Decoupling Global Value Chains*

Peter Eppinger
University of Tübingen

Gabriel Felbermayr
Kiel Institute for the World Economy

Oliver Krebs
University of Tübingen

Bohdan Kukharskyy
City University of New York

March 12, 2021

Latest version available here

Abstract

The major disruptions to global value chains (GVCs) caused by the Covid-19 pandemic have raised an important question: Can decoupling from GVCs increase a country's welfare by reducing its exposure to foreign shocks? We use a quantitative trade model to simulate such a decoupling and its consequences for international shock transmission. Across a wide range of scenarios, we find that the large welfare losses due to decoupling clearly dominate any reductions in shock exposure. In case of the U.S., a unilateral repatriation of GVCs would reduce national welfare by 1.6% but barely change U.S. exposure to foreign shocks.

JEL codes: F11, F12, F14, F17, F62.
Keywords: Quantitative trade model, input-output linkages, global value chains, Covid-19, supply chain contagion, shock transmission.

*Earlier versions of this paper circulated as "Cutting Global Value Chains To Safeguard Against Foreign Shocks?" or "Covid-19 Shocking Global Value Chains". We thank Lorenzo Caliendo, Davin Chor, Wilhelm Kohler, Sébastien Miroudot, Alireza Naghavi, Joschka Wanner, and Erwin Winkler, as well as participants at the AEA meeting, the Empirical Trade Online Seminar, and in seminars at the City University of New York and the University of Tübingen for valuable comments. Jaqueline Hansen provided excellent research assistance. All remaining errors are our own.

1 INTRODUCTION

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

The response to this question provided by a range of politicians is clear-cut: 'decoupling', 'repatriation', or 'reshoring' of GVCs has been advocated in many countries (see, e.g., Farage, 2020; Trump, 2020).[2] 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 individual countries, with a particular focus on the U.S. We then quantify the global repercussions of a major negative supply shock in one country via international trade and GVCs. Given the importance of China as a pivotal hub in GVCs, we focus on the *initial* Covid-19 shock in China in January–February

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

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

2020, i.e., before the epidemic turned into a pandemic.[3] To isolate the role of GVCs, we simulate the impact of the Covid-19 shock in China on all other countries both before and after decoupling. In our analysis of shock transmission after unilateral decoupling, we provide an answer to the policy-relevant question of whether the direct welfare losses due to decoupling can be justified by the reduced exposure to the Covid-19 shock in China. Finally, we examine generally whether unilateral decoupling can be beneficial to *any single country* by shielding it against adverse foreign shocks in *all other countries*. Across all of these scenarios, we consistently find that the losses from decoupling far exceed any mitigation effects. Thus, the model clearly predicts that a country cannot gainfully decouple from GVCs to reduce its vulnerability to foreign shocks.

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

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 GVCs for almost a decade (Costinot and Rodríguez-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 pair and sector of origin but also by the use category (i.e., final consumption vs. sectoral

[3] 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).

[4] The same Roy-Fréchet modelling approach to labor markets has been applied by Burstein et al. (2019), Hsieh et al. (2019), and Galle et al. (2018).

intermediate use) of the destination country.[5] 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. Specifically, we estimate the output drop in Chinese sectors in January–February 2020 in an event-study design using monthly time series. This estimated output drop is conceptualized as the 'zeroth degree' effect of the shock in China, i.e., before any response by all other countries, similar to the methodology in Allen et al. (2020). By inverting the model for the zeroth degree effect, we recover the underlying shocks to efficient labor supply by sector from the output drop.

In the following we preview our main findings on the effects of decoupling and global shock transmission. We begin by simulating a world without GVCs by setting the cost of international trade in intermediate goods to infinity. We find that this worldwide decoupling from GVCs causes welfare losses in all countries, ranging from -38% in Luxembourg to -2.5% in the U.S. The largest welfare losses accrue to small, highly integrated economies (including 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. We also find that shutting down GVCs is worse than shutting down only final goods trade for all individual countries.

In our analysis of the unilateral decoupling from GVCs by the U.S., we consider two alternative scenarios: (i) the U.S. repatriates its GVCs from all countries, and (ii) it decouples only from China. In the first scenario, the U.S. loses -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 decouples 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 GVCs in international shock transmission, we consider the global repercussions of the Covid-19 shock in China. This analysis is best thought of as answering the question of how the world economy would have responded if Covid-19 had permanently reduced production in China but if infections had not spread internationally.[6] In the baseline world, the drastic negative supply shock in China has moderate spillovers to all other countries, with welfare effects ranging from -0.98% in Russia to +0.24% in Turkey. We then shut down GVCs, as outlined

[5] 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.

[6] 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.

above, and subsequently compare the shock transmission in this 'no-GVCs' scenario to our baseline predictions. We find that shutting down GVCs reduces the welfare loss due to the Covid-19 shock in China by 34% 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).

To inform the ongoing policy debate more directly, we examine how U.S. exposure to the Covid-19 shock in China would change if the shock occurred after different scenarios of U.S. decoupling. The plain answer is: not much. If the U.S. were to fully repatriate all input production (at a cost of -1.6% of domestic welfare), the negative effect of the shock in China on the U.S. would remain almost unchanged. Also policy scenarios of decoupling that are more targeted (against China) or internationally coordinated (with the EU) would lead only to a meager mitigation of U.S. welfare losses from the Covid-19 shock of 0.04 percentage points (or less). These changes clearly cannot justify the much larger direct welfare costs of decoupling to the U.S. Our findings suggest that, even if U.S. trade policy were to effectively shut down GVCs involving a specific foreign country in which a large and long-lasting shock is known to materialize, decoupling from GVCs would not be beneficial.

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

This paper adds to a growing body of literature stressing the role of input-output linkages in quantitative trade models, in the tradition of Caliendo and Parro (2015).[7] Recent work has emphasized the role of GVCs for trade policy (Blanchard et al., 2016; Grossman and Helpman, 2021; Antràs et al., 2021) , with applications to Brexit (Cappariello et al., 2020, and Vandenbussche et al., 2019), European integration (Felbermayr et al., 2020), and the WTO (Beshkar and Lashkaripour, 2020). To the best of our knowledge, our paper is the first to quantify the global welfare effects of

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

decoupling GVCs and to isolate the role of GVCs in transmitting foreign shocks.[8] Our approach complements the 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. In analyzing how a shock in China affects other countries through international trade, our paper relates to the contributions by di Giovanni et al. (2014), Hsieh and Ossa (2016), Caliendo et al. (2019), and Kleinman et al. (2020), who consider international spillovers from Chinese productivity growth.

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

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

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

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

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

2 THE MODEL

Our 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 across intermediates and final goods, thus being able to exactly match each entry in multi-country I-O tables (i.e., each flow by producing country-sector and buying country-use category). We leverage this key feature of the model to simulate the decoupling of GVCs. 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 allowing us to model the imperfect mobility of labor across sectors in response to a shock. Second, it provides us with a means to introduce the reductions in efficient labor supply by sector that are at the heart of the Covid-19 shock.

2.1 ENDOWMENTS

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

2.2 PREFERENCES AND SECTOR CHOICE

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

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

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.

INTERSECTORAL 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 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 intersectoral mobility, workers pick sector s if it offers them the highest compensation as in (Roy, 1951). Therefore, given all compensations per unit of efficient labor w_{js} in all sectors s in country j we can derive the number of workers L_{js} who pick sector s as their workplace as

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

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

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

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

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 inputs.

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 $u \in \{1, \dots, S+1\}$, which can be one of the S sectors using the variety as an intermediate input or it can be final demand. Thus, $\tau_{ijru} \geq 1$ units need to be shipped from country i and sector r for one unit to arrive in country j and use category u. The resulting price at which variety 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:

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

and the share π_{ijru} that country i makes up in use category u's expenditure in country j on sector r:[10]

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

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

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

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

2.4 EQUILIBRIUM

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

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

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

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

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

GOODS MARKET CLEARING. In equilibrium, goods market clearing requires that the value of production in country 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 wage per capita given in (4) and the supply of sectoral labor (3) allows us to solve explicitly for the country- and sector-specific wages per efficiency unit of labor as

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

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 $\gamma_{js} R_{js}/L_{js}$.[11]

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.

[11] 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 $\varphi \leq 1$.

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

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

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

[12]See Table A.1 for a list of all countries in the WIOD and their ISO codes. Table A.2 provides a list of ISIC sectors.

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

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

[15]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}.

3.2 Estimating the initial impact of Covid-19 in Chinese sectors

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

Our choice of the event window in January–February 2020 exploits the exact timing of the Covid-19 crisis. The first official, public mentioning of the disease dates from December 31, 2019 (when the cases were few), so the earliest economic impact can be expected in January 2020. Most containment measures in China were then implemented over the course of the subsequent two months. Notably, the spread of the virus was almost exclusively confined to China until late February. More specifically, data from Dong et al. (2020) show that on February 29, 92% of all globally confirmed Covid-19 cases were recorded in China, with only 6,655 cases confirmed outside of China (mostly concentrated in South Korea, Italy, and Iran). One week earlier, on February 22, China's share was at 98%, with only 1,578 infections confirmed outside of China (of which 634 were recorded on 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.[16]

We use monthly sector-level data on output (or more broadly, performance) from the NBS of China. The NBS reports only cumulative numbers for the first two months of each year (not for January and February separately), due to the Chinese spring festival. Hence, we construct bi-monthly time series by sector. For the industrial sector (which encompasses mining, manufacturing, and utilities), we use data on operating revenues of industrial enterprises, deflated by the sectoral producer price index (PPI). These data are reported for 41 sectors, which can be mapped directly into 23 WIOD sectors, accounting for 57% of total Chinese output in the WIOD of 2014. For the tertiary sector, we use different time series measuring performance (mostly revenues, appropriately deflated) in specific services, corresponding to 17 WIOD sectors (including retail trade, telecommunications, and transport). We complement these data with the aggregate index of service production, applied to sectors for which disaggregate data are unavailable (corresponding to 14%

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

of total Chinese output). Since monthly data for the Chinese primary sector are unavailable, we use data from the industry 'processing of food from agricultural products' for this sector. Table A.2 provides the details on the selected time series and a concordance table of NBS and WIOD sectors (both following the ISIC, Revision 4).

