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Abstract

In the coming decades, Europe's and China's population will shrink, whereas other world regions will experience continuing population growth. Similarly, productivity growth will differ across developing and developed economies, leading to changes in future market sizes across countries. These changes will reshape countries' attractiveness as partners in free trade agreements (FTAs), impacting the geopolitical influence of economies like the European Union (EU) and China. Standard methods for evaluating FTAs abstract from these changes in market sizes. We use population and productivity projections to evaluate the welfare effects of future trade agreements as a function of market size. We apply our method to a potential EU-China FTA. For the EU, we find that as the EU's market size grows by 7.46% between 2025 and 2050, the welfare effect of a potential EU-China FTA increases by 23.8%. For China, a projected market size increase of 32.53% leads to a 13.3% decrease in the welfare effects of the FTA. We show that total factor productivity growth is a more relevant driver of welfare changes than population dynamics, suggesting that policy makers should prioritize future productivity growth when evaluating future trade agreements.

JEL Classification: F14, F15, F17, J11, O47

Keywords: quantitative trade theory, trade predictions, population growth, productivity growth, EU-China trade

1 Introduction

Population and productivity are evolving at different rates across countries, affecting economies' overall market sizes. The European Union (EU) with a collective population of about 448 million is projected to shrink faster than any other world region.[1] Asia's population is projected to shrink too, but at a relatively lower pace, and driven mainly by the falling population in China (We depict population projections in the left panel of Figure 1).[2] Besides population growth, the evolution of an economy's market size depends also on total factor productivity (TFP) growth, i.e., market size is determined not only by the sheer number of workers but also by their productivity. Projected TFP growth rates in developed economies are lower compared to those of emerging economies such as China and India (See right panel of Figure 1). For emerging markets, productivity and subsequent income per capita growth may counteract shrinking populations, but for developed countries such as EU member countries, productivity growth is unlikely to be enough to offset the population decline.

Countries with smaller markets are less attractive for foreign firms and less attractive partners for signing trade agreements. This is particularly true if negotiations are difficult, as potential partners may want to invest their political bargaining capital in negotiating an agreement with a larger market. Hence, especially negotiations of modern, i.e., deep trade agreements may be affected, as bargaining over technical standards and market regulations is inherently more difficult than agreeing on tariff rates. For instance, the smaller the EU becomes, the less important it is to make concessions with it in trade negotiations. This may translate into less norm-setting power for the EU in the foreseeable future, threatening the so-called "Brussels effect" (see Bradford, 2019). This reduced political influence may have important ramifications for geopolitical considerations and the newly returned systems competition between Western democracies and (far-)Eastern autocracies like Russia or China. Accordingly, the European Commission writes in its strategy and policy statement on the impact of demographic change on "Europe's position in the world" that "as the EU's share of the global population is projected to continue falling in the coming decades, the need for close cooperation at all levels to ensure the competitiveness of our Single Market becomes ever more pressing".[3] Others are more blunt: "These

[1] All population projections in this paper use data from the World Population Prospects (WPP) by the United Nations (2022). Europe is the first world region to experience negative population growth since 2019. Europe's total population is projected to shrink by more than 100 million until 2100.

[2] Asia's population shrinkage is delayed by India's population growth which is the world's most populous country now. Its population is projected to grow until 2063, with an average growth of 1% over the coming decade. The United States which is the third-most populous, will experience moderate positive population growth over the coming decades.

[3] `https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/new-push-european-democracy/impact-demographic-change-europe_en#the-power-of-demography`, accessed 19/09/2024.

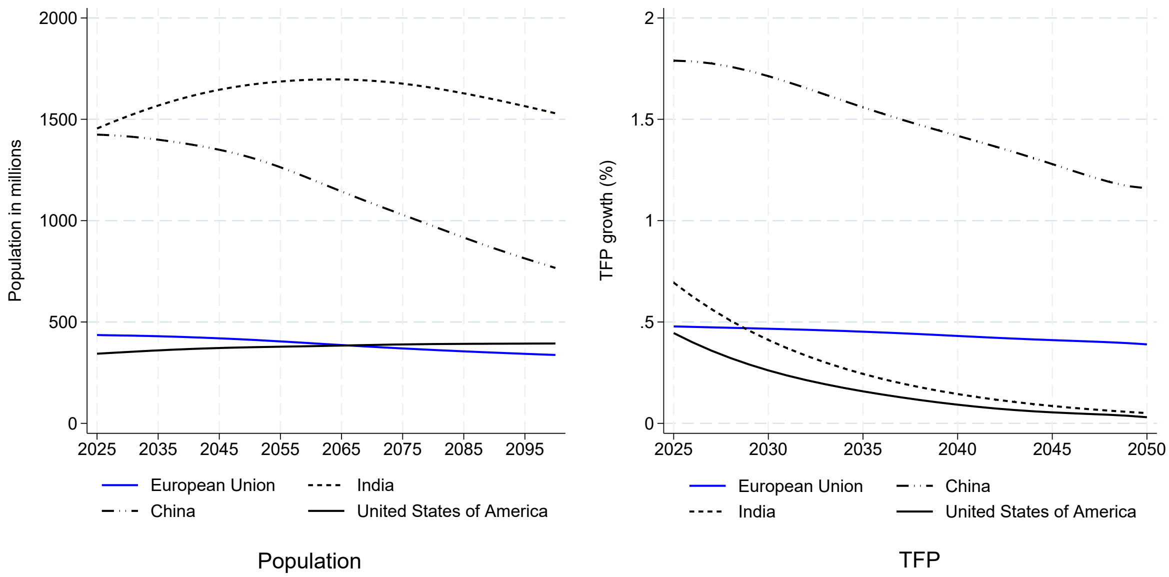

Figure 1: Population and productivity projections. Data source: Population projections are from the World Population Prospects by United Nations (2022) and TFP growth projections are from LTGM-TFP, an Excel-based toolkit from the World Bank by Kim and Loayza (2019).

demographic shifts will have geopolitical consequences".[4] Policy makers and the opinionated press seem to be affected by what the United Nations Population Fund (2023) calls "population anxiety".

Notably, standard evaluations of the trade and welfare effects of potential trade agreements abstract from these issues, as they typically use the current size of the market of the economies that may sign a trade agreement in the future. The standard formula used in these studies to quantify the welfare effects of trade liberalization episodes by Arkolakis et al. (2012) assumes that both the labor force and its productivity remain at current levels. Evaluations of trade agreements hence take the current global population distribution and their productivity as given. However, the value of signing a trade agreement with a country today may change significantly over time due to changes in countries' population and productivity tomorrow. This may well affect the willingness of policymakers to make concessions, taking into account that their country will shrink or grow in the future, and hence its economic relative weight. Surprisingly, little research has looked explicitly into these issues.

In this paper, we address these issues head-on and investigate how changes in population sizes and productivity across countries affect the results of standard evaluation methods

[4] The Economist, "The pecking order of the world's population is soon to change", July 14, 2022.

for the welfare gains from trade liberalization, such as signing a trade agreement, for its member and non-member countries. We illustrate our method by quantifying the effects of a potential EU-China free trade agreement. Such an agreement is ideal to illustrate the importance of projected changes of market sizes as i) it contains two large (groups of) economies that will undergo significant change in their projected populations and productivity, so if these changes matter for trade policy evaluations, we should see their impact clearly, and ii) while a EU-China FTA seems off the table for European policy makers for now, one of the reasons for this may be exactly the fear of China due to its sheer size. Investigating whether China's relative importance may grow even further in the coming decades due to the EU's shrinking population in the context of trade policy proposals seems pertinent. We focus on the key outcome of interest of standard trade policy evaluations: their welfare effects. This measure is the theory-consistent outcome reported in the literature, see, e.g., Anderson and van Wincoop (2003); Baier et al. (2019); Costinot and Rodríguez-Clare (2014); Head and Mayer (2014); Heid and Larch (2016); Heid and Stähler (2024); Mayer et al. (2019). It is easily interpreted as the change in the real wage caused by a trade agreement.[5] To measure the welfare effects, we turn to the standard counterfactual simulation framework used in the structural gravity literature but apply it using projected future income and trade flows, instead of observed current incomes. Our framework is consistent with a large class of standard trade models, see Arkolakis et al. (2012). For the projections, we use the standard projections available provided by the World Population Prospects by United Nations (2022) and the productivity growth projection of the World Bank by Kim and Loayza (2019). These projections are based on current best practices and reflect current expectations of future population and TFP growth that are widely used to inform government policies across the globe.[6] In contrast, standard counterfactual simulations based on quantitative trade models use observed bilateral trade data, typically of the last year available in the respective database. Therefore, this approach abstracts from the changes that will occur in terms of population and total factor productivity growth in the future, whereas our approach allows us to quantify their effects directly in our counterfactual simulations.

