overline{e} \Rightarrow$ Strong incentive to increase $e$ and $e/\overline{e}$
- **$e$ increases gradually, but by end of pandemic still far from $\overline{e}$**

**Heterogeneous outcomes:**

- Agent $e$ better off throughout
- Heterogeneous SDF dynamics: Agent $e$ becomes more impatient, borrowing to smooth consumption path as production scale increases

## Optimal Policy Analysis

**Q: Socially optimal dynamics? Or is there a role for policy to improve upon these?**

**Government's utilitarian population-weighted objective**

$$\mathcal{V}_t = \kappa_n V_{nt} + \kappa_e V_{et}$$

**Policy instruments**

1. Trade policy: Import tariff/subsidy, Export tax/subsidy
2. Industrial policy: Total sales subsidy

**Government's problem**

- Choice set: One value per instrument thru pandemic + Only consider policies on essentials
- Choose policies when pandemic shocks realized to maximize $\mathcal{V}_t$ (ex-post analysis)

# Optimal Policy Analysis: Redistribution vs. Efficiency + Steady-State

**Efficiency vs. redistribution**

1. Remove markup distortions with domestic subsidy (Gali and Monacelli 2005)
2. No direct redistribution: Rebated lump-sum to agents directly affected by these policies
3. Decompose role of efficiency vs. redistribution (Benabou 2002, Boar and Midrigan 2022)

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**No role for policy in pre-pandemic steady-state:**

| | Export tax | Import tariff | Total sales subsidy |
|---|---|---|---|
| **Trade policy** | 0.00% | 0.00% | — |
| **Industrial policy** | — | — | 0.00% |
| **Trade and industrial policy** | 0.00% | 0.00% | 0.00% |

# Optimal Trade and Industrial Policy Following a Pandemic

**Q: To what extent is there a role for trade and/or industrial policy during a pandemic?**

**Optimal policies following a pandemic**

| | Export tax | Import tariff | Total sales subsidy | Welfare gain vs. no policy |
|---|---|---|---|---|

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| **Trade policy** | 14.26% | −9.44% | — | 0.011% |

**Role for trade policy:**

- Intra-temporal motive: Reallocate exports toward domestic sales + Mitigate decline of imports
- But lowers incentives to increase production scale

## Optimal Trade and Industrial Policy Following a Pandemic

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| **Trade policy** | 14.26% | −9.44% | — | 0.011% |
| **Industrial policy** | — | — | 12.23% | 0.004% |

**Role for industrial policy:**

- Inter-temporal motive: Higher incentives to increase production scale
- But marginal units produced are exported

## Optimal Trade and Industrial Policy Following a Pandemic

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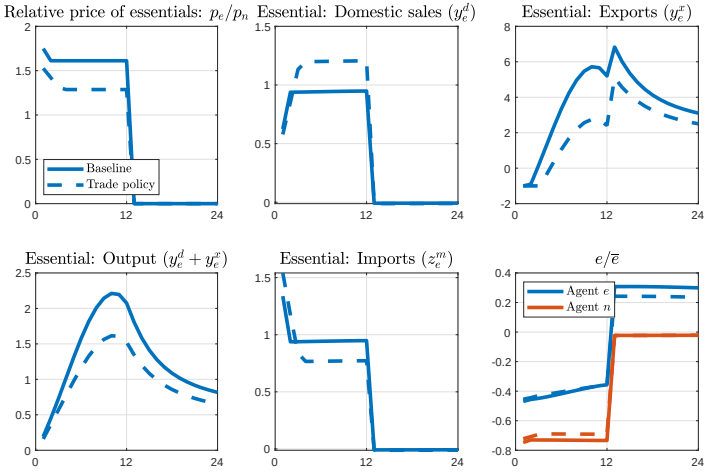
| **Trade policy** | 14.26% | −9.44% | — | 0.011% |
| **Industrial policy** | — | — | 12.23% | 0.004% |
| **Trade and industrial policy** | 25.02% | −18.28% | 27.97% | 0.033% |

**Interaction between trade and industrial policy:**

- Industrial policy mitigates disincentives of trade policy to scale up production
- Trade policy allows households to capture larger share of the increased production due to industrial policy