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

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

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.[17] Notably, equation (23) is estimated from bi-monthly time series over the pre-shock years 2017 to 2019, as is customary to ensure that the estimates are unaffected by the event itself, and it is then used to predict $\widehat{\Delta Y_{it}}$ for the first period of 2020.

The estimates show that the impact was dramatic.[18] The average sectoral output declined by 30% compared to its predicted value. The most affected sector (textiles) experienced a drop of almost 60%, while output in land transport and several other manufacturing sectors dropped by around 50% due to Covid-19 and the lockdown. Only few sectors experienced no significant drop or even a slight increase in output, in particular the oil extraction and telecommunication services sectors. The latter example points the relevance of I-O linkages for the estimated output drop, highlighting the need for backing out the underlying sectoral labor supply shocks from the estimated output drop, which is what we do in the next subsection.

The estimated effects are mapped to the WIOD according to Table A.2 and aggregated at the

[17] 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.

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

level of WIOD sectors, weighted by pre-shock values in January–February 2019. Table A.3 reports in column 3 the estimated output drop caused by Covid-19 for each WIOD sector in China.

3.3 Backing out labor supply shocks

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

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

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

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

The resulting labor supply shocks by sector in China are reported in column 4 of Table A.3. These shocks do not correspond one to one to the estimated output changes (in column 2), as they reflect, firstly, Chinese firms substituting workers for intermediates (as labor becomes less efficient), secondly, changes in Chinese firms' reliance on imported vs. domestic intermediate goods and, thirdly, changes in Chinese expenditure on intermediate and final goods. Nevertheless, the ranking of labor supply shocks is similar to that of the estimated output changes, with a correlation of 0.92.

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, with $i \neq j$, for all producing sectors r, and for all use categories u except final demand. Notably, this 'no-GVCs' scenario still allows for final goods trade and domestic input-output linkages.[19]

Figure 1: Welfare effects of decoupling GVCs

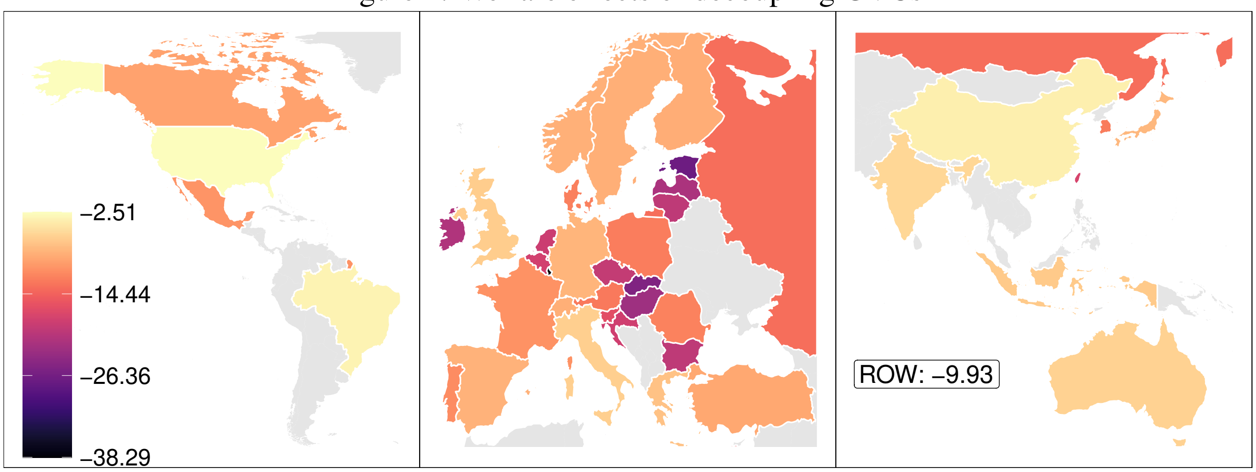


Figure 1 shows the welfare effects of a complete decoupling. It turns out that all countries in the WIOD lose from shutting down GVCs. The largest welfare losses are incurred by small, highly integrated EU economies such as Luxembourg (-38%), Malta (-33%) or Estonia (-27%), whose overall dependence on 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%).[20] Conversely, the smallest welfare losses are incurred by large countries with relatively low openness to trade and small shares of intermediates in these trade flows: the U.S. lose -2.5%, Brazil -3.3%, and China -3.6%. In general, we find that openness to intermediate goods trade

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

[20] For Russia, natural gas and other products from the mining sector make up 39% of total exports and contribute to a very high share of intermediates (91%) in exports, which explains the large losses from shutting down this type of trade.

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. This correlation is similarly high if we consider openness to intermediate imports or exports separately.

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

A shutdown of GVCs except within the EU leads to substantially smaller welfare losses (compared to the complete decoupling) in all EU countries, reflecting the importance of intra-EU value chains. By contrast, the predictions for non-EU countries remain almost unchanged. As a consequence, 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 -11%. 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 -2.7% and are thus comparable to the U.S. level. Figure A.3 presents the welfare effects by country.

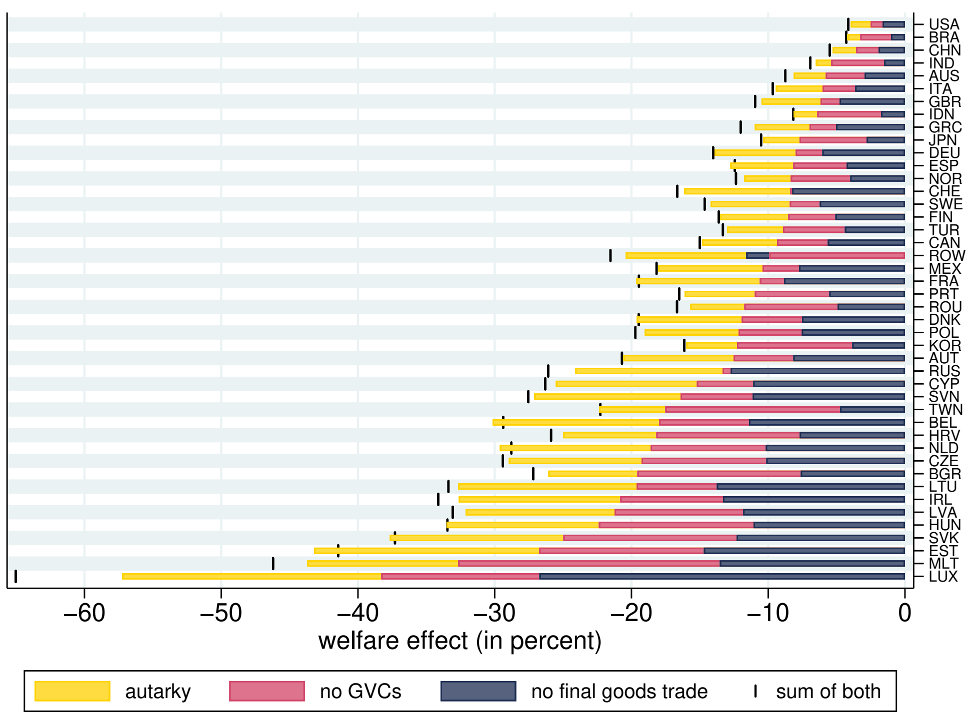
Next, we consider a partial decoupling of GVCs by increasing barriers on international trade in intermediate goods stepwise by 10%, 50%, 100%, and 200%. We find that the welfare effects of decoupling GVCs are monotonically decreasing in the size of the trade barriers for all countries, with their ranking being very stable across the different scenarios. Furthermore, the effects are generally falling at a diminishing rate: In the vast majority of countries, the welfare losses caused by increasing barriers to GVCs from zero to 10% exceed those caused by raising them from +200% to infinity. Doubling trade barriers (+100%) accounts for more than half of the total damage from shutting down GVCs entirely in all but one country—Russia. This exception may be rationalized by the fact that raw materials from Russia are very difficult to substitute and continue to be traded even at very high costs.[21] Figure A.4 shows detailed results for partial decoupling.

Finally, it is instructive to compare the shutdown of GVCs to a scenario in which final goods trade is shut down instead, and also to a world with no international trade at all, which corresponds to the autarky scenario that has been extensively studied in the literature. Figure 2 shows that a move to autarky naturally has the most adverse welfare effects. The analysis also reveals that

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

shutting down GVCs is worse than shutting down final goods trade for all countries, except for the synthetic ROW. The only two countries in which a loss of final goods trade is almost as bad as a world without GVCs are Switzerland, which has a strong comparative advantage in consumer goods, and Russia. Interestingly, for most countries the welfare loss from autarky is slightly smaller than the sum of the losses from shutting down only one of the two types of trade, as indicated in the graph. Arguably, this pattern may have two possible explanations. First, it is consistent with the concavity we have discussed above: The negative welfare effects of trade barriers are diminishing in the size of the barriers. Hence, shutting down one type of trade on top of the other (and thereby moving to autarky) reduces welfare by less than only shutting down the first type of trade. Second, one may think of trade in final and intermediate goods as being either 'complements' or 'substitutes' in the sense that one type of trade can partially replace the other if that is shut down to mitigate the welfare losses. The pattern in Figure 2 indicates that either the first explanation dominates or there is a complementary (rather than substitute) relationship between final and intermediate goods trade for the majority of countries.

