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# Unbalanced Trade 2.0

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**ABSTRACT:** Do trade imbalances boost incomes in surplus economies at the expense of deficit economies? We show that the answer is yes in an important subclass of quantitative trade models. This is the consequence of scale economies concentrated in the traded sector. A rise in net exports causes the traded sector to expand, which raises productivity and real income in surplus economies. The flipside is a decline in productivity and income in deficit economies. Under plausible calibrations of the strength and incidence of scale economies, observed trade imbalances cause a sizeable redistribution of the gains from trade towards surplus economies. If these imbalances are modelled as the outcome of steady-state equilibrium in international asset markets, major deficit economies may prefer to correct their traded-sector underproduction by moving to financial autarky. However, financial autarky reduces global welfare and is generally not the optimal policy to bolster the traded sector in the presence of scale economies.



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WORKING PAPERS

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We are grateful to Helge Berger, Diego Cerdeiro, Gino Gancia, Pierre-Oliver Gourinchas, Samuel Kortum, Konstantin Kucheryavyy, Andrei Levchenko, Andres Rodríguez-Clare, Lorenzo Rotunno and Petia Topalova as well as seminar participants at the IMF, the 1st Madrid Macro Mountain Conference and the 10th IMF-WB-WTO Trade Conference for helpful comments and suggestions. This project benefited from financial support from the Austrian Central Bank's Anniversary Fund under project nr. 18706, the research project on Macroeconomic Policy in Low-Income Countries (IATI Identifier GB-1-202960) financed by the U.K.'s Foreign, Commonwealth and Development Office (FCDO), and the program on Macroeconomic Research on Climate Change and Emerging Risks in Asia financed by the Ministry of Finance and Economy of the Government of Korea. The views expressed are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

# 1 Introduction

How do (changes in) trade imbalances influence economies' real incomes? We take a new look at this venerable question in international macroeconomics through the lens of a broad class of popular quantitative trade models. We show that a subset of these models is consistent with the common notion that trade imbalances boost incomes in surplus economies at the expense of deficit economies.[1] Depending on parameter assumptions, this may have quantitatively meaningful implications for the distribution of the gains from trade. Having documented it, we explore some of the implications of this finding.

The modern quantitative analysis of trade policy counterfactuals relies on models that generate a gravity equation of international trade. One appealing feature of these gravity models is that, despite differences in microfoundations, they imply a common macro structure that relates parameter shocks to changes in trade patterns and real incomes.[2] Within this structure, we show that there are two effects that relate a given change in imbalances to incomes. The first is a terms-of-trade effect, common to all gravity models. Since spending is home-biased in the presence of trade barriers, a deficit shifts demand towards the output of a deficit economy, which improves its equilibrium terms of trade and raises its real income. Meanwhile, a surplus economy experiences lower terms of trade and real income. This mechanism has a long pedigree in international macroeconomics, harking back to Germany's World War I reparations (Keynes, 1929). However, it contradicts the view that deficits hurt the deficit economy. Instead it is the surplus economy that experiences a "double burden", both from transferring consumption to the rest of the world and from a deterioration of its terms of trade.

The second is a productivity effect, which is present only if the production of traded goods is subject to relatively strong economies of scale. A trade deficit shifts labour towards non-traded activities, while a surplus shifts labour towards the traded sector. In the presence of scale economies concentrated in traded production, this reduces labour productivity and real income in deficit economies and raises productivity and income in surplus economies. Traded-sector scale economies arise naturally in the popular Krugman and Melitz models.[3] They can also arise from endogenous technical progress in other trade models.[4] Unlike the terms-of-trade effect, the resulting productivity

[1] Our focus throughout the paper is on the trade balance, and we use the terms "surplus economy" or "deficit economy" to describe economies with a surplus or deficit in the trade balance, respectively. This is distinct from the current account balance, which is the subject of the IMF's External Balance Assessment (EBA; see IMF, 2022).

[2] See Arkolakis et al. (2012) and Costinot and Rodríguez-Clare (2014).

[3] See Krugman (1979, 1980) and Melitz (2003).

[4] Krugman (1987) and Benigno et al. (2025) develop models in which the traded sector is

effect generates an income burden for deficit economies. Moreover, since the equilibrium labour allocation in multi-sector models with scale economies is generally not first-best, imbalances may alleviate underproduction of tradables in surplus economies while exacerbating it in deficit economies.

Armed with these insights, we take a generalised gravity model to recent trade and production data from the OECD Inter-Country Input-Output Database. In addition to conventional calibration choices, our analysis requires us to take a stance on the relative strength of scale economies in traded production. To this end, we survey the empirical literature on scale effects across different sectors of the economy. While there is a growing body of evidence supporting sizeable scale economies in goods production, there is virtually no evidence on the scale intensity of *tradable services*. This prompts us to explore a range of plausible parameter values. We show that if scale elasticities in tradable services are similar to those for goods, our model delivers a strong productivity effect of imbalances on incomes.

In a first step, and in line with common practice in the international trade literature, we treat imbalances as exogenous and explore the macroeconomic impacts of a counterfactual global shift to balanced trade for all economies. We use this to illustrate the relative quantitative importance of the terms-of-trade and productivity effects under different assumptions about scale economies. While the exogenous-imbalances framework is clearly limited, the two effects it highlights operate identically—for given parameter choices—in any model that combines a microfounded theory of trade imbalances with a gravity model of trade.[5]

Our results show that the terms-of-trade effect is generally small, and easily overturned by the productivity effect when traded-sector scale economies are present. Furthermore, when the relative strength of traded-sector scale economies is towards the upper end of the range of plausible values, the productivity effect has a sizeable impact on incomes. In this case, with otherwise standard parameter choices, the real income gains from trade to the U.S. are 2.3 percent using standard sufficient statistics.[6] However, the U.S. *loses* 1.2

the economy's main source of productivity growth, and this causes a trade deficit to reduce an economy's long-run level and growth rate of productivity. Ottonello et al. (2024) study exchange-rate policy in a small-open-economy model in which the strength of traded-sector EES depend on the economy's distance from the technology frontier.

[5]For example, the canonical international business cycle model—such as in Backus et al. (1994)—assumes that traded goods are differentiated by origin with a constant elasticity of substitution following Armington (1969). This is a special case, without scale economies, of the general class of gravity models we explore here.

[6]Arkolakis et al. (2012) first show that—abstracting from imbalances—the gains from trade in gravity models can be measured using a sufficient statistic comprised of model parameters and the share of economies' spending on domestic output.

percent of real income due to its trade deficit, wiping out half the gains from trade. By contrast, the gains from trade for China are 1.9 percent, and China gains an *additional* .7 percent from being a surplus economy. While the overall gains remain positive for all economies in this setting, the example shows that the productivity effect may cause a significant re-distribution of these gains from deficit to surplus economies relative to counterfactually balanced trade.[7]

The static quantitative trade model with exogenous imbalances is poorly suited to assessing the welfare consequences of shifting to balanced trade. This is because the shift implies a mechanical increase in *consumption* for surplus economies and corresponding decline for deficit economies—and this exceeds any *income* effects from balancing trade under plausible parameter values. To address this issue, we recast our generalised static gravity model as the steady state of a dynamic model that offers one particular interpretation of trade imbalances: economies' trade may not balance over the long run because of differences in their residents' lifetime income profiles, which give rise to a non-degenerate steady-state foreign asset distribution.[8] This allows us to model the shift to balanced trade as an endogenous outcome of policy-imposed de-facto financial autarky, and to compute the welfare consequences.

The welfare impact of moving to balanced trade depends on the size of an economy's initial trade balance, the strength of scale economies, and the intertemporal elasticity of substitution, which governs individuals' gains from smoothing their lifetime consumption. With modest traded-sector scale economies and standard values of the intertemporal substitution elasticity, economies with a small trade-deficit-to-GDP ratio gain from moving to balanced trade by withdrawing from international asset markets. This group encompasses several major economies, including the U.S. For these economies, the welfare losses from financial autarky are offset by the correction of traded-sector underproduction achieved by closing their trade deficits.[9] However,

[7]A different way to contextualise the potential income effects of trade imbalances is to note that between 2014 and 2024 the PPP-adjusted real GDP per capita for the U.S. grew by 1.95 percent annually, and for China by 7.13 percent annually, according to the IMF *World Economic Outlook* database. This comparison shows that any effect of imbalances on incomes are dwarfed by the drivers of long-term economic growth, including productivity growth. The U.S. retains a significant productivity advantage over major markets, with U.S. TFP exceeding E.U. TFP by about 20 percent (IMF, 2024).

[8]To ensure that there is a unique steady state independent of initial conditions, the dynamic component of our model assumes an OLG structure in which agents do not have infinite horizons, as in Cuñat and Zymek (2024) and Baqaee and Malmberg (2025).

[9]A crucial assumption we make is that observed trade imbalances reflect the outcome of an undistorted equilibrium in international asset markets, and a larger deficit or surplus thus translates into larger realised gains from international asset trade. In practice, a part of imbalances may reflect economic distortions—including from misaligned fiscal, monetary or financial policies. In a setting with strong traded-sector scale economies, tackling such distortions would confer a "double benefit" on deficit economies.

financial autarky reduces global welfare and it is easy to show that it does not constitute the first-best policy response to any distortions arising from the relative scale intensity of traded production.[10]

Our paper is most closely related to Dekle et al. (2007, 2008), who use a standard Eaton-Kortum model to assess the macroeconomic consequences of counterfactually balanced global trade and find small income effects from global imbalances. Our framework nests their Eaton-Kortum model and we show that we can replicate their findings. However, since Eaton and Kortum (2002) assume constant returns to scale, only the terms-of-trade effect is present. Our generalised gravity framework also features the opposing productivity effect. We highlight that under plausible calibrations of the strength of traded-sector scale economies, the qualitative effect of imbalances on real incomes is the opposite as in Dekle et al. (2007, 2008), and the quantitative effect may be one order of magnitude larger.

The gravity framework we utilise generalises a mechanism first illustrated by Epifani and Gancia (2017). They use a two-country Krugman model to show that a trade surplus increases product variety in the traded sector, which improves the surplus economy's real exchange rate and may overcome the traditional "double burden".[11] Embedding this insight into a generalised gravity framework, we demonstrate that it is germane to a broader class of quantitative trade models. It also enables us to take it to the data in a setting with an arbitrary number of heterogeneous economies, using the now-common "exact hat algebra" to explore counterfactuals relative to observed trade and production patterns. Finally, we complement the static treatment of imbalances in Dekle et al. (2007, 2008) and Epifani and Gancia (2017) with a dynamic block of "exact hat" equations that endogenise trade imbalances and allow for a formal analysis of the domestic welfare implications and international spillovers from trade-balancing policies.

Our generalised gravity framework builds on recent advances in the understanding of the properties, commonalities and peculiarities of gravity trade models. Costinot and Rodríguez-Clare (2014) review the range of microfoundations of the gravity equation, and categorise which assumptions influence the numerical output from trade policy counterfactuals relative to given observ-

[10]Given this, and the stylised nature of some of the modelling choices made for illustrative purposes, none of our counterfactuals should be construed to represent practical policy advice.

[11]Corsetti et al. (2013) analyse the real exchange rate effects of external adjustment in a two-country Krugman model but assume that scale economies are symmetric across the traded and non-traded sector—which precludes the productivity effect. Trionfetti (2018) performs a similar analysis in a Heckscher-Ohlin-Melitz model in which all goods are equally traded.

ables. Kucheryavyy et al. (2023a) establish properties under which gravity models with scale economies remain tractable for arbitrary trade barriers when countries trade in value added, and Kucheryavyy et al. (2023b) generalises to a setting with input-output linkages. Although trade models with scale economies have been widely used since the arrival of the "New Trade Theory", they have recently become popular in understanding the potential benefits of trade and industrial policy. Such models are used in Lashkaripour and Lugovskyy (2023) to examine the usefulness of trade restrictions in correcting sectoral misallocations, in Bartelme et al. (2025) to compute the potential welfare gains from optimal industrial policies in open economies, and in Caliendo et al. (2023) to explore optimal tariff design.

