The macroeconomic consequences of a US trade war for Europe*

Miquel Lorente†

October 31, 2026

[Click here for the latest version]

Abstract

This paper quantifies the macroeconomic and welfare consequences for Europe of a permanent increase in US protectionism. I develop a tractable dynamic spatial general equilibrium model featuring bilateral trade, multinational production, capital flows, and migration. For Europe, aggregate welfare losses are modest but heavily concentrated in highly exposed, export-oriented subnational regions. The shock is partially mitigated through an expansion of service exports to the United States. Furthermore, global demand for European capital increases as tariffs raise the relative price of US investment, ultimately restoring Europe's average real GDP in the long run while simultaneously amplifying regional disparities. Nevertheless, a persistent decline in European wealth deepens welfare losses for future generations. In the United States, tariffs raise goods-sector employment, attract multinational production, and temporarily reduce the trade deficit, but depress capital accumulation and long-run real GDP. Despite this, the policy generates long-run welfare gains: although older generations suffer immediate losses due to negative valuation effects on foreign assets, welfare gains compound for future cohorts as they accumulate wealth. Finally, I evaluate alternative policy responses and show that US tariffs put the EU in a difficult position, as neither retaliating against the US nor reaching a free trade agreement with China is sufficient to reverse the aggregate losses.

*I am incredibly grateful to my advisors Manuel García-Santana and Jaume Ventura for their invaluable guidance and continuous support throughout this project. I also thank Timothy Kehoe for his hospitality and insightful feedback during my research visit at the University of Minnesota. This paper has benefited enormously from discussions with Manuel Amador, Fernando Broner, Simon Fuchs, Elisa Giannone, Illenin O. Kondo, Luca Looser, Dávid Nagy, Giacomo Ponzetto, and Hugo Reichardt. I also thank participants at the CREi International Lunch and the 20th North American Meeting of the Urban Economics Association for their valuable feedback. I gratefully acknowledge financial support from the Fundación Ramón Areces through the "Ayudas Fundación Ramón Areces para la realización de Tesis Doctorales en Ciencias Sociales 2023" program. All remaining errors are my own.

†Department of Economics, Universitat Pompeu Fabra. Email: miquel.lorente@upf.edu. Website: miquel-lorente.github.io.

1 Introduction

Since the end of World War II, the world economy has experienced an extraordinary expansion of globalization, supported in part by successive tariff reductions under the GATT/WTO framework.[1] This environment has shifted sharply. In 2025, after decades of promoting international trade through low tariffs, US trade policy pivoted toward broad-based protectionism at a scale unseen in the last 80 years (Fajgelbaum and Khandelwal, 2026).[2] Motivated by this historic policy shift, the main objective of this paper is to quantify how a permanent increase in US protectionism would affect Europe in the medium and long run.

This policy shock is important for Europe because of its significant exposure to the US economy.[3] The US is the EU's largest single trading partner for both goods and services. In 2017, just before the beginning of the US–China trade war, sales to the US accounted for 1.8% of total EU sales, while 1.4% of total EU expenditure was allocated to US goods and services. These flows represent 17% of the EU's total external exports and 15% of its external imports, respectively.

Figure 1 documents substantial regional heterogeneity in EU exposure to trade with the US, both for exports and imports. While some NUTS-2 regions sell over 3% of their total output to the US or allocate more than 3% of their expenditure to US products, others have virtually zero direct trade exposure. Crucially, this spatial dispersion is predominantly a within-country phenomenon: high-exposure regions exist in almost all EU member states, and within-country differences account for over 70% of the overall spatial variance.[4]

Besides trade, US tariffs can have major effects on the European economy through other channels. For instance, tariffs can generate valuation effects on gross foreign asset positions (Itskhoki and Mukhin, 2025) or reshape international capital flows. Hence, it is also important to consider Europe's exposure to the US through asset markets. The value of all US assets held by European residents stood at 58% of EU GDP in 2024. As documented in Figure D.4a, this financial exposure exhibits substantial cross-country dispersion. While countries in the bottom quintile –mostly in Southeast Europe– hold US assets worth less than 3% of their GDP, these holdings exceed 50% in several Northern and Western European economies, such as the Netherlands, Sweden, and Denmark.[5]

In contrast to trade and asset markets, Europe exhibits more limited exposure to the US through direct labor market linkages. According to 2024 data, the recorded stock of EU migrants in the US from

[1] As a result, by the mid-2010s tariff barriers among the three largest trading blocs (the United States, Europe, and China) were low by historical standards. In 2017, trade-weighted average tariffs between the EU and the US were around 2% (Teti, 2024).

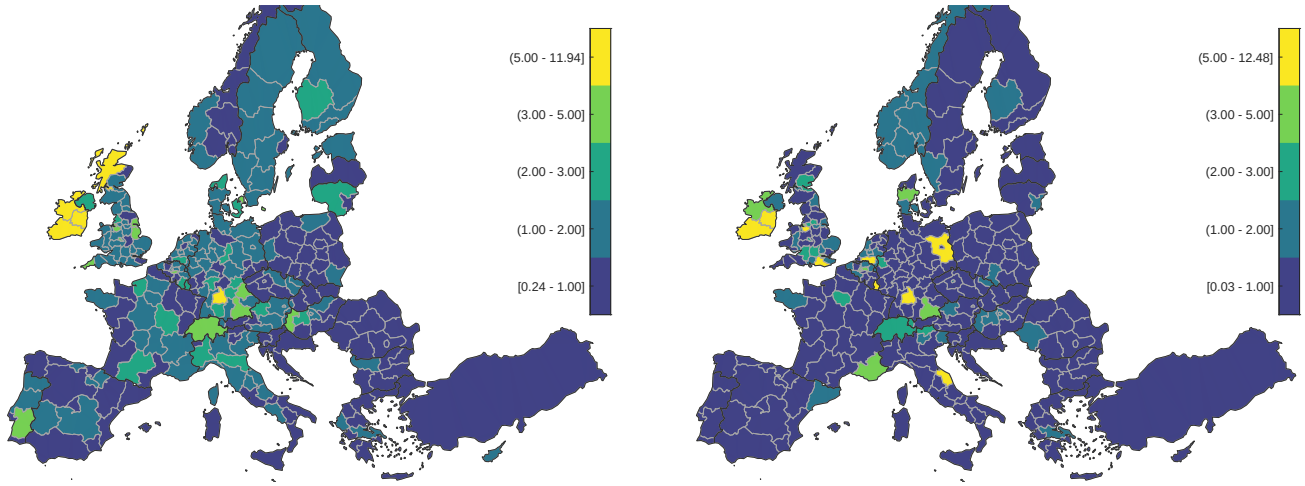
[2] A first wave of protectionism emerged during 2018–2019 under the first Trump administration, though it was largely confined to US–China trade.

[3] Throughout the paper, "Europe" and "EU" refer to the 27 European Union member states.

[4] The pooled within-country standard deviations are 0.98 percentage points for sales shares (Panel A) and 1.2 percentage points for expenditure shares (Panel B). Restricting the analysis solely to trade in goods yields higher baseline exposure levels due to higher tradability, but preserves the finding of substantial spatial variation across regions (Figure D.3).

[5] Among the four largest EU economies, the positions remain sizable and heterogeneous: Germany (29%), France (33%), Spain (14%), and Italy (13%). Luxembourg (3014%) and Ireland (438%) exhibit outsized raw positions due to their roles as "onshore offshore financial centers" that intermediate international investment flows (Beck et al., 2024). Model calibration incorporates restatement adjustments from Beck et al. (2024), Coppola et al. (2021), and Damgaard, Elkjaer, and Johannesen (2019) to estimate ultimate asset ownership.

Figure 1: Trade exposure to the US across European regions (2017)



(a) Share of sales to the US

(b) Share of expenditure on the US

Notes: International trade with the US at the NUTS-2 level in 2017. Panel A shows sales to the US as a share of total regional sales. Panel B shows purchases of US goods and services as a share of total regional expenditure. Source: FIGARO-REG database.

reporting member states is approximately 2.9 million, representing a fraction of a percent of the total EU population.[6]

Motivated by these facts, I develop a tractable dynamic spatial general equilibrium model in which tariffs affect the economy through several channels emphasized in the policy debate. Beyond the standard mechanisms featured in workhorse trade models, my framework captures the effects of tariffs on investment, current accounts, capital flows, migration, and the reallocation of multinational production. The rich spatial heterogeneity embedded in the framework allows me to quantify the importance of each of these channels at the regional level.

On the production side of the model, locations trade differentiated intermediate varieties à la Eaton and Kortum (2002) to produce composite goods and services, which are then combined into final consumption and investment goods. The production of intermediate varieties requires three inputs: capital, labor, and composite intermediate goods from all sectors, allowing the model to capture input-output linkages. This rich sectoral structure allows me to quantify how tariffs affect the sectoral composition of economic activity. In particular, imposing tariffs –which apply to goods but not services– induces substitution away from imports of goods toward imports of services, thereby triggering a reallocation of labor across sectors. Following Ramondo and Rodríguez-Clare (2013), firms can serve a given market in three ways: by producing at home and exporting to the destination, by producing directly in the destination market through multinational production, or by producing in a third location and exporting from there (export-platform production). Together, these features allow the model to speak directly to one of the central objectives of the 2025 US tariffs: bringing manufacturing production back to the United States.

On the household side, overlapping generations of individuals choose their location subject to mobility frictions, supply labor inelastically, consume final goods, and save. Following Kleinman et al. (2023),

[6] While overall migration exposure is weak, minor cross-country variation exists (e.g., Ireland and Germany record higher emigration relative to population). See Figure D.4b for details.

household wealth is managed by a continuum of fund managers who invest in international capital markets. International investment is subject to frictions, and fund managers draw idiosyncratic efficiency shocks from an extreme value distribution. This dynamic structure, which distinguishes the framework from most of the trade literature, is important for two reasons. First, consistent with the intertemporal approach to the current account (Obstfeld and Rogoff, 1995), trade imbalances are endogenously determined, so the model speaks directly to a central motivation of the current trade war: the US trade deficit. Second, the effects of permanent tariffs evolve over time, as changes in investment decisions generate capital flows that have limited impact on the stock of capital in the medium run but are quantitatively important in the long run (Baqaee and Malmberg, 2025).

I calibrate the model to the world economy in 2023. Crucially, I disaggregate Europe at the regional level. In total, the model includes 285 regions, 16 additional countries (which account for 88% of world GDP), and a rest-of-the-world block. The baseline equilibrium replicates several empirical regularities, including the observed gravity in trade flows and asset holdings. A key feature of this model is that one can evaluate how the economy reacts to a sequence of changes in fundamentals (or shocks) using the Dynamic Exact Hat Algebra technique, with minimal information requirements and without assuming that the economy is initially in a steady state (Caliendo, Dvorkin, and Parro, 2019). In particular, migration, trade, multinational production, and investment frictions, as well as productivity levels, do not need to be estimated.

The main counterfactual I explore is a world where the US suddenly and permanently raises tariffs on imports from all countries by 10 percentage points, which I compare to a baseline economy where all bilateral tariffs remain at their 2023 levels.[7]

The main results are the following. On the negative side, the model predicts a reduction in European exports of goods to the US by 0.4 pp as a share of EU GDP. While some exporters stop serving the US market, others respond by relocating production into the US. As a result, multinational production by EU firms in the US increases, capturing around three-quarters of the lost market share by EU exports of goods.

On the positive side, the model captures two key macroeconomic channels that limit these adverse effects. First, exports of EU services to the US increase by 0.10 pp as a share of EU GDP in the aggregate, offsetting around one-fourth of the drop in exports of goods to the US. Since tariffs do not apply to services, European services become more competitive in the US as the US terms of trade improve. In this sense, there is a leakage of imports through the service industry, which induces a shift in the European economy toward producing services.

[7]This particular choice has several appealing features. First, it closely aligns with recent US trade policy. A universal 10% baseline tariff (in addition to country-specific "reciprocal" tariffs) was initially announced on Liberation Day under the International Emergency Economic Powers Act. After the Supreme Court ruled those tariffs illegal, they were temporarily replaced by a universal 10% tariff invoked under Section 122. More recently, the Section 301 "Forced-Labor" tariffs that replaced the Section 122 measures maintained this 10% rate for several key trading partners, including the EU, while setting a 12.5% rate for others. Second, a 10 percentage point increase brings the average US tariff roughly back to its level in the 1940s, around the time the GATT was signed (Irwin, 2020). Third, a uniform rate constitutes a transparent benchmark. As demonstrated by a series of robustness exercises in Table C.2, assuming that the reported effects on Europe are linear in the universal US tariff increase provides a reasonable approximation, as long as the tariff increase is not too large.

Second, European capital expands by 0.35% in the long run.[8] The mechanism is the following. The US economy expands relative to Europe due to a standard terms of trade effect, which results in an enlargement of US wealth. Crucially, part of this wealth is not absorbed by the US. The reason is that to produce final investment goods, one needs to import (both directly and indirectly, through input-output linkages). Hence, US tariffs raise the relative price of US investment, which ultimately lowers the returns for investors. This leads to an increase in the foreign demand for EU capital. As a result, real investment in the EU rises, which translates into more capital in the long run.

Overall, while these mitigating channels ensure that aggregate European losses remain modest –with real GDP per capita falling by just 0.04% and welfare for the generation born on impact dropping by 0.07%– these aggregate figures mask severe spatial heterogeneity. The burden of the trade war is highly concentrated in a small number of regions specialized in a narrow range of export-intensive sectors and exposed to US demand. Examples include Southern Ireland (pharmaceuticals and medical products) and Stuttgart (automotive and high-tech). In addition, the losses fall disproportionately on Europe's richest regions, particularly those in the top decile of GDP per capita.

The exercise provides important additional results. In the long run, the negative effect on EU real GDP per capita vanishes, on average, thanks to the additional capital. However, investment in the hardest-hit regions decreases, which deepens their initial GDP losses and amplifies regional disparities. Furthermore, the recovery in average real GDP per capita does not prevent aggregate welfare losses. EU welfare declines progressively for future generations and is 0.15% below the baseline in the long run, on average. The main reason behind these adverse dynamics is that EU wealth enters a downward spiral in which lower returns successively depress wealth. Migration smooths out welfare effects across regions by allowing households in strongly affected regions to move elsewhere, which redistributes population across regions in the long run.

In the US, contrary to static models, the drop in exports due to a competitiveness loss falls short of the drop in imports, and the US trade deficit is reduced by 0.20 pp of GDP. This effect is only temporary and reverses in the long run. It is driven by a combination of a negative effect on US income (the valuation effect emphasized in Itskhoki and Mukhin (2025)) and the accumulation of net foreign assets. In addition, as the US becomes a net exporter of goods and a net importer of services, labor reallocates across industries, driving a 0.89 pp increase in the employment share of the goods sector. Thanks to the enlargement of tariff revenues, real GDP per capita increases by 0.05% initially even if real value added per capita falls (-0.43%). As the economy loses capital over time, however, the effect on real GDP per capita in the long run is pushed into negative territory (-0.07%). The initial young cohort in the US benefits from the tariffs, experiencing a welfare gain of 0.15%, whereas older generations suffer welfare losses (-0.57%) due to the negative valuation effect on their foreign asset holdings. Over the transition path, welfare gains grow across subsequent generations as households rebuild their real wealth, ultimately reaching 0.31% in the long run.

How would these results change if the EU were to retaliate against US tariffs? The second counterfactual considers a scenario in which all tariffs that the EU sets on imports of goods from the US increase one-for-one with the US tariff on EU goods (i.e., an increase of 10 pp). I also consider a scenario in which

[8] Since Europe's population also increases in the long run, the stock of capital rises by 0.18% in per capita terms.

the EU chooses to retaliate optimally, but the main results are virtually unaffected.

EU retaliation introduces an additional terms of trade effect as EU demand shifts away from US goods. However, the initial effect on EU real GDP per capita is the same as without retaliation. The reason why the 10% US tariff raises US GDP but the 10% EU tariff does not is that the retaliatory tariff is less powerful, since it only applies to imports from the US and generates trade diversion. In general, places where real GDP per capita falls more prominently without retaliation are also the places where it drops more under retaliation, although retaliation tends to smooth real GDP per capita effects across EU regions. Retaliation limits welfare losses for the current EU generation to some extent (-0.05% vs. -0.07%), but even then 87% of EU regions lose from the trade war. Similarly, long-run welfare effects remain negative, even if for most regions they are slightly less severe than without retaliation.

One reason why the EU has not retaliated against US tariffs is the fear of triggering a tariff escalation. What would be the consequences of such a scenario? The third counterfactual considers a setting in which the EU retaliates as in the previous counterfactual and the US responds by further raising tariffs on EU imports by the same amount.

US counter-retaliatory tariffs marginally improve US terms of trade at all times compared to the Retaliation scenario. However, the effect on US real GDP per capita is worse than under no retaliation and also lower than under retaliation. When the economy is already distorted, raising tariffs is not guaranteed to generate real GDP gains. Similarly, real GDP per capita in the EU is also lower than under the previous scenarios, and the effects are especially harsh precisely for regions that lose more under no retaliation. On average, welfare effects in the EU are only marginally worse than without retaliation, but they are more unequal across regions than under the previous scenarios. With the exception of older cohorts who suffer losses on impact, US generations continue to enjoy welfare gains. However, these gains are smaller than if the US had absorbed the EU retaliation without escalating, which suggests that the US administration might be motivated to avoid further escalation.

The previous counterfactuals show that the EU can never fully offset the negative effects of US tariffs by retaliating. Could reaching an agreement with China, the remaining economic power, be enough? In the last counterfactual, I simulate a world in which the EU and China respond to US tariffs by establishing a free trade agreement.

An EU–China free trade agreement offsets the loss of market access suffered by EU exporters in the US and improves the effect on EU real GDP per capita, especially for a handful of regions. However, this agreement only partially mitigates the average welfare decline and leaves a substantial share of EU regions strictly worse off. Hence, US tariffs put European policymakers in a difficult position, as neither retaliating against the US nor reaching a free trade agreement with China is sufficient to reverse the aggregate losses.

Related literature

This paper contributes to the body of theoretical work that develops gravity models for trade (surveyed in Head and Mayer, 2014; Costinot and Rodríguez-Clare, 2014) by developing a tractable dynamic gen-

eral equilibrium model that incorporates various features from several different literatures. First, the multinational production structure builds on Ramondo and Rodríguez-Clare (2013). They generalize the Eaton and Kortum (2002) framework to incorporate multinational production, intrafirm trade, and intermediate inputs, and use the model to study the interactions between trade and multinational production openness. Second, international investment is based on Kleinman et al. (2023). They build an open-economy neoclassical growth model featuring bilateral frictions in capital markets that affect capital accumulation and hence growth. Crucially, their framework is consistent with well-established empirical regularities, including the presence of home bias in portfolio holdings and a gravity model for international capital holdings (e.g., French and Poterba, 1991; Portes and Rey, 2005). Third, I follow the work by Caliendo, Dvorkin, and Parro (2019) to model spatial mobility. They develop a dynamic spatial trade model with migration that incorporates labor mobility frictions in a tractable way, and study the heterogeneous effects of the China shock across US labor markets. Despite combining these three blocks, the model can still be solved with the dynamic exact hat algebra of Caliendo, Dvorkin, and Parro (2019), which greatly simplifies its calibration.

This paper employs the model to study the recent increase in US protectionism and therefore relates to a rapidly growing literature that uses general equilibrium models to quantify the effects of recent US trade policy (e.g., Ignatenko et al., 2025; Rodríguez-Clare et al., 2025; Caliendo, Kortum, and Parro, 2025; Baqaee and Malmberg, 2025; Fajgelbaum and Khandelwal, 2026).[9] While most of this literature focuses on the United States, I focus on Europe and conduct the analysis at the regional level. I now discuss how the main features of my framework contribute to this literature.

International investment and capital accumulation. First, the paper shows that tariffs reallocate capital across countries. Most of the literature on trade policy relies on static models (e.g., Corden, 1984; Helpman and Krugman, 1989; Costinot and Rodríguez-Clare, 2014; Caliendo and Parro, 2022; Ossa and Redding, 2026), which by construction abstract from the effects of tariffs on investment and capital accumulation. Dynamic trade models show that trade costs also affect the gains from trade through investment and capital accumulation (Ravikumar, Santacreu, and Sposi, 2019; Kleinman et al., 2023). Building on this insight, Baqaee and Malmberg (2025) and Mehrotra and Waugh (2025) show that the 2025 US tariffs raise the price of investment goods, which depresses US investment and, in the long run, the US capital stock. Relative to their work, I contribute by showing how the reduction in US returns redirects capital toward other locations. In my framework, in which investors hold gross bilateral portfolios subject to frictions, this makes Europe relatively more attractive to investors, ultimately driving an expansion of its capital stock.[10] The channel is quantitatively important. When assets can only be held domestically, EU capital per capita decreases by 0.18% in the long run instead of expanding by

[9] Other contributions study tariff revenue (Alessandria et al., 2025; Martínez-García and Sposi, 2025; Pujolas and Rossbach, 2026), manufacturing employment and supply chains (Steinberg, 2025), the natural rate of interest (Mehrotra and Waugh, 2025), optimal tariffs in dynamic economies (Itskhoki and Mukhin, 2025; Dávila et al., 2025), and short-run dynamics and the monetary policy response in New Keynesian models (Auclert, Rognlie, and Straub, 2025; Auray, Devereux, and Eyquem, 2025; Bianchi and Coulibaly, 2025; Werning, Lorenzoni, and Guerrieri, 2025; Kalemli-Özcan, Soylu, and Yildirim, 2025; Ferrante et al., 2026).

[10] This mechanism differs from McKibbin, Noland, and Shuetrim (2025), in which capital flows out of the US and stimulates investment abroad when the tariffs are accompanied by a higher US risk premium. Here, the reallocation of capital is an endogenous consequence of the tariffs themselves.

0.18%, and hence EU real GDP per capita does not recover and remains 0.12% below the baseline in the long run.

Because international investment endogenously generates trade imbalances, the paper also relates to the debate on whether tariffs can reduce trade deficits.[11] In my model, the US trade deficit falls by 0.20 pp of GDP, but only temporarily. Caliendo, Kortum, and Parro (2025) also obtain a reduction in the US trade deficit, although the underlying mechanism is entirely different. In their dynamic model with complete markets and no capital, efficiency leads to the US transferring resources to the rest of the world via Arrow securities in states of nature where it imposes high tariffs, which leads to lower domestic consumption. In contrast, in my model, the tariff shock is completely unexpected and there is no pre-arranged transfer. Instead, US tariffs lead to a real exchange rate appreciation that generates a negative valuation effect on gross foreign asset positions –a mechanism aligned with the incomplete-markets framework of Itskhoki and Mukhin (2025).

Multinational production. Second, the paper quantifies how tariffs induce firms to relocate production. Most quantitative studies of the recent US tariffs abstract from multinational production. An exception is Celebi and Roeger (2025), who show in a two-country model that US tariffs attract inward FDI. I quantify this margin in a multi-country dynamic setting with input-output linkages and find that multinational production by EU firms in the US captures around three-quarters of the market share lost by EU exports of goods. This speaks directly to the goal of bringing manufacturing back to the US, and it shapes how the shock is transmitted to Europe: without multinational production, EU exports of goods to the US fall by less (−0.33 pp of EU GDP against −0.42), because some firms that could keep exporting to the US despite the tariffs choose instead to serve it from US plants when such option is available.

Regional heterogeneity and migration. Third, by conducting the analysis at the regional level and incorporating migration, the paper relates to the literature that uses dynamic spatial models to study the regional effects of trade shocks (Caliendo, Dvorkin, and Parro, 2019; Caliendo, Opromolla, et al., 2021). Among studies of the recent tariffs, Rodríguez-Clare et al. (2025) quantify the heterogeneous effects across US states in a model featuring unemployment due to downward nominal wage rigidities, but they assume away labor mobility across states and do not incorporate endogenous trade deficits or capital accumulation. My framework shifts the focus to European regions in a dynamic setting. I show that the burden of US tariffs in Europe is highly concentrated in a small number of regions specialized in export-intensive sectors.[12] In addition, the analysis delivers two further results. First, investment falls in the hardest-hit regions, which deepens their initial GDP losses and amplifies regional disparities over time. Second, while migration barely affects the aggregate effects, it shapes their distribution: allowing

[11] Theory shows that the answer is ambiguous (Costinot and Werning, 2025), and quantitative models disagree. Unilateral tariffs reduce the US trade deficit in Caliendo, Kortum, and Parro (2025) and in the New Keynesian model of Auclert, Rognlie, and Straub (2025), but widen it in the New Keynesian model of Auray, Devereux, and Eyquem (2025). In static frameworks, trade imbalances are typically held fixed, although in Ignatenko et al. (2025) they can fluctuate because exporting requires labor services from the destination.

[12] Using a static general equilibrium model in which capital and labor are immobile across regions, Magerman and Palazzolo (2026) also find that welfare losses are heterogeneous across EU regions.

for endogenous migration reduces the long-run dispersion of the effects across EU regions by about a quarter for real GDP per capita and a third for welfare, as workers leave the most affected regions.

The remainder of the paper is organized as follows. In Section 2, I present the dynamic spatial general equilibrium model and discuss its calibration. In Section 3, I conduct counterfactual analyses to quantify the effects of a permanent increase in US protectionism under alternative policy scenarios. Finally, Section 4 concludes.

2 Theoretical framework

2.1 Households

The setup is as follows. There are J regions, indexed by o, m, and d. Each region o belongs to a country $g(o)$, and is populated by overlapping generations of atomistic individuals that live for three periods and supply one unit of labor inelastically in the first two periods. Young individuals (but not middle-aged or old) are mobile across regions but face migration costs. Households derive utility from consuming the final good in every period, and from giving inter-generational bequests at the end of their lives, which are received during middle age. Individuals can save and invest through a local wealth fund, and there is no aggregate uncertainty.

The timing of a period in this model is the following. The young are born at the beginning of the period. Then, idiosyncratic location taste shocks are realized and young agents choose where to migrate. After spatial reallocation takes place, many things happen simultaneously: (i) production takes place; (ii) agents choose how much to consume, save, and bequeath; (iii) agents decide how to allocate their savings; and (iv) governments collect taxes and consume. Finally, the old die at the end of the period.

The lifetime utility of a household i born at time t in region o is given by:

$$v_{ot}^{1i} = \max_{d} \left\{ (1-\beta) \log\left(C_{odt}^{1}\right) + \beta v_{odt+1}^{2} - \log\left(\kappa_{odt}^{l}\right) + \upsilon \zeta_{odt}^{i} \right\}$$

where β measures patience, C_{odt}^{1} denotes young-age consumption of the final good for those migrating from o to d, κ_{odt}^{l} represents the youth migration cost, and ζ_{odt}^{i} is the idiosyncratic location taste shock, which is the only source of within-cohort heterogeneity. Notice that while the realized utility and the location choice vary by individual i, consumption and savings decisions depend only on the origin-destination path (odt). I follow the work by Caliendo, Dvorkin, and Parro (2019) and assume that the idiosyncratic shock ζ is i.i.d. over time and distributed Type-I Extreme Value with zero mean.

The middle-age utility is:

$$v_{odt}^{2} = (1-\beta) \log\left(C_{odt}^{2}\right) + \beta v_{odt+1}^{3}$$

Lastly, their old-age utility is:

$$v_{odt}^{3} = (1-\beta) \log\left(C_{odt}^{3}\right) + \beta \log\left(m_{odt}^{3}\right)$$

where β governs the taste for bequests (the "generosity" of the old), and m^3_{odt} denotes the real bequests transferred to the next generation.

The budget constraints for any household of the $o \to d$ cohort born at time t are given by:

$$C^1_{odt}P_{dt} + S^1_{odt} = w_{dt}(1-\iota_{dt}) \tag{1}$$

$$C^2_{odt+1}P_{dt+1} + S^2_{odt+1} = w_{dt+1}(1-\iota_{dt+1}) + S^1_{odt}R_{dt+1} + m^2_{odt+1}P_{dt+1} \tag{2}$$

$$C^3_{odt+2}P_{dt+2} + m^3_{odt+2}P_{dt+2} = S^2_{odt+1}R_{dt+2} \tag{3}$$

where labor income is taxed at a proportional rate ι_{dt}, P_{dt} is the price of the final consumption good, S_{odt} denotes end-of-period wealth, R_{dt} is the gross return, and m^2_{odt+1} are real bequests received by the middle aged. Importantly, the nominal bequest to be received ($m^2_{odt+1}P_{dt+1}$) does not depend on the migration decision, and is equalized across all households born in o at time t. Naturally, the real value of this transfer (m^2_{odt+1}) does depend on the location d.

In addition, no borrowing is allowed, so $S^1_{odt}, S^2_{odt+1} \geq 0$. I use the 2023 euro as the numéraire of the economy. That is, an accounting unit that has the same purchasing power as a euro in the euro area in 2023. This implies that aggregate inflation in the euro area in terms of this numéraire is zero at all times (although regional inflation does not need to be).

Consumption-Savings decisions

Old individuals solve the following problem:

$$\max_{m^3_{odt}, C^3_{odt}} (1-\beta)\log\big(C^3_{odt}\big) + \beta\log\big(m^3_{odt}\big) \quad s.t. \quad C^3_{odt}P_{dt} + m^3_{odt}P_{dt} = S^2_{odt-1}R_{dt}$$

The optimal allocation satisfies

$$m^3_{odt}P_{dt} = \beta S^2_{odt-1}R_{dt} \tag{4}$$

This implies that old individuals allocate a fraction $1-\beta$ of their resources to their own consumption, and they bequeath the remaining β share. The indirect utility is $\log\left(\frac{S^2_{odt-1}R_{dt}}{P_{dt}}\right) + \kappa_u$, where $\kappa_u = (1-\beta)\log(1-\beta) + \beta\log(\beta)$.

Knowing this, the middle-aged choose how much to save. The solution to their problem is:

$$P_{dt}C^2_{odt} = (1-\beta)W^2_{odt} \tag{5}$$

$$S^2_{odt} = \beta W^2_{odt} \tag{6}$$

where $W^2_{odt} = w_{dt}(1-\iota_{dt}) + S^1_{odt-1}R_{dt} + m^2_{odt}P_{dt}$. The indirect utility is $\log\big(W^2_{odt}\big) - (1-\beta)\log(P_{dt}) + \beta\log(R_{dt+1}) - \beta\log(P_{dt+1}) + \kappa_U$, where $\kappa_U = (1-\beta)\log(1-\beta) + \beta\log(\beta) + \beta\kappa_u$.

Lastly, conditional on a working location d, the young allocate their resources as follows:

$$S^1_{odt} = \max\left\{0,\ \beta w_{dt}(1-\iota_{dt}) - \frac{1-\beta}{R_{dt+1}}\left[w_{dt+1}(1-\iota_{dt+1}) + m^2_{odt+1}P_{dt+1}\right]\right\} \tag{7}$$

$$C^1_{odt}P_{dt} = w_{dt}(1-\iota_{dt}) - S^1_{odt} \tag{8}$$

The young would like to consume a fraction $1-\beta$ of their lifetime income. However, that is not always feasible as it might imply negative savings.

Migration decisions

Since the young born in o are equal before the realization of idiosyncratic migration shocks, the probability of migrating from o to d is the same for all agents and is given by:[13]

$$\mu_{odt} = \frac{\exp\left((1-\beta)\log\left(C^1_{odt}\right) + \beta(1-\beta)\log\left(C^2_{odt+1}\right) + \beta^2\log\left(\frac{S^2_{odt+1}R_{dt+2}}{P_{dt+2}}\right) - \log\left(\kappa^l_{odt}\right)\right)^{\frac{1}{\upsilon}}}{\sum_j \exp\left((1-\beta)\log\left(C^1_{ojt}\right) + \beta(1-\beta)\log\left(C^2_{ojt+1}\right) + \beta^2\log\left(\frac{S^2_{ojt+1}R_{jt+2}}{P_{jt+2}}\right) - \log\left(\kappa^l_{ojt}\right)\right)^{\frac{1}{\upsilon}}} \tag{9}$$

Population dynamics

At the beginning of every period, the middle-aged give birth to the new generation. The measure of young that are born in region d at t is l^1_{dt}, and l^2_{dt} denotes the measure of middle-aged that start period t in location d. I assume that fertility depends on the location where an individual spends their working years and gets old. Hence, the measure of individuals born in region d is

$$l^1_{dt} = l^2_{dt}\chi_{dt}$$

where χ_{dt} is the gross fertility rate of each adult in d, and hence determines population growth. I will use uppercase L to denote end-of-period populations, given that the young have the option to migrate. In particular, the measure of young individuals working in region d is

$$L^1_{dt} = \sum_o \mu_{odt} l^1_{ot}$$

which coincides with the measure of middle-aged that start (and end) period $t+1$ there ($L^2_{dt+1} = l^2_{dt+1} = L^1_{dt}$), as well as the measure of old that start (and end) period $t+2$ there ($L^3_{dt+2} = l^3_{dt+2} = L^2_{dt+1}$). Note that the labor force in d is given by $L^1_{dt} + L^2_{dt}$. Finally, I will denote total population after migration by $L_{dt} = L^1_{dt} + L^2_{dt} + L^3_{dt}$.

Bequests

Bequests received by a middle-aged agent who was born in o and migrated to region d are equal to the bequests given by the corresponding old generation (the one starting period t in o) to each child, which

[13] This expression follows from standard properties of the Type-I Extreme Value distribution. See, for instance, Chapter 3 of Train (2009).

are given by

$$m^2_{odt} P_{dt} = \frac{m^3_{ot} P_{ot}}{l^1_{ot-1}} \tag{10}$$

where m^3_{ot} denotes total real bequests given by the old from o, so that the numerator is the value of total bequests given by the old generation starting period t in o and the denominator is the measure of middle-aged who receive such bequests.

Total bequests received in region d by middle-aged who migrated from o at $t-1$ are equal to $\mu_{odt-1} m^3_{ot} P_{ot}$. Aggregating bequests (given by Equation (4)), $m^3_{ot} P_{ot} = \beta S^2_{ot-1} R_{ot}$, where $S^2_{ot-1} R_{ot}$ is total wealth at the beginning of period t in the hands of the old in o. Total bequests received in region d are then given by $\sum_o \mu_{odt-1} \beta S^2_{ot-1} R_{ot}$.

2.2 The intratemporal block

2.2.1 Intermediate goods production

There is a continuum of intermediate goods, indexed by $\omega^s \in [0,1]$, in each sector s. Production of these goods is constant returns to scale and markets are perfectly competitive. Firms from any location o are free to produce their variety elsewhere, hence becoming multinational enterprises. The setting builds on Ramondo and Rodríguez-Clare (2013).

Consider a specific variety ω^s. Firms from location o can produce locally with productivity $\lambda_{ost} z_{oost}(\omega^s)$, where λ_{ost} is a location-specific term and $z_{oost}(\omega^s)$ is a variety-specific component. In the standard Eaton and Kortum (2002) framework, this is their only option. In contrast, in this model firms from location o can also open a production plant in m (or multiple plants in many locations) by bringing their know-how regarding the production process to m, hence generating technology diffusion. As in Ramondo and Rodríguez-Clare (2013) and Arkolakis et al. (2018), the productivity associated with producing in m is $\frac{\lambda_{ost} z_{omst}(\omega^s)}{\varrho_{omst}}$, where ϱ_{omst} is an efficiency loss that captures various impediments that multinationals face when operating in a different environment ($\varrho_{oost} = 1$). The component $z_{omst}(\omega^s)$ is generally correlated with, but not equal to, $z_{oost}(\omega^s)$ and generates heterogeneity in location choices by o-firms, as explained below.

Production is divided into two stages. In the first stage, the headquarters assemble an input bundle (described below). The resulting unfinished product ($x^{HQ}_{ost}(\omega^s)$) can only be used by the corresponding firm (in any location) and belongs to the same sector as the finished product (i.e., it is classified as a good if s =goods). In the second stage, the production plant combines this product with the input bundle from its location m. Hence, production requires two input bundles: one from the firm's headquarters and one from the particular production location. The importance of the first is governed by $\varphi \in [0,1]$. If $\varphi = 0$, no inputs from the headquarters are required, and production can be fully offshored.