To implement our method, we need to parameterize our quantitative trade model, particularly 1.) the trade-cost-reducing effects of a potential FTA, and 2.) projected future market sizes, and 3.) future trade volumes. To parameterize the trade-cost reducing effect 1.), we estimate a current best-practice structural gravity model to obtain the trade-cost reducing effects of currently observed FTAs. In our estimation, we allow for this effect to

[5] Strictly speaking, in the class of models we use, welfare and real wage effects are identical if trade is balanced or trade imbalances are modelled as multiples of aggregate income; for additive trade imbalances, there is a slight difference between real wage and welfare effects, but typically of negligible size, see Baier et al. (2019).

[6] Budolfson and Spears (2021), Chao et al. (2023), Gu et al. (2021), and May and Goldstone (2022) use World Population Prospects data. Chao et al. (2023), Eberstadt (2020), May and Goldstone (2022), and Santos et al. (2021), use productivity growth projections by Kim and Loayza (2019).

depend on the depth of FTAs, as measured by the content of FTA provisions, using the cutting-edge approach by Fontagné et al. (2023) that classifies FTAs into different groups based on their depth, determined by the provisions they contain, categorizing them as deep, shallow, and medium-depth agreements. Our data on trade agreements comes from the Deep Trade Agreements database by Mattoo et al. (2020). In our baseline scenario of our counterfactual simulations of a EU-China FTA, we use our estimated effect of medium-depth agreements to simulate the potential trade cost reductions of a EU-China FTA. We project future market sizes from 2025 to 2050 by assuming that an increase in population or TFP lead both to a one-to-one increase in market size. From these future market sizes, we calculate future trade volumes by scaling up current trade flows by projected income growth. Using these projected, future trade flows, we solve for the welfare changes of a potential EU-China FTA for every year from 2025 to 2050 using the `ge_gravity` toolbox by Baier et al. (2019). This allows us to trace out how changing market sizes affect the welfare effects of a potential future FTA coming into force in each respective year. Since our objective is to study the effects of an FTA as a function of changing market sizes in future years, we use the same trade-cost-reducing effects of the FTA across all years. This way, any changes in welfare across years are solely due to changes in future market sizes.

We find that when accounting for these projected changes, the welfare impact of a future FTA, as measured in terms of changes in welfare, differs from the welfare changes calculated that abstract from these factors. Specifically, we compare the welfare effect of a potential EU-China FTA using current population and TFP levels in 2025 with those of an FTA in 2050. Between 2025 and 2050, the EU's projected market size will increase by 7.46%. We find that accordingly, the welfare effect for the EU of the potential EU-China FTA increases by 23.8%. For China, a 32.53% increase in its market size during this period results in a 13.3% reduction in the welfare effect of the trade agreement. Our results illustrate that taking into account projected changes in market size can lead to quantitatively meaningful differences in the evaluations of trade policy initiatives, highlighting the importance of taking into account projected changes in market sizes.

This paper contributes to three strands of literature. Firstly, it adds to the literature that quantifies the effects of trade cost changes using general equilibrium quantitative trade models that feature an estimable structural gravity equation. Anderson and van Wincoop (2003) pioneered this literature by analyzing the trade and welfare effects of the U.S.-Canadian border. Since then, variants of their quantitative trade model have been used by numerous scholars for counterfactual analyses, and best practices for structural gravity estimations have been established.[7] A common theme of this literature is the use

[7]Examples are plenty, some of them are the following: Egger et al. (2011) who analyzed the effect of FTAs using a structural gravity framework that incorporates an extensive margin. Felbermayr et al. (2015) use a similar structurally estimated quantitative trade model to quantify the welfare gains from a potential EU-U.S. Transatlantic Trade and Investment Partnership. Caliendo and Parro (2015) introduce sectoral linkages in a quantitative trade model to evaluate NAFTA. Bergstrand et al. (2015) conduct a counterfactual analysis using structural gravity estimates that were obtained after controlling for time-

of current, observed trade flows to evaluate counterfactual trade costs changes, whereas we focus on using projected trade flows to quantify the effects of potential future trade cost changes.

Secondly, our paper contributes to the literature that estimates the trade-creating effects of regional trade agreements according to their depth. Since the pioneering work by Dür et al. (2014) and Kohl (2014), instead of using a simple dummy variable to estimate the overall trade cost-reducing effect of all FTAs during gravity estimation, researchers have started considering the depth of FTAs based on the policy areas they cover and provisions they contain. This more fine-grained empirical approach allows trade agreements to have varying trade-cost reducing effects depending on the extent, both in terms of numbers and depth, of provisions and policy areas they cover. Mulabdic et al. (2017), Mattoo et al. (2020), Mattoo et al. (2022), Osnago et al. (2017), and Osnago et al. (2019) use aggregate indicators of depth such as counts of provisions to measure the deepness of an FTA. Fontagné et al. (2021) and Fontagné et al. (2023) use a machine learning algorithm to cluster FTAs based on the provisions they contain. We use the clustering of Fontagné et al. (2023) and follow their specification to estimate the effects of FTAs based on their depth. However, we apply these techniques to the WIOD database by Timmer et al. (2015) that allows us to construct measures of both international and domestic trade, in line with current best practice in the structural gravity literature, see Larch et al. (2022).

Finally, our paper contributes to the literature that studies a potential EU-China FTA, see Garcia (2010), Holslag (2011), Rios-Morales et al. (2014), Pelkmans et al. (2016), Hu and Pelkmans (2020) and Leal-Arcas (2022). Closest to our work, Pelkmans et al. (2016) perform a quantitative assessment of the EU-China FTA using CGE modeling, a complementary approach to our quantitative trade model that is parameterized using the estimated trade cost parameters from a theoretically consistent structural gravity estimation. They simulate the effects of a EU-China FTA in 2030 using data from GTAP9 (benchmarked to 2011), IIASA (International Institute for Applied Systems Analysis) - OECD macroeconomic projections, UN population projections, and labor force projections as of 2030. While Pelkmans et al. (2016) focus on an in-depth evaluation of the EU-China FTA, our paper highlights the impact of using different population and TFP projection data for future trade policy evaluations.

The remainder of the paper is structured as follows: Section 2 presents the empirical strategy and data we use. Section 3 presents the results. Section 4 reports robustness checks, and Section 5 concludes.

varying international border coefficients. Heid and Larch (2016) relax the assumption of perfect labor markets underlying quantitative trade models to quantity the employment and welfare effects of FTAs. Anderson et al. (2018) and Baier et al. (2019) provide Stata packages to quantify the effects of FTAs. For structural gravity best practice, see Yotov et al. (2016).

2 Empirical strategy and data

2.1 Roadmap

This section describes our empirical strategy. Subsection 2.2 describes the sources of the trade flow data as well as the population and TFP growth projections that we use to create future trade and expenditure projections. Subsection 2.3 describes the econometric specification of the structural gravity equation that we use to obtain an estimate of the trade-cost reducing effects of a medium depth FTA which we will use for our counterfactual simulation of a potential EU-China FTA. Armed with these projections and estimates, we describe the quantitative trade model we use to quantify the effects of the EU-China FTA for each year between 2025 and 2050 in subsection 2.4.

