

# Decoupling Global Value Chains\*

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## Abstract

Major disruptions to global value chains (GVCs) caused by the Covid-19 pandemic have raised an important question: Can decoupling from GVCs increase a country's welfare by reducing its exposure to foreign shocks? We use a quantitative trade model to simulate various decoupling scenarios and their consequences for international shock transmission. Across all of these scenarios, we find that the large welfare losses from decoupling far exceed any benefits due to lower shock exposure. In case of the U.S., a unilateral repatriation of GVCs would reduce national welfare by 2.2% but barely change U.S. exposure to foreign shocks.

*JEL codes:* F11, F12, F14, F17, F62.

*Keywords:* Quantitative trade model, input-output linkages, global value chains, Covid-19, supply chain contagion, shock transmission.

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# 1 INTRODUCTION

The Covid-19 pandemic has hit the world economy at a critical inflection point. Since the global financial crisis, the growth in international trade and global value chains (GVCs) has slowed down drastically (Antràs, 2020). This retreat from global economic integration—labeled ‘slowbalisation’ by The Economist (2019)—has been aggravated by the recent political backlash against globalization, culminating in Brexit and the U.S.–China trade war (Irwin, 2020a). The Covid-19 pandemic has added further momentum to this ongoing trend by providing a new rationale for protectionism. As firms around the world are suffering shortages of intermediate inputs from abroad, it may seem natural to ask: Would countries be better off by ‘decoupling’ from GVCs (and relying on domestic inputs instead) to reduce their exposure to foreign shocks?<sup>1</sup>

The response to this question provided by a range of politicians is clear-cut: ‘decoupling’, ‘repatriation’, or ‘reshoring’ of GVCs has been advocated in many countries (see, e.g., Farage, 2020; Trump, 2020).<sup>2</sup> However, the scientific answer is less obvious, as it involves two types of counterfactual analyses. First, one needs to know whether an adverse foreign shock would have had a smaller impact on a given country, had this country been less reliant on foreign inputs before the shock. Second, even if the response is affirmative, one still needs to answer another, frequently neglected question: What would be the direct costs to this country of decoupling from GVCs in the first place? It is only by weighing these costs and benefits that one can evaluate the net welfare effect of decoupling in the presence of foreign shocks.

Our paper contributes to this debate by providing model-based quantifications of both the losses from decoupling itself and its consequences for international shock transmission. To simulate the decoupling from GVCs, we shut down trade in intermediate goods, but not in final goods. We implement two main variants of this analysis: (i) a decoupling between *all* countries, resulting in a hypothetical world without GVCs; and (ii) a *unilateral* decoupling of individual countries, with a particular focus on the U.S. We then quantify the global repercussions of a major negative supply shock in one country via international trade and GVCs. Given the importance of China as a pivotal hub in GVCs, we focus on the *initial* Covid-19 shock in China in January–February

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<sup>1</sup>While GVCs disruptions have been occurring before the pandemic (e.g., in the wake of the Fukushima disaster), the unrivaled scale of the ‘supply chain contagion’ due to Covid-19 is causing, more than ever, a worldwide reconsideration of reliance on GVCs (cf. Baldwin and Evenett, 2020; Baldwin and Tomiura, 2020; Irwin, 2020b).

<sup>2</sup>The Trump administration had been pursuing this trade policy agenda even prior to the pandemic by disproportionately targeting imports of intermediate goods that are part of U.S. GVCs, in particular the ones involving China (cf. Lovely and Liang, 2018; Bown and Zhang, 2019; Grossman and Helpman, 2021).

2020, i.e., before the epidemic turned into a pandemic.<sup>3</sup> To isolate the role of GVCs, we simulate the impact of the Covid-19 shock in China on all other countries both before and after decoupling. In our analysis of shock transmission after unilateral decoupling, we provide an answer to the policy-relevant question of whether the direct welfare losses due to decoupling can be justified by the reduced exposure to the Covid-19 shock in China. Finally, we examine generally whether unilateral decoupling can be beneficial to *any single country* by shielding it against adverse foreign shocks in *all other countries*. Across all of these scenarios, we consistently find that the losses from decoupling far exceed any mitigation effects, that is, any reductions in negative spillovers. Thus, the model clearly predicts that no country can gainfully increase resilience to foreign shocks by decoupling from GVCs.

The framework we use for our analysis is a generalization of the quantitative Ricardian trade model by Eaton and Kortum (2002) with multiple sectors and input-output (I-O) linkages. Three key features of the model make it particularly suited for our purpose: First, it includes both domestic and international I-O linkages (as in Caliendo and Parro, 2015), and hence describes how sectors are affected directly and indirectly through GVCs. Second, it distinguishes trade costs for intermediate inputs and final goods (as in Antràs and Chor, 2018), which allows us to isolate the role of GVCs in transmitting shocks. Importantly, the shutting down of GVCs in our counterfactual analysis differs from disabling all I-O linkages (as simulated, e.g., by Caliendo and Parro, 2015) in allowing for domestic input trade; and it differs from a (gradual) return to autarky (as simulated in a similar context by Bonadio et al., 2020, and Sforza and Steininger, 2020) in allowing for final goods trade. Third, we model imperfect intersectoral mobility of labor (as in Lagakos and Waugh, 2013) to allow for the possibility that workers may not seamlessly relocate across sectors after a shock.<sup>4</sup>

Our main data source is the World Input-Output Database (WIOD, Timmer et al., 2015), which provides international I-O tables for 43 countries (and a synthetic rest of the world). We use data for 2014, the most recent year available. While these data have been a ‘go-to resource’ for studying GVCs for almost a decade (Costinot and Rodríguez-Clare, 2014), the distinct feature of this database has rarely been exploited to date: The fact that the WIOD distinguishes a given trade flow not only by country pair and sector of origin but also by the use category (i.e., final consumption

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<sup>3</sup>Between its first diagnosis in December 2019 and the end of February 2020, Covid-19 was predominantly confined to China (see Dong et al., 2020, and the discussion in Section 3.2), causing a complete or partial lockdown of most Chinese provinces. By mid-February 2020, firms around the world began experiencing disruptions of their production processes due to a lack of intermediate inputs from China; see e.g. the reports on Apple Inc. and Airbus SE in New York Times (2020) and The Economist (2020). More broadly, between February 1 and March 5, 2020, the majority of the global top 5,000 multinational enterprises (MNEs) revised their earnings forecasts for fiscal year 2020 and more than two thirds of the top 100 MNEs issued statements on the impact of Covid-19 on their business (UNCTAD, 2020).

<sup>4</sup>Similar Roy-Fréchet modelling approaches to labor markets have been applied by Burstein et al. (2019), Hsieh et al. (2019), and Galle et al. (2018).

vs. sectoral intermediate use) of the destination country.<sup>5</sup> Hence, we can use the data to pursue our strategy explained above and simulate decoupling of GVCs while leaving international trade in final goods and domestic trade in inputs unhindered.

To back out the sectoral labor supply shocks caused by the initial Covid-19 shock in China, we use Chinese administrative data. Specifically, we estimate the output drop in Chinese sectors in January–February 2020 in an event-study design using monthly time series. This estimated output drop is conceptualized as the ‘zeroth degree’ effect of the shock in China, i.e., before any response by all other countries, similar to the methodology in [Allen et al. \(2020\)](#). By inverting the model given this zeroth degree effect, we recover the underlying shocks to efficient labor supply by sector from the output drop.

In the following we preview our main findings on the effects of decoupling and global shock transmission. We begin by simulating a world without GVCs by setting the cost of international trade in intermediate goods to infinity. We find that this worldwide decoupling from GVCs causes welfare losses in all countries, ranging from -68.4% in Luxembourg to -3.3% in the U.S. The largest welfare losses accrue to small, highly integrated economies (including Malta, Ireland, and Estonia), while the losses are smallest for large economies that can revert to their own intermediate inputs after decoupling (such as the U.S., China, and Brazil). More generally, we identify a country’s participation in intermediate goods trade as a key driver of its welfare losses from GVCs decoupling. We also find that shutting down GVCs is worse than shutting down only final goods trade for all individual countries.

In our analysis of the unilateral decoupling from GVCs by the U.S., we consider two alternative scenarios: (i) the U.S. repatriates its GVCs from all countries, and (ii) it decouples only from China. In the first scenario, the U.S. loses -2.2% of domestic welfare and imposes a welfare loss on almost all other countries. Interestingly, the U.S. neighbor Canada loses even more than the U.S. itself. The picture is somewhat different if the U.S. unilaterally decouples only its GVCs from China. While welfare both in the U.S. and in China drops (by -0.12% and -0.11%, respectively), a large number of countries benefit from this policy due to trade diversion, most notably Mexico.

To shed light on the role of GVCs in international shock transmission, we consider the global repercussions of the Covid-19 shock in China. This analysis is best thought of as answering the question of how the world economy would have responded if Covid-19 had permanently reduced production in China but if infections had not spread internationally.<sup>6</sup> In the baseline world, the drastic negative supply shock in China has moderate spillovers to all other countries, with welfare

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<sup>5</sup>[Antràs and Chor \(2018\)](#) make use of this feature of the WIOD to study the differential effect of a decline in trade costs for final vs. intermediate goods in countries’ GVCs positioning over the period 1995–2011.

<sup>6</sup>Notably, the main goal of these exercises is not to explain the actual global developments during the Covid-19 crisis in 2020, but to analyze the global transmission of a major supply shock in China in a world economy that is less integrated via GVCs.

effects ranging from -1.00% in Russia to +0.28% in Turkey. We then shut down GVCs, as outlined above, and subsequently compare the shock transmission in this ‘no-GVCs’ scenario to our baseline predictions. We find that shutting down GVCs reduces the welfare loss due to the Covid-19 shock in China by 32% for the median adversely affected country, with pronounced heterogeneity across countries. Interestingly, in the world without GVCs, the welfare losses are magnified for several countries, including Germany, Japan, and France, while they are reversed for other countries. Further analyses reveal that these differences are mainly driven by a decoupling from China and less from reduced GVCs trade among all other countries. Finally, the cross-country patterns are similar when GVCs are shut down only partially, through finite (rather than infinite) intermediate goods trade barriers.

To inform the ongoing policy debate more directly, we examine how U.S. exposure to the Covid-19 shock in China would change if the shock occurred after different scenarios of U.S. decoupling. The plain answer is: not much. If the U.S. were to fully repatriate all input production (at a cost of -2.2% of domestic welfare), the negative effect of the shock in China on the U.S. would remain almost unchanged. Also policy scenarios of decoupling that are more targeted (against China) or internationally coordinated (with the EU) would lead only to a meager mitigation of U.S. welfare losses from the Covid-19 shock of 0.04 percentage points (or less). These changes clearly cannot justify the much larger direct welfare costs of decoupling to the U.S. Our findings suggest that, even if U.S. trade policy were to effectively shut down GVCs involving a specific foreign country in which a large and long-lasting shock is known to materialize, decoupling from GVCs would not be beneficial.

Our investigations of adverse shocks occurring in all foreign countries confirm and strengthen this main insight. Specifically, we consider shocks of the same magnitude as the Covid-19 shock in China hitting any country in the world. We find that no trading partner can substantially reduce its negative exposure to such shocks by decoupling from GVCs. Simulating foreign shocks and unilateral decoupling for all possible country combinations, the mitigation effects are by orders of magnitude smaller than the losses from decoupling in all cases. Moreover, even if an adverse supply shock were to hit *all other countries* in the world, still no single country could do better by unilaterally decoupling from GVCs before the shock. Hence, our findings generally negate the question of whether a country can gainfully protect itself from foreign shocks by decoupling from GVCs.

This paper adds to a growing body of literature stressing the role of input-output linkages in quantitative trade models, in the tradition of [Caliendo and Parro \(2015\)](#).<sup>7</sup> Recent work has emphasized the role of GVCs for trade policy ([Blanchard et al., 2016](#); [Grossman and Helpman, 2021](#); [Antràs et al., 2021](#)), with applications to Brexit ([Cappariello et al., 2020](#), and [Vandenbussche et al.,](#)

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<sup>7</sup>The importance of input trade has first been documented and quantified by [Hummels et al. \(2001\)](#) and [Yi \(2003\)](#).

2019), European integration (Felbermayr et al., 2020), and the WTO (Beshkar and Lashkaripour, 2020). To the best of our knowledge, our paper is the first to quantify the global welfare effects of decoupling GVCs and to isolate the role of GVCs in transmitting foreign shocks.<sup>8</sup> Our approach complements the analysis by Caliendo et al. (2018), who isolate the role of intersectoral and inter-regional trade linkages in transmitting productivity shocks within the U.S. economy. In analyzing how a shock in China affects other countries through international trade, our paper relates to the contributions by di Giovanni et al. (2014), Hsieh and Ossa (2016), Caliendo et al. (2019), and Kleinman et al. (2020), who consider international spillovers from Chinese productivity growth.

Our work also contributes to the fast growing literature studying the economic impact of the Covid-19 pandemic and proposed policy responses.<sup>9</sup> Within this literature, our paper is most closely related to the contemporaneous work by Bonadio et al. (2020) and Sforza and Steininger (2020), who consider the role of GVCs in transmitting the Covid-19 shock. These papers aim at quantifying the cross-border impact of quarantine and social distancing measures taken in many countries around the world, while we focus mainly on the initial shock in China. A unique feature of our analysis is that we specifically pin down the contribution of GVCs (as opposed to international trade in general) to the transmission of the Covid-19 shock and assess the counterfactual costs and benefits of GVCs decoupling in the presence of foreign shocks.

More broadly, our paper relates to the theoretical and empirical literature on the role of production networks in shaping economic outcomes (see Carvalho and Tahbaz-Salehi, 2019, for a review). The propagation of shocks through supply chains has been studied extensively both theoretically (see, e.g., Acemoglu et al., 2012, and Acemoglu and Tahbaz-Salehi, 2020) and empirically in the context of natural disasters (see, e.g., Barrot and Sauvagnat, 2016; Boehm et al., 2019; Carvalho et al., 2020). We complement these studies with a quantitative exercise demonstrating that, for some countries, international shock transmission can be magnified (rather than mitigated) in the absence of GVCs.

The paper is organized as follows. We present the model in Section 2. Section 3 describes the data and empirical methodology. In Section 4 we discuss our results for the decoupling of GVCs and in Section 5 we discuss our results for global shock transmission. Section 6 concludes.

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<sup>8</sup>Related contributions studying the role of input trade for international business cycle comovement include Burstein et al. (2008), Bems et al. (2010), di Giovanni and Levchenko (2010), Johnson (2014), and Huo et al. (2019).

<sup>9</sup>The macroeconomic effects of the pandemic have been assessed, e.g., by Baqaee and Farhi (2020a,b), Eichenbaum et al. (2020), Fornaro and Wolf (2020), Guerrieri et al. (2020), and McKibbin and Fernando (2020). Barrot et al. (2020), Bodenstein et al. (2020), and Inoue and Todo (2020) (among others) study the role of domestic supply chains in propagating the Covid-19 shock in a closed economy setup. Theoretical contributions on the international economics of pandemics include Antràs et al. (2020, on the interrelationship between trade and pandemics), Leibovici and Santacreu (2020, on trade in essential medical goods), and Cuñat and Zymek (2020, providing a structural gravity of people flows in the pandemic). Empirical analyses of the short-term impact of Covid-19 on trade are provided by Friedt and Zhang (2020), Meier and Pinto (2020), and Zajc Kejzar and Velic (2020).

## 2 THE MODEL

To simulate the decoupling of GVCs our model builds on [Antràs and Chor \(2018\)](#), who extend the multi-sector Eaton-Kortum model by [Caliendo and Parro \(2015\)](#) to allow for varying trade costs across intermediates and final goods. We add to this framework heterogeneity of workers in terms of the efficient labor they can provide to different sectors. While this adds realism capturing the imperfect mobility of labor across sectors, its main purpose is to provide a means to introduce the reductions in efficient labor supply by sector that are at the heart of the Covid-19 shock.

### 2.1 ENDOWMENTS

We consider a world economy consisting of  $J$  countries indexed by  $i$  and  $j$ , in which  $S$  sectors indexed by  $r$  and  $s$  can be active. Each country is endowed with an aggregate mass of worker-consumers  $L_j$ , with each individual inelastically supplying one unit of raw labor. Workers are immobile across countries. Concerning worker mobility across sectors, we consider different scenarios, ranging from immobility over imperfect to perfect mobility. In the latter two cases the number of workers  $L_{js}$  in each country-sector is endogenous in equilibrium, while it is exogenous in the case of immobility.

### 2.2 PREFERENCES AND SECTOR CHOICE

**PREFERENCES.** All consumers in country  $j$  draw utility from the consumption of a Cobb-Douglas compound good, which itself consists of CES compound goods from each of the sectors  $s \in \{1, \dots, S\}$ . Aggregate consumption  $C_j$  in country  $j$  is given by

$$C_j = \prod_{s=1}^S C_{js}^{\alpha_{js}}, \quad \text{where} \quad \sum_{s=1}^S \alpha_{js} = 1, \quad (1)$$

and  $\alpha_{js}$  denotes expenditure shares on sectoral compound goods  $C_{js}$ . Each  $C_{js}$  is a CES aggregate over a continuum of individual varieties  $\omega \in [0, 1]$  produced within each sector:

$$C_{js} = \left[ \int_0^1 x_{js}(\omega)^{\frac{\sigma_s-1}{\sigma_s}} d\omega \right]^{\frac{\sigma_s}{\sigma_s-1}}, \quad (2)$$

where  $x_{js}(\omega)$  is total final consumption in country  $j$  of variety  $\omega$  from sector  $s$ , and  $\sigma_s > 1$  is the elasticity of substitution across varieties.