The production function of a firm from o producing in m is given by:

$$x_{omst}(\omega^s) = \frac{\lambda_{ost} z_{omst}(\omega^s)}{\varrho_{omst}} \left[x^{HQ}_{omst}(\omega^s)\right]^{\varphi} \left[K_{omst}(\omega^s)^{\gamma_m \alpha_m} L_{omst}(\omega^s)^{\gamma_m(1-\alpha_m)} \prod_{r=1}^{S} (n^{rs}_{omt}(\omega^s))^{\gamma^{rs}_m}\right]^{1-\varphi}$$

where $x_{omst}(\omega^s)$ is output of ω^s, $x^{HQ}_{omst}(\omega^s)$ is the input bundle from the headquarters, $K_{omst}(\omega^s)$, $L_{omst}(\omega^s)$ are the capital and labor from m employed in production, and n^{rs}_{omt} are the composite intermediate goods from sector r region m used for the production of ω^s, and $\gamma_m + \sum_{r=1}^{S} \gamma^{rs}_m = 1 \; \forall m, s$.

Each input bundle is standard in the trade literature, as it combines three inputs, capital, labor and composite intermediate goods from all sectors through a Cobb-Douglas function.[14]

All intermediate goods are tradable at any stage, but are subject to iceberg trade costs when shipping abroad $\tilde{\kappa}_{mdst} \geq 1$ (from m to d). In addition, there are ad-valorem flat-rate tariffs $\tau_{mdst} \geq 1$.

By perfect competition, the FOB price of each unit of $x_{omst}(\omega^s)$ is $p_{omst}(\omega^s) = \frac{\varrho_{omst} c^{1-\varphi}_{mst} (\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}{\lambda_{ost} z_{omst}(\omega^s)}$, where c_{mst} is the cost of the input bundle:

$$c_{mst} = \left(\frac{R^K_{mt}}{\gamma_m \alpha_m}\right)^{\gamma_m \alpha_m} \left(\frac{w_{mt}}{\gamma_m(1-\alpha_m)}\right)^{\gamma_m(1-\alpha_m)} \prod_{r=1}^{S} \left(\frac{P_{mrt}}{\gamma^{rs}_m}\right)^{\gamma^{rs}_m} \tag{11}$$

and P_{mrt} is the price of the composite intermediate good from sector r region m.

Therefore, the price of selling ω^s in o to d from plant m is $p_{omdst}(\omega^s) = \frac{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst} c^{1-\varphi}_{mst} (\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}{\lambda_{ost} z_{omst}(\omega^s)}$.

For each sector s and period t, the shock $\{z_{omst}(\omega^s)\}_{o,m}$ is independent across varieties and is drawn from the following multivariate Fréchet distribution:

$$\tilde{F}(z) = \exp\left[-\sum_{o=1}^{J}\left(\sum_{m=1}^{J} z^{-\theta_1}_{omst}\right)^{\frac{\theta_2}{\theta_1}}\right] \quad \theta_1 \geq \theta_2 > \max\{\eta_s - 1, 0\}$$

Two properties are worth emphasizing. First, the joint CDF factorizes across origins, so blocks indexed by o are independent (i.e., draws are i.i.d. across origins). Second, within each block o, the vector $(z_{o1st}, \ldots, z_{oJst})$ exhibits positive dependence. Specifically, the marginal CDF for each o (after a particular transformation) corresponds to a Gumbel-Hougaard Copula with dependence parameter $\alpha_{copula} = \theta_1/\theta_2$.[15] Therefore, if $\frac{\theta_1}{\theta_2} = 1$ we obtain independence across m and as $\frac{\theta_1}{\theta_2} \to \infty$ we approach perfect positive dependence across m. Figure D.5 illustrates the importance of $\frac{\theta_1}{\theta_2}$ with an example.

[14] In particular, this is based on Caliendo and Parro (2015). The difference is that I include capital as a factor of production.

[15] In particular, $\tilde{F}(z) = \prod_{o=1}^{J} \tilde{F}_o(z_o)$, and $\tilde{F}_o(z_o) = \exp\left[-\left(\sum_{m=1}^{J}(-\log(u_{omst}))^{\alpha_{copula}}\right)^{\frac{1}{\alpha_{copula}}}\right]$, where $u_{omst} = \exp\left(-z^{-\theta_2}_{omst}\right)$.

2.2.2 Composite goods and expenditure allocation

Intermediate goods are aggregated into sectoral composite intermediate goods through a CES production function:

$$Q_{dst} = \left[\int_0^1 Q_{dst}(\omega^s)^{\frac{\eta_s-1}{\eta_s}} d\omega^s\right]^{\frac{\eta_s}{\eta_s-1}}$$

where $Q_{dst}(\omega^s)$ is the demand at region d of ω^s good. These sectoral composite intermediate goods can be used in two ways: as an input in intermediates production and as an input in final goods production.

It might be natural to break the problem into two parts by assuming that first the firms in o that can produce variety ω^s choose the cheapest location from where to serve market d ($m^* = \arg\max_m p_{omdst}(\omega^s)^{-1}$) and then composite producers in d select the cheapest alternative. However, this is equivalent to assuming that, for each variety, firms from all origins offer a menu of production locations, and composite producers in d select the cheapest alternative out of all possibilities ($(o^*, m^*) = \arg\max_{om} p_{omdst}(\omega^s)^{-1}$). I adopt this second approach for convenience.

Appendix G shows that, excluding intrafirm trade, the aggregate expenditure share in d, sector s on om-goods is given by

$$s_{omdst} = \left(\frac{\Xi_{odst}}{\Xi_{dst}}\right)^{\theta_2} \left(\frac{\lambda_{ost}}{\Xi_{odst}\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1} \tag{12}$$

where $\Xi_{odst} = \left(\sum_{j=1}^J \left(\frac{\lambda_{ost}}{\tilde{\kappa}_{jdst}\tau_{jdst}\varrho_{ojst}c_{jst}^{1-\varphi}(\tilde{\kappa}_{ojst}\tau_{ojst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{1}{\theta_1}}$ and $\Xi_{dst} = \left[\sum_{o=1}^J \Xi_{odst}^{\theta_2}\right]^{\frac{1}{\theta_2}}$.

The price of sectoral composite goods is:

$$P_{dst} = \Gamma\left(\frac{\theta_2 - \eta_s + 1}{\theta_2}\right)^{\frac{1}{1-\eta_s}} \left[\sum_{o=1}^J \left(\sum_{m=1}^J \left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{\theta_2}{\theta_1}}\right]^{\frac{-1}{\theta_2}} \tag{13}$$

This generalizes the Eaton and Kortum (2002) and Caliendo and Parro (2015) settings, which can be recovered by letting $\varrho_{omst} \to \infty$ for any $o \neq m$. The aggregate elasticity across production locations for a given origin is larger than the elasticity across origins.

The technology for producing final consumption and investment goods requires combining sectoral composite goods, potentially with different shares:

$$Q_{ot}^C = \prod_{s=1}^S \left(Q_{ost}^C\right)^{\alpha_{Cos}}$$
$$Q_{ot}^I = \prod_{s=1}^S \left(Q_{ost}^I\right)^{\alpha_{Ios}}$$

where $\sum_{s=1}^S \alpha_{Cos} = \sum_{s=1}^S \alpha_{Ios} = 1$.

So the unit prices of consumption and investment final goods are

$$P_{ot} = \prod_{s=1}^{S} \left(\frac{P_{ost}}{\alpha_{Cos}} \right)^{\alpha_{Cos}} \tag{14}$$

$$P_{ot}^{I} = \prod_{s=1}^{S} \left(\frac{P_{ost}}{\alpha_{Ios}} \right)^{\alpha_{Ios}} \tag{15}$$

2.2.3 Aggregate outcomes

Using the FOCs of intermediate producers, a share $(1-\varphi)\gamma_m$ of the revenues goes to factors of production located in m (the production location), and a share $\varphi\gamma_o$ goes to factors of production in o (the headquarters location). Aggregating the value generated by all production plants and headquarters in a region leads to regional gross value added (VA):

$$VA_{mt} = \sum_{s} \left[(1-\varphi)\gamma_m \sum_{d} \frac{s_{\cdot mdst} X_{dst}^{AL}}{\tau_{mdst}} + \varphi \sum_{m'} \frac{\gamma_m}{\tau_{mm'st}} \sum_{d} \frac{s_{mm'dst} X_{dst}^{AL}}{\tau_{m'dst}} \right] \tag{16}$$

This follows from the fact that, in equilibrium, total arm's-length sales of $omst$ varieties are equal to worldwide expenditure on those goods which is equal to $\sum_d \frac{s_{omdst} X_{dst}^{AL}}{\tau_{mdst}}$, as X_{dst}^{AL} denotes the total arm's-length expenditure in region d on sector s (excluding intrafirm expenditure), and $s_{\cdot mdst} \equiv \sum_o s_{omdst}$ is the share of expenditure from d on sector s that is allocated to production plants in region m, regardless of the headquarters location.

An analogous aggregation implies that the wage bill in m must satisfy the following equation:

$$(L_{mt}^{1} + L_{mt}^{2}) w_{mt} = (1-\alpha_m) VA_{mt} \tag{17}$$

Similarly, the capital income is:

$$K_{mt} R_{mt}^{K} = \alpha_m VA_{mt} \tag{18}$$

Total trade from m to d in sector s is equal to the sum of arm's-length and intrafirm trade:[16]

$$X_{mdst} = \frac{s_{\cdot mdst} X_{dst}^{AL}}{\tau_{mdst}} + \varphi \frac{1}{\tau_{mdst}} \sum_{d'} \frac{s_{mdd'st} X_{d'st}^{AL}}{\tau_{dd'st}} \tag{19}$$

[16] Note that X_{mst}^{AL} is expenditure on arm's-length trade including tariffs, while X_{mdst} excludes them. This is done for convenience.

One can also disaggregate across origins, which will be useful to quantify multinational production:[17]

$$X_{omdst} = \frac{s_{omdst} X^{AL}_{dst}}{\tau_{mdst}} + \mathbb{1}_{\{o=m\}} \varphi \frac{1}{\tau_{mdst}} \sum_{d'} \frac{s_{mdd'st} X^{AL}_{d'st}}{\tau_{dd'st}} \tag{20}$$

GDP only differs from VA due to the presence of tariffs:

$$GDP_{mt} = VA_{mt} + \sum_{j} \sum_{s} (\tau_{jmst} - 1) X_{jmst} \tag{21}$$

Total expenditure

Total arm's-length expenditure in region m sector r on intermediate goods must be equal to total sales of the composite good, $X^{AL}_{mrt} = P_{mrt} Q_{mrt}$. Given that the composite good is demanded by consumers, the government, investors, and intermediate goods producers (which includes local headquarters),

$$\begin{aligned} P_{mrt} Q_{mrt} = {} & P_{mrt} C_{mrt} + P_{mrt} G_{mrt} + P_{mrt} I_{mrt} \\ & + \sum_{s=1}^{S} \sum_{o} \int P_{mrt} n^{rs}_{omt}(\omega^s) d\omega^s + \sum_{s=1}^{S} \sum_{m'} \int P_{mrt} n^{rs,HQ}_{mm't}(\omega^s) d\omega^s \end{aligned}$$

Using the first order conditions of the producer and aggregating across varieties we get $\int P_{mrt} n^{rs}_{omt}(\omega^s) d\omega^s = \gamma^{rs}_m (1-\varphi) \int p_{omst}(\omega^s) x_{omst}(\omega^s) d\omega^s$, and $\int P_{mrt} n^{rs,HQ}_{mm't}(\omega^s) d\omega^s = \gamma^{rs}_m \varphi \int p_{mm'st}(\omega^s) x_{mm'st}(\omega^s) d\omega^s$. In equilibrium, total sales of intermediates are equal to worldwide expenditure on those goods (net of tariffs), $\int p_{omst}(\omega^s) x_{omst}(\omega^s) d\omega^s = \sum_d \frac{s_{omdst} X^{AL}_{dst}}{\tau_{mdst}}$. If we use E_{mrt} to denote final expenditure on sector r, we get the following condition:

$$X^{AL}_{mrt} = E_{mrt} + \sum_{s=1}^{S} \left[(1-\varphi) \gamma^{rs}_m \sum_{d} \frac{s_{\cdot mdst} X^{AL}_{dst}}{\tau_{mdst}} + \varphi \sum_{m'} \frac{\gamma^{rs}_m}{\tau_{mm'st}} \sum_{d} \frac{s_{mm'dst} X^{AL}_{dst}}{\tau_{m'dst}} \right] \tag{22}$$

In this model, final expenditure in any region m on sector r is the sum of final expenditure by the young, the middle-aged, the old, the government, and investors: $E_{mrt} = \alpha_{Cmr}(E^1_{mt} + E^2_{mt} + E^3_{mt} + E^G_{mt}) + \alpha_{Imr} E^I_{mt}$.

By market clearing, world level final expenditure must be equal to world GDP, $\sum_m E_{mt} = \sum_m GDP_{mt}$. To close the model it is crucial to determine how final expenditure is allocated across regions. Most of the trade literature focuses on static models. As a consequence, either trade is balanced or trade imbalances are exogenous. On the contrary, this model delivers endogenous trade imbalances, which are crucial to understand how a trade war affects the economy in general, and the Balance of Payments in particular.

[17] The indicator $\mathbb{1}_{\{o=m\}}$ captures the fact that o-firms produce all 'headquarters unfinished products' at o. It follows that total sales by o-firms in o in sector s ($X_{oo\cdot st}$) are arm's-length sales $\left(\sum_d \frac{s_{oodst} X^{AL}_{dst}}{\tau_{odst}}\right)$ plus headquarters sales $\left(\varphi \sum_m \sum_d \frac{s_{omdst} X^{AL}_{dst}}{\tau_{mdst}}\right)$, while their sales from any other location $m \neq o$ are only arm's-length sales.

2.2.4 The government

There is one government in each country. The two sources of revenues for the government are the labor income tax and tariffs. Tax revenues collected in region d equal $\iota_{dt} w_{dt}(L^1_{dt} + L^2_{dt})$.[18] Tariff revenues collected in region d are $\sum_j \sum_s (\tau_{jdst} - 1) X_{jdst}$.

The path of aggregate country-level government expenditure is taken as exogenous. This aggregate expenditure is allocated across domestic regions based on local population and time-invariant policy weights. Specifically, I assume the ratio of per-capita government spending between any pair of domestic regions d and d' is constant over time:

$$\frac{E^G_{dt}/L_{dt}}{E^G_{d't}/L_{d't}} = \alpha^G_{dd'}$$

This assumption is motivated by the empirical observation that relative per-capita expenditure across regions is roughly constant over time (Gabriel, Klein, and Pessoa, 2023).

Using this ratio and summing over all regions within a country, government expenditure in region d at time t is given by:

$$E^G_{dt} = L_{dt} \frac{E^G_{g(d)t}}{\sum_{d' \in \mathcal{G}(d)} \alpha^G_{d'd} L_{d't}} \tag{23}$$

where $\mathcal{G}(d)$ denotes the set of regions in the same country as d, and $\alpha^G_{d'd} \geq 0$ captures the time-invariant spatial bias in per-capita spending toward region d' relative to d.

Note that, even without regional biases in taxes ($\iota_{dt} = \iota_{g(d)t}$) and spending ($\alpha^G_{d'd} = 1$), the government redistributes resources across space by taxing high-income regions and distributing expenditure in proportion to population.

2.3 The intertemporal block

2.3.1 Capital

Physical capital is not movable across regions, depreciates at rate δ_m, and to produce one unit of capital in m at the end of period t one needs to input one unit of the local investment final good in that period. Anyone has access to this technology, so the price of capital in m at the end of period t is P^I_{mt}.

The value of the stock of capital in m at the end of period t is equal to its demand, which is the sum of holdings by all investors, $B_{mt} = \sum_o b_{omt} S_{ot}$, where b_{omt} denotes the share of asset m in investor o's

[18] Note that I assume taxes are linear in labor income. One way to interpret this is that income taxes have two components: a uniform tax rate applied across all regions within a country ($\iota_{g(d)t}$) and a tax rate that varies by region ($\iota_{dt} - \iota_{g(d)t}$). In my simulations, whenever the government needs to adjust the tax rate it changes all regional tax rates by the same amount, therefore maintaining regional differences.

portfolio. As a result, investment expenditure in m at t is:

$$E^I_{mt} = \sum_o b_{omt} S_{ot} - (1 - \delta_m) P^I_{mt} K_{mt} \tag{24}$$

Capital is rented to local intermediate producers in a perfectly competitive market.

2.3.2 Asset management

To evaluate quantitatively the effects of a shock in the long run it is crucial to capture how international capital flows react to changes in the economy. Therefore, it is important to build a model that can replicate the observed capital flows patterns in the baseline.

In particular, the literature has established two facts that are difficult to reconcile with theories featuring frictionless trade in assets. First, there is home bias in portfolio holdings, in the sense that saving portfolios are largely exposed to movements in the domestic assets (French and Poterba, 1991). Second, the gravity model also holds for international capital holdings (Portes and Rey, 2005).[19]

I hence introduce an assumption based on Kleinman et al. (2023) to capture this imperfection in the level of financial integration while keeping the model as tractable as possible. Asset management for investors from each location o is intermediated by a local wealth fund managed by a continuum of managers, indexed by $\nu \in [0, 1]$. Specifically, manager ν from region o is able to transform 1 unit of capital in region m at the end of period t into $\psi_{omt}(\nu)$ units at the beginning of the next period. This efficiency term is a combination of two components, $\psi_{omt}(\nu) = \frac{\phi_{omt}(\nu)}{\kappa_{omt}}$. The first component ($\frac{1}{\kappa_{omt}} \leq 1$) is bilateral and constant for all managers from a given location when managing capital in m. These frictions can be understood as reduced-form wedges that capture all costs associated with investing abroad, including legal restrictions and information acquisition costs. The second component ($\phi_{omt}(\nu)$) is an idiosyncratic draw for each manager, which captures unmodeled reasons that generate portfolio diversification, including idiosyncratic investment opportunities. I assume that, for any manager, the investment efficiency $\psi_{omt}(\nu)$ is the same for any pair of regions (m, m') located in the same country (M), so $\psi_{oMt} = \psi_{omt} = \psi_{om't}$. The shock is independent across managers and destination countries, and is drawn from the following Fréchet distribution:

$$\tilde{F}(\phi) = \exp\left[-\phi^{-\epsilon}\right] \quad \epsilon > 1$$

where ϵ measures the dispersion of these efficiency shocks (a lower value is associated with more dispersion). Finally, short positions are not allowed.

Since investment efficiency is equalized within country, all regional capitals in a country must be equally attractive in equilibrium, hence delivering the same returns. The (gross) return of capital in euros, which

[19] Admittedly, a model with frictionless trade in assets can replicate any portfolio allocation, provided that all assets deliver the same return. However, in that world the demand elasticity across assets is infinite –a clearly counterfactual feature–, while in my model this elasticity is calibrated using an empirical estimate from the literature. In any case, the frictionless world is a special case of my model.

is also the return generated by a manager with efficiency 1 ($\psi_{omt} = 1$) is:

$$r_{Mt} = \frac{P^I_{mt}}{P^I_{mt-1}} \left(\frac{R^K_{mt}}{P^I_{mt}} + 1 - \delta_m \right) \quad \forall m \in \mathcal{J}(M) \tag{25}$$

where $\mathcal{J}(M)$ denotes the set of regions in country M. Note that one euro at $t-1$ allows such manager to generate $\frac{1}{P^I_{mt-1}}$ units of capital, each of which generates a nominal rent of R^K_{mt}, and the undepreciated capital $1-\delta_m$ has a resale value of P^I_{mt} euros. For simplicity, I will refer to r_{Mt} as the return on capital M.

Note that this implies

$$r_{Mt} \sum_{m \in \mathcal{J}(M)} P^I_{mt-1} K_{mt} = \sum_{m \in \mathcal{J}(M)} P^I_{mt} K_{mt} \left(\frac{R^K_{mt}}{P^I_{mt}} + 1 - \delta_m \right) \tag{26}$$

The return on capital M is the total revenue generated at t divided by the value of that stock at the end of $t-1$.

2.3.3 Optimal portfolio choice

Wealth is allocated across competitive local managers before knowing the idiosyncratic draws $\phi_{oMt}(\nu)$, so wealth is distributed uniformly across them. For manager ν, investing in any region in country M generates a gross return of $\psi_{oMt}(\nu) r_{Mt+1}$. Therefore, each manager ν from o chooses to invest in $\arg\max_M \{\psi_{oMt}(\nu) r_{Mt+1}\}$. Let $R_{oMt+1} = \frac{\phi_{oMt}(\nu)}{\kappa_{oMt}} r_{Mt+1}$. Then, the aggregate share of capital M in o-investors' portfolio is given by (see Appendix G):

$$b_{oMt} = \frac{\left(r_{Mt+1}/\kappa_{oMt}\right)^\epsilon}{\sum_f \left(r_{ft+1}/\kappa_{oft}\right)^\epsilon} \tag{27}$$

And the expected return on savings is:

$$R_{ot+1} = \mathbb{E}\left(\max_M R_{oMt+1} \right) = \left[\sum_M \left(r_{Mt+1}/\kappa_{oMt}\right)^\epsilon \right]^{\frac{1}{\epsilon}} \Gamma\left(1 - \frac{1}{\epsilon}\right) \tag{28}$$

Investors from o allocate $b_{oMt} S_{ot}$ wealth to country M expecting to generate a return R_{ot+1} (regardless of M) from it. Let K_{omt+1} denote the stock of m capital owned by o investors at the beginning of period $t+1$, with $\sum_o K_{omt+1} = K_{mt+1}$. It must be that

$$b_{oMt} S_{ot} R_{ot+1} = \sum_{m \in \mathcal{J}(M)} P^I_{mt+1} K_{omt+1} \left(\frac{R^K_{mt+1}}{P^I_{mt+1}} + 1 - \delta_m \right)$$

Using Equation (25), we have

$$b_{oMt} S_{ot} R_{ot+1} = r_{Mt+1} \sum_{m \in \mathcal{J}(M)} P^I_{mt} K_{omt+1} \tag{29}$$

Summing across investors delivers the value of the stock of capital in country M in previous period prices:

$$\sum_{m\in\mathcal{J}(M)} P^I_{mt}K_{mt+1} = \sum_o \sum_{m\in\mathcal{J}(M)} P^I_{mt}K_{omt+1} = \frac{1}{r_{Mt+1}}\sum_o b_{oMt}S_{ot}R_{ot+1} \tag{30}$$

Investor composition (i.e., the share of revenue generated by capital in country M that corresponds to o-investors) is given by:

$$g_{oMt} = \frac{b_{oMt}S_{ot}R_{ot+1}}{\sum_j b_{jMt}S_{jt}R_{jt+1}} \tag{31}$$

The allocation of investment across M-regions is pinned down by Equation (25).[20] Given that, from the point of view of any manager in any location, investment is equally attractive across M's regions, I assume that the share of investment in M that is allocated to $m \in \mathcal{J}(M)$ is equalized across investors ($h_{omt} = h_{mt},\ \forall o$). Then, from Equation (29), the share of investment in M that is allocated to m is

$$h_{mt} \equiv \frac{\sum_o b_{omt}S_{ot}}{\sum_o b_{oMt}S_{ot}} = \frac{P^I_{mt}K_{mt+1}}{\sum_{m'\in\mathcal{J}(M)} P^I_{m't}K_{m't+1}} = \frac{\alpha_m \frac{VA_{mt+1}}{r_{Mt+1}-(1-\delta_m)P^I_{mt+1}/P^I_{mt}}}{\sum_{m'\in\mathcal{J}(M)} \alpha_{m'} \frac{VA_{m't+1}}{r_{Mt+1}-(1-\delta_{m'})P^I_{m't+1}/P^I_{m't}}} \tag{32}$$

Appendix E.1 contains a summary of all the equilibrium equations, and Appendix E.2 describes a steady state of the model.

2.4 Solving the model

An interesting feature of this model is that one can solve for the sequential equilibrium using the Dynamic Exact Hat Algebra technique (Caliendo, Dvorkin, and Parro, 2019). This method allows one to solve the model with minimal information requirements. In particular, the level of several unobservable fundamentals does not need to be known or estimated.

I structure the overlapping generations model with a 20-year period duration. This allows me to map the life cycle into three stages: young (20–40), middle-aged (40–60), and old (60+).

The Dynamic Exact Hat Algebra technique allows me to solve for the baseline economy by writing the model in relative changes to a reference period. The first period of the simulation is calibrated using data from 2023. For the following periods –which represent the future economy– I assume a convergent sequence of changes in fundamentals. Let $\dot{x}_t \equiv x_t/x_1$ denote the growth of x between period 1 and t.[21] Then, the equilibrium conditions can be rewritten in relative terms.

The resulting system of equations –shown in Appendix E.3– does not require information on the *initial level* of a large set of fundamentals, which encompasses productivity (λ_{os1}), multinational production

[20] Using Equation (18), investment in region m must be such that the following equation is satisfied:

$$r_{Mt} = \frac{P^I_{mt}}{P^I_{mt-1}}\left(\alpha_m \frac{VA_{mt}}{P^I_{mt}K_{mt}} + 1 - \delta_m\right) \quad \forall m \in \mathcal{J}(M)$$

[21] The only exception is for portfolio shares, where $\dot{b}_t \equiv b_t/b_0$.

frictions (ϱ_{oms1}), trade frictions ($\tilde{\kappa}_{mds1}$), migration frictions (κ^l_{od1}), and investment frictions (κ_{oM0}), nor does it require knowing the initial level of final prices or how they compare across regions (P_{o1}/P_{d1}). Another attractive feature of this technique is that one does not need to impose that the economy starts in a steady state.

Counterfactuals

The main goal of this paper is to compare counterfactual economies with different sets of bilateral tariffs. Just as in Caliendo, Dvorkin, and Parro (2019), the Dynamic Exact Hat Algebra technique can also be used to solve for a counterfactual economy with minimal information requirements by writing the model in relative changes to a baseline economy. In particular, suppose that there is a change in the sequence of productivity levels, tariffs, and frictions

$$\begin{aligned}
\text{from} \quad & \left\{ \left\{\lambda_{ost}\right\}_{o\in\mathcal{J},\, s\in\mathcal{S}}, \left\{\tau_{odst}, \varrho_{odst}, \tilde{\kappa}_{odst}\right\}_{o,d\in\mathcal{J},\, s\in\mathcal{S}}, \left\{\kappa^l_{odt}\right\}_{o,d\in\mathcal{J}}, \left\{\kappa_{oMt}\right\}_{o\in\mathcal{J},\, M\in\mathcal{M}} \right\}_{t=1}^{\infty} \\
\text{to} \quad & \left\{ \left\{\lambda'_{ost}\right\}_{o\in\mathcal{J},\, s\in\mathcal{S}}, \left\{\tau'_{odst}, \varrho'_{odst}, \tilde{\kappa}'_{odst}\right\}_{o,d\in\mathcal{J},\, s\in\mathcal{S}}, \left\{\kappa^l_{odt}{}'\right\}_{o,d\in\mathcal{J}}, \left\{\kappa'_{oMt}\right\}_{o\in\mathcal{J},\, M\in\mathcal{M}} \right\}_{t=1}^{\infty}
\end{aligned}$$

Let x' denote the value of x in the new equilibrium (variables without apostrophe refer to the previous equilibrium), and let $\hat{x} = x'/x$. Then, the equilibrium conditions can be rewritten in relative changes (the resulting system is shown in Appendix E.4). As before, by taking this approach one does not need to identify any of the aforementioned fundamentals of the baseline economy.

Welfare

In addition, I follow Caliendo, Dvorkin, and Parro (2019) to obtain a lifetime consumption equivalent measure to assess the effects of fundamental changes on welfare. I define Υ_{ot}, which is the common change in consumption (and also old bequests) in every period that would exactly offset any welfare change experienced by generation t in o relative to the baseline. As shown in Appendix E,

$$\Upsilon_{ot} = \left(\hat{\mu}_{oot}\right)^{-\upsilon} \left(\hat{C}^1_{oot}\right)^{1-\beta} \left(\hat{C}^2_{oot+1}\right)^{\beta(1-\beta)} \left(\hat{C}^3_{oot+2}\right)^{\beta^2} \quad \forall t \geq 1 \tag{33}$$

which tells us that to assess welfare effects for generation $t \geq 1$ in o it suffices to look at the welfare of those who do not migrate and the change in the share of stayers, which summarizes all the information regarding the welfare of migrants relative to stayers.

For the generations already alive in the first period (who do not migrate), the welfare equivalents can be derived analogously. For generation $t = -1$, which is old in period $t = 1$, welfare equivalent variation simply equals the relative change in their real consumption in that period because consumption and bequests change in the same proportion:

$$\Upsilon_{o,-1} = \hat{C}^3_{o1} \tag{34}$$

For generation $t = 0$, which is middle-aged in period $t = 1$, the welfare equivalent variation is a Cobb-

Douglas aggregate of their real consumption changes in those two periods:

$$\Upsilon_{o,0} = \left(\hat{C}^2_{o1}\right)^{1-\beta} \left(\hat{C}^3_{o2}\right)^{\beta} \tag{35}$$

2.5 Calibration

Because the Dynamic Exact Hat Algebra method explicitly conditions on the observed initial allocation, calibrating the model requires data on a specific set of endogenous variables –including the bilateral shares of trade, multinational production, asset holdings, and migration– along with exogenous variables (such as bilateral tariffs) and the model's structural parameters.

By construction, this solution method ensures that the simulated economy exactly matches these bilateral shares in the first period. Therefore, standard cross-sectional model validation exercises, which typically compare modeled allocations to observed data in the initial year, are not applicable here.

In this subsection, I first describe the data construction for the initial state of the economy ($t = 1$). I then outline the assumed sequence of fundamentals for the subsequent periods along the transition path ($t > 1$).

Initial period ($t = 1$)

I calibrate the initial period of the model using data for 2023 from multiple sources. The calibration of trade patterns employs data from Eurostat and the FIGARO-REG database (Rueda-Cantuche, Lopez Alvarez, and Galiano Bastarrica, 2017). In total, the model includes 285 regions, 16 additional countries (which account for 88% of world GDP), and a rest-of-the-world aggregate (ROW). In particular, I obtain bilateral trade, value added shares γ_m, sector composition of intermediate goods γ^{rs}_m, and sector composition of final goods α_{Cms}, α_{Ims}.[22] Appendix F.1 provides additional details on the estimation of these objects.

Multinational production is calibrated using country-level data from the OECD. In particular, it uses the bilateral matrix from the Analytical Activities of Multinational Enterprises (AMNE) database (2024 release). Appendix F.2 details how this dataset is combined with the trade data to obtain expenditure shares s_{omdst}.

Initial tariffs are taken from the Global Tariff Database (Teti, 2024) for 2021, except for tariffs either imposed by or imposed on the United States, for which I use 2023 data from The Global Tariff Database: U.S. Trade War Extension (Rodríguez-Clare et al., 2025).

Migration patterns are also calibrated by combining country-level data with regional datasets. At the country level, I combine bilateral migration stocks from Eurostat and the United Nations Global Migration Database. I regionalize the data in two steps. First, I distribute the bilateral stock at the country level across destination regions using Eurostat data on population by country of birth at the regional level. Second, I distribute the resulting stocks at the 'origin country, destination region' level across

[22] The following industries are aggregated into 'goods': Agriculture, forestry and fishing, Mining and quarrying, Manufacturing, Electricity, gas, steam and air conditioning supply, Water supply; sewerage, waste management and remediation activities. The rest –including Construction– are aggregated into 'services'.

origin regions using bilateral flows from the ESPON IRIE Project.[23] Stayers are estimated as a residual (domestic population minus the stock of domestic immigrants).

I calibrate asset holdings at the country level. The assumption is that bilateral investment frictions do not vary within country ($\kappa_{omt} = \kappa_{o'mt}$ whenever o and o' belong to the same country), so portfolios are equalized across regions in the same country. The main data sources are the IMF Portfolio Investment Positions by Counterpart Economy (PIP) and the IMF Direct Investment Positions by Counterpart Economy (DIP), to which I apply a number of adjustments. First, I use data from Beck et al. (2024) –who correct IMF's PIP data for the role of "onshore offshore financial centers" within the Euro Area– to redistribute the positions held by Irish and Luxembourgian funds in the PIP dataset to the ultimate investors.Second, I add domestic positions by using data from OECD Annual Financial Balance Sheets. Third, I restate the positions from residency to nationality using the restatement matrices provided by Coppola et al. (2021). Fourth, I add the DIP data after excluding phantom FDI by employing the estimates from Damgaard, Elkjaer, and Johannesen (2019). This gives me bilateral positions (including domestic) at the country level.

In the model, the aggregate value of any asset must equal the capital stock of the corresponding country. I impose this restriction by distributing the end-of-year capital stock from the Penn World Table (Feenstra, Inklaar, and Timmer, 2015) among investors (both domestic and foreign) in proportion to the bilateral positions constructed above. Finally, I adjust these implied portfolio shares to ensure that each country's net foreign asset position exactly matches the official Net International Investment Position (NIIP) from the Balance of Payments. Appendix F.3 provides additional details on the construction of capital holdings and this adjustment procedure.

To regionalize country-level savings I use regional data on property income.[24] Portfolio returns R_{ot} are estimated using IMF BOP and IIP data as one plus investment income divided by total assets in the previous year (the result is then raised to the power of 20 to convert annual returns to per-period returns).

Population by age group is obtained by combining data from Ardeco and the IMF WEO. Government expenditure at the country level is taken from IMF International Financial Statistics. Government expenditure is regionalized in proportion to VA of the non-market sector (obtained from Ardeco), which has been shown to be a good proxy for government spending (Gabriel, Klein, and Pessoa, 2023).

Taxes at the regional level are a combination of two terms: (1) current taxes on income and wealth from Ardeco, and (2) an adjustment factor –proportional to GDP– that ensures aggregate consistency at the country level.

The parameter that determines patience ($\beta = 0.5665$) is set such that US savings grow at the steady state rate in the first two periods of the baseline. Depreciation rates δ_o and capital shares α_o are retrieved

[23] For domestic pairs, however, the stock of domestic immigrants relative to foreign immigrants is assumed to be proportional to the flow of domestic immigrants relative to foreign immigrants.

[24] Regional property incomes are obtained using the Regional accounts database from Eurostat (specifically, the Income of households by NUTS-2 regions dataset), complemented with the QoG EU Regional dataset. Property income balance (i.e., property income received by resident households minus property income payable by resident households) is one of the components of primary income, and it is the sum of investment income (essentially the result of summing interests, dividends, and reinvested earnings) and income from renting natural resources. In the model, property income balance corresponds to $S_{ot-1}(R_{ot} - 1)$. Since I assume that bilateral investment frictions do not vary within country, relative property incomes within country identify relative wealth.

from the Penn World Table at the country level. Because depreciation rates are provided at the annual level (δ_o^{annual}), I set $\delta_o = 1 - (1 - \delta_o^{\text{annual}})^{20}$ to match depreciation after 20 years. Since a steady state requires constant $\gamma_m(1-\alpha_m)$ across all regions, I adjust α_m to match the average $\gamma_m(1-\alpha_m)$.[25] φ is set to 0.064 to match total exports of goods shipped to affiliates in the manufacturing sector as a share of affiliates' total costs in the US (from the U.S. Bureau of Economic Analysis).[26]

Elasticities are calibrated using standard values from the literature. In particular, the elasticity θ_2 is set to 5.03, the median of the literature's estimates according to Head and Mayer (2014). I set $\theta_1 = 10$, based on the estimation results of the restricted gravity equation in Arkolakis et al. (2018) (reported in their Table 1). Following Kleinman et al. (2023), the demand elasticity across assets ϵ is set to 10, which is based on Koijen and Yogo (2020). Lastly, following Head and Mayer (2021) I use a 1.63 migration elasticity, which implies $\upsilon = 1/1.63 \approx 0.61$.

Evolution of fundamentals ($t > 1$)

For periods extending into the future, the solution algorithm requires an assumed sequence for the evolution of all fundamentals. I adopt a parsimonious approach to these future paths in order to keep the model's mechanisms as transparent as possible.

Population growth is kept at zero, based on population projections (2022-2100) from Eurostat. Productivity fundamentals grow at a rate equal to $1.014^{20\times\gamma_m(1-\alpha_m)}$. This is consistent with a steady state GDP yearly growth rate of 1.4% (which is an estimate taken from the IMF World Economic Outlook projections). Governments maintain constant expenditure to GDP ratios over time (equal to the corresponding ratios in period 1), and labor income tax rates adjust as necessary. All other fundamentals (tariffs and frictions) are constant.

I simulate the economy for $T+2$ periods ($T = 13$) by assuming that expectations about the future after the final period are consistent with a steady state (e.g., prices are constant and the economy grows at a constant rate). I report results up until T because equilibrium variables (namely, migration) depend on the state of the economy two periods into the future.

