Cutting Global Value Chains To Safeguard Against Foreign Shocks?*

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Abstract

The supply chain contagion sparked by the Covid-19 pandemic has brought an important question to the forefront of the policy debate: Can cutting global value chains (GVCs) benefit a country by shielding it from foreign shocks? Using a quantitative trade model we find that shutting down GVCs causes substantial welfare losses in all countries. In this counterfactual world without GVCs, the international repercussions of a Covid-19 shock in China are reduced on average, but magnified in some countries. A unilateral repatriation of all GVCs by the U.S. would reduce national welfare by 1.6% but barely change U.S. exposure to a foreign shock. More generally, we find across a wide range of scenarios that the reduction in shock exposure due to decoupling does not compensate the direct welfare costs.

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 increasing participation in international trade and global value chains (GVCs) experienced in the post-World War II era has slowed down drastically (Antràs, 2020). This retreat from global economic integration has been aggravated by the recent political and public 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—labeled "slowbalisation" by The Economist (2019)— by providing a novel rationale for protectionism. As firms around the world are suffering from 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 safeguard against foreign shocks?[1]

The response to this question provided by a range of politicians is clear-cut: 'decoupling', 'repatriation', or 'renationalization' of GVCs has been advocated in many countries (see, e.g., Farage, 2020; Trump, 2020; Reuters, 2020). 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 answer 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 the U.S., inspired by trade policy efforts under the Trump administration. 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 2020, i.e., before the epidemic turned into a pandemic.[2] To isolate the role of

[1] While GVCs disruptions have been occurring even 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).

[2] 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).

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 by the U.S., 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 for all possible country combinations whether unilateral decoupling can be beneficial to safeguard against adverse foreign shocks in any other country to obtain a general answer to our main question.

The framework we use for our analysis is a generalization of the quantitative Ricardian trade model 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. It also differs from a (gradual) return to autarky (as simulated in the contemporaneous studies by Bonadio et al., 2020, and Sforza and Steininger, 2020) in allowing for final goods trade. Third, we model imperfect intersectoral mobility of labor (similar to Galle et al., 2018), to allow for the possibility that workers may not seamlessly relocate across sectors after a shock.

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 the 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 global supply linkages for almost a decade (Costinot and Rodriguez-Clare, 2014), the unique feature of this database has rarely been exploited to date: The fact that the WIOD distinguishes a given trade flow not only by country and sector of origin but also by the use category (i.e., final consumption vs. sectoral intermediate use) of the destination country.[3] This feature allows us to simulate the 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. More specifically, we estimate the output drop in Chinese sectors in January–February 2020 from 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 the rest of the world, similar to the methodology in Allen et al. (2020). By inverting the model for the zeroth degree effect, we recover the underlying shocks to efficient labor supply by sector from the output

[3] Antràs and Chor (2018) make use of this distinct feature in 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.

drop.

In the following we preview our main findings on the effects of decoupling and global shock transmission. We find that a worldwide decoupling from GVCs causes welfare losses in all countries, ranging from -38% in Luxembourg to -2.5% in the U.S. The largest welfare losses accrue to small, highly integrated economies (such as Luxembourg, Malta, Estonia, and Taiwan), while the losses are smallest for large economies that can revert to their own intermediate inputs after decoupling (such as the U.S., Brazil, and China). More generally, we identify a country's participation in intermediate goods trade as a key driver of its welfare losses from GVCs decoupling. Specifically, the ratio of aggregate intermediate exports plus imports over the sum of aggregate production and use has a correlation coefficient of 93% with the welfare effects. Furthermore, we 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 -1.6% of domestic welfare and imposes a welfare loss on almost all other countries. Interestingly, the U.S. neighbors Canada and Mexico lose even more than the U.S. itself. The picture is somewhat different if the U.S. unilaterally repatriates only its GVCs from China. While welfare both in the U.S. and in China drops (by -0.12% and -0.10%, respectively), a large number of countries benefit from this policy due to trade diversion, most notably Mexico.

To shed light on the role of trade and GVCs in international shock transmission, we first 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.[4] In the baseline world, the drastic negative supply shock in China has moderate spillovers to all other countries, with welfare effects ranging from -0.85% in Russia to +0.18% in Turkey. We then shut down GVCs by setting the cost of international trade in intermediate goods to infinity 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 20% 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. The cross-country patterns are similar when GVCs are shut down only partially (rather than entirely).

[4]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.

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. repatriates all of its value chains (which costs -1.6% of domestic welfare) the negative effect of the shock in China on the U.S. remains almost unchanged. Also policy scenarios of decoupling that are more targeted (against China) or internationally coordinated (with the EU) only lead 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. These 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 remains a losing game.

Our investigations of generic shocks occurring individually in all countries confirm this main insight. We show that if an economic shock of comparable magnitude hits any country in the world, no trading partner can significantly reduce its exposure to the negative welfare effects by decoupling from GVCs. Simulating shocks and GVCs decoupling for all possible country combinations, the mitigation effects are by orders of magnitude smaller than the losses from decoupling in all cases. Hence, our findings generally negate the question whether or not a country can protect itself — in terms of the total welfare effect — from foreign shocks through a repatriation of value chains.

This paper builds on recent innovations in the literature developing quantitative trade models with input-output linkages in the tradition of Caliendo and Parro (2015). Specifically, two recent papers emphasize the role of GVCs in amplifying the effects of protectionist trade policies, such as Brexit (Cappariello et al., 2020) or dissolving 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. Our approach complements the recent analysis by Caliendo et al. (2018), who isolate the role of intersectoral and interregional trade linkages in transmitting productivity shocks within the U.S. economy.

Our work also contributes to the fast growing literature studying the economic impact of the Covid-19 pandemic and the proposed policy responses. 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). 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.[5] These papers aim at quantifying the impact of quarantine and social distancing measures

[5] 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.

taken in many countries around the world, while we focus on the initial shock in China. A distinguishing 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 recent overview). 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, and Boehm et al., 2019, and Carvalho et al., 2020). We complement these studies with a quantitative exercise demonstrating that, for some countries, international shock transmission might 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 international shock transmission. Section 6 concludes.

2 The model

Our baseline model is strongly related to Antràs and Chor (2018), who extend the multi-sector Eaton-Kortum model by Caliendo and Parro (2015) to allow for varying trade costs for intermediates and final goods, thus being able to exactly match each entry in multi-country I-O tables (i.e., each flow by country-sector and country-use category). A new element that we introduce into this framework is heterogeneity of workers in terms of the efficient labor they can provide to different sectors. This approach has two important advantages for our application. First, it adds realism by acknowledging the imperfect mobility of labor across sectors that seems appropriate in our setting. Second, it allows us to analyze 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 j and i, in which S sectors indexed by s and r 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 and we consider different scenarios concerning their mobility across sectors, ranging from immobility in the short run over imperfect mobility in the medium run and perfect mobility in the long run. 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 $s \in \{1, ..., S\}$. Aggregate consumption C_j in country j is given by

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

and α_{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:

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

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

SECTORAL MOBILITY. We assume that if individual Ω 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

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

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 δ_{js} and independent of our choice of φ. The parameter δ_{js} will turn out to be our key shock parameter. A reduction in δ_{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 sectoral mobility, workers pick sector s if it offers them the highest compensation.

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

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

Notice that our approach 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

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

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 goods.