# Trade Policy and the Dynamics Following a Pandemic

**Q: How does trade policy affect the dynamics following a pandemic?**




- Export taxes reduce domestic prices, reallocating sales from exports toward domestic sales
- And reallocating purchases from imports toward domestic ⇒ Import subsidies partially restore consumption across sources
- **Consumption of essential goods increases relative to reference level**
- **But at a cost: Lower returns to investment and hiring, lower output**

# Industrial Policy and the Dynamics Following a Pandemic

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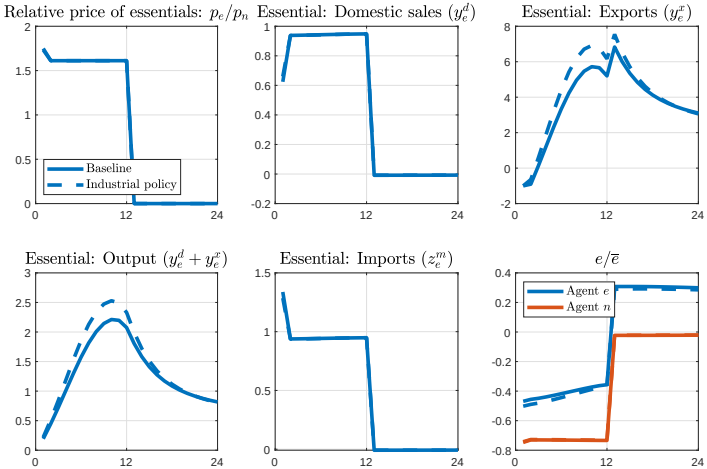
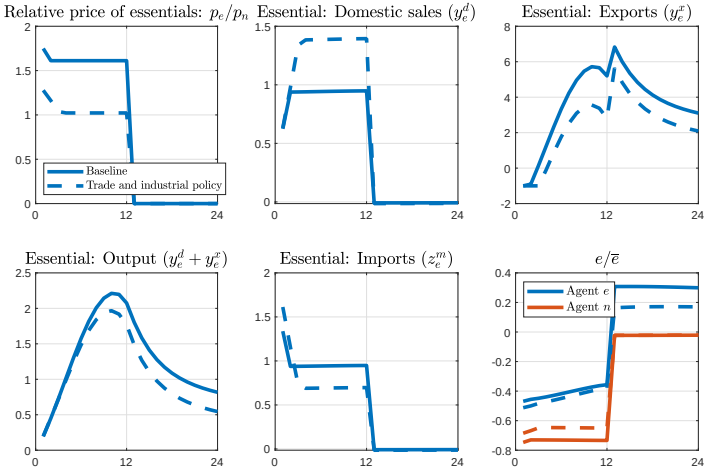



- Sales subsidies raise returns to capital and labor, increasing output
- Relative price between exports and domestic sales is not affected ⇒ No reallocation
- Given price of essentials is determined by world prices, this pins down domestic demand ⇒ **All additional output is exported**

# Trade and Industrial Policy and the Dynamics Following a Pandemic

**Q: How do trade and industrial policy affect the dynamics following a pandemic?**




- Trade policy allows policymakers to reallocate sales from export to domestic sales
- Industrial policy allows policymakers to mitigate the cost of reallocating via trade policy, increasing incentives to produce

## Key Channels + Efficiency vs. Redistribution

**Weaker/no role for policy if:**

1. No household heterogeneity: SDF dynamics identical, production decisions aligned with agg. welfare
2. Weaker intra-temporal complementarities: Can reallocate consumption to non-essentials
3. Weaker inter-temporal complementarities: Can reallocate consumption to the future
4. Weaker financial friction: Milder link between cash-flow and consumption-savings decisions

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**Efficiency vs. redistribution**

- Follow Benabou (2002), Boar and Midrigan (2022) to decompose relative importance for optimal policies

| | Export tax | Import tariff | Total sales subsidy |
|---|---|---|---|
| Efficient | 16.65% | −12.42% | 19.51% |
| Utilitarian (baseline) | 25.02% | −18.28% | 27.97% |
| Rawlsian | 65.20% | −29.62% | 40.16% |

## Evidence: Trade Dependence, Model vs. Data

1. **Model and data @ intro: Prevalent use of export barriers, import liberalization, industrial policy**
2. **Validation Q: Trade dependent countries more likely to introduce policies?**