Appendix F.4 describes the algorithm I use to solve for the equilibrium, both in the baseline economy and in the counterfactual exercises.

3 Counterfactual exercises

This section examines the economic implications of a US trade war. I simulate several counterfactual scenarios and compare each of them to the baseline economy in which all bilateral tariffs remain permanently at their 2023 levels.

[25] In one instance the resulting α_m from this procedure would be lower than 0.1, so I also adjust γ_m.

[26] Specifically, I combine tables II.H 2 and II.D 2 from the latest benchmark survey (2019) of BEA's Worldwide Activities of U.S. Multinational Enterprises. Using total sales instead of total costs only changes the ratio marginally (6.1%).

3.1 Counterfactual 1: Trade war without retaliation

In this counterfactual, I explore a world in which the US suddenly and permanently raises tariffs on imports from all countries by 10 percentage points. This particular choice has several appealing features.

First, it closely aligns with recent US trade policy. A universal 10% baseline tariff (in addition to country-specific "reciprocal" tariffs) was initially announced on Liberation Day under the International Emergency Economic Powers Act. After the Supreme Court ruled those tariffs illegal, they were temporarily replaced by a universal 10% tariff invoked under Section 122. More recently, the Section 301 "Forced-Labor" tariffs that replaced the Section 122 measures maintained this 10% rate for several key trading partners, including the EU, while setting a 12.5% rate for others.

Second, a 10 percentage point increase brings the average US tariff roughly back to its level in the 1940s, around the time the GATT was signed (Irwin, 2020).

Third, a uniform rate constitutes a transparent benchmark. As demonstrated by a series of robustness exercises in Table C.2, assuming that the reported effects on Europe are linear in the universal US tariff provides a reasonable approximation, as long as the tariff increase is not too large.

I first examine the effects on Europe, starting with the effects on impact (i.e., during the first period $t = t^* = 1$, which is meant to capture the first years), and then evaluating the dynamic effects. I assess the effects on the US economy at the end of the section.

3.1.1 Trade patterns

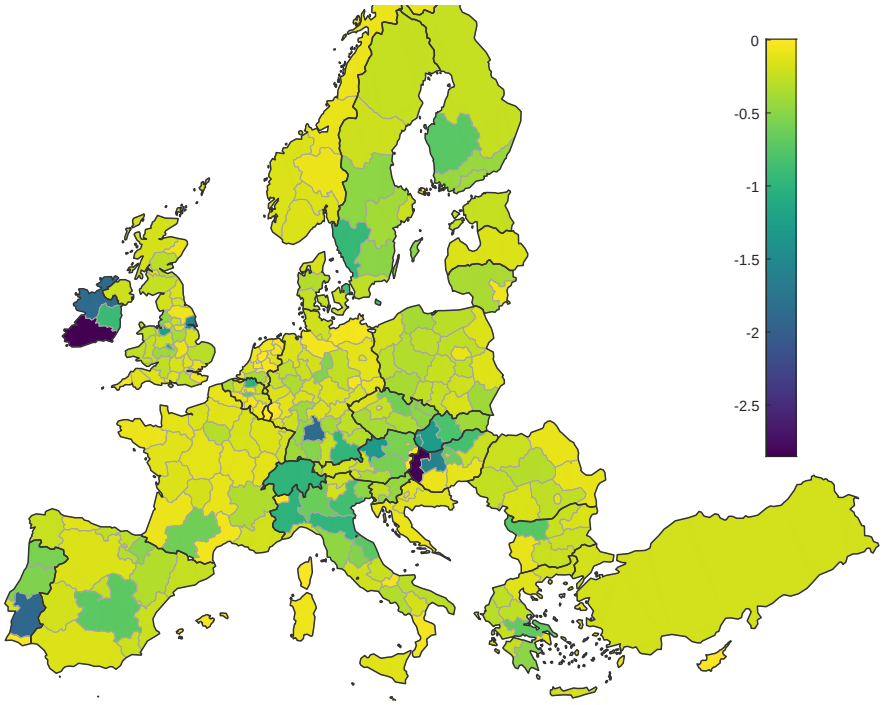
EU exports of goods to the US fall by 0.42 pp as a share of EU GDP due to US tariffs. The burden is, however, concentrated in a small number of regions: the median region experiences a decline of 0.21 pp, while for the last decile of regions the drop exceeds 0.7 pp. Figure 2 shows the geographical distribution of the effect on EU exports of goods to the US.

A striking feature of the results is that the burden of US tariffs is not only concentrated across countries but also strongly concentrated within countries. Specifically, the pooled within-country standard deviation is 80% of the overall standard deviation. Consistent with this, the most affected regions by this metric are precisely those that are more exposed to US demand in the baseline, measured by the share of exports of goods to the US over total sales (see Figure D.12).

Southern Ireland is the most extreme case (-6.4 pp), reflecting the importance of pharmaceutical and medical-product exports to the US. A second cluster is formed by a Central European manufacturing corridor running from southern Germany through Austria, western Hungary and western Slovakia into northern Italy, where regions are deeply embedded in automotive, machinery and transport-equipment value chains.[27] Many regions in this area report losses ranging from 1 to nearly 3 pp. A third group consists of more scattered, highly specialized production hubs, including Antwerpen (Belgium) in chemicals and pharmaceuticals, Alentejo (Portugal) in petrochemicals and refined products, Hovedstaden

[27] This corridor includes regions such as Stuttgart, Oberbayern (Germany), Oberösterreich (Austria), Nyugat-Dunántúl, Közép-Dunántúl (Hungary), Západné Slovensko, Bratislavský kraj (Slovakia), Piemonte, Emilia-Romagna and Veneto (Italy).

Figure 2: Regional exports of goods to the US



Notes: Change in European exports of goods to the US across NUTS-2 regions at $t = t^*$ as a share of own GDP (in pp). To facilitate visualization, values beyond limits are shown saturated. This only affects Southern Ireland (−6.4 pp).

(Denmark) in life sciences, Midi-Pyrénées (France) in aerospace, Västsverige (Sweden) in automotive production, and parts of Finland in forest-based and machinery-related exports.

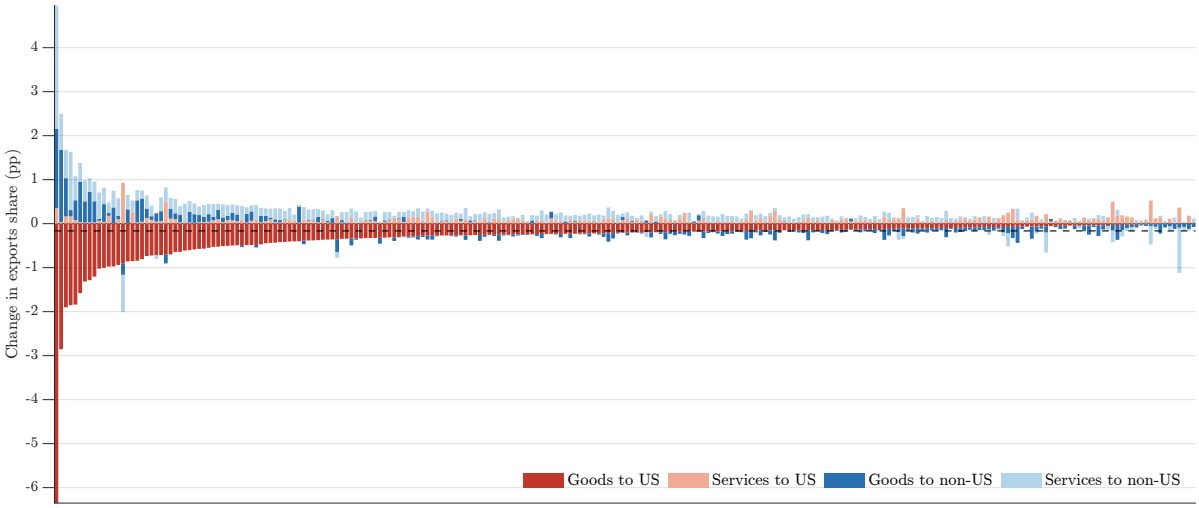
Outside the EU, the same pattern appears in Switzerland, where chemical and pharmaceutical products account for more than half of total exports.

These patterns show that the spatial incidence of the tariff shock is driven primarily by subnational sectoral specialization in a narrow range of export-intensive sectors, especially pharmaceuticals and medical products, automotive and transport equipment, machinery, chemicals, and aerospace.

Figure 3 reports how sales are affected for every EU region. Regions are sorted according to the effect on exports of goods to the US (dark red bars). As discussed, the distribution is heavily skewed. One might expect some of these lost exports to be diverted toward other destinations. The dark blue bars indeed show that the most affected regions start selling more elsewhere (including to other EU regions). But, as it turns out, most of these sales are essentially stealing sales by other regions, so the aggregate effect on sales of goods to non-US destinations is virtually zero (0.01 pp). Part of the reason why Europe as a whole fails to sell more goods in other foreign markets is that Europe is less affected than other economies, particularly Canada and Mexico. Hence, goods from these economies are abundant and cheap, capturing a share of non-US markets.

In contrast, exports of EU services to the US (light red bars) increase by 0.1 pp as a share of EU's GDP in the aggregate, offsetting around one-fourth of the drop in exports of goods to the US. The reason is a standard terms of trade effect. Tariffs make US consumers and firms shift demand toward domestically-produced goods, leading to an expenditure-shifting effect that improves US terms of trade. This is the

Figure 3: Decomposing regional exports



Notes: Change in European exports across NUTS-2 regions on impact ($t = t^*$), expressed as a share of regional GDP (in pp). For each region (x-axis), the four bars decompose the change in exports by destination (US in red vs. non-US in blue) and by sector (goods in dark shades vs. services in light shades). Regions are sorted according to the effect on exports of goods to the US (dark red bars).

standard terms of trade manipulation (Ossa and Redding, 2026). As a result, US-produced goods are now relatively more expensive than non-US goods. Crucially, US tariffs apply to goods but not to services. Therefore, European services become more competitive in the US. Interestingly, such an increase is not correlated with the drop in exports of goods, as regions that are competitive in one sector do not need to be competitive in the other. The light blue bars show that sales of services to other destinations increase (by 0.15 pp in the aggregate), especially for the highly affected economies. This is mostly driven by trade within country, as aggregate exports of services to the rest of the world remain roughly unaltered just like exports of goods.

The key reason why there is an increase in trade in services within Europe –but not for goods– is that the European economy broadly shifts to services. Such a sectoral shift is driven by US demand. US tariffs depress US demand for foreign goods relative to foreign services, while the rest of the world's demand for US goods relative to services remains unaltered. Terms of trade effects expand US imports of services, so overall the US becomes a net exporter of goods and a net importer of services. Recall that production requires intermediate inputs from all sectors. Naturally, goods (services) production is relatively intensive in goods (services) intermediates. Hence, when EU regions shift from exporting goods to services, their demand for intermediate services is expanded, boosting trade in services across regions.

Figure D.6 is an analogous figure for imports. As in Figure 3, regions are sorted according to the effect on exports of goods to the US. Due to the terms of trade effects, imports from the US fall both for goods and services (-0.14 pp and -0.22 pp in the aggregate, respectively). Regions that import a lot from the US –which are not necessarily the regions that sell more to the US– are the ones that shift more strongly away from US goods and services. These drops are largely offset by increased imports of goods and services from elsewhere (0.04 pp and 0.22 pp in the aggregate, respectively), with imports from the rest of the world contributing 0.09 pp.

Together with the results for exports, we see that aggregate EU exports fall by 0.16 pp as a share of EU

GDP while imports decrease by 0.1 pp, which implies that Europe's aggregate trade balance decreases (-0.06 pp). Interestingly, the bilateral trade balance with the US improves by 0.04 pp.

3.1.2 Multinational production

One of the core arguments put forward by the US administration for implementing a generalized increase in tariffs was to "reshore production". Part of the strategy was to attract multinational firms to produce in the US. The logic was that a high effective tariff rate would make the cost of importing goods so high that producing in the US would become the only viable option for major manufacturers.

Table C.4 reports the country-level effects on trade and multinational production vis-à-vis the US. Multinational production by EU firms in the US increases by 0.29 pp of EU GDP, indicating that a large share of the lost export volume is replaced by multinational production. In particular, almost three-quarters of the US goods market share lost by EU exporters is recaptured by US-based affiliates of EU multinationals. This substitution effect is particularly pronounced for Ireland, the Netherlands, Germany, and France (0.65, 0.46, 0.39, and 0.32 pp of their respective GDPs). The main reason for this is that tariffs distort the choice between exporting and multinational production, inducing some European firms to move production to the US (the extensive margin). But this increase additionally reflects an intensive margin effect: facing reduced competition in the US market (particularly from China, Canada, and Mexico), existing EU multinationals capture a larger share of US demand.

Conversely, US exports contract substantially in the EU and other foreign markets due to the general equilibrium increase in US production costs. As a result, US firms are incentivized to shift production offshore. However, the aggregate inflow of US multinational production into the EU is more modest (0.09 pp of EU GDP) and is highly concentrated in Ireland (1.36 pp).

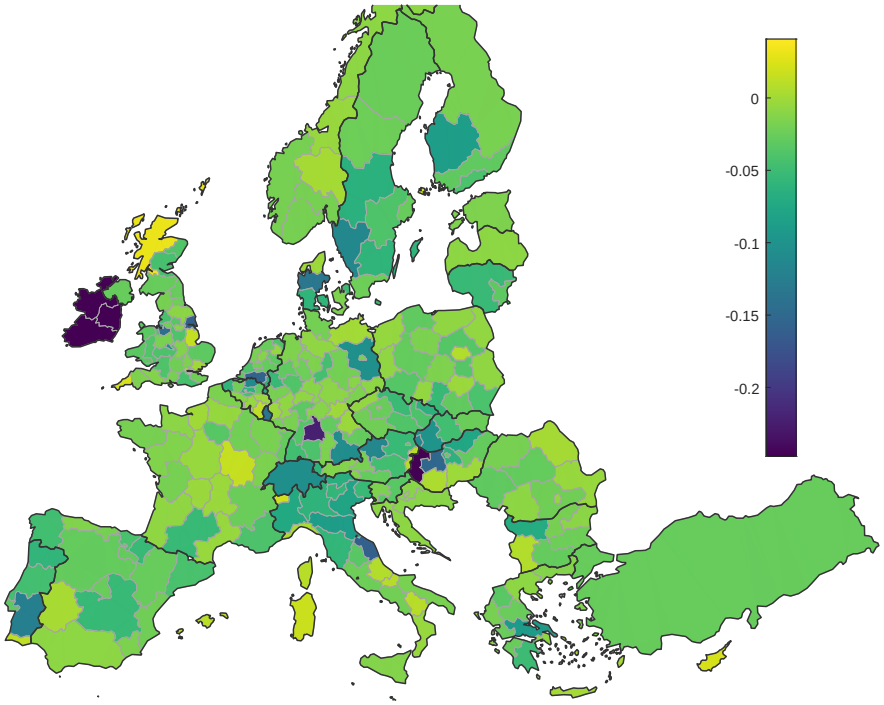
3.1.3 Regional GDP

Aggregate effects on GDP are limited, as real GDP per capita $\left(\frac{GDP_{mt}}{P_{mt}L_{mt}}\right)$ falls by 0.04% in the EU, on average.[28] In line with the results for trade patterns, Figure 4 shows that the regional heterogeneity is significant, with some regions losing up to 0.87% while others achieve marginal gains (0.04%).

Overall, the largest losses occur precisely where exports of goods to the US fall by more. But initial export exposure in goods is not enough to understand why real GDP per capita reacts differently across regions (the correlation is -0.89, see Figure D.13). In particular, regions that export a lot of services to the US tend to benefit from the expanded demand, while those that import a lot of goods or services from the US will suffer more from the terms of trade effect (i.e., higher US prices). Table C.5 shows that the four direct trade exposure variables are enough to capture almost all variation and have the expected sign, with exports exposure in services being the only one associated with better GDP effects. This does not mean, however, that input-output linkages and indirect exposure are not important. Appendix A.1 shows that ignoring intermediate goods reduces the effect on European VA by more than half.

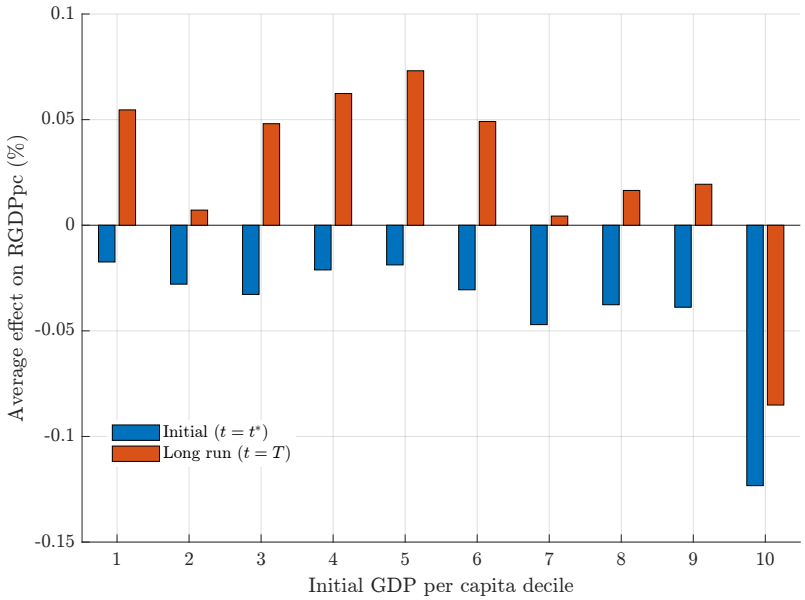
[28] For expositional brevity, references to changes in, or effects on, "real GDP" or "GDP" throughout the text refer to real GDP per capita.

Figure 4: GDP per capita ($t = t^*$)



Notes: Real GDP per capita across NUTS-2 regions at $t = t^*$ (in %). To facilitate visualization, values beyond limits are shown saturated. This affects the three Irish regions: Southern (-0.87%), Eastern and Midland (-0.42%), and Northern and Western (-0.30%).

Figure 5: Effects on real GDP per capita by initial GDP per capita decile



Notes: EU regions are assigned to deciles according to their GDP per capita at $t = t^*$ in the baseline. The bars report the average percentage change in real GDP per capita within each decile, weighted by baseline population. Blue bars show the effect at $t = t^*$, while orange bars show the effect at $t = T$.

The spatial distribution of the effects also raises the question of whether the shock affects poorer and richer regions differently. To examine this dimension of heterogeneity, Figure 5 groups EU regions into deciles according to their baseline GDP per capita and reports the population-weighted average effect within each group. It shows that the initial effects are relatively homogeneous across the first nine deciles, with average losses ranging from approximately 0.02% to 0.05%. In contrast, the richest decile experiences a substantially larger decline of around 0.12%. This pattern still holds if the Irish regions are excluded (although it is weaker, see Figure D.7) because the last decile includes severely affected places such as Luxembourg and several German, Dutch, and Danish regions. The incidence of the shock is therefore mildly equalizing: richer regions, and especially those in the top decile, bear larger losses than poorer and middle-income regions. Nevertheless, because the effects are quantitatively small, the resulting changes in conventional measures of regional inequality, such as the Gini coefficient and decile ratios, are negligible.

In the long run, the average effect improves in every decile because the whole distribution shifts to the right, as explained below. All low- and middle-income deciles record gains in real GDP per capita. The exception remains the richest decile, whose average real GDP per capita is still approximately 0.09% below the baseline.

3.1.4 Consumption and welfare

Figure D.8 disaggregates the effects of the trade war on consumption across European regions. The figure presents overlapping histograms for the young, the middle-aged, and the old, focusing on non-migrating individuals at time $t = t^*$ to facilitate comparison.

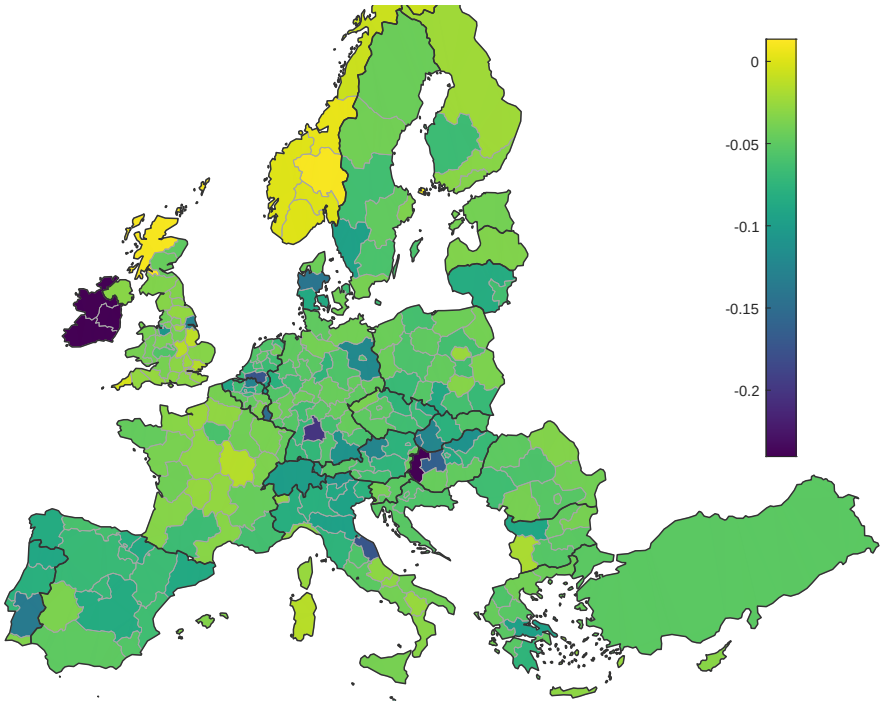
The key result is that the young suffer a drop in consumption in most regions, while the old experience gains and the middle-aged fall in between. The population-weighted average changes are: -0.04% for the young, 0.01% for the middle-aged, and 0.06% for the old. The old generally benefit from a geographically diversified portfolio of assets that provides direct exposure to the US economy. In addition, the correlation across regions between consumption effects of the young and old is slightly negative (-0.12), as the old are somewhat insulated from local economic conditions.

Figure 6 focuses on the spatial distribution of welfare changes for the generation born at time $t = t^*$. The population-weighted average is -0.07% in the EU, and is negative for virtually all regions. Broadly, the pattern clearly resembles the effects on real GDP per capita (see Figure D.9). However, contrary to standard trade settings, there is no equivalence between real GDP and welfare in this model.

Using Equation (33), welfare effects can be decomposed into four terms: $\log(\Upsilon_{ot}) = -\upsilon \log(\hat{\mu}_{oot}) + (1-\beta)\log\left(\hat{C}^1_{oot}\right) + \beta(1-\beta)\log\left(\hat{C}^2_{oot+1}\right) + \beta^2 \log\left(\hat{C}^3_{oot+2}\right)$. The first component captures the change in migration value (how attractive migrating is compared to staying in the birthplace), while the remaining terms capture changes in consumption for stayers.

Figure 7 reports the breakdown for all EU regions, sorted by the effect on real GDP per capita. Several results are worth emphasizing. First, lifetime income is strongly correlated with GDP, explaining why consumption falls more in regions where GDP declines by more. Second, old age consumption is the largest contributor to welfare losses. This is because old age consumption depends on savings but also on the

Figure 6: Welfare (generation t^*)



Notes: Lifetime consumption equivalent welfare change across birthplace (NUTS-2 regions) for generation t^* (in %).

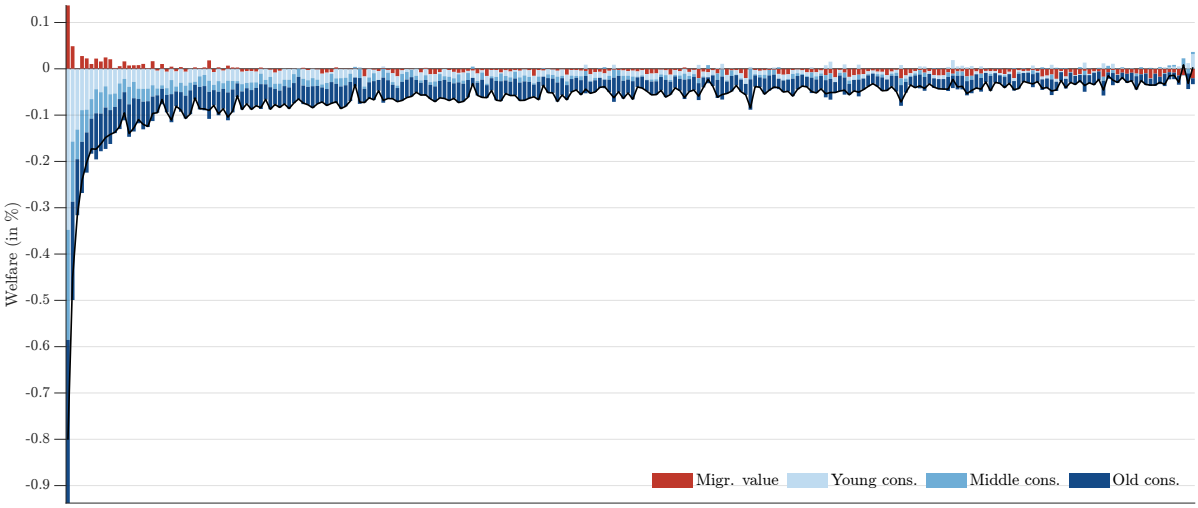
return on those, and it turns out that returns decline everywhere both because real VA decreases in Europe (which lowers real rental rates) and because US capital becomes less attractive (as explained below), which further pushes returns on all assets downwards as demand for EU capital expands. Therefore, the lower wealth in the middle period compounds with lower investment returns, hence inflicting a 'double hit' to old-age consumption. This also explains why the decline in welfare is larger than the real GDP per capita drop (see Figure D.9). Third, migration value smooths out welfare effects across regions. Essentially, households in strongly affected regions have the option to migrate to less affected regions, while the value of migrating for those in less affected regions declines. However, the smoothing-out effect is limited due to the high migration frictions implied by the data.

3.1.5 Migration

Aggregate migration patterns are only modestly affected by the shock. At the EU level, net migration changes by just 0.01 percentage points as a share of the EU population. This aggregate effect, however, masks substantial geographic heterogeneity. Figure 8a reports the change in net migration across regions following the trade war. As expected, these changes are closely related to the regional effects on real GDP per capita. The most adversely affected regions experience population outflows, including regions in Ireland, Luxembourg, and Germany. By contrast, many regions in Germany, Croatia, and France receive population inflows.

Most of the regional variation in net migration is driven by changes in immigration rather than emigration. Thus, regions that lose population do not generally experience a large increase in emigration. Instead,

Figure 7: Welfare decomposition



Notes: For each region, the black line reports lifetime consumption equivalent welfare changes for generation t^* (as a log difference in %). The four bars decompose the change into the four components specified by eq. (33). Regions are sorted based on real GDP per capita effects.

their population losses are mainly explained by a decline in immigration.

Although the migration effects are small in any individual period, they accumulate over time and gradually alter the spatial distribution of population. As shown in Figure 8b, these cumulative movements generate visible long-run changes in regional population. On top of this, total EU population rises by 0.17% in the long run.

3.1.6 Dynamics

Although the tariff shock is permanent, its effects evolve substantially over time due to capital accumulation and wealth dynamics.

Despite the initial GDP fall, real investment increases in Europe, leading to an expansion of the stock of capital in the long run of 0.35% (or 0.18% in per capita terms). Figure 9 decomposes the dynamic evolution of the aggregate EU capital stock by investor origin.[29] It clearly shows that the aggregate increase in EU capital is entirely accounted for by greater US demand. The mechanism is the following. The US economy expands relative to Europe due to a standard terms of trade effect, which results in a

[29] To aggregate the changes in real capital across regions, I construct a Laspeyres quantity index evaluated at baseline capital prices. The percentage change in the aggregate EU real capital stock relative to the baseline economy is given by the value-weighted average of regional capital changes:

$$\hat{K}^{EU}_{t+1} - 1 = \sum_{m \in \mathcal{E}} \frac{P^I_{mt} K_{mt+1}}{\sum_{j \in \mathcal{E}} P^I_{jt} K_{jt+1}} \left(\hat{K}_{mt+1} - 1 \right)$$

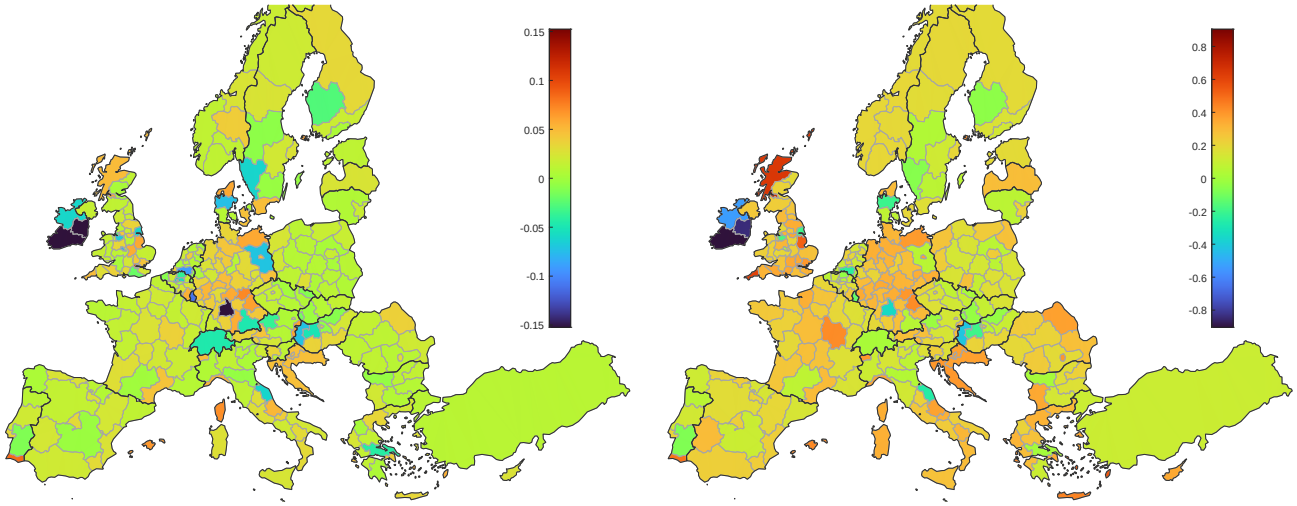
where $\mathcal{E}$ denotes the set of all regions in the European Union.

Using Equations (64) and (65), the change in the EU capital stock can be decomposed as the sum of contributions from all investors:

$$\hat{K}^{EU}_{t+1} - 1 = \sum_{o} \sum_{m \in \mathcal{E}} \frac{P^I_{mt} K_{mt+1}}{\sum_{j \in \mathcal{E}} P^I_{jt} K_{jt+1}} g_{oMt} \left(\frac{\hat{h}_{mt}}{\hat{P}^I_{mt}} \hat{b}_{oMt} \hat{S}_{ot} \frac{\hat{R}_{ot+1}}{\hat{r}_{Mt+1}} - 1 \right) \tag{36}$$

Lastly, I group the investors o into three groups (the EU, the US, and all other locations).

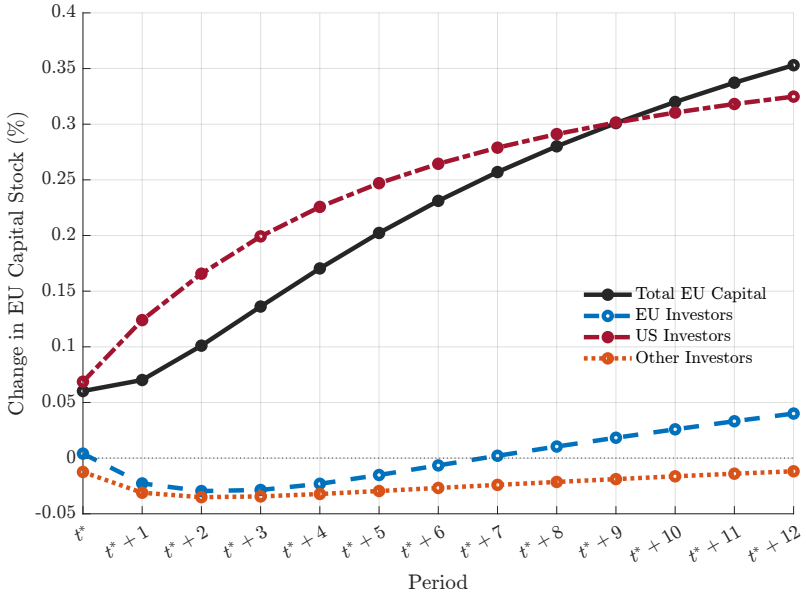
Figure 8: Migration and population dynamics



(a) Net migration, young, $t = t^*$ (b) Population, $t = T$

Notes: Panel A reports (the change in) net migration of the young at $t = t^*$ as a share of regional young population, in percentage points. Panel B reports (the change in) population at $t = T$, in %.

Figure 9: Decomposition of EU capital stock changes



Notes: Decomposition of the percentage change in the aggregate EU capital stock over the transition path, broken down by investor origin (EU, US, and all other investors). Footnote 29 explains how the contribution of each group is computed. Each period corresponds to 20 years.

permanent enlargement of US wealth. Crucially, part of this wealth is not absorbed by the US. The reason is that to produce final investment goods one needs to import, both directly and indirectly (through input-output linkages). Hence, US tariffs raise the relative price of US investment, which ultimately lowers the returns for investors. This leads to an increase in the foreign demand for EU capital. As a result, real investment in the EU rises, which translates into more capital in subsequent periods.[30]

The effect on the capital stock is, however, very unequal across regions. Figure 10a shows that, while the stock of capital in the long run increases in 95% of EU regions, it decreases in severely affected regions (as measured by the effect on initial GDP). The reason is that in strongly affected regions the decline in VA and hence capital returns is large enough to reduce investment. In general, the initial effect on real rental rates of capital –which is equal to the initial change in real VA– determines the capital inflows that each region receives.

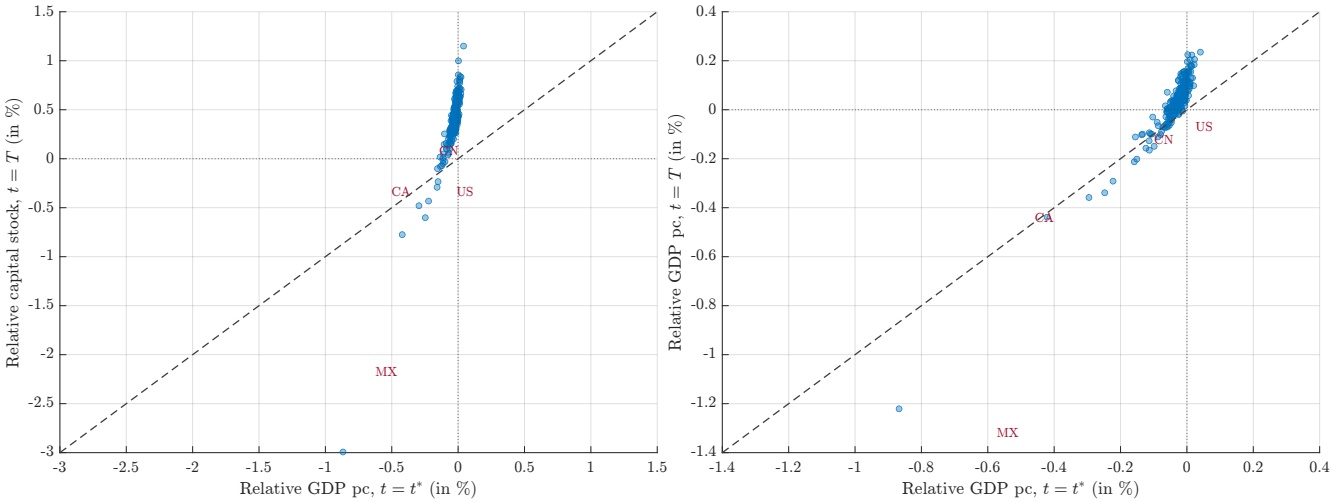
Figure 10b compares the initial and long-run effects on real GDP per capita. In more than nine-tenths of European regions (92%) the effect improves in the long run, and 75% of EU regions experience an increase in real GDP per capita relative to the baseline. As a result, the population-weighted average effect for the EU is marginally positive in the long run (0.02%). At the same time, the effects are more dispersed in the long run. Capital dynamics are fundamental for these results. For most regions, the greater abundance of capital raises real GDP per capita relative to its initial post-shock level. But the mechanism operates in the opposite direction for the regions that lose more in terms of GDP because they also lose capital, which further worsens the impact in the long run. This adjustment highlights the importance of international capital-market integration for the dynamic consequences of a trade war. In the absence of additional foreign investment (from the US), the European capital stock would decline rather than increase, further depressing real GDP per capita.