**INTERSECTORAL MOBILITY.** We assume that if individual  $\Omega$  in country  $j$  decides to work in sector  $s$ , the efficient labor in this country-sector increases by  $\delta_{js}(\Omega)$ . Intuitively, these values

‘translating’ raw into efficient labor reflect both the applicability of a worker’s skills and training to a particular sector and switching costs to this sector. The efficiency of labor  $\delta_{js}(\Omega)$  is drawn by each individual from sector- and country-specific Fréchet distributions with means  $\delta_{js} > 0$  and shape parameter  $\varphi > 1$ , such that the cumulative density function becomes

$$\Pr[\delta_{js}(\Omega) \leq \delta] = e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})} \delta^{-\varphi}},$$

where  $\Gamma(\cdot)$  denotes the gamma function. The normalization of the scale parameter ensures that the mean of  $\delta_{js}(\Omega)$  for sector  $s$  across all workers in country  $j$  is exactly equal to  $\delta_{js}$  and independent of our choice of  $\varphi$ . The parameter  $\delta_{js}$  will be our key shock parameter. A reduction in  $\delta_{js}$  reduces the supply of efficient labor in the economy, as all workers draw on average lower values  $\delta_{js}(\Omega)$  for country-sector  $js$ . This drop captures the essence of the Covid-19 shock in China, as workers are held back from going to work or operate under time-consuming or efficiency-reducing constraints, such as additional hygiene measures or the requirement to work from home.

As explained above, we consider several scenarios with regard to worker mobility across sectors. Under intersectoral mobility, workers pick sector  $s$  if it offers them the highest compensation as in (Roy, 1951). Therefore, given all compensations per unit of efficient labor  $w_{js}$  in all sectors  $s$  in country  $j$  we can derive the number of workers  $L_{js}$  who pick sector  $s$  as their workplace as

$$L_{js} = L_j \frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}. \quad (3)$$

Notice that imperfect labor mobility implies that wages per efficiency unit do not need to equalize across sectors in equilibrium. More specifically, a sector increasing its wages will, on average, attract workers that provide less efficient labor to this sector than those already working there.

Using the properties of the Fréchet distribution it is easy to show that the average wage  $w_j$  paid to each worker, i.e., the ex-ante expected wage, is the same in each sector in country  $j$  and given by

$$w_j = \left( \sum_{s=1}^S \delta_{js}^\varphi w_{js}^\varphi \right)^{\frac{1}{\varphi}}, \quad (4)$$

as derived in Appendix A.1.

## 2.3 PRODUCTION

**PRODUCTION.** On the production side we assume that, in each country  $j$ , each sector  $s$  potentially produces a continuum of varieties  $\omega \in [0, 1]$  under perfect competition and with constant



returns to scale. As in [Caliendo and Parro \(2015\)](#), production uses labor and CES compound goods from potentially all sectors as intermediate inputs.

More specifically, producers of variety  $\omega$  in country  $j$  and sector  $s$  combine efficient labor units  $l_{js}(\omega)$  and intermediate goods  $m_{jrs}(\omega)$  from all sectors  $r \in \{1, \dots, S\}$  in a Cobb-Douglas fashion:

$$q_{js}(\omega) = z_{js}(\omega) l_{js}(\omega)^{\gamma_{js}} \left( \prod_{r=1}^S m_{jrs}(\omega)^{\gamma_{jrs}} \right), \quad (5)$$

where  $\gamma_{js}, \gamma_{jrs} \in [0, 1]$  are the cost shares of labor and intermediates from each sector in production, and where  $\gamma_{js} + \sum_{r=1}^S \gamma_{jrs} = 1$ . Exogenous productivities  $z_{js}(\omega)$  are drawn from country- and sector-specific Fréchet distributions with the cumulative distribution functions  $\Pr[z_{js}(\omega) \leq z] = e^{-T_{js}z^{-\varepsilon_s}}$ , where  $T_{js}$  determines the average productivities in each country  $j$  and sector  $s$ , and  $\varepsilon_s$  measures their dispersion across countries, which we assume to satisfy  $\varepsilon_s > \sigma_s - 1$ . The compound intermediate goods  $m_{jrs}(\omega)$  are produced from individual varieties  $\omega$  using the same CES aggregator as specified in equation (2).

**PRICES.** Production technologies of all varieties within sector  $s$  and country  $j$  differ only with respect to productivities. Perfect competition, therefore, implies that all producers in sector  $s$  and country  $j$  face the same marginal production costs per efficiency unit  $c_{js}$  and set mill prices of  $p_{js}(\omega) = \frac{c_{js}}{z_{js}(\omega)}$ .

All varieties can be traded subject to iceberg trade costs between any two countries  $i$  and  $j$ . Following [Antràs and Chor \(2018\)](#), we assume that these trade costs depend not only on the country pair  $ij$  and sector  $r$  of the traded good, but also on the use category  $u \in \{1, \dots, S+1\}$ , which can be one of the  $S$  sectors using the variety as an intermediate input or it can be final demand. Thus,  $\tau_{ijru} \geq 1$  units need to be shipped from country  $i$  and sector  $r$  for one unit to arrive in country  $j$  and use category  $u$ . The resulting price at which variety  $\omega$  from sector  $r$  in country  $i$  is offered to use category  $u$  in country  $j$  can be expressed as

$$p_{ijru}(\omega) \equiv p_{ir}(\omega) \tau_{ijru} = \frac{c_{ir} \tau_{ijru}}{z_{ir}(\omega)}. \quad (6)$$

As prices depend on productivities, they inherit their stochastic nature. In particular, under the assumption that variety  $\omega$  from sector  $s$  is homogeneous across all possible producing countries, firms and consumers buy them from the cheapest source, implying a price of  $\min\{p_{ijru}; i \in J\}$ . Using the properties of the Fréchet distribution and following [Eaton and Kortum \(2002\)](#), we can

derive both the price  $P_{jru}$  of sector  $r$  compound goods paid in country  $j$  and use category  $u$ :

$$P_{jru} = \Gamma \left( \frac{\varepsilon_r + 1 - \sigma_r}{\varepsilon_r} \right)^{\frac{1}{1-\sigma_r}} \left[ \sum_{i=1}^J T_{ir} (c_{ir} \tau_{ijru})^{-\varepsilon_r} \right]^{-1/\varepsilon_r} \quad (7)$$

and the share  $\pi_{ijru}$  that country  $i$  makes up in use category  $u$ 's expenditure in country  $j$  on sector  $r$ :<sup>10</sup>

$$\pi_{ijru} = \frac{T_{ir} [\tau_{ijru} c_{ir}]^{-\varepsilon_r}}{\sum_{k=1}^J T_{kr} [\tau_{kjr} c_{kr}]^{-\varepsilon_r}}. \quad (8)$$

**COSTS.** Firms' profit maximization and the Cobb-Douglas production structure imply that the total expenditure  $E_{jrs}$  by sector  $s$  in country  $j$  on intermediates from sector  $r$  and its expenditure on labor are given by

$$E_{jrs} = \gamma_{jrs} R_{js} \quad \text{and} \quad L_{js} w_j = \gamma_{js} R_{js}, \quad (9)$$

where  $R_{js}$  denotes the total revenue of sector  $s$  in country  $j$ . Moreover, using the price indices (7), the input bundle cost per efficient unit of output becomes

$$c_{js} = \chi_{js} w_j^{\gamma_{js}} \prod_{r=1}^S P_{jrs}^{\gamma_{jrs}}, \quad (10)$$

with  $\chi_{js} \equiv \gamma_{js}^{-\gamma_{js}} \prod_{r=1}^S \gamma_{rjs}^{-\gamma_{rjs}}$  being a country- and sector-specific constant.

## 2.4 EQUILIBRIUM

**EXPENDITURE AND CONSUMPTION.** Balanced trade together with factor demands from equation (9) implies that aggregate expenditure  $E_{jr(S+1)}$  by consumers in any country  $j$  on goods from sector  $r$  can be expressed as:

$$E_{jr(S+1)} = \alpha_{jr} \left( \sum_{s=1}^S \gamma_{js} R_{js} \right). \quad (11)$$

Subsequently, aggregate consumer welfare, which is equivalent to real expenditure, can be derived by combining expenditures (11) with the price indices (7) to obtain:

$$C_j = \frac{\sum_{r=1}^S E_{jr(S+1)}}{\prod_{r=1}^S P_{jr(S+1)}^{\alpha_{jr}}}. \quad (12)$$

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<sup>10</sup>A derivation of the price index and these shares can be found in Appendix A.1.

GOODS MARKET CLEARING. In equilibrium, goods market clearing requires that the value of production in country  $i$  and sector  $s$  equals the value of world final and intermediate goods demand for that sector:

$$R_{is} = \sum_{j=1}^J \sum_{u=1}^{S+1} \pi_{ij su} E_{jsu} . \quad (13)$$

FACTOR MARKET CLEARING. In equilibrium, wages adjust such that factor markets clear. Specifically, combining sectoral labor compensation (9) with the definition of the wage per capita given in (4) and the supply of sectoral labor (3) allows us to solve explicitly for the country- and sector-specific wages per efficiency unit of labor as

$$w_{js} = \frac{(\gamma_{js} R_{js})^{\frac{1}{\varphi}} \left( \sum_{s=1}^S \gamma_{js} R_{js} \right)^{\frac{\varphi-1}{\varphi}}}{\delta_{js} L_j} . \quad (14)$$

It is instructive to point out two extreme cases. First, as  $\varphi$  approaches infinity, all workers draw the same parameter  $\delta_{js}$  for sector  $s$  in country  $j$ , and hence labor becomes perfectly mobile across sectors. In this scenario, which is the standard case in the literature, the sectoral wage per efficiency unit of labor simplifies to  $w_j/\delta_{js}$ . Second, we will also consider a scenario of worker immobility, in particular when modeling the immediate impact of the Covid-19 shock. In this case, equation (3) no longer holds and  $L_{js}$  is given exogenously instead. Also, sectoral per-capita wages no longer equalize but can be obtained directly from sectoral factor market clearing as  $\gamma_{js} R_{js}/L_{js}$ .<sup>11</sup>

EQUILIBRIUM CONDITIONS. An equilibrium in the model is defined by values of  $P_{jru}$  and  $R_{js}$  for all countries, sectors, and use categories that satisfy the following equilibrium conditions given all preference parameters  $\alpha_{js}$  and  $\sigma_s$ , cost shares  $\gamma_{js}$  and  $\gamma_{jrs}$ , sectoral and labor productivity distribution parameters  $T_{js}$ ,  $\delta_{js}$ ,  $\varepsilon_s$  and  $\varphi$ , and worker endowments  $L_j$ . The first set of equilibrium conditions is obtained from the price index equations (7) after replacing marginal costs using (10) and subsequently factor prices using (14). The second set of equilibrium conditions is obtained from goods market clearing (13) after plugging in expenditures from (11) and (9) as well as trade shares (8) combined with marginal costs (10) and factor prices (14).

EQUILIBRIUM IN CHANGES. Instead of solving the model in levels, we rely on the popular ‘exact hat algebra’ by Dekle et al. (2007) to solve for counterfactual equilibria in response to a shock in terms of changes. At the cost of using up all degrees of freedom, this allows to simulate shocks without specifying the elasticities of substitution  $\sigma_s$  and the current *levels* of technologies

<sup>11</sup>This scenario cannot be captured by letting  $\varphi$  approach 0 since, due to the nature of the Fréchet distribution, the average productivity of workers is not well defined for  $\varphi \leq 1$ .

$T_{js}$ , labor productivities  $\delta_{js}$ , or trade costs  $\tau_{ijru}$ . Denoting variables after the shock with a prime and their relative changes with a hat, we can restate the equilibrium as follows.

Given a shock defined by relative changes in average worker productivity draws  $\hat{\delta}_{ir}$ , average productivities  $\hat{T}_{ir}$ , and trade costs  $\hat{\tau}_{ijru}$  for all countries  $i, j$ , sectors  $r$  and use categories  $u$ , the equilibrium of the model in changes consists of values  $\hat{P}_{iru}$  and  $\hat{R}_{ir}$  for all countries  $i$ , sectors  $r$  and use categories  $u$  that satisfy the following equilibrium conditions given all  $\alpha_{ir}$ , cost shares  $\gamma_{ir}$  and  $\gamma_{irs}$ , distributional parameters  $\varepsilon_r$  and  $\varphi$ , as well as labor endowments  $L_i$ , trade shares  $\pi_{ijru}$ , and revenues  $R_{ir}$  in the ex-ante equilibrium:

$$\hat{P}_{jru} = \left[ \sum_{i=1}^J \pi_{ijru} \hat{T}_{ir} (\hat{c}_{ir} \hat{\tau}_{ijru})^{-\varepsilon_r} \right]^{-1/\varepsilon_r}, \quad (15)$$

$$\hat{R}_{ir} = \frac{1}{R_{ir}} \sum_{j=1}^J \sum_{u=1}^{S+1} \hat{\pi}_{ijru} \pi_{ijru} E'_{jru}, \quad (16)$$

where we use expenditures from (11) and (9), trade shares (8), marginal costs (10) and factor prices (14), all expressed in changes:

$$E'_{jr(S+1)} = \alpha_{jr} \left( \sum_{s=1}^S \gamma_{js} \hat{R}_{js} R_{js} \right), \quad (17)$$

$$E'_{jru} = \gamma_{jru} \hat{R}_{ju} R_{ju} \quad \forall u \leq S, \quad (18)$$

$$\hat{\pi}_{ijru} = \frac{\hat{T}_{ir} (\hat{c}_{ir} \hat{\tau}_{ijru})^{-\varepsilon_r}}{\sum_{k=1}^J \pi_{kjru} \hat{T}_{kr} (\hat{c}_{kr} \hat{\tau}_{kjru})^{-\varepsilon_r}}, \quad (19)$$

$$\hat{c}_{js} = \hat{w}_{js}^{\gamma_{js}} \prod_{r=1}^S \hat{P}_{jrs}^{\gamma_{jrs}}, \quad (20)$$

$$\hat{w}_{js} = \frac{\left( \hat{R}_{js} \right)^{\frac{1}{\varphi}} \left( \frac{\sum_{s=1}^S \gamma_{js} \hat{R}_{js} R_{js}}{\sum_{s=1}^S \gamma_{js} R_{js}} \right)^{\frac{\varphi-1}{\varphi}}}{\hat{\delta}_{js}}. \quad (21)$$

### 3 DATA AND EMPIRICAL METHODOLOGY

In this section, we first outline how the model is mapped to global data on trade in intermediate and final goods from multi-country I-O tables. We then describe our estimation of the initial impact of Covid-19 on the output of Chinese sectors using administrative data. Finally, we explain how we use the model to back out the sectoral labor supply shocks from the estimated output drop.

#### 3.1 MAPPING THE MODEL TO THE DATA

Our main data source is the latest release of the WIOD, which provides annual time-series of world input-output tables from 2000 to 2014. It covers 43 countries, jointly accounting for more than 85% of world GDP, and an synthetic ‘rest of the world’ (ROW). The input-output data are available at the level of 56 sectors classified according to the International Standard Industrial Classification (ISIC), Revision 4.<sup>12</sup> We use data from 2014, the latest available year.

We process the original data by applying the following three adjustments. First, we account for the static nature of our model and follow [Costinot and Rodríguez-Clare \(2014\)](#) in recalculating all flows in the WIOD as if positive inventory changes had been consumed and negative inventory changes had been produced in the current period. Second, to make the WIOD consistent with our theoretical framework, we purge it from aggregate trade imbalances (following the methodology by [Dekle et al. \(2008\)](#) and [Costinot and Rodríguez-Clare \(2014\)](#)) and examine all shocks starting from this counterfactual scenario.<sup>13</sup> Third, to guarantee the existence of the equilibrium in a counterfactual world without GVCs, we need to ensure that fixed (exogenous) intermediate requirements of different sectors can be met by an equivalent domestic supply when international intermediate trade is shut down. To address this issue, we assume that each sector in each country sources at least 1 USD worth of inputs domestically in all sectors from which it uses any inputs in the data (similar to [Antràs and Chor, 2018](#)).<sup>14</sup>

From the WIOD, we take initial values for the trade shares ( $\pi_{ijru}$ ) and the Cobb-Douglas structure of our model allows us to recover from the same data the values for cost shares ( $\gamma_{ir}$  and  $\gamma_{irs}$ ) and expenditure shares ( $\alpha_{js}$ ).<sup>15</sup> We take the values for sectoral trade elasticities ( $\varepsilon_r$ ) from [Felbermayr et al. \(2020\)](#), who estimate them from a structural gravity model. The elasticities are

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<sup>12</sup>See Table A.1 for a list of all countries in the WIOD and their ISO codes. Table A.2 provides a list of ISIC sectors.

<sup>13</sup>A commonly used alternative is to model trade imbalances as exogenous monetary transfers between countries. Pursuing this route as a robustness check, we find that the exogenous nature of these transfers can substantially alter the welfare effects of shocks in selected countries with large imbalances. However, real wage effects, which abstract from the direct cost of the transfer, are very similar throughout all simulations for both alternatives.

<sup>14</sup>It should be noted that this treatment of zeros does not significantly affect our baseline results: In all scenarios in which input trade is not shut down entirely, the welfare effects in all countries are identical to those reported below to at least 6 digits precision when zeros are kept in the data.