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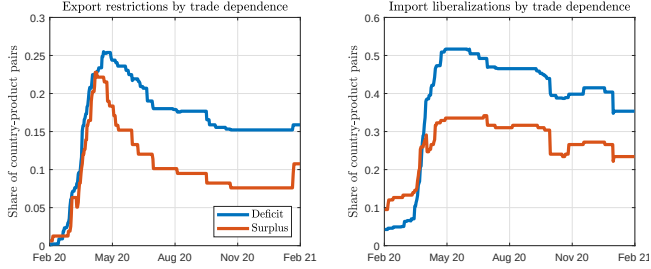


## Concluding Remarks

**Q: Global shortages of critical goods, role for trade and industrial policy?**

**We find:**

- Critical goods shortages create incentives to export, making domestic and imported varieties harder to get
- Trade and industrial policy are desirable to realign firms' incentives with social welfare
- Dynamics and policy response consistent with data

**Implications broader than COVID-19:**

- Other final goods: Food, vaccines, military equipment, etc.
- Production inputs: Semiconductors, other advanced technologies, etc.

**Our findings raise several questions...**

- Optimal policies ex-ante? Tension between comparative advantage and resilience to shocks
  $\Rightarrow$ **Work in progress: Adamopoulos and Leibovici (2023)**
- Strategic policies in a multi-country world? Cooperative solutions?

# Appendix

## Parametrization: Shocks

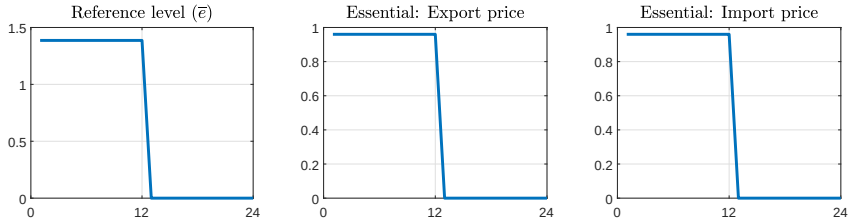
### 1. Shock to $\overline{e}$

- Data on estimated needs of essential medical goods by White House COVID-19 Supply Chain Task Force
- One-year increase, median across goods: $\Delta \ln \overline{e} \approx 1.39$

### 2. Shock to export and import prices of essential goods

- Unit values of critical COVID-19 goods from USITC
- Peak price change within first year, median across goods: $\Delta \ln q_e^x = \Delta \ln q_e^m = 0.96$

**Unexpected, transitory, one-time shocks:**



# Optimal Trade Policy Following a Pandemic

**Q: Which features of the model account for optimal trade policy?**

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| No household heterogeneity | 0.00% | 0.00% |

**No role for policy in two cases:**

- Steady-state / no shocks: Welfare weights chosen such that mg. increase in welfare equalized across agents
- No household heterogeneity: SDF dynamics are identical, investment/hiring aligned with agg. welfare

# Optimal Trade Policy Following a Pandemic

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| Baseline | 14.26% | −9.44% |
| No pandemic (steady-state) | 0.00% | 0.00% |
| No household heterogeneity | 0.00% | 0.00% |
| Weaker inter-temporal complementarity ($\xi = 0.50$ vs. $\xi = 2$) | − 0.50% | 0.50% |
| Weaker intra-temporal complementarity ($\rho = 0.80$ vs. $\rho = 0.27$) | 0.94% | − 0.37% |

**Complementarities:**

- Weaker role for trade policy if households can substitute essential goods more easily
- Trade policy as a way to ensure access to these goods when no alternatives are available

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| No adjustment costs ($e$) | 8.83% | −5.62% |
| Higher adjustment costs ($e$) | 19.47% | −29.30% |

**Larger adjustment costs:**

- Harder to adjust production, so less room for intertemporal policies, and greater need for intratemporal trade policy that reallocate across markets

## Optimal Trade Policy Following a Pandemic

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| No adjustment costs ($e$) | 8.83% | −5.62% |
| Higher adjustment costs ($e$) | 19.47% | −29.30% |
| Financial autarky (no bond) | 18.83% | −11.37% |

**Weaker financial markets:**

- Financial markets provide channel to finance investments while mitigating impact on consumption.
- W/o such channel, weaker role for inter-temporal policies, greater need for reallocation