The notion of beggar-thy-neighbour imbalances is generally associated with Keynesian macroeconomics, where a trade surplus may boost demand and income in surplus economies at the expense of deficit economies.[12] However, in this setting the international spillovers from imbalances arise due to nominal rigidities that can be offset by monetary policy, unless it is constrained (e.g. at the zero lower bound). We show that similar income spillovers arise in trade models with scale economies under fully flexible prices. These persist as long as imbalances are persistent. In turn, the dynamic component of our framework provides one example of a setting in which permanent trade imbalances are a steady-state feature of the global economy.[13]

The remainder of the paper is structured as follows. Section 2 derives a set of equations that can be used to perform trade-balance counterfactuals across a broad range of static quantitative trade models with exogenous imbalances. Section 3 takes these equations to the data and shows that the macroeconomic effects of balancing world trade depend on the strength of scale economies in traded production. Section 4 endogenises imbalances in a steady state equilibrium with international asset markets. Section 5 combines results from the previous sections to assess the welfare impacts from trade-balancing policies. Section 6 concludes.

## 2 Trade balance shocks with generalised gravity

In this section, we introduce the hat algebra that describes the economic effects of trade balance shocks in a generalised gravity model. It forms the corner-

[12]See Robinson (1952) for a classic treatment, and Obstfeld and Rogoff (1995) for a more contemporary one.

[13]As discussed in Itskhoki and Mukhin (2025), differences in economies' financial positions can give rise to long-run trade deficits in infinite-horizon economies. Ignatenko et al. (2025) recently show that a Melitz model delivers permanent imbalances if the size of fixed exporting costs is destination-specific and at least partially paid in the labour of destination economies.

stone of the quantitative analysis performed in the rest of the paper. For concreteness, we derive it from a model in which the traded sector is modelled à la Armington with external economies of scale (EES). However, we argue in Appendix A that the same expressions could be derived readily from a generalised Eaton-Kortum model and we show that, in both these settings, EES can be interpreted as the steady-state outcome of a learning-by-doing externality. Furthermore, we demonstrate that isomorphic traded-sector scale economies arise from endogenous entry of monopolistically competitive varieties under Krugman- or Melitz-style assumptions about the nature of trade. We treat the environment described in this section as static, but in Section 4 we embed it in the steady state of a dynamic model.

## 2.1 An Armington model with external economies of scale

### 2.1.1 Assumptions

*Preferences and endowments*

There are many economies, $n \in 1, ..., N$. The representative agent in each economy is endowed with $L_n$ units of labour. She supplies these inelastically in the local labour market at wage $W_n$. Out of her labour income, the consumer makes an exogenous transfer to the rest of the world, denoted by $T_n$. Transfers can be positive or negative, and must satisfy $\sum_n T_n = 0$. They thus correspond to trade balances in the static setting of this section.

The consumer derives utility from consumption $C_n$, which is assembled from the output of two sectors $i \in \{G, S\}$ in Cobb-Douglas fashion:

$$C_n = \left(\frac{C_{Gn}}{1-\sigma}\right)^{1-\sigma} \left(\frac{C_{Sn}}{\sigma}\right)^{\sigma}, \tag{1}$$

where $\sigma \in [0, 1)$. Hence, she maximises (1) subject to:

$$P_{Gn}C_{Gn} + P_{Sn}C_{Sn} \leq W_nL_n - T_n, \tag{2}$$

where $P_{in}$ is the price of sector-$i$ consumption in economy $n$.

*Technologies and market structure*

Profit-maximising firms in economy $n$ produce in the two sectors using the technologies:

$$q_{Sn} = Z_{Sn}L_{Sn}, \tag{3}$$

$$q_{Gn} = Z_{Gn}\left(\frac{L_{Gn}}{\nu}\right)^{\nu} \left(\frac{J_{Gn}}{1-\nu}\right)^{1-\nu}, \tag{4}$$

where $q_{Sn}$ is sector-$S$ output; $q_{Gn}$ denotes the output of an economy-$n$-specific variety in sector $G$; $Z_{in}$ is productivity; $L_{in}$ denotes the labour input used; $J_{Gn}$ denotes the use of aggregated sector-$G$ varieties as input in sector $G$; and $\nu \in (0, 1]$. Firms take $Z_{Sn}$ and $Z_{Gn}$ as given, but we allow for possible EES:

$$Z_{Sn} = A_{Sn} L_{Sn}^{\phi_S}, \tag{5}$$

$$Z_{Gn} = A_{Gn} L_{Gn}^{\phi_G}, \tag{6}$$

where the parameters $\phi_S, \phi_G \geq 0$ capture the strength of EES; and $A_{Sn}, A_{Gn}$ are exogenous shifters.

Goods and labour markets are perfectly competitive. Labour cannot move between economies, but it can move freely between sectors within economies. Output in sector $S$ is non-tradable. Origin-differentiated varieties in sector $G$ are tradable, but subject to an iceberg trade cost: $\tau_{n'n} \geq 1$ units of the economy-$n'$ variety must be shipped for one unit to arrive in economy $n$, with $\tau_{nn} = 1$ for all $n$. Sector-$G$ varieties are then assembled by economy-$n$ firms in CES fashion to produce a sector-$G$ aggregate that is used in consumption and as intermediate input:

$$X_{Gn} = \left( \sum_{n'=1}^{N} x_{Gn'n}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}}, \tag{7}$$

where $1 + \theta > 1$ is the elasticity of substitution between varieties.

For illustrative purposes, our exposition in this section allows for EES in both non-traded and traded production. However, we will generally explore settings in which returns to scale in non-traded production are constant ($\phi_S = 0$) but there may be significant EES in traded production ($\phi_G \geq 0$). The standard constant-returns Armington setup prevails in the special case $\phi_G = 0$.

*Equilibrium definition*

Market clearing requires:

$$L_{Sn} + L_{Gn} = L_n, \tag{8}$$

$$q_{Sn} = C_{Sn}, \quad q_{Gn} = \sum_{n'=1}^{N} \tau_{nn'} x_{Gnn'}, \tag{9}$$

$$X_{Gn} = C_{Gn} + J_{Gn}. \tag{10}$$

The equilibrium is then a set of wages and labour allocations $\{W_n, L_{Gn}\}_{n \in N}$ such that consumers and firms satisfy their optimality conditions, and (8)-(10) are satisfied.

### 2.1.2 Equilibrium characterisation

The equilibrium is fully characterised by the following set of equations:

$$W_n L_n + \frac{\sigma}{1-\sigma} T_n = \sum_{n'=1}^{N} m_{nn'} \left( W_{n'} L_{n'} + \frac{\sigma - \nu}{1-\sigma} T_{n'} \right); \tag{11}$$

$$L_{Gn} = \left( 1 - \sigma + \sigma \frac{T_n}{W_n L_n} \right) L_n; \tag{12}$$

$$m_{n'n} = \frac{\left( \tau_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} L_{Gn'}^{-\frac{\phi_G}{\nu}} W_{n'} / A_{Gn'}^{\frac{1}{\nu}} \right)^{-\theta}}{\sum_{n'=1}^{N} \left( \tau_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} L_{Gn'}^{-\frac{\phi_G}{\nu}} W_{n'} / A_{Gn'}^{\frac{1}{\nu}} \right)^{-\theta}}; \tag{13}$$

$$\sum_n W_n L_n = 1; \tag{14}$$

where $m_{n'n}$ denotes the share of spending by economy $n$ on sector-$G$ output from economy $n'$.

Equation (11) is a market-clearing condition that pins down relative wages as a function of trade balances and bilateral trade shares. Equation (12) determines the equilibrium allocation of labour to tradables production. Equation (13) describes the properties of bilateral trade shares. These take the form common to all gravity models. Economy-$n$ spending on economy-$n'$ output declines with bilateral trade barriers, with $\theta$ governing the responsiveness of trade flows to trade barriers. It also declines in the relative price of economy-$n'$ traded output. In turn, that price reflects economy-$n'$ wages and traded-sector labour productivity. In our framework labour productivity in tradables has two endogenous components. The first—captured by $m_{nn}^{(1-\nu)/(\theta\nu)}$—represents the cost of intermediate inputs, a portion of which is imported. The second—captured by $L_{Gn}^{-\phi_G/\nu}$—reflects potential scale economies in tradable production: everything else constant, the price of an economy's tradable output is lower the larger the scale of production. Finally, we impose the normalisation in (14) to ensure that trade balances can be interpreted in terms of fixed shares of world GDP.[14]

Following Arkolakis et al. (2012) and Costinot and Rodríguez-Clare (2014), we can write:

$$C_n = Y_n \left( 1 - \frac{T_n}{W_n L_n} \right), \tag{15}$$

$$Y_n \equiv \frac{W_n L_n}{P_n} = L_{Sn}^{\sigma\phi_S} \left( m_{nn}^{-\frac{1}{\theta}} L_{Gn}^{\phi_G} \right)^{\frac{1-\sigma}{\nu}} A_n L_n, \tag{16}$$

[14] It is straightforward to prove that there is a unique set of labour allocations and wages consistent with (11)-(14) by following the steps described in Kucheryavyy et al. (2023b).

where $Y_n$ represents the real GDP of $n$; $P_n \equiv P_{Gn}^{1-\sigma} P_{Sn}^{\sigma}$; and $A_n \equiv A_{Gn}^{\frac{1-\sigma}{\nu}} A_{Sn}^{\sigma}$.

Equation (16) encapsulates the two channels through which imbalances affect real incomes. The first is what we call the *terms-of-trade effect*. To see it, note that we can write $m_{nn} = (1 + S_n^{-\theta})^{-1}$, where $S_n$ is a measure of the price of economy-$n$ exports compared to the price of its imports—the terms of trade. The terms of trade depend on economies relative wages, as can be seen from equation (13). It follows from (11) that with some home bias in spending, a trade deficit in economy $n$ shifts demand from foreign labour towards economy-$n$ labour.[15] In equilibrium, this raises the relative wage of economy $n$ and improves its terms of trade. Conversely, a trade surplus reduces the economy's relative wage and worsens its terms of trade. Via terms-of-trade-induced changes of $m_{nn}$ in equation (16), trade imbalances thus raise real income in deficit economies, and lower it in surplus economies.

The second channel is what we call the *productivity effect*. Everything else constant, an improvement in the trade balance of economy $n$ shifts labour to the traded sector, as can be seen from equation (12). In turn, this raises aggregate productivity and real income via $L_{Gn}$ in equation (16) if scale economies are concentrated in the traded sector ($\phi_G > 0$, $\phi_S = 0$).

#### 2.1.3 A note on efficiency

It should be evident that the equilibrium characterised by (11)-(13) is not Pareto efficient if $\phi_G > 0$, $\phi_S = 0$. Since firms do not internalise the effect of their production choices on traded-sector productivity, the share of labour allocated to trade production is too low if scale economies are concentrated in traded production. While this is trivial in the case of our two-sector Armington model with EES, it is also a generic feature of multi-sector models with scale economies. The market equilibrium in these models delivers underproduction in high-returns-to-scale sectors.[16] The second-best nature of the market equilibrium explains why we find in Section 5 that *introducing* market frictions can be welfare-improving for some economies when scale economies in traded production are strong.

[15] There are two sources of home bias in our framework: the assumption that a share of output is non-tradable ($\sigma > 0$) and the presence of iceberg trade barriers in the traded sector which cause tradables spending to be biased towards an economy's own goods.

[16] For example, see Lashkaripour and Lugovskyy (2023) for a recent discussion.

## 2.2 Exact hat algebra

### 2.2.1 General trade balance shocks

Consider an initial equilibrium of the model described in Section 2.1 that corresponds to the empirically observed patterns of trade, production, imbalances and incomes. Now suppose we impose a new set of trade balances, $\{\tilde{T}_n\}_n$. For any endogenous variable $U$, let $\hat{U} \equiv \tilde{U}/U$ denote its change relative to the status-quo equilibrium. Then:

$$\hat{W}_n y_n + \frac{\sigma}{1-\sigma}\tilde{T}_n = \sum_{n'} \hat{m}_{nn'} m_{nn'} \left(\hat{W}_{n'} y_{n'} - \frac{\nu-\sigma}{1-\sigma}\tilde{T}_{n'}\right); \tag{17}$$

$$\hat{L}_{Gn} = \frac{y_n + \frac{\sigma}{1-\sigma}\frac{\tilde{T}_n}{\hat{W}_n}}{y_n + \frac{\sigma}{1-\sigma}T_n}; \tag{18}$$

$$\hat{m}_{n'n} = \frac{\left(\hat{m}_{nn}^{\frac{1-\nu}{\theta\nu}} \hat{L}_{Gn'}^{-\frac{\phi_G}{\nu}} \hat{W}_n\right)^{-\theta}}{\sum_n \left(\hat{m}_{nn}^{\frac{1-\nu}{\theta\nu}} \hat{L}_{Gn'}^{-\frac{\phi_G}{\nu}} \hat{W}_n\right)^{-\theta} m_{nn'}}; \tag{19}$$

$$\hat{C}_n = \hat{Y}_n \frac{y_n - \tilde{T}_n/\hat{W}_n}{y_n - T_n}; \quad \hat{Y}_n = \hat{L}_{Sn}^{\sigma\phi_S}\left(\hat{m}_{nn}^{-\frac{1}{\theta}} \hat{L}_{Gn}^{\phi_G}\right)^{\frac{1-\sigma}{\nu}}; \tag{20}$$

$$\sum_n \hat{W}_n y_n = 1; \tag{21}$$

where $y_n \equiv W_n L_n / \sum_n W_n L_n$ denotes the share of economy $n$ in world GDP in the initial equilibrium.