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

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

where $\gamma_{js}, \gamma_{jrs} \in [0, 1]$ are the cost shares of labor and intermediates from each sector in production, and where $\gamma_{js} + \sum_{r=1}^{S} \gamma_{jrs} = 1$. Following Eaton and Kortum (2002), 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 ε_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 ω 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 $u \in \{1, \ldots, S+1\}$, which can be one of the S sectors using the variety as an intermediate or it can be final demand. Thus, $\tau_{ijru} \geq 1$ units have 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 ω from sector r in country i is offered to use category u in country j can be expressed as

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

As prices depend on productivities, they inherit their stochastic nature. In particular, under the assumption that variety ω 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 as well as the share π_{ijru} that country i makes up in use category u's expenditure in country j on sector r:[6]

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

and

$$\pi_{ijru} = \frac{T_{ir}\left[\tau_{ijru}c_{ir}\right]^{-\varepsilon_r}}{\sum_{k=1}^{J} T_{kr}\left[\tau_{kjru}c_{kr}\right]^{-\varepsilon_r}}\ . \tag{8}$$

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

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

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

$$c_{js} = \chi_{js} w_{js}^{\gamma_{js}} \prod_{r=1}^{S} P_{jrs}^{\gamma_{jrs}}\ , \tag{10}$$

[6] A detailed derivation of the price index and these shares can be found in Appendix A.1.

with $\chi_{js} = \gamma_{js}^{-\gamma_{js}} \prod_{r=1}^{S} \gamma_{rjs}^{-\gamma_{rjs}}$ 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:

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

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

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

Goods market clearing. In equilibrium, goods market clearing requires that the value of production in country j and sector s equals the value of world final and intermediate goods demand for that sector:

$$R_{is} = \sum_{j=1}^{J} \sum_{u=1}^{S+1} \pi_{ijsu} E_{jsu} . \tag{13}$$

Factor Market Clearing. In equilibrium, wages adjust such that factor markets clear. Specifically, combining sectoral labor compensation (9) with the definition of the per capita wage 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

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

It is instructive to point out two extreme cases. First, as φ approaches infinity, all workers draw the same parameter δ_{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/δ_{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 $\gamma_{js}R_{js}/L_{js}$.[7]

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 α_{js} and σ_s, cost shares γ_{js} and γ_{jrs}, sectoral and labor productivity distribution parameters T_{js}, δ_{js}, ε_s and φ, 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. 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 $\hat{T}_{ir}$, 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 α_{ir}, cost shares γ_{ir} and γ_{irs}, distributional parameters ε_r and φ, as well as labor endowments L_i, trade shares π_{ijru}, and revenues R_{ir} in the ex-ante equilibrium:

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

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

where we use expenditures from (11) and (9), trade shares (8), marginal costs (10) and factor prices

[7] This scenario cannot be captured by letting φ approach 0 since, due to the nature of the Fréchet distribution, the average productivity of workers is not well defined for $\varphi \leq 1$.

(14), all expressed in changes:

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

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

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

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

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

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 most recent release of the WIOD, which provides annual time-series of the world input-output tables from 2000 to 2014. It covers 43 countries, jointly accounting for more than 85% of world GDP, and an artificial 'rest of the world' (see Table A.1 in Appendix A.3 for a list of countries and their ISO codes). The input-output data are available at the level of 56 sectors classified according to the International Standard Industrial Classification Revision 4 (see Table A.2 in Appendix A.2 for a list of sectors). In our baseline analysis, we use the 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 Rodriguez-Clare (2014) in recalculating all flows in the WIOD as if positive inventory changes had been consumed and negative inventory changes produced in the current period. Second, 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).[8] Third, 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 Rodriguez-Clare (2014)) and examine all shocks starting from this counterfactual scenario.

From the WIOD we take initial values for the trade shares (π_{ijru}) and the Cobb-Douglas structure of our model allows us to recover from the same data the values for cost shares (γ_{ir} and γ_{irs}) and expenditure shares (α_{js}).[9]

We take the values for trade elasticities (ε_r) from Felbermayr et al. (2018), who estimate them from a structural gravity model. The sectoral elasticities are reported in column 2 of Table A.3. We set the baseline sectoral labor mobility parameter (φ) to 1.5 (following Galle et al., 2018) and vary its value in the sensitivity analysis.

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 and 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

[8]It should be noted that this treatment of zeros does not significantly affect our baseline results, as the welfare effects in all countries are identical to those reported below to at least 6 digits precision.

[9]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 τ_{ijru}.

were recorded on he 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.

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 2014 WIOD. 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 in sectors for which more 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 in Appendix A.2 provides the details on the selected time series and a concordance table of NBS and WIOD sectors (both following the International Standard Industrial Classification Rev. 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):

$$\textit{Covid-19 impact}_{st} = \Delta Y_{st} - E[\Delta Y_{st}]. \tag{22}$$

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:

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

where u_{st} is the AR(1) disturbance, ρ 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.[10] 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.

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.[11] The estimates show that the impact was dramatic. The average sectoral output declined by 30% compared to its expected 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 the virus and the lockdown. Only few sectors experienced no significant drop or even a slight increase in output, in particular the oil extraction and telecommunication 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 WIOD sectors according to Table A.2 and aggregated at the level of WIOD sectors, weighted by initial values in January–February 2019. Table A.3 reports in column 3 the estimated drop in output 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), and in view of lengthy international shipping times and firms' inventory holdings, 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 trade models that the full general equilibrium response to a shock can be

[10]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.

[11]The autocorrelation plots for the AR(1) model residuals, depicted in Figure A.2, demonstrate that there is no significant autocorrelation pattern remaining.

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 until the general equilibrium is reached). In this spirit, we define the 'zeroth degree' effect in the current application focused on output drops in January-February 2020 as adjustments in China only, disregarding any response in the rest of the world or feedback effects thereof on China. Moreover, in consideration of warehousing, transportation times and binding contracts driving real world economies we take intermediate and final good prices to be fixed in our short term exercise. Finally, we assume that the short term view also restricts workers to be (sectorally) immobile. 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 equation (19), and (20) to derive the underlying sectoral labor efficiency shocks in China given that sectorally immobile labor implies $\hat{w}_{ir} = \hat{R}_{ir}/\hat{\delta}_{ir}$. [12] Thus,

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

Table A.3 reports in column 4 the labor supply shocks by sector in China. These shocks do not correspond one to one to the estimated revenue 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 versus 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 0.92.

4 Decoupling GVCs

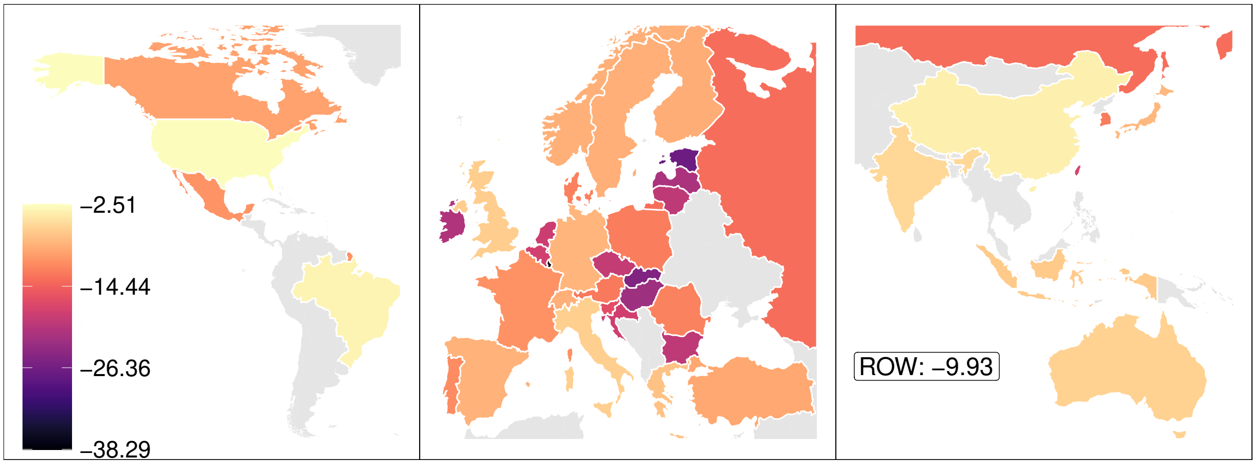
4.1 A world without GVCs

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 (τ_{ijru}) to infinity among all country pairs $ij, i \neq j$, 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.

Figure 1 shows the welfare effects of a complete decoupling. It turns out that all countries in the

[12] For the full derivation see appendix A.1.3.

