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Bank of Dallas

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Working Paper 2637

October 2026

Research Department

<https://doi.org/10.24149/wp2637>

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Shortages of Critical Goods in a Global Economy^{*}

Fernando Leibovici[†] and Ana Maria Santacreu[‡]

October 2026

Abstract

This paper studies shortages of critical goods in an open economy with credit market frictions and the role of trade and industrial policy in mitigating them. We develop a dynamic model with essential and non-essential goods, heterogeneous households, and concentrated firm ownership. When global demand for essential goods rises, leverage-dependent borrowing premia lead firms to underinvest, and trade amplifies domestic shortages as producers shift supply toward exports. Calibrated to the U.S. during COVID-19, we show that export taxes, import subsidies, and production subsidies can mitigate shortages and raise welfare. The effectiveness of financial support depends on its design and funding.

JEL Classification: F10

Keywords: shortages, critical goods, trade policy, industrial policy

^{*}We thank Baptiste Meunier for an insightful discussion, and George Alessandria, Jonathan Eaton, Ana Cecilia Fieler, Rafael Guntin, Aaron Hedlund, Sebnem Kalemli-Ozcan, Federico Kochen, Julian Kozlowski, Nelson Lind, Virgiliu Midrigan, Fernando Parro, B. Ravikumar, and various seminar participants for their helpful and generous feedback. We thank the Essential Goods Initiative at Global Trade Alert for assistance with the data. We thank Matthew Famiglietti, Jesse LaBelle, and Makenzie Peake for excellent research assistance. The views expressed in this paper are those of the individual authors and do not necessarily reflect official positions of the Federal Reserve Bank of Dallas, the Federal Reserve System, or the Board of Governors. Download the latest version of the paper from our websites: www.fernandoleibovici.com and www.anamariasantacreu.com. This paper supersedes previous versions titled "International Trade of Essential Goods During a Pandemic" and "International Trade Policy During a Pandemic."

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1 Introduction

After decades of trade liberalization, the global economy is witnessing a renewed turn toward protectionism. Recent crises, including the COVID-19 pandemic, the Russian invasion of Ukraine, and rising geopolitical tensions, have exposed the vulnerabilities of open economies heavily reliant on imports of critical goods such as semiconductors, energy and raw materials, and medical equipment. These episodes triggered severe shortages that prompted governments around the world to enact a wave of trade and industrial policy interventions, including export controls, import liberalizations, and production subsidies.

Motivated by these policy responses, we study how trade and industrial policies can mitigate shortages of critical goods after they occur. Our focus is on ex-post interventions, that is, on how policy can be used to mitigate the impact of shortages after they occur, rather than prevent them in advance. We develop a dynamic model of a small open economy in which firms produce essential and non-essential goods, accumulate capital, and trade with the rest of the world. Even in economies that rely heavily on imports of critical goods, domestic firms often have the capacity to expand production in response to shortages. However, this adjustment may be inefficient when the private cost of investment exceeds its social return, particularly when scaling up production requires large upfront investments financed through internal funds or costly borrowing.

Our model features two key frictions that can distort firms' investment behavior. First, households face incomplete financial markets and borrow subject to leverage-dependent borrowing premia. Second, firm ownership is imperfectly diversified across households. Because the premia rise with leverage, households that borrow to finance investment face a higher marginal cost of funds and discount future returns more heavily. Because ownership is concentrated, firms discount future profits using the stochastic discount factors of their owners. Together, these frictions can lead producers that need to borrow to expand to underinvest relative to the socially efficient allocation, creating scope for welfare-improving policy.

The first channel is well documented in the literature on financial frictions and incomplete markets in both emerging and advanced economies (Buera, Kaboski, and Shin 2011; Midrigan and Xu 2014; Dinlersoz et al. 2018; Leibovici and Wiczer 2023). A broad empirical literature shows that access to external finance affects firms' investment, employment, and growth, including among established firms in advanced economies. This evidence motivates the financial friction in our model as a general feature of the environment in which firms operate

across countries and time periods rather than as a friction specific to the COVID-19 episode.

The second channel is motivated by empirical evidence on the concentration of firm ownership, summarized in Table 1. In both the U.S. and Europe, ownership of private firms is highly concentrated, often by a single household, while public firms also exhibit substantial concentration, with the top 20 shareholders holding over 56% of firm value on average. Broader evidence on stock market participation and entrepreneurial risk further suggests that firm ownership is far from perfectly diversified across the population (Cooper et al. 2016; Asker, Farre-Mensa, and Ljungqvist 2015; Smith et al. 2019; Poterba et al. 1995).

In an economic environment featuring these frictions, we ask how governments can mitigate shortages of critical goods. Motivated by the policy responses observed during recent crises, our main analysis focuses on the trade and industrial policy instruments that governments widely used to alleviate such shortages: import subsidies, export taxes, and production subsidies. We study the desirability of these instruments when financial frictions limit firms' ability to expand production. We then complement this analysis by examining financial policies that target the friction directly, and we show that their effectiveness depends on how they are designed and funded.

Our model combines essential and non-essential goods through a constant elasticity of substitution (CES) technology to produce final goods. Essential goods can be complementary to non-essential goods, implying that even small disruptions can have large aggregate effects. Furthermore, the contribution of essential goods is evaluated relative to a time-varying reference level, which captures changes in the need for these goods, such as the surge in demand for PPE during COVID-19.

Firms hire labor and accumulate capital subject to sector-specific adjustment costs. Households supply labor inelastically, own the firms in their sector, and borrow subject to leverage-dependent premia. As described above, these features imply that households value future income differently depending on their financial positions, and that firms invest based on the valuations of their owners, which can lead to underinvestment following global demand shocks.

We model shortages of essential goods as arising from a global increase in demand. Similar mechanisms may also arise following negative supply shocks. Domestically, this is captured by a rise in the reference level of essential goods, reflecting heightened need (e.g., for PPE during a pandemic). Internationally, higher global demand raises the prices of both

imports and exports, encouraging producers to expand supply. Expanding production requires investment, which raises producers’ financing needs. The resulting increase in leverage raises borrowing costs and dampens investment, limiting the domestic production response to higher global demand.

We begin by qualitatively characterizing equilibrium outcomes relative to the social optimum. In the competitive equilibrium, the leverage-dependent borrowing premium distorts households’ intertemporal choices and generates heterogeneous stochastic discount factors across households. In contrast, a social planner can reallocate financial claims across households, pool domestic financial positions, and allocate aggregate borrowing at the world interest rate. As a result, the competitive equilibrium is inefficient: firms discount future profits using the SDFs of their owners, which are too low relative to the planner’s valuation, leading to underinvestment. The resulting inefficiency can be represented as a time-varying wedge in the firm’s investment. In the presence of a global demand shock, these wedges dampen firms’ incentives to scale up production, underscoring the potential for policy interventions to raise welfare.

We use our model to quantify the macroeconomic implications of shortages of critical goods and to study how trade and industrial policies can mitigate them. We focus on a concrete application: the shortages of essential medical goods that arose during the first year of the COVID-19 pandemic, prior to the widespread deployment of vaccines. To capture this episode, we model a transitory, unexpected global increase in the demand for essential goods. Domestically, the shock is represented by a rise in the reference level of essential goods; internationally, it is captured by increases in export and import prices, reflecting higher global need.¹ Agents are assumed to operate under perfect foresight.

We calibrate the model to match key features of the U.S. economy before and during the pandemic. We estimate that essential and non-essential goods are complementary (with an elasticity of substitution of 0.29), and that both labor and capital are subject to significant adjustment costs. These features imply that households are unable to easily substitute away from essential goods, and that firms are unable to quickly scale up production. As a result, although domestic producers increase output in response to higher prices, much of the additional supply is exported, limiting the domestic availability of essential goods.

¹We focus on the policy implications of large, sudden demand shocks for critical goods, rather than modeling the pandemic itself. In particular, we abstract from features like disease transmission or epidemiological dynamics (e.g., Çakmaklı et al. 2023).

We then investigate whether commonly used trade and industrial policy instruments can mitigate these distortions. We endow the government with three policy instruments targeted at essential goods: an import subsidy, an export tax, and a production subsidy. The government chooses the rates of these instruments to maximize a population-weighted utilitarian social welfare function, subject to a balanced budget. The policies are implemented during the shock and removed afterward. As in Itskhoki and Moll (2019), we focus on realistic policy instruments that have been widely implemented during recent crises such as export restrictions, import liberalizations, and production subsidies, rather than exploring the full space of theoretical first-best interventions. We exclude direct transfers across household types and offset markup distortions. Together with the absence of steady-state financial wedges, these assumptions ensure that the pre-shock competitive equilibrium is efficient.²

When the government is restricted to trade policy, the welfare-maximizing policy within this instrument set introduces a 14.45% export tax and a 9.54% import subsidy. These policies reallocate sales from foreign to domestic consumers and increase the availability of essential goods domestically. However, the export tax reduces firms' incentives to invest, leading to a decline in total output. In contrast, when only industrial policy is allowed, the government implements an 11.71% production subsidy. This raises output, but much of the additional supply is exported due to high global prices, with limited improvement in domestic consumption.

Then, we consider trade and industrial policies jointly. When these instruments are available together, the government combines an export tax of 25.18%, an import subsidy of 18.66%, and a production subsidy of 28.66%. The joint policy generates a consumption-equivalent welfare gain of 0.777%, compared with 0.267% under trade policy alone and 0.088% under industrial policy alone. These gains are measured using consumption compensation during the 12-month shock period. This combination exploits the complementarity between the two policy classes: the export tax reallocates essential goods toward domestic consumers, the production subsidy offsets its adverse effect on production incentives, and the import subsidy limits distortions in the composition of domestic absorption. As a result, the joint policy can redirect supply toward domestic users while largely preserving the economy's production response. This complementarity helps rationalize why many real-

²By studying a small open economy without markup distortions, we abstract from terms-of-trade effects and ensure that the economy is efficient in the pre-shock steady state. This allows us to isolate the role of financial frictions in shaping the welfare-maximizing trade and industrial policy response to shocks.

world policy responses combined export restrictions and domestic production support. In the U.S., for example, the Defense Production Act was used to scale up production of PPE and vaccines while limiting exports abroad (Bown 2022).

We next turn to policies that target the financial friction directly. Because the inefficiency in our model originates in the leverage-dependent borrowing premium, a natural question is whether improving the financing conditions of essential producers necessarily delivers large welfare gains. We compare three interventions: public co-financing, interest-rate subsidies, and credit guarantees. We find that their welfare effects depend critically on how they are designed and funded. Public co-financing, under which the government supplies outside funds at the world interest rate, can generate sizable welfare gains, although it requires the government to circumvent the financial friction itself. By contrast, interest-rate subsidies and credit guarantees, which are financed by the same worker-entrepreneur that operates the constrained firm, generate much smaller gains. We document that in the United States, private financing conditions tightened sharply at the onset of the pandemic, and the government responded with financial support measures closely related to those we study, such as public lending and loan guarantees.

Finally, we examine the roles of efficiency and redistribution in accounting for our findings. Following Benabou (2002) and Boar and Midrigan (2022), we show that a pure-efficiency social objective calls for the same trade and industrial interventions, at roughly two-thirds of their baseline magnitudes: efficiency considerations support substantial intervention, while redistributive considerations strengthen it. In the Appendix, we show how complementarities, adjustment costs, and the sensitivity of the borrowing premium to leverage shape these interventions. We also show that our findings are robust to alternative shock specifications, including labor supply disruptions and pandemics of different severity and duration, to alternative calibration targets and policy durations, and to the presence of markup distortions.

Related Literature Our paper contributes to several literatures. First, we relate to studies of optimal trade policy in open economies with heterogeneous firms (Costinot, Rodríguez-Clare, and Werning 2020; Demidova and Rodríguez-Clare 2009), and optimal industrial policy as a means to achieve long-term development (Juhász, Lane, and Rodrik 2024; Caliendo and Parro 2022; Bartelme et al. 2025; Lashkaripour and Lugovskyy 2023). In contrast to much of the literature, our paper studies how trade and industrial policies can improve welfare by mitigating distortions in the dynamic response to shocks, rather than from long-run

distortions in the allocation of production and trade across countries.

The role for policy interventions in our economy arises from the combination of incomplete markets and the concentration of firm ownership across a subset of the population. This channel is most closely related to Itskhoki and Moll (2019) and Caballero and Lorenzoni (2014), who study optimal policy design in dynamic environments where firms' decisions are distorted by frictions in financial markets. More broadly, our paper is related to the macroprudential policy literature studying pecuniary externalities arising from financial frictions, including Bianchi (2011), Schmitt-Grohé and Uribe (2016), and Bianchi and Mendoza (2018). As in this literature, financial frictions in our model create a wedge between private and socially efficient intertemporal decisions, which creates scope for welfare-improving policy. Our focus is on how this wedge shapes the use of trade and industrial policies in response to shortages of critical goods.

Our paper is also related to recent studies on the aggregate importance of small but systemic sectors. Baqaee and Farhi (2019) and Baqaee and Farhi (2024) show that small sectors can be systemically important if the elasticity of substitution between them and other production inputs is low and factors of production are fixed. We study the policy implications of related forces using a dynamic environment with goods essential for either consumption or production, with production decisions subject to distortions.

Finally, our paper is most closely related to recent studies of shortages of critical goods during crises and the potential for policy interventions. For instance, Traiberman and Rotemberg (2023), Grossman, Helpman, and Lhuillier (2023), and Adamopoulos and Leibovici (2024) study the role for policy interventions *ex-ante* rather than *ex-post*, as we do in our work. Shortages of critical goods during COVID-19 have also led to a surge of papers proposing international coordination mechanisms (Stellinger, Berglund, and Isakson 2020; Acharya et al. 2020; Evenett 2020; Baldwin and Evenett 2020) as well as domestic industrial policies (Athey et al. 2022; Bown 2022; Bown, Snyder, and Staiger 2022) to avoid future shortages. A broader set of papers has also recently studied the role of international trade as a transmission channel for shocks across countries (Çakmaklı et al. 2021; Bonadio et al. 2021; LaBelle, Leibovici, and Santacreu 2021; Antràs, Redding, and Rossi-Hansberg 2023; Eppinger et al. 2021).

2 Motivating Evidence

This section documents two facts that motivate our analysis. First, financial frictions are pervasive across countries, affecting firms’ ability to finance investment and expand production. Second, when shortages of critical goods arise, governments typically respond with trade and industrial policies. We first review evidence on financial frictions and firm ownership concentration. We then document the widespread use of trade and industrial policies in response to shortages during recent global shocks.

2.1 Financial Frictions across Firms and Countries

A large literature shows that financial frictions shape firms’ investment and growth decisions, not only among small firms in developing economies but also among large, established firms in advanced economies. Using survey data on more than 4,000 firms in 54 countries, Beck, Demirgüç-Kunt, and Maksimovic (2005) find that financial obstacles reduce firm growth and that their effects are strongest among small firms. Smaller firms have fewer sources of external finance and depend more heavily on banks, making them particularly exposed to collateral requirements, high interest rates, and disruptions in the supply of bank credit.

Financial constraints, however, are not limited to small firms or developing economies. Even in normal times, Nini, Smith, and Sufi (2009) find explicit capital-expenditure restrictions in 32% of private credit agreements with publicly traded U.S. corporations, and 42% of firms face such a restriction at some point in their sample. These frictions become more visible when credit conditions tighten. Surveying 1,050 chief financial officers in the United States, Europe, and Asia during the global financial crisis, Campello, Graham, and Harvey (2010) find that financially constrained firms planned larger reductions in investment, employment, and technology spending. Among large U.S. firms, 16% reported that their operations were severely affected by difficulties in accessing credit, and an additional 35% reported being somewhat affected.