2.2 Data

We obtain merchandise bilateral trade data between 43 countries from the World Input-Output Database (WIOD) by Timmer et al. (2015).[8] To estimate the trade cost-reducing effects of deep trade agreements, we use two data sources of FTAs. First, we take the bilateral level FTA information from the data set on the intensive margin by Mattoo et al. (2020) from the deep trade agreements database of the World Bank.[9] Second, to categorize FTAs into different groups based on their level of deepness, we use the FTA cluster list by Fontagné et al. (2023). Fontagné et al. (2023) cluster 278 FTAs with a total of 906 provisions across 18 policy areas based on their differences in terms of coverage and complexity using a kmeans++ algorithm.

The TFP growth projections are from the World Bank's LTGM-TFP, an Excel-based toolkit by Kim and Loayza (2019).[10] This toolkit predicts TFP growth until 2050; we therefore limit our analysis until 2050.[11] Population data come from the World Population Prospects by United Nations (2022). In particular, we use the "medium" and "zero

[8]We include sales to industries labeled 1 to 22. We include both intermediate and final goods trade. Intermediate goods trade includes sales to both goods and service producers. Similarly, final goods trade includes sales to both goods and services industries. As matching country-level productivity data to aggregates of countries is difficult, we omit trade with rest of the world (RoW) data from the analysis. The 43 countries in our sample represent 81% of world trade, so the omission should be innocous.

[9]Note that we use the term "FTA" to refer to all trade agreements included in the Mattoo et al. (2020) database. We use the dataset set as of June 2023.

[10]See https://www.worldbank.org/en/research/brief/LTGM.

[11]To predict TFP growth rates between 2025-2050 using the Excel Toolkit by Kim and Loayza (2019), we use the average historical annual TFP growth rates ("average number over the period of 1985 − 2014") for every country in our analysis. For projecting TFP growth rates of OECD countries, we choose the highest overall index in OECD countries (so-called "Scenario 1" in LTGM-TFP). For non-OECD countries, we choose the highest index by region as of 2014 (so- called "Scenario 2" in LTGM-TFP).

migration" population projections. For our baseline results, we use the "medium" projections, as is standard in the literature (see, e.g., Lee, 2011, and Vollset et al., 2020). As a robustness check, we use the "zero migration" projections, as population growth may be driven by migration flows that may not necessarily continue on the current level.

As the WIOD trade data are only available until 2014, we predict trade volumes until 2025 using observed TFP (until 2019), projected TFP (from 2020 onwards) and population growth data.We use the Penn World Tables version 10.01 (PWT) by Feenstra and Timmer (2015) as our source for observed TFP. Particularly, we use TFP measured at current PPPs (variable "ctfp" in the database).

2.3 Estimation of trade cost-reducing effects of deep trade agreements

We estimate the trade impact of three clusters of FTAs as categorized by Fontagné et al. (2023) by employing a structural gravity framework to obtain the partial effect of FTAs on trade associated with the different clusters. Our empirical specification is based on Fontagné et al. (2023) and Bergstrand et al. (2015). Fontagné et al. (2023) account for the differences in depth of FTAs by grouping them into three clusters. Bergstrand et al. (2015) account for lagged effects of FTAs while controlling for time-varying exogenous unobservable country-pair-specific changes in bilateral trade costs. Thus our specification is as follows:

$$\begin{aligned} X_{ij,t} = \exp\Bigg(&\sum_{K=k1}^{k3} \beta_K FTA_{ij,t}^K + \sum_{Y=2002}^{2014} \beta_Y INTLBRDR_{ij} \times \mathbf{I}(t=Y) \\ &+ \pi_{i,t} + \chi_{j,t} + \mu_{ij} + \epsilon_{ij,t} \Bigg), \end{aligned} \tag{1}$$

where $X_{ij,t}$ is trade from exporting country i to importing country j in year t, including both domestic and international trade flows. Domestic sales are included to avoid bias due to trade diversion from foreign to domestic trade in response to trade cost changes, see Yotov (2022) for an overview of the benefits of including domestic trade flows in gravity estimations. The variable $FTA_{ij,t}^K$ is 1 if there exists a trade agreement of depth K between countries i and j in year t. K can take on three values, distinguishing three levels of FTA deepness, identified by the three clusters in Fontagné et al. (2023): $FTA_{ij,t}^{k1=Deep}$, $FTA_{ij,t}^{k2=Medium}$, and $FTA_{ij,t}^{k3=Shallow}$ respectively group "deep", "medium", and "shallow" agreements.

We include lagged values of $FTA_{ij,t}^K$ four, eight, and twelve years after the year the FTA comes into effect. This allows us to account for FTA phase-in effects, following Bergstrand et al. (2015). This approach is also used by Anderson and Yotov (2016), Baier et al. (2019), and Besedes et al. (2020).

We control for time-varying exogenous unobservable country-pair-specific changes in bilateral trade costs: Following Bergstrand et al. (2015), we include a dummy $INTLBRDR_{ij}$, interacted with an indicator variable for 4-year intervals from 2002 to 2014 (leaving the period until 2002 as the reference category). We indicate this by $INTLBRDR_{ij} \times \mathbf{I}(t = Y)$. The dummy $INTLBRDR_{ij}$ takes the value of one in the case of international trade and zero for domestic sales.

To control for the omitted variable bias introduced by time-varying multilateral resistance terms (MRTs), see Anderson and van Wincoop (2003), we include exporter-time, $\pi_{i,t}$, and importer-time, $\chi_{j,t}$, fixed effects following Baier and Bergstrand (2007). To control for time-invariant unobserved characteristics of the country pairs that could lead to self-selection of countries into FTAs, we include bilateral fixed effects, μ_{ij}, as suggested by Baier and Bergstrand (2007).

For the estimation, we use the Poisson Pseudo Maximum Likelihood (PPML) estimator following the suggestion by Santos Silva and Tenreyro (2006). This avoids inconsistent parameter estimates due to heteroskedasticity arising in log-linearized gravity models traditionally estimated by OLS. Using PPML also allows to exploit the information embedded in zero trade flows that would have to be omitted in a log-linearized model. We use the `ppmlhdfe` STATA command by Correia et al. (2020).

2.4 Welfare effects of trade liberalization with population and TFP growth

In this section, we illustrate a simple way for incorporating future population and productivity growth projections into an otherwise standard quantitative trade model that is routinely used for counterfactual predictions of the change in welfare due to changes in trade costs, e.g., due to the signing of an FTA. We use the simplest possible quantitative trade model, a n country, one-sector Armington model that allows for cross-country differences in productivity and population size. While analytically simple, Arkolakis et al. (2012) have shown that its welfare implications for a given trade cost change are identical across a wide class of more complex models. In the following, we describe the so-called "exact hat algebra" à la Dekle et al. (2007) to quantify the welfare effects of a change in trade costs. Our derivations follow closely Costinot and Rodríguez-Clare (2014), while highlighting the differences between the standard approach using current data mainly used in the literature and our approach using future TFP and population growth projections.

Welfare in country j is measured by the utility of the representative household, U_j, and is given by a CES aggregate over varieties that are differentiated by country, i.e.,

$$U_j = \left(\sum_{i=1}^{n} \psi_{ij}^{(1-\sigma)/\sigma} q_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \tag{2}$$

where q_{ij} is the quantity consumed in j of variety from i, and ψ_{ij} is a preference parameter for variety from country i in j. σ is the elasticity of substitution between varieties. The ideal price index P_j is then given as

$$P_j = \left(\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} p_{ij}^{1-\sigma} \right)^{1/(1-\sigma)} . \tag{3}$$

The price of a variety from i sold in j is p_{ij}, which is the multiplication of the factory gate price p_{ii} by τ_{ij}, an iceberg-type trade cost of shipping goods from country i to country j. Domestic trade costs τ_{ii} are normalized to 1.