Figure 1: Welfare effects of decoupling GVCs



WIOD lose from shutting down GVCs. The largest welfare losses are incurred by small, highly integrated EU economies such as Luxembourg (-38%), Malta (-32%) or Estonia (-28%), whose overall dependence on international trade is high. The strongest welfare reductions outside the EU are found in Taiwan (-18%), also a highly integrated small economy, followed by Russia (-13%). For the latter country, 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 its exports, which in turn explains the large losses from shutting down this type of trade. Conversely, the smallest welfare losses are incurred by large countries with low export and import shares and relatively small shares of intermediates in these trade flows: the U.S. lose -2.5%, Brazil -3.3% and China -3.5%.

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 93% with the welfare effects.

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.

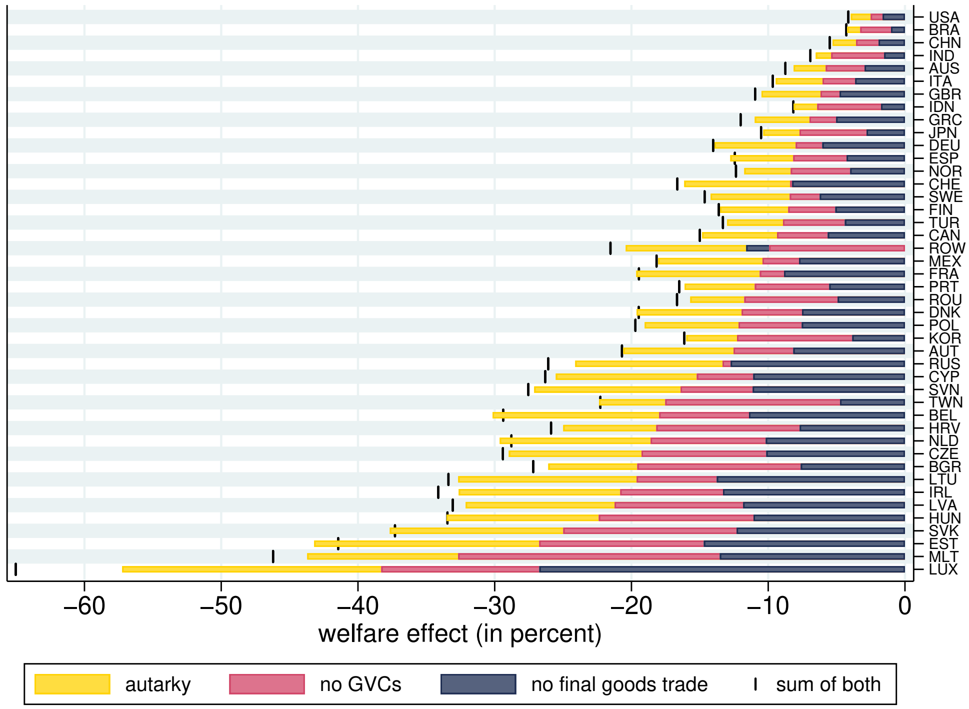
The welfare effects of a shutdown of GVCs except within the EU are summarized and compared to the baseline scenario of no GVCs at all in Figure A.3 in Appendix A.3. In comparison to the complete decoupling, this scenario leads to substantially smaller welfare losses in all EU countries, reflecting the importance of intra-EU value chains. By contrast, the predictions for non-EU countries remain almost unchanged. As a consequence, the largest welfare losses in this scenario are experienced by Taiwan (-17%), Russia (-13%), and Korea (-12%). Luxembourg still has the highest welfare losses of all EU countries and ranks fourth from the bottom, but its loss is cut from -38% to -10%. At the top of the ranking, the losses to Italy, Germany, the U.K., and France now lie in the range of -2.5% to -2.6% and are thus comparable to those in the U.S.

Next, we consider a partial decoupling of GVCs by increasing barriers on international trade in intermediate goods stepwise by 10%, 50%, 100%, and 200%. Figure A.4 in Appendix A.3 shows that the welfare effects of decoupling GVCs in this way are monotonically decreasing in the size of the trade barriers for all countries with their ranking very stable across the different scenarios. Moreover, the effects are generally falling at a diminishing rate: In the vast majority of countries, the welfare losses from increasing barriers to GVCs from zero to 10% exceed those from 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 even at very high costs.[13]

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, except for the synthetic rest of the world. 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. This pattern 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.

[13] 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 good abroad.

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



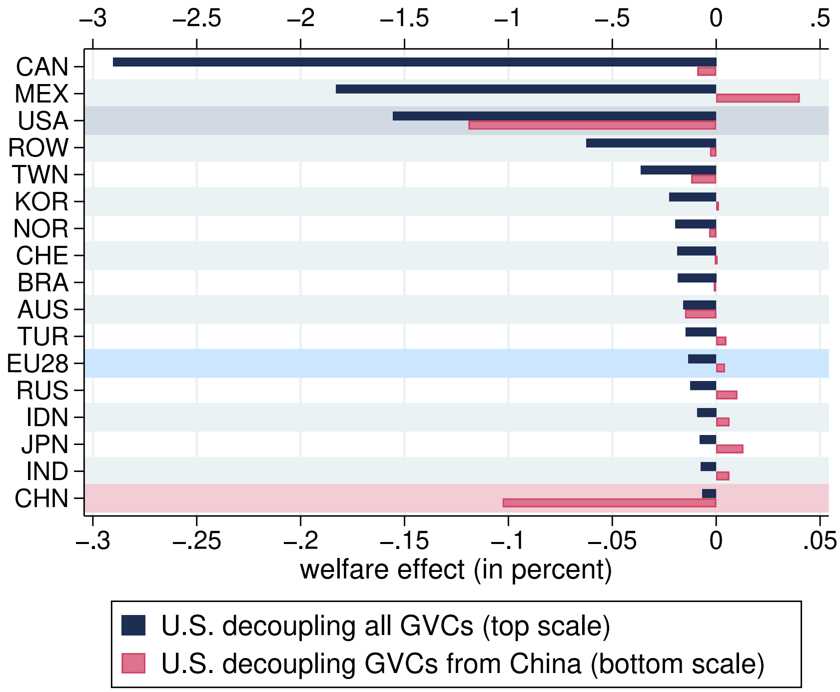
4.2 U.S. DECOUPLING

The complete shutdown of GVCs studied in the previous section is an interesting benchmark, but it is also an extreme scenario and unattainable by any individual country's trade policy. To bring the analysis closer to the ongoing debate on the decoupling or 'repatriation' of value chains, we investigate in this section more realistic policy 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 policy scenarios by increasing trade barriers on U.S. imports of intermediate inputs (but not on final goods) either (i) from all countries, or (ii) only from China. To obtain a clear picture, we set these barriers to prohibitive levels (as in the no-GVCs scenario). 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).

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

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



(population-weighted) average welfare effect for the EU28 in the main text.[14] We find that if the U.S. fully decouples from all GVCs, U.S. welfare drops by a sizeable -1.6%. Interestingly, the two neighboring countries – Canada and Mexico – would suffer even more from such a policy due to their strong GVCs ties with the U.S. and their 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 Slovakia and Cyprus), suggesting that U.S. GVCs participation is beneficial to the world as whole. Among all other countries, China is 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 -0.12% in the U.S. and by -0.10% 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.

[14]Figure A.5 in the Appendix shows the effects on all individual countries.