Episodes of disrupted credit supply provide sharp evidence that these frictions affect the real decisions of established firms in advanced economies. Almeida et al. (2012) find that U.S. firms with substantial debt maturing immediately after the onset of the 2007 credit crisis reduced investment by more than otherwise similar firms whose debt matured later. In Europe, Acharya et al. (2018) show that losses at relationship banks during the sovereign-debt crisis reduced lending to large firms with access to syndicated credit and depressed

Table 1: Firm Ownership Concentration in the U.S. and Europe

Firm type	Statistic	Value	Source
<i>United States</i>			
Private	Share of firms with <4 owners	97.4%	SBO
Private	Out of these: Avg. ownership share of top owner	86.2%	SBO
Public	Avg. ownership share of top 3 owners	23%	OECD
Public	Avg. ownership share of top 20 owners	56%	OECD
<i>Europe</i>			
Private	Share of firms owned by single household	74%	Peter (2021)
Private	Share of firms with single household owning >50%	90%	Peter (2021)
Public	Avg. ownership share of top 3 owners	49%	OECD
Public	Avg. ownership share of top 20 owners	66%	OECD

Note: The data on private firms in the U.S. are based on authors' calculations from the U.S. Census Bureau's 2007 Survey of Business Owners (SBO). The data on private firms in Europe are from Peter (2021). The data on public firms are from De La Cruz, Medina, and Tang (2019), an OECD report with ownership information on public firms across countries. The values corresponding to this report are approximated based on the report's figures.

their investment, employment, and sales growth. Taken together, this evidence suggests that financial frictions are a pervasive feature of firms' environment rather than specific to a particular type of firm, country, or crisis. They are typically more severe among small firms and are amplified when credit conditions tighten, but large firms in advanced economies are also subject to them.

Firm Ownership Concentration. Another salient feature of how firms are organized and financed is that their ownership tends to be highly concentrated. Table 1 summarizes patterns of ownership concentration across private and public firms in the United States and Europe. In the United States, private firms typically have very few owners: 97.4% have fewer than four owners, and within this group, the largest shareholder holds an average equity stake of over 86%. While public firms exhibit relatively more dispersed ownership, ownership remains concentrated, with the top three shareholders holding an average of 23% and the top 20 shareholders accounting for 56% of firm equity on average.

European data reveal similarly high levels of ownership concentration. Private firms are predominantly controlled by single households: 74% of these firms are entirely owned by one household, and 90% have majority ownership by a single household. Public firms in Europe also display substantial concentration among major shareholders; the top three owners control on average nearly half (49%) of firm equity, and the largest twenty shareholders control

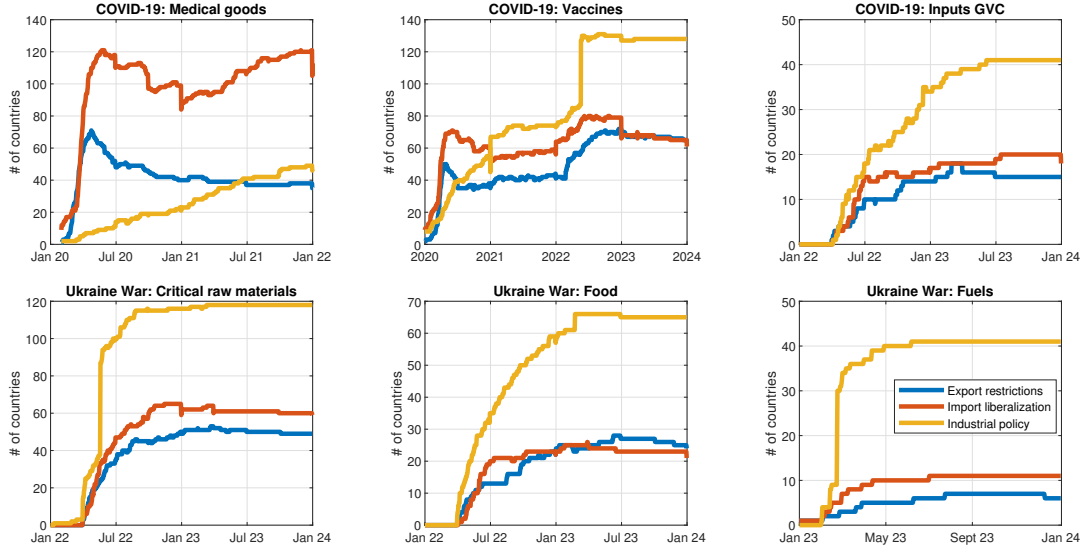


Figure 1: Trade and industrial policies following global shocks.

about two-thirds (66%).

These patterns motivate our assumption that firm ownership is imperfectly diversified across households, allowing financial frictions to affect investment through owners' intertemporal valuations.

2.2 Trade and Industrial Policies Following Shortages of Critical Goods

Financial frictions can limit how quickly firms adjust production when market conditions change abruptly. When such changes create shortages of critical goods, whether through surging demand or disrupted supply, governments have repeatedly stepped in with trade and industrial policies. Recent global shocks provide particularly visible examples of a broader pattern: when the domestic availability of critical goods becomes a concern, governments intervene both at the border and on the production side.

Despite differences in the nature of these shocks and the products affected, governments relied on a similar set of instruments: export restrictions, import liberalizations, and measures supporting domestic production.

Figure 1 documents the prevalence of these policy responses using data from Global Trade Alert (GTA).³ The figure reports the number of countries using export restrictions, import liberalizations, and industrial policies across six groups of goods affected by the COVID-19 pandemic and the war in Ukraine. The same broad policy toolkit appears across shocks and across countries, despite substantial differences in the goods involved and in the nature of

³Data from Global Trade Alert (GTA): <https://www.globaltradealert.org/>.

the underlying disruption.

The widespread use of these instruments motivates our focus on understanding the role of trade and industrial policy as responses to shortages of critical goods. In the quantitative analysis, we use the U.S. experience during COVID-19 as a specific application with which to discipline the model. The policy question we study, however, is broader: how trade and industrial policies shape the domestic availability of critical goods when shocks generate shortages in an open economy.

3 Model

We study a small open economy that trades goods and financial assets with the rest of the world. The economy is populated by four types of agents: worker-entrepreneurs, producers of sectoral composite goods, producers of final goods, and a government. There are two sectors, essential and non-essential. In each, worker-entrepreneurs produce a domestic variety and the rest of the world produces a foreign variety. We denote variables corresponding to these sectors using subscripts e and n , respectively. All varieties can be traded internationally — thus, the economy has access to four types of varieties: a domestic and imported variety of essential goods, and a domestic and imported variety of non-essential goods. We let the domestic non-essential varieties be the numeraire. Varieties in each sector are produced using labor and capital, which are mobile across sectors. Sectoral composite goods aggregate domestic and imported varieties in each sector, and final goods aggregate sectoral composite goods across sectors. In the rest of this section, we describe each of these agents in detail.

3.1 Worker-entrepreneurs

The economy is populated by a unit measure of infinitely-lived worker-entrepreneurs who discount the future at rate $\beta < 1$. There are two types, indexed by $i \in \{n, e\}$, who differ in the variety they produce: a worker-entrepreneur of type i is endowed with λ_i units of labor and owns and operates the representative firm that produces the domestic variety of good i .⁴ Labor is supplied inelastically to an economy-wide labor market at wage rate w_t .⁵ Thus, every period a worker-entrepreneur earns labor income $\lambda_i w_t$, operates its firm using capital and hired labor, and consumes the resulting income net of production and financing costs. In addition, every period worker-entrepreneurs receive lump-sum transfers $\mathcal{T}_{it}$ from the

⁴We normalize the economy's aggregate labor supply to unity — thus, $\lambda_n + \lambda_e = 1$.

⁵Labor supply is freely mobile across sectors, so the wage is equalized.

redistribution of revenue collected by the government through import tariffs, export taxes, or sales taxes.⁶

Technology. Worker-entrepreneurs of type $i \in \{n, e\}$ produce the domestic variety of good i using capital k_{it} and labor ℓ_{it} , with a time-invariant productivity A_i . The amount produced is $A_i \left(\ell_{it}^\alpha k_{it}^{1-\alpha} \right)^\eta$, where α controls the labor share, $1 - \alpha$ controls the capital share, and $\eta \in (0, 1)$ denotes the degree of decreasing returns to scale.⁷ In every period t , worker-entrepreneurs choose the amount of labor to use in that period and the amount of capital investment for production in period $t + 1$. Each sector's investment and capital stock are made up of non-essential goods. Thus, to increase the amount of capital by one unit in the following period requires investing I_{it} units of non-essential goods in the current period. Given that capital depreciates at rate δ , next period's capital stock k_{it+1} is $(1 - \delta)k_{it} + I_{it}$.

We introduce sectoral capital and labor adjustment costs to help us discipline the degree to which sectoral production can change over time. We assume that capital and labor adjustment costs are quadratic and denominated in units of non-essential goods:

$$\begin{aligned}\phi_{ki}(k_{it+1}, k_{it}) &= \frac{\Omega_{ki}}{2} \left(\frac{k_{it+1}}{k_{it}} - 1 \right)^2 \\ \phi_{\ell i}(\ell_{it}, \ell_{it-1}) &= \frac{\Omega_{\ell i}}{2} \left(\frac{\ell_{it}}{\ell_{it-1}} - 1 \right)^2,\end{aligned}$$

where Ω_{ki} and $\Omega_{\ell i}$ are non-negative sector-specific constants.

Sales across markets. Each worker-entrepreneur produces a differentiated variety that is sold domestically and abroad. Domestic sales are chosen subject to a downward-sloping demand function from domestic producers of composite goods. Exports are chosen subject to the perfectly elastic demand from the rest of the world at price p_{it}^x . Export revenues are subject to an ad-valorem tax rate τ_{it}^x , and total sales are subject to an ad-valorem subsidy τ_{it}^y .⁸ We denote by p_{it}^d and y_{it}^d the price and quantity of domestic sales, and by p_{it}^x and y_{it}^x the price and quantity of exports.

Financial markets. As in Bewley-Huggett-Aiyagari models (Bewley, 1977; Huggett, 1993; Aiyagari, 1994), we assume that worker-entrepreneurs have access to incomplete financial

⁶ $\mathcal{T}_{it} < 0$ denotes a lump-sum tax.

⁷We assume the production technology features decreasing returns to scale to ensure the existence of a steady state with positive exports across a nondegenerate set of parameters.

⁸Negative export taxes denote export subsidies, and negative sales subsidies denote taxes.

markets. They can trade a one-period risk-free bond vis-a-vis each other as well as with the rest of the world. The bond is denominated in units of the numeraire, and the rest of the world lends and borrows at a constant world interest rate r^* , with $1 + r^* = 1/\beta$. Borrowing, however, is subject to a leverage-dependent premium: a worker-entrepreneur that borrows more relative to the value of its capital faces a higher effective borrowing cost. Specifically, the effective gross interest rate at which type i trades bonds is $(1 + r^*) \Gamma(L_{it})$, where

$$\Gamma(L_{it}) = \exp\left[\psi(L_{it} - \bar{L})\right], \quad L_{it} = \frac{b_{it+1}}{p_{nt}k_{it}},$$

and L_{it} denotes the worker-entrepreneur's loan-to-value ratio — the ratio of its debt b_{it+1} to the value of its capital stock k_{it} , valued at the price of non-essential goods p_{nt} . The parameter $\psi \geq 0$ governs the sensitivity of the borrowing premium to leverage, and $\bar{L}$ denotes a reference level of leverage at which the premium vanishes. When $\psi > 0$, the premium is increasing in leverage, so that worker-entrepreneurs that borrow more relative to their collateral face higher marginal borrowing costs; when $\psi = 0$, the premium is inactive.

As in models of financially constrained producers (Buera, Kaboski, and Shin, 2011; Midrigan and Xu, 2014), the same agent chooses both how much to borrow and how much capital to hold, so the financial friction directly distorts capital accumulation: the worker-entrepreneur internalizes that investment raises the value of its collateral and lowers its borrowing premium, but the premium also raises its cost of funds and lowers the value it assigns to future returns. In the Appendix, we provide a microfoundation for this premium based on costly enforcement: lenders must invest in enforcement capacity to secure larger repayment pledges relative to collateral, which generates a leverage-dependent borrowing premium of exactly this form. Like the debt-elastic interest rate of Schmitt-Grohé and Uribe (2003), the premium also ensures that the economy's net foreign asset position is pinned down in the steady state.

Problem of worker-entrepreneurs. Worker-entrepreneur i 's period utility function is given by $u(c_{it}) = \frac{(c_{it}/\lambda_i)^{1-\xi}}{1-\xi}$, expressed as a function of per capita consumption, with $1/\xi$ denoting the intertemporal elasticity of substitution. Bringing the consumption-savings, production, investment, and pricing decisions together, the worker-entrepreneur of type i chooses consumption, bonds, labor, investment, capital, and market-specific prices and quantities to

maximize lifetime discounted utility given initial capital stock k_{i0} and bond position b_{i0} :

$$\begin{aligned}
& \max_{\{c_{it}, b_{it+1}, \ell_{it}, I_{it}, k_{it+1}, p_{it}^d, y_{it}^d, y_{it}^x\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{(c_{it}/\lambda_i)^{1-\xi}}{1-\xi} \\
& \text{subject to} \\
& p_t c_{it} + b_{it} + w_t \ell_{it} + p_{nt} I_{it} + p_{nt} \phi_{ki}(k_{it+1}, k_{it}) + p_{nt} \phi_{\ell i}(\ell_{it}, \ell_{it-1}) \\
& \quad = \lambda_i w_t + (1 + \tau_{it}^y) p_{it}^d y_{it}^d + (1 + \tau_{it}^y - \tau_{it}^x) p_{it}^x y_{it}^x + \frac{b_{it+1}}{(1 + r^*) \Gamma(L_{it})} + \mathcal{T}_{it} \\
& \quad k_{it+1} = (1 - \delta) k_{it} + I_{it} \\
& \quad y_{it}^d + y_{it}^x = A_i \left(\ell_{it}^\alpha k_{it}^{1-\alpha} \right)^\eta \\
& \quad y_{it}^d = \omega_i \left(\frac{p_{it}^d}{p_{it}} \right)^{-\sigma} y_{it} \\
& \quad y_{it}^x \geq 0,
\end{aligned}$$

for all $t = 0, \dots, \infty$, where the expectation operator is conditional on the information set in period $t = 0$. The first constraint is the budget constraint, with c_{it} denoting consumption of final goods, p_t the price of final goods, p_{nt} the price of the non-essential good composite, and $b_{it+1} > 0$ ($b_{it+1} < 0$) denoting debt (savings). The second constraint is the law of motion of capital, and the third is the production technology. The fourth constraint is the demand function faced domestically, which results from the problem of producers of composite good i described below.⁹ Given the perfectly elastic demand faced from the rest of the world, the fifth constraint ensures exports are weakly positive.

3.2 Producers of final goods

The final goods purchased by households and firms are produced by a representative firm combining essential e_t and non-essential n_t composite goods. To do so, the firm operates a constant elasticity of substitution technology given by:

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

⁹We abstract from the impact on optimal policy of markup distortions induced by monopolistic competition. To do so, we let the government subsidize domestic sales with a proportional subsidy equal to $\frac{1}{\sigma-1}$, financed via lump-sum taxes levied on the worker-entrepreneur; we omit this subsidy from the formulation above to simplify the exposition.

where the parameter γ controls the relative importance of the two goods for the aggregate absorption bundle, ρ denotes the elasticity of substitution between essential and non-essential goods, and $\bar{e}_t$ refers to the “reference level” of essential goods relative to which absorption of these goods is evaluated. We model this reference level as exogenous and time-varying. Moreover, we capture the critical nature of essential goods by assuming they are complementary with non-essential goods ($\rho < 1$) — in Section 5 we estimate this to be the case.