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



4.2 U.S. DECOUPLING

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

We implement these scenarios by increasing trade barriers on U.S. imports of intermediate inputs (but not of final goods) either (i) from all countries or (ii) only from China. To obtain a clear picture, we set these barriers to prohibitive levels (as in the no-GVCs scenario) in our main analysis and consider less extreme scenarios in sensitivity checks. In practice, policy makers seeking to decouple from GVCs would face the challenge of distinguishing intermediate inputs from final goods. While this distinction is not clear-cut at the level of broad sectors, such a policy could arguably be implemented by increasing trade barriers within each sector for typical inputs like fertilizers, heavy machinery, or trucks (as opposed to consumer goods like shampoo, game consoles, or sport cars). Note that, since we model decoupling in the form of increased real trade costs, these scenarios are best thought of as raising non-tariff barriers (or, more generally, non-rent-creating barriers) on inputs.[22]

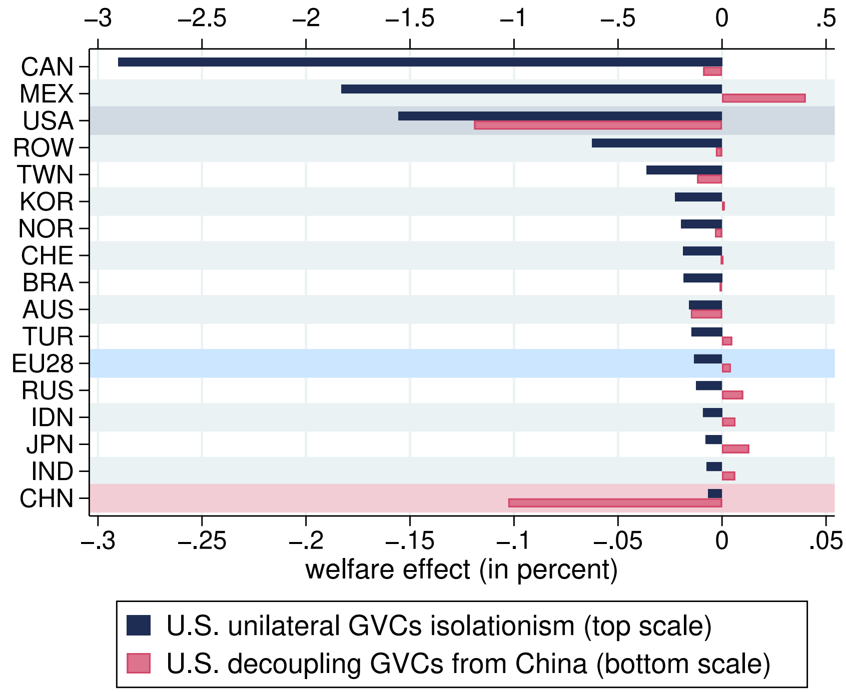
Figure 3 illustrates the welfare effects of both U.S. decoupling scenarios. Since the effects on most European countries are small and not the focus of this discussion, we report only the (population-weighted) average welfare effect for the EU28 in the main text.[23] We find that if the U.S. fully repatriates 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), demonstrating that U.S. GVCs participation is beneficial to the world as whole. Among the non-EU 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

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

[23] Figure A.5 shows the effects on all individual countries.

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



Section 5.2, where we contrast the losses from decoupling in the U.S. with the potential gains from safeguarding against an adverse shock in China.

5 Global shock transmission

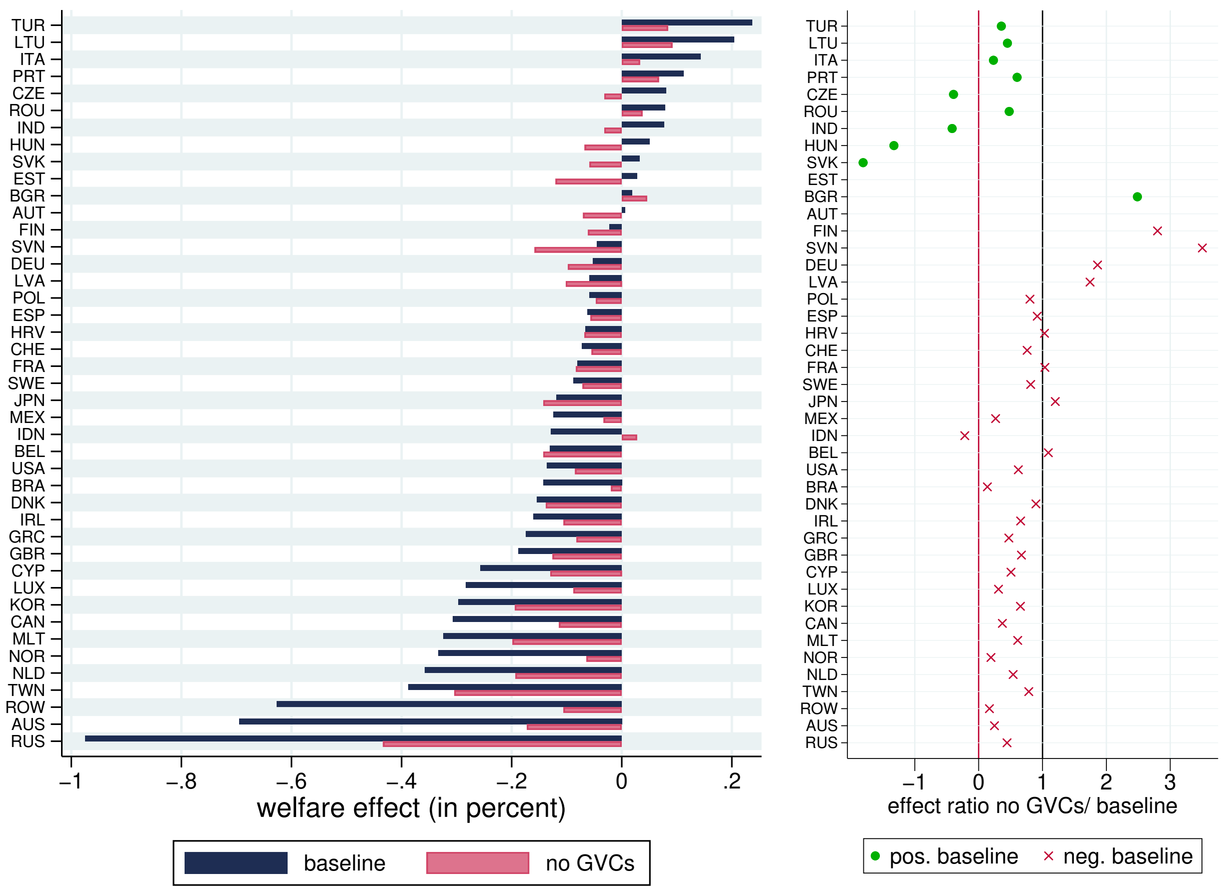
5.1 Covid-19 shock transmission in a world without GVCs

We now turn to our analysis of international shock transmission in a world with vs. without GVCs. To this end, we focus on the global repercussions of the Covid-19 shock in China in early 2020, as a realistic example of a major negative supply shock. Notably, we consider a shock that remains confined to China, in order to isolate the role of trade and GVCs, and we consider how a permanent shock of this size would affect the world economy. The domestic welfare loss in China from such a shock amounts to -31.5% in the new general equilibrium.

Figure 4 illustrates how welfare in all other WIOD countries is affected by the Covid-19 shock in China. Figure 4(a) illustrates the effects in the baseline world in the form of dark blue bars. The international repercussions are moderate and range from a welfare loss of -0.98% in Russia to a gain of +0.24% 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. (-0.14%) and Germany (-0.05%) 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 European countries that accessed the EU in or after 2004. Apparently, these countries experience gains from trade diversion (as importers around the world switch away from Chinese suppliers), which outweigh the direct losses due to higher input costs and the negative income effect in China.

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

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



To understand the role of GVCs in international shock transmission, we now consider the effects of the same Covid-19 shock in the counterfactual world without GVCs, which we studied in Section 4.1. To ensure that the effects are comparable across scenarios, all reported results are evaluated in terms of countries' initial (pre-decoupling) welfare. The welfare effects in the counterfactual world are shown as the light red bars in Figure 4(a). To facilitate 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 most countries, shock transmission is mitigated after decoupling (effect ratios are between 0 and 1). This reduction amounts to 34% 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 eight countries, including Japan, Germany, and France, as indicated by effect ratios above one in Figure 4(b). Third, in several countries the welfare effects of the Covid-19 shock in China are reversed in a world without GVCs (effect ratios below zero): Six (mostly European) countries switch from winners to losers.[24] By contrast, Indonesia, with losses in the baseline world, stands to gain from the shock in China after GVCs have been shut down.

To gain deeper insights into these findings and their sensitivity, we consider several variations 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, i.e., we raise intermediate goods trade barriers between all countries stepwise by 10%, 50%, 100%, and 200% before simulating the Covid-19 shock. In most countries, the welfare effects adjust monotonically between the baseline and a completely decoupled world. Compared to the welfare effects obtained from simulating the shock in the baseline world, there is a 99.5% cross-country correlation when simulating it after a 10% decoupling shock. This correlation is reduced to 87.6% after a 100% increase intermediate goods trade barriers and to 79.1% in a world without GVCs. There are few exceptions (including France, Indonesia, and Japan) for which the two extreme scenarios do not deliver the smallest and largest welfare effects, but the variations across scenarios in these countries are relatively small. Overall, the complex general equilibrium responses do not seem to generate major non-linearities in the welfare effects. Figure A.6 summarizes the country-level welfare effects for all partial decoupling scenarios.