5 Global shock transmission

5.1 Covid-19 shock transmission in a world without GVCs

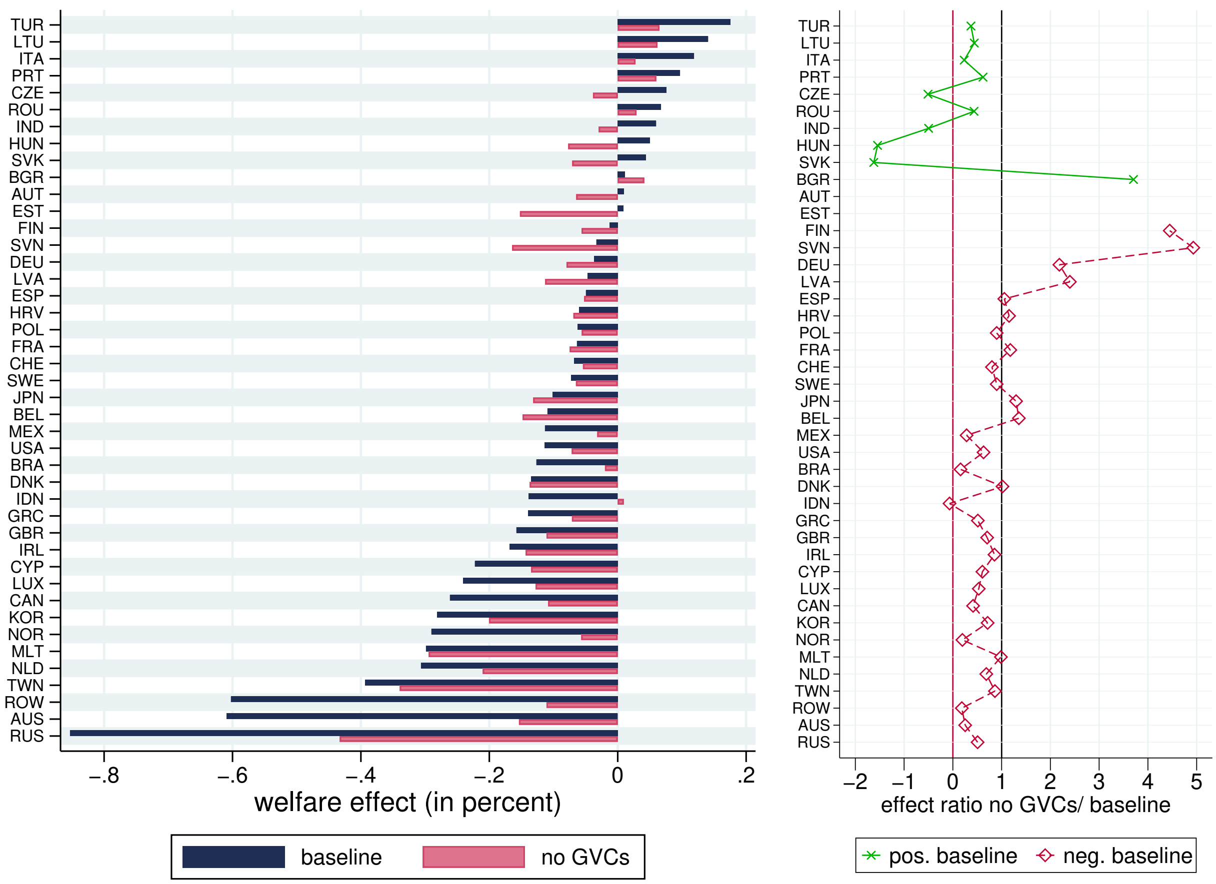
We now turn to our analysis of international shock transmission in a world with versus without GVCs. To this end, we focus on the global repercussions of the Covid-19 shock in China in early 2019, as a realistic example of a major shock to production. Notably, we consider a shock that remains confined 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 -30.4% in the new general equilibrium. In a world without GVCs, the impact on China would be slightly aggravated (-30.9%) since it becomes impossible to substitute domestic inputs with imports when productivity for the former falls.

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 -0.85% in Russia to a gain of +0.18% 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. (-0.11%) and Germany (-0.04%) experience small negative effects. Interestingly, twelve countries enjoy moderate welfare gains due to the adverse supply shock in China. Besides Turkey and India, these are mostly Central, Eastern, and Baltic European countries that accessed the EU in or after 2004 (Lithuania, Czech Republic, Romania, Hungary, and Slovakia, Bulgaria, and Estonia), as well as Italy, Portugal, and Austria. 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. The welfare effects are shown as the light red bars in Figure 4(a); and to simplify the comparison, Figure 4(b) displays ratios of the effects in a 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 decoupled 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 almost all positively affected and most of the negatively affected countries, shock transmission is mitigated after decoupling (ratios between 0 and 1). This reduction amounts to -20% 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 ten countries, including Japan, Germany, and France as witnessed by ratios above 1.Third, in several countries the welfare effects of the

Figure 4: Welfare effects of Covid-19 shock with GVCs vs. without GVCs in 2014

(a) Welfare effects (b) Effect ratio: no GVCs/ GVCs



Covid-19 shock in China are reversed in a world without GVCs: Six European countries switch from winners to losers with Austria (AUT) and Estonia (EST) whose very small baseline gains are turned into larger losses, resulting in ratios of -6.9 and -17.2, respectively, are omitted from the figure in the interest of readability. In 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 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, by raising 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.[15] Moreover, compared to the welfare effects obtained from simulating the shock in the baseline, there is a 99.6% cross-country correlation when simulating it after a 10% decoupling shock. However, this correlation is reduced to

[15] Figure A.6 depicts detailed results for all scenarios.

86.7% for a 100% intermediate goods trade barriers increase and to 75.5% for a world without GVCs. There are few exceptions (including Taiwan, Poland, and Bulgaria) where 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-linearities in the welfare effects.

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).[16] This complementary exercise is illustrated in Figure A.7 in Appendix A.3 and 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, compared to the shock in a world without GVCs the sign of the welfare effects is switched from negative to positive in 10 cases but only two times in reverse. Overall, the correlation of the country-level welfare effects between the no-GVCs and no-final goods scenarios is only 58%. It is evident that inhibiting international trade in final goods as opposed to intermediates has very different implications for shock transmission.

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 example. 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 shown in Figure A.8 in Appendix A.3 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 92.0%. These findings suggest that our results from Figure 4 are mainly driven by a decoupling from China and less from reduced intermediate goods trade among all other countries. Interestingly, nine countries do slightly worse if only China is decoupled compared to a complete decoupling of all GVCs.

As we have stressed before, our model allows us to vary the degree of intersectoral labor mobility in the worldwide response to the shock. To see how alternative assumptions about mobility affect the results, Figure A.9 illustrates the extreme cases of perfect and zero labor mobility alongside the baseline effects with imperfect mobility (each in a world with GVCs). We find that the predicted welfare effects for these alternative mobility assumptions are highly correlated (by 95.5–99.6%) with the baseline results. However, in terms of the absolute magnitudes, the differences are notable. An interesting pattern is that, on the one hand, among the countries that lose most due to the shock, moving from perfect to zero mobility typically reduces the losses, with the two

[16]Shock transmission in a world without any trade is trivially zero in our model, hence we do not consider a world with all countries in autarky.

exceptions of Taiwan and the Republic of Korea. On the other hand, among the countries that experience gains or only small losses, increasing intersectoral mobility consistently leads to worse welfare effects, i.e., it either reduces (or even reverts) the gains or magnifies the losses. Since a higher domestic mobility cannot be detrimental to the country itself, these results must be due to the altered general equilibrium effects from lower mobility in other countries. In terms of magnitudes, we find that varying intersectoral mobility can make a sizeable difference relative to the size of the baseline welfare effects: For instance, Russia loses an additional -0.3% and a gain of 0.2% for Lithuania is turned into a small loss in a world with immobile labor as opposed to one with perfect mobility. 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 -36% for the median losing country (versus 20% with imperfect mobility).

5.2 Covid-19 shock transmission after U.S. decoupling

Can the welfare losses in the U.S. due to its decoupling from GVCs, discussed in Section 4.2, be justified by reduced U.S. exposure to adverse shocks from abroad, in particular from China? We provide an answer to this question in the context of the Covid-19 shock in China.

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). The last column reports the difference in welfare effects from the shock for each decoupling scenario compared to the shock taking effect in the baseline world. Thus, this column quantifies the mitigation of the shock transmission through decoupling. The first two rows list, as a reference point, the baseline world and the world without GVCs from Section 4.1. 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 none of the different scenarios of decoupling GVCs is beneficial to the U.S. on the grounds of safeguarding against the shock in China. Across all scenarios, decoupling only leads to a meager shock mitigation of never more than 0.04 percentage points in U.S. welfare. This tiny benefit is clearly dominated by the welfare losses directly caused by decoupling in each case. What is more, decoupling might not even achieve a reduction in shock transmission at all.