Dekle et al. (2007) derive (17), (19) and (20) under the assumptions of constant returns to scale in sector $S$, so that $\phi_S = 0$, and canonical Eaton-Kortum production and trade in sector $G$, which implies $\phi_G = 0$.[17] In Appendix A, we show that (17)-(20) can also be derived by assuming that production and trade in sector $G$ follows variants of the Krugman and Melitz models, where generally $\phi_G > 0$. Appendix A further highlights that endogenous innovation via learning-by-doing, in the spirit of the semi-endogenous growth literature, can deliver $\phi_G > 0$ in otherwise standard Armington and Eaton-Kortum settings.

### 2.2.2 Special case of shift to balanced trade

Suppose now the shock is a shift to balanced trade for economy $n$. Then we can write (20) to a first-order approximation as:

$$\ln \hat{C}_n \simeq t_n + \ln \hat{Y}_n \simeq t_n + \frac{(1-\sigma)(1-m_{nn})}{\nu} \ln \hat{S}_n - \sigma\left(\frac{\phi_G}{\nu} - \phi_S\right) t_n, \tag{22}$$

[17] If $\phi = 0$, equation (18) is redundant for analysing the income and consumption effects from changes in imbalances.

where $t_n \equiv T_n/(W_n L_n)$. The first term on the right-hand-side of (22) represents the direct impact on consumption of removing the trade balance; the second term the indirect income effect via the terms of trade; and the third term the indirect income effect via productivity.

Equation (22) provides a useful preview of some of our quantitative findings below. First, if the non-traded sector is large (large $\sigma$) and trade barriers are generally high ($m_{nn}$ close to 1), the effect of changes in the terms of trade on real income and consumption is quantitatively small. Second, the magnitude of the trade elasticity does not play a first-order role in shaping the income responses in a shift to balanced trade. Third and most importantly, the strength of the productivity effect depends on the strength of traded-sector scale economies ($\phi_G$) *relative to* non-traded scale economies ($\phi_S$).

# 3 Global rebalancing with gravity, revisited

Below, we take the hat algebra introduced in the previous section to recent data on production, trade patterns and trade imbalances. We use it to explore the effects on real incomes of a global shift to balanced trade. This exercise is in the spirit of Dekle et al. (2007, 2008) but, unlike in their model, we now allow for the possibility of scale economies in traded production consistent with several prominent microfoundations of gravity in international trade.

## 3.1 Data and calibration

We calibrate our framework to data for 66 individual economies and the rest of the world from the OECD Inter-Country Input-Output Database (ICIO; OECD, 2023).[18] The data is averaged for the years 2017-19. Table 1 gives an overview of the main parameter values used in our baseline experiments. Further details and discussion can be found in Appendix B.1.

Most of our parameters are conventionally calibrated, and only the values for the scale elasticities merit some further discussion. As shown in Section 2.1, the strength of the productivity effect depends on the scale elasticity in traded relative to non-traded production. Therefore, we normalise $\phi_S = 0$ and define $\phi \equiv \phi_G$ as a measure of the strength of trade-sector scale economies

[18] The OECD ICIO are a suitable data source for calibrating our model which assumes that economies' foreign sales of their goods and services take place primarily via international trade. This abstracts from the delivery of goods via horizontal FDI, and of services via commercial presence ("Mode 3"). Generalising the framework to incorporate multinational production in both goods and services could facilitate a richer interpretation of the productivity effect and the nature of trade imbalances, but it would require the use of additional data sources. We leave this extension to future research.

Table 1: Calibration

| Object | Description | Value |
|---|---|---|
| $\sigma$ | Share of non-traded output in world final absorption | .49 |
| $\nu$ | Share of value added in world traded production | .44 |
| $\theta$ | Trade elasticity | 4.00 |
| $\phi_S$ | Scale elasticity in non-traded production | 0 |
| $\phi \equiv \phi_G$ | Scale elasticity in traded production | $\in [0,.50]$ |

Parameters $\sigma$ and $\nu$ are calibrated based on data from the OECD Inter-Country Input Output Database, averaged for the period 2017-2019. Sectors D, E, F, L, O, P, Q, R, S and T are defined as non-traded. The trade elasticity $\theta$ is based on Simonovska and Waugh (2014). The range of scale elasticities is based on model parameter relationships and empirical estimates. See text and Appendix B.1 for details.

relative to non-traded production. We include the limit case of $\phi = 0$ for comparison with Dekle et al. (2007, 2008). In Appendix B.1, we argue that the available empirical evidence on sectoral scale elasticities is incomplete but plausibly consistent with values as high as $\phi = .50$.

While there is a growing body of evidence supporting sizeable scale economies in *goods* production, goods account for only about half of what we define as traded-sector value added. There is some further evidence that finds weaker scale economies in overall services, but no systematic evidence on how these are distributed between traded and non-traded services. We show in Appendix B.1 that high values of $\phi$ are plausible if traded services are similarly scale intensive as goods, but otherwise lower values of $\phi$ are appropriate. To reflect the uncertainty resulting from the scarcity of empirical evidence on services scale elasticities, we experiment with different values of $\phi$, designating $\phi = .50$ as a plausible upper bound.

## 3.2 Main results

### 3.2.1 Major economies

Our main experiment involves setting the trade balances for the 66 sample economies and the rest of the world to zero: $\tilde{T}_n = 0$ for all $n$. Table 2 gives an overview of the impact on major economies under different parameterisations of the trade and scale elasticities.

Panel (a) replicates the analysis of Dekle et al. (2007, 2008) under the assumption of constant returns to scale in traded and non-traded production. In this setting, only the terms-of-trade effect operates. Deficit economies like India and the U.S. see demand shift away from their output as global trade moves

Table 2: Main counterfactuals output, major economies

Panel (a): $\theta = 4; \phi = 0$

| | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | $t_n$ | Real cons. | Real GDP | ToT effect | Prod. effect |
| China | 0.014 | 0.015 | 0.001 | 0.001 | |
| Germany | 0.076 | 0.086 | 0.008 | 0.008 | |
| India | -0.029 | -0.033 | -0.004 | -0.004 | |
| Japan | -0.005 | -0.005 | -0.001 | -0.001 | |
| United States | -0.028 | -0.031 | -0.004 | -0.004 | |

Panel (b): $\theta = 4; \phi = .25$

| | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | $t_n$ | Real cons. | Real GDP | ToT effect | Prod. effect |
| China | 0.014 | 0.011 | -0.003 | 0.001 | -0.004 |
| Germany | 0.076 | 0.067 | -0.012 | 0.008 | -0.020 |
| India | -0.029 | -0.025 | 0.004 | -0.005 | 0.008 |
| Japan | -0.005 | -0.004 | 0.000 | -0.001 | 0.001 |
| United States | -0.028 | -0.023 | 0.004 | -0.004 | 0.008 |

Panel (c): $\theta = 4; \phi = .50$

| | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | $t_n$ | Real cons. | Real GDP | ToT effect | Prod. effect |
| China | 0.014 | 0.008 | -0.007 | 0.001 | -0.008 |
| Germany | 0.076 | 0.047 | -0.031 | 0.009 | -0.041 |
| India | -0.029 | -0.017 | 0.012 | -0.005 | 0.017 |
| Japan | -0.005 | -0.003 | 0.002 | -0.001 | 0.003 |
| United States | -0.028 | -0.016 | 0.012 | -0.004 | 0.016 |

Table shows counterfactual consumption and income effects from balancing global trade, derived by applying the hat algebra from Section 2.2 to the economy sample described in Section 3.1.1. Unless otherwise specified, all parameters are calibrated as discussed in Section 3.1.2. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

to balance, causing a deterioration in their terms of trade that reduces their real GDPs. Conversely, surplus economies like China and Germany experience a terms-of-trade appreciation that bolsters their real incomes. However, the terms-of-trade effect is small, and dwarfed by the mechanical reallocation of consumption as economies' external "transfers" are removed.

Panel (b) introduces modest scale economies in traded production. This activates the productivity effect, which operates in the opposite direction of the terms-of-trade effect: as global trade moves to balance, former deficit economies allocate more labour to traded production and this raises labour productivity and incomes. Conversely, former surplus economies see their traded sector shrink and experience a productivity loss as their gains from scale

Table 3: Main counterfactuals output, all economies

Panel (a): $\theta = 4; \phi = 0$

| | $N$ / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.036 | 0.003 | 0.003 | |
| 75th pctile. | | 0.065 | 0.073 | 0.006 | 0.006 | |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.030 | -0.004 | -0.004 | |
| 25th pctile | | -0.063 | -0.069 | -0.009 | -0.009 | |

Panel (b): $\theta = 4; \phi = .25$

| | $N$ / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.027 | -0.005 | 0.003 | -0.009 |
| 75th pctile. | | 0.065 | 0.056 | -0.011 | 0.007 | -0.017 |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.023 | 0.003 | -0.004 | 0.007 |
| 25th pctile | | -0.063 | -0.052 | 0.009 | -0.010 | 0.018 |

Panel (c): $\theta = 4; \phi = .50$

| | $N$ / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.018 | -0.013 | 0.003 | -0.017 |
| 75th pctile. | | 0.065 | 0.040 | -0.027 | 0.008 | -0.035 |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.016 | 0.009 | -0.005 | 0.015 |
| 25th pctile | | -0.063 | -0.035 | 0.026 | -0.011 | 0.036 |

Table shows counterfactual consumption and income effects from balancing global trade, derived by applying the hat algebra from Section 2.2 to the economy sample described in Section 3.1.1. Unless otherwise specified, all parameters are calibrated as discussed in Section 3.1.2. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

diminish. With modest scale economies, the productivity effect is small—but it is sufficiently powerful to overcome the terms-of-trade effect. This reproduces the main finding of Epifani and Gancia (2017) in a more general setting.[19]

Finally, panel (c) allows for scale economies that are highly concentrated in traded production. This has little impact on the terms-of-trade effect but magnifies the productivity effect. The United States now experiences a permanent 1.2 percent real GDP gain from the removal of its deficit. At the other

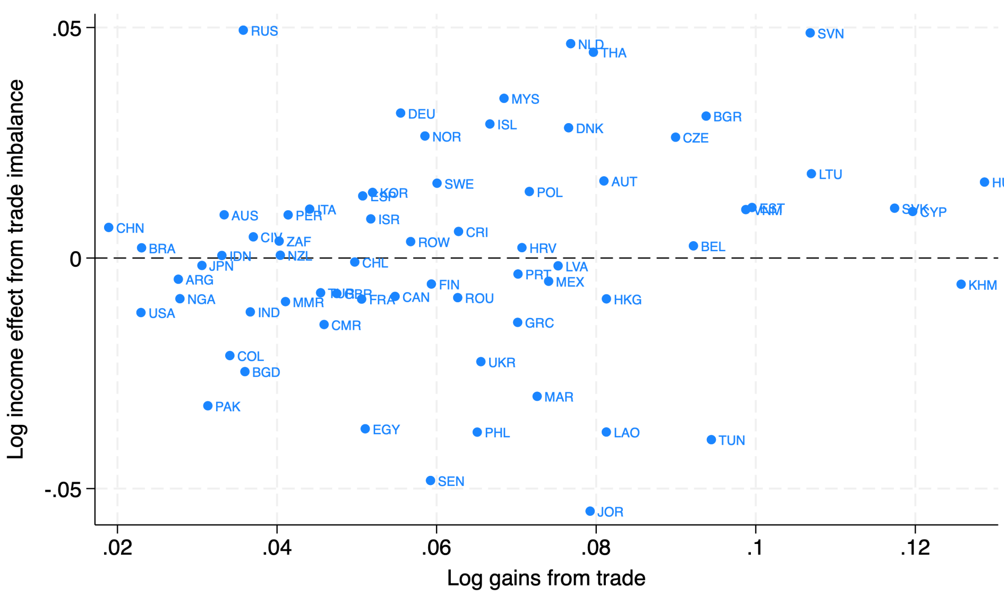
[19] In a more stylised two-economy model, Epifani and Gancia (2017) find combinations of parameters under which the productivity effect is strong enough to lower not just real income but *consumption* in former surplus economies. Calibrating our general gravity framework to observed trade patterns, we cannot replicate this result unless the traded-sector scale elasticity exceeds the upper end of the range of values discussed in Section 3.1.

end of the spectrum, Germany experiences a 3.1 percent permanent GDP loss from seeing its surplus disappear. These strong real GDP responses offset nearly half the consumption loss to the U.S. from balanced trade, and nearly half the consumption gains for China and Germany.