Since the recovery in GDP is largely driven by foreign (US) investment, a substantial share of the additional output accrues to foreign asset holders rather than domestic residents. Despite this, EU workers benefit from a gradual recovery in wages, on average.

The improvement in terms of GDP and wages does not, however, prevent welfare losses. On the contrary, average EU welfare declines gradually over time and is approximately 0.15% below the baseline in the long run (see Figure 11a). The main reason behind these adverse dynamics is that EU households decumulate real wealth over time, as shown in Figure 11b. In the first period, initial real wealth per capita $\left(\frac{R_{ot}S_{ot-1}}{P_{ot}L_{ot}}\right)$ slightly increases thanks to the real exchange rate depreciation with respect to the US $\left(\hat{P}_{ot}/\hat{P}_{USt}\right)$, a valuation effect that particularly benefits the old. For all other periods, returns on assets are lower than under the baseline. Lower returns reduce middle-aged agents' wealth both directly, by lowering the return on their own wealth, and indirectly, by reducing the value of inherited bequests. Middle-aged wealth consequently declines. In the following period, old-age wealth is further depressed by the combination of lower accumulated wealth and lower realized returns. Through its effect on bequests, this decline feeds back into the wealth of the next generation of middle-aged households. The resulting

[30]There are two main reasons why investment from the US rises over time. First, there is an initial valuation effect that makes portfolios slightly tilt toward the US temporarily. Second, US wealth rises over time. These two effects are discussed in Appendix B. On the other hand, investment by European investors (and the rest of the world) slightly declines over the first few periods because wealth decreases.

Figure 10: GDP and capital accumulation



(a) Capital and GDP

(b) GDP in the long run

Notes: t^* refers to the initial period, T refers to the last period of the simulation. Each point represents a NUTS-2 region.

process of real wealth decumulation lowers real gross national income per capita and gradually reduces consumption among middle-aged and, especially, older households.[31]

Overall, Figure 11a shows that the decumulation of real wealth dominates the welfare dynamics, despite the long-run recovery in real GDP per capita. The welfare deterioration across future generations is especially strong for those regions that lose capital over time, as real wages are further depressed (see Figure D.14).

3.1.7 The US

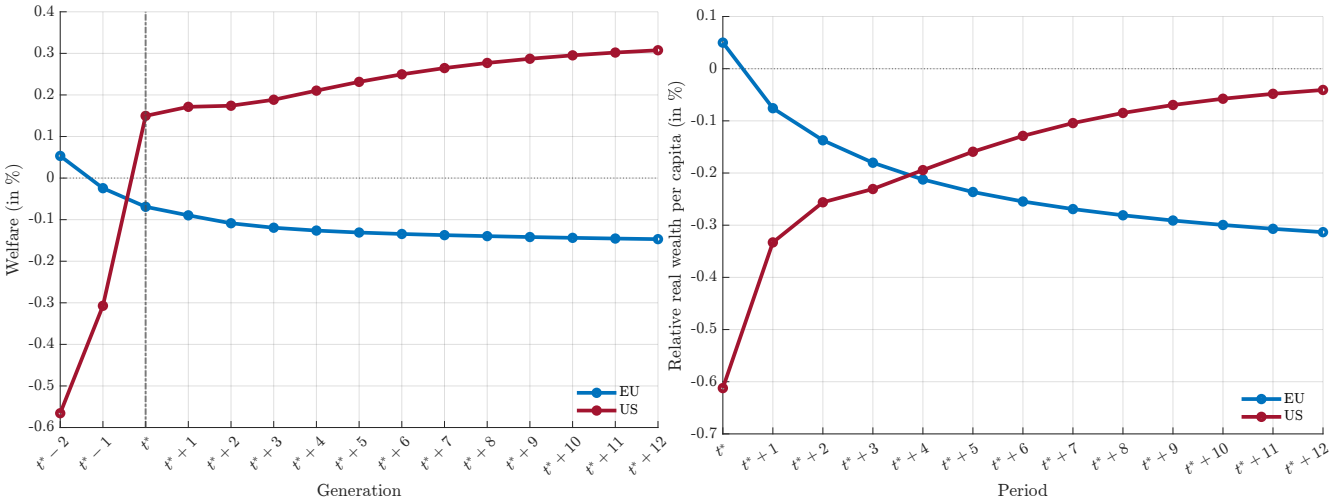
I now briefly turn to the effects of US tariffs on the US economy. Appendix B discusses them in detail.

Trade, production and GDP

US tariffs reduce US imports of goods by 3.15 pp of GDP, with almost no trade diversion. About one quarter of the drop in imports is offset by goods produced in the US by foreign firms, so the attraction of multinational production is quantitatively relevant but far from fully replacing lost imports. US exports also fall (both for goods and services), as the terms of trade improvement makes US products more expensive for the rest of the world. Overall, real VA per capita falls by 0.43%. Domestic production and production by foreign multinationals generate more VA, but the drop in VA generated by US exporters more than offsets these increases. Real GDP per capita nonetheless rises slightly (0.05%) thanks to the enlargement of tariff revenues. Since these revenues are effectively rebated to workers through a lower labor income tax, net real wages rise by 0.65%.

[31] Young households may in principle wish to reduce current consumption and increase saving in order to smooth consumption over the life cycle. At the same time, lower returns increase the relative price of future consumption. Under logarithmic preferences, these two forces offset each other in the allocation of expenditure across periods.

Figure 11: Welfare and wealth



(a) Welfare (b) Real wealth

Notes: For the EU, each point reports the constant population-weighted average change across regions. The x-axis in panel A shows the period in which a generation was born. In panel B, relative real wealth per capita at the beginning of the corresponding period is given by $\frac{\hat{R}_{ot}\hat{S}_{ot-1}}{\hat{P}_{ot}\hat{L}_{ot}}$. Each period corresponds to 20 years.

As tariffs apply to goods but not to services, the US becomes a net exporter of goods and a net importer of services, and the employment share of the goods sector rises by 0.89 pp, showing that tariffs can, to a certain extent, accomplish the goal of increasing manufacturing employment.

Investment

Producing investment goods requires imported inputs, both directly and through input-output linkages, so tariffs make US investment goods more expensive. Even if a transitory valuation effect tilts portfolios slightly toward the US, real investment falls and the US capital stock in the next period is 0.49% lower than in the baseline. As the economy loses capital, real GDP per capita falls below the baseline in the long run (-0.07%), which is in line with the capital adjustment in Baqaee and Malmberg (2025).

Trade imbalances

One of the main objectives of the tariffs is to reduce the US trade deficit. The simulation shows that the deficit falls by 0.20 pp of GDP, but only temporarily (Figure B.2). The main driver is a valuation effect, as emphasized by Itskhoki and Mukhin (2025). In the first period, the price of US final goods rises, so US assets provide unexpectedly high returns to foreign investors, while US savers collect lower returns from foreign assets. The resulting decrease in the US primary income balance improves its trade balance. In addition, tariffs induce US households to invest more abroad, improving the US net foreign asset position and further pushing the US toward a trade surplus. In the long run, however, the higher net investment income generated by these foreign assets dominates, and the trade balance ends up 0.09 pp of GDP below the baseline.

Welfare

The current young generation in the US gains from the tariffs (0.15%), whereas older generations lose (-0.57% for the old and -0.31% for the middle-aged) due to the negative valuation effect on their foreign asset holdings. Welfare gains grow across subsequent generations as households rebuild their real wealth, ultimately reaching 0.31% in the long run (Figure 11a). This happens despite lower long-run real GDP per capita because higher net real wages more than offset lower real returns on wealth.

3.1.8 The role of the main model features

I now describe how key features of the model affect the results. To do this, I remove one feature at a time (see Appendix A.2 for details on how these exercises are implemented).

International investment is crucial for long-run results. When assets can only be held domestically, the long-run stock of EU capital per capita decreases by 0.18% instead of expanding by 0.18%, as the drop in EU real income reduces savings. Hence, real GDP per capita does not recover and further falls to -0.12% in the long run (compared to $+0.02\%$).

Shutting down multinational production reduces to some extent the drop in EU exports of goods to the US (-0.33 pp of EU GDP against -0.42), because with multinational production some firms that could keep exporting to the US despite higher tariffs choose instead to serve it from US plants.

Lastly, migration barely affects the aggregate results, but it matters for their distribution across regions. When migration does not respond to the tariffs, the long-run dispersion of the effects across EU regions increases significantly: the standard deviation of the change in real GDP per capita rises from 0.12 to 0.17 pp, and that of welfare from 0.11 to 0.17 pp. The reason is that workers leave the most affected regions, which makes labor scarcer and improves real wages, so that migration smooths the effects of the shock across space.[32]

Appendix A.3 checks the robustness of the results to changing trade and migration elasticities ($\theta_2, \theta_1, \upsilon$), and to adding taxes on investment income.

3.2 Counterfactual 2: Trade war with EU retaliation

How would the results change if the EU were to retaliate against US tariffs? This counterfactual considers a scenario in which all tariffs that the EU sets on imports of goods from the US increase one-for-one with the US tariff on EU goods (i.e., an increase of 10 pp). Later I consider a scenario in which the EU chooses to retaliate optimally.

3.2.1 Aggregate production and trade imbalances

Relative to the No Retaliation scenario, EU demand shifts away from US goods (imports of US goods fall by 0.59 pp, compared to 0.14 pp without retaliation). As a result, terms of trade improve for the EU,

[32] Although Figure 7 seems to suggest that migration is not too important for welfare effects, note that the general equilibrium effects of migration on real wages are not included in the "migration value" component.

so it regains some of the lost weight as a share of World GDP. Still, US tariffs continue to be sufficient to expand the US economy in nominal terms. This is reported in the first row in both panels of Table 1.

Domestic EU producers are able to increase their share of world production compared to the baseline (see second row of Table C.9) thanks to the increased protection from US exporters. In addition, the higher trade barriers to imports from the US push US firms in the goods sector to start operating in the EU through subsidiaries, marginally expanding multinational production in the EU. As a result, retaliation allows the EU to virtually neutralize the hit in its production value.

The flip side is that US production does not increase as much as in the No Retaliation scenario. The smaller terms of trade effect limits the increase in US domestic production, and EU trade barriers further reduce US exports (see Panel B of Table C.9).

As mentioned, the US economy expands, but less so than under no retaliation. A side effect of this is that Net Investment Income improves for the US, as the difference between paid dividends to and received from the rest of the world decreases. Thus, net exports increase by less than under no retaliation (0.17 pp vs 0.20 pp of GDP), and the shift toward the goods sector is also softer. In the EU, the same mechanism operates in the opposite direction, leading to smaller trade deficits, as returns on investments in the US are more modest than under no retaliation (and vice versa for returns on foreign investments in the EU).

3.2.2 Regional GDP

At the EU level, real GDP per capita is roughly the same as without retaliation (see second row of Table 1). This might seem surprising at first glance, because the 10% US tariff raises US real GDP per capita but the 10% EU tariff does not. The fundamental difference is that the US tariff applies to *all* trading partners, while the retaliatory EU tariff only applies to the US. This makes the policy less powerful. In particular, after the introduction of the retaliatory tariff some EU demand for US goods shifts toward other non-EU origins, generating trade diversion. This has two immediate implications. First, it does not generate a positive terms of trade effect for the EU, in contrast to the demand that shifts toward EU goods. Second, it replaces US imports with more expensive imports.[33] These forces push real GDP per capita down, although the positive terms of trade effect offsets them.

Unsurprisingly, the effects on real GDP per capita are highly heterogeneous across locations. In general, places where real GDP per capita falls more prominently under the No Retaliation scenario are also the places where it drops by more under the Retaliation scenario (the spatial correlation is 0.96, see Figure D.15a). Figure D.15b reports how regional real GDP per capita in Europe responds compared to the No Retaliation scenario. Differences are limited in size, and the set of regions for which the effect improves under retaliation is essentially as numerous as the group for which it worsens. The regions that gain the most in terms of real GDP per capita by EU retaliation (relative to the No Retaliation scenario) tend to be large importers of US goods. Since there is a positive correlation across regions between imports from and exports to the US, retaliation tends to smooth real GDP per capita effects

[33] This second effect simultaneously reduces consumers' welfare (in the model, by raising the price of final goods) and makes producers effectively less productive (by raising the price of intermediate inputs, which propagate through input-output linkages).

across EU regions. Some of the largest beneficiaries are located in Southern Ireland, the Netherlands, Hungary, Germany, and Italy.

In the US, under the No Retaliation scenario, terms of trade effects more than offset the negative distortionary effects, causing real GDP per capita at t^* to rise by 0.05%. This is no longer true when the EU retaliates, leaving real GDP per capita virtually unchanged.

3.2.3 GDP dynamics

In contrast to the No Retaliation scenario, the long-run accumulation of EU capital is significantly muted, increasing by only 0.10% per capita (compared to 0.18% without retaliation). This is driven by the same mechanism that explains the decline in US capital following its own tariff hike: EU retaliation raises the relative price of final investment goods in Europe, thereby discouraging investment. Consequently, the average effect on EU real GDP per capita in the long run is worse than under no retaliation (see Table 1). In fact, retaliating slightly worsens real GDP per capita in the long run (compared to the No Retaliation scenario) for 92% of the EU regions.

Just as in the No Retaliation scenario, real investment in the US falls on impact, leading to lower subsequent capital (-0.51%), and thus worsening the effects on real GDP per capita over time. In the long run, the drop in real GDP per capita reaches 0.15%.

3.2.4 Welfare

Retaliating limits welfare losses for the current EU generation to some extent (-0.05% vs -0.07%), mostly thanks to the larger net real wage.[34] Figure D.16a shows that most (but not all, 87%) regions are better off under this scenario. But even then, 87% of EU regions still lose from the trade war. The welfare gains from retaliation are much more evenly distributed, especially within country, than the real GDP per capita gains. This is driven by an implicit transfer. The new tariffs are collected at the country level and distributed equally among workers through a uniform reduction in the labor income tax rate. Hence, regions that import relatively more goods from the US effectively transfer some of the additional tariff revenues to other regions. The flip side of the coin is that regions that import very little from the US can achieve welfare gains by benefiting from the tariff revenues generated elsewhere without distorting importing decisions.[35] Through these mechanisms, some of the largest potential beneficiaries of tariff retaliation are located in Ireland, the Netherlands, eastern Hungary, and southern Spain (see Figure D.16b).

Over time, real wealth in the EU adjusts downward, amplifying welfare losses just as in the No Retaliation case. The resulting long-run aggregate welfare decline is less severe than under the No Retaliation scenario, albeit not by a wide margin (-0.13% versus -0.15%). Furthermore, this aggregate improvement is not universal, as 23% of EU regions are actually marginally worse off in the long run when the EU retaliates.

[34] This is true despite real GDP per capita on impact not being higher than without retaliation because tariff revenues are effectively rebated to workers through a lower labor income tax.

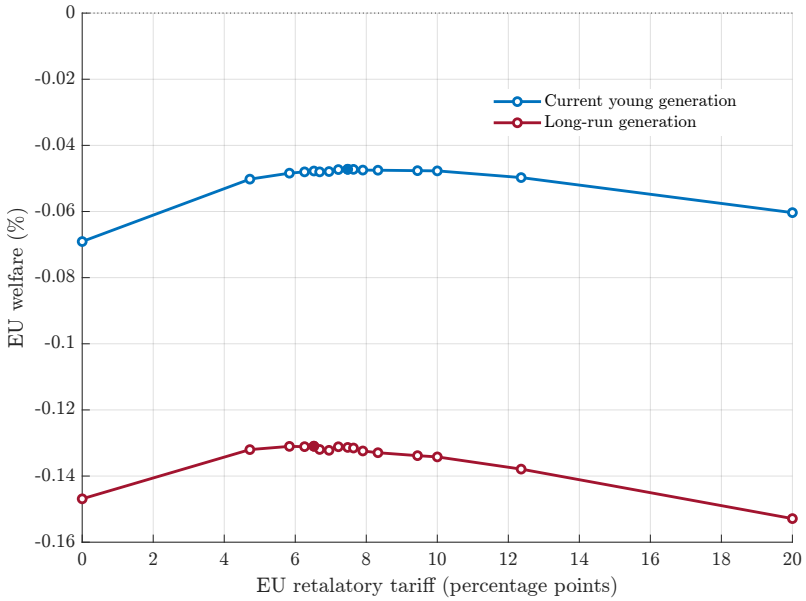
[35] They can further benefit from an increased demand precisely from those tariff revenue-generating regions.

Table 1: Main aggregate outcomes across scenarios

	No retaliation		Retaliation		Escalation		FTA China	
	t^*	Long run	t^*	Long run	t^*	Long run	t^*	Long run
Panel A. EU								
Share World GDP	-0.06	-0.16	-0.02	-0.12	-0.05	-0.20	-0.03	-0.10
Real GDP per capita	-0.04	0.02	-0.03	-0.00	-0.06	-0.06	-0.01	0.08
Welfare	-0.07	-0.15	-0.05	-0.13	-0.07	-0.20	-0.07	-0.10
Goods employment share	-0.15	-0.25	-0.08	-0.19	-0.15	-0.33	-0.07	-0.15
Population	0.00	0.17	0.01	0.17	0.00	0.15	0.00	0.19
Trade balance	-0.06	0.08	-0.03	0.07	-0.04	0.07	-0.08	0.08
BOP decomposition								
ΔNFA	*-0.01*	*-0.03*	*-0.00*	*-0.02*	*0.01*	*-0.03*	*-0.04*	*-0.03*
NI	*0.05*	*-0.11*	*0.03*	*-0.09*	*0.05*	*-0.10*	*0.03*	*-0.11*
Sectoral decomposition								
Goods	*-0.31*	*-0.47*	*-0.15*	*-0.36*	*-0.29*	*-0.63*	*-0.17*	*-0.29*
Services	*0.25*	*0.55*	*0.12*	*0.43*	*0.25*	*0.70*	*0.10*	*0.37*
Panel B. US								
Share World GDP	0.29	0.62	0.23	0.54	0.26	0.60	0.29	0.62
Real GDP per capita	0.05	-0.07	0.01	-0.15	-0.01	-0.21	0.05	-0.08
Welfare	0.15	0.31	0.08	0.21	0.05	0.17	0.16	0.32
Goods employment share	0.89	0.90	0.67	0.78	0.78	0.94	0.87	0.88
Population	0.05	0.32	0.04	0.28	0.04	0.19	0.05	0.33
Trade balance	0.20	-0.09	0.17	-0.08	0.19	-0.09	0.21	-0.10
BOP decomposition								
ΔNFA	*-0.03*	*0.05*	*-0.00*	*0.05*	*-0.01*	*0.05*	*-0.01*	*0.05*
NI	*-0.23*	*0.14*	*-0.17*	*0.13*	*-0.20*	*0.14*	*-0.22*	*0.15*
Sectoral decomposition								
Goods	*1.75*	*1.79*	*1.42*	*1.61*	*1.60*	*1.87*	*1.73*	*1.77*
Services	*-1.55*	*-1.88*	*-1.26*	*-1.70*	*-1.42*	*-1.95*	*-1.52*	*-1.87*

Notes: This table reports the main aggregate outcomes for the EU (Panel A) and the US (Panel B) across all counterfactual scenarios, relative to the baseline. For each counterfactual, results are shown both for the initial period $t = t^*$ and the long run (corresponding to the last period in the simulation, $t = T$). Row 1 reports the change in the share of world GDP accounted by the corresponding economy, in percentage points. Rows 2 and 3 report the relative change in real GDP per capita and welfare (measured as a lifetime consumption equivalent), in %. In the case of the EU, an average across regions, weighted by baseline population, is reported. Row 4 reports the change in the employment share accounted by the goods sector, in percentage points. Row 5 reports the change in population, in %. Row 6 reports the change in aggregate trade balance, as a share of own GDP and in percentage points. Rows 7 and 8 decompose this change using Balance of Payments accounting: $TB = \Delta NFA - NI$, where ΔNFA refers to the negative of the financial account (IMF definition) and NI is net primary income (which contains net investment income) plus the capital account (which includes migrants' transfers under capital transfers). Rows 9 and 10 decompose the change in aggregate trade balance by sector.

Figure 12: EU welfare under alternative retaliatory tariffs



Notes: The x-axis reports the additional tariff imposed by the EU on imports of US goods, in percentage points. The y-axis reports the population-weighted average welfare change across EU regions relative to the baseline, in percent. Blue markers report welfare for the young generation at $t = t^*$, while red markers report welfare for the generation born at $t = T$. The filled markers identify the welfare-maximizing tariffs.

In the US, welfare gains are still positive but significantly compressed relative to the No Retaliation scenario, both in the initial period (0.08% vs 0.15%) and in the long run (0.21% vs 0.31%).

3.3 Optimal retaliation

The symmetric-retaliation counterfactual considered above provides a natural benchmark. A policy under which the EU matches the US tariff increase one-for-one is transparent, reciprocal, and relatively easy to justify. Nevertheless, such a response need not be optimal from the perspective of the EU. I therefore consider a more favorable retaliation scenario in which the EU chooses the common tariff increase on imports of US goods that maximizes European welfare. Because the effects could be different across generations, I consider two alternative objectives. The first maximizes the welfare of the current young generation (generation $t = t^*$), while the second maximizes the welfare in the long run (i.e., for generation $t = T$).

Figure 12 shows that the two welfare objectives have very similar profiles, even though long-run welfare losses are larger at every tariff level. The tariff that maximizes the welfare of the current young generation is approximately 7.5%, while the long-run objective is maximized at approximately 6.5%. Thus, despite the different welfare levels, the two objectives imply very similar optimal responses.

Welfare is also relatively insensitive to the exact retaliatory tariff around the optimum. In particular, a broad range of tariff increases between approximately 5% and 10% produces very similar welfare outcomes. Hence, the simple symmetric-retaliation rule performs almost as well as the optimal policy.

Retaliation nevertheless provides only limited protection against the trade war. Relative to no retaliation,

the optimal response reduces the welfare loss by approximately 0.022 percentage points for the current young generation and 0.015 percentage points in the long run. Even under the most favorable retaliatory tariff welfare remains below the baseline for both generations. Retaliation can therefore mitigate the costs of the US tariff increase, but it cannot eliminate them.

3.4 Counterfactual 3: Trade war with EU retaliation and escalation

In response to the 2025 US tariffs, EU policymakers considered retaliatory measures but ultimately chose not to implement them, prioritizing negotiations. One of the main reasons was the desire to avoid escalating the trade conflict (Reuters, 2025b). This concern appears to be well founded, as the US administration had already shown a predisposition toward escalation, immediately announcing counter-retaliatory tariffs following China's retaliation on April 4. Moreover, the US administration explicitly threatened further tariff increases if trading partners retaliated. For example, President Trump warned that the United States could impose tariffs as high as 200% on European alcoholic beverages in response to EU countermeasures (BBC News, 2025).

To evaluate the implications of a trade war escalation between the US and the EU, I examine a setting in which EU retaliation triggers additional US (tit-for-tat) tariff increases. In particular, in the second counterfactual (Retaliation scenario), all tariffs imposed by the EU on imports of goods from the US increase by 10 percentage points. In this counterfactual (Escalation scenario), US tariffs on imports of goods from the EU increase by an additional 10 percentage points.

3.4.1 Aggregate production

Escalation improves terms of trade for the US at all times, compared to the Retaliation scenario, although not as much as under the No Retaliation scenario. The mechanism is the same as in Section 3.1, as counter-retaliatory tariffs shift US demand away from EU goods and exports of EU goods to the US fall by 0.74 pp (compared to 0.44 pp under retaliation). For this same reason, the effect goes in the opposite direction for the EU. Interestingly, the combined size of the EU and US economies is smaller than under no retaliation because the rest of the world captures some demand from these two economies (see Table 1).

Naturally, exporters of goods in the EU suffer an additional hit in terms of share of world production (see Table C.9). Nevertheless, the overall value of EU production remains slightly higher than in the No Retaliation benchmark. Just as in Section 3.1, the additional US tariffs further reduce US exports and simultaneously attract foreign multinationals to produce in the US, but the effects are almost negligible.

3.4.2 GDP

In the US, real GDP per capita (-0.01%) is lower than under no retaliation. Compared to that benchmark, the economy is further distorted to an extent that fully erases any GDP gains coming from terms of trade effects. What is more, US real GDP per capita turns out to be even slightly lower than under EU

retaliation. When the economy is already distorted, further raising tariffs is not guaranteed to generate GDP gains.

Similarly, real GDP per capita in the EU (-0.06%) is also lower than under the previous scenarios due to the additional negative terms of trade effect. As one might expect, regions that lose more under no retaliation tend to face the worst effects under escalation (the spatial correlation is 0.97, see Figure D.15c). The effects are worsened for 92% of the EU regions (compared to the No Retaliation scenario).[36] Contrary to retaliation, which tends to benefit disproportionately the severely affected regions, the escalation scenario exacerbates the heterogeneous effects. Ireland, Alentejo (Portugal), and Western Transdanubia (Hungary) are clear examples of this pattern (see Figure D.15d). The few regions that are better off than under the No Retaliation scenario –such as North Brabant and South Holland in the Netherlands, or Hainaut in Belgium– tend to be relatively unaffected by US tariffs while benefiting from EU tariffs.

3.4.3 GDP dynamics

The EU fails to attract as much investment as in the No Retaliation scenario. Because of this, the effect on real GDP per capita is roughly constant over time (-0.06% in the long run). Combined with the fact that without retaliation the effect on real GDP per capita improves over time, this implies that the costs of an escalation (relative to no retaliation) expand over time.

On the other hand, real investment –and hence the stock of capital– in the US falls even more than in the other scenarios (-0.59%). As the economy loses capital, US real GDP per capita losses compound and reach -0.21% in the long run.

3.4.4 Welfare

For the current young generation in the EU, there is not much of a difference between the No Retaliation and Escalation scenarios, on average. However, the average masks significant heterogeneity across regions (see Figure D.16c). The most affected regions under no retaliation naturally suffer more from the additional US counter-retaliation tariff. On top of that, regions that import goods from the US –which broadly coincide with those that export to the US– collect additional revenues that are then redistributed to other regions. As a result, welfare effects are more unequal than under the previous scenarios. Hence, for some regions the welfare cost of a potential escalation, relative to not retaliating, is considerable (see Figure D.16d). This is particularly true for some regions in Ireland, northern Italy, Hungary, Slovakia, Germany, and Portugal. On the other hand, a handful of regions achieve welfare gains by benefiting from the implicit transfers, just as in Section 3.2.

As in the other counterfactuals, welfare losses become larger over time as real wealth per capita diminishes. In the long run, EU households lose more than under any other scenario, although losses remain moderate (-0.2%).

The results for the US are broadly similar to those in the Retaliation scenario. Every generation born after the shock enjoys welfare gains, and these become larger in the long run (0.17%). Crucially, welfare

[36] Non-EU economies such as the UK, Switzerland, and Norway benefit from trade diversion effects.

effects are worse than under retaliation for all generations. This is in line with the result for real GDP per capita, as adding tariffs on top of already high tariffs generates large efficiency losses. This might motivate the US administration to avoid escalating the trade war, if the EU were to retaliate.

Taken together, the welfare effects across the different scenarios (Table 1) suggest that both the welfare cost and the potential gains of retaliating are modest. An international agreement that reverts the tariff setting to 2023 is welfare improving for all generations and virtually all EU regions.

3.5 Counterfactual 4: EU–China FTA

Despite the emergence of several trade disputes between the EU and China in recent years, including numerous EU anti-dumping measures, the prospect of a partial decoupling of the US from the world trading system has prompted US trading partners to consider alternative trade arrangements. One prominent candidate is a Free Trade Agreement (FTA) between the EU and China. This is an interesting counterfactual for several reasons.

First, China is the EU's second-largest goods trading partner (after the US), while the EU is China's largest trading partner. Second, following the introduction of additional US tariffs in 2025, China publicly expressed interest in negotiating an FTA with the EU (Reuters, 2025a). Third, some may dismiss this scenario as politically unrealistic, both because the probability of reaching an EU–China trade agreement might be low, and because (conditional on reaching an agreement) the tariff reduction might be incomplete. But the exercise is informative precisely because it provides an upper bound on the potential gains from deeper EU–China trade integration.

I therefore consider a scenario in which the EU and China respond to the US uniform 10% tariff by reciprocally eliminating tariffs through a bilateral FTA.

3.5.1 Regional GDP

The EU–China FTA offsets the loss of market access suffered by EU exporters in the US. Exports of goods to China rise by 0.61 pp of EU GDP, which largely replace exports to the US (-0.43 pp) and trade within the EU (-0.22 pp). As a result, EU exporters' share of world production remains roughly unaffected (see Table C.9), and the negative initial effect on real GDP per capita that emerges without retaliation is virtually neutralized, on average (see Table 1).

In contrast with the other counterfactuals, the spatial correlation with real GDP per capita effects in the No Retaliation scenario is weak (0.59, see Figure D.15e). Although in general the most affected locations under no retaliation continue to suffer more (this is particularly true for the three Irish regions) there are notable exceptions to this pattern. Both Stuttgart (Germany) and Western Transdanubia (Hungary) suffer large losses without retaliation (-0.22 and -0.25%, respectively) but overcome them and achieve real GDP per capita gains by additionally signing an FTA with China (0.12 and 0.06% respectively). In addition, Slovakia is the biggest winner from the FTA, particularly the Bratislava Region and Western Slovakia, where the effect improves by 1 and 0.8 pp.[37] The effects are improved for two-thirds of the EU

[37]The removal of bilateral tariffs disproportionately benefits Slovakian firms, reflecting the fact that China is Slovakia's

regions (compared to the corresponding effects under the No Retaliation scenario). On top of that, while the FTA with China results in a few large winners, it does not involve large, geographically concentrated losers (losses never exceed 0.06 pp, see Figure D.15f).

Thanks to the improvement in real value added, the EU attracts slightly more investment from abroad than in the No Retaliation scenario. Over time, this translates into an improvement on real GDP per capita, which ends up being significantly higher than in the baseline (0.08% in the long run). As a consequence, the share of regions for which the FTA is beneficial in terms of real GDP per capita rises from two-thirds to 90%.

3.5.2 Welfare

For the current EU generation, there is not much of a difference between concluding an FTA with China or not, on average, and in fact the effects are worse for almost three-quarters of the EU regions (73%, see Figure D.16e). Several factors contribute to this result. First, while the gains from having access to cheaper goods benefit all agents (including foreign investors, through higher rental rates of capital), only the young bear the cost of lower tariff revenues through higher taxes. In fact, net real wages fall on average despite a rise in real wages. Second, the current generation does not reap the benefits of a larger stock of capital in the long run. Just as with real GDP per capita, the most prominent exceptions to this negative result are Slovakia, Stuttgart, and Western Transdanubia (see Figure D.16f).

The FTA with China cannot avoid welfare losses from expanding over time, but it can limit them to some extent (-0.10 compared to -0.15% in the No Retaliation scenario). In the long run, 62% of the regions are better off with the FTA, although due to US tariffs only 5% attain welfare gains.[38]

These results are quantitatively modest –and perhaps disappointing–, especially considering they represent an upper bound on what an EU–China trade agreement could achieve. Three empirical facts rationalize these limited gains. First, China is a smaller trading partner for the EU than the US, particularly regarding exports.[39] Second, tariffs between the EU and China are already quite low, so removing them completely does not constitute a drastic reduction in trade frictions.[40] Third, bilateral trade in goods is highly unbalanced. A unilateral removal of import tariffs induces a welfare loss when the initial tariffs are weakly smaller than the optimal tariff. Consequently, any aggregate gains from the free trade agreement must be driven by the removal of Chinese tariffs on EU exports. However, these gains are heavily constrained by the fact that EU imports from China are two to three times larger than the reciprocal export flow.

largest trading partner outside of the European Union.

[38] Aside from Slovakia, only Southwestern Bulgaria, Stuttgart, Upper Bavaria, and Warsaw gain more than 0.05%.

[39] EU exports to the US are more than twice as large as exports to China.

[40] In the benchmark, the trade-weighted average tariffs are 5.7% (China on EU goods) and 3.2% (EU on Chinese goods).

4 Conclusion

There is a risk that the rise in US protectionism observed in recent years becomes a permanent feature of the global economy. In this paper, I evaluate the macroeconomic and welfare consequences of such a scenario through the lens of a dynamic spatial general equilibrium model. I find that the long-run effects on GDP depend crucially on capital flows, while welfare depends mostly on lifetime income. Because tariffs raise the relative price of US investment, they redirect capital toward Europe, which allows the EU to fully recover its aggregate real GDP in the long run while US real GDP shrinks. However, the US achieves persistent welfare gains, whereas Europe suffers a long-run welfare decline that is heavily concentrated in a subset of highly exposed regions. Crucially, I show that this shock leaves European policymakers in a difficult position: because neither retaliating nor establishing a free trade agreement with China is sufficient to reverse the aggregate losses, the findings provide a strong rationale for prioritizing negotiated agreements with the US.

In the EU, welfare falls on average by 0.07% for the generation born on impact, and 0.15% in the long run, whereas in the US welfare increases by 0.15% and 0.31%, respectively. While these numbers are modest per se, they are substantial for trade policy. For context, Caliendo and Parro (2015) estimate that NAFTA delivered a US welfare increase of 0.08%, while Costinot and Rodríguez-Clare (2014) find that reaching the optimal tariff in a static Armington model yields US welfare gains of 0.3%. Hence, the US tariffs evaluated here generate welfare effects in line with what we expect from big changes in trade policy, not only on the economy changing the policy (the US) but also on other economies (Europe).

Although the framework captures a rich set of transmission channels, there are clear opportunities for future improvement. First, the model assumes frictionless labor reallocation across sectors. Because tariffs affect industries asymmetrically, introducing switching frictions would allow the model to capture the distributional consequences across occupational groups. Second, while the theoretical framework accommodates an arbitrary number of sectors, the quantitative implementation aggregates industries into broad goods and services sectors. Calibrating the model at a finer sectoral resolution is currently constrained both by data availability (the regional input-output data is available at a 10-sector NACE disaggregation) and by the computational burden of solving transition paths across hundreds of regions.

An important limitation of the model is the absence of uncertainty, so it cannot be used to evaluate the implications of a world in which US tariffs are permanently more volatile. As highlighted by the literature, trade policy uncertainty can have important implications for exports and investment by increasing the option value of waiting (Caldara et al., 2020; Handley and Limão, 2022). Incorporating stochastic tariff volatility into dynamic spatial models is a promising avenue for future research.

Finally, the confidence in these long-run predictions depends heavily on the realization of standard terms of trade effects. In the model, US welfare gains, the surge in EU service exports, and the initial valuation effects on foreign assets are all fundamentally driven by a US real exchange rate appreciation. However, in the aftermath of the 2025 tariffs, this appreciation simply did not occur. There are several potential explanations for this disconnect. It is possible that other macroeconomic shocks, such as the AI-driven investment boom, dominated the exchange rate dynamics. Indeed, Ferrante et al. (2026) argue that absent other shocks, the US real exchange rate would have appreciated. Alternatively, it could also

reflect importers' expectations that the US Supreme Court would ultimately rule the tariffs illegal, so the US government would be required to pay back the collected tariff revenues. In that scenario, tariffs should only have a marginal effect. Reconciling this empirical disconnect between trade theory and exchange rate movements remains an important task for future research.

References

Alessandria, G., J. Ding, S. Y. Khan, and C. B. Mix (2025). *The Tariff Tax Cut: Tariffs as Revenue*. Working Paper 33784. National Bureau of Economic Research.

Arkolakis, C., N. Ramondo, A. Rodríguez-Clare, and S. Yeaple (2018). "Innovation and production in the global economy". In: *American economic review* 108(8), pp. 2128–2173.

Auclert, A., M. Rognlie, and L. Straub (2025). *The macroeconomics of tariff shocks*. Tech. rep. National Bureau of Economic Research Cambridge, MA.

Auray, S., M. B. Devereux, and A. Eyquem (2025). *Tariffs and Retaliation: A Brief Macroeconomic Analysis*. Working Paper 33739. National Bureau of Economic Research.

Baqaee, D. and H. Malmberg (2025). *Long-run effects of trade wars*. Tech. rep. National Bureau of Economic Research.