In the scenario labelled '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 magnified to -0.12% compared to -0.11% in the baseline scenario. This worsening adds to the direct U.S. welfare loss of -1.6% from GVCs isolationism. It is explained by a combination of two facts: First, the U.S. still 'imports' the shock from China via final

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

Scenario	Decoupling	Covid-19 shock	
	Welfare effect	Welfare effect	Difference to baseline
	(1)	(2)	(3)
Baseline	0.00	-0.11	0.00
No GVCs	-2.51	-0.07	0.04
U.S. unilateral GVCs isolationism	-1.56	-0.12	0.00
U.S.-China one-way decoupling	-0.12	-0.09	0.03
U.S.-China bilateral decoupling	-0.17	-0.08	0.04
U.S. & EU decoupling from China	-0.17	-0.08	0.04

The table reports for different decoupling scenarios the U.S. welfare effects (in percent) from decoupling and from the Covid-19 shock in China after decoupling.

goods trade, which is a relevant 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 or coordinated policy scenarios of decoupling: If the U.S. were to shut down intermediate goods imports only from China, but not from the rest of the world (U.S.–China one-way decoupling), the U.S. welfare loss due to the subsequent shock would be slightly reduced from -0.11% to -0.09%. Clearly, this reduction cannot justify the welfare loss induced by the policy itself (-0.12%). 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 in such a case, 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 can 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 the latter responds in kind. Once more, the welfare loss in the U.S. clearly outweighs the mitigation of the shock transmission.

5.3 Uniform shocks by country

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 Chinese Covid-19 shock. Put differently, we ensure 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 the effects of these shocks for our baseline scenario and in each case assess the welfare consequences around the world. Second, one by one, we decouple each country from GVCs by setting intermediate goods trade barriers only for this country to infinity. Third, we reassess how the shocks around the world now affect this country's welfare differently after decoupling. This allows us to obtain a general picture of the potential shock reduction through unilateral decoupling.

Figure 5 depicts the mitigation effect 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, each cell in the bottom row shows how a shock originating in one of the column countries is mitigated by India decoupling itself from GVCs.[17]

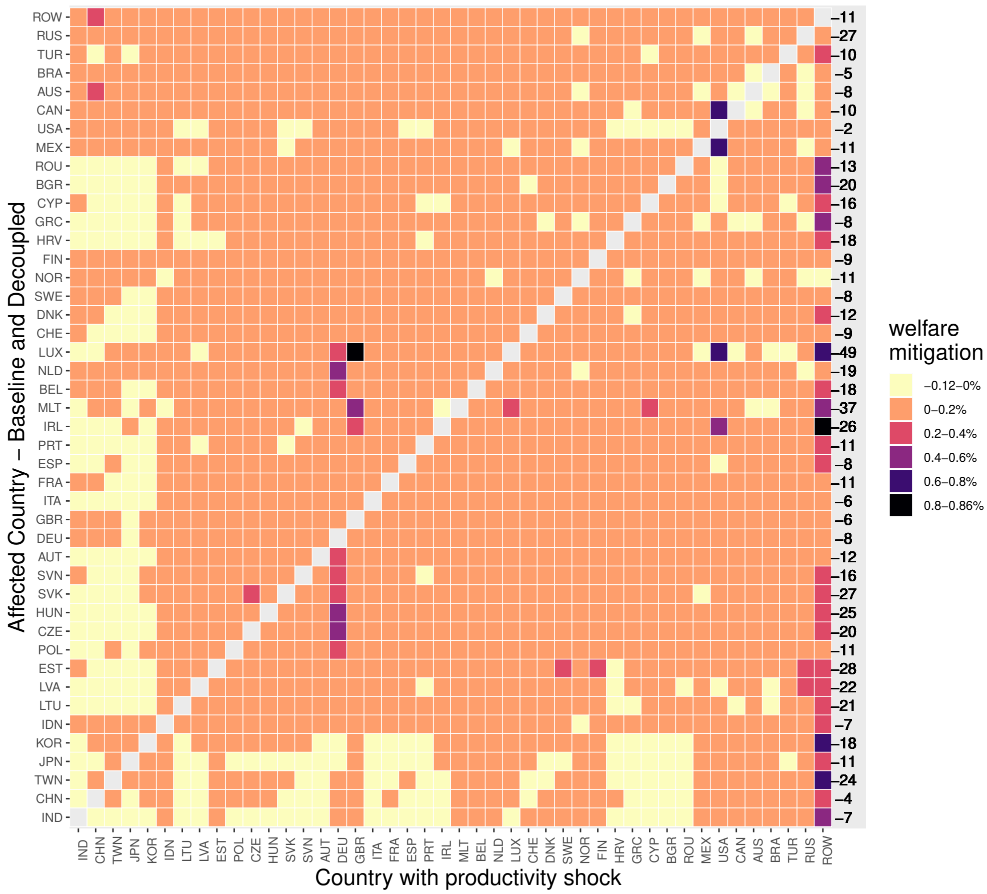
Importantly, we find that the mitigation effect of decoupling is very small throughout all bilateral scenarios, with an average of 0.3 percentage points (pp) less welfare reduction after decoupling. The largest mitigation effects are obtained when Ireland decouples and a shock hits the ROW (0.9pp), Luxembourg decouples and a shock hits the U.K. or the U.S. (0.8pp), or Taiwan decouples and a shock hits the ROW (0.8pp). Other strong combinations are mostly found for shocks occurring in the large artificial ROW, in the U.S., Germany, or the U.K.

Interestingly, the mitigation effect is negative (light areas), implying greater welfare losses through foreign shocks after decoupling, for most combinations of Asian countries with South Eastern and Eastern European Countries. Clearly, as these countries play similar roles in GVCs, they reduce their ability to serve as substitutes for the shocked country when they decouple themselves from intermediate goods trade.

Finally, the number at the end of each row indicates the initial welfare loss in percent of the country in this row due to its unilateral decoupling. It is immediately obvious that this welfare loss dominates the mitigation effects throughout and by at least one order of magnitude in most cases. We find that in the best case scenario, the U.S. decoupling itself and then experiencing a foreign

[17] Countries have been grouped according to their geographic location in Asia, Europe, North America, and the rest of the world.

Figure 5: Global shock mitigation through decoupling



shock in ROW, Mexico, or Canada leads to a total U.S. welfare loss that is 2.3 to 2.4 percentage points larger than if the same shock had hit these countries without the U.S. repatriating GVCs.

Overall, throughout all of our simulations, we find no single instance where a country can protect itself — in terms of improving the total welfare effect — by 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 lower exposure to foreign shocks does not justify substantial welfare losses from GVCs decoupling.

The key methodological contribution of this paper is to isolate the role of GVCs in the international transmission of shocks. We estimate the global repercussions of foreign shocks in a world with and without GVCs and contrast potential benefits from lower exposure to foreign shocks with the direct costs of decoupling. Motivated by the early days of the pandemic, we have examined the international transmission of a negative supply shock in China before and after decoupling. While a complete shutdown of GVCs would reduce the global repercussions of such a shock on average, the welfare effects are magnified or reversed in several countries. Focusing on U.S. trade policy, we have considered a unilateral repatriation of GVCs from all countries or only from China. In each case, the reduction in exposure to the shock in China is clearly dominated by the substantial welfare losses directly caused by decoupling.

Moreover, analyzing the effects of a similar shock in any country in the world we find that our results for the U.S. and China also hold when taking a more generalized perspective: The losses of decoupling for each country individually clearly dominate the mitigation effects that this decoupling has on a foreign shock in any partner country.

We hope that our approach of isolating the role of GVCs will prove useful also in future applications studying trade policy or the international transmission of different shocks. Since repatriation of 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:

Cutting Global Value Chains To Safeguard Against Foreign Shocks?