The firm’s problem in period t is then given by:

$$\begin{aligned} & \max_{y_t, n_t, e_t} p_t y_t - p_{nt} n_t - p_{et} e_t \\ & \text{subject to} \\ & y_t = \left[(1 - \gamma) n_t^{\frac{\rho-1}{\rho}} + \gamma \left(\frac{e_t}{\bar{e}_t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}. \end{aligned}$$

This specification captures two features of critical goods. First, complementarities with non-essential goods can amplify the aggregate effects of disruptions, even when essential goods account for a small share of expenditure. Second, the time-varying reference level captures changes in the need for essential goods. The final-goods technology can be interpreted as either a consumption aggregator or an aggregate production technology in which essential goods serve as inputs.

3.3 Producers of composite goods $j \in \{n, e\}$

The sectoral composite goods used to produce final goods are themselves produced by combining sectoral varieties produced domestically (q_{jt}^d) and abroad (q_{jt}^m). To do so, the firm operates a constant elasticity of substitution technology given by:

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

where $\omega_j \in (0, 1)$ denotes the relative weight of domestic vs. imported goods in the production of the composite good, and $\sigma > 0$ denotes the elasticity of substitution between domestic and imported varieties of good j .

The problem of the firm consists of choosing the amount of inputs q_{jt}^d and q_{jt}^m to maximize profits. The prices of the domestic and imported varieties are given by p_{jt}^d and p_{jt}^m , respectively. Imports are subject to sector-specific iceberg trade costs $\tau_j \geq 1$ and ad-valorem

import tariffs τ_{jt}^m .¹⁰

The firm's problem in period t is then given by:

$$\begin{aligned} & \max_{y_{jt}, q_{jt}^d, q_{jt}^m} p_{jt} y_{jt} - p_{jt}^d q_{jt}^d - (1 + \tau_{jt}^m) \tau_j p_{jt}^m q_{jt}^m \\ & \text{subject to} \\ & y_{jt} = \left[\omega_j^{\frac{1}{\sigma}} q_{jt}^{d \frac{\sigma-1}{\sigma}} + (1 - \omega_j)^{\frac{1}{\sigma}} q_{jt}^{m \frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}. \end{aligned}$$

The domestic input q_{jt}^d is purchased from the worker-entrepreneur of type j , whose domestic sales y_{jt}^d satisfy the resulting downward-sloping demand $q_{jt}^d = \omega_j \left(p_{jt}^d / p_{jt} \right)^{-\sigma} y_{jt}$.

3.4 Rest of the world

The rest of the world is the trade and financial partner of the domestic economy. On the one hand, it produces a differentiated imported variety in each sector $j \in \{n, e\}$, which is sold at a perfectly elastic price p_{jt}^m and subject to a sector-specific iceberg trade cost τ_j . These are the domestic economy's imports. On the other hand, the rest of the world has a perfectly elastic demand for the domestic economy's varieties in each sector $j \in \{n, e\}$ at price p_{jt}^x . These are the domestic economy's exports. Finally, the rest of the world is the financial counterpart of the domestic economy, with a perfectly elastic demand or supply of bonds at the constant world interest rate r^* ; domestic worker-entrepreneurs face an idiosyncratic borrowing premium $\Gamma(L_{it})$ that depends on their own leverage, as described above.

3.5 Government

Finally, the economy is populated by a government that collects revenue from taxes on imports $\{\tau_{jt}^m\}_{j \in \{n, e\}}$ and exports $\{\tau_{jt}^x\}_{j \in \{n, e\}}$, uses these revenues to subsidize domestic production, $\{\tau_{jt}^y\}_{j \in \{n, e\}}$, and provides lump-sum transfers to worker-entrepreneurs $\{\mathcal{T}_{it}\}_{i \in \{n, e\}}$. The government does not have access to financial markets, so its budget constraint has to be balanced every period. The government's budget constraint is given by:

$$\mathcal{T}_{nt} + \mathcal{T}_{et} = \sum_{j \in \{n, e\}} \left\{ \tau_{jt}^m \tau_j p_{jt}^m q_{jt}^m + \tau_{jt}^x p_{jt}^x y_{jt}^x - \tau_{jt}^y \left[p_{jt}^d y_{jt}^d + p_{jt}^x y_{jt}^x \right] \right\}.$$

Given a set of taxes and subsidies, there are multiple configurations of lump-sum transfers that can ensure the budget is balanced. To characterize the multiple arrangements available,

¹⁰Negative import tariffs denote import subsidies.

we let $\psi_{ijt}^k \in [0, 1]$ denote the share of revenue from policy $k \in \{m, x, y\}$ on good $j \in \{n, e\}$ in period t that is redistributed lump-sum to worker-entrepreneurs of type $i \in \{n, e\}$ — where $k = m$ denotes import tariffs, $k = x$ denotes export taxes, and $k = y$ denotes sales subsidies. Then, transfers $\{\mathcal{T}_{it}\}_{i \in \{n, e\}}$ need to satisfy:

$$\mathcal{T}_{it} + \sum_{j \in \{n, e\}} \psi_{ijt}^y \tau_{jt}^y (p_{jt}^d y_{jt}^d + p_{jt}^x y_{jt}^x) = \sum_{j \in \{n, e\}} \psi_{ijt}^x \tau_{jt}^x p_{jt}^x y_{jt}^x + \sum_{j \in \{n, e\}} \psi_{ijt}^m \tau_{jt}^m \tau_j p_{jt}^m q_{jt}^m,$$

where budget balance is ensured by $\psi_{njt}^k + \psi_{ejt}^k = 1$. We discuss our approach to specifying parameters $\{\psi_{ijt}^k\}$ when investigating optimal policy design in Section 6.

3.6 Equilibrium

Consider a sequence of shocks $\{\bar{e}_t, p_{jt}^x, p_{jt}^m\}_{t=0, j \in \{n, e\}}^\infty$, a sequence of trade policy instruments $\{\tau_{jt}^x, \tau_{jt}^m\}_{t=0, j \in \{n, e\}}^\infty$, a sequence of industrial policy instruments $\{\tau_{jt}^y\}_{t=0, j \in \{n, e\}}^\infty$, and initial values $\{b_{j0}, k_{j0}\}_{j \in \{n, e\}}$. We let the price of the domestic variety of non-essential goods in the home country p_{nt}^d be the numeraire. Then, a *competitive equilibrium* consists of:

- wages $\{w_t\}_{t=0}^\infty$, prices p_t and $\{p_{jt}, p_{jt}^d\}_{t=0, j \in \{n, e\}}^\infty$, borrowing premia $\{\Gamma(L_{nt}), \Gamma(L_{et})\}_{t=0}^\infty$,
- allocations:

$$\{c_{jt}, b_{jt+1}, \mathcal{T}_{jt}, \ell_{jt}, k_{jt+1}, I_{jt}, y_{jt}, y_{jt}^d, y_{jt}^x, q_{jt}^d, q_{jt}^m, y_t, n_t, e_t\}_{t=0, j \in \{n, e\}}^\infty,$$

such that the following conditions hold:

1. Given prices, allocations solve problem of each worker-entrepreneur type
2. Given prices, allocations solve problem of final good producers
3. Given prices, allocations solve problem of composite goods producers of each type
4. Government's budget is balanced
5. Labor market clears: $\ell_{nt} + \ell_{et} = \lambda_n + \lambda_e \forall t$
6. Domestic essential goods market clearing: $y_{et}^d = q_{et}^d \forall t$
7. Domestic non-essential goods market clearing: $y_{nt}^d = q_{nt}^d \forall t$

8. Essential composite goods market clearing: $e_t = y_{et} \forall t$

9. Non-essential composite goods market clearing:

$$n_t + \sum_{j \in \{n, e\}} \left[I_{jt} + \frac{\Omega_{kj}}{2} \left(\frac{k_{jt+1}}{k_{jt}} - 1 \right)^2 + \frac{\Omega_{\ell j}}{2} \left(\frac{\ell_{jt}}{\ell_{jt-1}} - 1 \right)^2 \right] = y_{nt} \forall t$$

10. Final goods market clearing: $\sum_{i \in \{n, e\}} c_{it} = y_t \forall t$.

11. Borrowing premia consistent with leverage: for each $i \in \{n, e\}$, worker-entrepreneur i faces effective gross interest rate $(1 + r^*) \Gamma(L_{it})$ with $\Gamma(L_{it}) = \exp \left[\psi (L_{it} - \bar{L}) \right]$ and $L_{it} = b_{it+1} / (p_{nt} k_{it})$

4 Mechanism

In this section, we characterize the sources of inefficiency in our model and examine how they shape equilibrium outcomes. We begin by describing the social planner's problem and contrasting it with the competitive equilibrium. We then identify key sources of inefficiency and analyze how these distortions affect equilibrium allocations. Finally, we examine the implications of these inefficiencies in the context of pandemic-like shocks, modeled as unexpected increases in the demand for essential goods. Throughout this analysis, we abstract from adjustment costs, as these represent real frictions that affect the planner's problem and competitive equilibrium symmetrically, and therefore do not constitute an independent source of inefficiency.

4.1 Planner's Problem

We begin by characterizing the social planner's problem, which provides a useful benchmark for evaluating the efficiency of market outcomes. The planner maximizes the population-weighted sum of worker-entrepreneurs' utilities subject to the economy's technological and resource constraints. Formally, the planner solves:

$$\max_{\{c_{it}, \ell_{it}, I_{it}, k_{it+1}, y_{it}^d, y_{it}^x, y_{it}^m, B_{t+1}\}} \mathcal{V}_t = \lambda_n V_{nt} + \lambda_e V_{et}$$

where $V_{it} = \sum_{t=0}^{\infty} \beta^t \frac{(c_{it}/\lambda_i)^{1-\xi}}{1-\xi}$ represents the lifetime utility of worker-entrepreneur $i \in \{n, e\}$, with per-capita consumption defined as (c_{it}/λ_i) , and λ_i denotes the mass of agents of type i . The planner faces the following constraints:

- Production technology: $y_{it}^d + y_{it}^x = A_i(\ell_{it}^\alpha k_{it}^{1-\alpha})^\eta$ for $i \in \{n, e\}$
- Capital accumulation: $k_{it+1} = (1 - \delta)k_{it} + I_{it}$ for $i \in \{n, e\}$
- Sectoral goods aggregation:

$$n_t + \sum_{i \in \{n, e\}} I_{it} = \left[\omega_n^{\frac{1}{\sigma}} (y_{nt}^d)^{\frac{\sigma-1}{\sigma}} + (1 - \omega_n)^{\frac{1}{\sigma}} (y_{nt}^m)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

$$e_t = \left[\omega_e^{\frac{1}{\sigma}} (y_{et}^d)^{\frac{\sigma-1}{\sigma}} + (1 - \omega_e)^{\frac{1}{\sigma}} (y_{et}^m)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

- Final goods aggregation: $c_{et} + c_{nt} = \left[(1 - \gamma) n_t^{\frac{\rho-1}{\rho}} + \gamma (e_t / \bar{e}_t)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$
- External constraint: $\sum_i \tau_i p_{it}^m y_{it}^m + B_t = \frac{B_{t+1}}{1 + r^*} + \sum_i p_{it}^x y_{it}^x$

where we denote imported quantities as y_{it}^m , corresponding to q_{jt}^m in the decentralized model, and B_t denotes the economy's net foreign liabilities.

Although the planner has full control over domestic allocations, the economy remains subject to an external constraint involving both goods prices (p_{it}^m and p_{it}^x) and the world interest rate r^* . These international prices and the world interest rate enter the planner's problem explicitly because we consider a small open economy: both trade in goods and borrowing in financial markets occur at terms determined externally. Thus, even the planner must take these external terms as given, reflecting the same external environment faced by worker-entrepreneurs in the decentralized equilibrium. The complete derivation, including the full set of first-order conditions and their economic interpretation, is provided in the Appendix.

Unlike worker-entrepreneurs, however, this country-level planner is not subject to the leverage-dependent borrowing premium $\Gamma(L_{it})$, which depends on each agent's own borrowing relative to its collateral. By pooling domestic financial positions, the planner nets out borrowing and lending across households, so the economy as a whole borrows abroad at r^* . The planner allocation thus faces the same technological and external constraints as the decentralized economy, but not the friction that distorts private decisions. As is standard in the literature on financial frictions, comparing the two isolates the resulting inefficiency (e.g., Buera, Kaboski, and Shin, 2011; Midrigan and Xu, 2014; Itskhoki and Moll, 2019).

4.2 Source of Inefficiency

In this section, we evaluate the efficiency of the competitive equilibrium by contrasting its first-order conditions with those of the planner, which identifies the wedges between private and social incentives. These wedges arise from the leverage-dependent borrowing premium, which distorts worker-entrepreneurs' consumption-savings and investment decisions. We focus on the main distortions here and relegate the full set of optimality conditions to the Appendix.

4.2.1 Characterizing Equilibrium Distortions

The borrowing premium distorts how worker-entrepreneurs discount future payoffs. To see this, we compare their Euler equations in the competitive equilibrium with the Euler equation implied by the planner's solution. In the competitive equilibrium, worker-entrepreneur i 's Euler equation is:

$$\underbrace{\beta \left(\frac{c_{it+1}}{c_{it}} \right)^{-\xi} \left(\frac{\bar{e}_t}{\bar{e}_{t+1}} \right)^{\frac{\rho-1}{\rho}} \frac{[c_{et+1} + c_{nt+1}]^{\frac{1}{\rho}}}{[c_{et} + c_{nt}]^{\frac{1}{\rho}}} \frac{e_{t+1}^{\frac{1}{\sigma}-\frac{1}{\rho}} q_{et+1}^{\frac{m-1}{\sigma}}}{e_t^{\frac{1}{\sigma}-\frac{1}{\rho}} q_{et}^{\frac{m-1}{\sigma}}} \frac{p_{et}^m}{p_{et+1}^m}}_{\text{SDF (competitive equilibrium), } m_{it+1}} = \underbrace{\frac{1 - \psi L_{it}}{(1 + r^*) \Gamma(L_{it})}}_{\text{Marginal cost of funds (agent-specific)}}$$

where $L_{it} = b_{it+1}/(p_{nt}k_{it})$ is the worker-entrepreneur's loan-to-value ratio and $\Gamma(L_{it}) = \exp[\psi(L_{it} - \bar{L})]$ is its leverage premium. The planner's Euler equation is instead:

$$\underbrace{\beta \left(\frac{c_{it+1}}{c_{it}} \right)^{-\xi} \left(\frac{\bar{e}_t}{\bar{e}_{t+1}} \right)^{\frac{\rho-1}{\rho}} \frac{[c_{et+1} + c_{nt+1}]^{\frac{1}{\rho}}}{[c_{et} + c_{nt}]^{\frac{1}{\rho}}} \frac{e_{t+1}^{\frac{1}{\sigma}-\frac{1}{\rho}} y_{et+1}^{\frac{m-1}{\sigma}}}{e_t^{\frac{1}{\sigma}-\frac{1}{\rho}} y_{et}^{\frac{m-1}{\sigma}}} \frac{p_{et}^m}{p_{et+1}^m}}_{\text{SDF (planner), } \tilde{m}_{t+1}} = \underbrace{\frac{1}{1 + r^*}}_{\text{Marginal cost of funds (common)}}$$

The key difference arises because each worker-entrepreneur faces a borrowing premium that depends on its own leverage L_{it} , while the planner, which is not subject to this friction, discounts future payoffs at the common world rate r^* . For a borrowing worker-entrepreneur, an additional unit of debt both carries the premium and raises leverage, increasing the premium paid on existing debt. The premium thus drives a wedge $\frac{1-\psi L_{it}}{\Gamma(L_{it})}$ between the private and social marginal cost of funds, which equals one at the steady state, where $L_{it} = \bar{L} = 0$, and falls below one as leverage rises. Because future payoffs are worth less when funds are more costly today, discount factors in the competitive equilibrium (m_{it+1}) are agent-specific and lower for more leveraged agents, while the planner uses a single, common

discount factor ($\widetilde{m}_{t+1}$). Worker-entrepreneur heterogeneity thus shapes the incidence of the distortion: the agent that borrows most relative to its capital faces the largest premium and the most distorted discount factor. When $\psi = 0$, the wedge disappears and the competitive equilibrium attains the planner's production and investment allocations.