BBC News (2025). *Trump Threatens 200% Tariff on Alcohol from EU*. URL: https://www.bbc.com/news/articles/c984pnedd6do.

Beck, R., A. Coppola, A. J. Lewis, M. Maggiori, M. Schmitz, and J. Schreger (2024). *The geography of capital allocation in the Euro Area*. Tech. rep. National Bureau of Economic Research.

Bianchi, J. and L. Coulibaly (2025). *The Optimal Monetary Policy Response to Tariffs*. Working Paper 33560. National Bureau of Economic Research.

Boehm, C. E., A. A. Levchenko, and N. Pandalai-Nayar (2023). "The Long and Short (Run) of Trade Elasticities". In: *American Economic Review* 113(4), pp. 861–905.

Caldara, D., M. Iacoviello, P. Molligo, A. Prestipino, and A. Raffo (2020). "The economic effects of trade policy uncertainty". In: *Journal of monetary economics* 109, pp. 38–59.

Caliendo, L., M. Dvorkin, and F. Parro (2019). "Trade and labor market dynamics: General equilibrium analysis of the china trade shock". In: *Econometrica* 87(3), pp. 741–835.

Caliendo, L., S. Kortum, and F. Parro (2025). *Tariffs and trade deficits*. Tech. rep. National Bureau of Economic Research.

Caliendo, L., L. D. Opromolla, F. Parro, and A. Sforza (2021). "Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement". In: *Journal of Political Economy* 129(12), pp. 3491–3545.

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

Caliendo, L. and F. Parro (2022). "Trade policy". In: *Handbook of international economics* 5, pp. 219–295.

Celebi, K. and W. Roeger (2025). *US Tariffs in a Model with Trade and FDI*. Discussion Paper 2111. DIW Berlin.

Coppola, A., M. Maggiori, B. Neiman, and J. Schreger (2021). "Redrawing the map of global capital flows: The role of cross-border financing and tax havens". In: *The Quarterly Journal of Economics* 136(3), pp. 1499–1556.

Corden, W. M. (1984). "The normative theory of international trade". In: *Handbook of international economics* 1, pp. 63–130.

Costinot, A. and A. Rodríguez-Clare (2014). "Trade theory with numbers: Quantifying the consequences of globalization". In: *Handbook of international economics*. Vol. 4. Elsevier, pp. 197–261.

Costinot, A. and I. Werning (2025). *How tariffs affect trade deficits*. Tech. rep. National Bureau of Economic Research.

Damgaard, J., T. Elkjaer, and N. Johannesen (2019). *What is real and what is not in the global FDI network?* International Monetary Fund.

Dávila, E., A. Rodríguez-Clare, A. Schaab, and S. Tan (2025). *A Dynamic Theory of Optimal Tariffs*. Working Paper 33898. National Bureau of Economic Research.

Eaton, J. and S. Kortum (2002). "Technology, geography, and trade". In: *Econometrica* 70(5), pp. 1741–1779.

Fajgelbaum, P., P. Goldberg, P. Kennedy, A. Khandelwal, and D. Taglioni (2024). "The US-China trade war and global reallocations". In: *American Economic Review: Insights* 6(2), pp. 295–312.

Fajgelbaum, P. and A. Khandelwal (2026). *Tariffs in 2025: Short-run impacts on the US economy*. Tech. rep. National Bureau of Economic Research.

Feenstra, R. C., R. Inklaar, and M. P. Timmer (2015). "The next generation of the Penn World Table". In: *American economic review* 105(10), pp. 3150–3182.

Ferrante, F., A. Prestipino, A. Raffo, and M. E. Waugh (2026). *Tariffs, Investment, and the Missing Trade Collapse*. Tech. rep. National Bureau of Economic Research.

French, K. R. and J. Poterba (1991). *Investor diversification and international equity markets*.

Gabriel, R. D., M. Klein, and A. S. Pessoa (2023). "The effects of government spending in the Eurozone". In: *Journal of the European Economic Association* 21(4), pp. 1397–1427.

Handley, K. and N. Limão (2022). "Trade policy uncertainty". In: *Annual Review of Economics* 14(1), pp. 363–395.

Head, K. and T. Mayer (2014). "Gravity equations: Workhorse, toolkit, and cookbook". In: *Handbook of international economics*. Vol. 4. Elsevier, pp. 131–195.

Head, K. and T. Mayer (2021). "The United States of Europe: a gravity model evaluation of the four freedoms". In: *Journal of Economic Perspectives* 35(2), pp. 23–48.

Helpman, E. and P. Krugman (1989). *Trade policy and market structure*. MIT press.

Ignatenko, A., A. Lashkaripour, L. Macedoni, and I. Simonovska (2025). "Making America great again? The economic impacts of Liberation Day tariffs". In: *Journal of International Economics*, p. 104138.

Irwin, D. A. (2020). "Trade policy in American economic history". In: *Annual Review of Economics* 12(1), pp. 23–44.

Itskhoki, O. and D. Mukhin (2025). *The optimal macro tariff*. Tech. rep. National Bureau of Economic Research.

Kalemli-Özcan, Ş., C. Soylu, and M. A. Yildirim (2025). *Global Networks, Monetary Policy and Trade*. Working Paper 33686. National Bureau of Economic Research.

Kehoe, T. J., K. J. Ruhl, and J. B. Steinberg (2018). "Global imbalances and structural change in the United States". In: *Journal of Political Economy* 126(2), pp. 761–796.

Kleinman, B., E. Liu, S. J. Redding, and M. Yogo (2023). *Neoclassical growth in an interdependent world*. Tech. rep. National Bureau of Economic Research.

Koijen, R. S. and M. Yogo (2020). *Exchange rates and asset prices in a global demand system*. Tech. rep. National Bureau of Economic Research.

Lind, N. and N. Ramondo (2023). "Trade with correlation". In: *American Economic Review* 113(2), pp. 317–353.

Magerman, G. and A. Palazzolo (2026). *The Impact of US 2025 Tariffs on the Belgian Economy*. Working Paper 2026-23. ECARES, Université libre de Bruxelles.

Martínez-García, E. and M. Sposi (2025). *A History of U.S. Tariffs: Quantifying Strategic Trade-Offs in Tariff Policy Design*. Working Paper 2529. Federal Reserve Bank of Dallas.

McFadden, D. (1977). "Modelling the choice of residential location". In.

McKibbin, W. J., M. Noland, and G. Shuetrim (2025). *The Global Economic Effects of Trump's 2025 Tariffs*. Working Paper 25-13. Peterson Institute for International Economics.

Mehrotra, N. and M. E. Waugh (2025). *Tariffs, Trade Wars, and the Natural Rate of Interest*. Working Paper 34206. National Bureau of Economic Research.

Obstfeld, M. and K. Rogoff (1995). "The intertemporal approach to the current account". In: *Handbook of international economics* 3, pp. 1731–1799.

Obstfeld, M. and K. Rogoff (2000). "The six major puzzles in international macroeconomics: is there a common cause?" In: *NBER macroeconomics annual* 15, pp. 339–390.

Ossa, R. and S. J. Redding (2026). *The economics of tariffs*. Tech. rep. National Bureau of Economic Research.

Portes, R. and H. Rey (2005). "The determinants of cross-border equity flows". In: *Journal of international Economics* 65(2), pp. 269–296.

Pujolas, P. S. and J. Rossbach (2026). *Fiscal Limits to Protectionism: The 2025 U.S. Tariff Laffer Curve*. Preprint 2602.18938. arXiv.

Ramondo, N. and A. Rodríguez-Clare (2013). "Trade, multinational production, and the gains from openness". In: *Journal of Political Economy* 121(2), pp. 273–322.

Ravikumar, B., A. M. Santacreu, and M. Sposi (2019). "Capital Accumulation and Dynamic Gains from Trade". In: *Journal of International Economics* 119, pp. 93–110.

Reuters (Nov. 6, 2025a). *China talks up EU trade deal, years after investment pact was frozen*. URL: https://www.reuters.com/world/china/china-says-it-is-willing-explore-trade-investment-agreements-with-eu-2025-11-06/.

Reuters (Feb. 12, 2025b). *EU Should Negotiate to Avert Trade War, Germany Says as EU Ministers Meet*. URL: https://www.reuters.com/markets/eu-should-negotiate-avert-trade-war-germany-says-bloc-ministers-meet-2025-02-12/.

Reyes-Heroles, R. (2016). "The role of trade costs in the surge of trade imbalances". Working paper.

Rodríguez-Clare, A., F. A. Teti, M. Ulate, J. P. Vásquez, and R. D. Zárate (2025). *The 2025 Trade War: Dynamic Impacts Across U.S. States and the Global Economy*. Tech. rep. 12179. Global Tariff Database: U.S. Trade War Extension (v_2025-10). CESifo Working Papers.

Rueda-Cantuche, J. M., J. Lopez Alvarez, and L. A. Galiano Bastarrica (2017). *FIGARO-REG 2017 10 sectors*. European Commission, Joint Research Centre (JRC). Dataset. URL: http://data.europa.eu/89h/dff29c8d-b85b-41fa-9cb7-7289c7324937.

Steinberg, J. B. (2025). *Tariffs, Manufacturing Employment, and Supply Chains*. Working Paper 34236. National Bureau of Economic Research.

Teti, F. A. (2024). *Missing Tariffs*. Tech. rep. 11590. Feodora Teti's Global Tariff Database (v_beta1-2024-12). CESifo Working Papers.

Train, K. E. (2009). *Discrete Choice Methods with Simulation*. 2nd ed. Cambridge University Press.

Werning, I., G. Lorenzoni, and V. Guerrieri (2025). *Tariffs as Cost-Push Shocks: Implications for Optimal Monetary Policy*. Working Paper 33772. National Bureau of Economic Research.

A Additional results

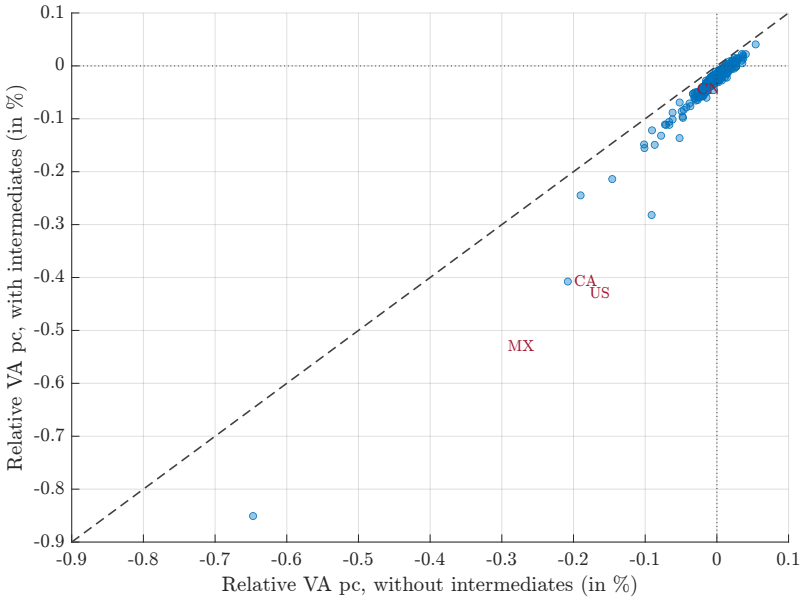
A.1 Intermediate inputs

To quantify the importance of intermediate inputs, I simulate how real VA per capita would change, in partial equilibrium, if we excluded intermediate inputs. In particular, let $\hat{c}^*_{mst}$ be the change in the input bundle cost that would emerge by setting $\gamma^{rs}_m = 0,\ \gamma_m = 1$ while keeping the changes in wages and rental rates of capital unaltered:

$$\hat{c}^*_{mst} = \left(\hat{R}^K_{mt}\right)^{\alpha_m} \hat{w}^{1-\alpha_m}_{mt} \tag{37}$$

I can then use these changes to recompute the effects on composite and final prices ($\hat{P}^*_{mt}$) using Equations (86) to (89). Lastly, I recompute the change in real VA per capita, $\frac{\widehat{VA}_{mt}}{\hat{P}^*_{mt}\hat{L}_{mt}}$. Figure A.1 compares the results of this exercise with the actual changes. The main result is that ignoring intermediate goods reduces the effect on European VA by more than half (-0.02% vs -0.05%, on average). The reason is that for all EU regions the price of intermediate composite goods rises relative to local factors of production (i.e., wages and rental rate of capital) due to negative terms of trade effects, which increase the cost of the input bundle. This effect is especially strong for the regions that suffer large negative terms of trade effects. In the case of the US, the presence of intermediate inputs strongly depresses the effect on real VA per capita mainly because the price of composite goods includes tariffs on imported goods.

Figure A.1: Real VA per capita: with and without intermediates



Notes: Each observation represents a NUTS-2 region. The x-axis reports how real VA per capita would react in partial equilibrium if intermediate inputs were to be excluded. The y-axis reports the actual change in real VA per capita (without the exclusion).

A.2 Shutting down main model features

Each exercise described in Section 3.1.8 removes one channel from the economy and solves the counterfactual. The exercises without international investment and without multinational production re-solve the baseline without the corresponding channel, while the exercise without a migration response keeps the main baseline. The difference with the main results measures the contribution of that channel.

No international investment. Every asset is held exclusively by investors from the same country: $g_{oM0} = 0$ whenever $o \notin \mathcal{J}(M)$, which corresponds to prohibitive frictions, $\kappa_{oMt} \to \infty$, for all foreign assets. Investors keep holding only domestic assets in every period ($b_{oMt} = 0$ for foreign assets), so net foreign assets are zero.

No multinational production. All production by firms from o in a different region m is reassigned to firms from m, $s'_{mmds1} = \sum_o s_{omds1}$ and $s'_{omds1} = 0$ for $o \neq m$. This preserves sales by production location, but firms can no longer serve markets through foreign plants or relocate production across plants in response to the tariffs. Headquarter inputs are then always sourced locally.

No migration response. To shut down endogenous migration, I simply fix migration shares at their baseline values in the counterfactual, $\mu'_{odt} = \mu_{odt}$, so population evolves exactly as in the baseline.

A.3 Robustness

Trade elasticity. In the main specification, $\theta_2 = 5.03$, the median estimate in Head and Mayer (2014). Recent estimates that exploit tariff changes over long horizons find lower long-run elasticities, around 2 (Boehm, Levchenko, and Pandalai-Nayar, 2023). I hence consider $\theta_2 = 2$. I also consider a higher value, $\theta_2 = 8.28$, as in Eaton and Kortum (2002). I keep $\theta_1 = 10$, which ensures $\theta_2 \leq \theta_1$. Because the calibration of the expenditure shares s_{omds1} depends on θ_2/θ_1 (Appendix F.2), I recalibrate them.

Multinational production elasticity. I set $\theta_1 = \theta_2 = 5.03$, so that composite good producers substitute between production locations of the same firm as easily as between firms from different origins. As before, the expenditure shares are recalibrated.

Migration elasticity. I double the migration elasticity, from 1.63 to 3.26 ($\upsilon \approx 0.31$).

Taxes on investment income. In the main specification, the income tax ι_{dt} applies only to labor income. In this exercise, it also applies to investment income (but not to bequests). Households in d earn the after-tax return $R^{net}_{dt} = 1 + (R_{dt} - 1)(1 - \iota_{dt})$ on their savings, which replaces R_{dt} in the budget constraints. The tax rate is common to all assets held by an investor, so portfolio choices are unchanged. The revenue finances government expenditure, and ι_{dt} adjusts so that government expenditure as a share of GDP remains unaffected. As a result, part of the tax burden shifts from labor to capital income.

Table A.1: Robustness

	EU				US			
	Real GDP pc		Welfare		Real GDP pc		Welfare	
	t^*	Long run	t^*	Long run	t^*	Long run	t^*	Long run
Main	-0.04	0.02	-0.07	-0.15	0.05	-0.07	0.15	0.31
Migr. elast. $\times 2$	-0.04	0.02	-0.07	-0.15	0.04	-0.10	0.15	0.29
$\theta_2 = 2$	-0.04	0.02	-0.07	-0.16	0.10	-0.02	0.24	0.41
$\theta_2 = 8.28$	-0.04	0.01	-0.07	-0.14	0.00	-0.13	0.05	0.21
$\theta_1 = \theta_2$	-0.05	0.03	-0.07	-0.17	0.13	0.08	0.28	0.51
Tax on inv. income	-0.04	0.02	-0.07	-0.17	0.06	-0.05	0.15	0.25

Notes: Counterfactual without retaliation. Changes relative to the corresponding baseline, in %, at $t = t^*$ and in the long run ($t = T$). Real GDP per capita is weighted by population, and welfare by the population of young agents at $t = 1$.

Table A.1 reports the results. The effects on the EU are very similar across specifications. The effects on the US are more sensitive: US welfare gains are larger the lower the trade elasticity θ_2. Taxing investment income barely changes the results: the effects at t^* are the same up to 0.01 pp, and the long-run welfare effects are -0.17% for the EU (against -0.15%) and 0.25% for the US (against 0.31%).

B The US: detailed results

This appendix provides a detailed discussion of the effects of US tariffs on the US economy, which are summarized in Section 3.1.7.

B.1 Trade patterns

Table C.3 reports the effects on trade patterns for the largest countries, the EU, and the world as a whole. Overall, the trade war leads to significant trade destruction (0.9 pp of world GDP) and limited trade creation.

Unsurprisingly, US tariffs deliver a large reduction in US imports of goods (-3.15 pp of US GDP), almost none of it offset by trade diversion.[41] Exports of US goods also decline, although to a smaller extent (-1.40 pp of US GDP). This is not due to higher tariffs on US goods; instead, it is driven by the fact that, from the point of view of the rest of the world, US goods are now relatively more expensive due to the terms of trade effect, so expenditure shifts away from US products even if they do not face retaliatory tariffs. This explains why US exports of services also decline (-1.15 pp of US GDP), and why US imports of services –which are not subject to tariffs– increase (0.4 pp of US GDP).

B.2 Reshoring multinational production

One of the key objectives of the 2025 US tariffs was to attract multinational production into the US. Table C.4 allows me to evaluate this objective. Due to the tariffs, US imports (net of taxes) fall by 2.75 pp as a share of GDP. Around one-quarter (0.78 pp) of this drop is offset by an increase in the value of goods produced in the US by foreign firms.[42] Hence, the reshoring of multinational production is quantitatively important but cannot prevent US firms and consumers from losing access to most foreign varieties. Naturally, the gap is covered by production from US producers that would not be competitive enough to operate under low tariffs.[43]

As discussed in Section 3.1.2, some US exporters relocate production out of the US as terms of trade effects raise the costs of producing in the US. Specifically, the market share of US firms producing in the US falls by 0.18 pp in the rest of the world, but 0.06 pp are regained by multinational production by US firms. Simultaneously, some US firms that were producing abroad to serve the US market are

[41] Fajgelbaum, Goldberg, et al. (2024) find substantial trade diversion to some countries (including Vietnam, Thailand, Korea, and Mexico) during the 2018-2019 US-China trade war. Such disparity of results is to be expected, as the US tariffs examined here apply to all countries, hence greatly limiting the scope for trade diversion.

[42] Roughly two-thirds of the drop in US imports come from the EU, China, Canada, and Mexico. The increase in foreign multinational production in the US originates in the EU, Japan, Canada, and China.

[43] Two additional observations are in order. The fact that some lost imports lead to foreign firms opening production plants in the US –as opposed to only leading to entrance of uncompetitive domestic alternatives, as in standard trade models– is relevant. In contrast with those models, not all is lost for a foreign producer that can no longer access the US market through exports, as it still has the option to produce there. If this option is chosen, it must be that the potential US producer is unproductive enough, and therefore US consumers are better off. This leads to a better economic outlook compared to a model in which this alternative is assumed to be impossible. Nevertheless, the principle of comparative advantage still applies and therefore the shift from imports toward multinational production is welfare decreasing (ignoring general equilibrium effects).

incentivized to bring production into the US. This effect accounts for 0.04 pp of US expenditure. Overall, multinational production by US firms as a share of US GDP falls (-0.22 pp) mostly because foreign expenditure declines relative to US GDP.

The changes in trade and multinational production have significant effects on the structure of world production, as illustrated by Figure D.10. US production now takes a larger share of world production (0.19 pp), as the terms of trade improvement implies that the US accounts for a larger share of the world economy. Domestic production (0.26 pp) and multinational production (0.1 pp) are further boosted by the shift in US expenditure allocation. On the other hand, US exports now account for 0.17 pp of world production less as the US becomes uncompetitive.

B.3 Production plants and value added

The simulation shows that real VA falls in the US as terms of trade effects are not enough to offset the increase in prices due to tariffs. Hence, (real) wages and rental rates of capital decrease. Put differently, the increase in capital demand in the US by foreign multinationals and new US firms is more than offset by a decrease in such demand by US exporters, hence lowering the real rental rate of capital (note that the supply of capital is initially fixed).

To extend upon this point, note that gross value added can be obtained by summing VA generated by four types of production (or firms): production by domestic firms sold domestically (domestic), exports by domestic firms (exports), production by foreign-owned firms sold domestically (multinational production), and production by foreign-owned firms exported abroad (export platforms). One can isolate the contribution of each of these four groups to the overall change in real VA per capita. Using Equation (46),[44]

$$\begin{aligned}\frac{\widehat{VA}_{mt}}{\hat{P}_{mt}\hat{L}_{mt}} - 1 = &\underbrace{\sum_{\substack{s \\ o\in\mathcal{G}(m) \\ d\in\mathcal{G}(m)}} s^{VA}_{omdst}\left(\frac{\widehat{VA}_{omdst}}{\hat{P}_{mt}\hat{L}_{mt}} - 1\right)}_{\text{domestic}} + \underbrace{\sum_{\substack{s \\ o\in\mathcal{G}(m) \\ d\notin\mathcal{G}(m)}} s^{VA}_{omdst}\left(\frac{\widehat{VA}_{omdst}}{\hat{P}_{mt}\hat{L}_{mt}} - 1\right)}_{\text{exports}} \\ &+ \underbrace{\sum_{\substack{s \\ o\notin\mathcal{G}(m) \\ d\in\mathcal{G}(m)}} s^{VA}_{omdst}\left(\frac{\widehat{VA}_{omdst}}{\hat{P}_{mt}\hat{L}_{mt}} - 1\right)}_{\text{multinational production}} + \underbrace{\sum_{\substack{s \\ o\notin\mathcal{G}(m) \\ d\notin\mathcal{G}(m)}} s^{VA}_{omdst}\left(\frac{\widehat{VA}_{omdst}}{\hat{P}_{mt}\hat{L}_{mt}} - 1\right)}_{\text{export platforms}}\end{aligned} \tag{38}$$

where $s^{VA}_{omdst} \equiv \frac{VA_{omdst}}{VA_{mt}}$ is the share of value added from m accounted by $o-m-d-s$ sales at t in the baseline economy, and $\mathcal{G}(m)$ denotes the set of regions in the same country as m.

Table C.6 reports the decomposition, together with real GDP per capita, for the largest economies and the

[44] Note that Equation (46) can be rewritten as $VA_{mt} = \sum_s \sum_o \sum_d VA_{omdst}$, where

$$VA_{omdst} = (1-\varphi)\gamma_m \frac{X^{AL}_{omdst}}{\tau_{mdst}} + \mathbb{1}_{\{o=m\}}\varphi\frac{\gamma_m}{\tau_{mdst}}\sum_{d'}\frac{s_{mdd'st}X^{AL}_{d'st}}{\tau_{dd'st}}$$

EU as a whole. Several points are noteworthy. First, in the US, the real demand of factors of production by domestic and multinational firms expands, contributing to an expansion of real VA per capita of 0.36 and 0.55%, respectively. Second, the drop in VA from exports (contributing -1.21%) dominates over the positive push, resulting in an overall VA per capita drop of 0.43%. This effect would be substantially smaller without input-output linkages (see Figure A.1) because the price of composite goods contains tariffs on imported goods. Third, real GDP per capita rises slightly (0.05%) thanks to the enlargement of tariff revenues (by around half a percentage point of GDP). Intuitively, the effect is small because tariffs deliver positive terms of trade effects but also distort what would otherwise be efficient spending decisions by US firms and consumers, generating misallocation. Fourth, given that government expenditure is a constant share of GDP and the government budget is balanced, tariff revenues are effectively rebated back to workers in the form of a lower income tax rate. This explains why net real wages grow (0.65%). Lastly, real GDP per capita (and VA) fall virtually everywhere, dragged by the downfall of exports to the US. Fundamentally, this is a consequence of the terms of trade effects of import tariffs.

B.4 Trade imbalances

On Liberation Day (April 2, 2025), Trump declared a national emergency based on the US trade deficit and imposed tariffs on all countries to solve it. Many economists argued that tariffs are not a suitable instrument for reducing trade deficits, and some pointed out that a trade war might lead to smaller trade imbalances by making intertemporal trade more costly by creating a wedge between the real interest rate faced by borrowers and lenders (a circumstance studied in Obstfeld and Rogoff (2000) and Reyes-Heroles (2016)). Costinot and Werning (2025) build on this mechanism and show that a tariff can reduce the trade deficit depending on the slope of the Engel curve for aggregate imports and exports.

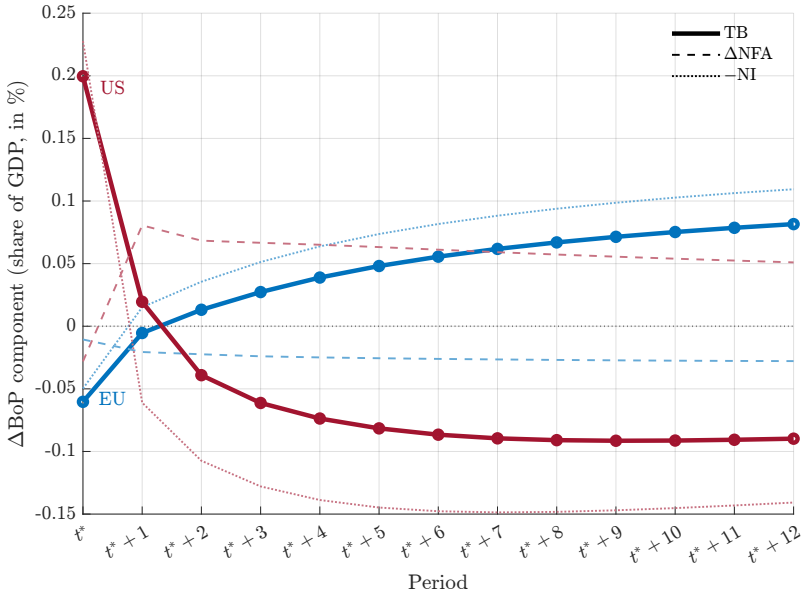
The simulation shows that the US trade deficit is reduced by 0.20 pp of GDP (solid red line in Figure B.2).[45] The main driver behind this result is not that trade frictions create a wedge between the real interest rates faced by borrowers and lenders, but rather a wealth effect. In the first period, US assets provide unexpectedly high returns as the price of US final goods hikes. Foreign investors benefit from the US real exchange rate appreciation, while US savers collect lower returns from foreign assets. This leads to a decrease in the US primary income balance (negative of the dotted line in Figure B.2), generating an improvement in its trade balance. This is the valuation effect emphasized by Itskhoki and Mukhin (2025).

However, an additional mechanism is at work. Tariffs also induce an expansion of foreign investment by US households (see Figure 9), improving the US net foreign asset position by 0.10 pp of GDP in the first period (and 0.19 pp in the long run). This further pushes the US toward a trade surplus by increasing the change in net foreign assets (the dashed line in Figure B.2).[46]

[45] For reference, the US trade deficit in 2023 was 2.8 pp of GDP.

[46] Two methodological observations regarding these asset dynamics are in order. First, despite the underlying improvement in the US position, Figure B.2 shows that the *change* in US net foreign assets is marginally negative in the first period. Because the US is initially a net debtor, the increase in US GDP at $t = 1$ mechanically shrinks the magnitude of its inherited net foreign liabilities when expressed as a fraction of GDP. This denominator effect depresses the counterfactual change in net foreign assets relative to the baseline, which is plotted as $\frac{NFA'_{ot} - NFA'_{ot-1}}{GDP'_{ot}} - \frac{NFA_{ot} - NFA_{ot-1}}{GDP_{ot}}$. Second, the upward shift in the change in US net foreign assets persists in the long run –rather than dissipating to zero– because the steady-state

Figure B.2: Trade imbalances



Notes: Variables regarding the US (EU) are shown in red (blue). The solid lines show the change in TB/GDP. The dashed and dotted lines decompose this change using Balance of Payments accounting: $TB = \Delta NFA - NI$, where ΔNFA (dashed line) refers to the negative of the financial account (IMF definition) and NI (negative of dotted line) is net primary income (which contains net investment income) plus the capital account (which includes migrants' transfers under capital transfers). Each period corresponds to 20 years.

However, the tariff hike only reduces the US trade deficit temporarily. In the long run, the trade balance actually falls 0.09 pp below its baseline level. This reversal occurs because, once US holdings of foreign assets stabilize relative to GDP, the periodic capital outflows required to maintain this position are more than offset by the higher net investment income generated by the accumulated stock of foreign wealth.[47]

The EU faces the opposite dynamics for symmetric reasons (blue lines). Specifically, its trade balance is initially worsened by 0.06 pp thanks to the income generated by the real appreciation of the US dollar, and in the long run the slightly weaker net investment position is more than offset by a smaller investment income.

B.5 Sectoral reallocation

Figure D.11 provides an alternative decomposition of the trade balance. Instead of using Balance of Payments accounting, it reports net exports by sector. Net exports of goods rise by 1.75 pp of GDP in the US, while net exports of services offset most of the increase (-1.55 pp), as the terms of trade improvement reduces US exports of services and raises US imports of services, which are not subject to tariffs (Appendix B.1). Therefore, US production shifts toward the goods sector. As a result, some US

economy features aggregate growth. Along a balanced growth path, maintaining a permanently higher NFA-to-GDP ratio requires a permanently higher periodic accumulation of net foreign assets.

[47] The overlapping generations structure is fundamental for this result. In the infinite horizon, representative agent setting of Itskhoki and Mukhin (2025), a change in initial wealth affects the trade balance similarly in the short and long run because the agent distributes the gains (or losses) over all periods. Instead, in the overlapping generations world, gains (or losses) are mostly consumed over the lifetime, so long run outcomes are not driven by initial wealth.

labor is reallocated across industries and the employment share of the goods sector rises by 0.89 pp. This is in contrast with the results from Itskhoki and Mukhin (2025), who find that a realistic calibration of the model generates a reduction in manufacturing jobs in response to an increase in import tariffs. The difference comes from the fact that their service sector is completely non-tradable, while in my setting trade frictions in the service sector are implicitly calibrated to replicate the trade patterns we observe in the data for services.

This result speaks directly to the main goal of the US trade policy in the second Trump administration: to recover the lost manufacturing employment. The counterfactual exercise shows that this is feasible to a certain extent. Quantitatively, however, the increase is a far cry from undoing the US manufacturing decline that has taken place since 1970 (roughly 15 pp). As shown by Kehoe, Ruhl, and Steinberg (2018), the main force behind the decline of US manufacturing is structural change, not US imports.

B.6 Investment and FDI

US tariffs result in an opening of new production plants in the US, some to produce foreign varieties and others to produce domestic varieties. These new plants require both US labor and US capital to operate. A crucial question is: does this policy lead to an expansion of investment in the US? To answer this question, it is appropriate to first examine the effects on real value added on impact. As discussed in Appendix B.3, real VA falls in the US, which reduces real wages and the rental rate of capital.

The drop in the real rental rate of capital is crucial for investment in general, and FDI in particular. Recall that the return on capital comprises two components (see Equation (63)): a valuation effect $\left(\frac{P^I_{mt}}{P^I_{mt-1}}\right)$ and the real rental rate plus undepreciated capital $\left(\frac{R^K_{omt}}{P^I_{mt}} + 1 - \delta_m\right)$. As discussed, this latter term does not increase, thereby failing to attract foreign investment.[48] Nevertheless, a transitory positive valuation effect dominates and shifts foreign portfolios slightly toward the US, as detailed below.

Such (limited) portfolio shift toward the US is combined with the aforementioned increase in US wealth, therefore expanding the funds available for capital investment in the US by 1.64% (in €). Table C.7 reports the contribution of the main investors to this change. Domestic investment accounts for 88%, while Canada, the UK, and Japan are the largest foreign contributors. Overall, the value of the stock of US capital gains 0.27 pp as a share of world wealth.[49] Yet this does not lead to more capital in the future. As investment goods (which are final goods that combine both goods and services) in the US become more expensive, real investment falls and real capital in the next period is 0.49% lower than under the baseline. Although this important point is usually overlooked, it is not novel and has been recently emphasized by Baqaee and Malmberg (2025) in the context of the US trade war.[50] It is now

[48] Technically, the analysis in Appendix B.3 shows that the real rental rate in terms of consumption goods $\left(\frac{R^K_{omt}}{P_{mt}}\right)$ decreases. The real rental rate in terms of investment goods $\left(\frac{R^K_{omt}}{P^I_{mt}}\right)$ falls by even more. Both consumption and investment final goods are produced by combining (composite) goods and services; however, investment goods are more intensive in (composite) goods than consumption goods. Given that the price of goods relative to services rises by 1.86% in the US due to the tariffs, US investment goods become more expensive even relative to consumption goods (0.35%).

[49] Note that such change is larger than the portfolio shift toward US capital for any individual investor except Canada. This is caused by a composition effect, as the US gains relative size as an investor.

[50] They find that capital stock adjustment is the main mechanism behind the drop in US consumption. In their simulation,

easy to see why there is a positive valuation effect in the US between periods t^* and t^*+1: in period t^* the available capital in the US is the same as in the baseline, while in period t^*+1 it is lower; so the US economy is relatively more capital-scarce in t^*+1, resulting in higher real rental rates (still below the baseline) and prices.

An important consequence of this is that the US economy is still too capital-abundant in period t^*+1, relative to the new steady state. As the economy converges toward its new steady state (by reducing capital in relative terms), the negative and deteriorating effect on real VA pushes the effect on real GDP into negative territory (-0.07%).

B.7 Welfare

The current young generation in the US benefits from these tariffs. Table C.8 shows that the 0.15% welfare gain comes almost entirely from an increase in young consumption, while the lower returns on wealth reduce their old-age consumption. On the other hand, older generations suffer welfare losses (-0.57% for the old, -0.31% for the middle aged) due to the negative valuation effect on their foreign asset holdings.

Figure 11a shows that welfare gains in the US compound over time as households accumulate wealth, reaching 0.31% in the long run. This might seem surprising, as the effect on US real GDP per capita becomes negative in the long run. On the one hand, net real wages are permanently higher than under the baseline, even if the capital stock reduction pushes against it. This is possible because I have assumed that the extra fiscal revenues generated by tariffs are effectively transferred to workers through a lower labor income tax. On the other hand, real returns on wealth fall, but not as much as in an environment without capital flows. As it turns out, the gain in net real wages more than offsets the lower real returns on wealth, thus leading to real wealth accumulation. So even if initial US real wealth suffers a sudden drop on impact due to low returns from foreign investments (measured in US prices), US households regain most of the lost wealth over time (see Figure 11b).[51]

Lastly, it is important to note that the distribution of tariff revenues is crucial. I have assumed that the extra fiscal revenues generated by tariffs are effectively transferred to workers through a lower labor income tax. This distribution is especially generous to Americans (except for the old in the first period). Consider three alternatives. First, suppose the tariff revenues are distributed across all factors of production (i.e., not only rebated to workers but also capital owners). This clearly redistributes from younger Americans to the old, but is not the best way to do it from the US perspective. A transfer to capital owners is mostly, but not only, a transfer to old Americans; it is also a transfer to foreign investors. Second, tax revenues might be unevenly distributed across households in a given generation, which could amplify inequality. For instance, non-uniform reductions in income taxes would affect high-income households differently, a channel that is not present here as all workers are endowed with the same amount of labor.

they take the tariff schedule presented by the Trump administration on April 2, 2025 and assume that the rest of the world retaliates by imposing symmetric import tariffs.

[51] Recall that Figure 11b reports (the change in) real wealth per capita available at the beginning of every period $\left(\frac{R_{ot}S_{ot-1}}{P_{ot}L_{ot}}\right)$. The fact that this metric is permanently lower than in the baseline does not mean that US households are poorer. In particular, their lifetime income, which crucially also includes their net real wage, increases.

Third, a fraction of these revenues might be allocated to government spending. To the extent that the additional provision of public goods is not desired by households, this lowers their welfare. Hence, the welfare effects for the US reported in these simulations can be seen as an upper bound.