### 3.2.2 All economies

Table 3 gives an overview of the macroeconomic impacts of balanced trade across all sample economies for the three different assumptions about relative scale economies. The table conveys two main points. First, the patterns described for the major economies in Table 2 are qualitatively typical for the broader sample of economies. Second, the GDP and consumption impacts in major economies are quantitatively in line with the sample median. Put differently, there is a significant number of smaller economies that experience larger consumption and GDP impacts from moving to balanced trade than do the major economies. This is because the status-quo trade imbalances of some smaller economies are much more sizeable on their own terms. This point bears emphasising: while major economies tend to dominate the policy debate about global trade imbalances—since their trade balances are large relative to *world* GDP—, many smaller economies experience much more unbalanced trade relative to their *own* GDPs.

Figure 1: Income effect from trade imbalance versus gains from trade




The real income effects from imbalances are defined as −1 times the impact on real GDP from moving to balanced trade. This impact is derived by applying the hat algebra from Section 2.2 to the economy sample described in Section 3.1.1, with $\theta = 4$ and $\phi = .50$. All other parameters are calibrated as discussed in Section 3.1.2. The gains from trade are defined as $m_{nn}^{-(1-\sigma)/(\theta\nu)}$. See text for details.

One way to contextualise the size of the income effects from imbalances is to compare them to the income effects of trade openness. In our framework, the latter are captured by $m_{nn}^{-(1-\sigma)/(\theta\nu)}$, an incarnation of the typical "gains from trade" sufficient statistic in gravity models. Figure 1 correlates the real income effects of imbalances with the gains from trade. The income effects from imbalances are defined as $-1$ times the impact on real GDP from moving to balanced trade in Table 3. The figure focuses on the upper-bound case in which the traded-sector scale economies are relatively strong.

As would be expected, the figure shows that the gains from trade are always positive, while the income effects of imbalances may be positive or negative. What is more striking is that the *ranges* of the two are similar when traded-sector scale economies are strong. A corollary of these two observations is that trade imbalances in this setting cause a significant re-distribution of the gains from trade. The example of the U.S. and China is illustrative. In this calibration of our framework, the U.S. gains from trade are 2.3 percent. However, half of these income gains are wiped out by the U.S. trade deficit. Conversely, China's gains from trade are 1.9 percent, but its real income is boosted by a further .7 percent due to its trade surplus.

### 3.2.3 Additional and alternative counterfactuals

Some additional and alternative counterfactuals are discussed in Appendix C. There we show that varying the trade elasticity does not have a major impact on our results (Appendix C.1), but that the strength of input-output linkages in traded production is an important amplifying mechanism for the productivity effect of trade imbalances in the presence of scale economies concentrated in trade production (Appendix C.2).

# 4 International assets and endogenous imbalances

We now re-cast the static framework from Section 2 as the steady state of a dynamic model in which imbalances arise as a feature of the equilibrium in international asset markets. Specifically, we assume that the world is populated by overlapping generations of individuals whose lifetime income profiles differ across economies.[20] International asset trade then leads to a non-degenerate steady-state foreign asset distribution, and a corresponding set of non-zero trade balances that support this steady state. We allow governments to influence their residents' (international) savings through taxes and subsidies.

[20] This can be thought of as a short-cut representation of different demographic structures.

This delivers a dynamic block of exact-hat equations that are modular to the previous set of exact-hat equations describing goods and labour market equilibrium. It allows us to compare the steady-state lifetime welfare of a typical cohort under status-quo imbalances with the case in which governments use taxes and subsidies to engineer de-facto financial autarky.

## 4.1 A model of lifetime consumption smoothing

### 4.1.1 Assumptions

*International asset markets and interest rates*

There is no aggregate uncertainty and the world economy is assumed to be in a zero-growth steady state, with all real aggregate quantities and prices constant.[21] Time subscripts on aggregate variables can thus be omitted, and we do so for notational ease.

Individuals can freely trade in a one-period international bond that yields a steady-state gross interest rate $R$. Let $B_n$ denote the net international assets of economy $n$. International asset market clearing requires that $R$ satisfies

$$\sum_{n=1}^{N} B_n = 0. \tag{23}$$

The government of economy $n$ may subsidise saving and tax borrowing at a rate $\delta_n$ that may be positive or negative. If $\delta_n < 0$, the government taxes savings and subsidises borrowing. As a result, the effective interest rate in $n$ is $R_n = R(1 + \delta_n)$. Governments are assumed to distribute the net revenue $D_n$ from this policy to their residents proportionally labour income.

*Additional assumptions about preferences and endowments*

Economies are populated by overlapping generations of individuals with unit mass and fixed lifetime of two periods, period 0 ("youth") and period 1 ("old age"). Individuals in economy $n$ receive $\omega_n L_n$ units of labour in youth and $(1-\omega_n)L_n$ in old age, where $\omega_n \in [0, 1]$ is exogenous. The total labour supply of the economy thus remains $L_n$ as in Section 2.

Individuals choose their international assets at the end of youth to maximise lifetime utility:

$$\max_{B_n} V_n = \left( C_{n0}^{\frac{\gamma-1}{\gamma}} + C_{n1}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \tag{24}$$

[21] It would be easy to introduce some constant, common rate of exogenous productivity growth without materially affecting any of the derivations below. Therefore, all aggregate variables in the model can be considered as the de-trended equivalents of their data counterparts.

subject to

$$P_n C_{n0} = \omega_n \left(W_n L_n + D_n\right) - B_n, \tag{25}$$

$$P_n C_{n1} = \left(1 - \omega_n\right)\left(W_n L_n + D_n\right) + R_n B_n, \tag{26}$$

where $\gamma > 0$ is the intertemporal elasticity of substitution.

#### 4.1.2 Trade balances and welfare in steady state equilibrium

Steady state equilibrium in asset markets is described by:

$$e_n = \frac{1}{1 + \left[\left(1 + \delta_n\right) R\right]^{\gamma - 1}}; \tag{27}$$

$$d_n \equiv \frac{D_n}{W_n L_n} = -\delta_n \frac{R B_n}{W_n L_n}; \tag{28}$$

$$B_n = \left[\left(1 - e_n\right)\omega_n - \frac{e_n\left(1 - \omega_n\right)}{\left(1 + \delta_n\right) R}\right]\left(1 + d_n\right) W_n L_n; \tag{29}$$

together with the asset market clearing condition in (23). Equation (27) describes the behaviour of $e_n$—the share of her lifetime income an agent in economy $n$ allocated to consumption in youth—as a function of the economy-$n$ effective interest rate. Equation (28) links net government revenue to the economy's foreign asset position. Finally, equation (29) represents the net foreign asset supply of economy $n$. Using (27) and (28), it is easy to show that foreign asset supply may be positive or negative, and is strictly monotonic in $R$. Consequently, for given world income shares, lifetime income profiles and subsidies $\{W_n L_n, \omega_n, \delta_n\}_n$, there is a unique international bond interest rate that clears asset markets. The economy-$n$ trade balance is then given by:

$$T_n = W_n L_n - P_n\left(C_{n0} + C_{n1}\right) = W_n L_n - P_n C_n = -\left(R - 1\right) B_n. \tag{30}$$

We can now express the lifetime welfare of an agent born in economy $n$ as follows:

$$V_n = v_n \left(1 + d_n\right) Y_n; \tag{31}$$

$$v_n \equiv \frac{\omega_n}{e_n^{\frac{1}{\gamma - 1}}} + \frac{1 - \omega_n}{\left(1 - e_n\right)^{\frac{1}{\gamma - 1}}}. \tag{32}$$

Equations (31) and (32) show that lifetime welfare corresponds to an economy's real income multiplied by two terms. The first captures the welfare gains from agents' ability to smooth lifetime consumption through international capital markets. The second captures welfare gains or losses from the tax policy implemented by the economy's government.

## 4.2 Additional exact hat algebra: dynamic block

### 4.2.1 General shocks to financial integration

For the remainder of our analysis, we assume that laissez-faire prevails in international asset markets in the initial steady state. The shock we consider is the introduction of a set of asset subsidies or taxes $\{\tilde{\delta}_n\}_n$ that alters the distribution of foreign asset positions and trade balances. The change relative to the status-quo steady state due to this shock is then captured by equations (17)-(21) and:

$$\hat{e}_n^{-1} = \left\{e + (1-e)\left[\left(1+\tilde{\delta}_n\right)\hat{R}\right]^{\gamma-1}\right\}^{-1}; \tag{33}$$

$$\tilde{d}_n = \tilde{\delta}_n \frac{R\hat{R}}{R\hat{R}-1}\frac{\tilde{T}_n}{\hat{W}_n y_n}; \tag{34}$$

$$\tilde{T}_n = -\left(R\hat{R}-1\right)\left[(1-e\hat{e}_n)\,\omega_n - \frac{e\hat{e}_n\,(1-\omega_n)}{\left(1+\tilde{\delta}_n\right)\hat{R}R}\right]\left(1+\tilde{d}_n\right)\hat{W}_n y_n; \tag{35}$$

$$0 = \sum_{n=1}^{N}\frac{\tilde{T}_n}{R\hat{R}-1}; \tag{36}$$

$$\hat{V}_n = \hat{v}_n\left(1+\tilde{d}_n\right)\hat{Y}_n; \quad \hat{v}_n = \frac{\omega_n\,(e\hat{e}_n)^{-\frac{1}{\gamma-1}} + (1-\omega_n)\,(1-e\hat{e}_n)^{-\frac{1}{\gamma-1}}}{\omega_n e^{-\frac{1}{\gamma-1}} + (1-\omega_n)\,(1-e)^{-\frac{1}{\gamma-1}}}, \tag{37}$$

where $e = (1+R^{\gamma-1})^{-1}$.