These distortions affect other margins in our economy, which we characterize next.

Investment. The distortions in worker-entrepreneurs' stochastic discount factors also affect their investment decisions. Specifically, in the planner's solution, investment satisfies:

$$\widetilde{m}_{t+1} \left[p_{it+1}^x \left((1 - \alpha) \eta A_i (\ell_{it+1}^\alpha k_{it+1}^{1-\alpha})^\eta / k_{it+1} \right) + \Omega_{nt+1}^m (1 - \delta) \right] = \Omega_{nt}^m,$$

whereas in the competitive equilibrium investment satisfies:

$$m_{it+1} \left[p_{it+1}^x \left((1 - \alpha) \eta A_i (\ell_{it+1}^\alpha k_{it+1}^{1-\alpha})^\eta / k_{it+1} \right) + \Omega_{nt+1}^m (1 - \delta) \right] + \underbrace{m_{it+1} \frac{b_{it+2}}{(1 + r^*) \Gamma(L_{it+1})} \frac{\psi L_{it+1}}{k_{it+1}}}_{\text{leverage value of capital}} = \Omega_{nt}^m,$$

where Ω_{nt}^m denotes the shadow value of non-essential goods, in which investment is denominated. The competitive equilibrium differs from the planner's solution along two dimensions. First, a borrowing worker-entrepreneur discounts future returns more heavily than the planner ($m_{it+1} < \widetilde{m}_{t+1}$), which lowers its incentive to invest. Second, and partly offsetting the first, investment carries an additional return in the decentralized economy: a larger capital stock lowers the agent's leverage and thereby reduces its borrowing costs, a financial motive for investment absent from the planner's problem. In our calibration, the first effect dominates: as we show in the Appendix, the financial policies studied in Section 7, which reduce the premium faced by essential producers, substantially raise their investment. The financial friction therefore leads to inefficiently low capital accumulation and muted production responses.

Labor. Labor choices follow identical first-order conditions in both the planner's solution and the competitive equilibrium:

$$p_{it}^x \left[\alpha \eta A_i (\ell_{it}^\alpha k_{it}^{1-\alpha})^\eta / \ell_{it} \right] = w_t.$$

However, the inefficiencies in capital accumulation imply that the competitive equilibrium features an inefficiently low capital stock relative to the planner's solution. This lower capital

stock reduces the marginal product of labor, thereby distorting relative wages and employment across sectors. As a result, even though worker-entrepreneurs respond optimally, the equilibrium labor allocation differs from the socially efficient outcome. Thus, the distortion originating in borrowing and investment decisions indirectly distorts the allocation of labor, amplifying the overall inefficiency of the decentralized equilibrium.

Production and Trade. Finally, the optimality conditions determining the composition of production between domestic sales and exports, as well as the choice between domestically produced goods and imports, remain identical in both environments.¹¹ However, the previously described distortions in capital accumulation imply a lower equilibrium capital stock in the competitive equilibrium relative to the planner's solution. Consequently, output and trade volumes are systematically lower in the decentralized equilibrium, reflecting the transmission of the inefficiencies from distorted borrowing and investment decisions into production and international trade patterns.

4.3 Impact of Pandemic Shocks

We now analyze how the inefficiencies characterized above affect the economy's response to pandemic-like shocks. We model a pandemic as a shock that increases the demand for essential goods ($\bar{e}_t$), accompanied by corresponding increases in global prices (p_{et}^m and p_{et}^x), which the small open economy takes as given. To illustrate the economic implications, we examine the direct effects on consumption and borrowing decisions, and then discuss how these effects affect investment, labor, and trade.

On the demand side, two main forces shape the response of essential goods consumption. First, the higher reference level ($\bar{e}_t$) directly increases essential goods consumption. Second, the complementarity between essential and non-essential goods ($\rho < 1$) restricts agents' ability to substitute away from essential goods, even as their relative prices rise:

$$\frac{e_t}{n_t} = \left(\frac{p_{et}}{p_{nt}} \right)^{-\rho} \left(\frac{\gamma}{1-\gamma} \right)^{\rho} \bar{e}_t^{1-\rho}.$$

Moreover, because households value smooth consumption paths ($\xi > 0$), they are reluctant to postpone consumption until after the shock, which sustains demand for final goods, and hence for essential goods, during the pandemic.

¹¹See the Appendix for detailed derivations of these optimality conditions.

On the supply side, the leverage-dependent borrowing premium distorts production responses during a pandemic. The essential-goods producer borrows to finance the expansion of production in response to the higher demand. As its borrowing rises relative to its capital, its leverage L_{et} increases, raising its borrowing premium $\Gamma(L_{et})$ and depressing its stochastic discount factor. The worker-entrepreneur therefore discounts future returns more heavily and invests less than is socially optimal, limiting the economy’s ability to scale up production precisely when essential goods are most valuable. These distortions create scope for welfare-improving policy interventions, which we study in the next section.

5 Quantitative analysis

While our model can be used to study shortages of critical goods in different episodes, we focus on a particular application: shortages of essential medical goods during the outbreak of COVID-19. We use this episode to explore the quantitative importance of the channels outlined in the previous section and evaluate the role for policy interventions. Specifically, the pandemic led to a massive increase in the demand for essential medical equipment and supplies (e.g., gowns, masks, gloves, intensive-care equipment, etc.) that have been critical to combat it and prevent the spread of the disease. While supply increased gradually in an attempt to satisfy the high demand for these goods, countries have faced supply shortages, forcing them to ration these goods and face exorbitant prices.

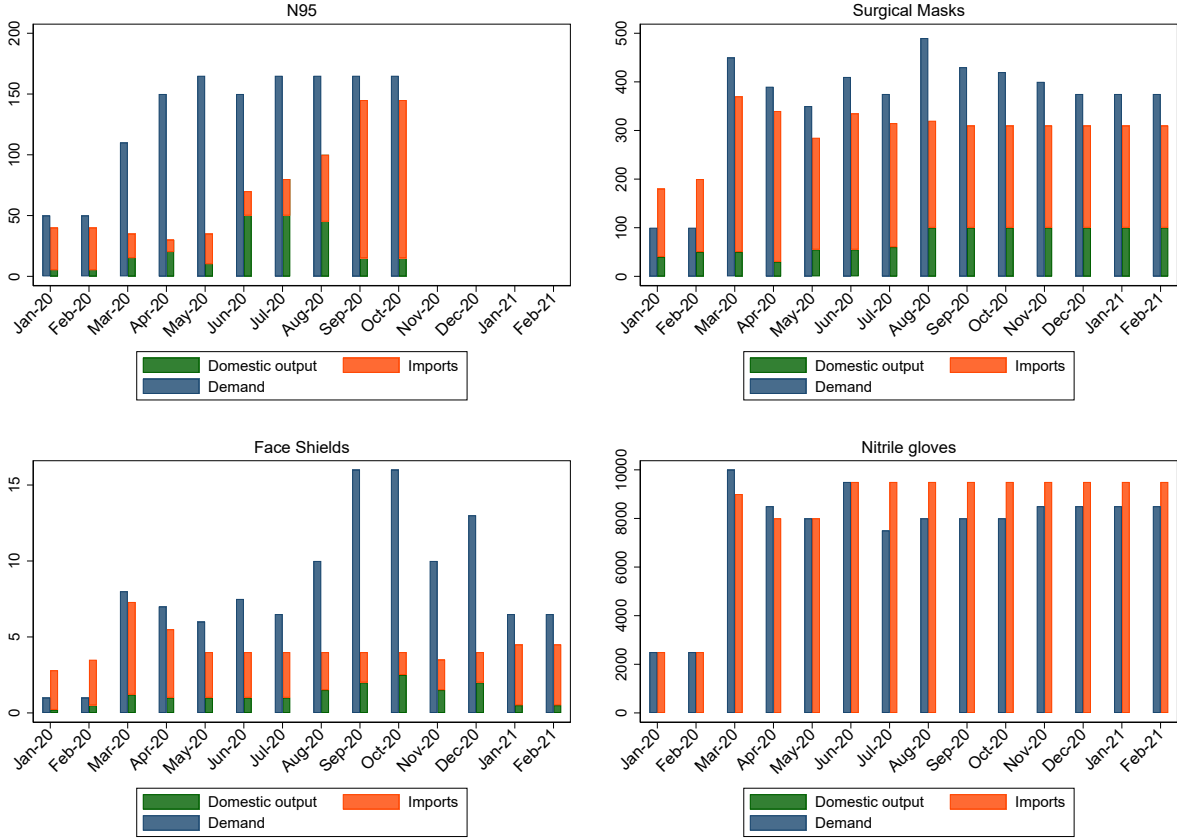
We begin by documenting salient features of the dynamics of demand, supply, and prices of essential medical goods during the COVID-19 pandemic. We then describe our approach to modeling this episode in our framework. We describe our estimation strategy to match salient features of the U.S. economy both prior to and during the COVID-19 pandemic. We conclude this section by studying the dynamics of the economy throughout this episode.

5.1 Essential medical goods during COVID-19 in the U.S.

To examine the dynamics of demand and supply of personal protective equipment (PPE) during COVID-19 in the U.S., we use data from the White House COVID-19 Supply Chain Task Force.¹² Consistent with this dataset, we focus on the following types of PPE: N95 respirators, surgical masks, gloves, and face shields. We interpret the evidence documented for these goods as representative of the broader category of PPE essential for preventing the spread of COVID-19.

¹²See <https://crsreports.congress.gov/product/pdf/R/R46628>.

Figure 2: PPE Demand and Supply in the U.S., Jan 2020 – Feb 2021



Note: The y -axes are expressed in millions of units. Data from the White House Supply Chain Task Force.

Demand vs. supply of personal protective equipment We begin by documenting the evolution of demand and supply of PPE. Our analysis is based on estimates of the demand and supply of these goods reported by the task force for Jan 2020 - Feb 2021, right before the introduction of COVID-19 vaccines. Figure 2 reports our findings, with blue bars representing PPE demand as estimated by the Task Force, while the sum of the green (absorption of domestic goods) and red (absorption of imported goods) bars represent PPE supply available for consumption. Therefore, observations with blue bars (demand) higher than the red-green bars (supply) reflect shortages of the given product in the given period. We highlight three key facts.

First, we observe that PPE demand across these four types of goods experienced a significant increase between February and March 2020, at the onset of the pandemic, remaining high through February 2021. For instance, the estimated demand for N95 masks doubled be-

tween February and March, tripling by April; the demand for the rest of the goods increased even more sharply.

Second, changes in PPE supply were generally not sufficient to meet the increased demand for these goods. While domestic and imported consumption of all such goods increased during the pandemic, this increase was not sufficiently large to meet the spike of demand, leading to shortages.

Finally, we observe that international trade is a critical source of PPE in the U.S. In particular, across all four types of goods, the average share of imports in total supply is higher than 70%. While nitrile gloves provide an extreme example, with virtually zero domestic production, the contribution of U.S. producers is minimal across all categories.

Price changes of personal protective equipment We now investigate the implications of shortages of essential goods for prices. To do so, we document the price changes across the four PPE categories identified by the White House COVID-19 Supply Chain Task Force. We obtain information on price changes by combining data from various sources.

For nitrile gloves, face shields, and surgical masks, we rely on international trade data from the United States International Trade Commission (USITC). In particular, we use monthly unit values of U.S. imports reported across disaggregate 10-digit HS product categories. First, we identify the set of 10-digit HS product codes corresponding to nitrile gloves, face shields, and surgical masks. For each 10-digit HS product, we compute the peak price change in 2020 relative to its average price in 2019. Then, for each broad product category under analysis, we compute the median price change across all 10-digit HS products that belong to such category.

Prices for N95 masks are not available in the USITC database before July 2020.¹³ Thus, we obtain prices of N95 masks from a study conducted by The Society for Healthcare Organization Procurement Professionals (SHOPP) in April 2020.¹⁴ The prices reported in the study are based on current market pricing and Centers for Disease Control and Prevention guidelines on PPE costs incurred by skilled nursing facilities and assisted living centers treating COVID-19 patients.

We report our findings in Table 2. We find that the price of PPE increased substantially

¹³The July 1st, 2020 Revision of the U.S. Harmonized Tariff Schedule introduced a dedicated product category to identify N95 masks: 6307.90.9845. Prior to this revision, N95 were included under subheading 6307.90.9889.

¹⁴See <https://shopp.org/>.

Table 2: PPE Prices

Peak price change relative to 2019 average	
N95 respirators	1,513%
Surgical masks	104.8%
Face shields	21.01%
Nitrile gloves	95.35%

Note: For nitrile gloves, face shields, and surgical masks, the peak price change is computed using data from March to December 2020. For N95 masks, the peak price change is based on data for April 2020.

during the pandemic, likely reflecting the severe supply shortages documented above. Relative to the average prices throughout 2019, the peak increase in the price of N95 respirators was 1,513%, while the respective values for surgical masks and nitrile gloves were 105% and 95%, respectively. Face shields experienced the lowest price increase, equal to 21% at the peak relative to the 2019 average. These price changes are consistent with Bown (2021).¹⁵

5.2 Global demand shock in the model

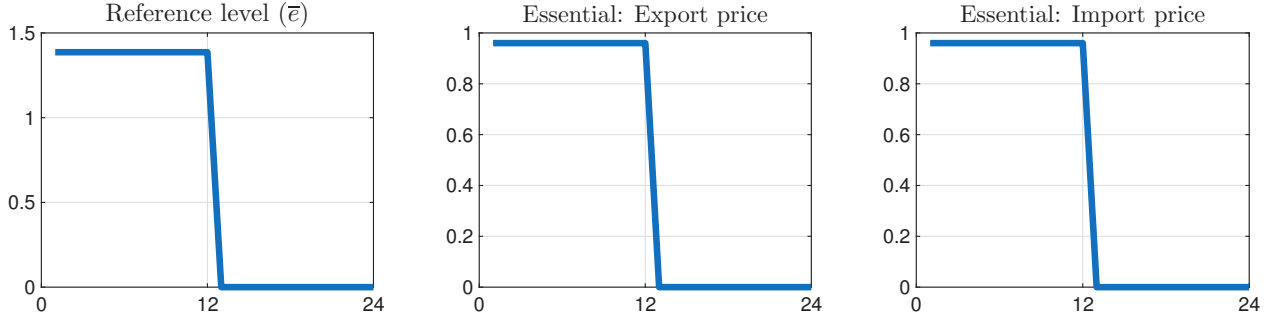
Motivated by this evidence, we model a pandemic in our model as consisting of a global increase in the demand for essential goods. We use the PPE evidence in Section 5.1 to discipline three model objects. First, the increase in PPE demand maps into an increase in the reference level of essential goods, $\bar{e}_t$, which captures the higher need for essential goods in the final-goods aggregator. Second, changes in import unit values map into shocks to the world import price of essential goods, p_{et}^m . Third, because the shock is global and raises the value of essential goods in foreign markets as well, we impose a symmetric shock to the export price, p_{et}^x .¹⁶ While essential goods in our model correspond to a broader category of medical goods needed to combat COVID-19, we use the set of PPE documented in Section 5.1 as a proxy to measure the shocks because it is the only category for which high-frequency data on demand and prices are available during the pandemic.

Given the high-frequency dynamics of the pandemic, we interpret a period in the model as a month in the data. And given our focus on shortages of essential medical goods prior to the development of vaccines, we study shocks that last for 12 months. We study the perfect

¹⁵See Cabral and Xu (2021) for a detailed analysis of the role of price gouging on observed price changes.

¹⁶To simplify the analysis, we assume that import and export prices increase by the same amount.