C Additional Tables

Table C.2: EU effects under alternative US tariff changes

	5%		10%		15%	
	t^*	Long run	t^*	Long run	t^*	Long run
RGDP per capita	-0.02	0.01	-0.04	0.02	-0.06	0.01
Welfare	-0.04	-0.08	-0.07	-0.15	-0.09	-0.19

Notes: This table reports how average real GDP per capita (row 1) and welfare (row 2) change for the EU under alternative US tariff changes: 5, 10, and 15%. Averages are weighted by baseline population.

Table C.3: Trade destruction and creation

Country	Sector	Exports			Imports		
		Total	Destruction	Creation	Total	Destruction	Creation
EU (all)	All	-0.32	-0.49	0.17	-0.26	-0.40	0.14
	Goods	*-0.42*	*-0.45*	*0.03*	*-0.10*	*-0.17*	*0.06*
	Services	*0.10*	*-0.04*	*0.14*	*-0.15*	*-0.24*	*0.08*
EU (intra)	All	0.02	-0.03	0.05	0.02	-0.03	0.05
	Goods	*0.00*	*-0.02*	*0.02*	*0.00*	*-0.02*	*0.02*
	Services	*0.02*	*-0.01*	*0.03*	*0.02*	*-0.01*	*0.03*
EU (extra)	All	-0.34	-0.46	0.13	-0.28	-0.37	0.09
	Goods	*-0.42*	*-0.44*	*0.02*	*-0.10*	*-0.15*	*0.04*
	Services	*0.08*	*-0.03*	*0.11*	*-0.17*	*-0.22*	*0.05*
US	All	-2.55	-2.55	0.00	-2.75	-3.15	0.40
	Goods	*-1.40*	*-1.40*	*0.00*	*-3.15*	*-3.15*	*0.00*
	Services	*-1.15*	*-1.15*	*0.00*	*0.40*	*0.00*	*0.40*
CN	All	-0.30	-0.49	0.19	-0.26	-0.28	0.03
	Goods	*-0.33*	*-0.48*	*0.15*	*-0.18*	*-0.21*	*0.02*
	Services	*0.04*	*-0.00*	*0.04*	*-0.07*	*-0.08*	*0.00*
DE	All	-0.30	-0.46	0.16	-0.24	-0.33	0.09
	Goods	*-0.40*	*-0.44*	*0.04*	*-0.10*	*-0.16*	*0.06*
	Services	*0.09*	*-0.02*	*0.11*	*-0.14*	*-0.17*	*0.04*
JP	All	-0.39	-0.51	0.11	-0.27	-0.36	0.09
	Goods	*-0.46*	*-0.50*	*0.04*	*-0.12*	*-0.18*	*0.06*
	Services	*0.07*	*-0.01*	*0.08*	*-0.15*	*-0.18*	*0.03*
UK	All	-0.17	-0.42	0.25	-0.06	-0.28	0.21
	Goods	*-0.30*	*-0.31*	*0.00*	*-0.03*	*-0.15*	*0.12*
	Services	*0.13*	*-0.11*	*0.24*	*-0.03*	*-0.13*	*0.10*
FR	All	-0.19	-0.33	0.14	-0.13	-0.26	0.13
	Goods	*-0.28*	*-0.29*	*0.01*	*-0.04*	*-0.11*	*0.06*
	Services	*0.09*	*-0.04*	*0.13*	*-0.09*	*-0.15*	*0.06*
IN	All	-0.17	-0.38	0.20	-0.14	-0.24	0.10
	Goods	*-0.35*	*-0.35*	*0.00*	*-0.04*	*-0.12*	*0.07*
	Services	*0.17*	*-0.02*	*0.20*	*-0.10*	*-0.13*	*0.02*
IT	All	-0.32	-0.56	0.24	-0.25	-0.27	0.03
	Goods	*-0.42*	*-0.55*	*0.14*	*-0.14*	*-0.16*	*0.02*
	Services	*0.10*	*-0.01*	*0.10*	*-0.11*	*-0.12*	*0.01*
RU	All	-0.03	-0.06	0.03	-0.02	-0.05	0.03
	Goods	*-0.06*	*-0.06*	*0.00*	*0.02*	*-0.01*	*0.03*
	Services	*0.02*	*-0.00*	*0.03*	*-0.04*	*-0.04*	*0.01*
BR	All	-0.21	-0.28	0.07	-0.19	-0.25	0.06
	Goods	*-0.26*	*-0.28*	*0.01*	*-0.06*	*-0.10*	*0.05*
	Services	*0.05*	*-0.00*	*0.05*	*-0.14*	*-0.15*	*0.01*
CA	All	-2.51	-3.68	1.17	-2.34	-2.44	0.10
	Goods	*-3.32*	*-3.68*	*0.36*	*-1.59*	*-1.69*	*0.10*
	Services	*0.81*	*-0.00*	*0.81*	*-0.74*	*-0.75*	*0.01*
AU	All	-0.20	-0.24	0.05	-0.12	-0.29	0.18
	Goods	*-0.21*	*-0.21*	*0.00*	*-0.04*	*-0.17*	*0.13*
	Services	*0.02*	*-0.03*	*0.04*	*-0.07*	*-0.12*	*0.05*
ES	All	-0.19	-0.32	0.13	-0.14	-0.26	0.13
	Goods	*-0.26*	*-0.28*	*0.02*	*-0.08*	*-0.17*	*0.09*
	Services	*0.08*	*-0.04*	*0.12*	*-0.06*	*-0.09*	*0.03*
World	All	-0.85	-0.93	0.08	-0.85	-0.93	0.08
	Goods	*-0.75*	*-0.75*	*0.00*	*-0.75*	*-0.75*	*0.00*
	Services	*-0.10*	*-0.18*	*0.08*	*-0.10*	*-0.17*	*0.08*

Notes: For each country, column 1 (3) reports the change in international exports (imports) as a share of GDP, in percentage points. Columns 2 and 3 (4 and 5) decompose the change in exports (imports) into trade destruction, computed as the sum of all negative changes, and trade creation, computed as the sum of all positive changes. The whole EU is added as an additional country. "EU (intra)" refers to all trade between EU Member States, "EU (extra)" refers to all trade between EU members and non-members, and "EU (all)" includes all international trade in the EU.

Table C.4: Trade and multinational production vis-à-vis the US

Country	Unit	Exports	Imports	Out. MP	In. MP
EU	pp GDP	-0.32	-0.36	0.29	0.09
	pp US GDP	*-0.47*	*-0.57*	*0.26*	*-0.16*
CA	pp GDP	-3.15	-2.27	1.06	0.65
	pp US GDP	*-0.42*	*-0.32*	*0.08*	*-0.00*
CN	pp GDP	-0.46	-0.20	0.08	0.06
	pp US GDP	*-0.44*	*-0.20*	*0.06*	*0.00*
MX	pp GDP	-3.96	-2.34	0.27	0.81
	pp US GDP	*-0.36*	*-0.23*	*0.02*	*0.03*
IE	pp GDP	-2.25	-3.49	0.65	1.36
	pp US GDP	*-0.09*	*-0.16*	*0.01*	*-0.01*
DE	pp GDP	-0.33	-0.28	0.39	0.07
	pp US GDP	*-0.13*	*-0.11*	*0.09*	*-0.03*
JP	pp GDP	-0.43	-0.34	0.67	0.10
	pp US GDP	*-0.12*	*-0.10*	*0.11*	*0.01*
KR	pp GDP	-1.11	-0.60	0.40	0.18
	pp US GDP	*-0.12*	*-0.07*	*0.03*	*0.01*
CH	pp GDP	-0.70	-0.76	0.99	0.27
	pp US GDP	*-0.06*	*-0.07*	*0.04*	*-0.03*
IT	pp GDP	-0.50	-0.14	0.23	0.03
	pp US GDP	*-0.08*	*-0.03*	*0.03*	*-0.02*
IN	pp GDP	-0.18	-0.23	0.05	0.07
	pp US GDP	*-0.04*	*-0.05*	*0.01*	*-0.00*
FR	pp GDP	-0.12	-0.22	0.32	0.05
	pp US GDP	*-0.03*	*-0.06*	*0.04*	*-0.02*
UK	pp GDP	-0.02	-0.27	0.21	0.02
	pp US GDP	*-0.02*	*-0.07*	*0.02*	*-0.07*
BR	pp GDP	-0.20	-0.24	0.19	0.05
	pp US GDP	*-0.03*	*-0.04*	*0.02*	*-0.02*
NL	pp GDP	0.01	-0.59	0.45	0.09
	pp US GDP	*-0.00*	*-0.06*	*0.02*	*-0.03*
SA	pp GDP	-0.23	-0.33	0.07	0.07
	pp US GDP	*-0.02*	*-0.03*	*0.00*	*0.00*
ES	pp GDP	-0.16	-0.24	0.15	0.05
	pp US GDP	*-0.02*	*-0.03*	*0.01*	*-0.01*
AU	pp GDP	-0.06	-0.29	0.11	0.06
	pp US GDP	*-0.01*	*-0.04*	*0.01*	*-0.02*
ID	pp GDP	-0.21	-0.15	0.01	0.04
	pp US GDP	*-0.02*	*-0.02*	*0.00*	*-0.00*
SE	pp GDP	-0.33	-0.35	0.34	0.09
	pp US GDP	*-0.02*	*-0.02*	*0.01*	*-0.00*
Total	*pp US GDP*	*-2.75*	*-2.55*	*0.78*	*-0.22*

Notes: For each country, column 1 (2) reports the change in exports to (imports from) the US in percentage points of GDP, while the second row reports the change in the same amount in percentage points of US GDP. Similarly, column 3 (4) reports the change in outward (inward) multinational production in (from) the US. The whole EU is added as an additional country.

Table C.5: Trade Exposure and Regional GDP per Capita Effects

	RGDP per capita effect
	(1)
Exports exposure services	0.016***
	(0.003)
Exports exposure goods	−0.069***
	(0.003)
Imports exposure services	−0.017***
	(0.001)
Imports exposure goods	−0.024***
	(0.003)
Constant	0.006***
	(0.001)
Observations	240
R^2	0.979

Notes: The dependent variable is the effect on regional real GDP per capita. Robust standard errors in parentheses.

Table C.6: Real VA per capita decomposition

Country	RGDPpc	RGVApc				
	Total	Total	Domestic	Exports	Multinational	Exp. plat.
EU	-0.05	-0.05	0.05	-0.12	0.05	-0.04
US	0.05	-0.43	0.37	-1.21	0.55	-0.13
CN	-0.07	-0.05	0.03	-0.11	0.03	-0.00
DE	-0.05	-0.04	0.06	-0.12	0.04	-0.02
JP	-0.05	-0.05	0.10	-0.20	0.05	-0.00
UK	-0.02	-0.02	0.07	-0.06	-0.00	-0.03
FR	-0.02	-0.02	0.05	-0.08	0.02	-0.01
IN	-0.03	-0.02	0.04	-0.08	0.03	-0.00
IT	-0.05	-0.05	0.06	-0.14	0.03	-0.00
RU	-0.00	-0.00	0.01	-0.01	-0.00	-0.00
BR	-0.04	-0.03	0.05	-0.11	0.03	-0.00
CA	-0.43	-0.41	0.30	-0.97	0.60	-0.35
AU	-0.02	-0.02	0.05	-0.09	0.02	-0.00
ES	-0.03	-0.03	0.04	-0.08	0.03	-0.01
KR	-0.15	-0.13	0.11	-0.32	0.08	0.00
ID	-0.03	-0.02	0.03	-0.08	0.02	-0.00
NL	-0.05	-0.05	0.06	-0.10	0.04	-0.04
SA	-0.05	-0.04	0.06	-0.15	0.05	-0.00
MX	-0.54	-0.53	0.35	-1.46	0.73	-0.15
CH	-0.10	-0.10	0.09	-0.29	0.13	-0.02

Notes: For each country, columns 1 and 2 report the relative change in real GDP per capita and real VA per capita in the initial period ($t = t^*$), in %. Columns 3 to 6 decompose the change in VA per capita into the four sources of VA, as specified by eq. (38). "Domestic" denotes production by domestic firms sold domestically; "Exports" denotes exports by domestic firms; "Multinational" denotes production by foreign-owned firms sold domestically (multinational production); and "Exp. plat." denotes production by foreign-owned firms exported abroad (export platforms). The whole EU is added as an additional country. Averages –at the country level, for the EU, and for the whole world– are weighted by baseline VA, which is also used to sort countries.

Table C.7: Decomposing investment into the US

	Contribution	Rel. contr.	Portf. shift
World	1.64	100.00	0.27
US	1.44	87.65	0.15
CA	0.03	1.62	0.31
UK	0.02	1.47	0.09
JP	0.02	1.31	0.08
DE	0.01	0.82	0.04
CH	0.01	0.51	0.12
CN	0.01	0.46	0.02
NL	0.01	0.45	0.09
AU	0.01	0.43	0.07
MX	0.01	0.41	0.16

Notes: Column 1 decomposes the change in investment expenditure in the US by investor in percentage points. In particular, it uses the fact that $100(\hat{B}_{USt} - 1) = \sum_o \frac{b_{oUSt}S_{ot}}{B_{USt}} 100(\hat{b}_{oUSt}\hat{S}_{ot} - 1)$. Column 2 reports the relative contribution. Column 3 reports the shift in each investor's portfolio toward US capital, measured as a percentage points difference.

Table C.8: Welfare decomposition

Country	Welfare	Migr. value	Young cons.	Middle cons.	Old cons.
IN	-0.05	-0.00	-0.00	-0.01	-0.03
CN	-0.10	0.00	-0.02	-0.03	-0.05
EU	-0.07	-0.00	-0.02	-0.01	-0.04
ID	-0.05	-0.00	-0.01	-0.01	-0.03
US	0.15	0.01	0.19	0.02	-0.06
BR	-0.08	0.00	-0.01	-0.02	-0.05
MX	-0.65	0.08	-0.21	-0.18	-0.33
RU	-0.02	-0.00	-0.00	-0.00	-0.01
TR	-0.05	-0.00	-0.01	-0.01	-0.03
ZA	-0.05	0.00	-0.00	-0.01	-0.04
JP	-0.06	-0.00	-0.03	-0.00	-0.02
DE	-0.07	-0.01	-0.02	-0.01	-0.03
UK	-0.03	-0.01	-0.01	0.01	-0.02
FR	-0.05	-0.00	-0.01	-0.01	-0.03
SA	-0.07	-0.00	-0.01	-0.02	-0.04
AR	-0.05	0.00	-0.00	-0.01	-0.03
KR	-0.18	-0.00	-0.07	-0.03	-0.07
IT	-0.06	-0.01	-0.02	-0.01	-0.03
ES	-0.07	-0.00	-0.01	-0.01	-0.04
CA	-0.40	-0.00	-0.19	-0.07	-0.14
Average	-0.09	0.00	-0.01	-0.02	-0.06

Notes: For each country, column 1 reports lifetime consumption equivalent welfare changes for generation t^* (as a log difference in %). Columns 2 to 5 decompose the change into the four components specified by eq. (33). The whole EU is added as an additional country. Averages –at the country level, for the EU, and for the whole world– are weighted by baseline young population, which is also used to sort countries.

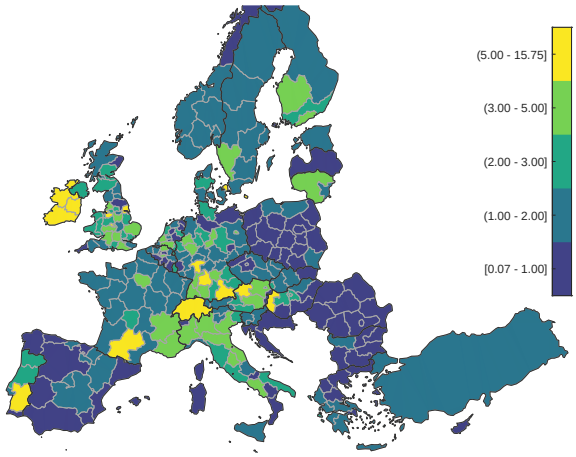
Table C.9: World production across scenarios

	No retaliation			Retaliation			Escalation			FTA China		
	Total	Goods	Services	Total	Goods	Services	Total	Goods	Services	Total	Goods	Services
Panel A. EU												
Total production	-0.03	-0.05	0.02	-0.01	-0.03	0.02	-0.04	-0.05	0.02	0.01	-0.01	0.02
Dom prod - dom	*-0.00*	*-0.00*	*0.00*	*0.02*	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*	*-0.00*	*-0.01*	*0.01*
Dom prod - exports	*-0.03*	*-0.04*	*0.01*	*-0.03*	*-0.04*	*0.00*	*-0.05*	*-0.06*	*0.01*	*0.01*	*0.01*	*0.00*
Foreign prod - dom	*0.01*	*0.00*	*0.01*	*0.02*	*0.01*	*0.01*	*0.02*	*0.01*	*0.01*	*-0.00*	*-0.01*	*0.01*
Foreign prod - exports	*-0.01*	*-0.01*	*-0.00*	*-0.01*	*-0.01*	*-0.00*	*-0.02*	*-0.02*	*0.00*	*0.00*	*0.00*	*-0.00*
Panel B. US												
Total production	0.19	0.17	0.02	0.15	0.13	0.01	0.17	0.15	0.01	0.19	0.17	0.02
Dom prod - dom	*0.26*	*0.17*	*0.09*	*0.24*	*0.16*	*0.08*	*0.26*	*0.18*	*0.08*	*0.26*	*0.17*	*0.09*
Dom prod - exports	*-0.15*	*-0.08*	*-0.07*	*-0.17*	*-0.11*	*-0.06*	*-0.18*	*-0.11*	*-0.07*	*-0.15*	*-0.08*	*-0.07*
Foreign prod - dom	*0.10*	*0.10*	*-0.00*	*0.10*	*0.10*	*-0.00*	*0.11*	*0.11*	*-0.00*	*0.10*	*0.10*	*-0.00*
Foreign prod - exports	*-0.02*	*-0.02*	*-0.00*	*-0.02*	*-0.02*	*-0.00*	*-0.02*	*-0.02*	*-0.00*	*-0.02*	*-0.02*	*-0.00*

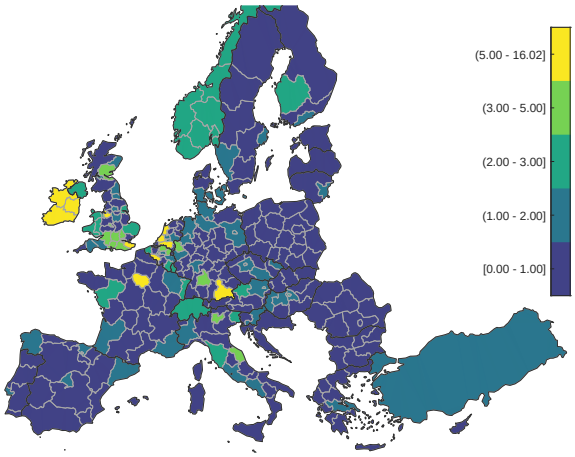
Notes: This table reports how production changes in the EU (Panel A) and the US (Panel B) across all counterfactual scenarios in the initial period ($t = t^*$), relative to the baseline. Row 1 reports the change in each economy's share of world production (percentage points). Rows 2 to 5 decompose this change by ownership (domestic vs. foreign firms) and destination (domestic vs. foreign markets). "Dom prod–dom" denotes production by domestic firms sold domestically; "Dom prod–exports" denotes exports by domestic firms; "Foreign prod–dom" denotes production by foreign-owned firms sold domestically (multinational production); and "Foreign prod–exports" denotes production by foreign-owned firms exported abroad (export platforms).

D Additional Figures

Figure D.3: Trade in goods with the US (2017)



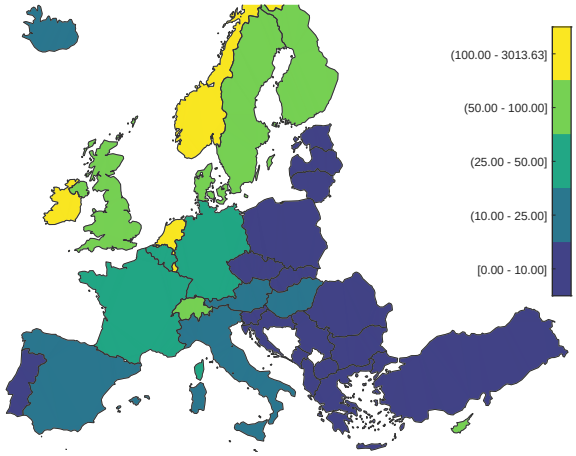
(a) Share of sales to the US



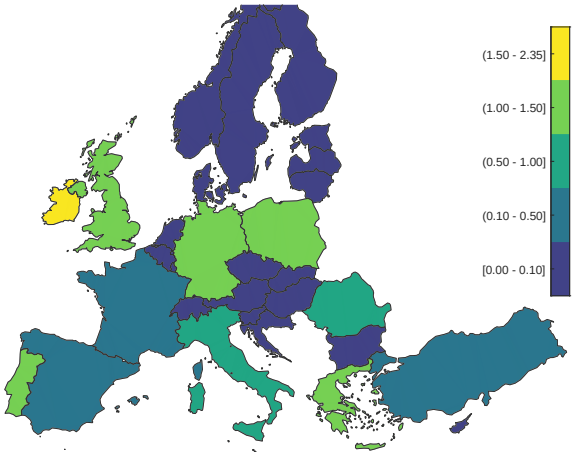
(b) Share of expenditure on the US

Notes: International trade in goods with the US at the NUTS-2 level in 2017. Panel A shows the value of sales of goods to the US as a share of total goods sales. Panel B shows the value of purchases of US goods as a share of total expenditure on goods. Source: FIGARO-REG database.

Figure D.4: US asset holdings and migration (2024)



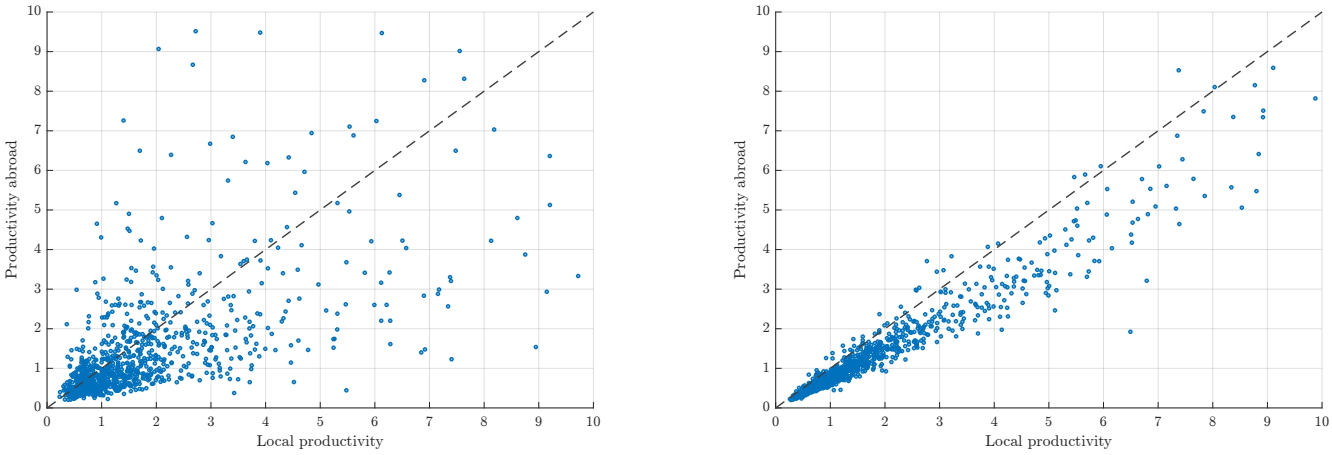
(a) US asset holdings (share of GDP)



(b) Migration to the US (stock, share of population)

Notes: Panel A. Holdings of US assets as a share of GDP in 2024. Source: Author's own calculations based on IMF data (PIP, DIP, and WEO). Panel B. Stock of migrants in the US as a share of origin population in 2024. Source: Author's own calculations based on the UN International Migrant Stock dataset and WDI.

Figure D.5: The multivariate Fréchet: an example

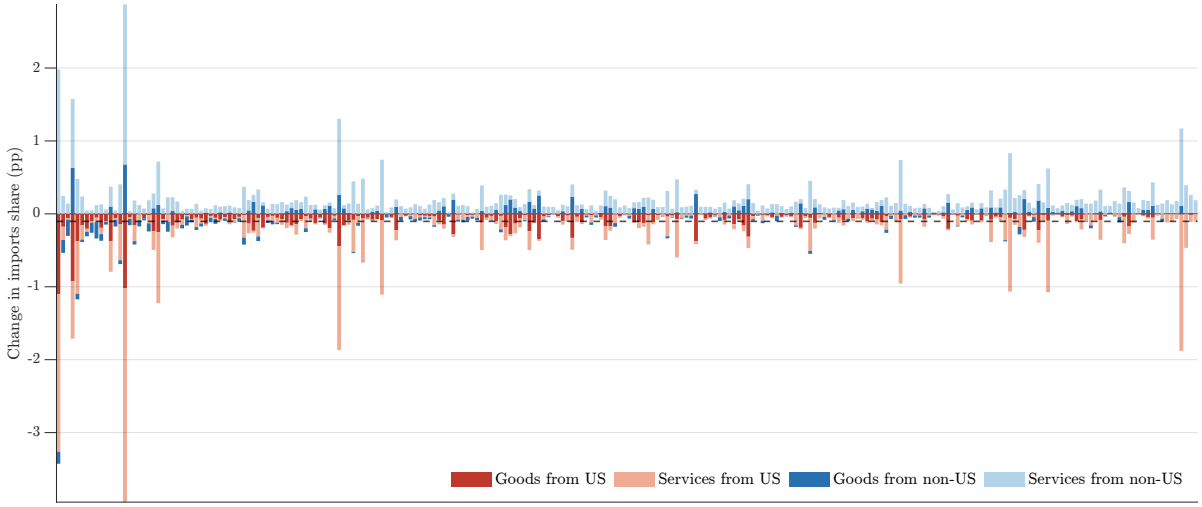


(a) Low dependence

(b) High dependence

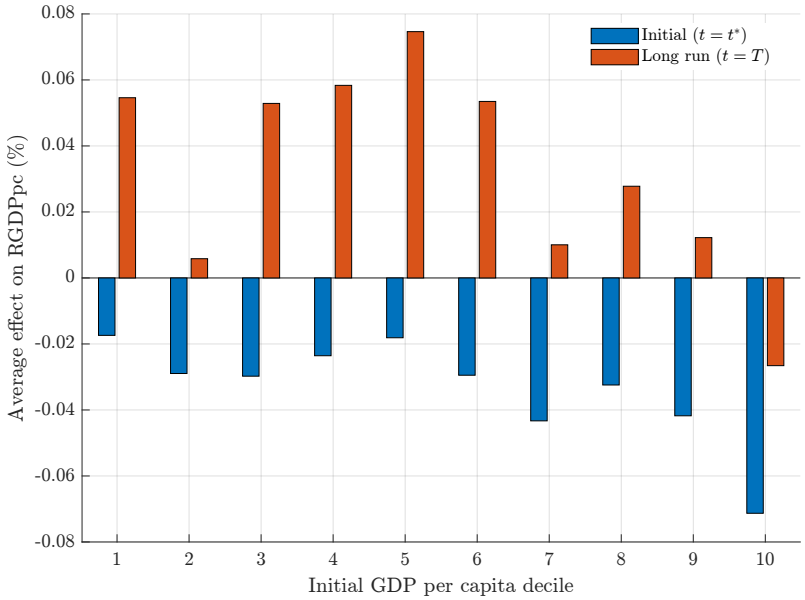
Notes: Each panel displays a simulation ($N = 1000$) of productivity for firms in location 1 when producing domestically (x-axis) and in location 2 (y-axis). Panel A uses $\theta_1 = 3$ and $\theta_2 = 1.5$; Panel B uses $\theta_1 = 10$ and $\theta_2 = 1.5$. In both panels, $\lambda_{1t} = 1$, $\varrho_{11t} = 1$, and $\varrho_{12t} = 4/3$.

Figure D.6: Decomposing regional imports



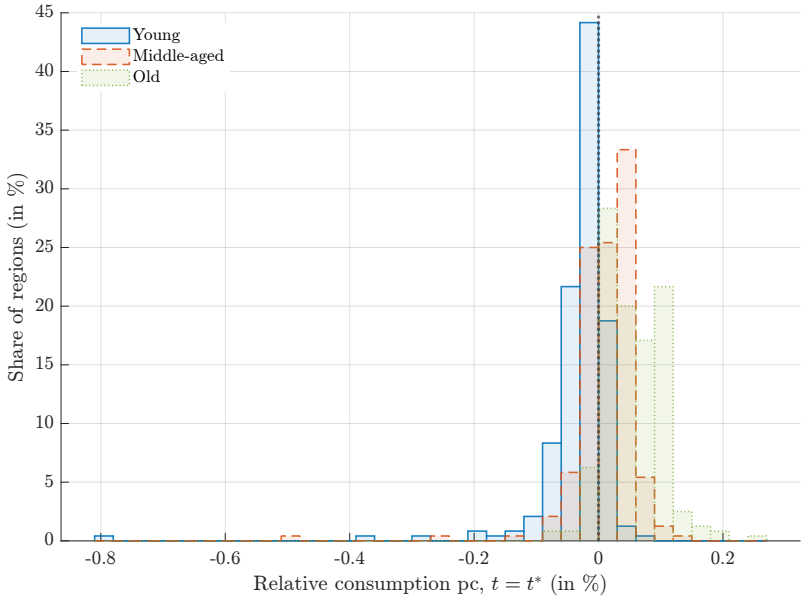
Notes: Change in European imports across NUTS-2 regions on impact ($t = t^*$), expressed as a share of regional GDP (in pp). For each region (x-axis), the four bars decompose the change in imports by origin (US in red vs. non-US in blue) and by sector (goods in dark shades vs. services in light shades). Regions are sorted according to the effect on exports of goods to the US.

Figure D.7: Effects on real GDP per capita by initial GDP per capita decile excluding Ireland



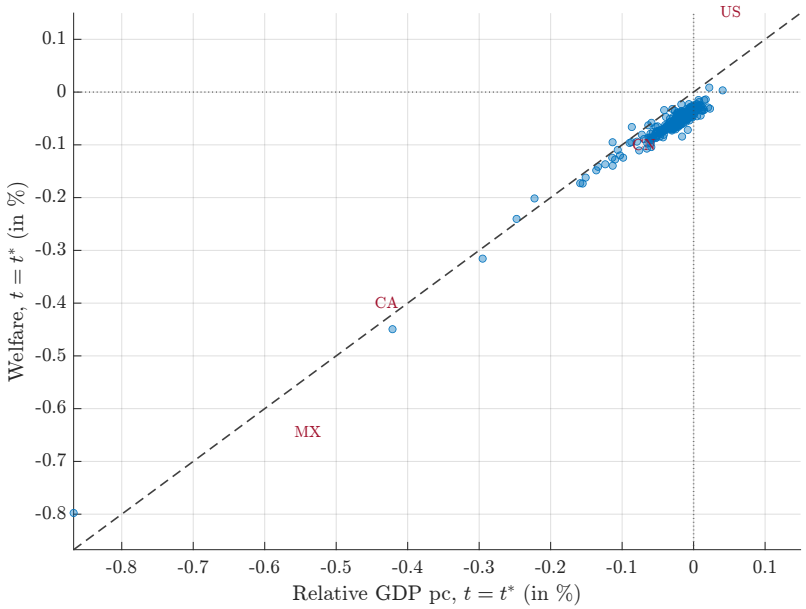
Notes: EU regions (excluding Ireland) are assigned to deciles according to their GDP per capita at $t = t^*$ in the baseline. The bars report the average percentage change in real GDP per capita within each decile, weighted by baseline population. Blue bars show the effect at $t = t^*$, while orange bars show the effect at $t = T$.

Figure D.8: Consumption per capita (stayers)



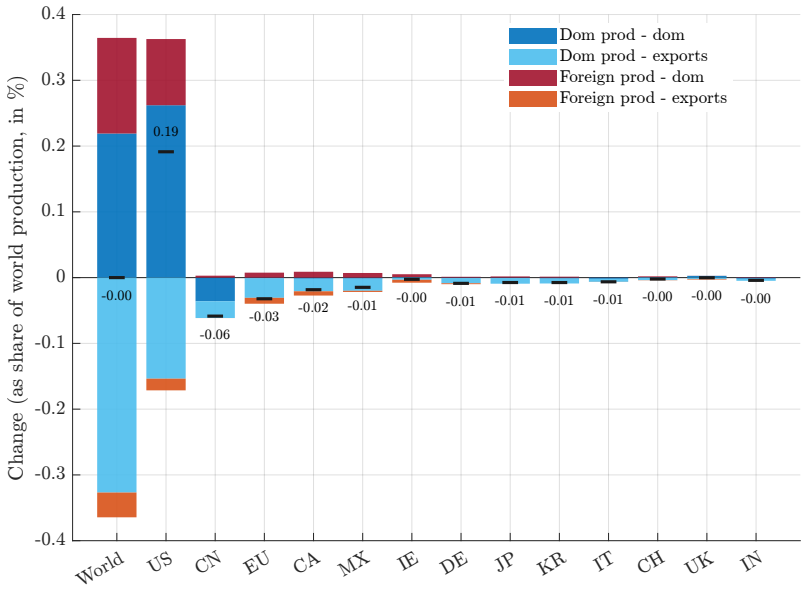
Notes: Each observation represents a NUTS-2 EU region.

Figure D.9: Welfare and GDP



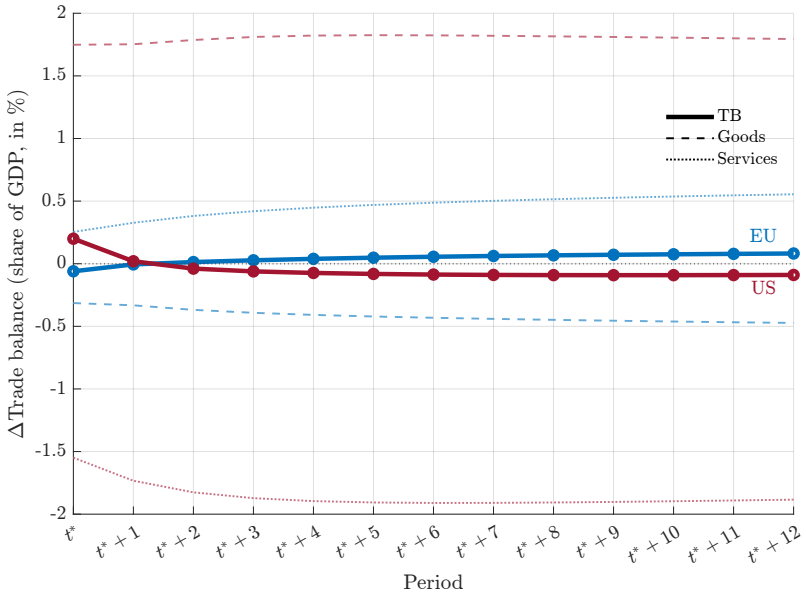
Notes: Each observation represents a NUTS-2 region. The y-axis reports lifetime consumption equivalent welfare changes for generation t^* (in %).

Figure D.10: Reshaping world production



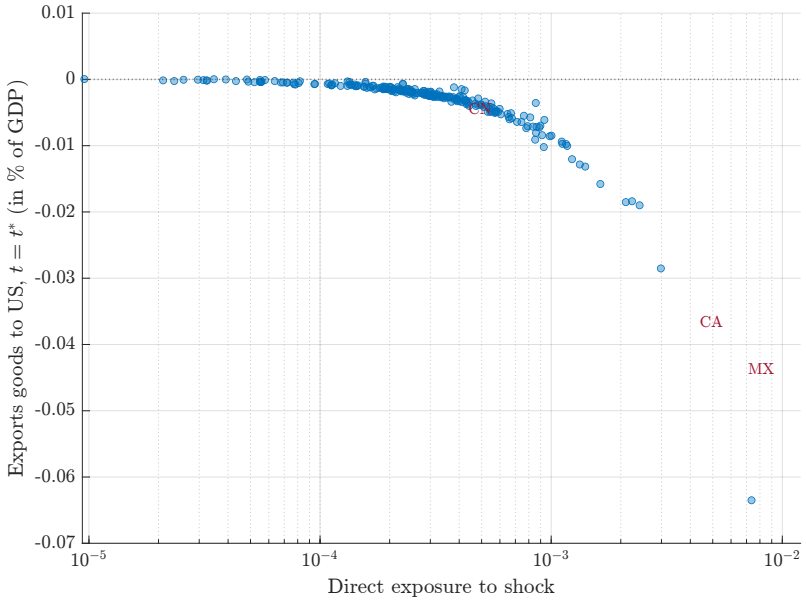
Notes: The figure reports the change in each component's share of world production (percentage points). Production is decomposed by location (x-axis), ownership (domestic vs. foreign firms), and destination (domestic vs. foreign markets). "Dom prod–dom" denotes production by domestic firms sold domestically; "Dom prod–exports" denotes exports by domestic firms; "Foreign prod–dom" denotes production by foreign-owned firms sold domestically (multinational production); and "Foreign prod–exports" denotes production by foreign-owned firms exported abroad (export platforms). For each location, the components sum to the total change in its share of world production.