Maximizing (2) subject to a country's budget constraint, bilateral trade flows from exporting country i to importing country j, X_{ij}, can be derived as

$$X_{ij} = \left(\frac{\psi_{ij} p_{ij}}{P_j} \right)^{1-\sigma} E_j, \tag{4}$$

where $E_j = \sum_{i=1}^{n} X_{ij}$, i.e., expenditure of j is the sum over all its purchases. Accordingly, we can define country j's expenditure share on goods from i as $\lambda_{ij} \equiv X_{ij}/E_j$.

Country i is populated by L_i workers with productivity A_i who receive wage w_i. Under perfect competition, the price of a variety produced in i and sold in j is given by $p_{ij} = \tau_{ij} p_{ii} = \tau_{ij} w_i / A_i$, and aggregate nominal income is given by $Y_i = w_i L_i$.

This concludes the model description. Costinot and Rodríguez-Clare (2014) show how to derive the change in income brought about by a counterfactual change in trade costs.[12] It is given by the following system of equations:

$$\hat{Y}_j Y_j = \sum_{i=1}^{n} \frac{\lambda_{ji} \left(\hat{Y}_j \hat{\tau}_{ji} \right)^{1-\sigma} \hat{Y}_i Y_i}{\sum_{l=1}^{n} \lambda_{li} \left(\hat{Y}_l \hat{\tau}_{li} \right)^{1-\sigma}}, \tag{5}$$

where variables in the counterfactual scenario after the trade cost change are denoted by using a prime. Then counterfactual income is given by $Y_i' = \hat{Y}_i Y_i$, where $\hat{Y}_i \equiv Y_i'/Y_i$, i.e., the hat refers to ratios of values between the baseline and counterfactual scenario, the so-called (new) hat notation.

From Equation (5), one can derive changes in prices, and therefore, ultimately, the changes in a country's welfare or real wage brought about by a change in trade costs, $\hat{\tau}_{ji}$. This equation is the basis for numerous studies that use current trade flows to quantify future trade policies. To highlight the difference between this standard and our approach, it is useful to introduce a more explicit notation that distinguishes between present (world in 2025) and future (world in 2050) values of variables, in addition to baseline (world without a EU-China FTA) and counterfactual (world with a EU-China FTA) values.

[12]See Appendix D for derivations.

We denote the values of the last observed income and expenditure share data using the subscript T (as in time series where T denotes the last observation in the data set) and let us denote the predicted, i.e., future values for income (and expenditure shares) s periods into the future using the subscript $T+s$. We continue to denote counterfactual scenarios using $'$. Using this notation, we can rewrite Equation (5) that is used in standard analyses as follows:

$$\hat{Y}_{j,T} Y_{j,T} = \sum_{i=1}^{n} \frac{\lambda_{ji,T} (\hat{Y}_{j,T} \hat{\tau}_{ji,T+S})^{1-\sigma} \hat{Y}_{i,T} Y_{i,T}}{\sum_{l=1}^{n} \lambda_{li,T} (\hat{Y}_{l,T} \hat{\tau}_{li,T+S})^{1-\sigma}}. \tag{6}$$

$\hat{Y}_{i,T}$ is solved for counterfactual changes in trade costs, $\hat{\tau}_{ji,T+S}$, that will happen in the future. In solving Equation (6), the standard approach takes future income, $Y_{j,T+s}$, to be the same as today's income, $Y_{j,T}$. Hence, this approach abstracts from future population and TFP changes.

Therefore, we propose solving the following system of equations that uses projected future incomes, $Y_{j,T+S}$, and expenditure shares, $\lambda_{ij,T+S}$:

$$\hat{Y}_{j,T+S} Y_{j,T+S} = \sum_{i=1}^{n} \frac{\lambda_{ji,T+S} (\hat{Y}_{j,T+S} \hat{\tau}_{ji,T+S})^{1-\sigma} \hat{Y}_{i,T+S} Y_{i,T+S}}{\sum_{l=1}^{n} \lambda_{li,T+S} (\hat{Y}_{l,T+S} \hat{\tau}_{li,T+S})^{1-\sigma}}, \tag{7}$$

where we solve for $\hat{Y}_{i,T+s}$, for a given change in future trade costs, $\hat{\tau}_{ji,T+S}$, and future aggregate incomes, $Y_{i,T+S}$, are calculated by

$$Y_{i,T+S} = Y_{i,T} \prod_{s=1}^{S} (1 + g_{i,T+s})(1 + p_{i,T+s}), \tag{8}$$

where $g_{i,T+s}$ and $p_{i,T+s}$ are the projected per period TFP and population growth rates of country i and S is the forecast horizon. For later use, we introduce $\sim$ to denote ratios of baseline values across time, and accordingly rewrite Equation (8) as

$$\tilde{Y}_{i,T+S} \equiv \frac{Y_{i,T+S}}{Y_{i,T}} = \prod_{s=1}^{S} (1 + g_{i,T+s})(1 + p_{i,T+s}) \tag{9}$$

This leaves us with coming up with a projection of future expenditure shares, $\lambda_{ij,T+S}$. In our model, we can express the ratio of future to current expenditure shares as

$$\tilde{\lambda}_{ij,T+S} \equiv \frac{\lambda_{ij,T+S}}{\lambda_{ij,T}} = \frac{(\tilde{Y}_{i,T+S})^{1-\sigma} \tilde{\chi}_{ij,T+S}}{\sum_{l=1}^{n} \lambda_{lj,T} (\tilde{Y}_{l,T+S})^{1-\sigma} \tilde{\chi}_{lj,T+S}}, \tag{10}$$

where $\chi_{ij,T+S} \equiv (L_{i,T+S} A_{i,T+S} / \psi_{ij})^{\sigma-1}$, and $\sim$ again denoting ratios of baseline values across time.[13]

[13]See Appendix D for derivations.

We can further simplify by noting that

$$\tilde{\chi}_{ij,T+S} = \left[\prod_{s=1}^{S}(1+g_{i,T+s})(1+p_{i,T+s})\right]^{\sigma-1} = \left(\tilde{Y}_{i,T+S}\right)^{\sigma-1} \tag{11}$$

such that Equation (10) simplifies to

$$\lambda_{ij,T+S} = \frac{(\tilde{Y}_{i,T+S})^{1-\sigma}(\tilde{Y}_{i,T+S})^{\sigma-1}}{\sum_{l=1}^{n}\lambda_{lj,T}(\tilde{Y}_{l,T+S})^{1-\sigma}(\tilde{Y}_{l,T+S})^{\sigma-1}}\lambda_{ij,T} = \lambda_{ij,T}. \tag{12}$$

From Equation (12), it becomes clear that future expenditure shares $\lambda_{ij,T+S}$, will remain at their baseline values $\lambda_{ij,T}$, i.e., we can use observed expenditure shares in the last year T of our dataset of observed trade flows.[14]

Armed with this insight, we have all ingredients for our counterfactual simulations that take into account changes in future market sizes: Equation (7) simplifies to

$$\hat{Y}_{j,T+S}Y_{j,T+S} = \sum_{i=1}^{n}\frac{\lambda_{ji,T}(\hat{Y}_{j,T+S}\hat{\tau}_{ji,T+S})^{1-\sigma}\hat{Y}_{i,T+S}Y_{i,T+S}}{\sum_{l=1}^{n}\lambda_{li,T}(\hat{Y}_{l,T+S}\hat{\tau}_{li,T+S})^{1-\sigma}}. \tag{13}$$

Noting that (13) is identical to Equation (5) except for using projected future values, it can easily be implemented in STATA using the `ge_gravity` package by Baier et al. (2019). For our simulations, we set σ, the elasticity of substitution, to 3.8 in our baseline scenario, the median value of the recent meta study by Bajzik et al. (2020). In our robustness checks, we also use $\sigma = 5.03$, the median value from the influential meta study by Head and Mayer (2014).