Figure 3: Global demand shock



Note: The x -axes denote time periods. The y -axes are expressed as log deviations from steady state.

foresight solution of the model in response to these shocks. We let period 0 denote the initial steady state. The full path of shocks is observed in period 1. Agents observe an increase of $\bar{e}$, p_e^x , and p_e^m for 12 periods, with their values reverting back to their initial steady-state levels in period 13. To simplify the analysis, we assume that each shocked parameter increases once before reverting back to steady state.

We parameterize the shocks by restricting attention to the four essential medical goods identified by the White House COVID-19 Supply Chain Task Force and described in detail in Section 5.1. We set the shock to the reference level $\bar{e}$ to match the increased demand for these goods documented in Figure 2. In our model, $\bar{e}$ captures the time-varying reference level of essential goods in the final goods aggregator, and a higher value of $\bar{e}$ reflects a greater perceived need for essential goods, such as that observed during a public health emergency. Under the alternative interpretation of final goods as an aggregate production technology, an increase in $\bar{e}$ instead represents a decline in the efficiency with which essential inputs contribute to final output; in either case, it is distinct from changes in the productivity of producing essential goods.¹⁷ Because the model shock is stylized as a constant 12-month disturbance, we summarize the empirical time series by peak log changes across goods. This choice targets the severity of shortages at the height of the episode while abstracting from within-pandemic monthly variation. For each good, we first identify the peak demand over this period relative to pre-pandemic demand and then compute the median across goods. The demand for the median good increases by 1.39 log-points at the peak. Thus, we consider

¹⁷Since our welfare analysis compares economies with and without policy that face the same path of $\bar{e}$, our welfare findings do not depend on comparing welfare across different preferences (Baqae and Burstein, 2023).

an increase of $\bar{e}$ such that $\Delta \ln \bar{e} = 1.39$ throughout the 12 months of the pandemic. Figure 3 plots the dynamics of the shocks that characterize a pandemic in our model.

We set the shocks to import and export prices to match changes in the unit values of essential COVID-19 goods from the USITC and the World Customs Organization. First, we identify the set of product codes corresponding to goods identified as essential, as described above.¹⁸ For each good we identify the highest price change relative to pre-pandemic prices, and then compute the median across goods. While we rely on the same data used for Table 2, here we pool all underlying product codes and abstract from the broad product categories. We find the price of the median good increased by 0.96 log-points at the peak. Thus, we consider an increase of import and export prices such that $\Delta \ln p_e^x = \Delta \ln p_e^m = 0.96$ during the 12 months of the pandemic.

5.3 Parameterization

To parameterize the model, we partition the parameter space into three sets of parameters: predetermined parameters, parameters estimated to match moments of the U.S. economy prior to the onset of COVID-19, and parameters estimated to match the dynamics of the U.S. economy following COVID-19.

Predetermined parameters Predetermined parameters are set to standard values from the literature and consist of the discount factor β , the intertemporal elasticity of substitution $1/\xi$, the elasticity of substitution between domestic and imported varieties of essential and non-essential goods σ , the labor share α , the degree of returns to scale η , and the capital depreciation rate δ . We normalize weights ω_e and ω_n to $1/2$, and the productivity of essential goods producers to 1. We focus on an economy in which worker-entrepreneurs of each type hold zero debt in the steady state, so that trade is balanced. Accordingly, we set the reference level of leverage to $\bar{L} = 0$, its steady-state value, so that the leverage premium $\Gamma(L_i)$ is inactive at the steady state. This allows us to isolate the role of financial frictions in shaping the economy’s dynamic response to shocks.

Table 3 reports the parameter values used throughout. We set β to 0.9967, which implies an annual interest rate of approximately 4% given we set $r^* = 1/\beta - 1$. We set the intertemporal elasticity of substitution $1/\xi$ to 0.50 ($\xi = 2$), consistent with empirical estimates using aggregate data (Hall 1988; Campbell and Mankiw 1989). The elasticity of substitution σ is

¹⁸We restrict attention to products with non-missing data throughout the first 12 months of the pandemic. Thus, we exclude N95 masks since they were not separately reported prior to July 2020.

Table 3: Predetermined parameters

Parameter	Value	Description
β	$0.96^{\frac{1}{12}}$	Discount factor
$1/\xi$	0.50	Intertemporal elasticity of substitution
σ	4	Armington elasticity
α	0.66	Labor share
η	0.85	Returns to scale
δ	0.01	Capital depreciation rate

set to 4 following Simonovska and Waugh (2014), implying domestic and imported varieties are relatively substitutable. We set the labor share α to 2/3 and returns to scale η to 0.85 from Midrigan and Xu (2014) and Atkeson and Kehoe (2007). We set the monthly depreciation rate δ to 1%, implying an annual depreciation rate $\approx 11\%$, consistent with equipment depreciation estimates in U.S. manufactures (Albonico, Kalyvitis, and Pappa 2014).

Parameters estimated to match targets prior to shocks The set of parameters estimated to match moments of the U.S. economy prior to COVID-19 consists of the productivity of non-essential goods producers A_n , the iceberg trade costs τ_e and τ_n , the reference level of essential goods $\bar{e}$ in the steady state, the weight γ of essential goods in the technology of final goods producers, and the measures λ_n and λ_e of worker-entrepreneurs of each type. We normalize the mass of agents in the economy to unity. Thus, given a value of $\lambda_n \in (0, 1)$, we have $\lambda_e = 1 - \lambda_n$.

We choose the remaining six parameters to ensure that the steady state of our model captures the following features of the U.S. economy prior to the onset of COVID-19: (i) the net exports-to-GDP ratio in essential goods, (ii) the share of essential goods in aggregate GDP, (iii) the share of essential goods absorption that is imported, (iv) the share of non-essential goods absorption that is imported, (v) the aggregate absorption of essential goods relative to their reference level, and (vi) the share of aggregate labor supplied by agents of type n .

To compute empirical counterparts to these moments, we begin by classifying goods into essential and non-essential. Limited data availability prior to COVID-19 prevents us from

Table 4: Estimated parameters, pre-shock steady state

Parameter	Value	Description
A_n	1.592	Sectoral productivity
τ_e	1.138	Trade costs on essential goods
τ_n	1.342	Trade costs on non-essential goods
$\bar{e}$	0.312	Reference level of essential goods
γ	0.0021	Weight on essential goods
λ_n	0.957	Measure of agents of type n
λ_e	$1 - \lambda_n$	Measure of agents of type 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
Aggregate $e/\bar{e}$	1.000	1.000
HH n labor share	0.957	0.957

restricting attention solely to PPE that was key at the onset of COVID-19.¹⁹ Thus, we define essential goods as consisting of a broader range of medical goods: (i) medical equipment and supplies manufacturing and (ii) pharmaceutical and medicine manufacturing. Non-essential goods are defined as consisting of all other goods produced in the U.S.²⁰ We compute all moments using data from the Bureau of Economic Analysis and the U.S. Census.²¹ Finally, we set the target values of moments (v) and (vi) as follows: First, we assume aggregate consumption of essential goods is equal to the reference level in the pre-shock steady state— $e = \bar{e}$. Second, we assume that the share of aggregate labor supplied by agents of type n is equal to the share of aggregate output accounted for by the firms they operate.²²

The estimated parameters as well as the empirical targets and their model counterparts

¹⁹The key constraint that we face is that the product-level gross output data are not sufficiently disaggregated to distinguish between personal protective equipment and other medical goods.

²⁰Thus, our empirical counterpart to GDP in the model is U.S. goods GDP.

²¹International trade data from U.S. Census consist of product-level data at the HS-6-digit level of disaggregation. There are a total of 5,402 product categories, from which 92 belong to the medical sector.

²²In the Appendix we examine the sensitivity of our findings to alternative targets for the output share of essential goods.

are reported in Table 4. We find that the six estimated parameters can be chosen to match the six targets exactly. To have lower net exports of essential goods than non-essential goods, the model requires producers of non-essentials to be more productive than producers of essential goods. The model also requires a very low utility weight on essential goods in order to match the low share of essential goods in aggregate GDP. And, finally, trade costs determine the extent to which absorption of essential and non-essential goods is imported.

Parameters estimated to match dynamics following shocks We estimate the remaining parameters to match salient features of the dynamics of the U.S. economy following the onset of the shocks: the elasticity of substitution ρ between essential and non-essential goods, the capital and labor adjustment costs $\{\Omega_{ke}, \Omega_{\ell e}\}$ faced by producers of essential goods, the capital and labor adjustment costs $\{\Omega_{kn}, \Omega_{\ell n}\}$ faced by producers of non-essential goods, and the slope ψ of the leverage-dependent borrowing premium. We simplify the estimation by assuming that $\Omega_{ke} = \Omega_{\ell e}$ and $\Omega_{kn} = \Omega_{\ell n}$.

In mapping the data to the model, we interpret domestic sales plus imports of PPE as the empirical counterpart of essential absorption, and goods GDP net of the medical-goods sector as the empirical counterpart of non-essential absorption and output. We choose the four estimated parameters to match the following features of the U.S. economy after the onset of COVID-19 relative to pre-pandemic levels: (i) the growth of essential goods consumption, (ii) the growth of absorption of non-essential goods, (iii) the growth of output of non-essential goods, and (iv) the change of the aggregate net exports to GDP ratio. All moments are computed as the average monthly change throughout Q2 and Q3 of 2020 relative to Q4 of 2019.²³

We compute empirical counterparts for these moments as follows: We compute moment (i) using estimates of domestic sales and imports of four critical goods from the White House COVID-19 Supply Chain Task Force, as described in Section 5.1. We first compute median monthly growth across goods, and then average these monthly medians. We use data on U.S. goods GDP net of the medical-goods sector from the BEA to measure absorption and output of non-essential goods, as well as the net exports-to-GDP ratio.

We estimate the parameters through a simulated method of moments (SMM) algorithm, designed to minimize the sum of absolute deviations between the empirical moments and

²³The only exception is moment (i), which is computed relative to January 2020 due to data availability.

Table 5: Estimated parameters, post-shock dynamics

Parameter	Value	Description
ρ	0.291	Elasticity essential and non-essential
$\Omega_{k,n} = \Omega_{\ell,n}$	32.212	Adjustment costs: Non-essential
$\Omega_{k,e} = \Omega_{\ell,e}$	4.630	Adjustment costs: Essential
ψ	0.168	Leverage premium slope

Moment	Target value	Model
$e_t : \log(\text{Avg. Q2-Q3 '20} / \text{Pre-pandemic})$	0.619	0.619
$n_t : \log(\text{Avg. Q2-Q3 '20} / \text{Pre-pandemic})$	-0.062	-0.062
$y_{n,t} : \log(\text{Avg. Q2-Q3 '20} / \text{Pre-pandemic})$	-0.070	-0.066
$NX/GDP: \text{Avg. Q2-Q3 '20} - \text{Pre-pandemic}$	-0.009	-0.009

their model counterparts, assigning equal weight to each of the moments.²⁴ Table 5 reports the estimated parameters as well as the empirical targets and their model counterparts. All moments are matched almost exactly except for the growth of non-essential good output. We find that essential and non-essential goods are estimated to be complementary, with an elasticity of substitution equal to 0.291. We estimate positive sectoral adjustment costs in both sectors, with larger costs faced by producers of non-essential goods. Finally, we estimate the slope of the leverage-dependent borrowing premium to be $\psi = 0.168$. In the Appendix, we examine the sensitivity of our findings to alternative values of ψ .

5.4 Dynamics following shortages of essential goods

We now study the impact of a global demand shock by computing impulse response functions following the shocks presented in Figure 3. The dynamics of key variables, expressed as percent deviations from their steady-state values, are presented in Figures 4 and 5.²⁵ We restrict attention to the dynamics over the first two years (24 periods) following the onset of the shocks.

Production and trade of essential goods We begin with the dynamics of production and trade of essential goods, illustrated in Figure 4. Our starting point is that higher export and import prices of essential goods significantly increase the overall price of essential goods.

²⁴We study the perfect foresight solution of the model numerically using global methods.

²⁵We report the dynamics of a broader set of variables in the Appendix.

This result is partially driven by the nontrivial fraction of essential goods that are imported. But, moreover, this is also accounted for by the rise of export prices, which leads producers of essential goods to increase the domestic price of domestically produced essential goods.

These higher prices of essential goods increase the returns to accumulating capital and hiring labor for producers of essential goods, raising the optimal production scale—as described in Section 4. However, production increases gradually given the costs to adjust capital and labor. The essential-goods worker-entrepreneur finances this expansion through borrowing and reduced consumption, which raises its leverage and the borrowing premium it faces; these short-run financing costs are more than offset by increased revenues thereafter.

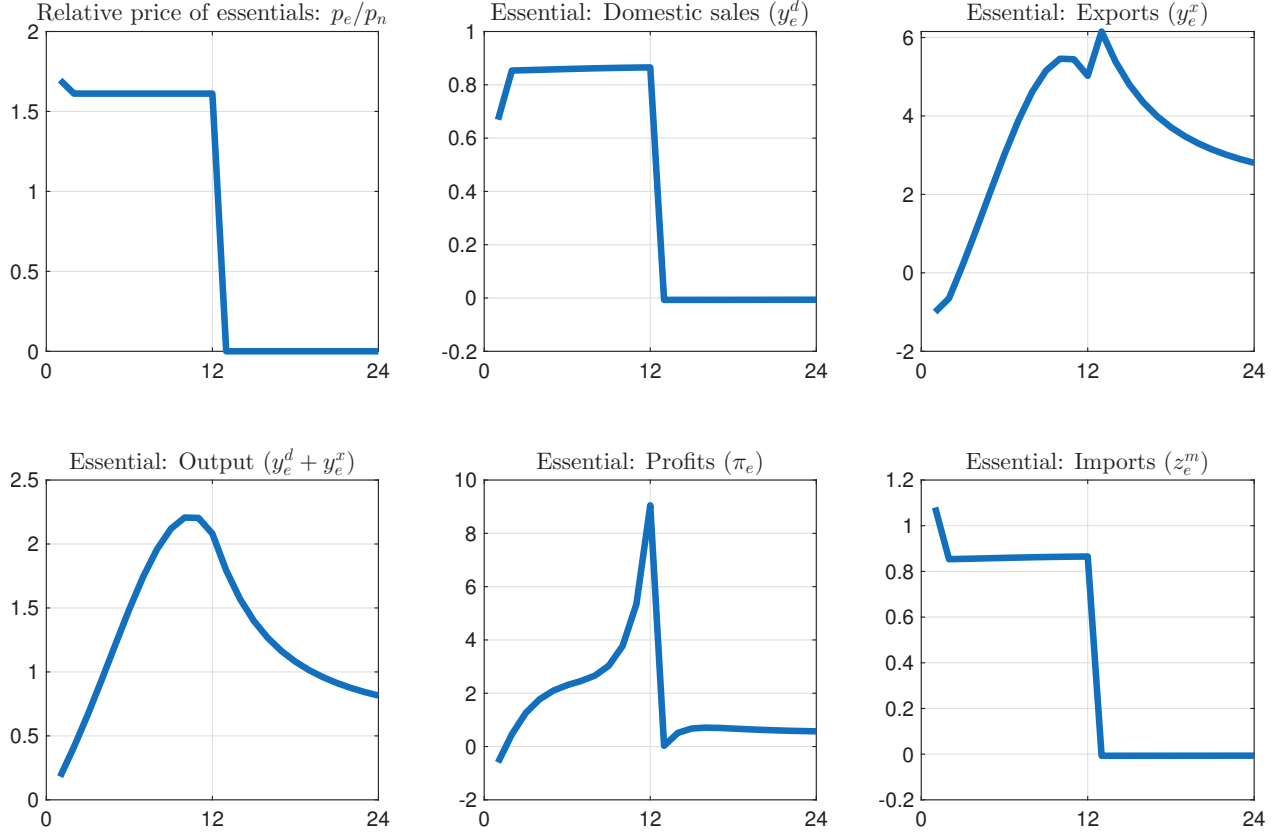
The increased production of essential goods is distributed across all destination markets: Both domestic sales and exports of these goods increase. On the one hand, and despite sizable price increases, domestic demand for essential goods increases given the higher reference level along with the complementarity between essential and non-essential goods—as described in Section 4. Thus, both domestic sales and imports increase significantly throughout the pandemic. On the other hand, exports increase given the attractiveness of the higher export price along with the perfectly elastic demand faced by domestic producers when selling internationally.