### 4.2.2 Special case of shift to financial autarky

Moving to financial autarky from laissez-faire requires the government of economy $n$ to implement:

$$1+\tilde{\delta}_n = \frac{1}{\hat{R}R}\left(\frac{1-\omega_n}{\omega_n}\right)^{\frac{1}{\gamma}}. \tag{38}$$

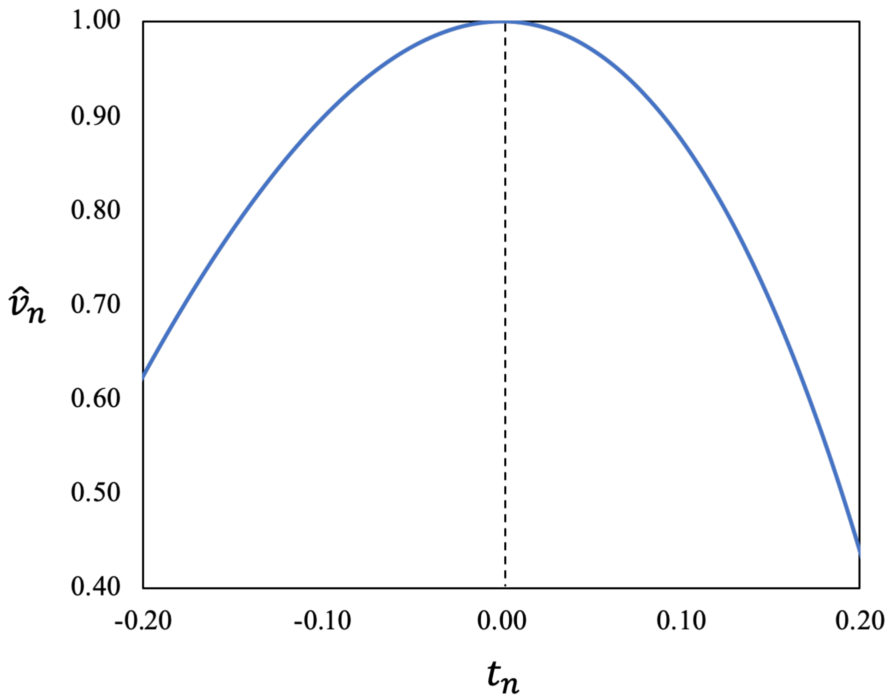
This delivers $\tilde{T}_n = \tilde{d}_n = 0$, and the welfare impact from losing the opportunity to smooth lifetime consumption can be computed as:

$$\hat{V}_n = \hat{v}_n\hat{Y}_n \tag{39}$$

$$\hat{v}_n = \frac{\left[\omega_n^{\frac{\gamma-1}{\gamma}} + (1-\omega_n)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}}{\omega_n e^{-\frac{1}{\gamma-1}} + (1-\omega_n)\,(1-e)^{-\frac{1}{\gamma-1}}}. \tag{40}$$

Figure 2 illustrates how this welfare impact relates to the economy's trade balance in initial equilibrium. From (30), an economy with a large trade sur-

Figure 2: Trade balance and gains from lifetime consumption smoothing




Computed using (27), (29), (30) and (40), and imposing $\delta_n = 0$, $R = 1.02^{30}$ and $\gamma = .50$. $\hat{v}_n$ the lifetime welfare penalty from shutting down international asset trade relative to a laissez-faire steady state. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

plus relative to GDP also holds large foreign debts in steady state. An economy with a large trade deficit holds large foreign assets. Both such economies benefit significantly from the consumption smoothing facilitated by international asset markets. Hence, they experience larger welfare losses from financial autarky than an economy with a smaller trade imbalance. The closer an economy is to balanced trade in the initial equilibrium, the smaller the consumption smoothing benefits it receives from trade in international asset markets.

In a world of endowment economies, equation (40) would be sufficient to describe the welfare impact on economy $n$ from moving to financial autarky.[22] However, this is not the case in our framework because—as discussed in Sections 2 and 3—moving to balanced trade also impacts welfare by changing an economy's real income. In the next section, we explore quantitatively how these two effects interact for different economies.

# 5 Welfare effects of global rebalancing

We now re-visit the static analysis performed in Section 3, but use the results from Section 4 to let the global shift to balance trade arise as an endogenous

[22] This is nested in our model as the limit case $\theta \to \infty$, $\phi = 0$.

steady-state outcome of government policies that limit the use of international asset markets. This has no bearing on the *income effects* of balancing trade quantified in Section 3. However, it allows to weigh their impact on *welfare* formally against the loss from a reduced ability to smooth lifetime consumptions.

## 5.1 Additional calibration

We conservatively set the intertemporal elasticity of substitution $\gamma = 0.5$, and we impose $R = 1.81$, roughly corresponding to a 2-percent annual interest rate with a model period representing 30 years. Appendix B.2 provides some further discussion of these parameter choices. It also shows that they allow us to back out $\{\omega_n\}_n$ from observed trade balances in an initial laissez-faire steady state. This gives us all that is needed to operationalise (33)-(37).

## 5.2 Results

### 5.2.1 Major economies

We focus on the most interesting case in which relative traded-sector scale economies are strong ($\phi = .50$). Table (4) reproduces most of panel (c) of Table (2), but replaces the consumption impact of balancing global trade with the welfare impact. Given (39) and (40), the welfare impact is the sum of the real GDP impact and the loss from removing the consumption smoothing opportunities available under laissez-faire.

Table 4: Welfare effects of global rebalancing, major economies

Key parameters: $\theta = 4; \phi = .50; \gamma = .50$

| | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | $t_n$ | Welfare | Real GDP | ToT effect | Prod. effect |
| China | 0.014 | -0.009 | -0.007 | 0.001 | -0.008 |
| Germany | 0.076 | -0.104 | -0.031 | 0.009 | -0.041 |
| India | -0.029 | 0.002 | 0.012 | -0.005 | 0.017 |
| Japan | -0.005 | 0.001 | 0.002 | -0.001 | 0.003 |
| United States | -0.028 | 0.003 | 0.012 | -0.004 | 0.016 |

Table shows counterfactual welfare and income effects from balancing global trade through appropriate choice of $\{\tilde{\delta}_n\}_n$, derived by applying the hat algebra from Sections 2.2 and 4.2 to the economy sample described in Section 3.1.1. Unless otherwise specified, all parameters are calibrated as discussed in Sections 3.1.2 and 5.1. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

There are two striking contrasts with panel (c) of Table (2). First, the major surplus economies are *unambiguously* worse off under balanced trade, even though their aggregate consumption is increased. This is because a negative income impact from balancing trade—due to the dominant productivity effect−combines with a loss of consumption smoothing. Germany is especially adversely affected, with a permanent welfare loss of 10.4 percent.

Second, the major deficit economies are marginally better off under balanced trade. This is because their income gains from exploiting scale economies in traded production under balanced trade offset the loss from moving to de-facto financial autarky. For the U.S., the balanced-trade steady state implies a permanent 0.3 percent welfare gain.

The reason for this unconventional finding is the second-best nature of the initial equilibrium. As explained in Section 2.1.3, in multi-sector models there is generally underproduction in high-returns-to-scale sectors. Under the calibration used here, the welfare gains from using international asset markets for the U.S. and India are sufficiently small as to be outweighed be the partial correction of traded-sector underproduction in a the counterfactual balanced-trade steady state.

### 5.2.2 All economies

Figure 3 highlights that the major deficit economies are not representative of the broader set of economies in our sample. The distribution of welfare impacts inherits the shape of the distribution of consumption smoothing losses from Figure 2. However, it is shifted north west through the origin due to the income transfer from surplus to deficit economies caused by the productivity effect. Consequently, economies in the tails of the distribution of trade balances are made worse off by the move to balanced trade. This includes *all* surplus economies. It also includes many economies with large trade deficits relative to their GDPs. Several low-income economies, such as Senegal and Laos, are especially adversely affected.

To benefit from the move to balanced trade, an economy needs to have a small trade deficit in steady state relative to its own GDP. It is no coincidence that several major economies satisfy this criterion. Since the laissez-faire international bond interest rate is weighted average of economies' lifetime income profiles, it is necessarily similar to the autarky interest rates of the largest economies. A corollary is that large economies benefit least from consumption smoothing in international asset markets, and this is reflected in small foreign asset positions and imbalances relative to their GDPs.

Given the distribution of welfare changes shown in Figure 3, it is unsurprising that global rebalancing via de-facto financial autarky leads to a net welfare loss of about 2 percent for the world as a whole. This implies that

Figure 3: Welfare effects of global rebalancing, all economies

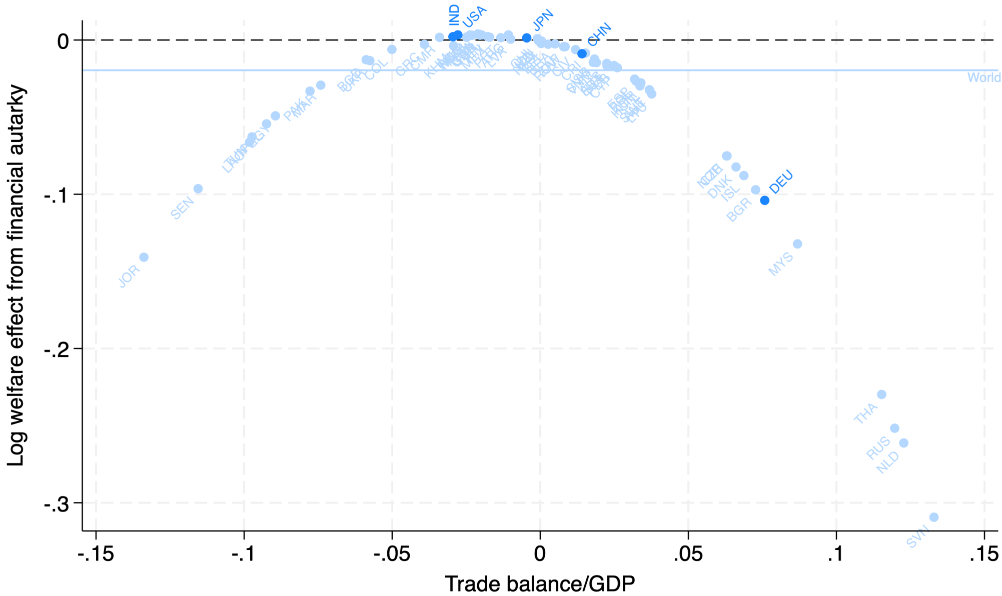



Figure shows counterfactual welfare effects from balancing global trade through appropriate choice of $\{\tilde{\delta}_n\}_n$, derived by applying the hat algebra from Sections 2.2 and 4.2 to the economy sample described in Section 3.1.1, with $\theta = 4$, $\phi = .50$ and $\gamma = .50$. Unless otherwise specified, all parameters are calibrated as discussed in Sections 3.1.2 and 5.1.

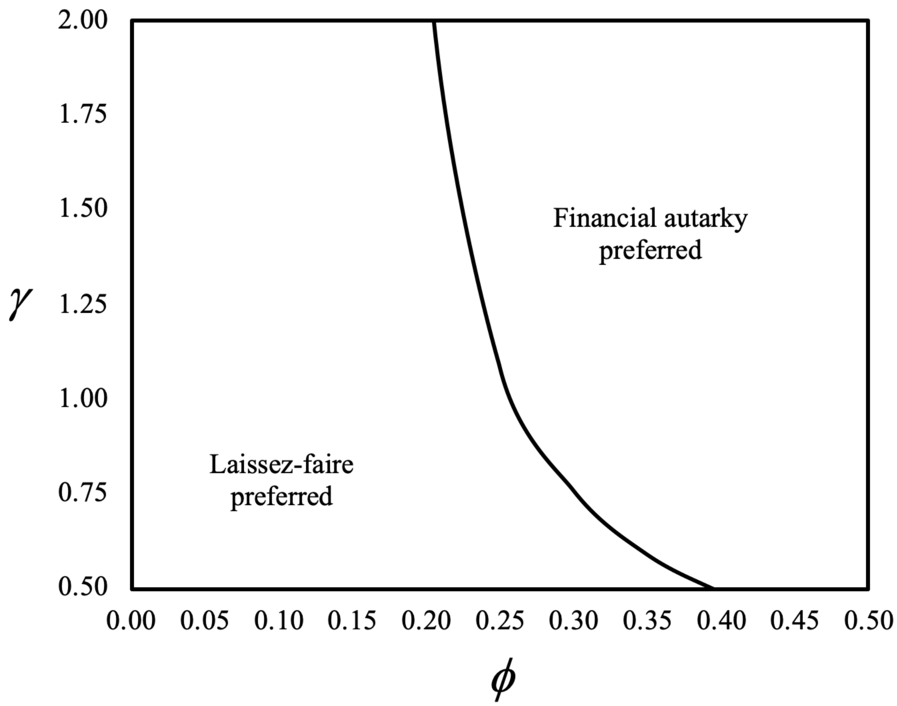
coordination around a set of policies that preserve financial openness is desirable from a global standpoint. Section 5.2.4 discusses one example of a policy that addresses the inefficiencies arising from relatively strong scale economies in traded production without targeting imbalances.

### 5.2.3 Alternative parameter calibrations

The extent to which (some) deficit economies may benefit from moving to balanced trade is governed by two key parameters: the concentration of scale economies in traded production captured by $\phi$, and the intertemporal elasticity of substitution $\gamma$. If the traded-sector scale elasticity is relatively large, the productivity effect is strong and reducing a trade deficit has a large positive effect on real income. If the intertemporal substitution elasticity is large, the welfare gains from consumption smoothing are low. We illustrate this in Figure 4 using the example of the U.S. economy.