A.1 Theory Appendix

A.1.1 Sectoral Mobility

The probability that a given worker Ω draws a productivity for working in country j and country s that is no larger than δ is given by:

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

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

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

$$\frac{d\mathbb{G}_{js}\left(w\right)}{dw} = e^{-\frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\varphi w_{js}^{\varphi} w^{-\varphi-1}.$$

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

$$\Pr\left[\delta_{js}\left(\Omega\right) w_{js} \geq \max_{s\neq r} \delta_{jr}\left(\Omega\right) w_{jr}\right] = \int_0^{\infty} \Pr\left[\max_{s\neq r} \delta_{jr}\left(\Omega\right) w_{jr} \leq w\right] \frac{d\mathbb{G}_{js}\left(w\right)}{dw} dw$$

$$= \int_0^{\infty} \prod_{s\neq r} \Pr\left[\delta_{jr}\left(\Omega\right) w_{jr} \leq w\right] e^{-\frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\varphi w_{js}^{\varphi} w^{-\varphi-1} dw$$

$$= \int_0^{\infty} \prod_{s\neq r} e^{-\frac{\delta_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\left(\frac{w}{w_{jr}}\right)^{-\varphi}} e^{-\frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\left(\frac{w}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\varphi w_{js}^{\varphi} w^{-\varphi-1} dw$$

$$= \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} w_{js}^{\varphi} \int_0^{\infty} e^{-\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw$$

$$= \frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi} \sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi} w_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}} \int_{0}^{\infty} \left(\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi} w_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \right) e^{-\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw$$

$$= \frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}} \int_{0}^{\infty} \left(\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi} w_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \right) e^{-\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \varphi w^{-\varphi-1} dw$$

$$= \frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}} \left[e^{-\sum_{r=1}^{S} \frac{\delta_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{w}{w_{jr}}\right)^{-\varphi}} \right]_{0}^{\infty} = \frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}} \equiv \frac{L_{js}}{L_j},$$

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

$$\Pr\left[w_{js}\delta_{js}(\Omega) < w | w_{js}\delta_{js}(\Omega) \geq \max_{s \neq r} w_{jr}\delta_{jr}(\Omega) \right]$$

$$= \frac{1}{\frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}}} \int_{0}^{w} \Pr\left[\max_{s \neq r} w_{jr}\delta_{jr}(\Omega) < x \right] \frac{d\mathbb{G}_{js}(x)}{dx} dx$$

$$= \frac{1}{\frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}}} \int_{0}^{w} \prod_{s \neq r} \Pr\left[w_{jr}\delta_{jr}(\Omega) \leq x \right] e^{-\frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \varphi w_{js}^{\varphi} x^{-\varphi-1} dx$$

$$= \frac{1}{\frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}}} \int_{0}^{w} e^{-\sum_{s=1}^{S} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \varphi w_{js}^{\varphi} x^{-\varphi-1} dx$$

$$= \frac{1}{\frac{\delta_{js}^{\varphi} w_{js}^{\varphi}}{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}}} \int_{0}^{w} e^{-\sum_{s=1}^{S} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \varphi w_{js}^{\varphi} x^{-\varphi-1} dx$$

$$= \int_{0}^{w} \left(\frac{\sum_{r=1}^{S} \delta_{jr}^{\varphi} w_{jr}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \right) e^{-\sum_{s=1}^{S} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \varphi x^{-\varphi-1} dx$$

$$= \left[e^{-\sum_{s=1}^{S} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{x}{w_{js}}\right)^{-\varphi}} \right]_{0}^{w} = e^{-\sum_{s=1}^{S} \frac{\delta_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}} \left(\frac{w}{w_{js}}\right)^{-\varphi}}.$$

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:

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

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

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

$$\int_0^\infty e^{-x} \varphi x dw$$

$$= \varphi \int_{x(0)}^{x(\infty)} e^{-x} x \frac{dw}{dx} dx$$

$$= -\left(\frac{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}{\sum_s \delta_{js}^{\varphi} w_{js}^{\varphi}}\right)^{-\frac{1}{\varphi}} \int_\infty^0 e^{-x} x^{-\frac{1}{\varphi}} dx$$

$$= \left(\frac{\sum_s \delta_{js}^{\varphi} w_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\right)^{\frac{1}{\varphi}} \int_0^\infty e^{-x} x^{-\frac{1}{\varphi}} dx$$

$$= \left(\frac{\sum_s \delta_{js}^{\varphi} w_{js}^{\varphi}}{\Gamma\left(1-\frac{1}{\varphi}\right)^{\varphi}}\right)^{\frac{1}{\varphi}} \Gamma\left(1-\frac{1}{\varphi}\right)$$

$$= \left(\sum_s \delta_{js}^{\varphi} w_{js}^{\varphi}\right)^{\frac{1}{\varphi}} \equiv w_j,$$

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 (ω) in sector r is given by $p_{jru}(\omega) \equiv \underset{i}{min}\ p_{ijru}(\omega)$. Let us denote the probability $\mathbb{F}_{jru}(p)$ that this lowest price is below some price p as follows:

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

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:

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

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

$$P_{jru}^{1-\sigma_r} = \int_0^\infty \left(\frac{x}{\Phi_{jru}}\right)^{\frac{1-\sigma_r}{\varepsilon_r}} \frac{dx}{dp} e^{-x} dp = \int_0^\infty \left(\frac{x}{\Phi_{jru}}\right)^{\frac{1-\sigma_r}{\varepsilon_r}} e^{-x} dx$$

$$= \Phi_{jru}^{-\frac{1-\sigma_r}{\theta_r}} \int_0^\infty x^{\frac{1-\sigma_r}{\varepsilon_r}} e^{-x} dx = \; = \Phi_{jru}^{-\frac{1-\sigma_r}{\varepsilon_r}} \Gamma\left(\frac{\varepsilon_r + 1 - \sigma_r}{\varepsilon_r}\right),$$