<sup>15</sup>Notice that WIOD is the only data base that allows disentangling trade shares according to use category, thereby allowing for use category specific trade costs  $\tau_{ijru}$ .

reported in column 2 of Table A.3. We set the intersectoral labor mobility parameter ( $\varphi$ ) to 1.5 (as in Galle et al., 2018) for our baseline analysis of shock transmission and vary its value in sensitivity analyses.

### 3.2 ESTIMATING THE INITIAL IMPACT OF COVID-19 IN CHINESE SECTORS

To estimate the initial output drop in Chinese sectors due to Covid-19, we adopt an event-study approach that is widely used in economics and finance (see MacKinlay, 1997). We exploit sectoral time series from the National Bureau of Statistics (NBS) of China over three years before the Covid-19 shock (the ‘estimation window’) to predict the counterfactual output in the absence of the shock in January–February 2020 (the ‘event window’). The difference between observed and predicted output in the event window is our estimate of the initial Covid-19 impact by sector.

Our choice of the event window in January–February 2020 exploits the exact timing of the Covid-19 crisis. The first official, public mentioning of the disease dates from December 31, 2019 (when the cases were few), so the earliest economic impact can be expected in January 2020. Most containment measures in China were then implemented over the course of the subsequent two months. Notably, the spread of the virus was almost exclusively confined to China until late February. More specifically, data from Dong et al. (2020) show that on February 29, 92% of all globally confirmed Covid-19 cases were recorded in China, with only 6,655 cases confirmed outside of China (mostly concentrated in South Korea, Italy, and Iran). One week earlier, on February 22, China’s share was at 98%, with only 1,578 infections confirmed outside of China (of which 634 were recorded on the cruise ship ‘Diamond Princess’). Not before March 11 did the WHO declare Covid-19 a pandemic. While certain containment measures in China remained effective into March and beyond, the disease had by then spread internationally. Hence, we cannot exclude the possibility that the output data in these later months reflect also a response to international infections or to international repercussions of the initial shock in China. It is the latter channel that we investigate in detail in our main analysis, but we want to rule it out in our estimate of the initial shock. Thus, we do not consider data after February 2020 in this exercise.<sup>16</sup>

We use monthly sector-level data on output (or more broadly, performance) from the NBS of China. The NBS reports only cumulative numbers for the first two months of each year (not for January and February separately), due to the Chinese spring festival. Hence, we construct bi-monthly time series by sector. For the industrial sector (which encompasses mining, manufacturing, and utilities), we use data on operating revenues of industrial enterprises, deflated by the sectoral producer price index (PPI). These data are reported for 41 sectors, which can be mapped directly into 23 WIOD sectors, accounting for 57% of total Chinese output in the WIOD of 2014.

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<sup>16</sup>In a related study, Luo and Tsang (2020) examine the impact of the lockdown in the Chinese province Hubei in early 2020 through the lens of a network model.

For the tertiary sector, we use different time series measuring performance (mostly revenues, appropriately deflated) in specific services, corresponding to 17 WIOD sectors (including retail trade, telecommunications, and transport). We complement these data with the aggregate index of service production, applied to sectors for which disaggregate data are unavailable (corresponding to 14% of total Chinese output). Since monthly data for the Chinese primary sector are unavailable, we use data from the industry ‘processing of food from agricultural products’ for this sector. Table A.2 provides the details on the selected time series and a concordance table of NBS and WIOD sectors (both following the ISIC, Revision 4).

We denote the output of sector  $s$  in 2-month period  $t$  by  $Y_{st}$  and define the annual (6-period) difference in output as  $\Delta Y_{st} \equiv Y_{st} - Y_{s(t-6)}$ . Our goal is to estimate the impact of the Covid-19 shock as the difference between the observed and expected output change in the first period of 2020 (i.e., the so-called ‘abnormal return’ in the event study literature):

$$\text{Covid-19 impact}_{st} = \Delta Y_{st} - E[\Delta Y_{st}]. \quad (22)$$

Our preferred estimator  $\widehat{\Delta Y}_{st}$  for the expected output change  $E[\Delta Y_{st}]$  is the seasonally differenced model with a first-order autoregressive AR(1) disturbance:

$$\Delta Y_{st} = u_{st}, \quad \text{with} \quad u_{st} = \rho u_{s(t-1)} + e_{st}, \quad (23)$$

where  $u_{st}$  is the AR(1) disturbance,  $\rho$  is the autocorrelation parameter, and  $e_{st}$  is the i.i.d., mean-zero, and normally distributed error term. This estimator is chosen to purge the bi-monthly time series of sector-specific seasonality while taking into account the serial correlation present in the data.<sup>17</sup> Notably, equation (23) is estimated from bi-monthly time series over the pre-shock years 2017 to 2019, as is customary to ensure that the estimates are unaffected by the event itself, and it is then used to predict  $\widehat{\Delta Y}_{it}$  for the first period of 2020.

The estimates show that the impact was dramatic.<sup>18</sup> The average sectoral output declined by 30% compared to its predicted value. The most affected sector (textiles) experienced a drop of almost 60%, while output in land transport and several other manufacturing sectors dropped by around 50% due to Covid-19 and the lockdown. Only few sectors experienced no significant drop or even a slight increase in output, in particular the oil extraction and telecommunication

<sup>17</sup>The size of the estimated impact by sector hardly changes at all if we include a constant term in equation (23) to allow for a trend in the growth rate. This model as well as alternative models of the ARIMA class (adding, e.g., moving averages, or autoregressive disturbances of higher order) turn out to be inferior to the AR(1) model in most sectors by the Akaike and Bayesian information criteria.

<sup>18</sup>Figure A.1 summarizes the estimates. It shows for each sector: the differenced time series, the prediction of the differenced AR(1) model, and the predicted abnormal return in the first period of 2020 – our estimate of the initial impact of Covid-19. The autocorrelation plots for the AR(1) model residuals, depicted in Figure A.2, demonstrate that there is no significant autocorrelation pattern remaining.

services sectors. The latter example points the relevance of I-O linkages for the estimated output drop, highlighting the need for backing out the underlying sectoral labor supply shocks from the estimated output drop, which is what we do in the next subsection.

The estimated effects are mapped to the WIOD according to Table A.2 and aggregated at the level of WIOD sectors, weighted by pre-shock values in January–February 2019. Table A.3 reports in column 3 the estimated output drop caused by Covid-19 for each WIOD sector in China.

### 3.3 BACKING OUT LABOR SUPPLY SHOCKS

The estimated output drop in Chinese sectors due to Covid-19 reflects not only the underlying labor supply shock in a given sector, but also an equilibrium response to the shock in other sectors linked via I-O relationships. For instance, output in the Chinese steel sector might drop not only because steel workers are forced to stay at home, but also because other sectors, such as the machinery, auto, and construction sectors use less steel. Given the short time frame of only two months (between the very first announcement of the outbreak and the end of our event window), any second-round feedback effect to China from an early response in other countries is likely to be negligible. Thus, it seems suitable to interpret the estimated output drop as a short-term response of the Chinese economy to its domestic Covid-19 shock in January–February 2020.

Conceptually, this approach is related to Allen et al. (2020), who formally demonstrate in a broad class of gravity models that the full general equilibrium response to a shock can be decomposed into a ‘zeroth-degree’ effect (occurring only in the directly affected countries) and higher-order effects (starting with the immediate effect on affected countries’ trading partners, followed by the feedback effects on all trading partners’ trading partners, and so forth). In this spirit, we define the ‘zeroth degree’ effect in our application as the sectoral output drop in China in January–February 2020 due to domestic adjustments only, disregarding any response in other countries or feedback effects to these responses in China. Moreover, in consideration of warehousing, shipping times, and binding contracts, we take intermediate and final goods prices to be fixed. Finally, we assume that workers are immobile across sectors in their short-term response to the shock.

Under these assumptions, the estimated output drop in China can immediately be translated into changes in Chinese final and intermediate goods expenditures using equations (17) and (18). With third-country import shares and intermediate goods prices fixed in the short run, we can combine equations (19) and (20) and use the fact that sectorally immobile labor implies  $\hat{w}_{ir} = \hat{R}_{ir}/\hat{\delta}_{ir}$  to derive the underlying sectoral labor supply shocks in China as (see Appendix A.1.3):

$$\hat{\delta}_{CHN,r} = \left( \frac{\hat{R}_{CHN,r} - \frac{1}{R_{CHN,r}} \sum_{j \neq CHN}^J \sum_{u=1}^{S+1} \pi_{CHN,jru} E_{jru}}{\frac{1}{R_{CHN,r}} \sum_{u=1}^{S+1} \pi_{CHN,CHN,ru} E'_{CHN,ru} \hat{R}_{CHN,r}^{-\gamma_{CHN,r} \varepsilon_r}} \right)^{\frac{1}{\gamma_{CHN,r} \varepsilon_r}}. \quad (24)$$



The resulting labor supply shocks by sector in China are reported in column 4 of Table A.3. These shocks do not correspond one to one to the estimated output changes (in column 2), as they reflect, firstly, Chinese firms substituting workers for intermediates (as labor becomes less efficient), secondly, changes in Chinese firms’ reliance on imported vs. domestic intermediate goods and, thirdly, changes in Chinese expenditure on intermediate and final goods. Nevertheless, the ranking of labor supply shocks is similar to that of the estimated output changes, with a correlation of 0.93.

## 4 DECOUPLING GVCs

### 4.1 A WORLD WITHOUT GVCs

We begin by presenting our results on the effects of a worldwide decoupling of GVCs. We simulate such a counterfactual world by raising the barriers to international trade in intermediate goods ( $\tau_{ijru}$ ) to infinity among all country pairs  $ij$ , with  $i \neq j$ , for all producing sectors  $r$ , and for all use categories  $u$  except final demand. Notably, this ‘no-GVCs’ scenario still allows for final goods trade and domestic input-output linkages.<sup>19</sup>

Figure 1: Welfare effects of decoupling GVCs

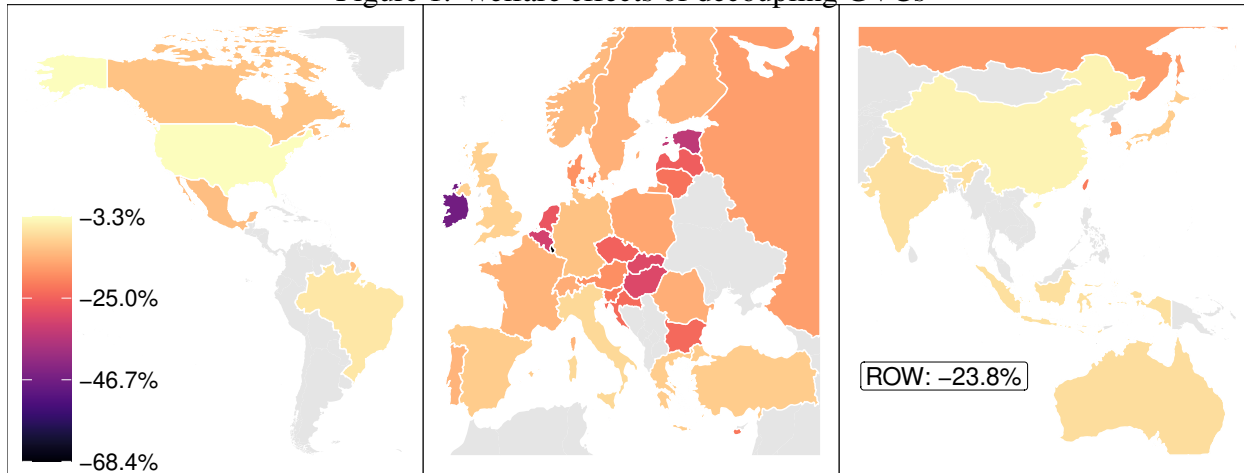


Figure 1 shows the welfare effects of a complete decoupling. It turns out that all countries in the WIOD lose from shutting down GVCs. This result is not trivial, since trade diversion effects in principle allow for gains in individual countries. The largest welfare losses are incurred by small, highly integrated EU economies such as Luxembourg (-68%), Malta (-54%) or Ireland (-46%), whose overall dependence on international trade is high. The worst welfare effects outside the EU

<sup>19</sup>In simulating this and all subsequent decoupling scenarios, we allow for perfect intersectoral labor mobility, corresponding to a long-run equilibrium.

are found in Taiwan (-21%), also a small open economy, followed by Russia (-16%).<sup>20</sup> Conversely, the smallest welfare losses are incurred by large countries with relatively low openness to trade and small shares of intermediates in these trade flows: the U.S. lose -3.3%, China -4.7%, and Brazil -6.3%. In general, we find that openness to intermediate goods trade is highly correlated with the welfare effects of shutting down GVCs. To be precise, the ratio of aggregate intermediate exports plus imports over the sum of aggregate production and use has a correlation coefficient of -96% with the welfare effects. This correlation is similarly high if we consider openness to intermediate imports or exports separately.

The world without GVCs studied above serves as a clear benchmark, but it is highly stylized. We proceed by varying two dimensions of the exercise to assess the generality of the patterns identified above. First, accounting for the exceptionally strong integration of the EU single market, we continue to allow for intermediate goods trade between 28 EU members (as of 2014; henceforth, the EU28) but shut down all other GVCs. Second, we examine a partial decoupling, which amounts to raising trade barriers on intermediate goods by finite values. The results of these simulations are illustrated in Appendix A.3.

A shutdown of GVCs except within the EU leads to much smaller welfare losses (compared to the complete decoupling) in all EU countries, reflecting the importance of intra-EU value chains. By contrast, the predictions for non-EU countries remain almost unchanged. As a consequence, Taiwan (-21%) and Russia (-16%) now rank among the most affected countries. Their losses are exceeded by only two EU members, Ireland (-25%) and Luxembourg (-24%), which see their losses cut substantially (from -46% and -68%, respectively). At the top of the ranking, the losses to Italy, France, Germany, and the U.K. now lie in the range of -3.4% to -4.2% and are thus comparable to the U.S. level. Figure A.3 presents the welfare effects by country.

Next, we consider a partial decoupling of GVCs by increasing barriers on international trade in intermediate goods stepwise by 10%, 50%, 100%, and 200%. We find that the welfare effects of decoupling GVCs are monotonically decreasing in the size of the trade barriers for all countries, with their ranking being very stable across the different scenarios. Furthermore, the effects are generally falling at a diminishing rate: In the vast majority of countries, the welfare losses caused by increasing barriers to GVCs from zero to 10% exceed those caused by raising them from +200% to infinity. Doubling trade barriers (+100%) accounts for more than half of the total damage from shutting down GVCs entirely in all but one country—Russia. This exception may be rationalized by the fact that raw materials from Russia are very difficult to substitute and continue to be traded

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<sup>20</sup>For Russia, natural gas and other products from the mining sector make up 39% of total exports and contribute to a very high share of intermediates (91%) in exports, which explains the large losses from shutting down this type of trade. Note that the synthetic ROW loses -24%, but since this is an artificial construct, and not an actual country, we neglect the ROW in our discussion of the results here and below.

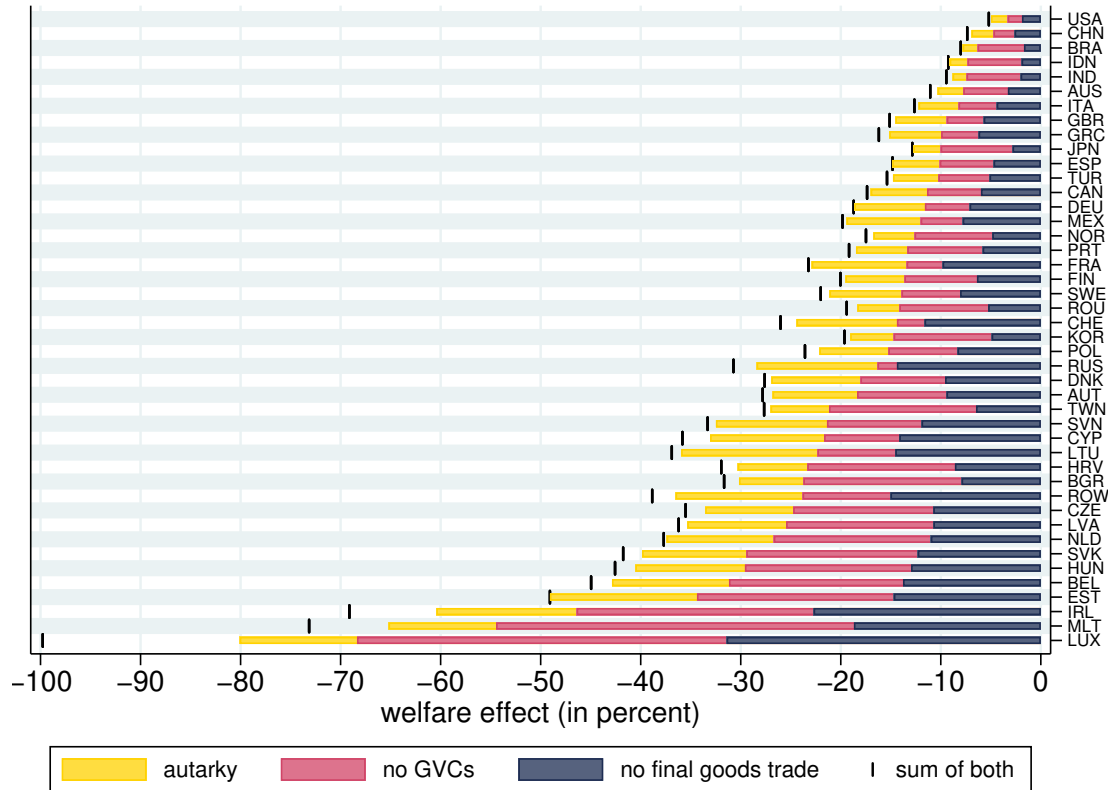
even at very high costs.<sup>21</sup> Figure A.4 shows detailed results for partial decoupling.