Interestingly, we find that exports increase relatively more than domestic sales. Thus, despite the higher domestic need and demand for essential goods, most of the increased production scale is actually exported rather than sold domestically. This implication raises questions about the desirability of the equilibrium outcomes and the potential for policy to increase welfare.

Consumption and discounting Given our setup with heterogeneous worker-entrepreneurs and incomplete markets, the consumption and discounting dynamics implied by the model differ across types, as described in Section 4. Figure 5 plots key variables in the dynamics of consumption and discounting for agents of each type.

The consumption dynamics vary markedly across types. Type e worker-entrepreneurs increase their consumption gradually, whereas type n agents show little dynamic adjustment after the initial shock. This divergence arises from the time-varying income of type e agents: the expansion of essential-goods production entails substantial initial outlays—investment and rising borrowing costs—followed by significant returns toward the later stages of the pandemic. Because of the financial friction, agents are unable to fully borrow against their

Figure 4: Dynamics of production and trade of essentials



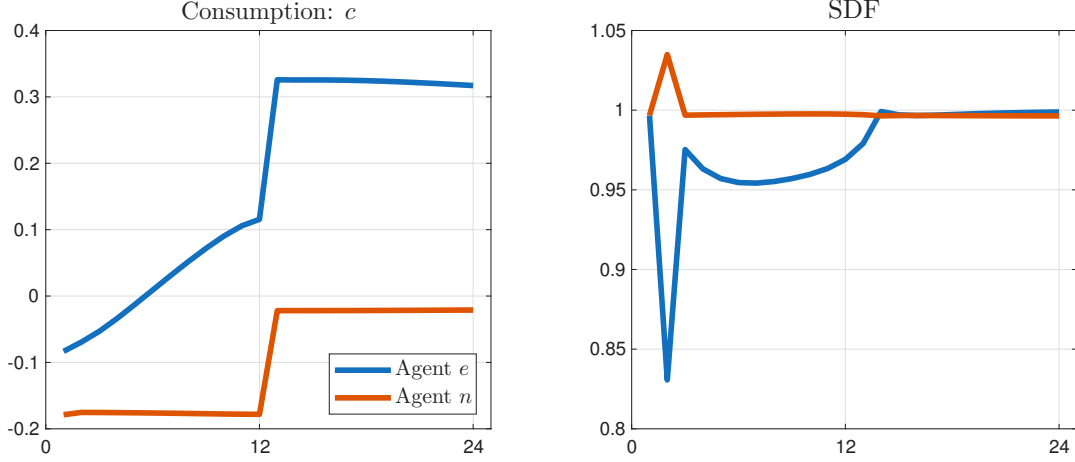
Note: The x -axes denote time periods (months). The y -axes are expressed as percent deviations from steady state. Specifically, percent changes are obtained by multiplying the values in the panel by 100.

future income, prompting them to adopt consumption paths that are smooth but steadily increasing.

The heterogeneous path followed by the consumption (and borrowing) dynamics across types is mirrored by the dynamics of each agent's SDF. On the one hand, the SDF of type n agents remains relatively unchanged, reflecting their relatively flat pattern of consumption and borrowing throughout the pandemic. On the other hand, the SDF of type e agents declines significantly below its steady-state level throughout the pandemic. These agents finance investment through increased borrowing, which raises their leverage L_e and the borrowing premium $\Gamma(L_e)$ they face, depressing their SDF.

Differences in discounting across types are also critical to determine investment and hiring decisions in each sector. The lower SDF of type e agents implies that producers of essential goods make investment and hiring decisions assigning relatively lower value to future

Figure 5: Dynamics of consumption and discounting



Note: The x -axes denote time periods (months). The y -axes are expressed as percent deviations from steady state, except for the SDF which is in levels. Specifically, percent changes are obtained by multiplying the values in the panel by 100.

returns, as described in Section 4. This implication raises questions about the desirability of the equilibrium outcomes. We study these and other related questions in the next section.

6 Policy Instruments and Welfare Gains

We now study the potential for trade and industrial policies to address the inefficiencies identified in Section 4 following pandemic-like shocks. Motivated by the policy responses observed during COVID-19, we restrict attention to three instruments: export taxes, import subsidies, and production subsidies. We study the extent to which these instruments can mitigate the distortions characterized above and quantify the welfare gains they may deliver. Our focus is therefore on the desirability of policies that governments actually used in response to shortages, as documented in Section 2, rather than on the first-best set of interventions that would implement the efficient allocation. This approach follows Itskhoki and Moll (2019), who study the optimal use of realistic policy instruments in an economy with financial frictions.

6.1 Policy instruments and economic mechanisms

The policy instruments we study affect different margins related to the distortions characterized in Section 4. The leverage-dependent borrowing premium creates an intertemporal wedge: essential producers discount future returns too steeply when their borrowing rises relative to collateral, leading to inefficiently low investment and a muted production response.

Industrial policy addresses the production-side consequences of this friction by raising the private return to expanding output of essential goods. Trade policy, in contrast, acts on the allocation of essential goods across markets: an export tax redirects domestic production away from foreign buyers and toward domestic consumers, while an import subsidy lowers the domestic cost of imported essential varieties.

These differences are central for the results below. Increasing production need not alleviate domestic shortages in a small open economy. When world prices are taken as given and foreign demand is perfectly elastic, additional domestic output may be exported rather than consumed at home. As a result, industrial policy can partially offset the investment distortion and raise production without substantially increasing domestic access to essential goods. Export taxes, by contrast, directly affect the domestic allocation of scarce essential goods during the shock. The policy problem therefore involves two distinct margins: expanding domestic production and redirecting scarce goods toward domestic consumers.

6.2 Government Problem

We endow the government with three policy instruments targeted at essential goods: (i) ad-valorem import tariffs τ_{et}^m , (ii) ad-valorem export taxes τ_{et}^x , and (iii) ad-valorem sales subsidies τ_{et}^y .²⁶ We refer to (i) and (ii) as trade policies and to (iii) as industrial policy. Negative values of τ_{et}^m and τ_{et}^x denote subsidies, while negative values of τ_{et}^y denote sales taxes. To simplify the analysis, we restrict attention to one-time transitory changes to these policy instruments, which become active during the pandemic and revert back to zero (their steady-state values) after the pandemic ends in period 13.

We assume the government's budget constraint is balanced every period. Our setup allows for multiple ways to distribute the revenues and costs of these instruments across worker-entrepreneurs. As in Itskhoki and Moll (2019), we do not allow the government to use them to transfer resources directly across agents, so that the policies we find are not driven by direct redistribution. In particular, we assume that (i) revenues from import tariffs on essential goods are rebated back to agents in proportion to the share of total imports consumed (that is, $\psi_{iet}^m = q_{it}^m / \sum_k q_{kt}^m$), (ii) revenues from export taxes on essential goods are rebated back to the worker-entrepreneurs who produce essential goods (that is, $\psi_{eet}^x = 1$ and $\psi_{net}^x = 0$), and (iii) subsidies on the production of essential goods are financed by the worker-entrepreneurs who produce essential goods ($\psi_{eet}^y = 1$ and $\psi_{net}^y = 0$). These

²⁶We keep all non-essential policies equal to zero throughout.

assumptions prevent the government, for instance, from taxing the firm owned by agent e to rebate the revenues to agent n . As a result, policies affect welfare only through their effects on prices and allocations.

Finally, we focus on a standard utilitarian government objective function whose value in period t consists of the population-weighted average between the value functions V_{nt} and V_{et} of agents n and e , respectively, from period t onward. That is, the government's objective is given by:

$$\mathcal{V}_t = \lambda_n V_{nt} + \lambda_e V_{et},$$

where λ_n and λ_e denote the respective population shares of each type, as in the planner's problem in Section 4.

The government's problem consists of choosing policies $(\tau_e^m, \tau_e^x, \tau_e^y)$ throughout the pandemic to maximize its objective function starting from the period in which the shocks are first realized (period 1):

$$\max_{\tau_e^m, \tau_e^x, \tau_e^y} \mathcal{V}_1(\tau_e^m, \tau_e^x, \tau_e^y).$$

To isolate the role of the distortions discussed in Section 4 on the welfare-maximizing policies, we abstract from terms-of-trade effects by removing markup distortions due to monopolistic competition. We do so by introducing a constant domestic sales subsidy as in Gali and Monacelli (2005). As we show in the Appendix, this implies that the welfare-maximizing policies in the pre-shock steady state are all zero. Policies are determined and set in period 1, and remain unchanged thereafter until the end of the pandemic—i.e., we assume full commitment.

6.3 Welfare-maximizing Policies

We solve the government's problem under each policy class in isolation—(i) trade policy and (ii) industrial policy—and then (iii) under trade and industrial policies jointly.²⁷ Table 6 reports welfare-maximizing policies within each restricted instrument set.

Trade Policy The first row of Table 6 shows that when constrained to trade policy instruments, the welfare-maximizing trade policy consists of a 14.45% export tax on essential

²⁷To solve the government's problem under each restricted set of instruments, we set the remaining instruments to zero.

goods, alongside a 9.54% import subsidy. This policy mix serves two complementary goals: the export tax reallocates essential goods toward domestic consumers during the pandemic, while the import subsidy offsets the resulting shift away from imported varieties by lowering their price as well.

The export tax directly lowers the domestic price of essential goods relative to the world price. Since firms are price takers in international markets, the export tax reduces the revenue they receive from foreign sales, increasing the attractiveness of selling domestically. As a result, firms reallocate goods toward the domestic market, increasing domestic sales and reducing prices. The resulting domestic price of essential goods is given by:

$$p_{et}^d = \frac{\sigma}{\sigma - 1} \cdot \frac{(1 + \tau_{et}^y - \tau_{et}^x)p_{et}^x}{(1 + \tau_{et}^y)},$$

where τ_{et}^x is the export tax and τ_{et}^y is the production subsidy (which is zero when restricting to trade policy instruments). A higher export tax τ_{et}^x lowers the numerator, thus reducing p_{et}^d , and raising domestic absorption of essential goods.

However, this intervention creates a secondary distortion: by lowering domestic prices, the export tax shifts consumption toward domestically produced essential goods and away from imported varieties, distorting the efficient allocation across sources. To offset this imbalance, the government introduces an import subsidy, which lowers the relative price of foreign varieties and restores the efficient composition of essential goods consumption. The role of the import subsidy is captured by the following optimality condition:

$$\frac{(1 + \tau_{et}^m)\tau_e}{\frac{\sigma}{\sigma - 1} \cdot \frac{(1 + \tau_{et}^y - \tau_{et}^x)}{(1 + \tau_{et}^y)}} \cdot \frac{p_{et}^m}{p_{et}^x} = \left(\frac{1 - \omega_e}{\omega_e} \right)^{\frac{1}{\sigma}} \cdot \frac{q_{et}^{m^{-1/\sigma}}}{q_{et}^{d^{-1/\sigma}}},$$

which equates the marginal utility-adjusted cost of imported and domestic essential goods. The import subsidy (negative τ_{et}^m) ensures that agents do not substitute too strongly toward domestic varieties.

Industrial Policy The second row of Table 6 shows that, when restricted to industrial policy, the welfare-maximizing industrial policy consists of an 11.71% ad-valorem subsidy on the total sales of essential goods. This policy is designed to offset the contraction in investment caused by agents' excessive discounting of future returns.

In the model, worker-entrepreneurs face a leverage-dependent borrowing premium that

distorts their intertemporal choices, reducing the effective value they place on future consumption and returns to investment. As a result, they underinvest in capital and labor, relative to the socially efficient allocations. The production subsidy partially mitigates this by raising the marginal revenue product of inputs and thus restoring investment and production incentives. Formally, the subsidy enters the optimality conditions for capital and labor:

$$\begin{aligned}
m_{e,t+1} & \left[(1 + \tau_{e,t+1}^y - \tau_{e,t+1}^x) p_{e,t+1}^x (1 - \alpha) \eta A_e \frac{(\ell_{e,t+1}^\alpha k_{e,t+1}^{1-\alpha})^\eta}{k_{e,t+1}} + \Omega_{n,t+1}^m (1 - \delta) \right] \\
& + m_{e,t+1} \frac{b_{e,t+2}}{(1 + r^*) \Gamma(L_{e,t+1})} \frac{\psi L_{e,t+1}}{k_{e,t+1}} = \Omega_{n,t}^m, \\
(1 + \tau_{e,t}^y - \tau_{e,t}^x) p_{e,t}^x A_e \alpha \eta (\ell_{e,t}^\alpha k_{e,t}^{1-\alpha})^{\eta-1} \ell_{e,t}^{\alpha-1} k_{e,t}^{1-\alpha} & = w_t.
\end{aligned}$$

The sales subsidy τ_{et}^y raises the price received by producers, boosting the marginal benefit of labor and capital inputs and encouraging firms to scale up production. The second term in the capital condition is the leverage value of capital discussed in Section 4, which is unaffected by the subsidy. The subsidy therefore operates by raising the direct return to capital, partially offsetting the lower value that the producer assigns to future returns.

However, the increase in production does not automatically lead to higher domestic consumption. Because essential goods are traded in international markets at exogenous world prices, a share of the additional output is exported. In the absence of complementary trade policy instruments that reallocate sales toward domestic consumers, the gains from increased production primarily accrue to foreign consumers. As a result, industrial policy has limited capacity to alleviate domestic shortages, even though it addresses the underlying production-side inefficiency.

Joint Trade and Industrial Policy The third row of Table 6 reports the welfare-maximizing policy when trade and industrial policy instruments are available jointly. The government combines an export tax, an import subsidy, and a production subsidy. We find that these instruments are complementary: each is used more intensively when the others are available, with the export tax rising from 14.45% to 25.18%, the import subsidy from 9.54% to 18.66%, and the production subsidy from 11.71% to 28.66%. The export tax redirects essential goods toward domestic consumers, the production subsidy strengthens firms' incentives to expand output, and the import subsidy offsets the distortion in the composition

Table 6: Welfare-maximizing policies following shocks

	Export tax	Import tariff	Sales subsidy	Welfare gain
Trade policy	14.45%	−9.54%	—	0.267%
Industrial policy	—	—	11.71%	0.088%
Joint policy	25.18%	−18.66%	28.66%	0.777%

of domestic absorption induced by the export tax.

This complementarity is important because neither policy class addresses both margins on its own. Trade policy directly improves domestic availability but weakens production incentives by lowering the domestic price received by firms. Industrial policy raises output but, absent trade intervention, much of the additional supply is exported. Used jointly, trade and industrial policies can therefore increase domestic consumption of essential goods while avoiding the contraction in production associated with trade policy alone.

Our findings raise questions about the impact of these policies and the channels that account for the welfare-maximizing response to shortages of critical goods. To address these questions, we first examine the welfare gains from trade and industrial policies. Then, we investigate their impact on equilibrium outcomes. In the Appendix we study the role played by various features of the model in accounting for our findings.²⁸

6.4 Welfare gains

The welfare gains reported in Table 6 measure the improvement in lifetime welfare delivered by each set of policy instruments, expressed in consumption-equivalent units. For each set of instruments, we compare the government’s objective in period 1, which reflects lifetime utility from that period onward, under the welfare-maximizing policy and in the economy without policy interventions. To express the difference in consumption units, we ask: what uniform percentage increase in every agent’s consumption, applied only during the twelve months of the shock, would make the government indifferent between the two economies?

²⁸In the Appendix we show that countries more dependent on trade for essential goods, that is, those running trade deficits prior to the pandemic, were more likely to adopt trade policies during COVID-19.