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

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

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

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

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
7	Manufacture of wood & of products of wood & cork, except furniture	15	Timber, Manufacture of Wood, Bamboo, Rattan, Palm & Straw Products
8	Manufacture of paper & paper products	17	Paper & Paper Products
9	Printing & reproduction of recorded media	18	Printing, Reproduction of Recording Media
10	Manufacture of coke & refined petroleum products	20	Processing of Petroleum, Coal & Other Fuels
11	Manufacture of chemicals & chemical products	21	Raw Chemical Materials & Chemical Products
11	Manufacture of chemicals & chemical products	23	Chemical Fibers
12	Manufacture of pharmaceutical products	22	Medicines
13	Manufacture of rubber & plastic products	24	Rubber & Plastics
14	Manufacture of other non-metallic mineral products	25	Non-metallic Mineral Products
15	Manufacture of basic metals	26	Smelting & Pressing of Ferrous Metals
15	Manufacture of basic metals	27	Smelting & Pressing of Non-Ferrous Metals
16	Manufacture of fabricated metal products, except machinery & equipment	28	Metal Products
17	Manufacture of computer, electronic & optical products	34	Communication Equipment, Computers & Other Electronic Equipment
17	Manufacture of computer, electronic & optical products	35	Measuring Instruments
18	Manufacture of electrical equipment	33	Electrical Machinery & Equipment
19	Manufacture of machinery & equipment n.e.c.	29	General Purpose Machinery
19	Manufacture of machinery & equipment n.e.c.	30	Special Purpose Machinery
20	Manufacture of motor vehicles, trailers & semi-trailers	31	Automobiles
21	Manufacture of other transport equipment	32	Railway, Shipping, Aerospace & Other Transport
22	Manufacture of furniture; other manufacturing	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
23	Repair & installation of machinery & equipment	38	Repair of Metal Products, Machinery & Equipment
24	Electricity, gas, steam & air conditioning supply	39	Production & Supply of Electric Power & Heat Power
24	Electricity, gas, steam & air conditioning supply	40	Production & Supply of Gas
25	Water collection, treatment & supply	41	Production & Supply of Water
26	Sewerage; waste & disposal activities; recycling; etc.	37	Comprehensive Utilization of Waste
27	Construction	70	Investment of Real Estate, Construction
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	42	Total Retail Sales of Consumer Good
31	Land transport & transport via pipelines	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
32	Water transport	63	Passenger-Kilometers of Waterways
32	Water transport	67	Freight Ton-Kilometers of Waterways
33	Air transport	64	Civil Aviation Passenger Kilometers
33	Air transport	68	Civil Aviation Freight Ton Kilometers
34	Warehousing & support activities for transportation	400	Index of Service Production (ISP)
35	Postal & courier activities	43	Revenue from Postal Services
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 (estimated)	Labor supply shock (backed out)
(1)	(2)	(3)	(4)
1	1.956	-36.1	-41.4
2	1.869	-36.1	-25.0
3	3.584	-36.1	-40.5
4	3.584	-25.5	-28.7
5	1.634	-24.8	-19.0
6	3.584	-45.8	-62.1
7	3.584	-54.9	-68.7
8	1.037	-38.1	-55.3
9	2.042	-51.8	-78.2
10	6.039	-12.0	0.0
11	3.776	-37.5	-44.0
12	7.630	-21.7	-22.4
13	2.815	-49.0	-70.0
14	1.417	-43.3	-70.6
15	4.715	-18.9	-6.5
16	1.841	-39.7	-64.0
17	5.731	-18.1	-21.5
18	6.424	-33.4	-42.9
19	7.509	-44.1	-52.1
20	4.390	-37.6	-44.6
21	5.173	-32.1	-37.2
22	3.416	-41.5	-56.5
23	7.509	-19.1	0.0
24	5.959	-11.2	0.0
25	5.959	-15.1	-9.1
26	5.959	-33.2	-36.3
27	5.959	-26.0	-23.8
28	5.959	-27.4	0.0
29	5.959	-27.4	-27.8
30	5.959	-27.4	-27.8
31	5.959	-37.7	-40.6
32	5.959	-30.5	-33.3
33	5.959	-30.3	-36.9
34	5.959	-18.6	-12.7
35	5.959	-25.9	-26.9
36	5.959	-18.6	-14.9
37	5.959	-18.6	0.0
38	5.959	-18.6	0.0
39	5.959	-0.9	0.0
40	5.959	-20.7	-18.7
41	5.959	-18.6	-16.7
42	5.959	-18.6	-15.0
43	5.959	-18.6	0.0
44	5.959	-37.6	-39.4
45	5.959	-18.6	-15.9
46	5.959	-18.6	0.0
47	5.959	-18.6	-14.9
48	5.959	-18.6	0.0
49	5.959	-18.6	-14.9
50	5.959	-18.6	-15.3
51	5.959	-18.6	-15.1
52	5.959	-18.6	-15.4
53	5.959	-18.6	-12.9
54	5.959	-18.6	-15.5
55	5.959	-18.6	0.0
56	5.959	-18.6	0.0

The table reports for each WIOD sector r the trade elasticity ε_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).

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. Barlett's formula for MA(q) 95% confidence bands. Data source: NBS.

A.3 ADDITIONAL RESULTS

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

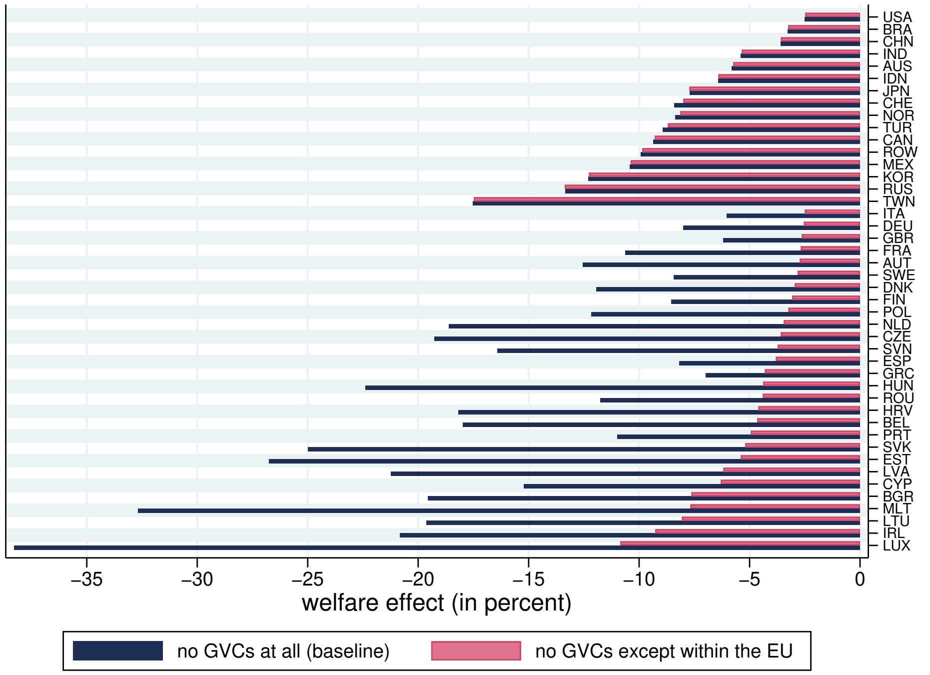

Figure A.4: Partial decoupling: Stepwise increase in intermediate goods trade barriers