Using Equation (13), we can calculate the income and from these the welfare effects of the specific counterfactuals we consider: We want to evaluate the EU-China FTA that may come into effect in any of the future years between 2025 and 2050, using countries' future market sizes projected for the respective year. Solving Equation (13) for each year, we can trace out how the welfare change brought about by a potential EU-China FTA changes due to future changes in market sizes.

[14] The reason for this result is that projecting income growth in every country to increase one to one with population and TFP growth is essentially akin to a small open economy assumption, i.e., we assume that for our income projections, we do not have to take into account indirect effects of incomes of other countries. This assumption is (implicitly) applied in nearly all policy analyses engaging in country-level population and TFP growth projections. Importantly, general equilibrium effects that take into account such indirect income effects are typically small in the context of bilateral trade cost changes, for evidence see, e.g., Behar and Nelson (2014).

3 Results

3.1 Gravity estimations

Before discussing the welfare results, our ultimate object of interest, in this subsection we describe the estimates from the gravity model specified in Equation (1) which we use to parameterize our quantitative trade model. Impatient readers who do not care about the detailed estimation results may skip to the next subsection.

We present estimates of variants of Equation (1) in Table 1. The reported coefficients can be interpreted as semi-elasticities of bilateral trade to FTAs of different levels of deepness and at different time horizons. Columns (1) to (4) are estimated by the standard PPML estimator recommended by Santos Silva and Tenreyro (2006), whereas columns (5) to (8) use the bias-corrected PPML estimator by Weidner and Zylkin (2021). All specifications control for importer-time, exporter-time, and country-pair fixed effects, and include domestic trade flows, as recommended by current best practice.

Column (1) uses the standard contemporaneous FTA dummy and adds the three 4-year interval lags to allow for phase-in effects of FTAs. We find that in the year of entry into force, an FTA increases trade flows by about 29%.[15] Four years later, trade flows increase by a further 11%; eight years after entry into force by another 3%, and twelve years later by an additional 4%. All coefficients are significant with exception of the eight year lag.

Column (2) reestimates column (1) but now distinguishes between deep, medium, and shallow FTAs ($FTA_{ij,t}^{k1=Deep}$, $FTA_{ij,t}^{k2=Medium}$ and, $FTA_{ij,t}^{k3=Shallow}$), respectively. As intuition suggests, deep FTAs have the largest trade-creating effect (+50%), whereas medium FTAs increase trade by less than half of that (+20%). Interestingly, we do not find a significant trade effect for shallow FTAs. Our results suggest that it is indeed important to distinguish between FTAs of different depths for a correct analysis of FTA trade effects.

Column (3) re-estimates column (1) but follows Bergstrand et al. (2015) and controls for time-varying unobservable country-pair-specific changes in bilateral export costs by including the interaction term $INTLBRDR_{ij} \times \mathbf{I}(t = Y)$ (not reported for brevity). Results are quite similar, albeit slightly less significant. We find that phase-in effects to be more pronounced and significant for medium depth FTAs, in comparison to deep FTAs. This may well be due to larger transition periods and regulations in medium depth agreements, whereas deep agreements seem to go deep more quickly, probably reflecting the bigger commitment of members for deep integration. The provisions of shallow FTAs, in contrast, seem to be so inconsequential as that they do not need to be phased-in.

Column (4) re-estimates column (2) but controls for time-varying pair-specific trade costs. Again, results remain similar.

[15] In the remainder of the paper, all reported semi-elasticities are calculated as $(e^{\hat{\beta}} - 1) \times 100$, where $\hat{\beta}$ is the estimated regression coefficient.

Columns (5) to (8) reestimate the previous specifications but correct for the incidental parameter problem that occurs when the number of time periods in the sample is small by using the estimator proposed by Weidner and Zylkin (2021). In our application, the incidental parameter problem arises due to the inclusion of 3-way fixed-effects (time-invariant country-pair, exporter, and importer time fixed effects) in the PPML estimator. It potentially leads to biased coefficients and standard errors. In our application, we see that overall, the bias in both point estimates and standard errors seems to be small, and coefficients remain significant. Standard errors become ever so slightly larger, but the overall issue seems to be of minor importance.

Summing up, we find robust and consistent FTA effects across a set of specifications recommended by current best practice in the structural gravity literature. Reassuringly, we can take away from this that the variation in the estimated FTA coefficient is of a minor issue in the specific context of our research question.

However, there is one remaining issue: The question of which FTA coefficient to use for our counterfactual simulations, and how to incorporate the phase-in effects. For our research question, we are interested in the long-run effects of an FTA, not so much in the short-run phase-in dynamics. We therefore calculate total or long-run FTA effects for each of the specifications in Table 1 by summing up all FTA coefficients, i.e., summing up the contemporaneous and the phase-in FTA effects, following Bergstrand et al. (2015). We report these at the bottom of Table 1. Again, results are consistent across columns. Interestingly, medium FTAs seem to consistently have the largest trade effects across all specifications that distinguish between FTA depth levels. However, this effect does not hold up to statistical scrutiny: We fail to reject the null hypothesis that the total FTA effect of deep FTAs is identical to those of medium FTAs.[16] Hence, it seems that deep and medium agreements have similar long-run trade effects.

For our counterfactual simulations, we assume that the EU-China FTA increases trade by 89%, i.e., using the long-run effect of medium depth FTAs from column (8). A medium depth FTA is what one could reasonably expect for an FTA between the EU and China: According to Fontagné et al. (2023)'s FTA clustering we use, the European Union can be considered a deep FTA. As trade integration between China and the EU will stop short of the political integration implied by the EU, it seems sensible to assume a medium depth. At the same time, in 2020, China and the EU already have reached an in-principle agreement on an investment agreement, the EU-China Comprehensive Agreement on Investment. Therefore, it seems reasonable to assume that any FTA between the two regions would go beyond shallow agreements that only deal with small commitments on trade and that ignore investment aspects that have become more important in modern FTAs, see Heid and Vozzo (2020). Still, in our robustness checks for our counterfactual simulations, we also investigate the effects using a lower trade-creating effect of FTAs.

[16] H_0: $FTA^{Deep}_{ij,t}$ + $FTA^{Deep}_{ij,t-4}$ + $FTA^{Deep}_{ij,t-8}$ + $FTA^{Deep}_{ij,t-12}$ - $FTA^{Medium}_{ij,t}$ - $FTA^{Medium}_{ij,t-4}$ - $FTA^{Medium}_{ij,t-8}$ - $FTA^{Medium}_{ij,t-12} = 0$. The p-value of the test is 0.459.

Table 1: Structural gravity estimates of the elasticity of trade to FTAs by deepness