We contrast our findings from the world without GVCs with an alternative world in which international trade in final goods is abolished instead (while allowing for intermediate goods trade).[25] This complementary exercise reveals that a Covid-19 shock in China would play out quite differently in a world without final goods trade compared to the world without GVCs. While the average welfare effect across countries is similar, the effects on individual countries differ substantially. Most notably, with no final goods trade, the sign of the welfare effect from the shock switches from negative to positive in ten countries but only twice in reverse compared to the no-GVCs scenario. Overall, the correlation of the country-level welfare effects between both scenarios is only 59.8%. It is evident that inhibiting international trade in final goods as opposed to intermediates has very different implications for shock transmission. Figure A.7 illustrates the results by country.

[24]For Austria and Estonia the very small baseline gains are turned into larger losses. The resulting effect ratios are -11.1 and -4.4, respectively. Hence we omit these countries from Figure 4(b) in the interest of readability.

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

One may wonder if shock transmission may be more beneficially reduced if all countries could decouple only GVCs involving China, the country from which the adverse shock originates in our counterfactual. To understand this, we reconsider the scenario of the Covid-19 shock hitting China after unilaterally decoupling it from GVCs, i.e., after setting prohibitively high trade barriers on intermediate goods trade into and out of China. The simulation results demonstrate that this gives rise to rather similar, though on average more favorable welfare effects for other countries. The correlation with the shock transmission effects in the no-GVCs scenario is 93.8%. These findings suggest that our results from Figure 4 are mainly driven by a decoupling from China and less from the shutdown of intermediate goods trade among all other countries. Interestingly, fifteen countries do slightly worse if only China is decoupled compared to a complete decoupling of all GVCs. See Figure A.8 for shock transmission effects on all countries after decoupling China.

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, we examine the extreme cases of perfect and zero labor mobility. 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 magnitudes, the differences are notable. An interesting pattern is that, on the one hand, among the countries that lose most from the shock, moving from zero to perfect mobility typically reduces the losses (with the two exceptions of Taiwan and South 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 shock response in the country itself, these results are due to the altered general equilibrium effects from higher mobility in other countries. It turns out that the countries gaining from trade diversion gain much less if intersectoral labor mobility in all countries is very high. In terms of magnitudes, we find that varying intersectoral mobility can make a substantial difference relative to the size of the baseline welfare effects: For instance, Russia loses an additional -0.35% and Lithuania increases its welfare gain from 0.01% to 0.27% in a world with immobile labor compared 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 -42% for the median losing country (vs. -34% with imperfect mobility). Figure A.9 illustrates the welfare effects by country for the three mobility scenarios (in the baseline world with GVCs).

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

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

Table 1 summarizes, for different decoupling scenarios, the effects on U.S. welfare of both the decoupling itself (in column 1) and of the Covid-19 shock in China occurring after decoupling (in column 2). Column 3 lists the cumulative effects from decoupling and the shock and column 4 reports the difference between this cumulative effect and the impact of the shock in China in the baseline world (without any decoupling). Thus, the final column allows us to assess how the shock mitigation effect of decoupling compares to the costs directly caused by decoupling. The first row lists the baseline world as a reference point. The subsequent two rows then consider the U.S. decoupling policies discussed in Section 4.2, and the last two rows show two additional variations of U.S. decoupling described further below.

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

Scenario	Decoupling	Covid-19 shock (after decoupling)	Cumulative effect (decoupling+shock)	Difference to baseline
	(1)	(2)	(3)	(4)
Baseline		-0.136		
U.S. unilateral GVCs isolationism	-1.556	-0.140	-1.696	-1.560
U.S. decoupling GVCs from China	-0.119	-0.108	-0.227	-0.091
U.S.–China bilateral decoupling	-0.171	-0.096	-0.267	-0.131
U.S. & EU decoupling from China	-0.168	-0.095	-0.263	-0.127

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

It is immediately obvious from Table 1 that none of the different decoupling scenarios 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 0.041 percentage points in U.S. welfare (compared to -0.136% in the baseline; see column 2). This tiny benefit is dwarfed by the welfare losses directly caused by decoupling in each case (see column 1). As a consequence, the U.S. is clearly worse off from experiencing the shock after decoupling compared to suffering the shock only (in the baseline world), as evidenced by the negative numbers in column 4.

What is more, decoupling might not even achieve a reduction in shock transmission at all. In the main scenario labeled 'U.S. unilateral GVCs isolationism', in which the U.S. sets prohibitively high barriers on intermediate goods imports from all countries, the U.S. welfare loss from a Covid-

19 shock in China would even be slightly magnified compared to the baseline scenario (-0.140% vs. -0.136%). This contrasts with the substantial U.S. welfare loss of -1.556% caused directly by unilateral GVCs isolationism. As a consequence, the cumulative effect of decoupling plus shock transmission on U.S. welfare is by -1.560% worse than shock transmission to the U.S. in the baseline world. The magnification is explained by a combination of two facts: First, the U.S. still 'imports' the shock from China via final goods trade, which is a channel that gains importance after decoupling. Second, by foregoing the option to import intermediate goods, U.S. firms lose flexibility in their response to the shock, as they cannot substitute domestic inputs (that become more expensive) with imports, which raises prices and aggravates the welfare loss.

We proceed by considering more targeted or coordinated policy scenarios of decoupling: If the U.S. were to decouple GVCs only from China, but not from any other country, the U.S. welfare loss due to the subsequent shock would be slightly reduced from -0.136% to -0.108%. Clearly, this reduction cannot justify the welfare loss induced by the policy itself (-0.119%), resulting in a worsening of -0.091% compared to the shock in the baseline world. These results illustrate that decoupling does not enhance U.S. welfare even if it specifically targets China, the country where the adverse supply shock originates. Since one can in practice expect China to retaliate against such a policy, we also consider bilateral decoupling of GVCs between the U.S. and China, which causes a greater direct loss to the U.S. and gives rise to the same main conclusion. Finally, one might imagine a transatlantic coordination of trade policy. In this scenario, the U.S. and the EU28 jointly decouple from China by setting prohibitively high trade barriers on Chinese intermediate goods imports and China responds in kind. Once more, the welfare loss in the U.S. clearly outweighs the mitigation effect of decoupling.

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

5.3 UNIFORM SHOCKS TO ALL COUNTRIES

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

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

The analysis proceeds in three steps. First, we simulate the effects of these shocks in each country in the baseline world and in each case assess the welfare effects (shock transmission) on all other countries. Second, one by one, we decouple each country from GVCs by setting barriers to intermediate goods trade to infinity only for the country in question. Third, we reassess how the shocks around the world affect this country's welfare differently after unilateral decoupling. This allows us to obtain a general picture of the potential shock reduction through decoupling.

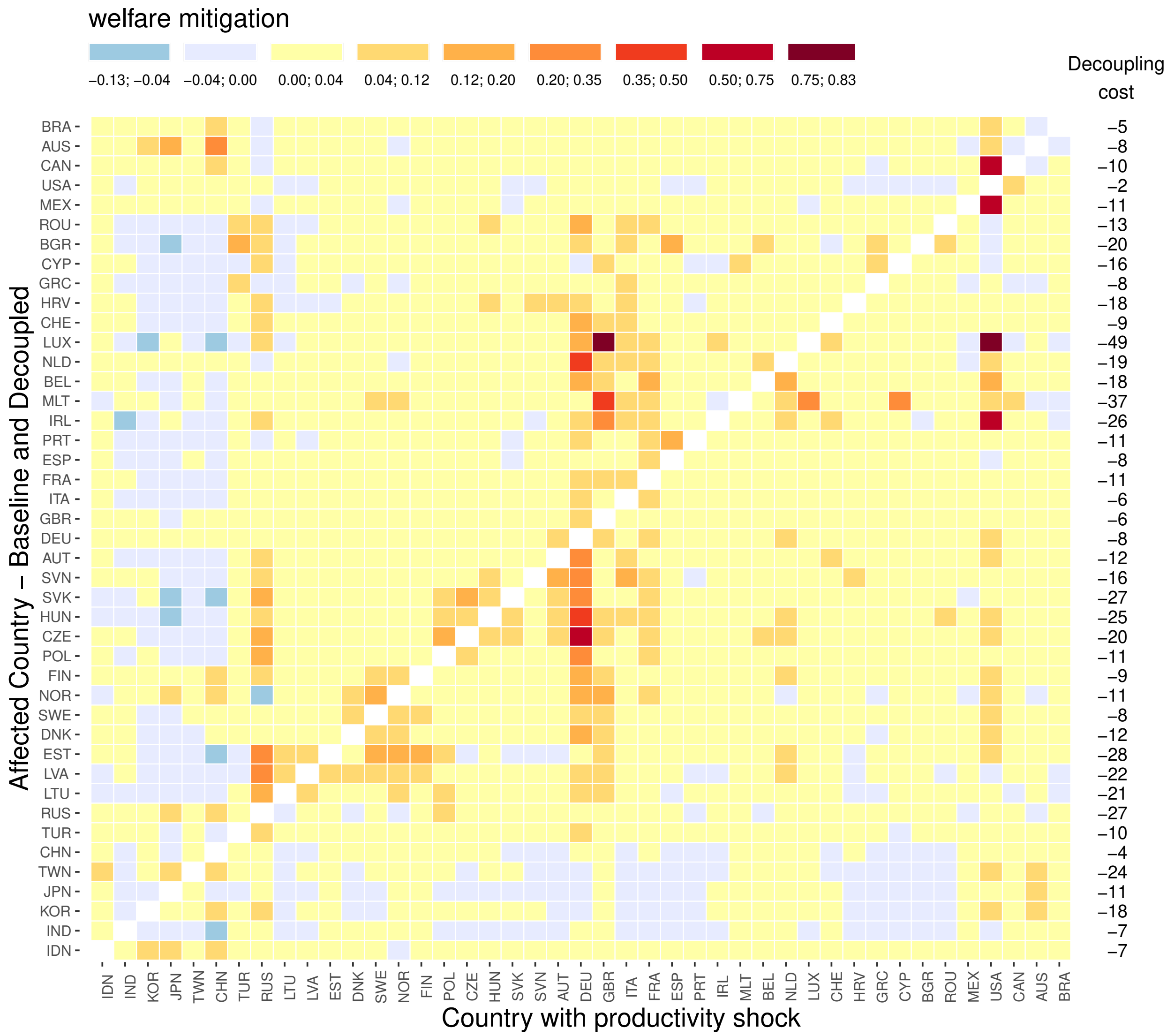
Figure 5 depicts the mitigation effect of decoupling, i.e., the difference between the welfare effects in the two scenarios (baseline vs. decoupled) for each combination of shocked and (indirectly) affected country. To provide a specific example, each cell in the bottom row shows how a shock originating in the respective column country is mitigated by India through decoupling itself from GVCs.[26]

Importantly, we find that the mitigation effect of unilateral decoupling is very small throughout all bilateral shock transmission scenarios, with a welfare effect that is on average by 0.3 percentage points (pp) more favorable after decoupling. The largest mitigation effects are obtained when Luxembourg decouples and a shock hits the U.K. or the U.S. (0.8pp), or if Canada or Mexico decouple and a shock hits the U.S. (0.7pp and 0.6pp). Other country pairs for which mitigation effects are sizeable are mostly found for shocks occurring in large economies like the U.S., Germany, or the U.K.