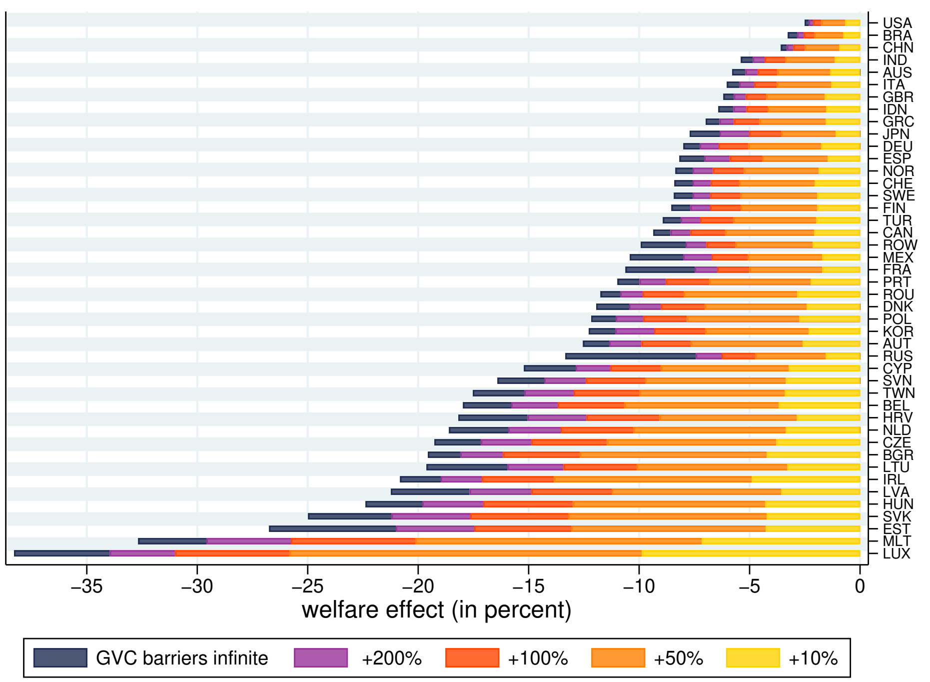

Figure A.5: Welfare effects of U.S. decoupling for individual countries

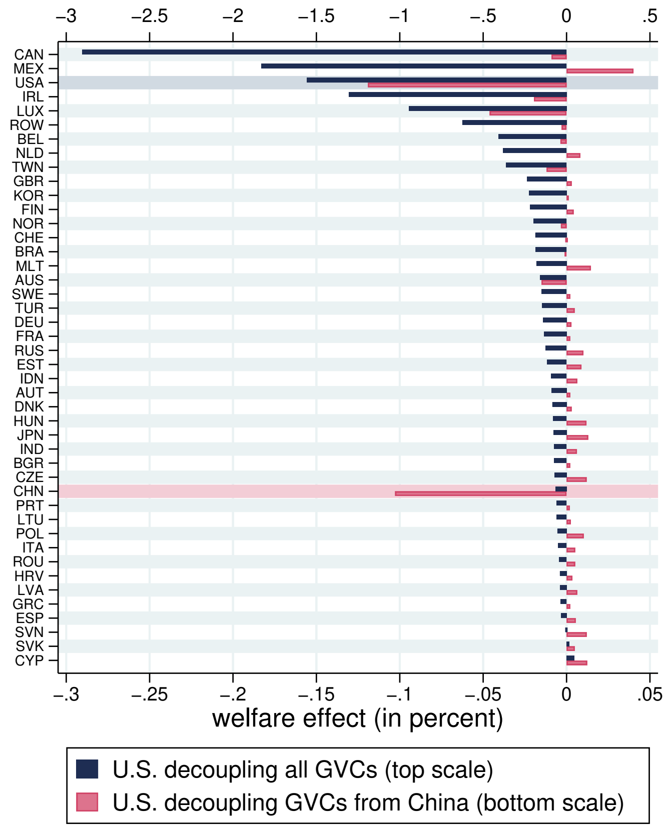

Figure A.6: Welfare effects of Covid-19 shock after partial decoupling

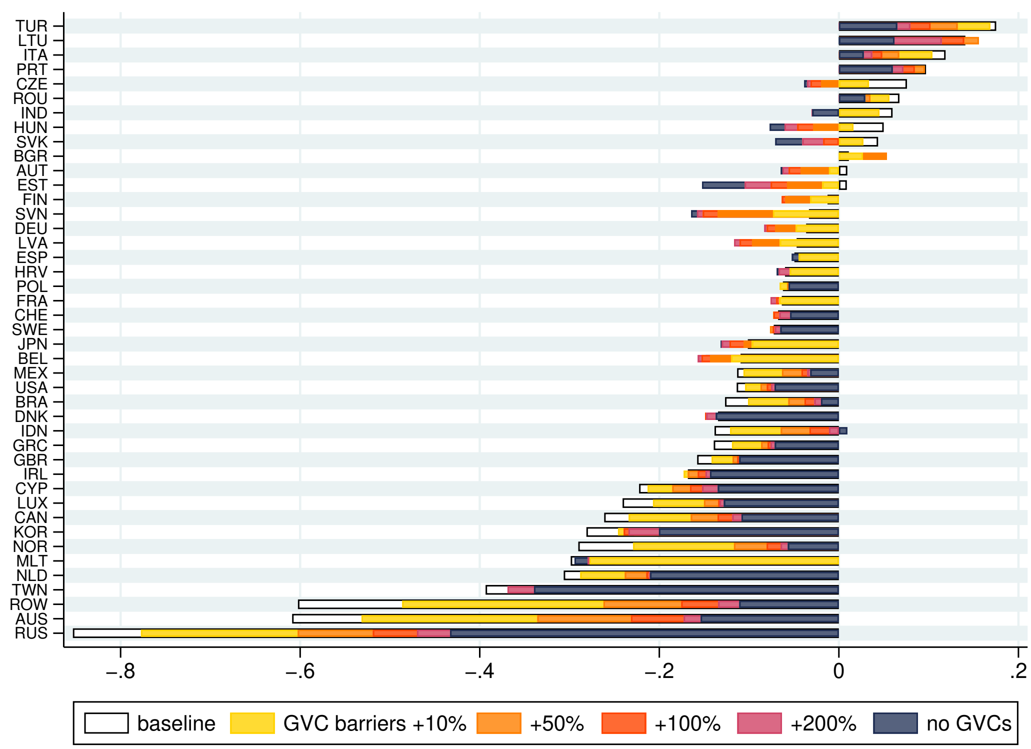

Figure A.7: Welfare effects of Covid-19 shock after shutting down GVCs vs. final goods trade

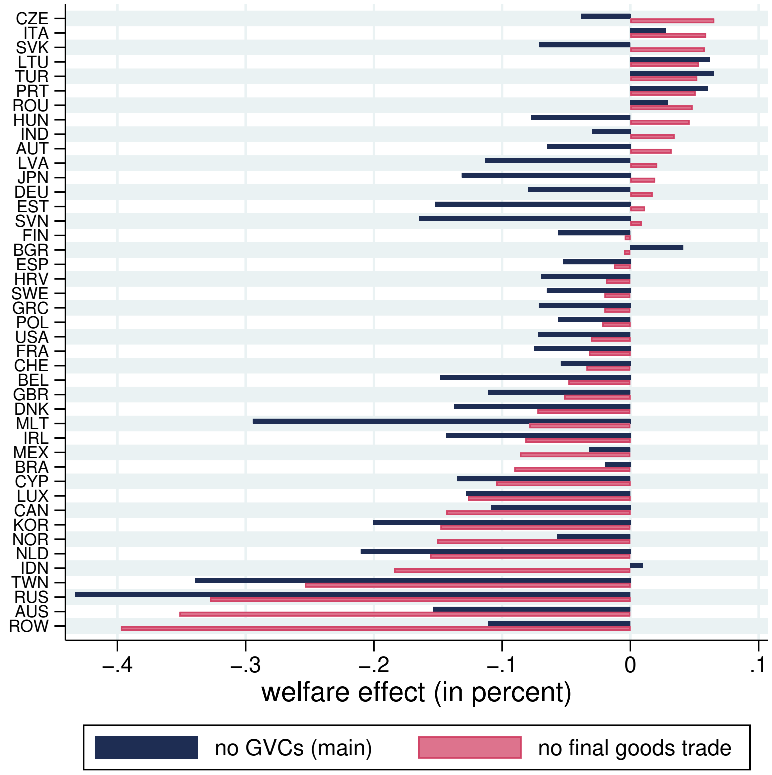

Figure A.8: Welfare effects of Covid-19 shock after decoupling China from GVCs

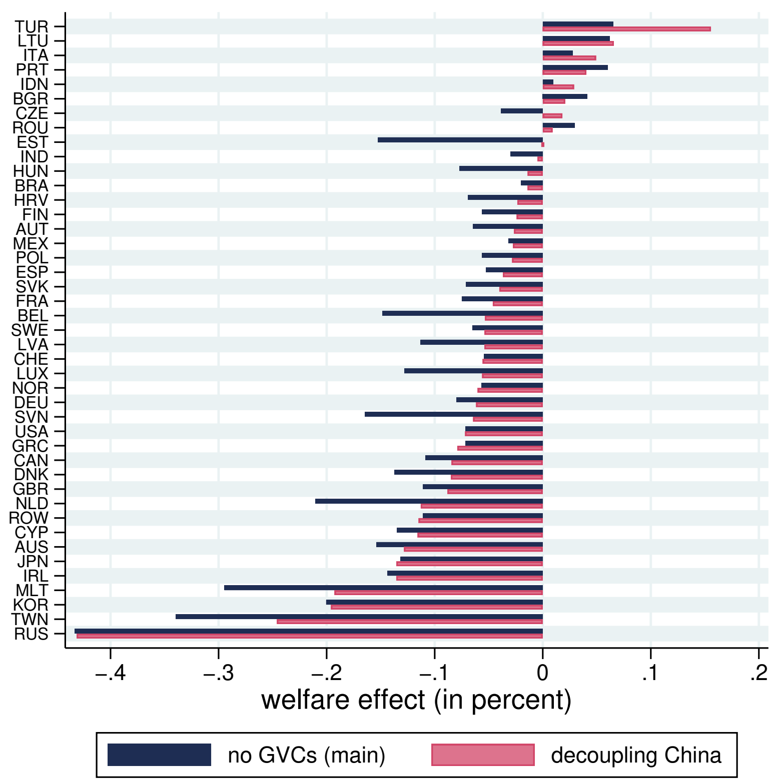

Figure A.9: Welfare effects of Covid-19 shock for varying intersectoral labor mobility