Finally, it is instructive to compare the shutdown of GVCs to a scenario in which final goods trade is shut down instead, and also to a world with no international trade at all, which corresponds to the autarky scenario that has been extensively studied in the literature. Figure 2 shows that a move to autarky naturally has the most adverse welfare effects. The analysis also reveals that shutting down GVCs is worse than shutting down final goods trade for all countries. The only two countries in which a loss of final goods trade is almost as bad as a world without GVCs are Switzerland, which has a strong comparative advantage in consumer goods, and Russia. Interestingly, for most countries the welfare loss from autarky is slightly smaller than the sum of the losses from shutting down only one of the two types of trade, as indicated in the graph. Arguably, this pattern may have two possible explanations. First, it is consistent with the concavity we have discussed above: The negative welfare effects of trade barriers are diminishing in the size of the barriers. Hence, shutting down one type of trade on top of the other (and thereby moving to autarky) reduces welfare by less than only shutting down the first type of trade. Second, one may think of trade in final and intermediate goods as being either ‘complements’ or ‘substitutes’ in the sense that one type of trade can partially replace the other if that is shut down to mitigate the welfare losses. The pattern in Figure 2 indicates that either the first explanation dominates or there is a complementary (rather than substitute) relationship between final and intermediate goods trade for the majority of countries.

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<sup>21</sup>Interestingly, while shutting down GVCs triggers a decline in Russian exports from the mining and quarrying sector, which contains crude oil and natural gas production, we also see a strong increase in exports of refined petroleum and gas. So as intermediate goods trade is shut off, Russia takes up the refinement process domestically and sells the final goods abroad.

Figure 2: Shutting down trade in final goods vs. intermediate goods vs. all (autarky)



## 4.2 U.S. DECOUPLING

The shutdown of GVCs between all countries studied in the previous section is clearly unattainable by any individual country. To bring the analysis closer to the ongoing policy debate on the decoupling or ‘repatriation’ of value chains, we investigate in this section more attainable scenarios, with a focus on the U.S. More precisely, we tackle the following questions: What would be the consequences of the U.S. either (i) repatriating its input production from all other countries (unilateral GVCs isolationism) or (ii) decoupling only its GVCs from China?

We implement these scenarios by increasing trade barriers on U.S. imports of intermediate inputs (but not of final goods) either (i) from all countries or (ii) only from China. To obtain a clear picture, we set these barriers to prohibitive levels in our main analysis (as in the no-GVCs scenario) and relegate a discussion of partial decoupling scenarios to Section 5.2. In practice, policy makers seeking to decouple from GVCs would face the challenge of distinguishing intermediate inputs from final goods. While this distinction is not clear-cut at the level of broad sectors, such a policy could arguably be implemented by increasing trade barriers within each sector for typical inputs like fertilizers, heavy machinery, or trucks (as opposed to consumer goods like shampoo, game consoles, or sport cars). Note that, since we model decoupling in the form of increased real trade

costs, these scenarios are best thought of as raising non-tariff barriers (or, more generally, non-rent-creating barriers) on inputs.<sup>22</sup>

Figure 3: Global welfare effects of U.S. decoupling

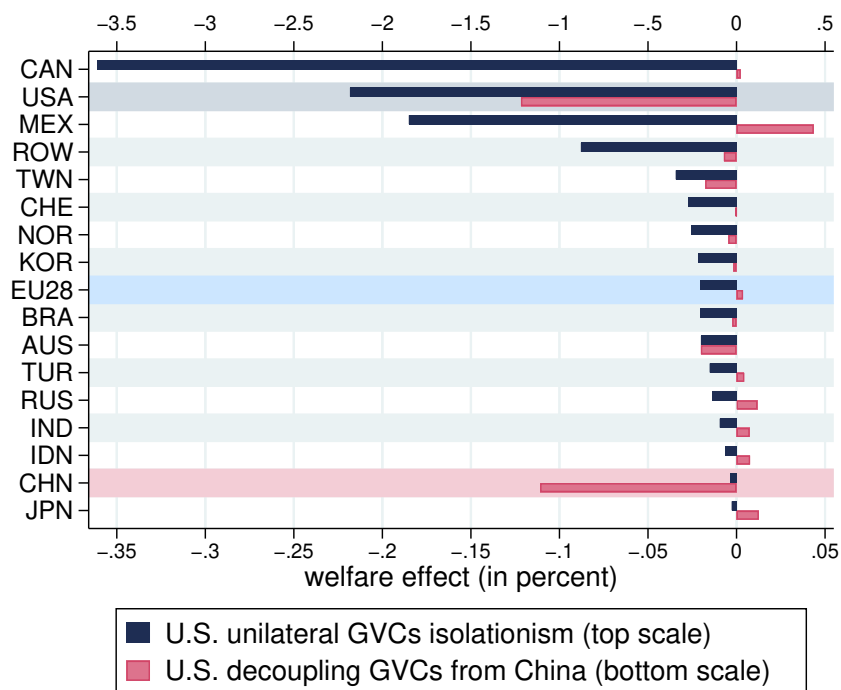


Figure 3 illustrates the welfare effects of both U.S. decoupling scenarios. Since the effects on most European countries are small and not the focus of this discussion, we report only the (population-weighted) average welfare effect for the EU28 in the main text.<sup>23</sup> We find that if the U.S. fully repatriates all GVCs, U.S. welfare drops by a sizeable -2.2%. Interestingly, its neighbor Canada would suffer even more from such a policy due to its strong GVC ties with the U.S. and its overall greater dependence on international trade. It should be noted that almost all other countries in the WIOD would lose from this policy as well (with the exception of very small gains in Slovenia and Slovakia), demonstrating that U.S. GVCs participation is beneficial to the world as whole. Among the non-EU countries, Japan and China are hurt the least by U.S. unilateral GVCs isolationism.

If the U.S. withdraws input production only from China, it suffers a welfare loss that is smaller by an order of magnitude, but nevertheless the largest among all countries. Welfare drops by

<sup>22</sup>Examples of such barriers are procurement policies favoring domestic suppliers, such as the “Made in America Laws”, which were strengthened by both the Trump and Biden administration (see, e.g., [Trump, 2020](#), and [Biden, 2021](#)). In principle, tariffs can be incorporated into the model as in [Caliendo and Parro \(2015\)](#). We abstain from this approach since (i) in our main decoupling scenarios with infinite trade barriers, zero tariff revenue on input trade would arise, and (ii) we expect any changes in the relatively small levels of tariff revenue (on final goods trade) to have little influence on our welfare predictions.

<sup>23</sup>Figure A.5 shows the effects on all individual countries.

-0.12% in the U.S. and by -0.11% in China. In this case, the majority of all other countries benefit from the policy, as Chinese input production for the U.S. is partly shifted to third countries instead of being repatriated. The largest positive effect arises in Mexico, which experiences welfare gains of 0.04% due to trade diversion from its Asian competitor. We will return to these results in Section 5.2, where we contrast the losses from decoupling in the U.S. with the potential gains from safeguarding against an adverse shock in China.

## 5 GLOBAL SHOCK TRANSMISSION

### 5.1 COVID-19 SHOCK TRANSMISSION IN A WORLD WITHOUT GVCs

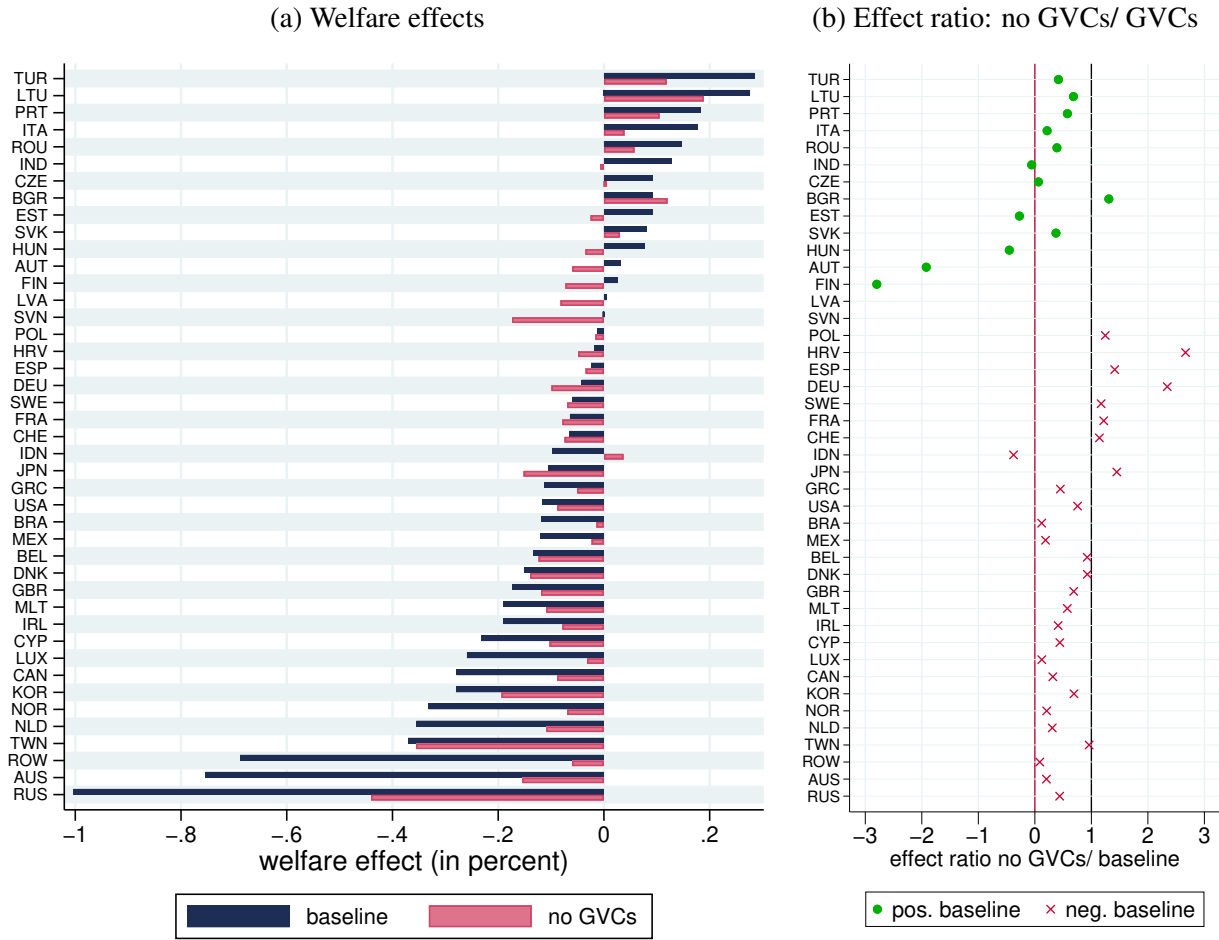
We now turn to our analysis of international shock transmission in a world with vs. without GVCs. To this end, we focus on the global repercussions of the Covid-19 shock in China in early 2020, as a realistic example of a major negative supply shock. Notably, we consider a shock that remains confined to China, in order to isolate the role of trade and GVCs, and we consider how a permanent shock of this size would affect the world economy. The domestic welfare loss in China from such a shock amounts to -30.0% in the new general equilibrium.

Figure 4 illustrates how welfare in all other WIOD countries is affected by the Covid-19 shock in China. Figure 4(a) illustrates the effects in the baseline world in the form of dark blue bars. The international repercussions are moderate and range from a welfare loss of -1.00% in Russia to a gain of +0.28% in Turkey. The most negatively affected countries (including Russia, Australia, and Taiwan) are in relatively close geographic proximity and have strong trade linkages to China. The U.S. (-0.12%) and Germany (-0.04%) experience small negative effects. Interestingly, fourteen countries enjoy moderate welfare gains due to the adverse supply shock in China. Besides Turkey and India, these are mostly European countries that accessed the EU in or after 2004. Apparently, these countries experience gains from trade diversion (as importers around the world switch away from Chinese suppliers), which outweigh the direct losses due to higher input costs and the negative income effect in China.

To understand the role of GVCs in international shock transmission, we now consider the effects of the same Covid-19 shock in the counterfactual world without GVCs, which we studied in Section 4.1. To ensure that the reported effects are comparable across scenarios, all welfare changes are computed relative to countries' initial (pre-decoupling) welfare. The welfare effects in the decoupled world are shown as the light red bars in Figure 4(a). To visualize the role of GVCs in mitigating or magnifying shock transmission, Figure 4(b) displays ratios of the effects in the no-GVCs world relative to those in the baseline world.

We find that the global repercussions of the shock in China are on average smaller in a decou-

Figure 4: Welfare effects of Covid-19 shock with GVCs vs. without GVCs



pled world without GVCs, so shutting down the GVCs channel indeed reduces international shock transmission on average. However, there is vast heterogeneity in the effects across individual countries. We can distinguish three interesting patterns. First, for most countries, shock transmission is mitigated after decoupling (effect ratios are between 0 and 1). This reduction amounts to 32% for the median country among those that experienced welfare losses in the baseline scenario. Second, and perhaps more surprisingly, the losses are *magnified* after decoupling for nine countries, including France, Germany, and Japan, as indicated by effect ratios above one in Figure 4(b).<sup>24</sup> Bulgaria is the only country that sees its gains magnified. Third, in several countries the welfare effects of the Covid-19 shock in China are reversed in a world without GVCs (effect ratios below zero): Six (mostly European) countries switch from winners to losers. By contrast, Indonesia, with losses in the baseline world, stands to gain from the shock in China after GVCs have been shut down.

To gain deeper insights into these findings and their sensitivity, we consider several variations

<sup>24</sup>This group includes Slovenia, for which a very small baseline loss is much increased, resulting in an effect ratio of 165. Slovenia and Latvia (with an effect ratio of -16) are omitted from Figure 4(b) in the interest of readability.

of our main simulations, the results of which are presented in Appendix A.3. We begin by reexamining shock transmission after a partial (instead of complete) shutdown of GVCs. Specifically, we raise intermediate goods trade barriers between all countries stepwise by 10%, 50%, 100%, and 200% before simulating the Covid-19 shock. In most countries, the welfare effects adjust monotonically between the baseline and a completely decoupled world. Compared to the welfare effects obtained from simulating the shock in the baseline world, there is a 99.7% cross-country correlation when simulating it after a 10% decoupling shock. This correlation is reduced to 90.6% after a 100% increase intermediate goods trade barriers and to 77.5% in a world without GVCs. There are few exceptions (including Belgium, Japan, and Taiwan) for which the two extreme scenarios do not deliver the smallest and largest welfare effects, but the variations across scenarios in these countries are relatively small. Overall, the complex general equilibrium responses do not seem to generate major non-monotonicities in the welfare effects. Figure A.6 summarizes the country-level welfare effects for all partial decoupling scenarios.

We contrast our findings from the world without GVCs with an alternative world in which international trade in final goods is abolished instead (while allowing for intermediate goods trade).<sup>25</sup> This complementary exercise reveals that a Covid-19 shock in China would play out quite differently in a world without final goods trade compared to the world without GVCs. While the average welfare effect across countries is similar, the effects on individual countries differ substantially. Most notably, with no final goods trade, the sign of the welfare effect from the shock switches from negative to positive in twelve countries but only once in reverse compared to the no-GVCs scenario. Overall, the correlation of the country-level welfare effects between both scenarios is only 56.3%. It is evident that inhibiting international trade in final goods as opposed to intermediates has very different implications for shock transmission. Figure A.7 illustrates the results by country.

One may wonder if shock transmission may be more beneficially reduced if all countries could decouple only GVCs involving China, the country from which the adverse shock originates in our counterfactual. To understand this, we reconsider the scenario of the Covid-19 shock hitting China after unilaterally decoupling it from GVCs, i.e., after setting prohibitively high trade barriers on intermediate goods trade into and out of China. The simulation results demonstrate that this gives rise to rather similar, though on average more favorable welfare effects for other countries. The correlation with the shock transmission effects in the no-GVCs scenario is 93.2%. These findings suggest that our results from Figure 4 are mainly driven by a decoupling from China and less from the shutdown of intermediate goods trade among all other countries. Interestingly, sixteen countries do slightly worse if only China is decoupled compared to a complete decoupling of all

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<sup>25</sup>Shock transmission without international trade is trivially zero in our model, so we do not consider a world with all countries in autarky.



GVCs. See Figure A.8 for shock transmission effects on all countries after decoupling China.

To see how alternative assumptions about intersectoral mobility affect the results, we examine the extreme cases of perfect and zero labor mobility. While predicted welfare effects from a shock in China are highly correlated across these scenarios (by 96.0–99.7%), the differences are quantitatively important. For instance, in a scenario with immobile labor Russia loses -1.1% welfare compared to only -0.74% in a world with perfect mobility, whereas Turkey’s welfare gains decrease from 0.34% to 0.13%. Interestingly, as for these two countries, moving from zero to perfect mobility generally mitigates the losses of the most negatively affected countries (except for Taiwan and South Korea) but also makes positively or slightly negatively affected countries worse off. Since higher domestic mobility must be beneficial these results are due to the altered general equilibrium effects from higher mobility in other countries. Intuitively, we show that countries gaining from trade diversion after the China shock will gain less if the sectoral composition of production in third countries can better adapt.