Figure D.11: Trade imbalances by sector



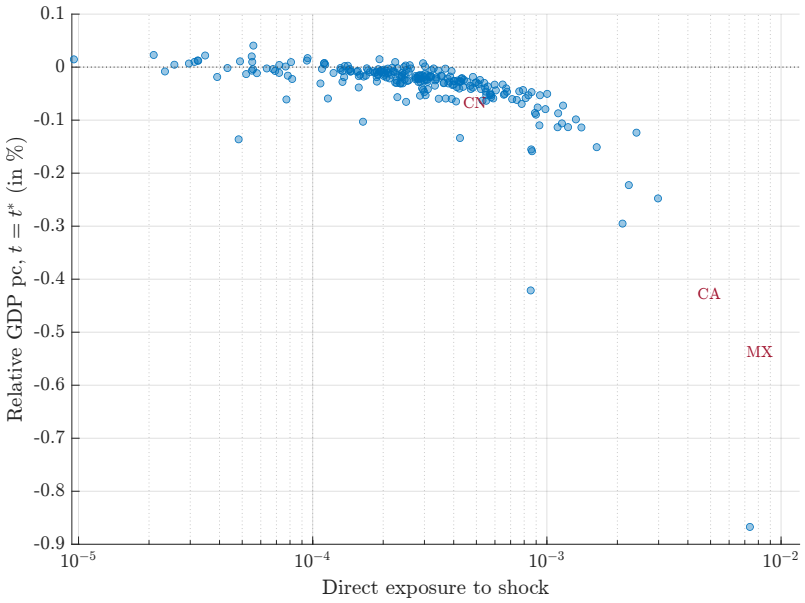
Notes: Variables regarding the US (EU) are shown in red (blue). The solid lines show the change in TB/GDP. The dashed and dotted lines decompose this change by sector. The dashed (dotted) line reports the trade balance in the goods (services) sector. Each period corresponds to 20 years.

Figure D.12: Exports of goods to the US and exposure



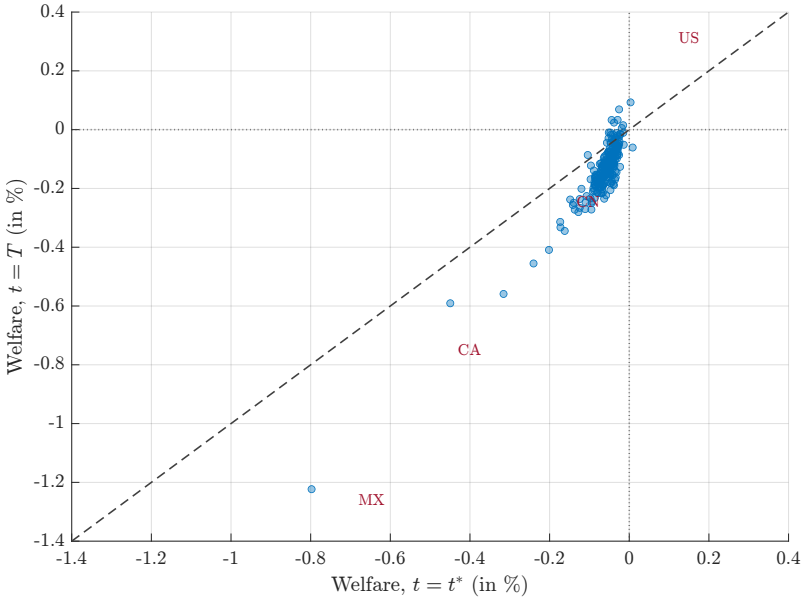
Notes: Each point represents a NUTS-2 region. Direct exposure is defined as share of total sales times the tariff increase.

Figure D.13: GDP and exposure



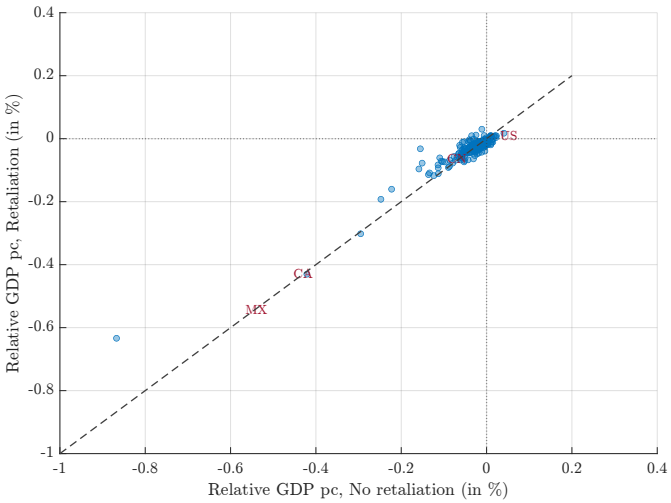
Notes: Each point represents a NUTS-2 region. Direct exposure is defined as share of total sales times the tariff increase.

Figure D.14: Welfare in the long run

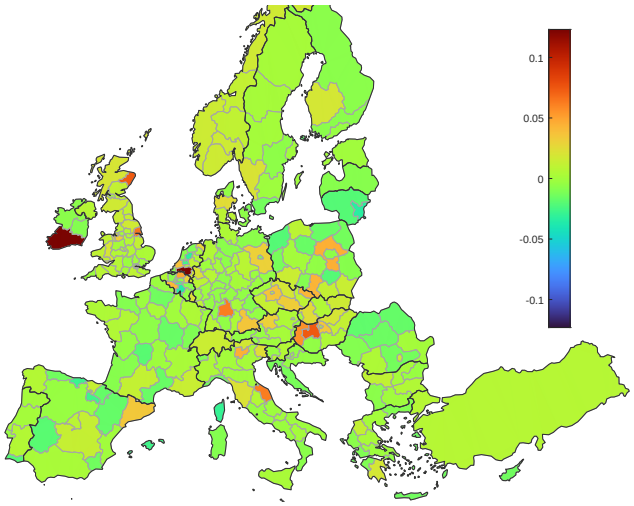


Notes: Each point represents a NUTS-2 region. Welfare for generations t^* (x-axis) and T (y-axis), measured as a lifetime consumption equivalent (in %).

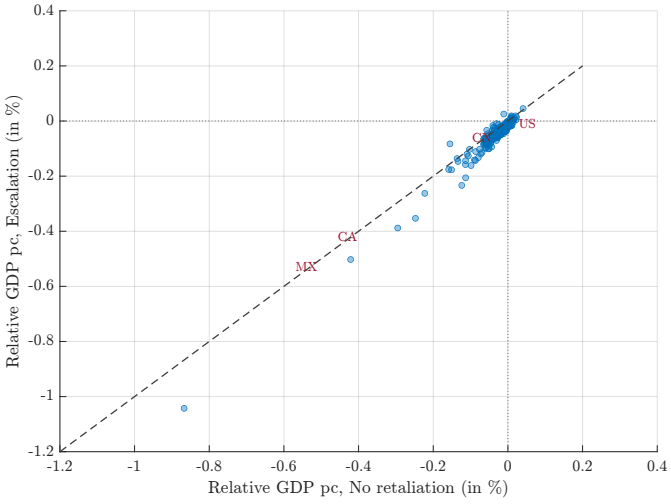
Figure D.15: Regional Real GDP per capita across scenarios ($t = t^*$)



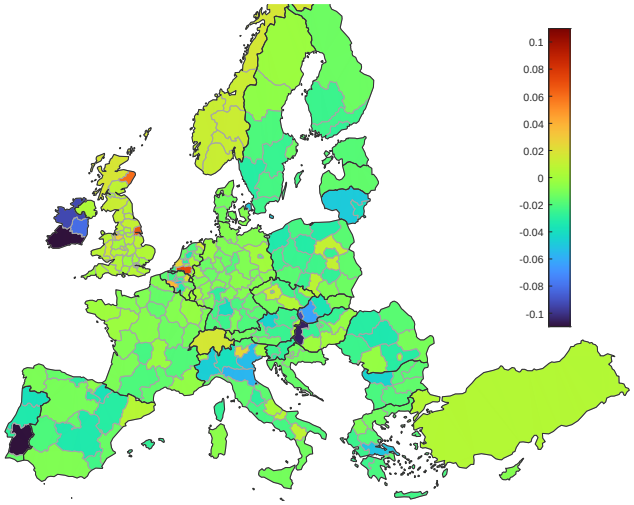
(a) Retaliation vs. No Retaliation



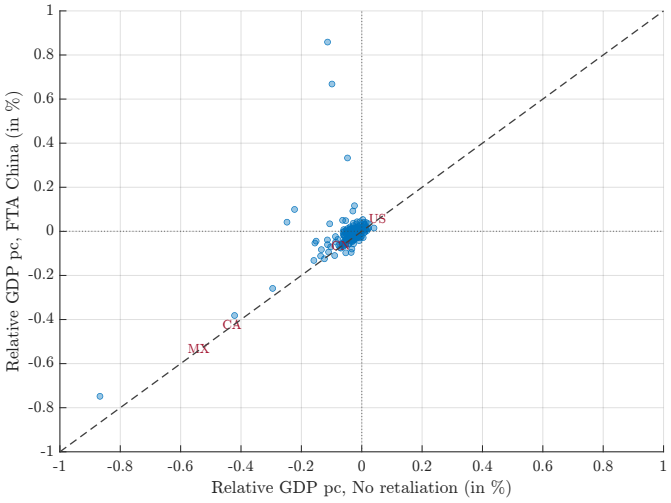
(b) Difference (Retaliation − No Retaliation)



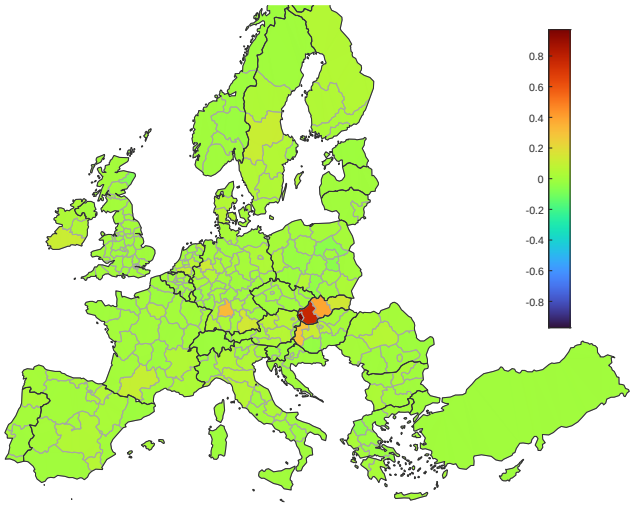
(c) Escalation vs. No Retaliation



(d) Difference (Escalation − No Retaliation)



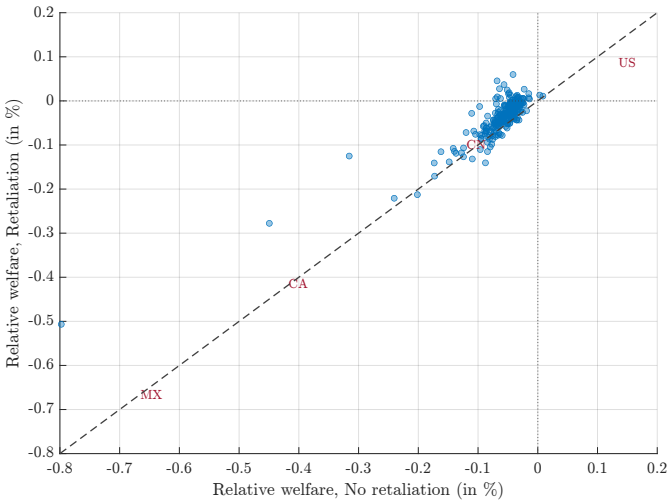
(e) China FTA vs. No Retaliation



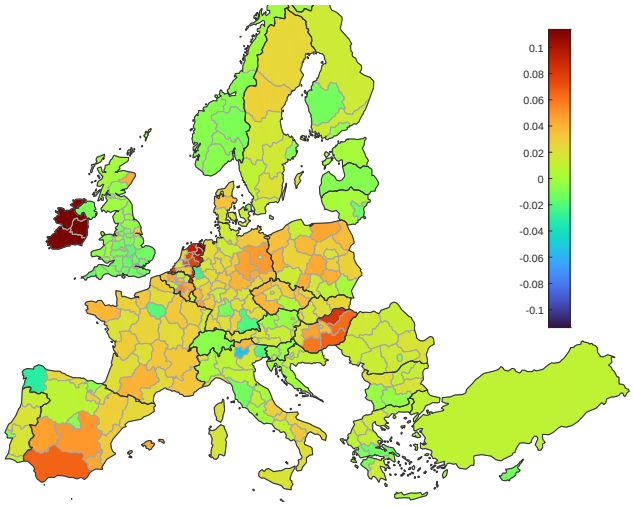
(f) Difference (China FTA − No Retaliation)

Notes: Percentage change in real GDP per capita across regions evaluated at $t = t^*$. The left column presents scatter plots comparing the regional effects in each alternative scenario against the No Retaliation scenario. The right column maps the spatial distribution of these differences (Alternative Scenario − No Retaliation) in percentage points. To facilitate visualization, values beyond the color scale limits are shown saturated (this only affects Southern Ireland, IE05).

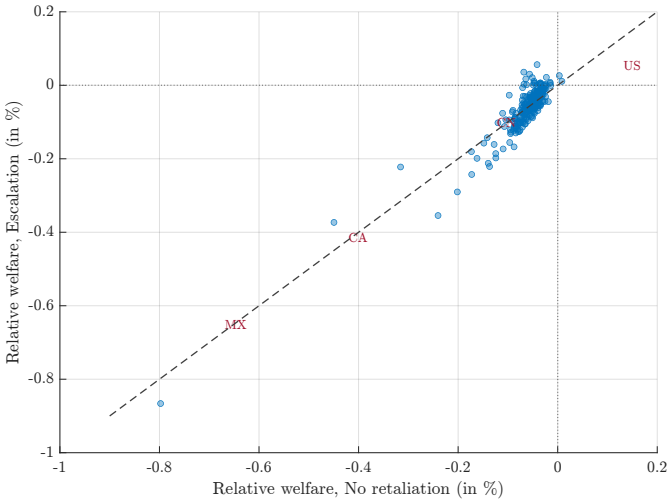
Figure D.16: Regional Welfare across scenarios ($t = t^*$)



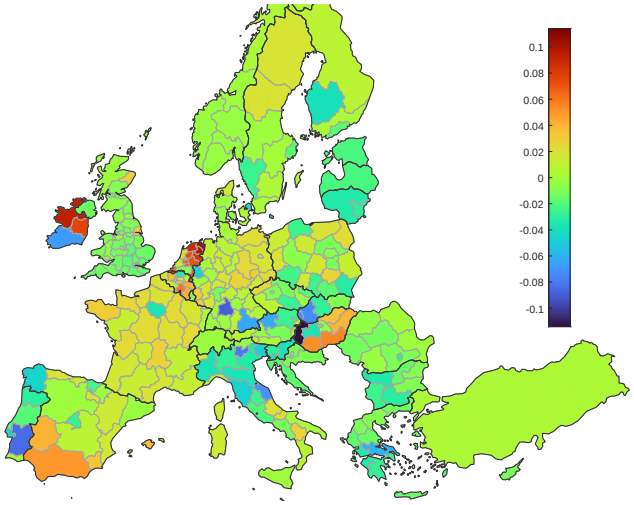
(a) Retaliation vs. No Retaliation



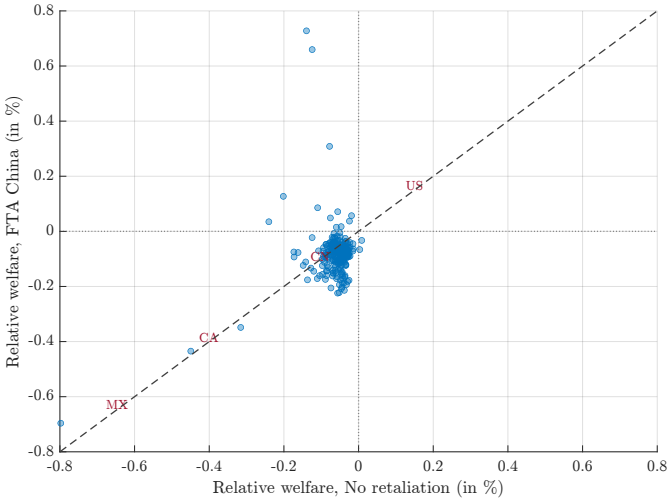
(b) Difference (Retaliation − No Retaliation)



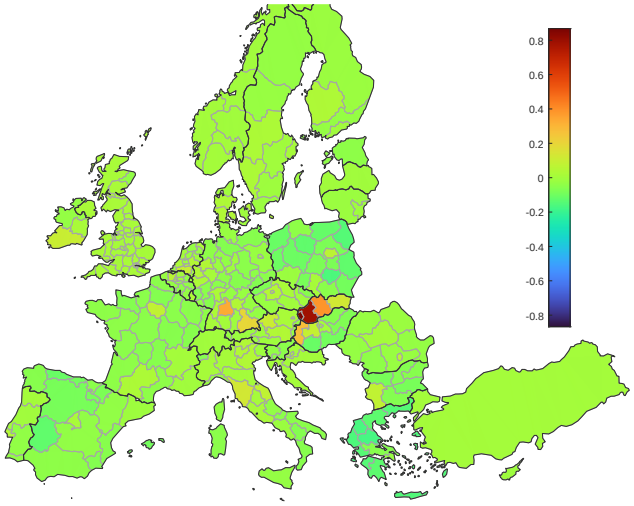
(c) Escalation vs. No Retaliation



(d) Difference (Escalation − No Retaliation)



(e) China FTA vs. No Retaliation



(f) Difference (China FTA − No Retaliation)

Notes: Percentage change in welfare (in consumption-equivalent terms) across regions for generation t^*. The left column presents scatter plots comparing the regional effects in each alternative scenario against the No Retaliation scenario. The right column maps the spatial distribution of these differences (Alternative Scenario − No Retaliation) in percentage points. To facilitate visualization, values beyond the color scale limits are shown saturated (this only affects Southern Ireland, IE05).

E Equilibrium equations and Dynamic Exact Hat Algebra

E.1 Summary of equilibrium equations

Input bundle:

$$c_{mst} = \left(\frac{R^K_{mt}}{\gamma_m \alpha_m}\right)^{\gamma_m \alpha_m} \left(\frac{w_{mt}}{\gamma_m(1-\alpha_m)}\right)^{\gamma_m(1-\alpha_m)} \prod_{r=1}^{S} \left(\frac{P_{mrt}}{\gamma^{rs}_m}\right)^{\gamma^{rs}_m} \tag{39}$$

Composite prices:

$$P_{dst} = \Gamma\left(\frac{\theta_2 - \eta_s + 1}{\theta_2}\right)^{\frac{1}{1-\eta_s}} \left[\sum_{o=1}^{J}\left(\sum_{m=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c^{1-\varphi}_{mst}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{\theta_2}{\theta_1}}\right]^{\frac{-1}{\theta_2}} \tag{40}$$

Final prices:

$$P_{ot} = \prod_{s=1}^{S}\left(\frac{P_{ost}}{\alpha_{Cos}}\right)^{\alpha_{Cos}} \tag{41}$$

$$P^I_{ot} = \prod_{s=1}^{S}\left(\frac{P_{ost}}{\alpha_{Ios}}\right)^{\alpha_{Ios}} \tag{42}$$

Expenditure shares (arm's-length trade):

$$s_{omdst} = \left(\frac{\Xi_{odst}}{\Xi_{dst}}\right)^{\theta_2}\left(\frac{\lambda_{ost}}{\Xi_{odst}\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c^{1-\varphi}_{mst}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1} \tag{43}$$

where $\Xi_{odst} = \left(\sum_{j=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{jdst}\tau_{jdst}\varrho_{ojst}c^{1-\varphi}_{jst}(\tilde{\kappa}_{ojst}\tau_{ojst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{1}{\theta_1}}$ and $\Xi_{dst} = \left[\sum_{o=1}^{J}\Xi^{\theta_2}_{odst}\right]^{\frac{1}{\theta_2}}$.

Arm's-length expenditure:

$$\begin{aligned} X^{AL}_{mrt} &= \alpha_{Cmr}(E^1_{mt} + E^2_{mt} + E^3_{mt} + E^G_{mt}) + \alpha_{Imr}E^I_{mt} \\ &+ \sum_{s=1}^{S}\left[(1-\varphi)\gamma^{rs}_m \sum_d \frac{s_{\cdot mdst}X^{AL}_{dst}}{\tau_{mdst}} + \varphi\sum_{m'}\frac{\gamma^{rs}_m}{\tau_{mm'st}}\sum_d \frac{s_{mm'dst}X^{AL}_{dst}}{\tau_{m'dst}}\right] \end{aligned} \tag{44}$$

Total trade:

$$X_{omdst} = \frac{s_{omdst}X^{AL}_{dst}}{\tau_{mdst}} + \mathbb{1}_{\{o=m\}}\varphi\frac{1}{\tau_{mdst}}\sum_{d'}\frac{s_{mdd'st}X^{AL}_{d'st}}{\tau_{dd'st}} \tag{45}$$

Gross value added:

$$VA_{mt} = \sum_s \left[(1-\varphi)\gamma_m \sum_d \frac{s_{\cdot mdst} X^{AL}_{dst}}{\tau_{mdst}} + \varphi \sum_{m'} \frac{\gamma_m}{\tau_{mm'st}} \sum_d \frac{s_{mm'dst} X^{AL}_{dst}}{\tau_{m'dst}} \right] \tag{46}$$

Wage bill:

$$(L^1_{mt} + L^2_{mt}) w_{mt} = (1-\alpha_m) VA_{mt} \tag{47}$$

Capital income:

$$K_{mt} R^K_{mt} = \alpha_m VA_{mt} \tag{48}$$

GDP:

$$GDP_{mt} = VA_{mt} + \sum_j \sum_s (\tau_{jmst} - 1) X_{jmst} \tag{49}$$

Savings:

$$S^1_{odt} = \max \left\{ 0,\ \beta w_{dt}(1-\iota_{dt}) - (1-\beta) \left[\frac{w_{dt+1}(1-\iota_{dt+1})}{R_{dt+1}} + \frac{\beta S^2_{ot} R_{ot+1}}{l^1_{ot} R_{dt+1}} \right] \right\} \tag{50}$$

$$S^1_{dt} = \sum_o \mu_{odt} l^1_{ot} S^1_{odt} \tag{51}$$

$$S^2_{dt} = \beta \left[w_{dt} L^2_{dt} (1-\iota_{dt}) + S^1_{dt-1} R_{dt} + \sum_o \mu_{odt-1} \beta S^2_{ot-1} R_{ot} \right] \tag{52}$$

$$S_{dt} = S^1_{dt} + S^2_{dt} \tag{53}$$

Final expenditure:

$$E^1_{odt} = w_{dt}(1-\iota_{dt}) - S^1_{odt} \tag{54}$$

$$E^1_{dt} = \sum_o \mu_{odt} l^1_{ot} E^1_{odt} \tag{55}$$

$$E^2_{dt} = (1-\beta) \left[w_{dt} L^2_{dt} (1-\iota_{dt}) + S^1_{dt-1} R_{dt} + \sum_o \mu_{odt-1} \beta S^2_{ot-1} R_{ot} \right] \tag{56}$$

$$E^3_{dt} = (1-\beta) S^2_{dt-1} R_{dt} \tag{57}$$

$$E^G_{dt} = L_{dt} \frac{E^G_{g(d)t}}{\sum_{d' \in \mathcal{G}(d)} \alpha^G_{d'd} L_{d't}} \tag{58}$$

$$E^I_{dt} = h_{dt} \sum_o b_{og(d)t} S_{ot} - (1-\delta_d) P^I_{dt} K_{dt} \tag{59}$$

Government consumption expenditure:

$$E_{gt}^{G} = \sum_{d \in \mathcal{J}(g)} \left(\iota_{dt} w_{dt} (L_{dt}^{1} + L_{dt}^{2}) + \sum_{j} \sum_{s} (\tau_{jdst} - 1) X_{jdst} \right) \tag{60}$$

Investment return:

$$R_{ot} = \left[\sum_{M} \left(r_{Mt} / \kappa_{oMt-1} \right)^{\epsilon} \right]^{\frac{1}{\epsilon}} \Gamma \left(1 - \frac{1}{\epsilon} \right) \tag{61}$$

Portfolio shares:

$$b_{oMt} = \frac{\left(r_{Mt+1} / \kappa_{oMt} \right)^{\epsilon}}{\sum_{f} \left(r_{ft+1} / \kappa_{oft} \right)^{\epsilon}} \tag{62}$$

Returns on capital:

$$r_{Mt} = \frac{P_{mt}^{I}}{P_{mt-1}^{I}} \left(\frac{R_{mt}^{K}}{P_{mt}^{I}} + 1 - \delta_{m} \right) \quad \forall m \in \mathcal{J}(M) \tag{63}$$

Investor composition:

$$g_{oMt} = \frac{b_{oMt} S_{ot} R_{ot+1}}{\sum_{j} b_{jMt} S_{jt} R_{jt+1}} \tag{64}$$

Capital stock in country M:

$$P_{Mt}^{I} K_{Mt+1} \equiv \sum_{m \in \mathcal{J}(M)} P_{mt}^{I} K_{mt+1} = \frac{1}{r_{Mt+1}} \sum_{o} b_{oMt} S_{ot} R_{ot+1} \tag{65}$$

Capital allocation within country:

$$P_{mt}^{I} K_{mt+1} = h_{mt} \sum_{m' \in \mathcal{J}(M)} P_{m't}^{I} K_{m't+1} \tag{66}$$

$$h_{mt} = \frac{\alpha_{m} \frac{VA_{mt+1}}{r_{Mt+1} - (1-\delta_{m}) P_{mt+1}^{I} / P_{mt}^{I}}}{\sum_{m' \in \mathcal{J}(M)} \alpha_{m'} \frac{VA_{m't+1}}{r_{Mt+1} - (1-\delta_{m'}) P_{m't+1}^{I} / P_{m't}^{I}}} \tag{67}$$

Young migration:

$$\mu_{odt} = \frac{\exp\left((1-\beta)\log\left(\frac{E^1_{odt}}{P_{dt}}\right) + \beta(1-\beta)\log\left((1-\beta)\frac{W^2_{odt+1}}{P_{dt+1}}\right) + \beta^2\log\left(\frac{S^2_{odt+1}R_{dt+2}}{P_{dt+2}}\right) - \log\left(\kappa^l_{odt}\right)\right)^{\frac{1}{\upsilon}}}{\sum_j \exp\left((1-\beta)\log\left(\frac{E^1_{ojt}}{P_{jt}}\right) + \beta(1-\beta)\log\left((1-\beta)\frac{W^2_{ojt+1}}{P_{jt+1}}\right) + \beta^2\log\left(\frac{S^2_{ojt+1}R_{jt+2}}{P_{jt+2}}\right) - \log\left(\kappa^l_{ojt}\right)\right)^{\frac{1}{\upsilon}}} \tag{68}$$

where $W^2_{odt} = w_{dt}(1-\iota_{dt}) + S^1_{odt-1}R_{dt} + \frac{\beta S^2_{ot-1}R_{ot}}{l^1_{ot-1}}$, and $S^2_{odt+1} = \beta W^2_{odt+1}$.

Population dynamics:

$$l^1_{dt} = l^2_{dt}\chi_{dt},\ L^3_{dt+2} = l^3_{dt+2} = L^2_{dt+1} = l^2_{dt+1} = L^1_{dt} \tag{69}$$

$$L^1_{dt} = \sum_o \mu_{odt} l^1_{ot} \tag{70}$$

E.2 Steady state

Suppose that, from some period onwards, productivity growth is constant over time (in particular, the exogenous productivity parameters λ_{ost} grow at a constant gross rate χ_λ), population grows at a constant gross rate across regions and time (χ_l), and all frictions remain constant. Suppose that, in addition, (i) bilateral tariffs are constant and government expenditure is a constant share of GDP, and (ii) the labor share of gross output, $\gamma_m(1-\alpha_m)$, is equalized across locations.

Under these conditions, there exists a steady state in which: (i) the spatial distribution of world population is constant; (ii) all aggregate prices, rental rates of capital, capital returns, average portfolio returns, and tax rates are constant; (iii) expenditure shares, portfolio shares, and migration shares are constant; (iv) GDP, expenditure, capital, and savings grow by a factor of $\chi \equiv \chi_\lambda^{\frac{1}{\gamma_m(1-\alpha_m)}}\chi_l$; and (v) real wages and consumption grow by a factor of χ/χ_l.

To verify point (i), it suffices to show that the end-of-period young population grows at the same rate everywhere, as this immediately implies the same is true for the remaining generations. Under constant migration shares, the end-of-period young population in region d at time t (L^1_{dt}) can be related to the previous period as follows:

$$L^1_{dt} = \sum_o \mu_{od} l^1_{ot} = \sum_o \mu_{od}(\chi_l L^1_{ot-1}) = \chi_l \sum_o \mu_{od} L^1_{ot-1}$$

Let $\mathbf{M}$ be a $J \times J$ matrix with typical (d,o) entry equal to $\chi_l \mu_{od}$, and let L^1_t be the vector of young populations in every region. Then, $L^1_t = \mathbf{M}L^1_{t-1}$. Under mild regularity conditions, the ratio L^1_{dt}/L^1_{dt-1} converges to χ_l for all d.[52] Hence, the spatial distribution of the world population converges to a stationary

[52] This follows from the Perron-Frobenius Theorem. Because $\sum_d \mu_{od} = 1$, the columns of $\mathbf{M}/\chi_l$ sum to 1, meaning it is a column-stochastic matrix with a dominant eigenvalue of exactly 1. Therefore, $\mathbf{M}$ has a unique dominant eigenvalue of χ_l. Assuming the initial population vector L^1_0 has a non-zero component in the direction of the dominant eigenvector,

solution.

The remaining points can be easily verified by using eqs. (39) to (70).

E.3 Dynamic Exact Hat Algebra: Changes over time

Input bundle:[53]

$$\dot{c}_{mst} = \left(\dot{P}^I_{mt} \frac{\dot{R}^K_{mt}}{\dot{P}^I_{mt}} \right)^{\gamma_m \alpha_m} \dot{w}_{mt}^{\gamma_m (1-\alpha_m)} \prod_{r=1}^{S} \dot{P}_{mrt}^{\gamma^{rs}_m} \tag{71}$$

Composite price:

$$\dot{P}_{dst} = \dot{\Xi}^{-1}_{dst} \tag{72}$$

$$\dot{\Xi}_{dst} = \left[\sum_{o=1}^{J} s_{o \cdot ds1} \dot{\Xi}^{\theta_2}_{odst} \right]^{\frac{1}{\theta_2}} \tag{73}$$

$$\dot{\Xi}_{odst} = \left(\sum_{m=1}^{J} s_{m|ods1} \left(\frac{\dot{\lambda}_{ost}}{\dot{\tilde{\kappa}}_{mdst} \dot{\tau}_{mdst} \dot{\varrho}_{omst} \dot{c}^{1-\varphi}_{mst} \left(\dot{\tilde{\kappa}}_{omst} \dot{\tau}_{omst} \dot{c}_{ost} \right)^{\varphi}} \right)^{\theta_1} \right)^{\frac{1}{\theta_1}} \tag{74}$$

where $s_{m|odst} \equiv \frac{s_{omdst}}{s_{o \cdot dst}}$, $s_{o \cdot dst} \equiv \sum_m s_{omdst}$.

Final prices:

$$\dot{P}_{ot} = \prod_{s=1}^{S} \dot{P}^{\alpha_{Cos}}_{ost} \tag{75}$$

$$\dot{P}^I_{ot} = \prod_{s=1}^{S} \dot{P}^{\alpha_{Ios}}_{ost} \tag{76}$$

Expenditure shares (arm's-length trade):

$$\dot{s}_{omdst} = \left(\frac{\dot{\Xi}_{odst}}{\dot{\Xi}_{dst}} \right)^{\theta_2} \left(\frac{\dot{\lambda}_{ost}}{\dot{\Xi}_{odst} \dot{\tilde{\kappa}}_{mdst} \dot{\tau}_{mdst} \dot{\varrho}_{omst} \dot{c}^{1-\varphi}_{mst} \left(\dot{\tilde{\kappa}}_{omst} \dot{\tau}_{omst} \dot{c}_{ost} \right)^{\varphi}} \right)^{\theta_1} \tag{77}$$

Capital income:

$$\frac{\dot{R}^K_{mt}}{\dot{P}^I_{mt}} \dot{K}_{mt} \dot{P}^I_{mt} = \dot{VA}_{mt} \tag{78}$$

$L^1_t = \mathbf{M}^t L^1_0 \Rightarrow L^1_{dt} / L^1_{dt-1} \to \chi_l$.

[53] Backing out $\frac{R^K_{ot}}{P^I_{ot}}$ from the data is a feasible task thanks to equation (48). However, separately identifying R^K_{ot} is unnecessary, as it is not directly an object of interest and the model can easily be rewritten in terms of $\frac{R^K_{ot}}{P^I_{ot}}$. This is the approach I take from now on.

Investment return:

$$\dot{R}_{ot} = \left(\sum_{M} b_{oM0} \left(\frac{\dot{r}_{Mt}}{\dot{\kappa}_{oMt-1}} \right)^{\epsilon} \right)^{\frac{1}{\epsilon}} \tag{79}$$

In some cases it is more convenient to work with the following equation:

$$S_{ot-1} R_{ot} = \sum_{M} g_{oMt-1} \sum_{m \in \mathcal{J}(M)} \left(\alpha_m V A_{mt} + P^I_{mt} K_{mt} \left(1 - \delta_m \right) \right) \tag{80}$$

This equation simply states that aggregate investment income must be equal to income generated by owned capital.

Portfolio shares:

$$\dot{b}_{oMt} = \dot{R}_{ot}^{-\epsilon} \left(\dot{r}_{Mt+1} / \dot{\kappa}_{oMt} \right)^{\epsilon} \tag{81}$$

Returns on capital:

$$r_{Mt} = \frac{\dot{P}^I_{mt}}{\dot{P}^I_{mt-1}} \left(\frac{\dot{R}^K_{mt}}{\dot{P}^I_{mt}} \frac{R^K_{m1}}{P^I_{m1}} + 1 - \delta_m \right) \quad \forall m \in \mathcal{J}(M) \tag{82}$$

However, at $t = 1$, ex post returns are given by Equation (26):

$$r_{Mt} \sum_{m \in \mathcal{J}(M)} P^I_{mt-1} K_{mt} = \sum_{m \in \mathcal{J}(M)} P^I_{mt} K_{mt} \left(\frac{R^K_{mt}}{P^I_{mt}} + 1 - \delta_m \right) \tag{83}$$

Young migration:

$$\mu_{odt} = \frac{\mu_{od1} \left(\dot{E}^1_{odt} / \dot{P}_{dt} \right)^{\frac{1-\beta}{\upsilon}} \left(\frac{W^2_{odt+1} / \dot{P}_{dt+1}}{W^2_{od2} / \dot{P}_{d2}} \right)^{\frac{\beta(1-\beta)}{\upsilon}} \left(\frac{W^2_{odt+1} \dot{R}_{dt+2} / \dot{P}_{dt+2}}{W^2_{od2} \dot{R}_{d3} / \dot{P}_{d3}} \right)^{\frac{\beta^2}{\upsilon}} \left(\dot{\kappa}^l_{odt} \right)^{\frac{-1}{\upsilon}}}{\sum_j \mu_{oj1} \left(\dot{E}^1_{ojt} / \dot{P}_{jt} \right)^{\frac{1-\beta}{\upsilon}} \left(\frac{W^2_{ojt+1} / \dot{P}_{jt+1}}{W^2_{oj2} / \dot{P}_{j2}} \right)^{\frac{\beta(1-\beta)}{\upsilon}} \left(\frac{W^2_{ojt+1} \dot{R}_{jt+2} / \dot{P}_{jt+2}}{W^2_{oj2} \dot{R}_{j3} / \dot{P}_{j3}} \right)^{\frac{\beta^2}{\upsilon}} \left(\dot{\kappa}^l_{ojt} \right)^{\frac{-1}{\upsilon}}} \tag{84}$$

where $W^2_{odt} = w_{d1} \dot{w}_{dt} (1 - \iota_{dt}) + S^1_{odt-1} R_{d1} \dot{R}_{dt} + \frac{\beta S^2_{ot-1} R_{o1} \dot{R}_{ot}}{l^1_{ot-1}}$.