As discussed in the previous section, the U.S. is better off under financial autarky than in the laissez-faire steady state with $\phi = \gamma = .5$. Holding $\gamma$ constant, the U.S. prefers the laissez-faire steady state if $\phi$ falls below .4. However, the U.S. may prefer financial autarky in the face of weak traded-sector scale economies if the intertemporal substitution elasticity is higher. With $\gamma > 1$, the U.S. would prefer financial autarky even for a modest relative scale elasticity of $\phi = .25$.

Figure 4: Different parameter configurations, U.S. economy




Computed by applying the hat algebra from Sections 2.2 and 4.2, with $\theta = 4$. Unless otherwise specified, all parameters are calibrated as discussed in Sections 3.1.2 and 5.1.

No matter what the intertemporal substitution elasticity is, financial autarky is never preferred for values of $\phi < .2$. The reason is that the terms-of-trade effect from balancing trade dominates the productivity effect beyond this point. In this case, a deficit economy suffers a real income *loss* from financial autarky, making laissez-faire preferable even if $\gamma \to \infty$ and the gains from consumption smoothing tend to zero.

### 5.2.4 Alternative policies

Changing trade balances through interventions in asset markets is not the first-best policy to correct the production and price distortions that arise in multi-sector models with scale economies. Instead, the first-best policy targets the source of these distortions more directly. While the details of this policy will be model-contingent, consider the Armington model with EES from Section 2.1 by way of example. Assuming lump-sum taxation is feasible, the government can use it to finance a set of sector-specific wage subsidies such that firms in sectors $S$ and $G$ respectively face net wages characterised by

$$W_{Sn} = \frac{1}{1+\phi_S} W_n, \tag{41}$$

$$W_{Gn} = \frac{\nu}{\nu + \phi_G} W_n. \tag{42}$$

It is straightforward to show that this implements the first-best equilibrium in the model of Section 2.1 by causing firms to internalise the productivity externality from their labour choices.

There are however reasons why the first-best policy could be infeasible. The government may not have access to non-distortionary taxation, or may lack sufficient information on the magnitude of external economies to calibrate subsidies appropriately. Moreover, the first-best policy would require governments to subsidise traded-sector production relatively highly, assuming—as we have throughout—that scale economies are concentrated there. This may violate international agreements.[23] It would also require *all* economies to implement the subsidies to avoid distortions in the relative prices of tradable varieties. If only some economies were to implement (41) and (42), they would correct their domestic distortions and the cost of creating international distortions.

# 6 Conclusion

Standard trade models can accommodate the view that trade imbalances have a beggar-thy-neighbour quality, improving the incomes of surplus economies at the expense of deficit economies. It requires external economies of scale (EES) concentrated in traded production, an assumption consistent with many prominent gravity models and supported by empirical evidence on sectoral scale intensities. Under plausible calibrations of the relative strength of traded-sector scale economies, trade imbalances lead to a significant redistribution of the gains from trade from deficit towards surplus economies. When observed imbalances are interpreted as the steady state outcome of consumption smoothing via international asset markets, some major deficit economies may benefit from retreating into financial autarky. This is because their deficits exacerbate the second-best underproduction of traded goods that arises when traded production is relatively scale-intensive.

There remains some uncertainty about the strength of the mechanism our work highlights. While there is a growing body of evidence on EES in the production of traded goods, there is virtually no systematic evidence on the prevalence of EES in traded and non-traded services. Since our mechanism hinges on the *relative* strength of scale economies in traded versus non-traded

[23] In our simple setting, the optimal traded-sector subsidy is the same for all economies. However, it is easy to conceive of generalisations in which traded-sector scale economies—and hence optimal subsidies—vary across economies. This could be due to differences in economies' comparative advantages among traded activities, and would be even more challenging to accommodate in many existing trade agreements.

production, we can only present a plausible range of income and welfare effects from balancing global trade. Further efforts to quantify the strength of EES in services are critical for a more precise assessment of the macroeconomic effects of persistent imbalances. If their spillovers a large, it strengthens the case for policy cooperation to support the balanced growth of international trade.

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# Appendix

# A Microfoundations of general gravity

## A.1 Preliminaries

All through Appendix A, assumptions about production, market structure and tradability for sector $S$ remain the same. In addition, Appendices A.2, A.3 and A.4 impose assumptions that ensure $W_n L_{Gn} = \nu p_{Gn} q_{Gn}$. Therefore, equations (11) and (12)—and their "hat-algebra equivalents" (17) and (18)—still hold. Maintaining the same normalisation as in Section 2.1, we thus only need to prove isomorphisms with respect to equations (19) and (20) to show that the models below deliver the same hat algebra as the Armington model with EES.

## A.2 Eaton-Kortum model

### A.2.1 Assumptions

The hat algebra in equations (17)-(21) can be derived straightforwardly from the Eaton-Kortum model of Dekle et al. (2007, 2008) by introducing a generalised traded-sector labour productivity parameter allowing for EES in line with (6).

### A.2.2 Learning-by-doing as a source of EES

One possible microfoundation for traded-sector EES in the Armington model of Section 2.1 or the Eaton-Kortum model sketched here is to assume a learning-by-doing externality in traded production. Specifically, let our equations describe the steady state of a dynamic model in which productive ideas in the traded sector as generated according to

$$\frac{Z_{Gnt+1}}{Z_{Gnt}} = L_{Gnt}^{\lambda} \left( \frac{A_{Gn}}{Z_{Gnt}} \right)^{\beta}, \tag{43}$$

where $\lambda > 0$ reflects the strength of the learning-by-doing externality; and $\beta > 0$ captures the rate at which ideas are getting harder to find. This corresponds to a sectoral analogue of the common semi-endogenous growth equation (Jones, 2022).

It is easy to see that in a steady state with $Z_{Gnt+1} = Z_{Gnt} = Z_{Gn}$ and $L_{.Gnt+1} = L_{Gnt} = L_{Gn}$ this corresponds to (6) with $\phi = \lambda/\beta$.

## A.3 Krugman model

### A.3.1 Assumptions

Unless otherwise indicated, all assumptions are as in Section 2.1.1 and all variables and parameters have the same definitions as provided therein.

*Technologies and market structure*

The economy-$n$-specific output in sector $G$ is now produced with a production function characterised by:

$$q_{Gn} = A_{Gn} \left(\frac{\bar{L}_{Gn}}{\nu}\right)^{\nu} \left(\frac{J_{Gn}}{1-\nu}\right)^{1-\nu}, \tag{44}$$

which replaces equation (4). Firms' production technology uses a composite labour input $\bar{L}_{Gn}$ that is assembled from labour varieties supplied by an endogenous mass $H_{Gn}$ of providers according to:

$$\bar{L}_{Gn} = \left[\int_0^{H_{Gn}} l_{Gn}(h)^{\frac{\chi-1}{\chi}} dh\right]^{\frac{\chi}{\chi-1}}; \tag{45}$$

where $\chi > 1$ is the elasticity of substitution between these varieties.

Labour providers are monopolistic competitors. Providers can enter freely after paying a fixed cost entry cost $\Psi_n$ in units of domestic labour.

### A.3.2 Equilibrium characterisation

By symmetry, optimal pricing implies:

$$w_{Gn} = w_{Gn}(h) = \frac{\chi}{\chi-1} W_n; \quad l_{Gn} = l_{Gn}(h) = \frac{\nu(\chi-1)}{\chi} \frac{p_{Gn} q_{Gn}}{W_n H_{Gn}}; \tag{46}$$

$$p_{Gn} = \left(\frac{\chi}{\chi-1}\right)^{\nu} \frac{W_n^{\nu} P_{Gn}^{1-\nu}}{H_{Gn}^{\phi} A_{Gn}}; \tag{47}$$

where $\phi \equiv \nu/(\chi-1)$. Free entry drives profits to zero such that:

$$W_n L_{Gn} = W_n H_{Gn}(l_{Gn} + \Psi_n) =$$

$$= \left(1 - \frac{1}{\chi}\right) \nu p_{Gn} q_{Gn} + W_n H_{Gn} \Psi_n = \nu p_{Gn} q_{Gn}; \tag{48}$$

$$H_{Gn} = \frac{1}{\chi} \frac{L_{Gn}}{\Psi_n}. \tag{49}$$

It is now straightforward to show that:

$$P_{Gn} = \Xi_K \left[ \sum_{n'=1}^{n} \left( \tau_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right)^{-\theta} \right]^{-\frac{1}{\theta}}; \tag{50}$$

$$m_{n'n} = \frac{\left( \tau_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right)^{-\theta}}{\sum_{n'=1}^{n} \left( \tau_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right)^{-\theta}}; \tag{51}$$

where $\bar{A}_{Gn} \equiv A_{Gn}/\Psi_n^{\phi}$; and $\Xi_K$ is a constant. The isomorphisms to (19) and (20) are then immediate.

## A.4 Melitz model

### A.4.1 Assumptions

Unless otherwise indicated, all assumptions are as in Section 2.1.1 and all variables and parameters have the same definitions as provided therein.

*Technologies and market structure*
Output in sector $G$ is now origin- and destination-specific with a production function characterised by:

$$q_{Gnn'} = A_{Gn} \left( \frac{\bar{L}_{Gnn'}}{\nu} \right)^{\nu} \left( \frac{J_{Gnn'}}{1-\nu} \right)^{1-\nu}, \tag{52}$$

which replaces equation (4); and where $\bar{L}_{Gnn'}$ denotes use of a composite labour input, and now $J_{Gn} \equiv \sum_{n'} J_{Gnn'}$. Economy $n$ then assembles the sector-$G$ goods it receives from all origin economies to produce a sector-$G$ aggregate for consumption and input use according to:

$$X_{Gn} = \left( \sum_{n'=1}^{N} x_{Gn'n}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}; \tag{53}$$

$$q_{Gnn'} = \tau_{nn'} x_{Gnn'}; \quad p_{Gn} q_{Gn} \equiv \sum_{n'=1}^{N} p_{Gnn'} q_{Gnn'}; \tag{54}$$

which replace equations (7) and (9), respectively; and where $\eta > 1$ is the elasticity of substitution between the sector-$G$ output of different economies.

The composite labour input $\bar{L}_{Gnn'}$ is assembled from labour varieties supplied by an endogenous mass $H_{Gnn'}$ of providers according to:

$$\bar{L}_{Gnn'} = \left[ \int_0^{H_{Gnn'}} l_{Gnn'}(h)^{\frac{\chi-1}{\chi}} dh \right]^{\frac{\chi}{\chi-1}}; \tag{55}$$

where $\chi > 1$ is the elasticity of substitution between these varieties.

Labour providers are monopolistic competitors. They differ in their productivity $a$ which is drawn from a Pareto distribution with shape parameter $\varphi > \chi - 1$ and location parameter $a_n > 0$, $a \geq a_n$. Providers learn their productivity after entering the market, which they do freely by paying a fixed cost entry cost $\Psi_n$ in units of domestic labour. Having learned their productivity, labour providers in economy $n$ need to pay an additional fixed marketing cost $\Psi_{nn'} X^{\psi}_{Gn'}$ to supply to the production for any destination $n'$, and this is paid in units of good destined for economy $n'$. The parameter $\psi \in [0, 1]$ represents a possible congestion effect in the destination market.