Concerning the shutdown of GVCs, it should be noted that in the perfect mobility scenario, the average reduction (mitigation) in shock transmission is stronger and amounts to approximately 44% for the median losing country (vs. 32% with imperfect mobility). Figure A.9 illustrates the welfare effects by country for the three mobility scenarios (in the baseline world with GVCs).

## 5.2 COVID-19 SHOCK TRANSMISSION AFTER U.S. DECOUPLING

Can the welfare losses in the U.S. due to unilateral decoupling from GVCs, which we have discussed in Section 4.2, be justified by reduced U.S. exposure to adverse foreign shocks? Here we provide an answer to this question in the context of the Covid-19 shock in China, before considering alternative shocks originating in all (other) countries in the subsequent section.

Table 1 summarizes, for different decoupling scenarios, the effects on U.S. welfare of both the decoupling itself (in column 1) and of the Covid-19 shock in China occurring after decoupling (in column 2). Column 3 lists the cumulative effects from decoupling and the shock and column 4 reports the difference between this cumulative effect and the impact of the shock in China in the baseline world (without any decoupling). Thus, the final column allows us to assess how decoupling with its subsequent shock mitigation fares in comparison to no active policy. The first row lists the baseline world as a reference point. The subsequent two rows then consider the U.S. decoupling policies discussed in Section 4.2, and the last two rows show two additional variations of U.S. decoupling described further below.

It is immediately obvious from Table 1 that despite their mitigation effects none of the different decoupling scenarios are beneficial to U.S. welfare. Across all scenarios, decoupling only leads to a meager shock mitigation of never more than 0.04 percentage points in U.S. welfare (compared to

Table 1: U.S. decoupling from GVCs and shock transmission

| Scenario                          | Decoupling | Covid-19 shock<br>(after decoupling) | Cumulative effect<br>(decoupling+shock) | Difference<br>to baseline |
|-----------------------------------|------------|--------------------------------------|---|---------------------------|
|                                   | (1)        | (2)                                  | (3)                                     | (4)                       |
| Baseline                          |            | -0.12                                |   |                           |
| U.S. unilateral GVCs isolationism | -2.18      | -0.13                                | -2.31                                   | -2.20                     |
| U.S.–China one-way decoupling     | -0.12      | -0.09                                | -0.21                                   | -0.10                     |
| U.S.–China bilateral decoupling   | -0.19      | -0.08                                | -0.27                                   | -0.15                     |
| U.S. & EU decoupling from China   | -0.18      | -0.08                                | -0.26                                   | -0.14                     |

The table reports for different decoupling scenarios the U.S. welfare effects (in percent of baseline welfare) from decoupling itself (in column 1) and from the Covid-19 shock in China after decoupling (in column 2). Column 3 reports the cumulative effect from decoupling and the shock while column 4 reports the difference between this cumulative effect and the welfare effect of the shock in the baseline world.

-0.12% in the baseline; see column 2). This tiny benefit is dwarfed by the welfare losses directly caused by decoupling in each case (see column 1). As a consequence, the U.S. is overall clearly worse off from experiencing the shock after decoupling compared to suffering the shock only (in the baseline world), as evidenced by the negative numbers in column 4.

What is more, decoupling might not even achieve a reduction in shock transmission at all. In the main scenario labeled ‘U.S. unilateral GVCs isolationism’, in which the U.S. sets prohibitively high barriers on intermediate goods imports from all countries, the U.S. welfare loss from a Covid-19 shock in China would even be slightly magnified compared to the baseline scenario (-0.13% vs. -0.12%). This contrasts with the substantial U.S. welfare loss of -2.18% caused directly by unilateral GVCs isolationism. As a consequence, the cumulative effect of decoupling plus shock transmission on U.S. welfare is much worse than shock transmission to the U.S. in the baseline world. The magnification is explained by a combination of two facts: First, the U.S. still ‘imports’ the shock from China via final goods trade, which is a channel that gains importance after decoupling. Second, by foregoing the option to import intermediate goods, U.S. firms lose flexibility in their response to the shock, as they cannot substitute domestic inputs (that become more expensive) with imports, which raises prices and aggravates the welfare loss.

We proceed by considering more targeted and coordinated policy scenarios of decoupling: If the U.S. were to decouple GVCs only from China, but not from any other country, the U.S. welfare loss due to the subsequent shock would be slightly reduced from -0.12% to -0.09%. Clearly, this reduction cannot justify the welfare loss induced by the policy itself (-0.12%), resulting in a worsening of -0.10% compared to the shock in the baseline world. These results illustrate that decoupling does not enhance U.S. welfare even if it specifically targets China, the country where the adverse supply shock originates. Since one can in practice expect China to retaliate against such a policy, we also consider bilateral decoupling of GVCs between the U.S. and China, which causes

a greater direct loss to the U.S. and gives rise to the same main conclusion. Finally, one might imagine a transatlantic coordination of trade policy. In this scenario, the U.S. and the EU28 jointly decouple from China by setting prohibitively high trade barriers on Chinese intermediate goods imports and China responds in kind. Once more, the welfare loss in the U.S. clearly outweighs the mitigation effect of decoupling.

To conclude this section, we vary two important dimensions of the U.S. unilateral decoupling scenario: the size of the trade barriers and the assumptions on intersectoral mobility. First, our conclusion does not hinge on the fact that we have focused on a complete decoupling. If we consider partial decoupling (raising input trade barriers e.g. by 10%, 50%, 100%, or 200%), we continue to find small magnification effects and consequently negative net welfare effects of decoupling. Second, the magnification result for U.S. unilateral GVCs isolationism turns out to be closely linked to the assumption on intersectoral labor mobility. We find that the effects are more strongly magnified in a world with immobile labor, while with perfect intersectoral labor mobility we find a very small mitigation effect. Interestingly, perfect labor mobility only *within* the U.S. is not sufficient for this result, but it requires perfect labor mobility domestically and abroad. In any case, the mitigation effects are by orders of magnitude smaller than the direct costs of decoupling. Table A.4 reports the key numbers from these additional simulations.

### 5.3 UNIFORM SHOCKS TO ALL COUNTRIES

Our analysis of international shock transmission has so far focused on one particular shock in China. Also, in the unilateral decoupling scenarios of the previous section, we have restricted attention to the U.S. as the decoupling country. One may wonder to what extent our findings hinge on the specific features of these two countries. Relatedly, the cross-sectoral heterogeneity of the shock is rather special and may play a relevant role for the simulation results.

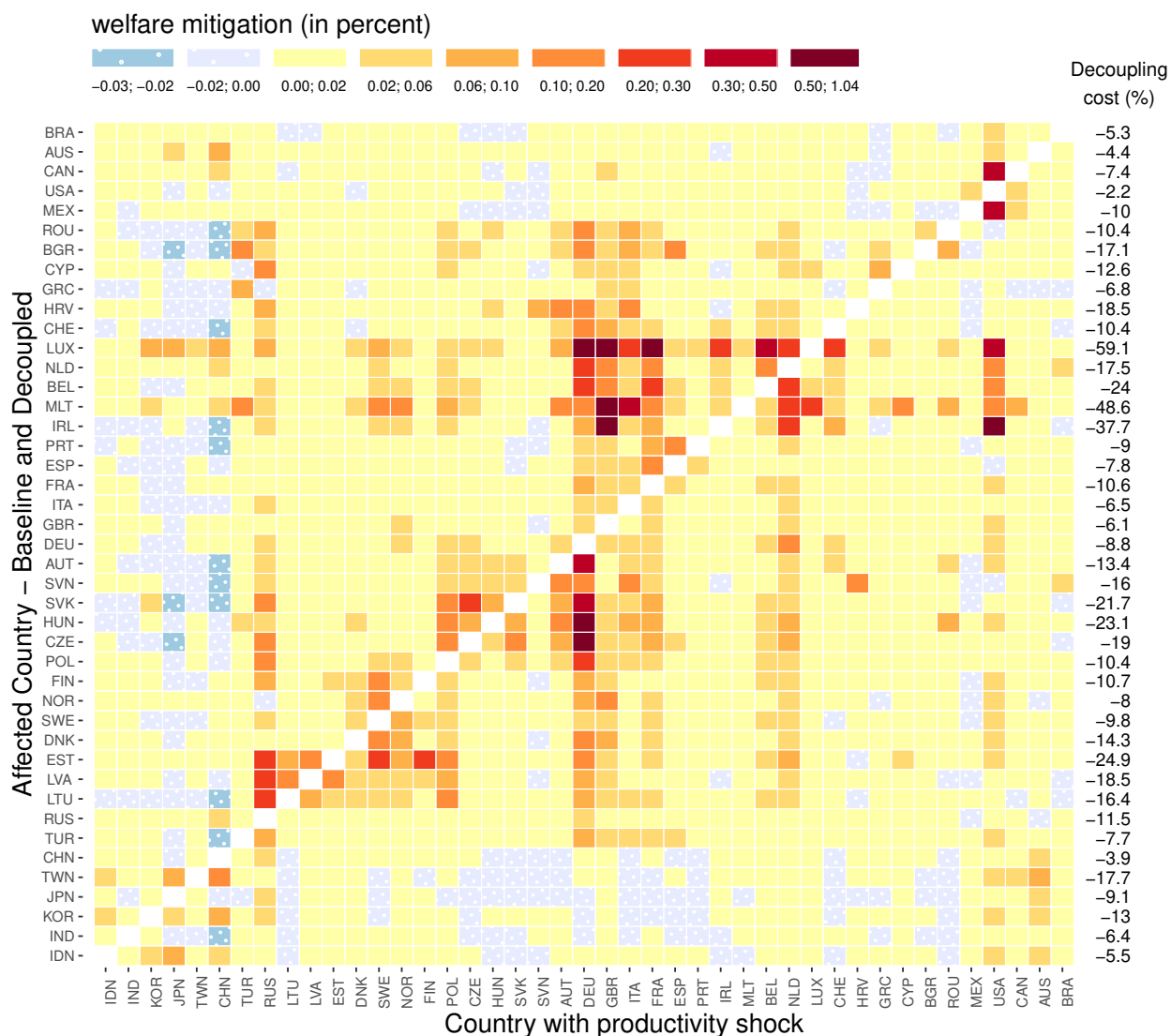
To assess the generality of our findings, we proceed by investigating the international transmission of shocks that alternatively originate in each one of the countries in the WIOD. To ensure that the shocks are (i) comparable across countries, (ii) not driven by cross-sectoral heterogeneity, and (iii) comparable in terms of size to our previous analysis, we hit all countries one by one with sectorally uniform labor productivity shocks of -29%, the GDP weighted sectoral average of our estimated Covid-19 shock in China. This ensures that the direct effect of the shock on domestic GDP is equivalent in each shocked country.

The analysis proceeds in three steps. First, we simulate these shocks in each country in the baseline world and in each case assess the welfare effects (shock transmission) on all other countries. Second, one by one, we unilaterally decouple each country from GVCs by setting barriers to intermediate imports to infinity only for the country in question. Third, we reassess how the

shocks around the world affect this country’s welfare differently after unilateral decoupling. This allows us to obtain a general picture of the potential shock reduction through decoupling.

Figure 5 depicts the mitigation effects of decoupling, i.e., the difference between the welfare effects in the two scenarios (baseline vs. decoupled) for each combination of shocked and (indirectly) affected country. To provide a specific example, the top left cell in the figure shows how a shock originating in Indonesia is mitigated by Brazil through unilateral decoupling of Brazil from GVCs.<sup>26</sup>

Figure 5: Global shock mitigation through decoupling



Importantly, we find that the mitigation effect of unilateral decoupling is very small throughout all bilateral shock transmission scenarios, with a welfare effect that is on average by 0.35 percent-

<sup>26</sup>In Figure 5, countries are grouped according to their geographic location in Asia, Europe, and North America.

age points (pp) more favorable after decoupling. The largest mitigation effects are obtained when Malta, Luxembourg or Ireland decouple and a shock hits the U.K. (1.0pp, 0.8pp, and 0.6pp), if Luxembourg decouples and a shock hits Germany (0.9pp) or if Ireland decouples and a shock hits the U.S. (0.7pp). Other country pairs for which mitigation effects are sizeable are mostly found for shocks occurring in large economies like the U.S., Germany, or the U.K.

Interestingly, for many combinations of Asian countries with South Eastern and Eastern European countries the mitigation effect is negative (blue areas) and thus implies that decoupling *magnifies* the welfare loss created by the foreign shock. Clearly, as these countries play similar roles in GVCs, they reduce their ability to substitute intermediate inputs from the shocked country when they decouple from GVCs.

Finally, the number at the end of each row indicates the initial welfare cost of unilateral decoupling for the row country (in percent). It is immediately obvious that this welfare loss dominates the mitigation effects throughout and almost always by at least one order of magnitude in most cases. We find that in the most favorable scenario, the U.S. decoupling from GVCs and then experiencing a foreign shock in Mexico or Canada leads to a total U.S. welfare loss that is by 2.1–2.2pp larger than if the same shock had hit these countries without the U.S. repatriating GVCs.

One might argue that the reason for the relatively small mitigation effects is due to the simulated shock hitting only a single country, whereas in practice (e.g. in the pandemic) several trading partners might be affected simultaneously. This would lead to stronger spillovers with a correspondingly greater potential for mitigation effects and, one might guess, could ultimately tip the scale in favor of repatriating value chains. To test this hypothesis, we again compare for each country the welfare effects of a foreign shock occurring before and after the country decouples from GVCs. In contrast to the above analysis, however, we simulate the -29% labor productivity shock hitting not only one but *all* foreign trade partners. We find that in this extreme ‘global shock’ scenario the mitigation effects of decoupling are indeed much stronger than above, with a maximum of 6.89pp for Luxembourg and an average of 0.74pp. Nevertheless, for every single country the initial welfare cost of decoupling still clearly dominates the mitigation effect. In the most favorable scenario, the U.S. welfare loss from unilaterally decoupling and experiencing a foreign shock in all other countries in the world is 1.98 percentage points larger than if the same shock had hit these countries without the U.S. repatriating GVCs. The welfare mitigation effects in all countries after the global shock are depicted in Figure A.10.

To sum up, throughout all of our simulations, we find no single instance in which the potential benefits from lower exposure to foreign shocks would outweigh the welfare losses from repatriating GVCs.

## 6 CONCLUSION

In addition to triggering a devastating humanitarian catastrophe, the Covid-19 pandemic has threatened to “[...] change the nature of globalization, with which we have lived for the past 40 years” (Macron, 2020). As globally interconnected firms are trying to recover from supply chain disruptions caused by the pandemic, policy makers around the world are debating an important question: Would repatriating GVCs improve a country’s welfare by shielding it against foreign shocks? Using a multi-country, multi-sector quantitative trade model with input-output linkages, we find that, by and large, the answer to this question is negative: The slight (if any) reduction in exposure to foreign shocks cannot justify the substantial welfare losses directly caused by decoupling GVCs.

To arrive at this conclusion, we have conducted two types of counterfactual analyses: First, we have assessed the direct welfare costs of decoupling from GVCs through increased barriers to international trade in intermediate goods. The simulations show that all countries lose from decoupling, whether global or unilateral, and the losses to small open economies are large. Second, we have examined the international transmission of negative supply shocks, before and after decoupling. Motivated by the early days of the pandemic, we have focused on an adverse supply shock in China, but we have also considered generic shocks in individual countries and all foreign trading partners. It turns out that shutting down GVCs as a propagation channel does mitigate international shock transmission on average, but more strikingly, it magnifies the welfare losses from foreign shocks in some countries. Across all scenarios, whenever we find positive mitigation effects, those are dwarfed by the direct welfare losses due to decoupling.

The key methodological contribution of this paper is to isolate the role of GVCs in the international transmission of shocks. We hope that this approach will prove useful also in future applications studying trade policy or the international transmission of different shocks. Since decoupling GVCs has lasting implications, this paper focuses on long-term general equilibrium effects. A potentially fruitful line of work would be to investigate the short-run repercussions of foreign shocks and contrast them with the long-run welfare effects reported in this paper.