Interestingly, for most combinations of Asian countries with South Eastern and Eastern European countries the mitigation effect is negative (blue areas) and thus implies that decoupling magnifies the welfare loss created by the foreign shock. Clearly, as these countries play similar

[26] In Figure 5, countries are grouped according to their geographic location in Asia, Europe, and North America.

Figure 5: Global shock mitigation through decoupling



roles in GVCs, they reduce their ability to substitute intermediate inputs from the shocked country when they decouple from GVCs.

Finally, the number at the end of each row indicates the initial welfare cost of unilateral decoupling for the row country (in percent). It is immediately obvious that this welfare loss dominates the mitigation effects throughout and by at least one order of magnitude in most cases. We find that in the most favorable scenario, the U.S. decoupling from GVCs and then experiencing a foreign shock in Mexico or Canada leads to a total U.S. welfare loss that is by 2.3–2.4pp larger than if the same shock had hit these countries without the U.S. repatriating GVCs.

One might argue that the reason for the relatively small mitigation effects is due to the simulated shock hitting only a single country, whereas in practice (e.g. in the pandemic) several trading partners might be affected simultaneously. This would lead to stronger spillovers with a correspondingly greater potential for mitigation effects and might ultimately tip the scale in favor of repatriating value chains. To test this hypothesis, we again compare for each country the welfare effects of a foreign shock occurring before and after the country decouples from GVCs. In contrast to the above analysis, however, we simulate the -29% labor productivity shock to hit not only one but *all* foreign trade partners. We find that in this extreme 'global shock' scenario the mitigation effects of decoupling are indeed much stronger than above, with a maximum of 3.6pp for Luxembourg and an average of 1.2pp. Nevertheless, for every single country the initial welfare cost of decoupling still clearly dominates the mitigation effect. In the most favorable scenario, the U.S. welfare loss from decoupling and experiencing a foreign shock in all other countries is 2.1 percentage points larger than if the same shock had hit these countries without the U.S. repatriating GVCs. The welfare mitigation effects in all countries after the global shock are depicted in Figure A.10.

To sum up, throughout all of our simulations, we find no single instance in which a country can gainfully—in terms of national welfare—protect itself from foreign shocks 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 slight (if any) reduction in exposure to foreign shocks cannot justify the substantial welfare losses directly caused by decoupling GVCs.

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

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

REFERENCES

Acemoglu, D., Carvalho, V. M., Ozdaglar, A., and Tahbaz-Salehi, A. (2012). The Network Origins of Aggregate Fluctuations. *Econometrica*, 80(5):1977–2016.

Acemoglu, D. and Tahbaz-Salehi, A. (2020). Firms, Failures, and Fluctuations: The Macroeconomics of Supply Chain Disruptions. Technical report, NBER Working Paper No. 27565.

Allen, T., Arkolakis, C., and Takahashi, Y. (2020). Universal Gravity. *Journal of Political Economy*, 128(2):393–433.

Antràs, P. (2020). De-Globalization? Global Value Chains in the Post-COVID-19 Age. Harvard University, mimeo.

Antràs, P. and Chor, D. (2018). On the Measurement of Upstreamness and Downstreamness in Global Value Chains. In Ing, L. Y. and Yu, M., editors, *World Trade Evolution: Growth, Productivity and Evolution*, pages 126–194. Routledge.

Antràs, P., Fadeev, E., Fort, T., Gutierrez, A., and Tintelnot, F. (2021). Import Tariffs and Global Sourcing. Harvard University, mimeo.

Antràs, P., Redding, S. J., and Rossi-Hansberg, E. (2020). Globalization and Pandemics. *COVID Economics: Vetted and Real-Time Papers*, 21.

Baldwin, R. and Evenett, S. J. (2020). COVID-19 and Trade Policy: Why Turning Inward Won't Work. CEPR Press.

Baldwin, R. and Tomiura, E. (2020). Thinking Ahead about the Trade Impact of COVID-19. In Baldwin, R. and Weder di Mauro, B., editors, *Economics in the Time of COVID-19*. CEPR Press.

Baqaee, D. R. and Farhi, E. (2020a). Keynesian Production Networks with an Application to the Covid-19 Crisis. Harvard University, mimeo.

Baqaee, D. R. and Farhi, E. (2020b). Nonlinear Production Networks with an Application to the Covid-19 Crisis. Harvard University, mimeo.

Barrot, J.-N., Grassi, B., and Sauvagnat, J. (2020). Sectoral Effects of Social Distancing. *CEPR*

COVID Economics, 3:85–102.

Barrot, J.-N. and Sauvagnat, J. (2016). Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks. *Quarterly Journal of Economics*, 131(3):1543–1592.

Bems, R., Johnson, R. C., and Yi, K.-M. (2010). Demand Spillovers and the Collapse of Trade in the Global Recession. *IMF Economic Review*, 58(2):295–326.

Beshkar, M. and Lashkaripour, A. (2020). The Cost of Dissolving the WTO: The Role of Global Production Networks. Indiana University, mimeo.

Biden, J. R. (2021). Executive Order on Ensuring the Future Is Made in All of America by All of America's Workers. Available at https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/25/executive-order-on-ensuring-the-future-is-made-in-all-of-america-by-all-of-americas-workers/ (last checked February 24, 2021).

Blanchard, E. J., Bown, C. P., and Johnson, R. C. (2016). Global Supply Chains and Trade Policy. NBER Working Papers 21883, National Bureau of Economic Research, Inc.

Bodenstein, M., Corsetti, G., and Guerrieri, L. (2020). Social Distancing and Supply Disruptions in a Pandemic. Technical Report CWPE2031, Cambridge Working Papers in Economics.

Boehm, C., Flaaen, A., and Pandalai-Nayar, N. (2019). Input Linkages and the Transmission of Shocks: Firm Level Evidence from the 2011 Tohoku Earthquake. *Review of Economics and Statistics*, 101(1):60–75.

Bonadio, B., Huo, Z., Levchenko, A. A., and Pandalai-Nayar, N. (2020). Global Supply Chains in the Pandemic. NBER Working Papers 27224, National Bureau of Economic Research, Inc.

Bown, C. and Zhang, E. (2019). Measuring Trump's 2018 Trade Protection: Five Takeaways. Peterson Institute for International Economics, February 15.

Burstein, A., Kurz, C., and Tesar, L. (2008). Trade, Production Sharing, and the International Transmission of Business Cycles. *Journal of Monetary Economics*, 55(4):775–795.

Burstein, A., Morales, E., and Vogel, J. (2019). Changes in Between-Group Inequality: Computers, Occupations, and International Trade. *American Economic Journal: Macroeconomics*, 11(2):348–400.

Caliendo, L., Dvorkin, M., and Parro, F. (2019). Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock. *Econometrica*, 87(3):741–835.

Caliendo, L. and Parro, F. (2015). Estimates of the Trade and Welfare Effects of NAFTA. *Review of Economic Studies*, 82(1):1–44.

Caliendo, L., Parro, F., Rossi-Hansberg, E., and Sarte, P.-D. (2018). The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy. *Review of Economic Studies*, 85(4):2042–

2096.

Cappariello, R., Franco-Bedoya, S., Gunnella, V., and Ottaviano, G. (2020). Rising Protectionism and Global Value Chains: Quantifying the General Equilibrium Effects. CEPR Discussion Papers 14423, C.E.P.R. Discussion Papers.

Carvalho, V., Nirei, M., Saito, Y., and Tahbaz-Salehi, A. (2020). Supply Chain Disruptions: Evidence from the Great East Japan Earthquake. *Quarterly Journal of Economics*, forthcoming.

Carvalho, V. and Tahbaz-Salehi, A. (2019). Production Networks: A Primer. *Annual Review of Economics*, 11:635–663.

Costinot, A. and Rodríguez-Clare, A. (2014). Trade Theory with Numbers: Quantifying the Consequences of Globalization. In Gopinath, G., Helpman, E., and Rogoff, K., editors, *Handbook of International Economics*, volume 4, chapter 4, pages 197–261. Elsevier.

Cuñat, A. and Zymek, R. (2020). The (Structural) Gravity of Epidemics. CESifo Working Paper No. 8295.

Dekle, R., Eaton, J., and Kortum, S. (2007). Unbalanced Trade. *American Economic Review*, 97(2):351–355.