The remaining equations (equations (44) - (47), (49) - (60), (64) - (67), and (69) - (70)) do not need to be adjusted.

Note that the reference period for portfolio shares is $t = 0$. This is simply convenient notation because b_{OM0} (and not b_{OM1}) is calibrated from the data.

E.4 Dynamic Exact Hat Algebra: Relative changes

Input bundle:

$$\hat{c}_{mst} = \left(\hat{P}^I_{mt} \frac{\hat{R}^K_{mt}}{\hat{P}^I_{mt}} \right)^{\gamma_m \alpha_m} \hat{w}_{mt}^{\gamma_m (1-\alpha_m)} \prod_{r=1}^{S} \hat{P}_{mrt}^{\gamma^{rs}_m} \tag{85}$$

Composite price:

$$\hat{P}_{dst} = \hat{\Xi}^{-1}_{dst} \tag{86}$$

$$\hat{\Xi}_{dst} = \left[\sum_{o=1}^{J} s_{o \cdot dst} \hat{\Xi}^{\theta_2}_{odst} \right]^{\frac{1}{\theta_2}} \tag{87}$$

$$\hat{\Xi}_{odst} = \left(\sum_{m=1}^{J} s_{m|odst} \left(\frac{\hat{\lambda}_{ost}}{\hat{\tilde{\kappa}}_{mdst} \hat{\tau}_{mdst} \hat{\varrho}_{omst} \hat{c}^{1-\varphi}_{mst} \left(\hat{\tilde{\kappa}}_{omst} \hat{\tau}_{omst} \hat{c}_{ost} \right)^{\varphi}} \right)^{\theta_1} \right)^{\frac{1}{\theta_1}} \tag{88}$$

where $s_{m|odst} \equiv \frac{s_{omdst}}{s_{o \cdot dst}}$, $s_{o \cdot dst} \equiv \sum_m s_{omdst}$.

Final prices:

$$\hat{P}_{ot} = \prod_{s=1}^{S} \hat{P}^{\alpha_{Cos}}_{ost} \tag{89}$$

$$\hat{P}^I_{ot} = \prod_{s=1}^{S} \hat{P}^{\alpha_{Ios}}_{ost} \tag{90}$$

Expenditure shares (arm's-length trade):

$$\hat{s}_{omdst} = \left(\frac{\hat{\Xi}_{odst}}{\hat{\Xi}_{dst}} \right)^{\theta_2} \left(\frac{\hat{\lambda}_{ost}}{\hat{\Xi}_{odst} \hat{\tilde{\kappa}}_{mdst} \hat{\tau}_{mdst} \hat{\varrho}_{omst} \hat{c}^{1-\varphi}_{mst} \left(\hat{\tilde{\kappa}}_{omst} \hat{\tau}_{omst} \hat{c}_{ost} \right)^{\varphi}} \right)^{\theta_1} \tag{91}$$

Capital income:

$$\frac{\hat{R}^K_{mt}}{\hat{P}^I_{mt}} \hat{K}_{mt} \hat{P}^I_{mt} = \widehat{VA}_{mt} \tag{92}$$

Investment return:

$$\hat{R}_{ot} = \left(\sum_{M} b_{oMt-1} \left(\frac{\hat{r}_{Mt}}{\hat{\kappa}_{oMt-1}} \right)^{\epsilon} \right)^{\frac{1}{\epsilon}} \tag{93}$$

However, this equation will not hold at $t = 1$, as ex-post returns are potentially different from expected

returns at $t = 0$. In that period, the relevant equation is:

$$S'_{ot-1}R'_{ot} = \sum_M g'_{oMt-1} \sum_{m \in \mathcal{J}(M)} \left(\alpha_m V A'_{mt} + \hat{P}^I_{mt} \hat{K}_{mt} P^I_{mt} K_{mt} \left(1 - \delta_m\right) \right) \tag{94}$$

This equation –which always holds– simply states that aggregate investment income must be equal to income generated by owned capital.

Portfolio shares:

$$\hat{b}_{oMt} = \hat{R}^{-\epsilon}_{ot+1} \left(\hat{r}_{Mt+1} / \hat{\kappa}_{oMt} \right)^{\epsilon} \tag{95}$$

Returns on capital:

$$r'_{Mt} = \frac{\hat{P}^I_{mt}}{\hat{P}^I_{mt-1}} \frac{P^I_{mt}}{P^I_{mt-1}} \left(\frac{\hat{R}^K_{mt}}{\hat{P}^I_{mt}} \frac{R^K_{mt}}{P^I_{mt}} + 1 - \delta_m \right) \quad \forall m \in \mathcal{J}(M) \tag{96}$$

However, at $t = 1$, ex post returns are given by Equation (26):

$$r'_{Mt} \sum_{m \in \mathcal{J}(M)} P^I_{mt-1} K_{mt} = \sum_{m \in \mathcal{J}(M)} \hat{P}^I_{mt} P^I_{mt} K_{mt} \left(\frac{R^K_{mt}}{P^I_{mt}} \frac{\hat{R}^K_{mt}}{\hat{P}^I_{mt}} + 1 - \delta_m \right) \tag{97}$$

Young migration:

$$\mu_{odt}{}' = \frac{\mu_{odt} \left(\hat{E}^1_{odt} / \hat{P}_{dt} \right)^{\frac{1-\beta}{\upsilon}} \left(\hat{W}^2_{odt+1} / \hat{P}_{dt+1} \right)^{\frac{\beta(1-\beta)}{\upsilon}} \left(\hat{W}^2_{odt+1} \hat{R}_{dt+2} / \hat{P}_{dt+2} \right)^{\frac{\beta^2}{\upsilon}} \left(\hat{\kappa}^l_{odt} \right)^{\frac{-1}{\upsilon}}}{\sum_j \mu_{ojt} \left(\hat{E}^1_{ojt} / \hat{P}_{jt} \right)^{\frac{1-\beta}{\upsilon}} \left(\hat{W}^2_{ojt+1} / \hat{P}_{jt+1} \right)^{\frac{\beta(1-\beta)}{\upsilon}} \left(\hat{W}^2_{ojt+1} \hat{R}_{jt+2} / \hat{P}_{jt+2} \right)^{\frac{\beta^2}{\upsilon}} \left(\hat{\kappa}^l_{ojt} \right)^{\frac{-1}{\upsilon}}} \tag{98}$$

where $W^2_{odt} = w_{dt} \hat{w}_{dt} (1 - \iota'_{dt}) + S^1_{odt-1}{}' R_{dt} \hat{R}_{dt} + \frac{\beta S^2_{ot-1}{}' R_{ot} \hat{R}_{ot}}{l^1_{ot-1}{}'}$.

Welfare

I now derive an expression to measure welfare changes by following Caliendo, Dvorkin, and Parro (2019). For a young agent, expected lifetime utility is:[54]

$$\mathbb{E}_t v^{1i}_{ot} = \upsilon \log \left[\sum_d \exp\Big((1-\beta) \log\big(C^1_{odt}\big) + \beta(1-\beta) \log\big(C^2_{odt+1}\big) + \beta^2 u^3_{odt+2} - \log\Big(\kappa^l_{odt}\Big) \Big)^{\frac{1}{\upsilon}} \right]$$

where $u^3_{odt} = \log\left(\frac{S^2_{odt-1} R_{dt}}{P_{dt}} \right) + \kappa_u$ is the old age indirect utility.

[54] This expression follows from standard properties of the Type-I Extreme Value distribution. See, for instance, Chapter 3 of Train (2009).

Let $\Phi_{odt} = (1-\beta)\log\big(C^1_{odt}\big) + \beta(1-\beta)\log\big(C^2_{odt+1}\big) + \beta^2 u^3_{odt+2}$. From equation (9) for $d = o$ we get:

$$-\log(\mu_{oot}) = \log\sum_j \exp\Big(\Phi_{ojt} - \Phi_{oot} - \log\Big(\kappa^l_{ojt}\Big)\Big)^{\frac{1}{\upsilon}}$$

Combining the last two equations,

$$\begin{aligned}\mathbb{E}_t v^{1i}_{ot} &= \Phi_{oot} + \upsilon\log\sum_j \exp\Big(\Phi_{ojt} - \Phi_{oot} - \log\Big(\kappa^l_{ojt}\Big)\Big)^{\frac{1}{\upsilon}} \\ &= \Phi_{oot} - \upsilon\log(\mu_{oot})\end{aligned}$$

To measure changes in welfare, I define Υ_{ot}, which is the common change in consumption (and also old bequests) in every period that would exactly offset any welfare change experienced by generation t in o relative to the baseline. Hence,

$$\begin{aligned}\mathbb{E}_t v^{1i\prime}_{ot} &= \upsilon\log\left[\sum_d \exp\Big(\log(\Upsilon_{ot}) + (1-\beta)\log\big(C^1_{odt}\big) + \beta(1-\beta)\log\big(C^2_{odt+1}\big) + \beta^2 u^3_{odt+2} - \log\Big(\kappa^l_{odt}\Big)\Big)^{\frac{1}{\upsilon}}\right] \\ &= \log(\Upsilon_{ot}) + \Phi_{oot} - \upsilon\log(\mu_{oot})\end{aligned}$$

Given that $\mathbb{E}_t v^{1i\prime}_{ot} = \Phi'_{oot} - \upsilon\log(\mu_{oot}{}')$, we have that $\log(\Upsilon_{ot}) + \Phi_{oot} - \upsilon\log(\mu_{oot}) = \Phi'_{oot} - \upsilon\log(\mu_{oot}{}')$. Hence,

$$\Upsilon_{ot} = (\hat{\mu}_{oot})^{-\upsilon}\left(\hat{C}^1_{oot}\right)^{1-\beta}\left(\hat{C}^2_{oot+1}\right)^{\beta(1-\beta)}\left(\hat{U}^3_{oot+2}\right)^{\beta^2}$$

where $U^3_{odt} \equiv \exp\big(u^3_{odt}\big)$. Given that the old consume a constant share of their wealth, $\hat{U}^3_{odt} = \hat{C}^3_{odt}$. So we can simply write

$$\Upsilon_{ot} = (\hat{\mu}_{oot})^{-\upsilon}\left(\hat{C}^1_{oot}\right)^{1-\beta}\left(\hat{C}^2_{oot+1}\right)^{\beta(1-\beta)}\left(\hat{C}^3_{oot+2}\right)^{\beta^2} \tag{99}$$

This equation says that to assess welfare effects for generation t in o it suffices to look at the welfare of those who do not migrate and the change in the share of stayers, which summarizes all the information regarding the welfare of migrants relative to stayers.

F Calibration details

F.1 Trade flows

The main source for estimating trade flows is the FIGARO-REG database (Rueda-Cantuche, Lopez Alvarez, and Galiano Bastarrica, 2017), which provides an I–O table at the regional level in 2017. I obtain value added shares γ_m by aggregating across industries and then dividing value added by gross production. I estimate the sector composition of intermediate goods $\frac{\gamma_m^{rs}}{1-\gamma_m}$ as the share of expenditure of sector s in sector r over the total intermediate expenditure of sector s. Similarly, I estimate the sector composition of final goods α_{Cms}, α_{Ims} as the share of expenditure of the corresponding final good of region m in sector s over its total expenditure.[55]

To estimate the trade flows in 2023, I combine this dataset with inter-country I-O tables from Eurostat. First, I assume that total expenditure in 2023 in region d, country D is

$$X_{\cdot ds2023} = \frac{X_{\cdot ds2017}\frac{GDP_{d2023}}{GDP_{d2017}}}{\sum_{d'\in D} X_{\cdot d's2017}\frac{GDP_{d'2023}}{GDP_{d'2017}}} X_{\cdot Ds2023}$$

This is close to assuming that total expenditure grows at the same rate as GDP, but it ensures aggregation consistency at the country level as total expenditure at the country level matches $X_{\cdot Ds2023}$ (taken from Eurostat). Second, I do the same for total sales. Third, I assume that trade flows from m to d in sector s in 2023 are given by $X_{mds2023} = \frac{X_{mds2017}a_{ms}b_{MDs}}{\sum_{m'} X_{m'ds2017}a_{m's}b_{M'Ds}} X_{\cdot ds2023}$, where a_{ms} is an origin-sector component, and b_{MDs} is bilateral at the country level and sector-specific. Even if these unobservable components cannot be identified, the matrix of trade flows $X_{mds2023}$ is uniquely pinned down with the described data and has the following properties: (i) Country-level aggregation $X_{MDs2023} = \sum_{m\in M}\sum_{d\in D} X_{mds2023}$, (ii) total regional expenditure $X_{\cdot ds2023} = \sum_m X_{mds2023}$, (iii) total regional sales $X_{m\cdot s2023} = \sum_d X_{mds2023}$.

F.2 Constrained calibration

Without additional assumptions, calibrating the baseline model and simulating counterfactuals using Appendix G requires knowing how much firms from o sold in market d through subsidiaries located in m in 2023 for any triplet. Data with such an extreme degree of detail is not available yet. I therefore need to estimate such data.

I first construct a regional target for multinational production. Let

$$T_{mds} \equiv \sum_o X_{omds}, \qquad A_{oms} \equiv \sum_d \frac{s_{omds}X_{ds}^{AL}}{\tau_{mds}}$$

denote trade from region m to region d in sector s, and non-headquarters multinational production by firms from o through plants located in m in that sector, respectively (I suppress the time index $t = 1$ for clarity). Multinational production is then $MP_{oms} \equiv \sum_d X_{omds} = A_{oms} + \mathbb{1}_{\{o=m\}}\varphi\sum_d \frac{A_{mds}}{\tau_{mds}}$.

[55] Investment includes gross fixed capital formation and changes in inventories.

Define $MP_{OMs} \equiv \sum_{o \in O} \sum_{m \in M} MP_{oms}$ and $Q_{ms} \equiv \sum_d T_{mds}$. I observe regional trade, T^{data}_{mds}, and country-level multinational production, MP^{data}_{OMs}. The goal is to construct a regional target for A_{oms} that satisfies the accounting and feasibility restrictions implied by the model.

Regional accounting requires

$$Q_{ms} = \sum_o A_{oms} + \varphi \sum_d \frac{A_{mds}}{\tau_{mds}} \qquad \forall m, s \tag{100}$$

The first term is arm's length production through plants located in m, while the second term is headquarters production by firms from m shipped to their plants in all regions d. Pairwise feasibility requires:[56]

$$\varphi \frac{A_{oms}}{\tau_{oms}} \leq T^{data}_{oms} \qquad \forall o, m, s \tag{101}$$

In principle, there are infinitely many regional allocations satisfying these restrictions. I therefore construct a prior $\bar{A}_{oms}$ using the raw country-level MP data and observed regional trade.

I guess that A_{oms} is proportional to bilateral trade T_{oms} (which I take directly from the data, $T_{mds} = T^{data}_{mds}$), so $\frac{A_{oms}}{A_{OMs}} = \frac{T_{oms}}{T_{OMs}}$, and that country-level MP is perfectly matched ($MP_{OMs} = MP^{data}_{OMs}$). This implies:[57]

$$\bar{A}_{oms} = \begin{cases} \frac{T^{data}_{oms}}{T^{data}_{OMs}} MP^{data}_{OMs} & \text{if } o \in O,\ m \in M,\ O \neq M \\ \max\left\{0, \frac{T^{data}_{oms}}{T^{data}_{OMs}} \frac{MP^{data}_{OOs} - \varphi \sum_{o' \in O} \sum_{m' \notin O} \frac{\bar{A}_{o'm's}}{\tau_{o'm's}}}{1+\varphi}\right\} & \text{if } o, m \in O \end{cases}$$

The calibrated regional target is the feasible allocation closest to this prior. Specifically, for each sector s, I solve the following problem:

$$\begin{aligned} \min_{\{A_{oms}\}_{o,m}} \quad & \sum_o \sum_m \left(A_{oms} - \bar{A}_{oms}\right)^2 \\ \text{s.t.} \quad & Q_{ms} = \sum_o A_{oms} + \varphi \sum_d \frac{A_{mds}}{\tau_{mds}} \qquad \forall m, \\ & 0 \leq A_{oms} \leq \tau_{oms} \chi \frac{T^{data}_{oms}}{\varphi} \qquad \forall o, m \end{aligned}$$

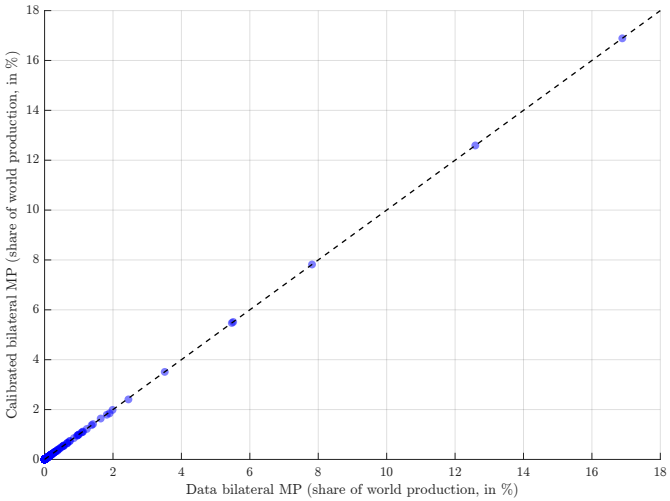
where $\chi = 0.99$. I use the raw country-level MP data only to construct the prior $\bar{A}_{oms}$; I do not impose exact matching of MP^{data}_{OMs} as a constraint. However, the calibrated country-level multinational production turns out to be virtually identical to the raw data, with an $R^2 \approx 1$ (see Figure F.17).

[56] To see this, note that Equation (20) implies that T_{mds} can be written as:

$$T_{mds} = \frac{s_{\cdot mdst} X^{AL}_{dst}}{\tau_{mdst}} + \varphi \frac{A_{mds}}{\tau_{mds}}$$

[57] The second case uses the fact that $MP_{OOs} = A_{OOs} + \varphi \sum_d \sum_m \frac{A_{mds}}{\tau_{mds}} = (1+\varphi) A_{OOs} + \varphi \sum_{o \in O} \sum_{d \notin O} \frac{A_{ods}}{\tau_{ods}}$.

Figure F.17: Multinational production: data and calibration



Notes: This figure compares the country-level multinational production in the calibration (y-axis) with the raw data (x-axis).

Given the projected target A_{oms}, I calibrate the structural expenditure shares. Define

$$x_{mds} \equiv \left(\frac{1}{\tilde{\kappa}_{mds}\tau_{mds}c_{ms}^{1-\varphi}}\right)^{\theta_1},$$
$$q_{oms} \equiv \left(\frac{\lambda_{os}}{c_{os}^{\varphi^2}}\right)^{\theta_1} \varrho_{oms}^{-\theta_1} x_{oms}^{\varphi}.$$

Then $\Xi_{ods}^{\theta_1} = \sum_{j=1}^{J} q_{ojs}x_{jds}$ and, using Equation (43), expenditure shares can be written as

$$s_{omds} = \frac{\left(\Xi_{ods}^{\theta_1}\right)^{\theta_2/\theta_1 - 1}}{\sum_{\ell=1}^{J}\left(\Xi_{\ell ds}^{\theta_1}\right)^{\theta_2/\theta_1}} q_{oms}x_{mds}. \tag{102}$$

Combining x_{mds} and q_{oms}, there are $2J^2$ unknowns for each sector. They are jointly identified only up to scale.[58] Therefore one can impose $2J$ normalizations per sector, leaving $2J^2 - 2J = 2J(J-1)$ free objects. These are disciplined by $J(J-1)$ independent regional trade shares, $\frac{T_{mds}^{data}}{T_{\cdot ds}^{data}}$, and $J(J-1)$ independent regional MP shares, $\frac{MP_{oms}}{MP_{\cdot ms}}$ (implied by the estimated A_{oms}).

The calibration proceeds as follows. First, I guess x_{mds} and q_{oms}, and compute s_{omds} from Equation (102). Second, I recover arm's-length expenditure from Equation (19).[59] Third, I use Equation (20) to compute model-implied trade shares and regional MP shares. Lastly, I update x_{mds} to match regional trade shares

[58] In particular, for any positive $\{a_{ds}\}_{d,s}$ and $\{b_{ms}\}_{m,s}$, the transformation

$$x'_{mds} = a_{ds}b_{ms}^{-1}x_{mds}, \qquad q'_{oms} = b_{ms}q_{oms}$$

leaves all s_{omds} unchanged.

[59] To see this, define $D_{ds} \equiv \sum_m \frac{s_{\cdot mds}}{\tau_{mds}}$, $\quad M_{dd',s} \equiv \sum_m \frac{s_{mdd's}}{\tau_{mds}\tau_{dd's}}$.

Summing Equation (19) across origins m gives

$$X_{ds} = D_{ds}X_{ds}^{AL} + \varphi \sum_{d'} M_{dd',s}X_{d's}^{AL}$$

and q_{oms} to match regional MP shares until convergence.

F.3 Asset portfolios

After constructing the baseline bilateral investment positions (by combining PIP, DIP, and domestic holdings, and restating them from residency to nationality), I obtain unadjusted investor composition shares (g_{OM}, such that $\sum_O g_{OM} = 1$). I use these unadjusted bilateral shares to distribute the aggregate capital stock of the host country (from the Penn World Table) among investors, leaving the unadjusted investor composition unaltered.

To ensure macroeconomic consistency of the net foreign asset position of each country with the official Net International Investment Position (NIIP) from the Balance of Payments, I introduce an investor-specific scaling factor, η_O. The adjusted ownership share $\tilde{g}_{OM}$ is calculated as:

$$\tilde{g}_{OM} = \frac{\eta_O g_{OM}}{\sum_i \eta_i g_{iM}} \tag{103}$$

This formulation guarantees that the shares of any country's capital continue to sum to one ($\sum_O \tilde{g}_{OM} = 1$). The vector of η is chosen such that the implied net position of every country exactly matches its targeted $NIIP_O$. Finally, any global discrepancy in the reported official NIIP data is assigned to the Rest of the World aggregate to ensure that global net positions sum to exactly zero.

F.4 Algorithm

In this section, I describe the algorithm I use to solve for the equilibrium in the baseline economy. I then explain how I adapt the algorithm to solve for the counterfactual equilibria.

Step 1. Guess.

I guess wages $\{w_{mt}\}_{m,t}$, returns on capital $\{r_{Mt}\}_{M,t}$, labor income tax rates $\{\iota_{mt}\}_{m,t}$, migration $\{\mu_{odt}\}_{o,d,t}$, and tariff revenues.

Step 2. Population and value added.

Given initial population and the migration matrix, I compute population dynamics and employment from Equations (69) and (70). Combined with the guess on wages, I recover VA from Equation (47).

In vector form,

$$\mathbf{X}_s = (\mathbf{D}_s + \varphi \mathbf{M}_s)\, \mathbf{X}_s^{AL}$$

where $\mathbf{D}_s$ is diagonal with d-th diagonal element D_{ds}. Hence,

$$\mathbf{X}_s^{AL} = (\mathbf{D}_s + \varphi \mathbf{M}_s)^{-1}\, \mathbf{X}_s.$$

Step 3. Initial returns on capital and portfolio composition.

Given the initial value of the stock of capital $K_{m1}P^I_{m1}$ and VA, I compute the initial real rental rate of capital $\frac{R^K_{m1}}{P^I_{m1}}$ from Equation (48). I can then recover initial returns on capital r_{M1} from Equation (83) by assuming $P^I_{m0} = P^I_{m1}$, and I also recover previous savings S_{m0} from Equation (80).[60] Lastly, initial portfolio composition b_{oM0} is retrieved using Equation (29).

Step 4. β**.**

β is chosen such that US savings grow at the steady state rate between $t = 0$ and $t = 1$, employing Equations (50) to (53). Since determining young savings requires knowing future returns R_{m2}, in the first iteration I guess $R_{mt} = R_{m1}$ for all t.

The next steps (5 to 7) are solved sequentially for each period under a single loop.

Step 5. Input bundle costs and composite prices.

Since these variables are relative to the initial period, this step is omitted for $t = 1$. Input bundle costs ($\dot{c}_{mst}$), composite prices ($\dot{P}_{mrt}$), and final investment prices ($\dot{P}^I_{mt}$) are simultaneously computed using a fixed point algorithm based on Equations (71) to (74) and (76). After convergence, final consumption prices are computed from Equation (75), and the numéraire normalization is implemented (inflation in the Euro Area is zero). Given $K_{mt}P^I_{mt-1}$, I can then compute $K_{mt}P^I_{mt}$.

Step 6. Investment returns and savings.

Investment returns are obtained from Equation (80), which ensures that aggregate investment income equals the income generated by capital. Savings are computed from Equations (50) to (53).

Step 7. Returns on capital.

I guess the vector of returns on capital in the next period r_{Mt+1} and use Broyden's method to ensure that the (vector of) demand for capital generated by the guess leads to a stock of capital in the following period that exactly delivers the guessed returns. Specifically, I first compute portfolio shares using Equations (79) and (81). I then compute the implied capital stock from Equation (65). Given the guess on VA at $t + 1$, returns on capital in the next period are obtained from Equations (48) and (63). Hence, this step also delivers portfolio shares $\dot{b}_{oMt}$, capital in the next period $K_{mt+1}P^I_{mt}$. I can also compute the investor composition for the next period (from Equation (64)) and how capital is distributed within country h_{mt}.

[60] The initial savings S_{m0} are distributed across generations (S^1_{m0}, S^2_{m0}) so that relative per capita wealth $\left(\frac{S^2_{mt}/L^2_{mt}}{S^1_{mt}/L^1_{mt}}\right)$ is as in the long run.

Step 8. Final expenditure.

The guess on tariff revenues from the previous iteration allows me to compute final consumption expenditure and final investment expenditure for all periods by employing Equations (54) to (60).

Step 9. Expenditure shares, arm's-length expenditure, and total trade.

Expenditure shares are computed from Equation (43). To obtain arm's-length expenditure, I start from Equation (44):

$$X_{mrt}^{AL} = E_{mrt} + \sum_{s=1}^{S} \left[(1-\varphi)\gamma_m^{rs} \sum_d \frac{s_{\cdot mdst}}{\tau_{mdst}} X_{dst}^{AL} + \varphi \sum_{m'} \frac{\gamma_m^{rs}}{\tau_{mm'st}} \sum_d \frac{s_{mm'dst}}{\tau_{m'dst}} X_{dst}^{AL} \right]$$

For fixed t, define the $J \times J$ matrices for each pair of sectors r, s:

$$\left(\mathcal{B}_{rs,t}^{(1)}\right)_{md} \equiv (1-\varphi)\gamma_m^{rs} \frac{s_{\cdot mdst}}{\tau_{mdst}}$$
$$\left(\mathcal{B}_{rs,t}^{(2)}\right)_{md} \equiv \varphi\gamma_m^{rs} \sum_{m'} \frac{s_{mm'dst}}{\tau_{mm'st}\tau_{m'dst}}$$

The first matrix captures intermediate demand for arm's-length inputs produced in m and used by destination d. The second matrix captures headquarters input requirements: firms from m supply headquarters inputs to their affiliates located in m', whose output is ultimately purchased by destination d.

Define the (r, s) block of $\mathcal{B}_t \in \mathbb{R}^{JS \times JS}$ as

$$\mathcal{B}_{rs,t} \equiv \mathcal{B}_{rs,t}^{(1)} + \mathcal{B}_{rs,t}^{(2)}$$

Stack sectors into a single vector:

$$x_t^{AL} \equiv \text{vec}(X_t^{AL}) = \begin{bmatrix} X_{1,t}^{AL} \\ \vdots \\ X_{S,t}^{AL} \end{bmatrix} \in \mathbb{R}^{JS}, \qquad e_t \equiv \text{vec}(E_t)$$

Then Equation (44) is equivalent to the linear system $x_t^{AL} = e_t + \mathcal{B}_t x_t^{AL}$. Hence arm's-length expenditure can be solved in one step as $x_t^{AL} = (I_{JS} - \mathcal{B}_t)^{-1} e_t$.

After solving for X_{dst}^{AL}, total trade is recovered from Equation (45).

Step 10. Value added and tariff revenues.

Gross value added is computed from Equation (46), which immediately delivers a new set of wages using Equation (47). Tariff revenues are computed as $\sum_{d \in \mathcal{J}(g)} \sum_j \sum_s (\tau_{jdst} - 1) X_{jdst}$. By adding them to value added, I compute GDP (Equation (49)).

Step 11. Migration and labor income taxes.

New migration shares are computed using Equation (84). Using Equation (60), I compute the change in the labor income tax rate ι_{dt} that exactly matches the target ratio of government expenditure to GDP $\frac{E^G_{gt}}{GDP_{gt}}$.

Step 12. Convergence check and update guess.

I check if the new wages, returns on capital, labor income tax rates, and migration are within a small tolerance from the corresponding guesses. If at least one of them is not, I update the guess and go back to Step 2 until convergence.

Counterfactuals.

The algorithm I use to solve for the counterfactual equilibria is analogous to the one described here, with two main differences. First, I replace the equations from Appendix E.3 with the corresponding equations from Appendix E.4. Second, steps 3 and 4 are omitted, and initial counterfactual returns on capital r'_{M1} are obtained from Equation (97) after Step 5.

G Additional derivations

G.1 Expenditure shares and composite prices

The CDF of p_{dst}^{-1} is given by

$$F(p_{dst}^{-1}) = \exp\left[-\sum_{o=1}^{J}\left(\sum_{m=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}(p_{omdst}^{-1})^{-\theta_1}\right)^{\frac{\theta_2}{\theta_1}}\right]$$
$$= \exp\left[-G(p_{11dst}^{\theta_2},\ldots,p_{J1dst}^{\theta_2},p_{12dst}^{\theta_2},\ldots,p_{JJdst}^{\theta_2})\right]$$

where $G(x_1,...,x_M) := \sum_{o=1}^{J}\left(\sum_{m=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}x_{omst}^{\frac{\theta_1}{\theta_2}}\right)^{\frac{\theta_2}{\theta_1}}$.

Then, by Theorem 1 in McFadden (1977),

$$\mathbb{P}\left(p_{omdst} = \min_{ij} p_{ijdst}\right) = \mathbb{P}\left(-\theta_2\ln(p_{omdst}) = \max_{ij} -\theta_2\ln(p_{ijdst})\right) = \frac{G_{om}(1,...,1)}{G(1,...,1)}$$
$$= \frac{\left(\sum_{j=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{jdst}\tau_{jdst}\varrho_{ojt}c_{jt}}\right)^{\theta_1}\right)^{\frac{\theta_2}{\theta_1}-1}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mt}}\right)^{\theta_1}}{\sum_{i=1}^{J}\left(\sum_{j=1}^{J}\left(\frac{\lambda_{it}}{\tilde{\kappa}_{jdst}\tau_{jdst}\varrho_{ijt}c_{jt}}\right)^{\theta_1}\right)^{\frac{\theta_2}{\theta_1}}}$$

where G_{om} is the derivative with respect to the om-th argument.

Defining $\Xi_{odst} = \left(\sum_{j=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{jdst}\tau_{jdst}\varrho_{ojst}c_{jst}^{1-\varphi}(\tilde{\kappa}_{ojst}\tau_{ojst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{1}{\theta_1}}$ and $\Xi_{dst} = \left[\sum_{o=1}^{J}\Xi_{odst}^{\theta_2}\right]^{\frac{1}{\theta_2}}$, this probability can be rewritten as:

$$\mathbb{P}\left(p_{omdst} = \min_{ij} p_{ijdst}\right) = \frac{\Xi_{odst}^{\theta_2-\theta_1}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}}{\Xi_{dst}^{\theta_2}}$$
$$= \left(\frac{\Xi_{odst}}{\Xi_{dst}}\right)^{\theta_2}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}$$

Moreover, using Lemma A.2 from Lind and Ramondo (2023), the conditional distribution of the maximum is identical to the unconditional distribution of the maximum:

$$\mathbb{P}\left(\max_{ij} p_{ijdst}^{-1} \leq a | p_{omdst}^{-1} = \max_{ij} p_{ijdst}^{-1}\right) = \mathbb{P}\left(\max_{ij} p_{ijdst}^{-1} \leq a\right)$$

Combined with a LLN, this implies that the aggregate expenditure share in d on om-goods is also given

by

$$s_{omdst} = \left(\frac{\Xi_{odst}}{\Xi_{dst}}\right)^{\theta_2} \left(\frac{\lambda_{ost}}{\Xi_{odst}\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}$$

It can easily be verified that the maximum of the multivariate Fréchet is (univariate) Fréchet:

$$\mathbb{P}\left(\max_{ij} p_{ijdst}^{-1} \leq a\right) = \exp\left[-G(1,...,1)a^{-\theta_2}\right]$$

The cost minimization problem of composite intermediate goods producers implies that the marginal cost of the composite good in d is $\left[\int_0^1 p_{dst}(\omega^s)^{1-\eta_s}d\omega^s\right]^{\frac{1}{1-\eta_s}}$, which is equal to $\mathbb{E}\left[\left(p_{dst}(\omega^s)^{-1}\right)^{\eta_s-1}\right]^{\frac{1}{1-\eta_s}}$. By perfect competition in the composite goods market, the price of these goods is:

$$P_{dst} = \kappa\Xi_{dst}^{-1} = \kappa\left[\sum_{o=1}^{J}\left(\sum_{m=1}^{J}\left(\frac{\lambda_{ost}}{\tilde{\kappa}_{mdst}\tau_{mdst}\varrho_{omst}c_{mst}^{1-\varphi}(\tilde{\kappa}_{omst}\tau_{omst}c_{ost})^{\varphi}}\right)^{\theta_1}\right)^{\frac{\theta_2}{\theta_1}}\right]^{\frac{-1}{\theta_2}}$$

where $\kappa^{1-\eta_s} = \Gamma\left(\frac{\theta_2-\eta_s+1}{\theta_2}\right)$.

Trade shares (i.e., the share of immediate origin m in d) can be computed by simply summing across origins:

$$s_{\cdot mdst} = \sum_o s_{omdst}$$

G.2 Wealth allocation

Given the assumptions, for a given o, R_{oMt+1} is also Fréchet distributed:

$$F(R_{oMt+1}) = \tilde{F}\left(\frac{\kappa_{oMt}}{r_{Mt+1}}R_{oMt+1}\right) = \exp\left[-\left(\frac{r_{Mt+1}}{\kappa_{oMt}}\right)^{\epsilon}R_{oMt+1}^{-\epsilon}\right]$$

Then, the probability of choosing M is:

$$\mathbb{P}\left(R_{oMt+1} = \max_f R_{oft+1}\right) = \frac{(r_{Mt+1}/\kappa_{oMt})^{\epsilon}}{\sum_f (r_{ft+1}/\kappa_{oft})^{\epsilon}} \tag{104}$$

Moreover, the conditional distribution of the maximum is identical to the unconditional distribution of the maximum:

$$\mathbb{P}\left(\max_M R_{oMt+1} \leq a \;\middle|\; R_{oMt+1} = \max_f R_{oft+1}\right) = \mathbb{P}\left(\max_M R_{oMt+1} \leq a\right)$$

It can easily be verified that the maximum of the Fréchet is also Fréchet:

$$\mathbb{P}\left(\max_{M} R_{oMt+1} \leq a\right) = \exp\left[-a^{-\epsilon}\sum_{M}\left(r_{Mt+1}/\kappa_{oMt}\right)^{\epsilon}\right]$$

Thus, the expected return is:

$$\mathbb{E}\left(R_{ot+1}\right) = \left[\sum_{M}\left(r_{Mt+1}/\kappa_{oMt}\right)^{\epsilon}\right]^{\frac{1}{\epsilon}}\Gamma\left(1-\frac{1}{\epsilon}\right) \tag{105}$$