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# Appendix to:

## Decoupling Global Value Chains

### A.1 THEORY APPENDIX

#### A.1.1 SECTORAL MOBILITY

The probability that a given worker  $\Omega$  draws a productivity for working in country  $j$  and country  $s$  that is no larger than  $\delta$  is given by:

$$\Pr[\delta_{js}(\Omega) \leq \delta] = e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \delta^{-\varphi}}.$$

Then the distribution of potential compensation of a worker in country  $j$  and sector  $s$  is

$$\begin{aligned} \mathbb{G}_{js}(w) &= \Pr[\delta_{js}(\Omega) w_{js} \leq w] = e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}}, \\ \frac{d\mathbb{G}_{js}(w)}{dw} &= e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi w^{-\varphi-1}. \end{aligned}$$

The probability of any worker having the highest compensation in sector  $s$  is:

$$\begin{aligned} \Pr\left[\delta_{js}(\Omega) w_{js} \geq \max_{s \neq r} \delta_{jr}(\Omega) w_{jr}\right] &= \int_0^\infty \Pr\left[\max_{s \neq r} \delta_{jr}(\Omega) w_{jr} \leq w\right] \frac{d\mathbb{G}_{js}(w)}{dw} dw \\ &= \int_0^\infty \prod_{s \neq r} \Pr[\delta_{jr}(\Omega) w_{jr} \leq w] e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi w^{-\varphi-1} dw \\ &= \int_0^\infty \prod_{s \neq r} e^{-\frac{\delta_{jr}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} e^{-\frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi w^{-\varphi-1} dw \\ &= \frac{\delta_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi} w_{js}^\varphi \int_0^\infty e^{-\sum_{r=1}^S \frac{\delta_{jr}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw \\ &= \frac{\delta_{js}^\varphi w_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi \sum_{r=1}^S \frac{\delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi}} \int_0^\infty \left(\sum_{r=1}^S \frac{\delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi}\right) e^{-\sum_{r=1}^S \frac{\delta_{jr}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw \end{aligned}$$

$$\begin{aligned}
&= \frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi} \int_0^\infty \left( \sum_{r=1}^S \frac{\delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \right) e^{-\sum_{r=1}^S \frac{\delta_{jr}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw \\
&= \frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi} \left[ e^{-\sum_{r=1}^S \frac{\delta_{jr}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \right]_0^\infty = \frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi} \equiv \frac{L_{js}}{L_j},
\end{aligned}$$

which is equivalent to equation (3). The CDF of the compensation of workers that actually move to sector  $s$  is:

$$\begin{aligned}
&\Pr \left[ w_{js} \delta_{js} (\Omega) < w | w_{js} \delta_{js} (\Omega) \geq \max_{s \neq r} w_{jr} \delta_{jr} (\Omega) \right] \\
&= \frac{1}{\frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}} \int_0^w \Pr \left[ \max_{s \neq r} w_{jr} \delta_{jr} (\Omega) < x \right] \frac{dG_{js}(x)}{dx} dx \\
&= \frac{1}{\frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}} \int_0^w \prod_{s \neq r} \Pr [w_{jr} \delta_{jr} (\Omega) \leq x] e^{-\frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi x^{-\varphi-1} dx \\
&= \frac{1}{\frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}} \int_0^w e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi x^{-\varphi-1} dx \\
&= \frac{1}{\frac{\delta_{js}^\varphi w_{js}^\varphi}{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}} \int_0^w e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \varphi w_{js}^\varphi x^{-\varphi-1} dx \\
&= \int_0^w \left( \frac{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \right) e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \varphi x^{-\varphi-1} dx \\
&= \left[ e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \right]_0^w = e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}}.
\end{aligned}$$

This shows that the distribution of the compensation of workers is the same in each sector and for the economy of country  $j$  as a whole. The PDF is:

$$\frac{de^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}}}{dw} = \left( \frac{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \right) e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma\left(1 - \frac{1}{\varphi}\right)^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \varphi w^{-\varphi-1}.$$

These results allow to derive the average or ex-ante expected wage of a worker conditional on working in any sector  $s$ :

$$\begin{aligned} w_j &= \int_0^\infty w \frac{d \left( e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \right)}{dw} dw \\ &= \int_0^\infty \left( \frac{\sum_{r=1}^S \delta_{jr}^\varphi w_{jr}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \right) e^{-\sum_{s=1}^S \frac{\delta_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \left(\frac{w}{w_{js}}\right)^{-\varphi}} \varphi w^{-\varphi} dw. \end{aligned}$$

Define  $x(w) = w^{-\varphi} \frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi}$  and thus  $dx/dw = -\varphi w^{-\varphi-1} \frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} = -\varphi \frac{x}{w}$  and  $w = \left( \frac{x \Gamma(1-\frac{1}{\varphi})^\varphi}{\sum_s \delta_{js}^\varphi w_{js}^\varphi} \right)^{-\frac{1}{\varphi}}$ ,

yielding  $\frac{dw}{dx} x = -\frac{1}{\varphi} \left( \frac{x \Gamma(1-\frac{1}{\varphi})^\varphi}{\sum_s \delta_{js}^\varphi w_{js}^\varphi} \right)^{-\frac{1}{\varphi}}$  to transform the above into

$$\begin{aligned} \int_0^\infty e^{-x} \varphi x dw &= \varphi \int_{x(0)}^{x(\infty)} e^{-x} x \frac{dw}{dx} dx \\ &= - \left( \frac{\Gamma(1-\frac{1}{\varphi})^\varphi}{\sum_s \delta_{js}^\varphi w_{js}^\varphi} \right)^{-\frac{1}{\varphi}} \int_\infty^0 e^{-x} x^{-\frac{1}{\varphi}} dx \\ &= \left( \frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \right)^{\frac{1}{\varphi}} \int_0^\infty e^{-x} x^{-\frac{1}{\varphi}} dx \\ &= \left( \frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma(1-\frac{1}{\varphi})^\varphi} \right)^{\frac{1}{\varphi}} \Gamma\left(1-\frac{1}{\varphi}\right) \\ &= \left( \sum_s \delta_{js}^\varphi w_{js}^\varphi \right)^{\frac{1}{\varphi}} \equiv w_j, \end{aligned}$$

which is equivalent to the wage described by equation (4).

### A.1.2 DERIVATION OF PRICES

Productivity is identically and independently distributed Fréchet on a sector region level. The cumulative distribution function of productivities is given by:

$$\Pr[z_{ir}(\omega) \leq z] = e^{-T_{ir} z^\varepsilon r}.$$

This functional form implies that the prices that sector  $r$  in region  $i$  offers sector  $u$  in region  $j$  are also distributed Fréchet with the CDF  $\mathbb{F}_{ijru}(p)$  given by:

$$\begin{aligned}\mathbb{F}_{ijru}(p) &= \Pr[p_{ijru}(\omega) \leq p] = \Pr\left[\frac{c_{ir}\tau_{ijru}}{z_{ir}(\omega)} \leq p\right] = \Pr\left[\frac{c_{ir}\tau_{ijru}}{p} \leq z_{ir}(\omega)\right] \\ &= 1 - \Pr\left[z_{ir}(\omega) \leq \frac{c_{ir}\tau_{ijru}}{p}\right] = 1 - e^{-T_{ir}\left(\frac{c_{ir}\tau_{ijru}}{p}\right)^{-\varepsilon_r}}.\end{aligned}$$

The equilibrium price in sector  $u$  in region  $j$  for variety  $(\omega)$  in sector  $r$  is given by  $p_{jru}(\omega) \equiv \min_i p_{ijru}(\omega)$ . Let us denote the probability  $\mathbb{F}_{jru}(p)$  that this lowest price is below some price  $p$  as follows:

$$\begin{aligned}\mathbb{F}_{jru}(p) &= \Pr\left[\min_i p_{ijru}(\omega) \leq p\right] = 1 - \Pr\left[\min_i p_{ijru}(\omega) > p\right] \\ &= 1 - \prod_{i=1}^J \Pr[p_{ijru}(\omega) > p] = 1 - \prod_{i=1}^J (1 - \mathbb{F}_{ijru}(p)) \\ &= 1 - \prod_{i=1}^J \left(1 - \left(1 - e^{-T_{ir}\left(\frac{c_{ir}\tau_{ijru}}{p}\right)^{-\varepsilon_r}}\right)\right) = 1 - \prod_{i=1}^J e^{-T_{ir}\left(\frac{c_{ir}\tau_{ijru}}{p}\right)^{-\varepsilon_r}} \\ &= 1 - e^{-\sum_{i=1}^J T_{ir}\left(\frac{c_{ir}\tau_{ijru}}{p}\right)^{-\varepsilon_r}} \\ &= 1 - e^{-p^{\varepsilon_r} \Phi_{jru}}\end{aligned}$$

with  $\Phi_{jru} \equiv \sum_{i=1}^J T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}$ . The CES price index of sector  $r$  compound goods paid in country  $j$  and use category  $u$  can then be derived in the following way:

$$\begin{aligned}P_{jru} &= \left(\int_0^1 p_{jru}(\omega)^{1-\sigma_r} d\omega\right)^{\frac{1}{1-\sigma_r}} \\ \Leftrightarrow P_{jru}^{1-\sigma_r} &= \left(\int_0^1 p_{jru}(\omega)^{1-\sigma_r} d\omega\right) = \int_0^\infty p^{1-\sigma_r} \frac{d\mathbb{F}_{jru}(p)}{dp} dp \\ &= \int_0^\infty p^{1-\sigma_r} \varepsilon_r \Phi_{jru} p^{\varepsilon_r-1} e^{-p^{\varepsilon_r} \Phi_{jru}} dp.\end{aligned}$$

Defining  $x \equiv p^{\varepsilon_r} \Phi_{jru}$  we get:

$$\begin{aligned}P_{jru}^{1-\sigma_r} &= \int_0^\infty \left(\frac{x}{\Phi_{jru}}\right)^{\frac{1-\sigma_r}{\varepsilon_r}} \frac{dx}{dp} e^{-x} dp = \int_0^\infty \left(\frac{x}{\Phi_{jru}}\right)^{\frac{1-\sigma_r}{\varepsilon_r}} e^{-x} dx \\ &= \Phi_{jru}^{-\frac{1-\sigma_r}{\varepsilon_r}} \int_0^\infty x^{\frac{1-\sigma_r}{\varepsilon_r}} e^{-x} dx = \Phi_{jru}^{-\frac{1-\sigma_r}{\varepsilon_r}} \Gamma\left(\frac{\varepsilon_r + 1 - \sigma_r}{\varepsilon_r}\right),\end{aligned}$$

where  $\Gamma(t) \equiv \int_0^\infty x^{t-1} e^{-x} dx$  is the gamma function. Consequently:

$$P_{jru} = \Phi_{jru}^{-1/\varepsilon_r} \Gamma\left(\frac{\varepsilon_r + 1 - \sigma_r}{\varepsilon_r}\right)^{\frac{1}{1-\sigma_r}} = \Gamma\left(\frac{\varepsilon_r + 1 - \sigma_r}{\varepsilon_r}\right)^{\frac{1}{1-\sigma_r}} \left(\sum_{j=1}^J T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}\right)^{-1/\varepsilon_r}.$$

Similarly, the chance that users from category  $u$  in country  $j$  will, in sector  $r$ , buy goods from country  $i$  can be derived by aggregating for any price level  $p$  the probability that country  $i$  offers a variety at this price and no other country offering it at a cheaper price. Due to the law of large numbers, the probability of buying from country  $i$  is equal to the share  $\pi_{ijru}$  of goods in sector  $r$  that  $j$ - $u$  will actually buy from country  $i$  in equilibrium. Hence we can derive:

$$\begin{aligned} \pi_{ijru} &= \int_0^\infty \frac{d\mathbb{F}_{ijru}}{dp} \prod_{k \neq i} \Pr[p_{kjr}(\omega) \geq p] dp \\ &= \int_0^\infty (1 - \mathbb{F}_{ijru}) T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r} \varepsilon_r p^{\varepsilon_r - 1} \prod_{k \neq i} (1 - \mathbb{F}_{kjr}) dp \\ &= \int_0^\infty -T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r} \varepsilon_r p^{\varepsilon_r - 1} \prod_{k=1}^J (1 - \mathbb{F}_{kjr}) dp \\ &= \int_0^\infty T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r} \varepsilon_r p^{\varepsilon_r - 1} e^{-\sum_{k=1}^J T_{kr}(\frac{c_{kr}\tau_{kjr}}{p})^{-\varepsilon_r}} dp \\ &= \frac{T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}}{\Phi_{jru}} \int_0^\infty \Phi_{jru} \varepsilon_r p^{\varepsilon_r - 1} e^{-p^{\varepsilon_r} \Phi_{jru}} dp \\ &= \frac{T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}}{\Phi_{jru}} \int_0^\infty \frac{d\mathbb{F}_{jru}}{dp} dp \\ &= \frac{T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}}{\Phi_{jru}} [1 - 0] \\ &= \frac{T_{ir}(c_{ir}\tau_{ijru})^{-\varepsilon_r}}{\Phi_{jru}} \end{aligned}$$

### A.1.3 DERIVATION OF LABOR SUPPLY SHOCKS

We begin with equation (16) applied to the Chinese sectors ( $i = CHN$ ) subject to the labor efficiency shock. Plugging in equations (19) and (20) gives

$$\hat{R}_{CHN,r} = \frac{1}{R_{CHN,r}} \sum_{j=1}^J \sum_{u=1}^{S+1} \frac{\left(\hat{w}_{CHN,r}^{\gamma_{CHN,r}} \prod_{s=1}^S \hat{P}_{CHN,rs}^{\gamma_{CHN,rs}}\right)^{-\varepsilon_r}}{\hat{P}_{jru}^{-\varepsilon_r}} \pi_{CHN,jru} E'_{jru}.$$



Under our assumption of intermediate and final use prices remaining constant in the short term, we have  $\hat{P}_{jru} = 1$  for all  $j$ ,  $r$ , and  $u$ . Moreover, with sectoral labor immobility relative wage changes depend only on changes in the relative sectoral revenue (of which a constant share is paid to workers) and changes in labor efficiency ( $\hat{w}_{js} = \hat{R}_{js}/\hat{\delta}_{js}$ ). Finally, foreign imports and thus expenditure shares from China are also fixed in the zeroth-degree world, implying that we can rewrite the above equation as

$$\hat{R}_{CHN,r} = \frac{1}{R_{CHN,r}} \sum_{j \neq CHN}^J \sum_{u=1}^{S+1} \pi_{CHN,jru} E_{jru} + \frac{1}{R_{CHN,r}} \sum_{u=1}^{S+1} \pi_{CHN,CHN,ru} E'_{CHN,ru} \left( \frac{\hat{R}_{CHN,r}}{\hat{\delta}_{CHN,r}} \right)^{-\gamma_{CHN,r} \varepsilon_r} .$$

Solving this expression for  $\hat{\delta}_{CHN,r}$  yields equation (24) in the main text.

## A.2 DATA APPENDIX

Table A.1: List of countries in WIOD and ISO country codes

| Country code | Country name   | Country code | Country name      |
|--------------|----------------|--------------|-------------------|
| AUS          | Australia      | IRL          | Ireland           |
| AUT          | Austria        | ITA          | Italy             |
| BEL          | Belgium        | JPN          | Japan             |
| BGR          | Bulgaria       | KOR          | Korea             |
| BRA          | Brazil         | LTU          | Lithuania         |
| CAN          | Canada         | LUX          | Luxembourg        |
| CHE          | Switzerland    | LVA          | Latvia            |
| CHN          | China          | MEX          | Mexico            |
| CYP          | Cyprus         | MLT          | Malta             |
| CZE          | Czech Republic | NLD          | Netherlands       |
| DEU          | Germany        | NOR          | Norway            |
| DNK          | Denmark        | POL          | Poland            |
| ESP          | Spain          | PRT          | Portugal          |
| EST          | Estonia        | ROU          | Romania           |
| FIN          | Finland        | RUS          | Russia            |
| FRA          | France         | SVK          | Slovak Republic   |
| GBR          | United Kingdom | SVN          | Slovenia          |
| GRC          | Greece         | SWE          | Sweden            |
| HRV          | Croatia        | TUR          | Turkey            |
| HUN          | Hungary        | TWN          | Taiwan            |
| IDN          | Indonesia      | USA          | United State      |
| IND          | India          | ROW          | Rest of the World |