Dekle, R., Eaton, J., and Kortum, S. (2008). Global Rebalancing with Gravity: Measuring the Burden of Adjustment. *IMF Economic Review*, 55(3):511–540.

di Giovanni, J. and Levchenko, A. A. (2010). Putting the Parts Together: Trade, Vertical Linkages, and Business Cycle Comovement. *American Economic Journal: Macroeconomics*, 2(2):95–124.

di Giovanni, J., Levchenko, A. A., and Zhang, J. (2014). The Global Welfare Impact of China: Trade Integration and Technological Change. *American Economic Journal: Macroeconomics*, 6(3):153–83.

Dong, E., Du, H., and Gardner, L. (2020). An Interactive Web-based Dashboard to Track COVID-19 in Real Time. *The Lancet Infectious Diseases*.

Eaton, J. and Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica*, 70(5):1741–1779.

Eichenbaum, M. S., Rebelo, S., and Trabandt, M. (2020). The Macroeconomics of Epidemics. NBER Working Paper 26882, National Bureau of Economic Research.

Farage, N. (2020). Coronavirus Has Shown We Are All Nationalists Now: Does Boris Johnson Realise That? The Daily Telegraph.

Felbermayr, G., Groeschl, J., and Heiland, I. (2018). Undoing Europe in a New Quantitative Trade Model. Technical report, ifo Working Paper No. 250.

Felbermayr, G., Groeschl, J., and Heiland, I. (2020). Complex Europe: Quantifying the Cost of Disintegration. CEPR Discussion Papers 15200, CEPR Discussion Papers.

Fornaro, L. and Wolf, M. (2020). Covid-19 Coronavirus and Macroeconomic Policy. Working Papers 1168, Barcelona Graduate School of Economics.

Friedt, F. L. and Zhang, K. (2020). The Triple Effect of Covid-19 on Chinese Exports: First Evidence of the Export Supply, Import Demand and GVC Contagion Effects. *COVID Economics: Vetted and Real-Time Papers*, 53.

Galle, S., Rodríguez-Clare, A., and Yi, M. (2018). Slicing the Pie: Quantifying the Aggregate and Distributional Consequences of Trade. Technical report, mimeo.

Grossman, G. and Helpman, E. (2021). When Tariffs Disrupt Global Supply Chains. Harvard University, mimeo.

Guerrieri, V., Lorenzoni, G., Straub, L., and Werning, I. (2020). Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages? NBER Working Paper 26918, National Bureau of Economic Research.

Hsieh, C.-T., Hurst, E., Jones, C. I., and Klenow, P. J. (2019). The Allocation of Talent and U.S. Economic Growth. *Econometrica*, 87(5):1439–1474.

Hsieh, C.-T. and Ossa, R. (2016). A Global View of Productivity Growth in China. *Journal of International Economics*, 102:209–224.

Hummels, D., Ishii, J., and Yi, K.-M. (2001). The Nature andGgrowth of Vertical Specialization in World Trade. *Journal of International Economics*, 54(1):75–96.

Huo, Z., Levchenko, A. A., and Pandalai-Nayar, N. (2019). International Comovement in the Global Production Network. NBER Working Papers 25978, National Bureau of Economic Research, Inc.

Inoue, H. and Todo, Y. (2020). The Propagation of the Economic Impact through Supply Chains: The Case of a Mega-City Lockdown against the Spread of Covid-19. *Covid Economics: A Real-Time Journal*, 2:43–59.

Irwin, D. (2020a). *Free Trade Under Fire*. Princeton: Princeton University Press, 5th edition.

Irwin, D. (2020b). The Pandemic Adds Momentum to the Deglobalisation Trend. Technical report, VoxEU. Available at https://voxeu.org/article/pandemic-adds-momentum-deglobalisation-trend (Last checked August 18, 2020).

Johnson, R. C. (2014). Trade in Intermediate Inputs and Business Cycle Comovement. *American Economic Journal: Macroeconomics*, 6(4):39–83.

Kleinman, B., Liu, E., and Redding, S. J. (2020). International Friends and Enemies. Working

Paper 27587, National Bureau of Economic Research.

Lagakos, D. and Waugh, M. E. (2013). Selection, Agriculture, and Cross-Country Productivity Differences. *American Economic Review*, 103(2):948–980.

Leibovici, F. and Santacreu, A. M. (2020). International Trade of Essential Goods During a Pandemic. *COVID Economics: Vetted and Real-Time Papers*, 21.

Lovely, M. and Liang, Y. (2018). Trump Tariffs Primarily Hit Multinational Supply Chains, Harm US Technology Competitiveness. Peterson Institute for International Economics Policy Brief 18-12, May 2018.

Luo, S. and Tsang, K. P. (2020). China and World Output Impact of the Hubei Lockdown During the Coronavirus Outbreak. *Contemporary Economic Policy*, 38(4):583–592.

MacKinlay, A. C. (1997). Event Studies in Economics and Finance. *Journal of Economic Literature*, 35(1):13–39.

Macron, E. (2020). Interview: It is Time to Think the Unthinkable. Financial Times, April 16.

McKibbin, W. and Fernando, R. (2020). The Economic Impact of COVID-19. In Baldwin, R. and Weder di Mauro, B., editors, *Economics in the Time of COVID-19*. CEPR Press.

Meier, M. and Pinto, E. (2020). Covid-19 Supply Chain Disruptions. *COVID Economics: Vetted and Real-Time Papers*, 48.

New York Times (2020). Apple Signals Coronavirus's Threat to Global Businesses. February 17.

Roy, A. D. (1951). Some Thoughts On The Distribution Of Earnings. *Oxford Economic Papers*, 3(2):135–146.

Sforza, A. and Steininger, M. (2020). Globalization in the Time of Covid-19. CESifo Working Paper Series 8184, CESifo.

The Economist (2019). Slowbalisation: The Steam Has Gone out of Globalization. January 24.

The Economist (2020). The New Coronavirus Could Have a Lasting Impact on Global Supply Chains. February 15.

Timmer, M., Dietzenbacher, E., Los, B., Stehrer, R., and de Vries, G. J. (2015). An Illustrated User Guide to the World Input–Output Database: The Case of Global Automotive Production. *Review of International Economics*, 23(3):575–605.

Trump, D. J. (2020). Executive Order on Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries. Available at https://www.federalregister.gov/documents/2020/10/05/2020-22064/addressing-the-threat-to-the-domestic-supply-chain-from-reliance-on-critical-minerals-from-foreign (last checked

February 24, 2021).

UNCTAD (2020). Impact of the Coronavirus Outbreak on Global FDI. Technical report, United Nations Conference on Trade and Development.

Vandenbussche, H., Connell, W., and Simons, W. (2019). Global Value Chains, Trade Shocks and Jobs: An Application to Brexit. CESifo Working Paper Series 7473, CESifo.

Yi, K.-M. (2003). Can Vertical Specialization Explain the Growth of World Trade? *Journal of Political Economy*, 111(1):52–102.

Zajc Kejzar, K. and Velic, A. (2020). Covid-19, Trade Collapse and GVC Linkages: European Experience. *COVID Economics: Vetted and Real-Time Papers*, 61.

Appendix to:

Decoupling Global Value Chains

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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:

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

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

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

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 $\mathrm{d}x/\mathrm{d}w = -\varphi w^{-\varphi-1}\frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi} = -\varphi\frac{x}{w}$ 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 $\frac{\mathrm{d}w}{\mathrm{d}x}x = -\frac{1}{\varphi}\left(\frac{x\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi}{\sum_s \delta_{js}^\varphi w_{js}^\varphi}\right)^{-\frac{1}{\varphi}}$ to transform the above into

$$\int_0^\infty e^{-x}\varphi x\mathrm{d}w = \varphi\int_{x(0)}^{x(\infty)} e^{-x}x\frac{\mathrm{d}w}{\mathrm{d}x}\mathrm{d}x$$
$$= -\left(\frac{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi}{\sum_s \delta_{js}^\varphi w_{js}^\varphi}\right)^{-\frac{1}{\varphi}}\int_\infty^0 e^{-x}x^{-\frac{1}{\varphi}}\mathrm{d}x$$
$$= \left(\frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi}\right)^{\frac{1}{\varphi}}\int_0^\infty e^{-x}x^{-\frac{1}{\varphi}}\mathrm{d}x$$
$$= \left(\frac{\sum_s \delta_{js}^\varphi w_{js}^\varphi}{\Gamma\left(1-\frac{1}{\varphi}\right)^\varphi}\right)^{\frac{1}{\varphi}}\Gamma\left(1-\frac{1}{\varphi}\right)$$
$$= \left(\sum_s \delta_{js}^\varphi w_{js}^\varphi\right)^{\frac{1}{\varphi}} \equiv w_j,$$

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:

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

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:

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

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

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

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:

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

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

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

where $\Gamma(t) \equiv \int_0^\infty x^{t-1}e^{-x}\mathrm{d}x$ 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). Note that for twelve sectors, the shocks are set to zero because either output is zero for China in the WIOD (nine cases) or the model would suggest an implausible positive labor supply shock due to Covid-19 (three cases).