## Optimal Industrial Policy Following a Pandemic

**Q: Which features of the model account for optimal industrial policy?**

| | Total sales subsidy |
|---|---|
| Baseline | 12.23% |
| No pandemic (steady-state) | 0.00% |
| No household heterogeneity | 0.00% |
| Weaker inter-temporal complementarity ($\xi = 0.50$ vs. $\xi = 2$) | 2.33% |
| Weaker intra-temporal complementarity ($\rho = 0.80$ vs. $\rho = 0.27$) | 14.43% |
| No adjustment costs ($e$) | 16.12% |
| Higher adjustment costs ($e$) | 45.17% |
| Financial autarky (no bond) | 20.96% |

**Key difference vs. trade policy: Intra-temporal complementarities**

- Not important for role of industrial policy
- Why? Industrial policy affects intertemporal decisions, not intra-temporal allocations across goods

## Optimal Policy: Efficiency vs. Redistribution

**Q: What is the role of efficiency vs. redistribution in accounting for the optimal policies?**

**Our approach: Decompose their relative importance (Benabou 2002, Boar and Midrigan 2022)**

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**Our approach: Decompose their relative importance (Benabou 2002, Boar and Midrigan 2022)**

| **Efficiency** | Export tax | Import tariff | Total sales subsidy |
|---|---|---|---|
| Trade policy | 6.56% | −4.34% | — |
| Industrial policy | — | — | 6.02% |
| Trade and industrial policy | 16.65% | −12.42% | 19.51% |

| **Utilitarian (baseline)** | Export tax | Import tariff | Total sales subsidy |
|---|---|---|---|
| Trade policy | 14.26% | −9.44% | — |
| Industrial policy | — | — | 12.23% |
| Trade and industrial policy | 25.02% | −18.28% | 27.97% |

| **Rawlsian** | Export tax | Import tariff | Total sales subsidy |
|---|---|---|---|
| Trade policy | 36.87% | −33.46% | — |
| Industrial policy | — | — | 66.92% |
| Trade and industrial policy | 65.20% | −29.62% | 40.16% |

## Evidence: Trade and Industrial Policy Interventions During COVID-19

**Finally, we ask:**

1. To what extent have countries implemented trade and industrial policy changes?
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**Finally, we ask:**

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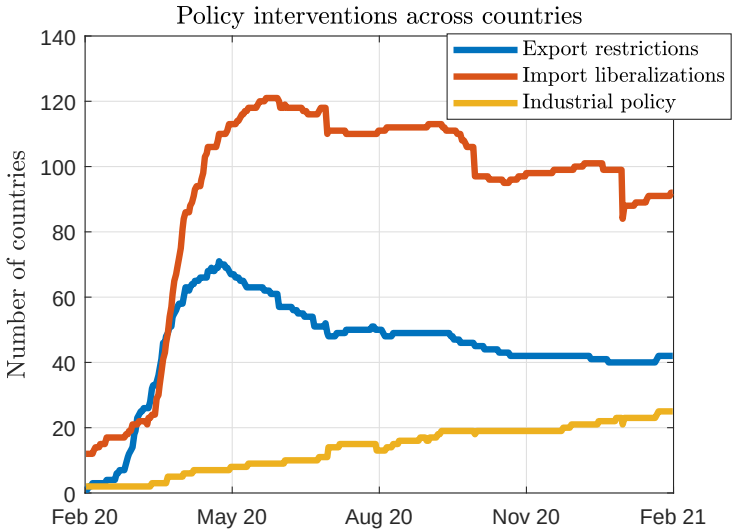
**How we answer this question:**

- Use cross-country data on trade and industrial policy interventions from Global Trade Alert
- Each entry of the database documents a unilateral policy change with information on:
  - Country, policy instrument, date (announcement, implementation, expiry), sectors / products targeted, direction of the change (harmful or liberalising)
- Identify three types of policies:
  1. Export barriers
  2. Import barriers
  3. Industrial policy (e.g., production subsidies, financial aid, state loans, etc.)
- Focus on 24 COVID-related products (prior to vaccines) as classified by WTO

# Evidence: Cross-Country Policy Interventions During COVID-19



## Evidence: U.S. Trade and Industrial Policy Interventions During COVID-19

⇒ **Cross-country evidence consistent with implications of the model**

- Prevalence of unilateral trade and industrial policies
- Trade dependent countries more likely to introduce policies

**Not just broadly across countries, but also specifically in the US:**

- **Defense Production Act** as a combination of industrial and trade policies
  - Incentives to increase production
  - Constraints on their destination
- Bown (2022): DPA accounts for rapid initial increase of vaccine production in the U.S. + Subsequent stagnation of vaccine production as firms largely constrained to sell domestically.