Table A.2: Sector correspondence: WIOD and NBS

| WIOD sector | Time series from NBS   |     |  |
|-------------|--|-----|--|
| 1           | Crop & animal production, hunting & related service activities               | 8   | Processing of Food from Agricultural Products                          |
| 2           | Forestry & logging   | 8   | Processing of Food from Agricultural Products                          |
| 3           | Fishing & aquaculture  | 8   | Processing of Food from Agricultural Products                          |
| 4           | Mining & quarrying   | 1   | Mining & Washing of Coal   |
| 4           | Mining & quarrying   | 2   | Extraction of Petroleum & Natural Gas                                  |
| 4           | Mining & quarrying   | 3   | Mining & Processing of Ferrous Metal Ores                              |
| 4           | Mining & quarrying   | 4   | Mining & Processing of Non-Ferrous Metal Ores                          |
| 4           | Mining & quarrying   | 5   | Mining & Processing of Nonmetal Ores                                   |
| 4           | Mining & quarrying   | 6   | Mining & Support Activities  |
| 4           | Mining & quarrying   | 7   | Mining of Other Ores   |
| 5           | Manufacture of food products, beverages & tobacco products                   | 8   | Processing of Food from Agricultural Products                          |
| 5           | Manufacture of food products, beverages & tobacco products                   | 9   | Foods  |
| 5           | Manufacture of food products, beverages & tobacco products                   | 10  | Wine, Beverages & Refined Tea  |
| 5           | Manufacture of food products, beverages & tobacco products                   | 11  | Tobacco  |
| 6           | Manufacture of textiles, wearing apparel & leather products                  | 12  | Textile  |
| 6           | Manufacture of textiles, wearing apparel & leather products                  | 13  | Textile Wearing Apparel & Clothing                                     |
| 6           | Manufacture of textiles, wearing apparel & leather products                  | 14  | Leather, Fur, Feather & Related Products                               |
| 6           | Manufacture of textiles, wearing apparel & leather products                  | 15  | Timber, Manufacture of Wood, Bamboo, Rattan, Palm & Straw Products     |
| 7           | Manufacture of wood & of products of wood & cork, except furniture           | 17  | Paper & Paper Products   |
| 8           | Manufacture of paper & paper products  | 18  | Printing, Reproduction of Recording Media                              |
| 9           | Printing & reproduction of recorded media                                    | 20  | Processing of Petroleum, Coal & Other Fuels                            |
| 10          | Manufacture of coke & refined petroleum products                             | 21  | Raw Chemical Materials & Chemical Products                             |
| 11          | Manufacture of chemicals & chemical products                                 | 23  | Chemical Fibers  |
| 11          | Manufacture of chemicals & chemical products                                 | 22  | Medicines  |
| 12          | Manufacture of pharmaceutical products                                       | 24  | Rubber & Plastics  |
| 13          | Manufacture of rubber & plastic products                                     | 25  | Non-metallic Mineral Products  |
| 14          | Manufacture of other non-metallic mineral products                           | 26  | Smelting & Pressing of Ferrous Metals                                  |
| 15          | Manufacture of basic metals  | 27  | Smelting & Pressing of Non-Ferrous Metals                              |
| 15          | Manufacture of basic metals  | 28  | Metal Products   |
| 16          | Manufacture of fabricated metal products, except machinery & equipment       | 34  | Communication Equipment, Computers & Other Electronic Equipment        |
| 17          | Manufacture of computer, electronic & optical products                       | 35  | Measuring Instruments  |
| 17          | Manufacture of computer, electronic & optical products                       | 33  | Electrical Machinery & Equipment                                       |
| 18          | Manufacture of electrical equipment  | 29  | General Purpose Machinery  |
| 19          | Manufacture of machinery & equipment n.e.c.                                  | 30  | Special Purpose Machinery  |
| 19          | Manufacture of machinery & equipment n.e.c.                                  | 31  | Automobiles  |
| 20          | Manufacture of motor vehicles, trailers & semi-trailers                      | 32  | Railway, Shipping, Aerospace & Other Transport                         |
| 21          | Manufacture of other transport equipment                                     | 16  | Furniture  |
| 22          | Manufacture of furniture; other manufacturing                                | 19  | Articles for Culture, Education, Art, Sport & Entertainment Activities |
| 22          | Manufacture of furniture; other manufacturing                                | 36  | Other Manufacturing  |
| 22          | Manufacture of furniture; other manufacturing                                | 38  | Repair of Metal Products, Machinery & Equipment                        |
| 23          | Repair & installation of machinery & equipment                               | 39  | Production & Supply of Electric Power & Heat Power                     |
| 24          | Electricity, gas, steam & air conditioning supply                            | 40  | Production & Supply of Gas   |
| 24          | Electricity, gas, steam & air conditioning supply                            | 41  | Production & Supply of Water   |
| 25          | Water collection, treatment & supply   | 37  | Comprehensive Utilization of Waste                                     |
| 26          | Sewerage; waste & disposal activities; recycling; etc.                       | 70  | Investment of Real Estate, Construction                                |
| 27          | Construction   | 42  | Total Retail Sales of Consumer Good                                    |
| 28          | Wholesale & retail trade & repair of motor vehicles & motorcycles            | 42  | Total Retail Sales of Consumer Good                                    |
| 29          | Wholesale trade, except of motor vehicles & motorcycles                      | 42  | Total Retail Sales of Consumer Good                                    |
| 30          | Retail trade, except of motor vehicles & motorcycles                         | 61  | Railways Passenger Kilometers  |
| 31          | Land transport & transport via pipelines                                     | 62  | Highways Passenger Kilometers  |
| 31          | Land transport & transport via pipelines                                     | 65  | Railways Freight Ton Kilometers  |
| 31          | Land transport & transport via pipelines                                     | 66  | Highways Freight Ton Kilometers  |
| 31          | Land transport & transport via pipelines                                     | 63  | Passenger-Kilometers of Waterways                                      |
| 32          | Water transport  | 67  | Freight Ton-Kilometers of Waterways                                    |
| 32          | Water transport  | 64  | Civil Aviation Passenger Kilometers                                    |
| 33          | Air transport  | 68  | Civil Aviation Freight Ton Kilometers                                  |
| 33          | Air transport  | 400 | Index of Service Production (ISP)                                      |
| 34          | Warehousing & support activities for transportation                          | 43  | Revenue from Postal Services   |
| 35          | Postal & courier activities  | 400 | Index of Service Production (ISP)                                      |
| 36          | Accommodation & food service activities                                      | 400 | Index of Service Production (ISP)                                      |
| 37          | Publishing activities  | 400 | Index of Service Production (ISP)                                      |
| 38          | Movie, TV, and video production; music publishing; broadcasting              | 400 | Index of Service Production (ISP)                                      |
| 39          | Telecommunications   | 44  | Revenue from Telecommunication Services                                |
| 40          | Computer programming, consultancy; information services                      | 45  | Software Revenue   |
| 41          | Financial service activities, except insurance & pension funding             | 400 | Index of Service Production (ISP)                                      |
| 42          | Insurance, reinsurance & pension funding, except compulsory social security  | 400 | Index of Service Production (ISP)                                      |
| 43          | Activities auxiliary to financial services & insurance activities            | 400 | Index of Service Production (ISP)                                      |
| 44          | Real estate activities   | 46  | Development & Sales of Real Estate, Transaction Value of Land          |
| 44          | Real estate activities   | 47  | Total Sale of Commercialized Buildings Sold                            |
| 45          | Legal & accounting; activities of head offices; management consultancy       | 400 | Index of Service Production (ISP)                                      |
| 46          | Architectural & engineering activities; technical testing & analysis         | 400 | Index of Service Production (ISP)                                      |
| 47          | Scientific research & development  | 400 | Index of Service Production (ISP)                                      |
| 48          | Advertising & market research  | 400 | Index of Service Production (ISP)                                      |
| 49          | Other professional, scientific & technical activities; veterinary activities | 400 | Index of Service Production (ISP)                                      |
| 50          | Administrative & support service activities                                  | 400 | Index of Service Production (ISP)                                      |
| 51          | Public administration & defence; compulsory social security                  | 400 | Index of Service Production (ISP)                                      |
| 52          | Education  | 400 | Index of Service Production (ISP)                                      |
| 53          | Human health & social work activities  | 400 | Index of Service Production (ISP)                                      |
| 54          | Other service activities   | 400 | Index of Service Production (ISP)                                      |
| 55          | Activities of households as employers  | 400 | Index of Service Production (ISP)                                      |
| 56          | Activities of extraterritorial organizations & bodies                        | 400 | Index of Service Production (ISP)                                      |

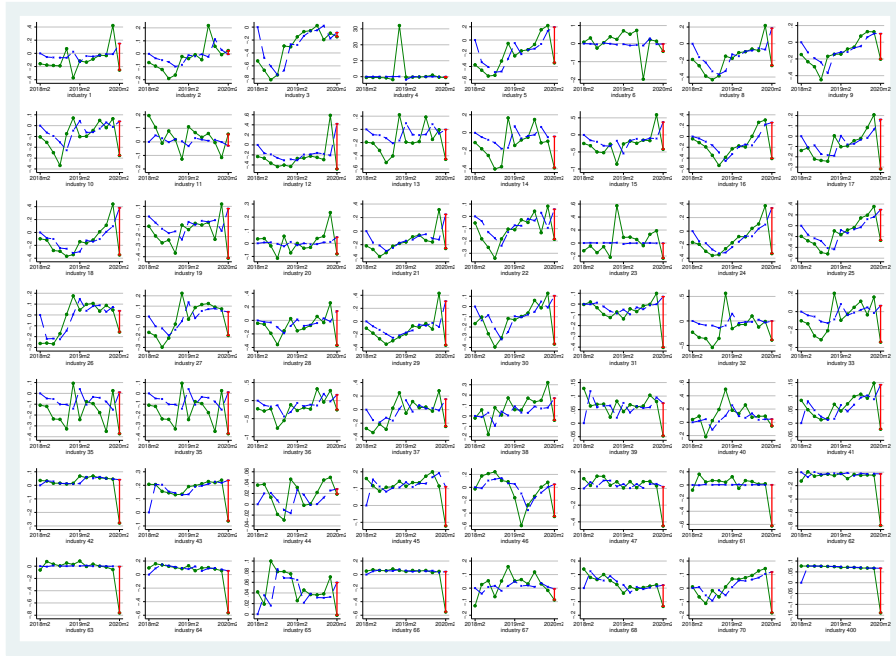
The table reports the sector correspondence between WIOD and NBS of China and the time series used to measure performance. For NBS sectors 1-41 we use time series of operating revenue deflated by the sector-specific PPI. To deflate the nominal series in the tertiary sector, we use the retail price index for sector 42; the "Transport & Communication" component of CPI for sectors 43-45; and the "Residential" component of the CPI in sectors 46, 47, and 70. Sectors 61-68 refer to physical quantities, which need no deflating; here we use the simple mean in aggregating to WIOD sectors. Sector 400 refers to a real performance index, which needs no deflating.

Table A.3: Sectoral trade elasticities, output drop and labor supply shocks in China

| Sector | Trade elasticity | Output drop<br>(estimated) | Labor supply shock<br>(backed out) |
|--------|------------------|----------------------------|------------------------------------|
| (1)    | (2)              | (3)                        | (4)                                |
| 1      | 3.468            | -36.1                      | -39.2                              |
| 2      | 3.468            | -36.1                      | -30.4                              |
| 3      | 3.468            | -36.1                      | -40.7                              |
| 4      | 3.468            | -25.5                      | -28.8                              |
| 5      | 3.468            | -24.8                      | -22.0                              |
| 6      | 3.468            | -45.8                      | -70.2                              |
| 7      | 3.468            | -54.9                      | -70.2                              |
| 8      | 3.468            | -38.1                      | -44.4                              |
| 9      | 1.202            | -51.8                      | -88.4                              |
| 10     | 6.027            | -12.0                      | 0.0                                |
| 11     | 3.543            | -37.5                      | -45.2                              |
| 12     | 11.479           | -21.7                      | -22.2                              |
| 13     | 2.270            | -49.0                      | -77.4                              |
| 14     | 1.375            | -43.3                      | -72.9                              |
| 15     | 3.206            | -18.9                      | 0.0                                |
| 16     | 1.558            | -39.7                      | -71.9                              |
| 17     | 7.771            | -18.1                      | -22.5                              |
| 18     | 6.012            | -33.4                      | -47.2                              |
| 19     | 7.868            | -44.1                      | -54.1                              |
| 20     | 4.610            | -37.6                      | -44.8                              |
| 21     | 2.915            | -32.1                      | -42.8                              |
| 22     | 3.714            | -41.5                      | -83.6                              |
| 23     | 1.442            | -19.1                      | -12.4                              |
| 24     | 1.442            | -11.2                      | 0.0                                |
| 25     | 1.442            | -15.1                      | 0.0                                |
| 26     | 1.442            | -33.2                      | -45.7                              |
| 27     | 1.442            | -26.0                      | -16.4                              |
| 28     | 1.442            | -27.4                      | -27.9                              |
| 29     | 1.442            | -27.4                      | -29.1                              |
| 30     | 1.442            | -27.4                      | -29.1                              |
| 31     | 1.442            | -37.7                      | -49.6                              |
| 32     | 1.442            | -30.5                      | -45.2                              |
| 33     | 1.442            | -30.3                      | -63.1                              |
| 34     | 1.442            | -18.6                      | 0.0                                |
| 35     | 1.442            | -25.9                      | -30.0                              |
| 36     | 1.442            | -18.6                      | -1.9                               |
| 37     | 1.442            | -18.6                      | -14.8                              |
| 38     | 1.442            | -18.6                      | -12.8                              |
| 39     | 1.442            | -0.9                       | 0.0                                |
| 40     | 1.442            | -20.7                      | -10.6                              |
| 41     | 1.442            | -18.6                      | -10.2                              |
| 42     | 1.442            | -18.6                      | -1.7                               |
| 43     | 1.442            | -18.6                      | -13.1                              |
| 44     | 1.442            | -37.6                      | -44.7                              |
| 45     | 1.442            | -18.6                      | -4.6                               |
| 46     | 1.442            | -18.6                      | -13.0                              |
| 47     | 1.442            | -18.6                      | -2.1                               |
| 48     | 1.442            | -18.6                      | -12.7                              |
| 49     | 1.442            | -18.6                      | -2.2                               |
| 50     | 1.442            | -18.6                      | -3.4                               |
| 51     | 1.442            | -18.6                      | -3.2                               |
| 52     | 1.442            | -18.6                      | -4.6                               |
| 53     | 1.442            | -18.6                      | 0.0                                |
| 54     | 1.442            | -18.6                      | -4.5                               |
| 55     | 1.442            | -18.6                      | -10.2                              |
| 56     | 1.442            | -18.6                      | 0.0                                |

The table reports for each WIOD sector  $r$  the trade elasticity  $\varepsilon_r$  (in column 2) and (in columns 3-4, respectively, each in percent): the estimated output drop caused by Covid-19 in China (see Section 3.2) and the implied labor supply shock  $\hat{\delta}_{CHN,r}$  (see Section 3.3). Note that for eight sectors, the shocks are set to zero because either output is zero for China in the WIOD even after the adjustments described in section 3.1 (one case) or the model would suggest an implausible positive labor supply shock due to Covid-19 (seven cases).

Figure A.1: Performance of Chinese sectors over time: Data vs. AR(1) model



Seasonally differenced data (green, solid line, dots); seasonally differenced AR(1) model (blue, dashed line, crosses); predicted effect of Covid-19 (red, vertical spike). Data source: NBS. See the text for details.

Figure A.2: Autocorrelation plot of residuals from AR(1) model



Autocorrelations of residuals  $(\Delta Y_{it} - \widehat{\Delta Y_{it}})$  from seasonally differenced AR(1) model. 95% confidence intervals are based on Barlett's formula. Data source: NBS.

### A.3 ADDITIONAL RESULTS

Figure A.3: Complete decoupling vs. decoupling except within the EU

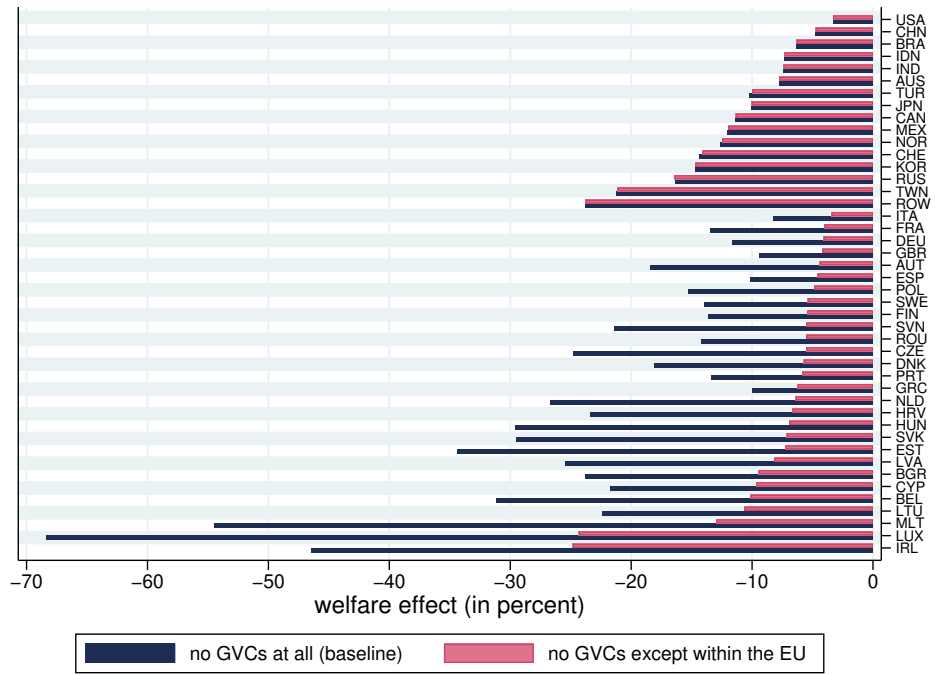


Figure A.4: Partial decoupling: Stepwise increase in intermediate goods trade barriers