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

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

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

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

A.3 Additional results

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

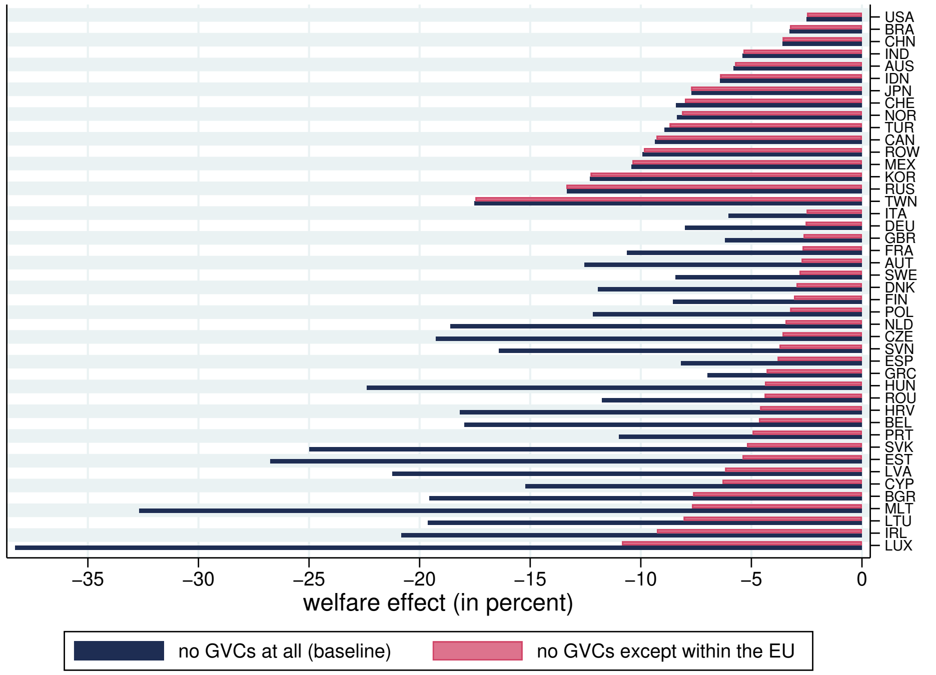


Figure A.4: Partial decoupling: Stepwise increase in intermediate goods trade barriers

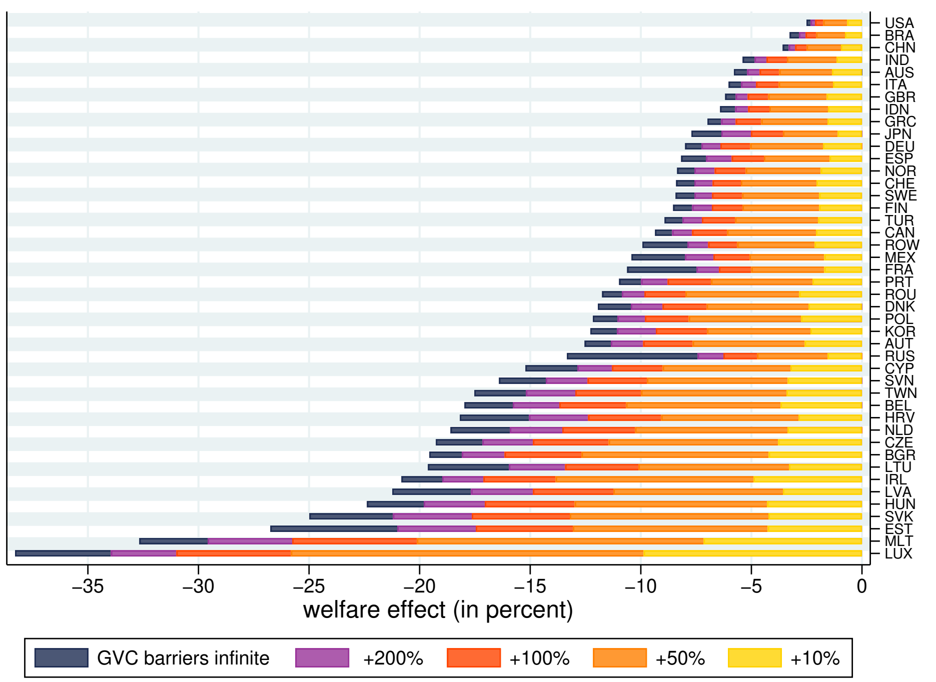


Figure A.5: Welfare effects of U.S. decoupling for individual countries

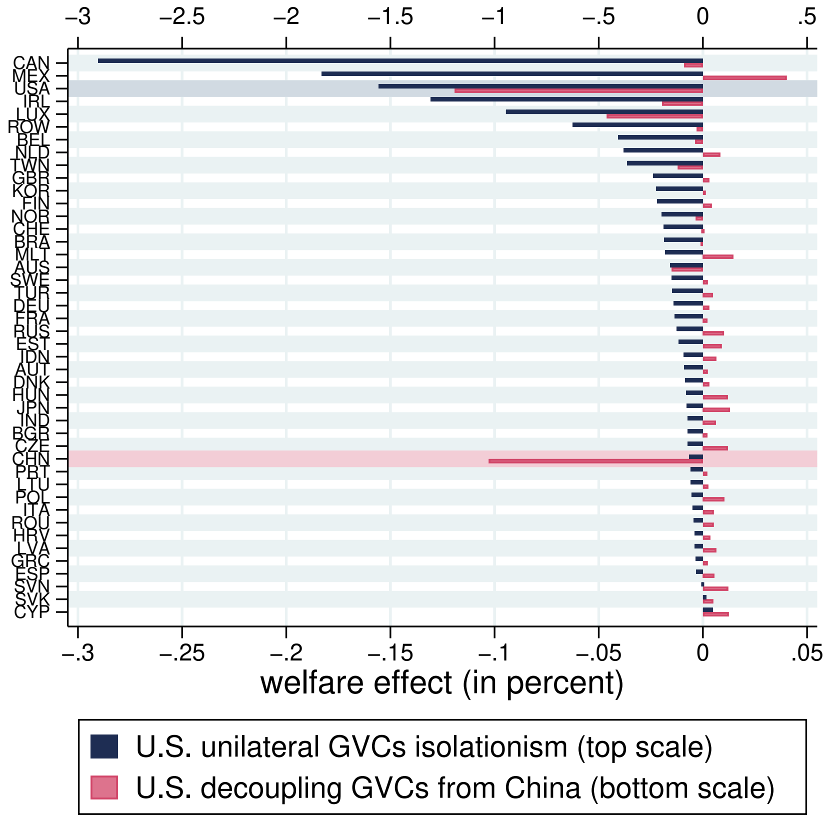


Figure A.6: Welfare effects of Covid-19 shock after partial decoupling

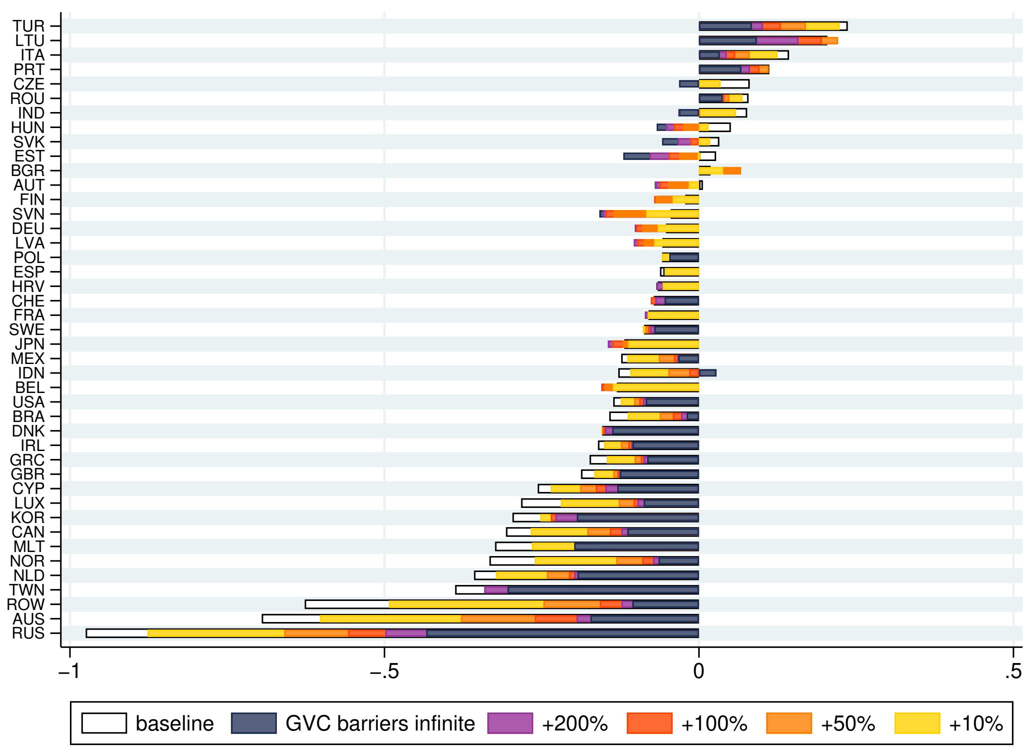


Figure A.7: Welfare effects of Covid-19 shock after shutting down GVCs vs. final goods trade