Dependent variable: $X_{ij,t}$	PPML (standard)				PPML (unbiased)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$FTA_{ij,t}$	0.258***		0.247***		0.299***		0.288***	
	(0.033)		(0.033)		(0.042)		(0.041)	
$FTA^{Deep}_{ij,t}$		0.402***		0.391***		0.447***		0.436***
		(0.034)		(0.033)		(0.052)		(0.051)
$FTA^{Medium}_{ij,t}$		0.185***		0.171***		0.205***		0.190***
		(0.039)		(0.039)		(0.047)		(0.046)
$FTA^{Shallow}_{ij,t}$		0.080		0.074		0.080		0.075
		(0.082)		(0.083)		(0.097)		(0.099)
$FTA_{ij,t-4}$	0.108***		0.091***		0.121***		0.104***	
	(0.014)		(0.014)		(0.022)		(0.021)	
$FTA_{ij,t-8}$	0.028		0.026		0.031		0.030	
	(0.018)		(0.018)		(0.028)		(0.027)	
$FTA_{ij,t-12}$	0.037***		0.023*		0.036*		0.021	
	(0.013)		(0.013)		(0.019)		(0.019)	
$FTA^{Deep}_{ij,t-4}$		0.106***		0.090***		0.115***		0.099***
		(0.016)		(0.016)		(0.025)		(0.024)
$FTA^{Deep}_{ij,t-8}$		0.017		0.015		0.018		0.018
		(0.020)		(0.020)		(0.032)		(0.031)
$FTA^{Deep}_{ij,t-12}$		0.023		0.012		0.024		0.011
		(0.015)		(0.016)		(0.022)		(0.021)
$FTA^{Medium}_{ij,t-4}$		0.073**		0.058*		0.092**		0.076*
		(0.034)		(0.033)		(0.041)		(0.040)
$FTA^{Medium}_{ij,t-8}$		0.143***		0.139***		0.157***		0.154***
		(0.020)		(0.020)		(0.025)		(0.026)
$FTA^{Medium}_{ij,t-12}$		0.210***		0.198***		0.231***		0.219***
		(0.041)		(0.040)		(0.060)		(0.058)
$FTA^{Shallow}_{ij,t-4}$		0.096***		0.083***		0.110***		0.097***
		(0.018)		(0.018)		(0.022)		(0.021)
$FTA^{Shallow}_{ij,t-8}$		0.047		0.046		0.059		0.060
		(0.030)		(0.030)		(0.037)		(0.037)
$FTA^{Shallow}_{ij,t-12}$		0.014		-0.005		0.006		-0.013
		(0.021)		(0.022)		(0.025)		(0.026)
Total $FTA_{ij,t} = \sum_k FTA_{ij,t-k}$	0.432***		0.387***		0.487***		0.443***	
	(0.046)		(0.046)		(0.070)		(0.068)	
Total $FTA^{Deep}_{ij,t} = \sum_k FTA^{Deep}_{ij,t-k}$		0.549***		0.507***		0.605***		0.564***
		(0.047)		(0.047)		(0.079)		(0.076)
Total $FTA^{Medium}_{ij,t} = \sum_k FTA^{Medium}_{ij,t-k}$		0.611***		0.566***		0.685***		0.639***
		(0.071)		(0.070)		(0.107)		(0.104)
Total $FTA^{Shallow}_{ij,t} = \sum_k FTA^{Shallow}_{ij,t-k}$		0.237***		0.199***		0.255***		0.218**
		(0.075)		(0.074)		(0.094)		(0.092)

Notes: This table reports panel gravity estimates with data on merchandise trade of 43 countries, from 2000 to 2014. Total number of observations are 27,735. Exporter-time (it), importer-time (jt), and exporter-importer (ij) fixed effects are included in all specifications but estimates are not reported for brevity. Columns 1 to 4 are estimated using the Stata `ppmlhdfe` command by Correia et al. (2020) and 5 to 8 are estimated using `ppml_fe_bias` Stata command by Weidner and Zylkin (2021). Columns 1, 3, 5, and 7 are estimated by pooling the FTAs regardless of their deepness. Columns 2, 4, 6, and 8 are estimated by grouping trade agreements into clusters based on their deepness. Control for time-varying exogenous unobservable country-pair-specific changes in bilateral export costs by Bergstrand et al. (2015) are added while estimating columns 3,4,7, and 8 but not reported for brevity. The total effect of an FTA is calculated by summing both contemporaneous and lagged effects. Robust standard errors clustered by country-pair are in parentheses. *** p <0.01, ** p <0.05, * p <0.10.

3.2 Counterfactual welfare analyses

3.2.1 The welfare effects of a potential EU-China FTA as a function of population changes

Equipped with the parameter estimates from the previous section, we now simulate the welfare effects of a potential EU-China FTA. We conduct 26 counterfactual simulations, one for each of the years from 2025 to 2050, assuming that the FTA comes into force in the respective year, and using the projected population sizes and trade flows for the respective year. We plot the FTA's welfare effect and how it evolves over time in Figure 2. The top panel shows how the EU's welfare gain from the FTA changes as a function of the fall in its population. In a similar way, the middle panel shows how China's welfare gain changes while its population shrinks, and the bottom panel does the same for a population-weighted average of the welfare changes for non-member countries of the EU-China FTA. For an easier interpretation of specific quantities, we also report the results from the first and last year (2025 and 2050) in the first row of Table 2.[17]

We see that from 2025 until 2050, the EU's population declines by 5.16% to short of 425 million people. If the EU signed a trade agreement with China in 2025, it could expect its welfare or average real wage to increase by about 0.8%, whereas using the population in 2050, the FTA's welfare effect would be 0.79%, a mere 1.3% difference. For China, the FTA would increase its welfare in 2025 by 0.3%, whereas in 2050, with its population having shrunk by 7.57%, the FTA would increase its welfare by 0.31%, again only a mere difference of 3.3%.[18] Looking at the "innocent bystanders", i.e., the non-member countries of the FTA, we see that their population increases by 10.21% from 2025 to 2050. The welfare impact of the FTA on them, while negative, is considerably smaller: -0.022% in 2025, and -0.023% in 2050, a difference of 4.5%. The conclusion to draw from the analysis is that the EU would benefit two to three times more than China from a FTA. Trade diversion and destruction, to use the Vinerian terms somewhat sloppily in our differentiated goods context, affect non-members negatively, but the overall size of these effects is small, even though the FTA includes the two largest economic blocs in the

[17] We report detailed country-level results in Table A.1 in Section A of the Appendix.

[18] In passing, we compare our results to Pelkmans et al. (2016) who analyze the effects of a EU-China FTA in 2030 using a 'modest' and an 'ambitious' scenario in terms of the trade cost reductions implied by the FTA. Their study reports aggregate GDP changes as well as real wage changes for three groups of labor (low, medium, and high-skilled), hence results are only partly comparable. As in our simulations, they find that both the gains in terms of percent of GDP as well as percent of real wages are larger for China than for the EU. In their 'modest' scenario, they find that the liberalization of goods trade and the related reduction in non-tariff barriers through the FTA increases the real wage of EU low, medium and high-skilled workers by 0.31%, 0.24% and 0.25% respectively, whereas we find a real wage increase by 0.31% in 2030. For China, they find a real wage increase for low, medium, and high-skilled workers of 0.36%, 0.30%, and 0.36% respectively, whereas we find a 0.1% real wage gain. Hence, though there are modelling differences, our results broadly confirm the results by Pelkmans et al. (2016).

world. Importantly, however, even though the populations of both the EU and China as well as of non-member countries change considerably from 2025 to 2050, we would judge from these simulations that neglecting population growth does not create much of a bias in terms of evaluating the consequences of the EU-China FTA. However, this judgement would be premature, as things change when taking into account projected TFP growth, in addition to population growth. We discuss these scenarios in the following subsection.

3.2.2 The welfare effects of potential EU-China FTA as a function of both population and TFP changes

In this subsection, we repeat our counterfactual simulations, but now also use the projected TFP growth in all countries in our sample to project future incomes from 2025 until 2050. Everything else remains as in the previous counterfactuals. We present results in the second row of Table 2 as well as graphically in Figure 3. The left panel shows the welfare effects for the three world regions, both for the full TFP and population growth scenario as well as for the population growth only scenario from the previous subsection for ease of comparison. The right panel shows the predicted TFP growth (in percent) for each year from 2025 to 2050 as well as the projected population in levels. Now, interesting differences emerge: Over time, the EU's welfare effect of the EU-China FTA increases from 0.84% in 2025 to 1.04% in 2050, increasing by 23.8%. Interestingly, the welfare effect, which was hump-shaped in Figure 2, is now monotonically increasing, but plateaus off towards 2050. To the contrary, China's welfare gain from the FTA now decreases monotonically (before it was increasing) from 0.3% in 2025 to 0.26% in 2050, or by about 13.3%. The impact of taking into account TFP growth is even more important for the non-members of the FTA: the negative impact on them increases from -0.023% in 2025 to -0.034% in 2050, or by 47.8%.