That is, we solve for the value of χ that satisfies

$$\sum_{i \in \{n, e\}} \lambda_i \left[\sum_{t=1}^{12} \beta^{t-1} u((1 + \chi)c_{it}^0) + \sum_{t=13}^{\infty} \beta^{t-1} u(c_{it}^0) \right] = \mathcal{V}_1^{\text{policy}},$$

where c_{it}^0 denotes consumption in the economy without policy interventions and $\mathcal{V}_1^{\text{policy}}$ is the value of the government's objective under the welfare-maximizing policy.²⁹

We find that the welfare gain from trade policy is 0.267% in consumption-equivalent units. That is, agents in an economy without policy changes would need their consumption bundle to rise by 0.267% each period for the duration of the shocks to be indifferent to living in the economy that implements the welfare-maximizing trade policies during the pandemic.

The welfare gain from industrial policy is smaller, at 0.088%. This ranking highlights the importance of addressing the shortage directly—by reallocating essential goods toward domestic consumers through export taxes—rather than only boosting production through sales subsidies. Industrial policy raises output, but much of the additional supply is exported.

The welfare gain from the joint policy is 0.777%, more than twice the sum of the gains from trade policy and industrial policy alone. This reflects the complementarity between the two policy classes discussed above: the production subsidy offsets the adverse effect of the export tax on production incentives, allowing the government to redirect essential goods toward domestic users more aggressively.

6.5 Dynamics under welfare-maximizing policies

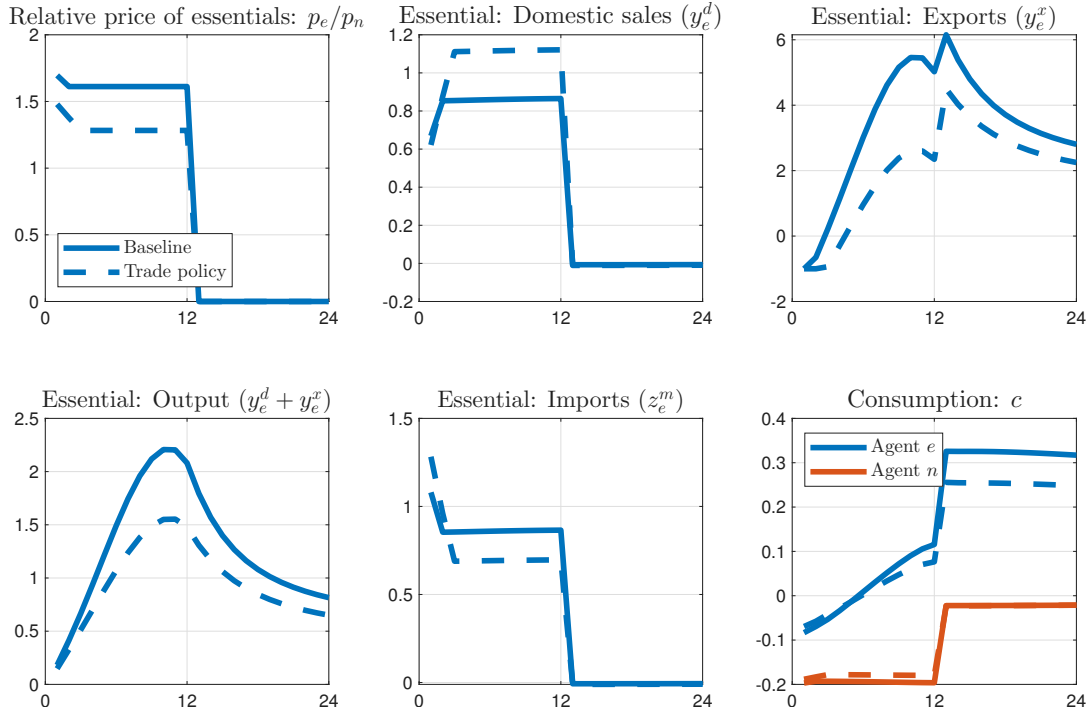
Next, we investigate the impact of the welfare-maximizing policies on the equilibrium dynamics following the shocks. To do so, we contrast the impulse response functions for key variables of the model with vs. without the optimal policy interventions.

Trade policy We begin with the impact of the welfare-maximizing trade policy interventions, presented in Figure 6. We find that the welfare-maximizing trade policy allows agents to increase their consumption of essential goods throughout the duration of the shocks relative to the economy without trade policy changes.

The tax on exports leads firms to lower the domestic price of essential goods. While this discourages production of essential goods, slowing down the increase of output, it leads to

²⁹Because the compensating consumption change is concentrated in the twelve months of the shock, rather than spread over the entire horizon, this metric is considerably larger than a conventional consumption equivalent applied in every period. For small gains, the two differ by roughly the ratio of the effective horizon, $1/(1 - \beta)$, to the twelve-month duration of the shock.

Figure 6: Dynamics under welfare-maximizing trade policy



Note: The x -axes denote time periods (months). The y -axes are expressed as percent deviations from steady state. Specifically, percent changes are obtained by multiplying the values in the panel by 100.

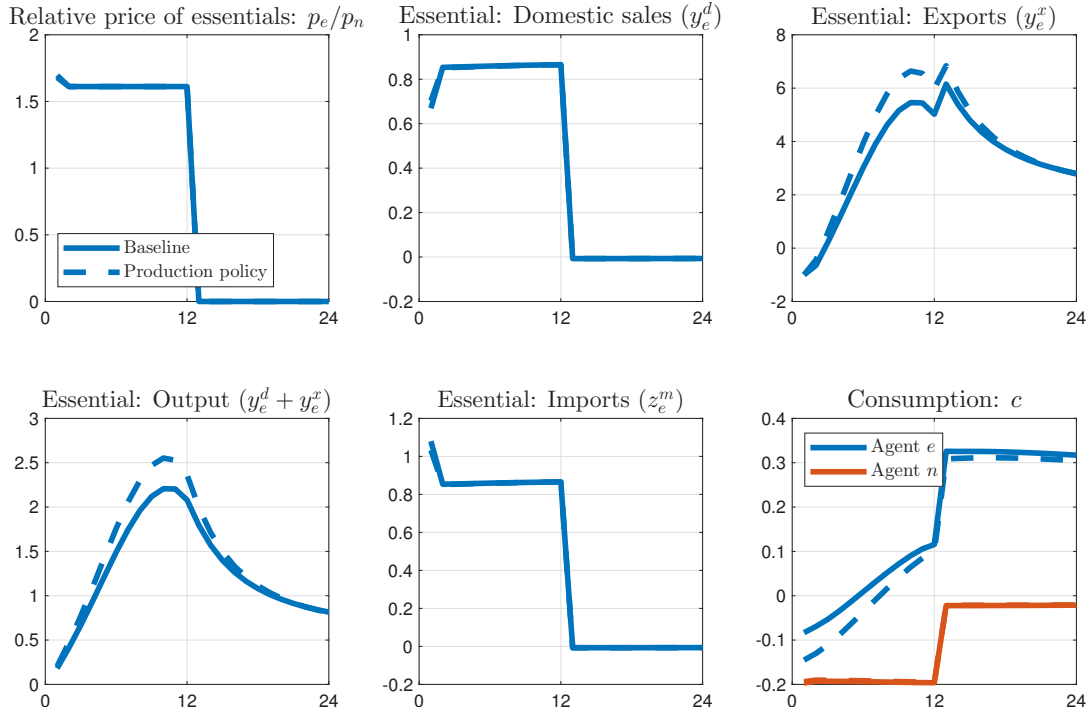
a reallocation of sales from exports to domestic consumers. Thus, domestic sales increase relatively more than under the baseline, while exports decline substantially. Optimal export taxes therefore result from balancing two conflicting forces: they reduce the incentives to produce essential goods, but they also increase domestic access to such goods.

The lower price of domestic varieties due to the export tax also reallocates consumption of essential goods from imported to domestic varieties. The government finds it optimal to offset this reallocation by introducing an import subsidy.³⁰ This allows agents to purchase imports of essential goods at a lower price, limiting the decline in imports induced by the export tax. Together, export taxes and import subsidies increase total consumption of essential goods, mitigating the negative impact of the increase in the reference level $\bar{e}$.

Industrial policy We now examine the impact of the welfare-maximizing industrial policy, presented in Figure 7. In contrast to the welfare-maximizing trade policy, industrial policy leads to an increase in the production of essential goods. This is intuitive, since subsidizing sales raises the effective return to producing them, leading producers of essential goods to

³⁰In the Appendix, we show that there is no role for import subsidies when introduced in isolation.

Figure 7: Dynamics under welfare-maximizing industrial policy



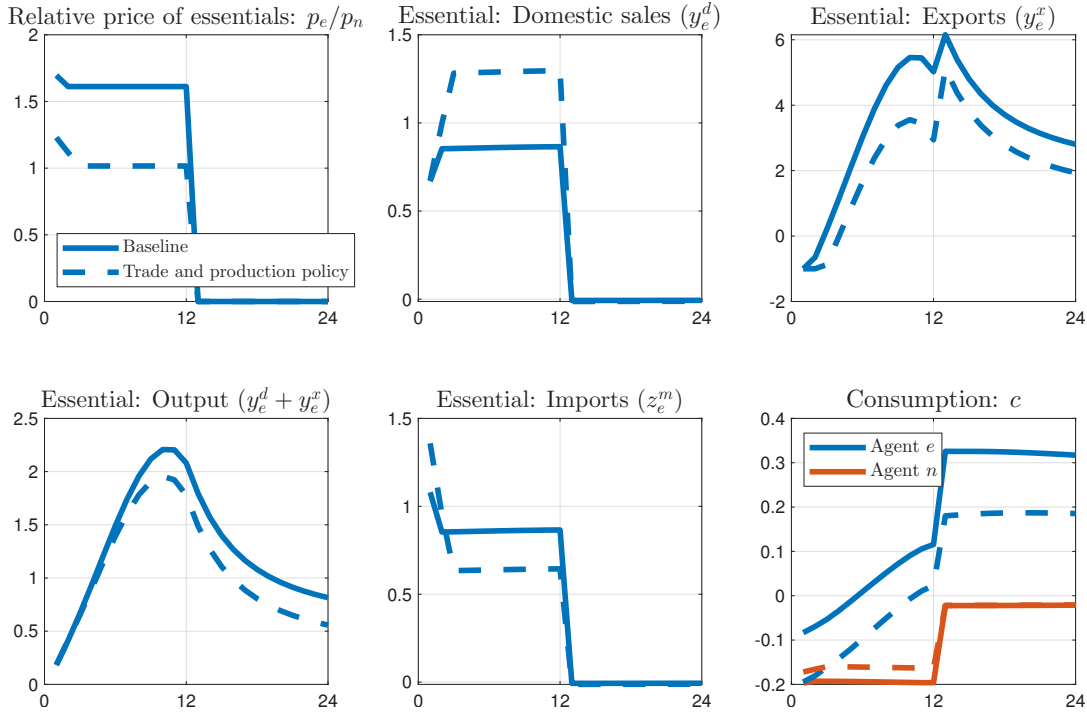
Note: The x -axes denote time periods (months). The y -axes are expressed as percent deviations from steady state. Specifically, percent changes are obtained by multiplying the values in the panel by 100.

increase their accumulation of physical capital and labor. Yet, we find that industrial policy is not effective at increasing the consumption of essential goods relative to the reference level, despite the increased production.

The missing link between increased production and consumption is accounted for by international trade: industrial policy is effective at encouraging firms to increase production of essential goods, but the increased output is primarily exported rather than sold domestically. Given that the price of essential goods is determined internationally, it largely pins down the level of domestic demand, leading most additional output to be sold internationally.

Joint trade and industrial policy Figure 8 presents the dynamics under the welfare-maximizing joint policy. The larger export tax lowers the domestic price of essential goods by more than under trade policy alone, leading to a stronger reallocation of sales from exports toward domestic consumers. Imports of essential goods fall relative to the no-policy economy as households substitute toward cheaper domestic varieties, but the import subsidy limits this decline. The production subsidy, in turn, offsets much of the adverse effect of the export tax on production incentives: whereas output falls substantially below its no-policy

Figure 8: Dynamics under welfare-maximizing joint trade and industrial policy



Note: The x -axes denote time periods (months). The y -axes are expressed as percent deviations from steady state. Specifically, percent changes are obtained by multiplying the values in the panel by 100.

path under trade policy alone, it remains close to that path under the joint policy. The joint policy therefore delivers a larger reallocation toward domestic consumers while largely preserving the economy's production response, which accounts for its substantially larger welfare gains.

6.6 Efficiency vs. redistribution

We now examine the relative importance of efficiency and redistributive considerations in accounting for our policy findings. The policies we study operate through firms' production and sales decisions rather than through direct transfers across households. Nevertheless, they can raise social welfare through two channels: by increasing the aggregate amount of goods consumed domestically, an efficiency consideration, or by changing the distribution of consumption across households, a redistributive consideration.

To decompose the relative importance of these motives, we follow Benabou (2002) and Boar and Midrigan (2022). Their approach specifies an alternative social welfare function that nests the standard utilitarian objective, but is parameterized to span objectives ranging from pure efficiency to a Rawlsian criterion. In particular, for each household type $i \in \{n, e\}$,

we solve for the value ω_{it} that satisfies

$$\sum_{k=0}^{\infty} \beta^k \frac{\omega_{it}^{1-\xi}}{1-\xi} = V_{it},$$

where ω_{it} is the constant level of consumption that generates the same lifetime utility from period t onward as the equilibrium consumption path underlying value function V_{it} . Thus, ω_{it} expresses the equilibrium welfare of household i in consumption units.

Given a constant $\Delta \geq 0$, we define an alternative government objective that aggregates the household-specific welfare levels ω_{it} :

$$\tilde{\mathcal{V}}_t = \left(\sum_{i \in \{n,e\}} \lambda_i \omega_{it}^{1-\Delta} \right)^{\frac{1}{1-\Delta}},$$

where λ_i weights each household type's welfare by its population share. If $\Delta = \xi$, then $\tilde{\mathcal{V}}_t$ is a strictly increasing transformation of the baseline utilitarian objective $\mathcal{V}_t = \sum_i \lambda_i V_{it}$ and yields the same policy ranking and consumption-equivalent welfare gains. If $\Delta > \xi$, the alternative objective features a stronger redistributive motive than the utilitarian objective; as $\Delta \rightarrow \infty$, it approaches a Rawlsian objective that places all weight on the worst-off household. Conversely, if $\Delta < \xi$, the alternative objective places relatively greater weight on efficiency. At $\Delta = 0$, it becomes the population-weighted average of consumption-equivalent welfare, $\sum_i \lambda_i \omega_{it}$, which we refer to as the pure-efficiency objective.

To evaluate the importance of efficiency vs. redistribution in accounting for our findings, we recompute the joint policy analysis under the pure-efficiency objective ($\Delta = 0$), retaining the baseline calibration, shocks, policy duration, and fiscal arrangements. We report the results in Table 7. The qualitative role for policy intervention is independent of the redistributive motive: when the government's objective restricts attention to efficiency, the welfare-maximizing trade and industrial policies have the same signs as in the baseline. The pure-efficiency objective calls for an export tax of 16.78%, an import subsidy of 12.16%, and a total sales subsidy of 19.48%. These interventions are approximately two-thirds of the corresponding baseline rates. Thus, efficiency considerations account for a substantial part of the policy interventions that we find, while redistributive considerations strengthen their magnitudes.

Table 7: Welfare-maximizing policy, efficiency vs. redistribution

	Export tax	Import tariff	Total sales subsidy
Pure efficiency ($\Delta = 0$)	16.78%	-12.16%	19.48%
Baseline ($\Delta = \xi$)	25.18%	-18.66%	28.66%

Note: Each row reports the policy rates chosen jointly under the indicated social objective. A negative import tariff denotes an import subsidy. Both cases use the same calibration, shocks, twelve-month policy duration, and fiscal arrangements.