### A.4.2 Equilibrium characterisation

Optimal pricing implies:

$$w_{Gnn'}(a) = \frac{\chi}{\chi - 1} \frac{W_n}{a}; \quad l_{Gnn'}(a) = \frac{\nu (\chi - 1)(\varphi - \chi + 1) a^{\chi}}{\chi \varphi a_n^{\varphi} a_{nn'}^{*-(\varphi - \chi + 1)}} \frac{p_{Gnn'} q_{Gnn'}}{W_n H_{Gn}}; \tag{56}$$

$$p_{Gnn'} = \left(\frac{\chi}{\chi - 1}\right)^{\nu} \left(\frac{\varphi}{\varphi - \chi + 1}\right)^{\frac{\nu}{1-\chi}} \tau_{nn'} \left(\frac{a_{nn'}^{*\varphi - \chi + 1}}{a_n^{\varphi} H_{Gn}}\right)^{\frac{\nu}{\chi - 1}} \frac{W_n^{\nu} P_{Gn}^{1-\nu}}{A_{Gn}}; \tag{57}$$

where $a^*_{nn'}$ is the productivity cut-off for labour providers from $n$ serving destination $n'$; and $H_{Gn}$ is the total mass of active labour-providers in $n$. This cut-off is pinned down by:

$$H_{Gnn'} = \left(\frac{a^*_{nn'}}{a_n}\right)^{-\varphi} H_{Gn} = \frac{(\varphi - \chi + 1)\nu}{\chi\varphi} \frac{q_{Gnn'}}{\Psi_{nn'} X^{\psi}_{Gn'}}, \tag{58}$$

so that the ex-post profits of economy-$n$ labor providers serving market $n'$ are:

$$\frac{\nu}{\chi} p_{Gnn'} q_{Gnn'} - H_{nn'} p_{Gnn'} \Psi_{nn'} X^{\psi}_{Gn'} = \frac{(\chi - 1)\nu}{\chi\varphi} p_{Gnn'} q_{Gnn'}. \tag{59}$$

Free entry drives ex-ante expected profits to zero, such that

$$W_n L_{Gn} = W_n \left[\sum_{n'=1}^{N} \int_0^{H_{Gnn'}} l_{Gnn'}(h)\, dh + H_{Gn} \Psi_n\right] =$$

$$= \left(1 - \frac{\chi - 1}{\chi\varphi}\right) \nu p_{Gn} q_{Gn} + W_n H_{Gn} \Psi_n = \nu p_{Gn} q_{Gn}; \tag{60}$$

$$H_{Gn} = \frac{\chi - 1}{\chi\varphi} \frac{L_{Gn}}{\Psi_n}. \tag{61}$$

Combining (57), (58) and the equilibrium condition $q_{Gnn'} = (p_{Gnn'}/P_{Gn'})^{-\eta} X_{Gn'}$:

$$a_{nn'}^{*\nu} = \left(\frac{\chi}{\chi-1}\right)^{\nu} \frac{\tau_{nn'}}{p_{Gnn'}} \left[\frac{\chi}{\nu}\left(\frac{P_{Gn'}}{p_{Gnn'}}\right)^{-\eta} \Psi_{nn'} X_{Gn'}^{-(1-\psi)}\right]^{\frac{\nu}{\chi-1}} \frac{W_n^{\nu} P_{Gn}^{1-\nu}}{A_{Gn}}.$$

Substituting into (57) and solving for $p_{Gnn'}$:

$$p_{Gnn'}^{1-\eta\frac{\nu}{\varphi}\left(\frac{\varphi}{\chi-1}-1\right)} = \Xi_M \bar{\tau}_{nn'} X_{Gn'}^{-\nu(1-\psi)\frac{\varphi-(\chi-1)}{\varphi(\chi-1)}} L_{Gn}^{-\phi} \frac{W_n^{\nu} P_{Gn}^{1-\nu}}{\bar{A}_{Gn}} P_{Gn'}^{-\eta\frac{\nu}{\varphi}\left(\frac{\varphi}{\chi-1}-1\right)}; \qquad (62)$$

where $\bar{\tau}_{nn'} \equiv \tau_{nn'} \Psi_{nn'}^{(\nu/\varphi)[\varphi/(\chi-1)-1]}$; $\bar{A}_{Gn} \equiv A_{Gn} a_n^{\nu}/\Psi_n^{\phi}$; $\phi \equiv \nu/\varphi$; and $\Xi_M$ is a constant. It is now straightforward to show that:

$$P_{Gn} = \Xi_M \left\{ \sum_{n'=1}^{N} \left[ \bar{\tau}_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} X_{Gn}^{-\frac{1-\psi}{\varphi}\left(\frac{\varphi}{\chi-1}-1\right)} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right]^{-\theta} \right\}^{-\frac{1}{\theta}}; \qquad (63)$$

$$m_{n'n} = \frac{\left[ \bar{\tau}_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} X_{Gn}^{-\frac{1-\psi}{\varphi}\left(\frac{\varphi}{\chi-1}-1\right)} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right]^{-\theta}}{\sum_{n'=1}^{N} \left[ \bar{\tau}_{n'n} m_{n'n'}^{\frac{1-\nu}{\theta\nu}} X_{Gn}^{-\frac{1-\psi}{\varphi}\left(\frac{\varphi}{\chi-1}-1\right)} L_{Gn'}^{-\frac{\phi}{\nu}} W_{n'} / \bar{A}_{Gn'}^{\frac{1}{\nu}} \right]^{-\theta}}; \qquad (64)$$

where $\theta \equiv \varphi(\eta-1)/\{\nu\eta + \varphi[1-\nu\eta/(\chi-1)]\}$.[24] The isomorphisms to (19) and (20) are then immediate in the special case in which $\psi = 1$.

Equations (63) and (64) highlight that in the Melitz model there are generally *two* scale effects that act on productivity: the scale of production in the origin economy ($L_{Gn'}$) *and* the scale of absorption in the destination market ($X_{Gn}$). The first reflects the standard mechanism in models with monopolistic competition and free entry whereby an increase in the mass of active varieties in the origin economy reduces the cost of supplying any destination market. The second reflects a mechanism specific to the Melitz model: more demand in a destination market endogenously raises the subset of active origin varieties that select into supplying that destination. By imposing $\psi = 1$, we shut down the second mechanism here, to focus on the scale effect common across a broader class of gravity models.[25]

[24] Note $\chi - 1 > \nu\eta$ is a sufficient condition to ensure that the trade elasticity has the conventional sign.

[25] See Ignatenko et al. (2025) for another recent paper that explores trade imbalances in a Melitz model by imposing a similar restriction.

# B Data and calibration

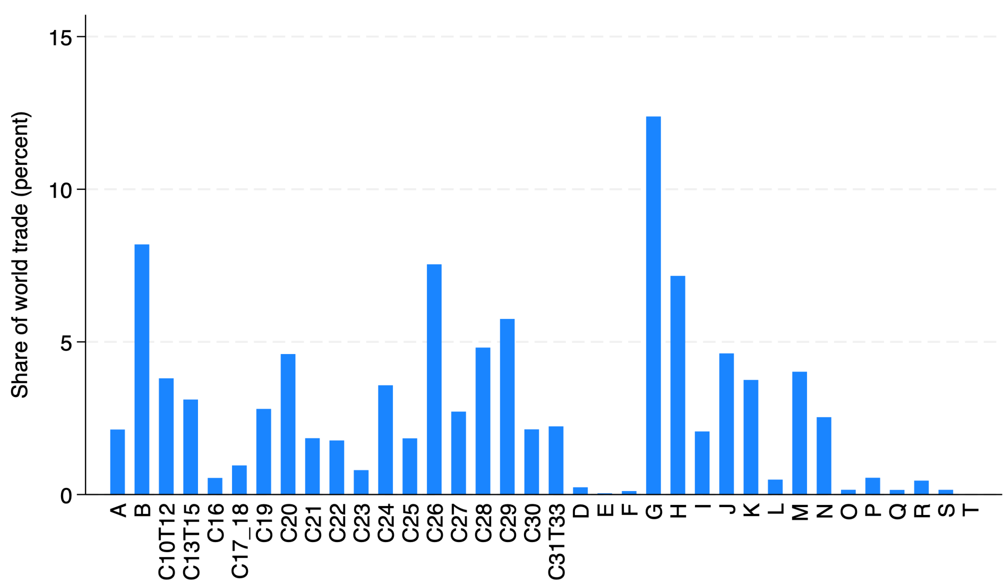
## B.1 Static global rebalancing

### B.1.1 Data

We take data from the OECD Inter-Country Input-Output Database (ICIO; OECD, 2023), averaged for the years 2017-2019. These are the latest available years that do not coincide with the Covid-19 pandemic. We use a three-year average to smooth out short-run fluctuations in the values of trade balances, output and trade shares.

The OECD Database provides us with a matrix of bilateral expenditure shares $\{m_{n'n}\}_{n',n}$, a vector of world GDP shares $\{y_n\}$, and of trade balances relative to world GDP $\{T_n\}$ for 76 individual economies and a residual rest-of-the-world region.[26] We fold four highly oil-dependent economies (Brunei, Belarus, Kazakhstan, Saudi Arabia) and six small, highly service-dependent economies with exceptionally large imbalances (Ireland, Luxembourg, Malta, Singapore, Switzerland and Taiwan) into the rest of the world. This leaves us with a sample of 66 individual economies.

Figure B1: Sector contributions to world trade




World totals from the OECD ICIO, averaged for the period 2017-19. Sector codes based on ISIC Rev. 4.

[26] The full list of economies can be found on the OECD website.

### B.1.2 Calibration

*Non-traded sector*

Figure (B1) shows the contribution of different broad ISIC sectors to world trade. Based on this, we identify as non-traded sectors D (electricity, gas), E (water supply), F (construction), L (real estate), O (public administration), P (education), Q (health), R (arts, entertainment), S (other services) and T (activities of households as employers). Together these sectors account for less than 2.5 percent of world trade in 2017-19. However, their share of world final spending is .49 in the OECD Database, and we use this value to parameterise $\sigma$. We treat all other sectors as traded.

*Input-output linkages in traded production*

Having identified the set of traded sectors, we compute the share of value added in their total global output. This yields .44 as the baseline value for $\nu$.

*Trade elasticity*

For the aggregate trade elasticity $\theta$, the value 4 is commonly used in quantitative work based on estimates by Simonovska and Waugh (2014). We adopt this value as our baseline, but experiment with an alternative, lower value in Appendix C.1.

*Relative traded-sector scale elasticity*

Table B1 provides an overview of empirical estimates of the scale elasticity across different groups of sectors from several prominent studies. We include only published papers that estimate the scale elasticity at sector level, consistent with our model; that use U.S. data or a sample including the U.S. and other advanced economies; and that cover more than just a single ISIC 2-digit sector. Where multiple estimates are reported (e.g. OLS and IV), the table presents the authors' preferred estimate. Where the authors provide disaggregated estimates at ISIC 2-digit—or roughly equivalent—level, we report a weighted average by sector group using the sectors' shares in average world final absorption for the years 2017-2019 based on OECD ICIO data.

Table B1: Literature estimates of sector-level scale economies

| Broad sector groups | Goods: Prim. | Goods: Manufactured | Services: Traded | Services: Non-traded private | Services: Non-traded public |
|---|---|---|---|---|---|
| Burnside et al. (1995) | | -.16 | | | |
| Burnside (1996) | | .00 | | | |
| Basu and Fernald (1997) | | .08 | .01 | | |
| Antweiler and Trefler (2002) | .07 | .09 | | | |
| Basu et al. (2006) | | .03 | -.09 | | |
| Diewert and Fox (2008) | | .45 | | | |
| Lashkaripour and Lugovsky (2023) | .14 | .31 | | | |
| Bartelme et al. (2024) | | .29 | | | |
| Bartelme et al. (2025) | | .21 | | | |

Columns scaled to reflect sector groups' shares in average world final absorption for the years 2017-2019, based on OECD ICIO data: primary (A01-B09) = .03; manufacturing (C10-C33) = .21; traded services (G, H, I, J, K, L, M, N) = .26; non-traded private services (F, L, S, T) = .23; non-traded public services (D, E, O, P, Q, R) = .26. Estimates taken from: Burnside et al. (1995) Table 3, column 3; Burnside (1996) Table 6; Basu and Fernald (1997) Table 3, row 1; Antweiler and Trefler (2002) Table 3; Basu et al. (2006) Table 1; Diewert et al. (2008) Table 2; Lashkaripour and Lugovsky (2023) Table 3; Bartelme et al. (2024) Section 6.3; Bartelme et al. (2025) Table 1. Where sector-level estimates are available, we aggregate them consistently using sectors' shares in world final absorption from OECD ICIO data for the years 2017-2019.

For our purposes, there are three main takeaways from Table B1. First, most relevant studies have focused on estimating scale elasticities for goods-producing sectors. This partly reflects the recognition that available measures of output, factor inputs and trade are less noisy and more consistent across countries for goods sectors than comparable measures for services. However, as the table shows, goods-producing sectors only account for about one quarter of global value added, and only about one half of the value added in sectors we consider "traded", as defined above.