The reasons behind this lie in the relative changes in projected future market sizes. Using our TFP and population growth projections to predict future market sizes, we find that the EU's market size in 2050 will increase by 7.46% of its size in 2025. This is due to the combination of the EU's population shrinking by 5.16%, whereas its TFP grows by 12.07%.[19] In comparison, China's market potential in 2050 will increase by 32.53%. This is due to projected Chinese TFP growth of 46.84%, compensating the 7.57% population decline. Non-members are the only region that will experience both population and TFP growth of 10.21% and 12.44%, respectively, leading to an increase in their market potential by 21.88%.

Hence, taking into account not only projected population growth but also TFP growth, in relative terms, the EU's importance as a world market will decrease considerably from

[19]Note that summing the (arithmetic) average annual population and TFP growth rates will not deliver the combined growth rates. For the calculations of the combined TFP and growth rates across the whole period, we use the exact multiplicative growth factors.

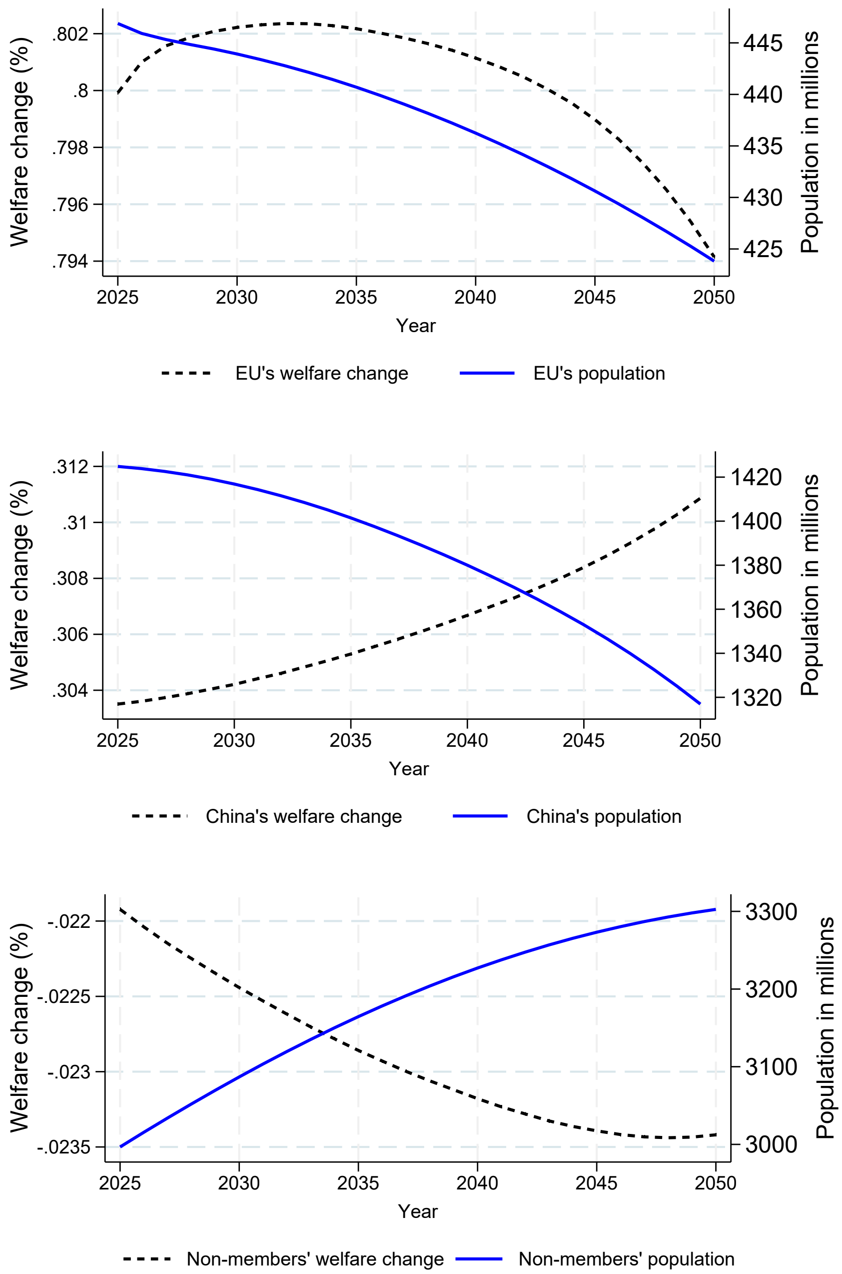

Figure 2: Per period welfare effects of a potential EU-China FTA, coming into force into different years between 2025 and 2050, and population projections for the three country groups in separate panels. Simulations use the sum of estimated trade cost elasticities of a medium-depth agreement from column (8) in Table 1, i.e., 0.639. We set the elasticity of substitution, σ, to 3.8, and use 'medium' population projections. The non-members' welfare change is a population-weighted average.

2025 to 2050. As the EU's market size shrinks, its share in world expenditure shrinks, and hence the same trade cost reduction leads to a larger welfare change. This is due to terms-of-trade effects: The smaller a region, the lower its influence on world market prices due to its lower share in world expenditure, and hence the larger the price changes caused by the same trade cost changes. Accordingly, as China's world expenditure share increases from 2025 to 2050, the trade cost reduction by the EU-China FTA will change the prices it faces less, and hence its welfare gains from signing the FTA become smaller.

Comparing the population growth only scenario with the combined population and TFP growth scenario delivers a clear message: The key driver of changes in the evaluation of the EU-China FTA is projected TFP growth. Population growth alone does not materially change how the benefits of an FTA are distributed. From this perspective, "population anxiety" seems to be misguided. If anything, policy makers should worry about TFP growth.