Key ingredients Finally, in the Appendix we explore the key economic mechanisms that underpin our policy findings by conducting a series of counterfactual exercises. We find that the leverage-dependent borrowing premium and worker-entrepreneur heterogeneity are central to our findings. The strength of intra- and inter-temporal complementarities also plays a crucial role: when essential and non-essential goods are more substitutable, or when agents can more easily shift consumption intertemporally, the need for policy interventions diminishes. Additionally, sectoral adjustment costs affect the magnitude of the welfare-maximizing policies, as higher frictions in scaling production amplify the role for government interventions.

7 Financial policies

We now turn to policies that target the financial friction directly. Because the inefficiencies identified in Section 4 originate in the leverage-dependent borrowing premium, a natural question is whether improving the financing conditions of essential producers necessarily delivers large welfare gains. The model does not point to a unique financial instrument: the premium can be mitigated by providing funds at the world interest rate, by subsidizing the cost of private borrowing, or by guaranteeing part of the firm’s debt. We therefore compare three interventions that capture these alternatives: public co-financing, an interest-rate subsidy, and a credit guarantee. We first describe these interventions and evaluate their welfare effects. We then relate them to the U.S. experience during COVID-19, documenting the tightening of private financing conditions at the onset of the pandemic and the financial support measures adopted in response.

7.1 Alternative Financial Policies

Let B_{et} denote the face value of essential producers’ borrowing, $R_t = 1 + r^*$ the gross world interest rate, and $\Gamma(L_{et})$ the leverage-dependent borrowing premium. Without policy

interventions, a promise to repay B_{et} delivers

$$F_{et} = \frac{B_{et}}{R_t \Gamma(L_{et})}$$

units of funds today. Each intervention improves this financing tradeoff, but the source of the improvement differs across policies.

Public co-financing. The first intervention improves the financing tradeoff by supplying outside funds at the world interest rate. The government borrows abroad at the world rate and lends a share ϕ_t of the producer's debt, while private lenders finance the rest at the leverage-dependent rate. The producer receives

$$F_{et}^P = \frac{(1 - \phi_t)B_{et}}{R_t \Gamma(L_{et})} + \frac{\phi_t B_{et}}{R_t}.$$

The public loan is matched by a foreign liability, which the producer's repayment services, so the policy requires no contemporaneous lump-sum tax. We abstract from default, administrative costs, sovereign spreads, and limits on public borrowing.

Interest-rate subsidy. The second intervention instead lowers the cost of private borrowing. The government subsidizes a share s_t of the net interest cost on all essential-sector debt, so the producer receives

$$F_{et}^I = \frac{B_{et}}{1 + [R_t \Gamma(L_{et}) - 1](1 - s_t)}.$$

The government recovers the fiscal cost through a contemporaneous lump-sum tax on the essential worker-entrepreneur,

$$\mathcal{T}_{et}^I = F_{et}^I - \frac{B_{et}}{R_t \Gamma(L_{et})},$$

which the worker-entrepreneur takes as given when choosing how much to borrow. The subsidy therefore changes its marginal borrowing incentives without adding to its resources.

Credit guarantee. The third intervention subsidizes borrowing by guaranteeing part of the firm's debt. The government guarantees a share g_t of current essential-sector borrowing, so that lenders fund the guaranteed tranche at the world rate while the rest remains subject

Table 8: Welfare gains from alternative financial policies

	Common policy rate			Welfare-maximizing	
	10%	25%	50%	Rate	Welfare gain
Public co-financing	0.025%	0.074%	0.216%	95%*	2.533%
Interest-rate subsidy	0.002%	-0.008%	-0.143%	9.08%	0.002%
Credit guarantee	0.002%	-0.007%	-0.128%	9.55%	0.002%

Note: Entries are population-weighted consumption-equivalent welfare gains relative to the no-policy economy, computed as in Table 6. Policies are constant during the twelve months of the shock and zero thereafter. *For public co-financing, the rate is a near-full-financing benchmark rather than an interior optimum.

to the leverage-dependent premium. The producer receives

$$F_{et}^G = \frac{(1 - g_t)B_{et}}{R_t\Gamma(L_{et})} + \frac{g_t B_{et}}{R_t}.$$

Because the model has no explicit default, the guarantee acts as a subsidy that eliminates the premium on the guaranteed tranche. The government finances this subsidy through a contemporaneous lump-sum tax on the essential worker-entrepreneur equal to the funding advantage,

$$\mathcal{T}_{et}^G = \frac{g_t B_{et}}{R_t} - \frac{g_t B_{et}}{R_t\Gamma(L_{et})}.$$

When $g_t = \phi_t$, the credit guarantee and public co-financing give the producer the same financing schedule. They differ in how the improvement is funded: public co-financing supplies foreign funds through the public balance sheet, whereas the credit guarantee is financed by the worker-entrepreneur that operates the firm.

7.2 Welfare effects

We evaluate each intervention at common policy rates of 10, 25, and 50 percent, as well as at their welfare-maximizing rate. As in Section 6, each policy is constant during the twelve months of the shock and zero thereafter, with all trade and industrial policies set to zero. Table 8 reports the resulting consumption-equivalent welfare gains relative to the no-policy economy.

The design of financial support matters for its welfare effects. Under public co-financing, welfare gains increase with the public share, from 0.025% at a 10 percent share to 0.216% at a

50 percent share, and reach 2.533% at a near-full-financing share of 95%.³¹ Since we abstract from default, sovereign spreads, and administrative costs, this gain should be interpreted as an upper bound. By contrast, the interest-rate subsidy and the credit guarantee deliver small gains at low rates and losses at higher ones. Their welfare-maximizing rates are 9.08% and 9.55%, respectively, and both deliver gains of only 0.002%.

These differences reflect how each policy is funded. At a common rate, public co-financing and the credit guarantee give the producer the same financing schedule and generate nearly identical firm-side dynamics, as we show in the Appendix. Public co-financing, however, supplies foreign funds at the world interest rate, whereas the interest-rate subsidy and the credit guarantee are financed by the same worker-entrepreneur that operates the constrained firm. These two policies therefore improve its marginal borrowing incentives without expanding its resources. Public co-financing instead effectively removes the financial friction for the share of debt that the government finances. This requires the government to borrow abroad on the producer's behalf at the world interest rate and to secure repayment in a way that private lenders cannot, a capacity that governments may not have in practice. The interest-rate subsidy and the credit guarantee, by contrast, operate through standard tax and subsidy instruments. In our environment, access to outside funds can thus be much more effective than a reduction in the firm's perceived cost of borrowing, but it relies on the government's ability to circumvent the friction itself.

7.3 U.S. Evidence on Financial Conditions and Policy Responses

We conclude this section by relating our analysis to the U.S. experience during COVID-19. In our model, expanding the production of essential goods requires external finance, and the cost of this finance rises as producers borrow more. In the episode we study, this mechanism operated against the backdrop of a sharp tightening in private financing conditions. In addition to the trade and industrial policies documented in Section 2, governments responded with financial support measures closely related to the instruments analyzed above, such as public lending, interest payment subsidies, and loan guarantees. We document these two patterns below. This evidence is not intended to identify the financial friction in our model or a causal effect of financing conditions on policy adoption; rather, it shows that the financing margin we study was relevant during the pandemic and that governments actively intervened

³¹Full public financing is equivalent to removing the essential producer's borrowing premium during the policy window. We report a near-full-financing share of 95%, since the premium is needed to keep borrowing well-defined, as in Schmitt-Grohé and Uribe (2003).

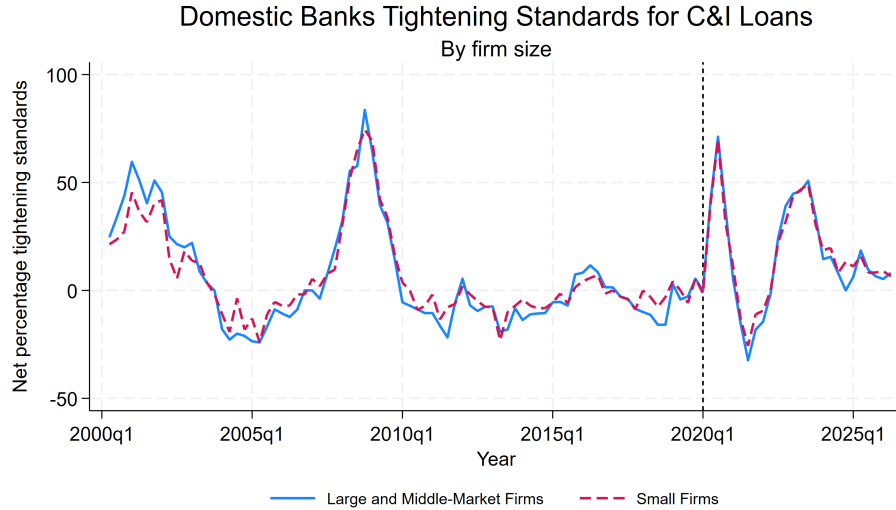


Figure 9: Domestic banks tightening standards for commercial and industrial loans by firm size. Positive values indicate a net increase in the fraction of banks reporting tighter lending standards.

on it.

Financial conditions. We consider two complementary indicators of private financing conditions: bank lending standards, which capture changes in the supply of bank credit, and corporate bond spreads, which reflect the cost of borrowing in capital markets. Figure 9 reports the net percentage of domestic banks reporting tighter standards for commercial and industrial (C&I) loans to large and middle-market firms and to small firms. Positive values indicate that more banks tightened lending standards than eased them. While lending standards fluctuate over time, the figure shows an abrupt increase at the onset of the pandemic for both large and small firms, indicating that banks became considerably more restrictive in extending credit.

Figure 10 reports the spread between corporate bond yields and the 10-year Treasury yield for Aaa- and Baa-rated corporate debt, which measures the additional compensation investors require to hold private debt relative to a safe asset. Corporate spreads increased sharply at the onset of the pandemic, particularly for lower-rated Baa debt, consistent with financial frictions disproportionately affecting riskier borrowers.

Together, these indicators point to a broad tightening in private financing conditions during the pandemic. Neither measure directly observes whether firms were credit constrained, but both indicate that obtaining external finance became more costly and more difficult.

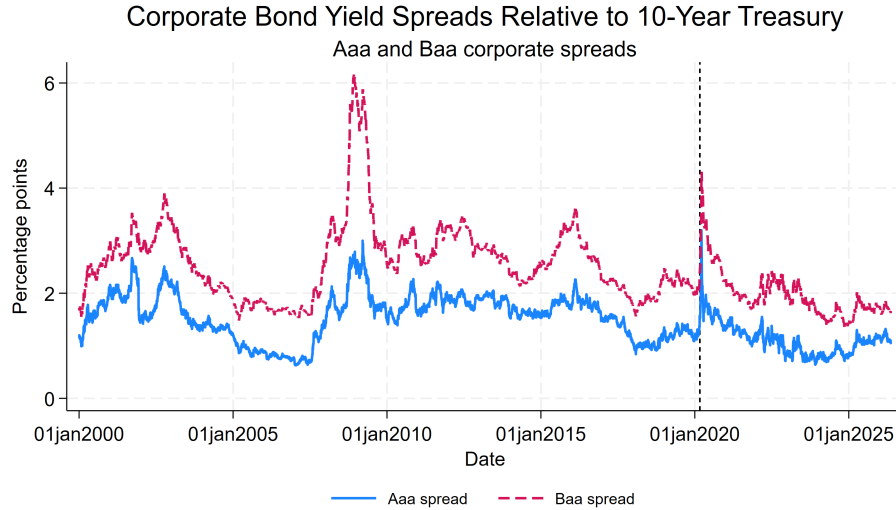


Figure 10: Corporate bond yield spreads relative to the 10-year Treasury yield for Aaa and Baa debt. Higher spreads indicate tighter financing conditions and higher perceived risk in corporate debt markets.

This tightening applied to private borrowers rather than to governments, which typically retain access to relatively safe financing instruments.

Financial policy responses. To examine whether governments responded with policies aimed at alleviating firms’ financing constraints, we use data from the Global Trade Alert New Industrial Policy Observatory (GTA–NIPO), which tracks government interventions affecting production and trade. We focus on financial interventions implemented by the United States, including trade finance programs, state loans, financial grants, loan guarantees, and capital injections. Unlike aggregate fiscal expenditures, these are targeted instruments that affect firms’ financing and production decisions.

Figure 11 reports the number of new financial interventions over time. Intervention activity increases sharply at the onset of the pandemic, after a period in which most categories remain relatively stable at low levels. The increase is concentrated in instruments associated with liquidity provision and financing support, particularly financial grants and state loans, and its timing coincides closely with the tightening in private financing conditions documented in Figures 9 and 10.

While this evidence does not establish a causal relationship, it is consistent with governments expanding financial support when private credit became more costly and more difficult to obtain. In this sense, financial policies complemented trade and industrial policies during

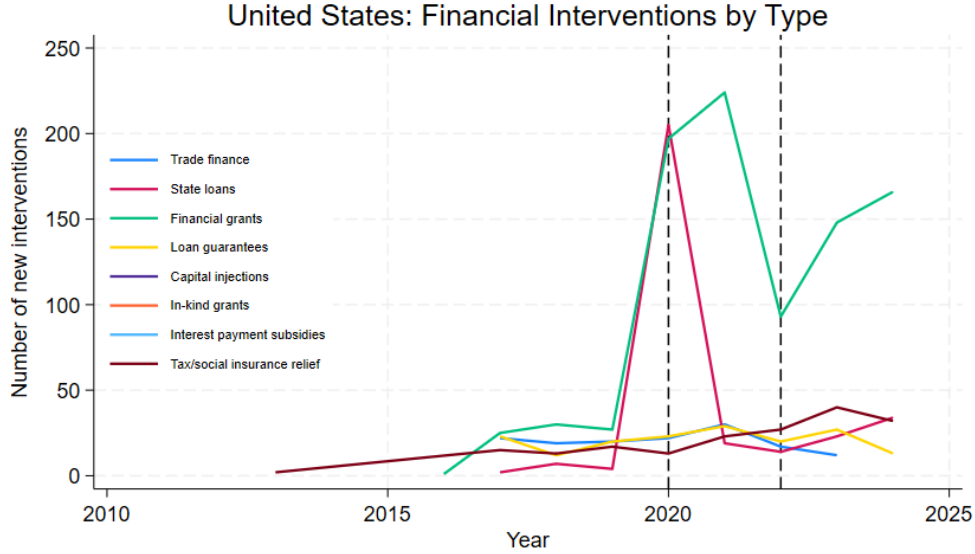


Figure 11: United States financial interventions by type. The figure reports the number of new financial interventions recorded in GTA–NIPO. Vertical lines indicate 2020 and 2022.

the pandemic: both were used to sustain production during a period of severe disruption, but they operated through different margins.

8 Concluding remarks

This paper studies how trade and industrial policies can mitigate shortages of critical goods in an open economy with financial frictions. We develop a dynamic model in which leverage-dependent borrowing premia and concentrated firm ownership distort investment decisions, limiting producers’ ability to respond to increases in global demand.

Our quantitative analysis, calibrated to the U.S. experience during COVID-19, shows that trade and industrial policies can improve welfare by addressing complementary margins of adjustment. Export taxes redirect supply toward domestic consumers but weaken production incentives, while production subsidies encourage output expansion without necessarily increasing domestic availability. Combining these instruments with import subsidies generates substantially larger welfare gains than implementing them separately.

We also show that financial policies targeting the underlying borrowing friction can improve welfare, but their effectiveness depends critically on policy design and financing arrangements. These findings highlight the importance of considering production incentives, domestic availability, and fiscal incidence jointly when evaluating policy responses to shortages of critical goods.

Our analysis focuses on interventions after shortages occur. An important direction for future research is to study how ex-ante policies, including strategic inventories, investment incentives, and international coordination, interact with ex-post interventions in economies exposed to disruptions in critical goods markets.

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