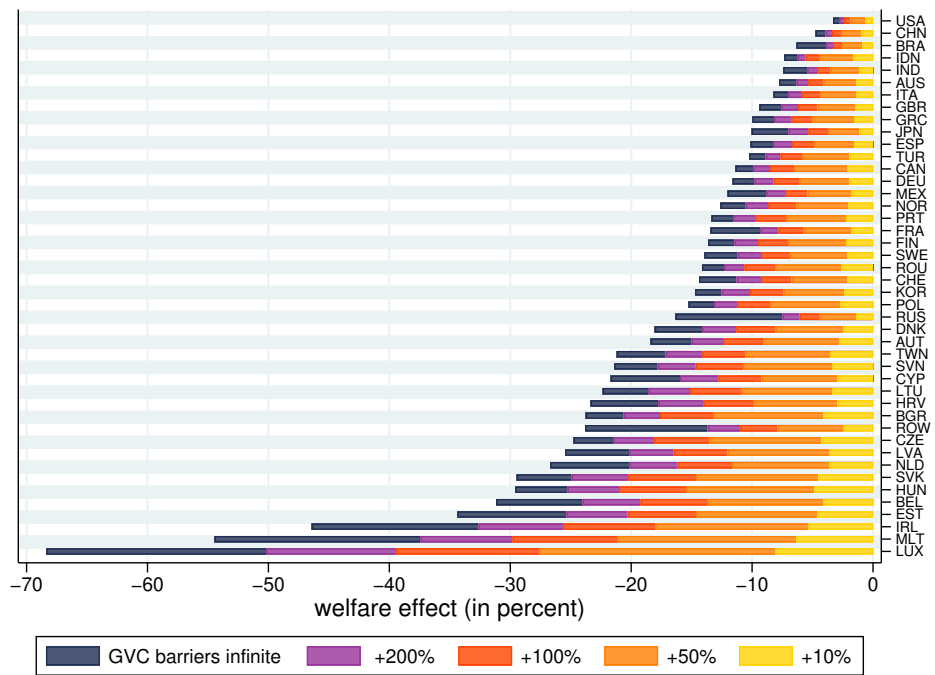


Figure A.5: Welfare effects of U.S. decoupling for individual countries

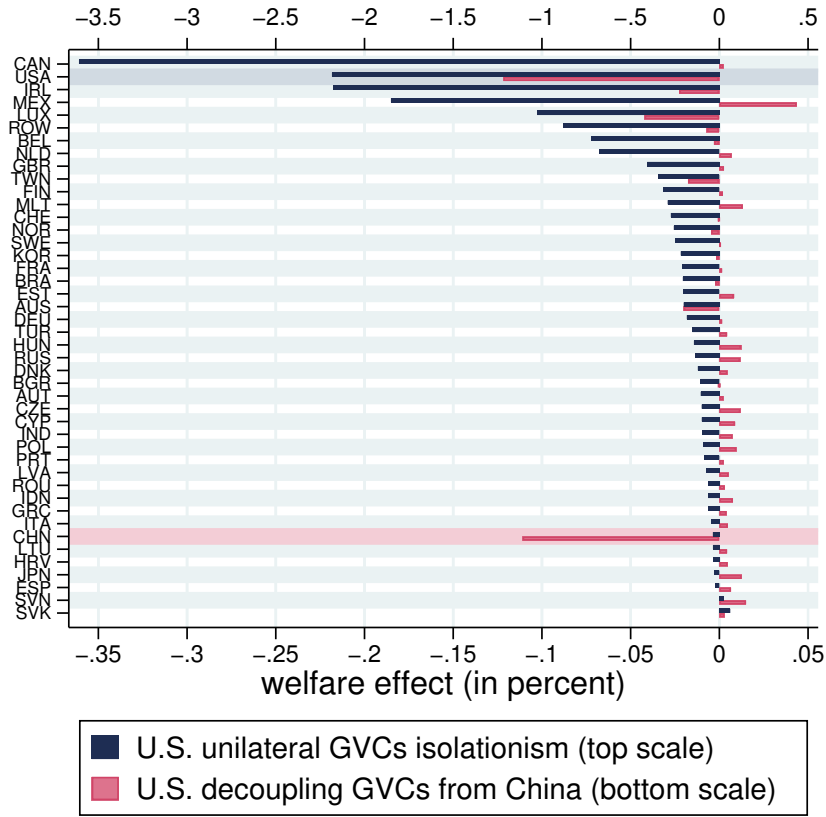


Figure A.6: Welfare effects of Covid-19 shock after partial decoupling

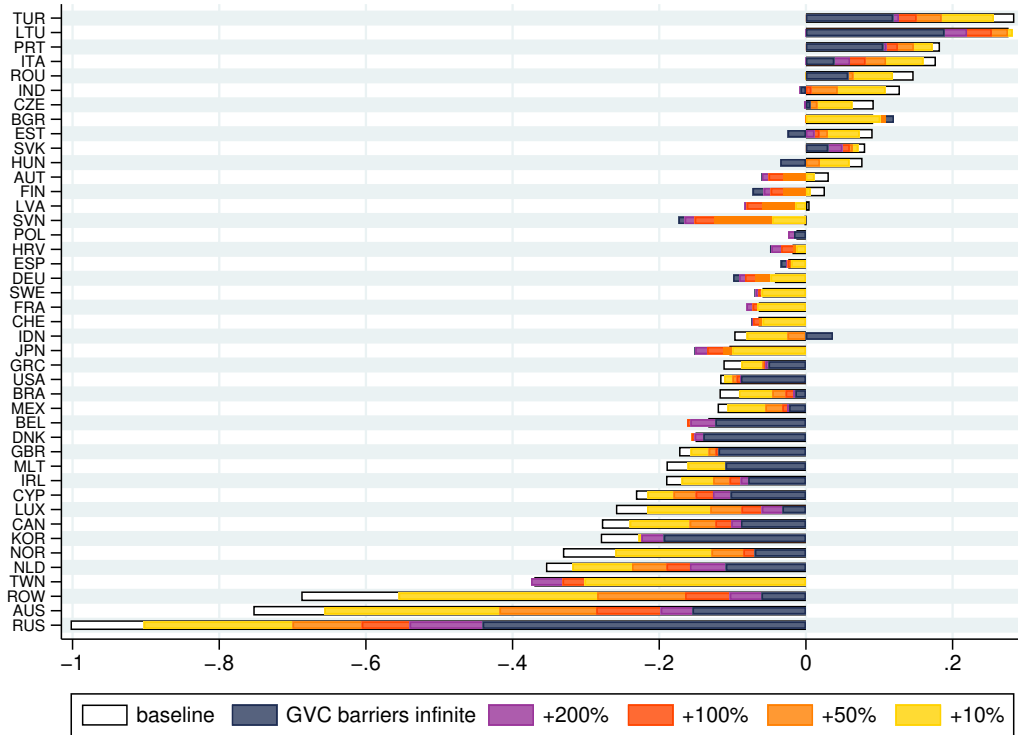


Figure A.7: Welfare effects of Covid-19 shock after shutting down GVCs vs. final goods trade

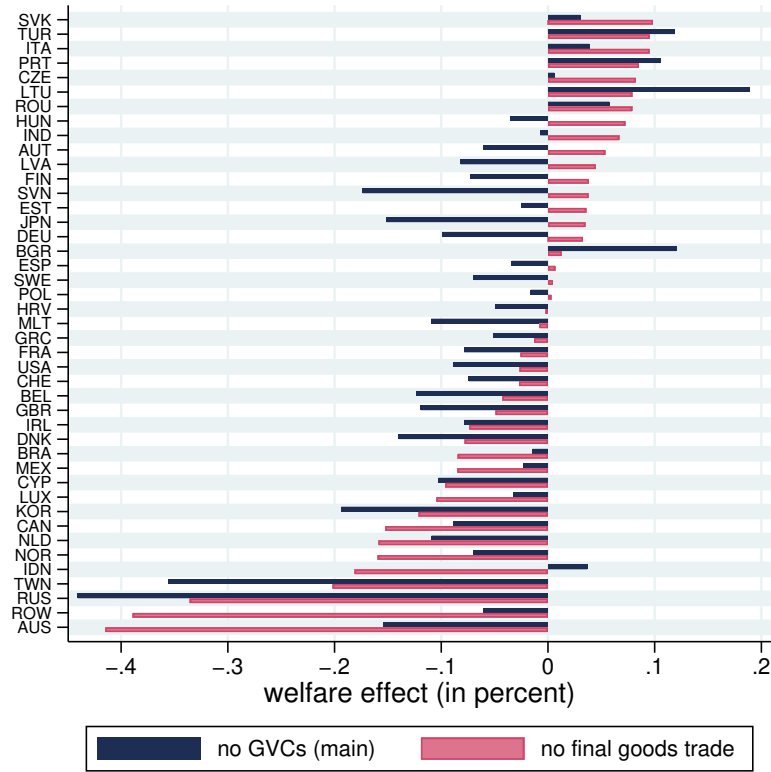


Figure A.8: Welfare effects of Covid-19 shock after decoupling China from GVCs

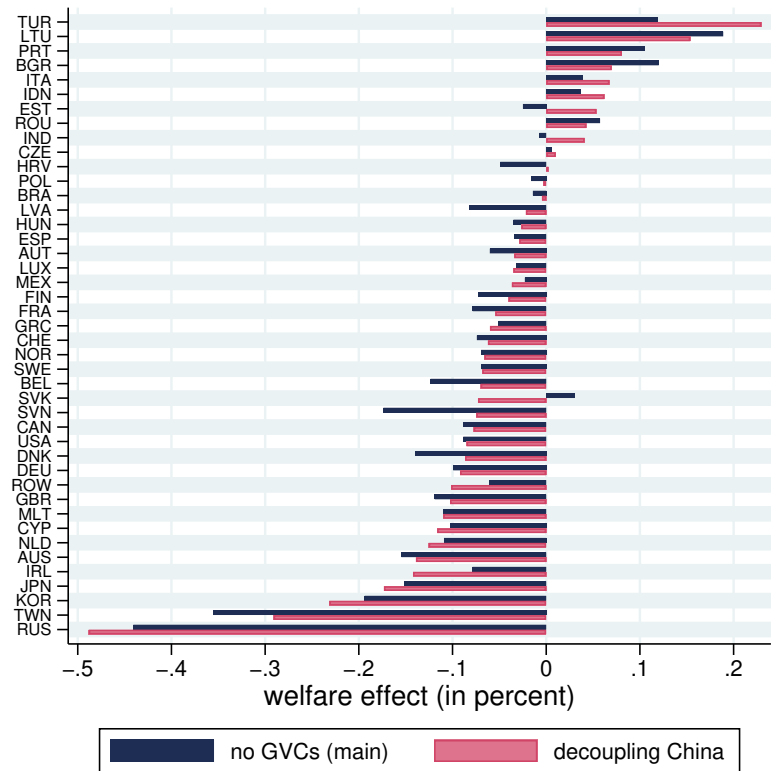




Figure A.9: Welfare effects of Covid-19 shock for varying intersectoral labor mobility

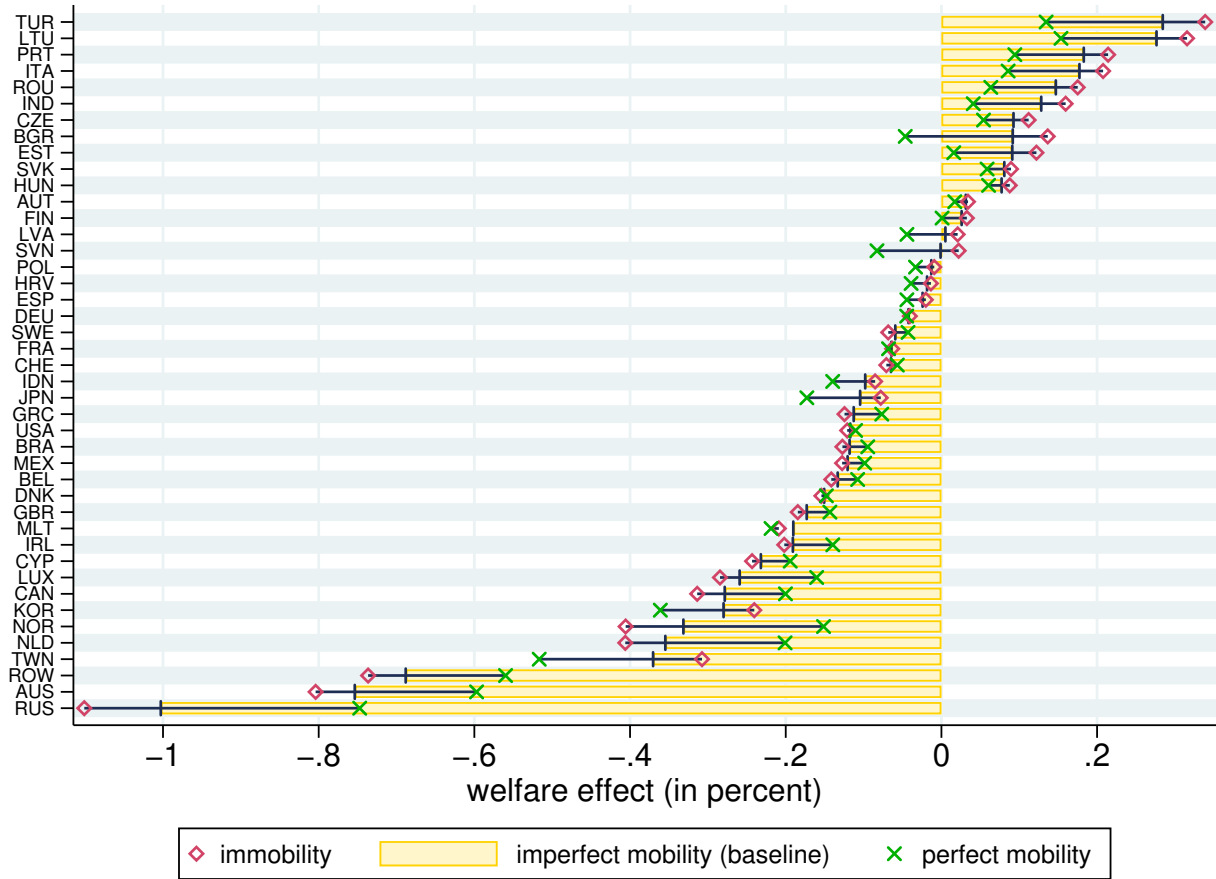


Figure A.10: Welfare mitigation effects of shocks hitting all trade partners simultaneously

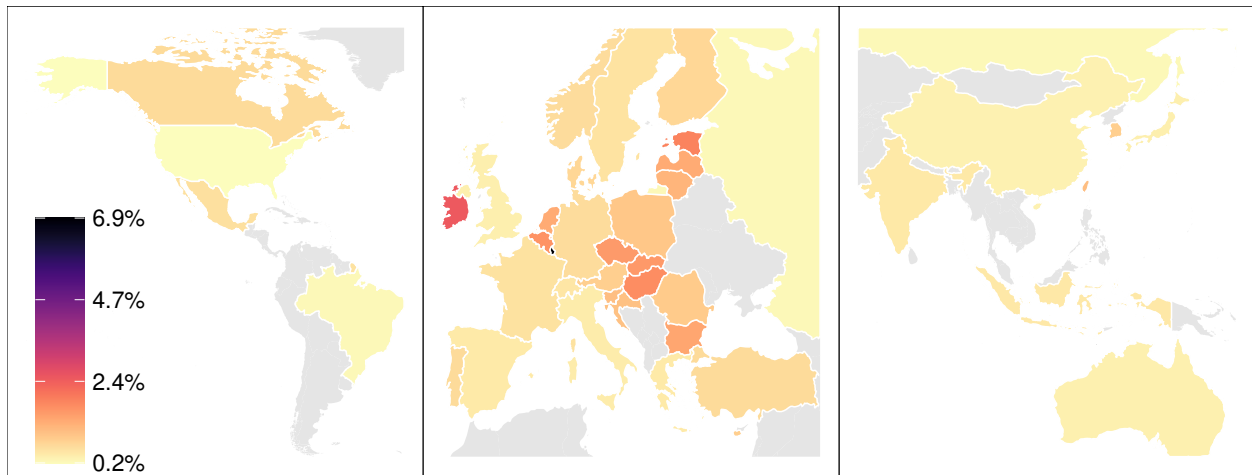


Table A.4: Variations of U.S. unilateral decoupling and shock transmission

| Scenario                                 | Decoupling | Covid-19 shock<br>(after decoupling) | Cumulative effect<br>(decoupling+shock) | Difference<br>to baseline |
|--|------------|--------------------------------------|---|---------------------------|
|  | (1)        | (2)                                  | (3)                                     | (4)                       |
| <b>A. Imperfect mobility</b>             |            |                                      |   |                           |
| Baseline                                 |            | -0.12                                |   |                           |
| U.S. unilateral GVCs isolationism        | -2.18      | -0.13                                | -2.31                                   | -2.20                     |
| U.S. input import barriers +10%          | -0.39      | -0.12                                | -0.50                                   | -0.39                     |
| U.S. input import barriers +50%          | -1.19      | -0.12                                | -1.32                                   | -1.20                     |
| U.S. input import barriers +100%         | -1.59      | -0.13                                | -1.72                                   | -1.60                     |
| U.S. input import barriers +200%         | -1.88      | -0.13                                | -2.01                                   | -1.89                     |
| <b>B. Immobility all countries</b>       |            |                                      |   |                           |
| Baseline                                 |            | -0.12                                |   |                           |
| U.S. unilateral GVCs isolationism        | -2.18      | -0.14                                | -2.33                                   | -2.21                     |
| <b>C. Perfect mobility all countries</b> |            |                                      |   |                           |
| Baseline                                 |            | -0.11                                |   |                           |
| U.S. unilateral GVCs isolationism        | -2.18      | -0.10                                | -2.28                                   | -2.17                     |
| <b>D. Immobility U.S.</b>                |            |                                      |   |                           |
| Baseline                                 |            | -0.12                                |   |                           |
| U.S. unilateral GVCs isolationism        | -2.18      | -0.13                                | -2.32                                   | -2.20                     |
| <b>E. Perfect mobility U.S.</b>          |            |                                      |   |                           |
| Baseline                                 |            | -0.11                                |   |                           |
| U.S. unilateral GVCs isolationism        | -2.18      | -0.12                                | -2.30                                   | -2.19                     |

The table reports for different variations of the ‘U.S. unilateral GVCs isolationism’ scenario the U.S. welfare effects (in percent of baseline welfare) from decoupling itself (in column 1) and from the Covid-19 shock in China after decoupling (in column 2). Column 3 reports the cumulative effect from decoupling and the shock and column 4 reports the difference between this cumulative effect and the welfare effect of the shock in the baseline world. Panel A considers partial decoupling, maintaining the assumption of imperfect mobility in all countries. Panels B–C vary intersectoral labor mobility in all countries, while Panels D–E vary intersectoral labor mobility only in the U.S., while maintaining the assumption of imperfect mobility in all other countries.