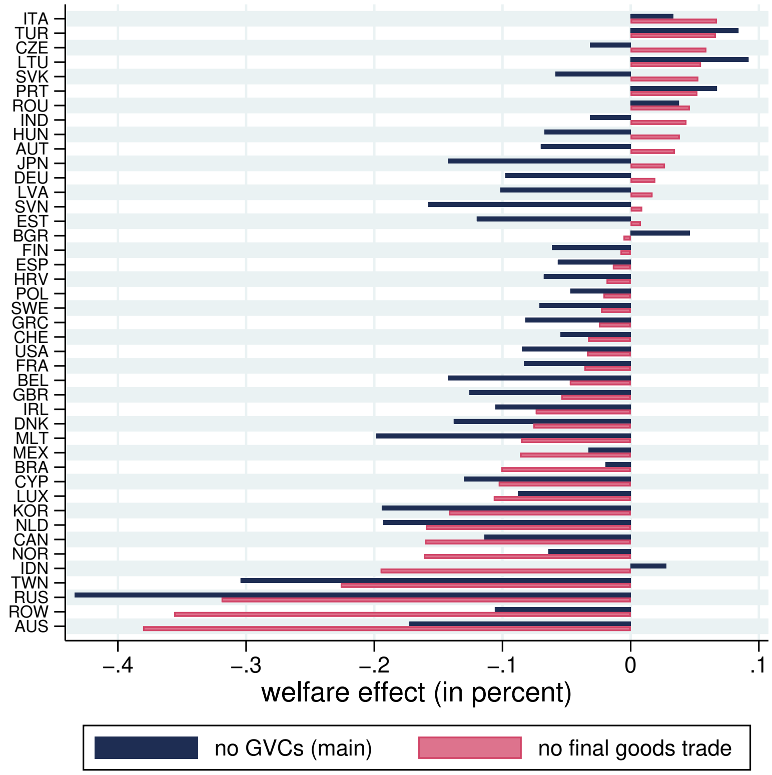


Figure A.8: Welfare effects of Covid-19 shock after decoupling China from GVCs

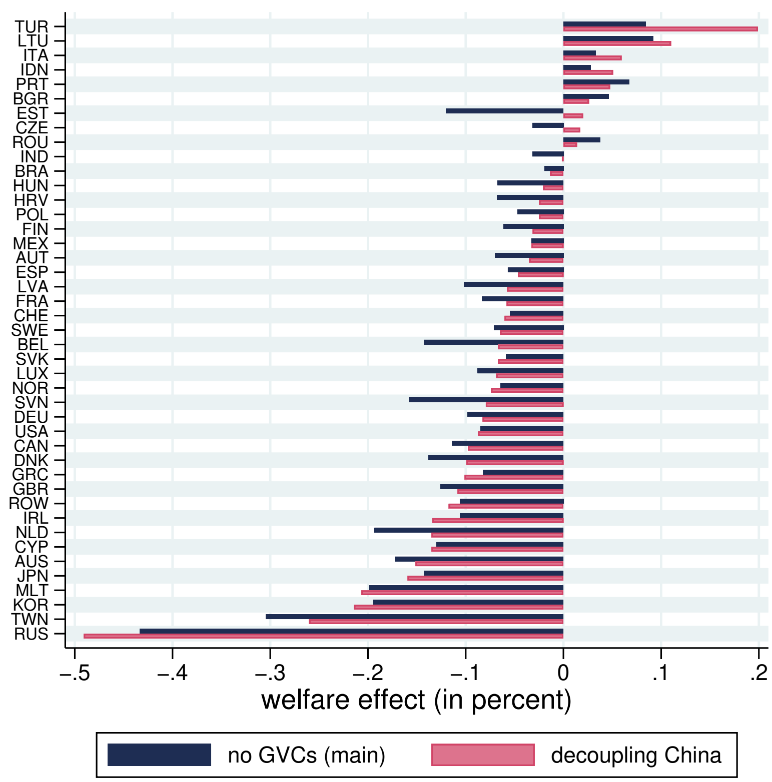


Figure A.9: Welfare effects of Covid-19 shock for varying intersectoral labor mobility

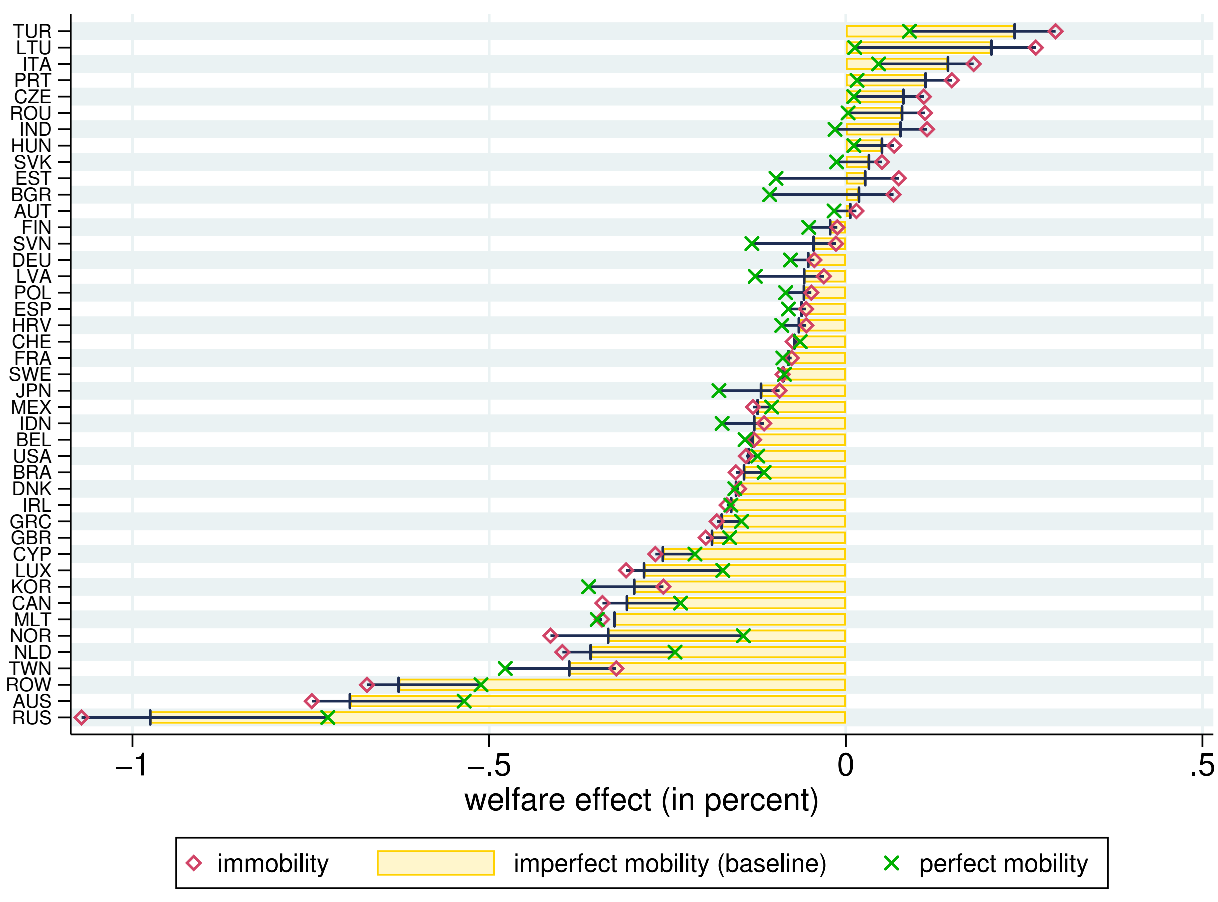


Figure A.10: Welfare mitigation effects of shocks hitting in all trade partners simultaneously

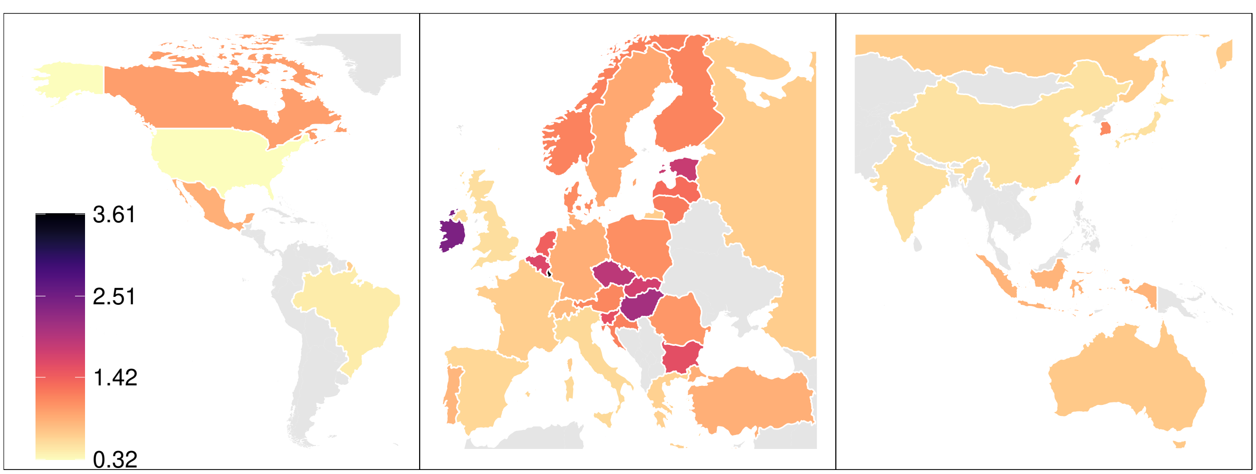


Table A.4: Variations of U.S. unilateral decoupling and shock transmission

Scenario	Decoupling	Covid-19 shock (after decoupling)	Cumulative effect (decoupling+shock)	Difference to baseline
	(1)	(2)	(3)	(4)
A. Imperfect mobility				
Baseline		-0.136		
U.S. unilateral GVCs isolationism	-1.556	-0.140	-1.696	-1.560
U.S. input import barriers +10%	-0.362	-0.137	-0.499	-0.363
U.S. input import barriers +50%	-1.030	-0.140	-1.170	-1.034
U.S. input import barriers +100%	-1.285	-0.141	-1.426	-1.290
U.S. input import barriers +200%	-1.431	-0.141	-1.572	-1.436
B. Immobility all countries				
Baseline		-0.140		
U.S. unilateral GVCs isolationism	-1.556	-0.150	-1.706	-1.566
C. Perfect mobility all countries				
Baseline		-0.123		
U.S. unilateral GVCs isolationism	-1.556	-0.110	-1.666	-1.543
D. Immobility U.S.				
Baseline		-0.138		
U.S. unilateral GVCs isolationism	-1.556	-0.142	-1.698	-1.560
E. Perfect mobility U.S.				
Baseline		-0.132		
U.S. unilateral GVCs isolationism	-1.556	-0.133	-1.689	-1.557

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