Second, an early set of papers found relatively modest or no scale economies in goods production, including Burnside et al. (1995) and Basu and Fernald (1997). However, subsequent papers that improve on earlier estimates through the use of new data sources, the elimination of possible sources of misspecification and the use of novel instrumentation strategies have produced evidence of significant scale economies in goods-producing sectors. These more recent studies suggest that the goods scale elasticity could be around .25, implying that an increase in factor inputs by 1 percent would be expected to raise output by approximately 1.25 percent.

Third, to the extent that the literature has produced estimates that cover sectors other than the set of goods-producing activities, these support the notion that private services—spanning both traded and some non-traded services under our definition—are characterised by weaker scale economies on average than goods sectors. Indeed, evidence from these studies is compatible with the common assumption in macroeconomics that the returns to scale for the aggregate economy are broadly constant. This could in principle be the result of weak scale economies in both traded or non-traded services, or a combination of strong scale economies in traded services and *diseconomies* of scale in non-traded services.[27] The available evidence does not allow us to rule out either with any degree of confidence, but the two possibilities have very different implications for our productivity effect from balancing trade.

Table B2 illustrates this. Using our model structure and calibration, it derives the implications for the traded-sector scale elasticity ($\phi_G$), the aggregate scale elasticity, and the productivity effect of different assumptions about the strength and incidence of scale economies across traded and non-traded services.[28] Throughout, we fix the goods-production scale elasticity at .25 in line with the discussion above. Row 1 shows that constant returns to scale in *all* services production is consistent with small aggregate scale economies, and

[27]The second case is plausible because our traded services include Communications Services (J), Financial Services (K) and Professional Services (M) whose provision is frequently argued to be subject to significant scale economies, while our non-traded services are dominated by public services (D, E, O, P, Q) prone to crowding and with limited scope for labour-saving technological progress.

[28]The strength of the productivity effect corresponds to the absolute value of the coefficient on the trade balance $t_n$ in equation (22).

results in a small productivity effect. Letting traded-services scale economies match those of goods while keeping constant returns in non-traded production, as in row 2, results in a stronger productivity effect but also unconventionally large aggregate scale economies. Therefore, with strong traded-services scale economies, diseconomies of scale in non-traded production are required to fix aggregate scale economies at a more plausible strength. As can be seen in row 3, this increases the productivity effect because it amplifies the *difference* between traded and non-traded scale elasticities.

Table B2: Scale elasticity in the Krugman and Melitz models

| Assumptions | $\phi_G$ | Agg. scale elasticity: $\sigma\phi_S + (1-\sigma)\phi_G/\nu$ | Productivity effect: $\sigma(\phi_G/\nu - \phi_S)$ |
|---|---|---|---|
| Scale elasticity goods = .25; Scale elasticity traded services = 0; $\phi_S = 0$ | .12 | .14 | .13 |
| Scale elasticity goods = .25; Scale elasticity traded services = .25; $\phi_S = 0$ | .25 | .29 | .28 |
| Scale elasticity goods = .25; Scale elasticity traded services = .25; $\phi_S = -.30$ | .25 | .14 | .43 |
| Scale elasticity goods = .50; Scale elasticity traded services = .50; $\phi_S = 0$ | .50 | .58 | .56 |

The traded-sector scale elasticity $\phi_G$ is computed as the weighted average of the goods scale elasticity and traded-service scale elasticity, using sector groups' shares in average world final absorption for the years 2017-2019, based on OECD ICIO data: goods (A01-C33) = .24; traded services (G, H, I, J, K, L, M, N) = .26. Parameters $\sigma$ and $\nu$ are calibrated as discussed above and shown in Table 1. The formula for the aggregate scale elasticity can be derived straightforwardly from (16). The productivity effect corresponds to the absolute value of the coefficient on the trade balance $t_n$ from equation (22).

The productivity effect in row 3 is in the same ballpark as for the upper-bound calibration we adopt in the body of the paper, which is reproduced in row 4 for comparison. This upper bound can thus be interpreted as reflecting similarly-sized scale elasticities in goods and traded-services production meeting diseconomies of scale in non-traded production. As row 4 makes clear, our upper-bound calibration implies unrealistically large aggregate scale economies because it normalises the non-traded scale elasticity to zero. However, this is immaterial for our quantitative analysis since we keep total labour endowments constant throughout. All shocks we introduce only change the allocation of these fixed endowments between traded and non-traded production, and the resulting productivity impacts depend solely on the relative scale elasticities of the two sectors.

### B.1.3 Initial world GDP shares

Equation (11) implies a particular equilibrium relationship between status-quo trade shares, trade balances and world GDP shares for given values of $\sigma$ and $\nu$. This relationship may not be satisfied in the data, because the production structure assumed in our framework is a much-simplified version of actual trade and production linkages. Following the convention established in other quantitative work, we therefore first run the hat algebra in (17)-(21) with the status-quo trade balances: $\tilde{T}_n = T_n$ for all $n$.[29] This delivers a new set of world GDP shares, and we adopt this set as our initial shares for all trade-balance counterfactuals.

These initial world GDP shares are highly, but not perfectly, correlated with world GDP shares in the OECD Database. However, they vary across the different calibrations of $\sigma$ and $\nu$. As a result, the cross-economy distribution of trade balances shares in own GDP ($t_n$) shown in Table (C2)—assuming a counterfactually low intermediate input share—is different from the baseline distribution shown in Table (3).

## B.2 Additional calibration for steady state global rebalancing

*Intertemporal elasticity of substitution*

The typical calibration of the intertemporal elasticity of substitution in macroeconomics is in the range 1-2. However, this in the context of models that represent data at quarterly or annual frequencies. In our OLG setting, a period instead represents multiple decades. In this case, lower values of the intertemporal elasticity are sometimes used. For example, studies of long-run growth in the context of climate change have tended to use elasticities as low as .50 (Weitzman, 2007; Acemoglu et al., 2012).

We adopt $\gamma = .50$ as our baseline value. This is conservative: the higher the intertemporal elasticity of substitution, the lower the gains from lifetime consumption smoothing via international asset markets. Therefore, our baseline parametrisation raises the bar for overturning the gains from permitting unbalanced trade. We illustrate this by exploring alternative parameter values in Section 5.2.3.

[29] For example, see Bonadio et al. (2023).

*Lifetime income profiles and world interest rate*

From (27)-(30), in an initial laissez-faire steady state:

$$t_n = -\frac{R-1}{R}\frac{(R^\gamma + 1)\,\omega_n - 1}{1 + R^{\gamma-1}}. \tag{65}$$

Given values for $\gamma$ and $R$, we can readily back out $\{\omega_n\}_n$ from data on trade balances.

We impose $R = 1.02^{30} \approx 1.81$, corresponding to an annual interest rate of 2 percent with a model period representing 30 years.[30] From (23) and (29):

$$R = \left[\sum_n (1-\omega_n)\, y_n / \sum_n \omega_n y_n\right]^{1/\gamma}, \tag{66}$$

so fixing $\gamma$ and $R$ amounts to calibrating the weighted average lifetime income profile across economies. Our parameter choices imply that in the "average" economy, agents get 57 percent of their income in the first half of their lives.

# C Additional and alternative counterfactuals

## C.1 Varying the trade elasticity

### C.1.1 Results

In our experiments in Section 3.2, we keep the trade elasticity fixed at $\theta = 4$. Here, we discuss the implications of imposing a lower trade elasticity of $\theta = 2$. This is the value often imposed in open-economy macroeconomics and, more recently, Boehm et al. (2023) provide evidence that the trade elasticity tends to this value in the long run.

The comparison of Table C1 with Table 3 reveals that a lower trade elasticity strengthens the terms-of-trade effect a little, while leaving the productivity effect unchanged. The productivity effect remains dominant, but the overall impact of imbalances on real incomes is reduced. This impact nevertheless remains sizeable. If relative traded-sector scale economies are strong ($\phi = .50$), half of surplus economies see a real GDP decline greater than 1.1 percent from shifting to balanced trade, while half of deficit economies experience an increase greater than .6 percent.

[30] Since our model can be interpreted as the de-trended equivalent of a model with a constant, common exogenous growth rate, strictly speaking the value of $R$ represents the interest-growth *differential*. For example, with an annual productivity growth rate of 1 percent, our calibration would imply a long-run real interest rate of 3 percent.

Table C1: Low trade elasticity, all economies

Panel (a): $\theta = 2; \phi = 0$

| | N / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.037 | 0.006 | 0.006 | |
| 75th pctile. | | 0.065 | 0.077 | 0.010 | 0.010 | |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.033 | -0.007 | -0.007 | |
| 25th pctile | | -0.063 | -0.076 | -0.016 | -0.016 | |

Panel (b): $\theta = 2; \phi = .25$

| | N / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.028 | -0.004 | 0.006 | -0.009 |
| 75th pctile. | | 0.065 | 0.061 | -0.006 | 0.012 | -0.017 |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.026 | 0.000 | -0.008 | 0.007 |
| 25th pctile | | -0.063 | -0.060 | 0.001 | -0.018 | 0.018 |

Panel (c): $\theta = 2; \phi = .50$

| | N / $t_n$ | | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|---|
| | | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | | |
| Median | | 0.032 | 0.019 | -0.011 | 0.006 | -0.017 |
| 75th pctile. | | 0.065 | 0.045 | -0.022 | 0.013 | -0.035 |
| Deficit | 32 | | | | | |
| Median | | -0.026 | -0.020 | 0.006 | -0.009 | 0.015 |
| 25th pctile | | -0.063 | -0.044 | 0.018 | -0.020 | 0.036 |

Table shows counterfactual consumption and income effects from balancing global trade, derived by applying the hat algebra from Section 2.2 to the economy sample described in Section 3.1.1. Unless otherwise specified, all parameters are calibrated as discussed in Section 3.1.2. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

## C.2 Varying the strength of input-output linkages

Our baseline calibration parameterises the strength of input-output linkages in the traded sector based on international input-output data. In this subsection, we illustrate that these input-output linkages are an important amplifying mechanism for the productivity effect of trade imbalances in the presence of scale economies. We do this by reducing by one half the share of intermediate inputs in production $1 - \nu$, and then re-running our main trade-balancing experiment. The results are presented in Table C2.

Table C2: Weak input-output linkages, all economies

Panel (a): $\nu = .72; \phi = 0$

| | $N$ / $t_n$ | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | |
| Median | 0.037 | 0.041 | 0.003 | 0.003 | |
| 75th pctile. | 0.084 | 0.094 | 0.006 | 0.006 | |
| Deficit | 32 | | | | |
| Median | -0.025 | -0.029 | -0.004 | -0.004 | |
| 25th pctile | -0.056 | -0.063 | -0.009 | -0.009 | |

Panel (b): $\nu = .72; \phi = .25$

| | $N$ / $t_n$ | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | |
| Median | 0.037 | 0.035 | -0.004 | 0.003 | -0.006 |
| 75th pctile. | 0.084 | 0.081 | -0.007 | 0.007 | -0.014 |
| Deficit | 32 | | | | |
| Median | -0.025 | -0.025 | 0.000 | -0.004 | 0.004 |
| 25th pctile | -0.056 | -0.053 | 0.001 | -0.009 | 0.010 |

Panel (c): $\nu = .72; \phi = .50$

| | $N$ / $t_n$ | Log change in | | Log real GDP impact from | |
|---|---|---|---|---|---|
| | | Real cons. | Real GDP | ToT effect | Prod. effect |
| Surplus | 35 | | | | |
| Median | 0.037 | 0.029 | -0.009 | 0.003 | -0.012 |
| 75th pctile. | 0.084 | 0.067 | -0.020 | 0.007 | -0.027 |
| Deficit | 32 | | | | |
| Median | -0.025 | -0.020 | 0.004 | -0.004 | 0.009 |
| 25th pctile | -0.056 | -0.044 | 0.010 | -0.009 | 0.019 |

Table shows counterfactual consumption and income effects from balancing global trade, derived by applying the hat algebra from Section 2.2 to the economy sample described in Section 3.1.1. Unless otherwise specified, all parameters are calibrated as discussed in Section 3.1.2. $t_n$ denotes the initial trade balance as share of economy-$n$ GDP.

Compared with Table 3 the productivity effect is significantly weaker, with minimal impacts on the terms-of-trade effect. This is consistent with the discussion in Section 2.2.2. The intuition is that an increase in output raises labour productivity, which also reduces the cost of inputs (for given trade shares). In turn, this raises productivity further, further reducing input costs, and so forth. The weaker is input reliance, the weaker this amplification effect.

PUBLICATIONS

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