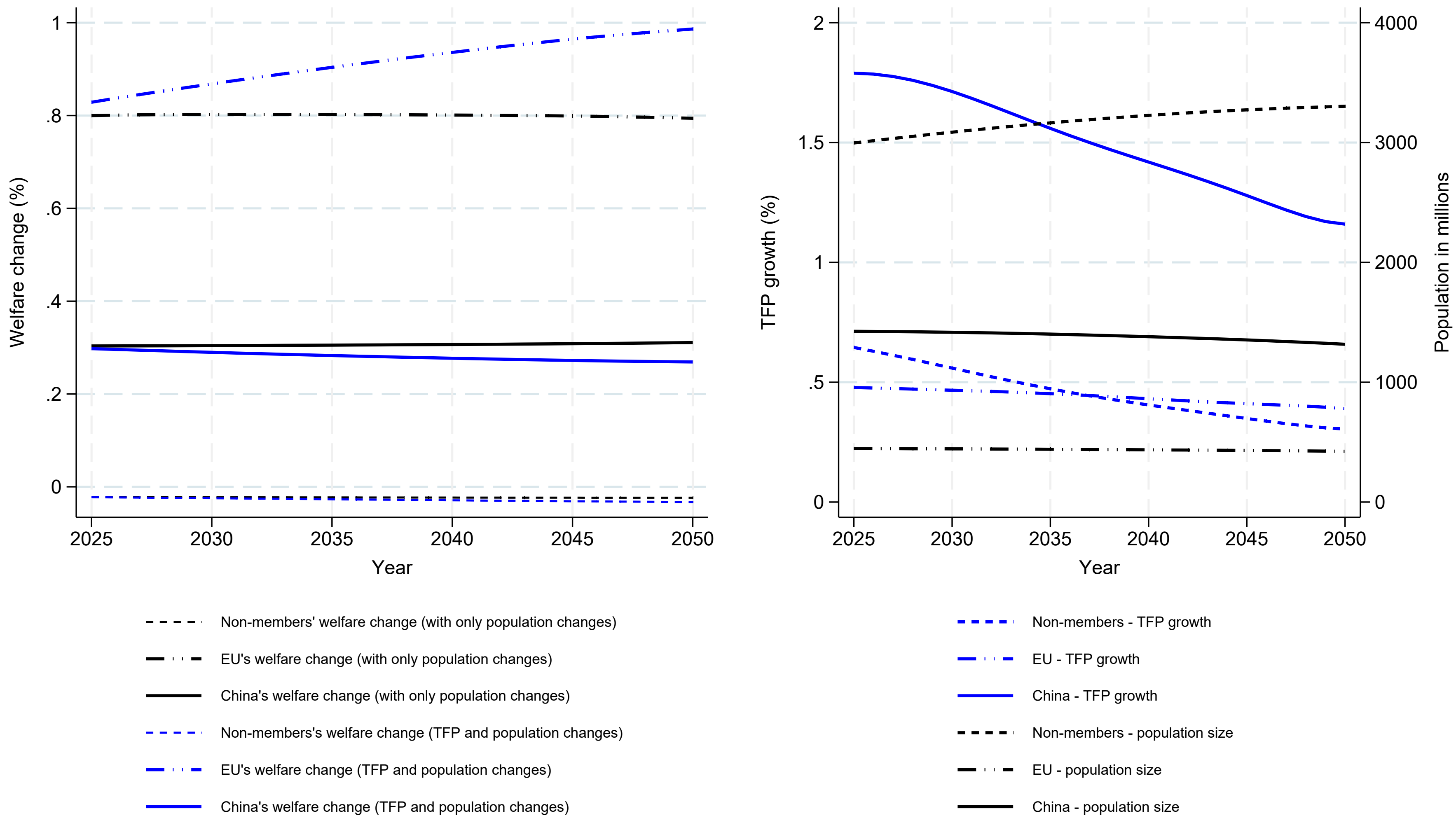

Figure 3: Right panel: Population and Population weighted average TFP growth projections; Left panel: Per period welfare effects of a potential EU-China FTA using population and TFP projections. Simulations use the sum of estimated trade cost elasticities of a medium-depth agreement from column (8) in Table 1, i.e., 0.639. We set the elasticity of substitution, σ, to 3.8, and use 'medium' population projections. The non-members' welfare change is a population-weighted average.

Table 2: Counterfactual simulations of welfare effects of EU-China FTA

Counterfactual scenarios	EU			China			Non-members of EU-China FTA		
	Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)
	2025	2050		2025	2050		2025	2050	
Population only ('medium' projection)	0.8	0.79	-1.3	0.3	0.31	3.3	-0.022	-0.023	4.5
Population and TFP ('medium' projection of pop)	0.84	1.04	23.8	0.3	0.26	-13.3	-0.023	-0.034	47.8
Population weighted average annual TFP growth in % (2025 - 2050)			0.44			1.49			0.45
Population growth in % (2025 - 2050) ('medium' projection)			-5.16			-7.57			10.21
Population weighted average TFP growth in % (2025 - 2050)			12.07			46.84			12.44
Market size growth in % (2025 - 2050)			7.46			32.53			21.88

Notes: This table summarises the welfare change results of the potential EU-China FTA using population and TFP projections. The simulations use the sum of estimated trade cost elasticities of a medium-depth agreement (0.639) from column (8) in Table 1. We set the elasticity of substitution to $\sigma = 3.8$ and use 'medium' population projections. Population data is from United Nations (2022). The TFP growth projections are obtained using the LTGM-TFP, an Excel-based toolkit from the World Bank by Kim and Loayza (2019). Annual averages are arithmetic averages.

4 Robustness checks

Different population projections—A hotly debated issue is the impact of immigration on countries' populations, as immigration is often touted as a solution to shrinking populations. At the same time, Western societies recently have turned hostile towards immigration. Our population projections may therefore be based on immigration levels that are overly optimistic. Therefore, we perform a robustness check using population projections that assume that there is no immigration. We present results graphically in Figure 4; see the second row of Table 3 for the numerical values. In this scenario, compared to our baseline population projection in Figure 2 where the EU's population is projected to shrink by 5.16% until 2050, the EU's population is projected to shrink by 8.75%. At the same time, China's population will actually shrink slightly less (by 43 million to 1,327 million people instead of by 95 million to 1,316 million people by 2050) by 6.9%, as in this scenario, there is no emigration from China. See the last three rows of Table 3. For a visual representation, compare Figures 2 and 4. Non-member states' populations will grow by 8.99%, less than in the medium population scenario, mostly driven by lower population in Japan, Korea, Russia, and Taiwan. These differences in the population trajectories lead to quite different trajectories in the welfare effects of a potential EU-China FTA: Whereas in our baseline results, the welfare effect of a potential FTA was hump-shaped for the EU, it is now monotonically increasing. For China, we now find that the FTA's welfare effect declines until 2046, and then increases again. For the non-member countries, the qualitative evolution of the negative FTA effect remains identical to our baseline results. Overall, however, we confirm the main conclusion from the population growth only scenarios in Section 3.2.1 that the differences between the welfare effects of an FTA in 2025 versus 2050 are quite small.

We therefore again recalculate our simulations and, in addition to using the zero-migration population projection, we also allow productivity to change using the TFP projections to calculate the potential future welfare effect of the EU-China FTA. We present results in the fourth row of Table 3. Similar to the results presented in Section 3.2.2 (compare rows 3 and 4 of Table 3), we find that what matters most for differences in the projected future welfare effects of a potential EU-China FTA are the TFP projections. Overall, results are quite similar for both population projections, as the percentage differences between the evaluations in 2025 and 2050 are in the same ballpark for both population projections.

Different FTA effect estimates—Our results may be sensitive to the estimated FTA effect we use for our counterfactual simulations. In particular, the effect we use is on the higher end of the estimates presented in the meta study by Head and Mayer (2014). Also, by using the sum of the estimated contemporaneous and lagged FTA effects, we may overstate the impact of an FTA. Therefore, instead of assuming that the trade-creating effect of an FTA is given by the estimated total FTA effect for medium depth FTAs from column (8) in Table 1, we use a more conservative point estimate. We reestimate the specifications presented in Table 1 but omit the lagged FTA effects, which may arguably be more in line with the majority of structural gravity specifications to estimate FTA effects used in the literature. We present results in Table A.2 in Appendix B. To be comparable to our baseline results, we stick to the point estimate in column (8), i.e., 0.201. We then redo our counterfactual simulations of the EU-China FTA between 2025 and 2050, while keeping everything else identical to the main results ($\sigma = 3.8$, medium population projections). We present results in Figure A.1 in the Appendix. As expected, a lower estimated FTA trade cost reducing effect translates into overall lower levels of welfare changes brought about by the EU-China FTA. Importantly for our main research question, we reconfirm that changes in population alone hardly affect the welfare consequences of the EU-China FTA.

Different σ values—Results may be sensitive to our choice of the elasticity of substitution, σ. In our baseline results, we set σ to 3.8, the median value from the meta study Bajzik et al. (2020). We redo our analysis setting $\sigma = 5.03$, the median value from the meta study by Head and Mayer (2014), which also brackets the median and upper bound in the meta study by Bajzik et al. (2020). We present results in Figure A.2 of the Appendix. For this exercise, we again focus on population growth only scenarios. Everything else remains as in the baseline results. As expected, the level of welfare effects is lower with a higher σ, as varieties become more substitutable, and hence trade liberalization via the FTA is less important for welfare. Importantly, we see that the influence of population changes is similar for the different σ values.

Finally, We also plot the welfare effects when allowing both σ and the estimated FTA effect to differ simultaneously. We present results in Figure A.3 in the Appendix. As before, while level effects are different, as expected, the difference between the welfare effects of the EU-China FTA between 2025 and 2050 is small when only allowing for population changes. When allowing for both population and TFP to change, however, we again find that the welfare effects of the FTA differ markedly between 2025 and 2050. We report results in Table A.3 in the Appendix (see the middle of the table between the two horizontal bars): Now, the welfare effect for the EU is 21.4% larger in 2050, 7.5% smaller for China, and 150% larger for the non-member countries. Hence we again confirm the relative importance of TFP growth in comparison to population growth for evaluations of potential future FTAs.

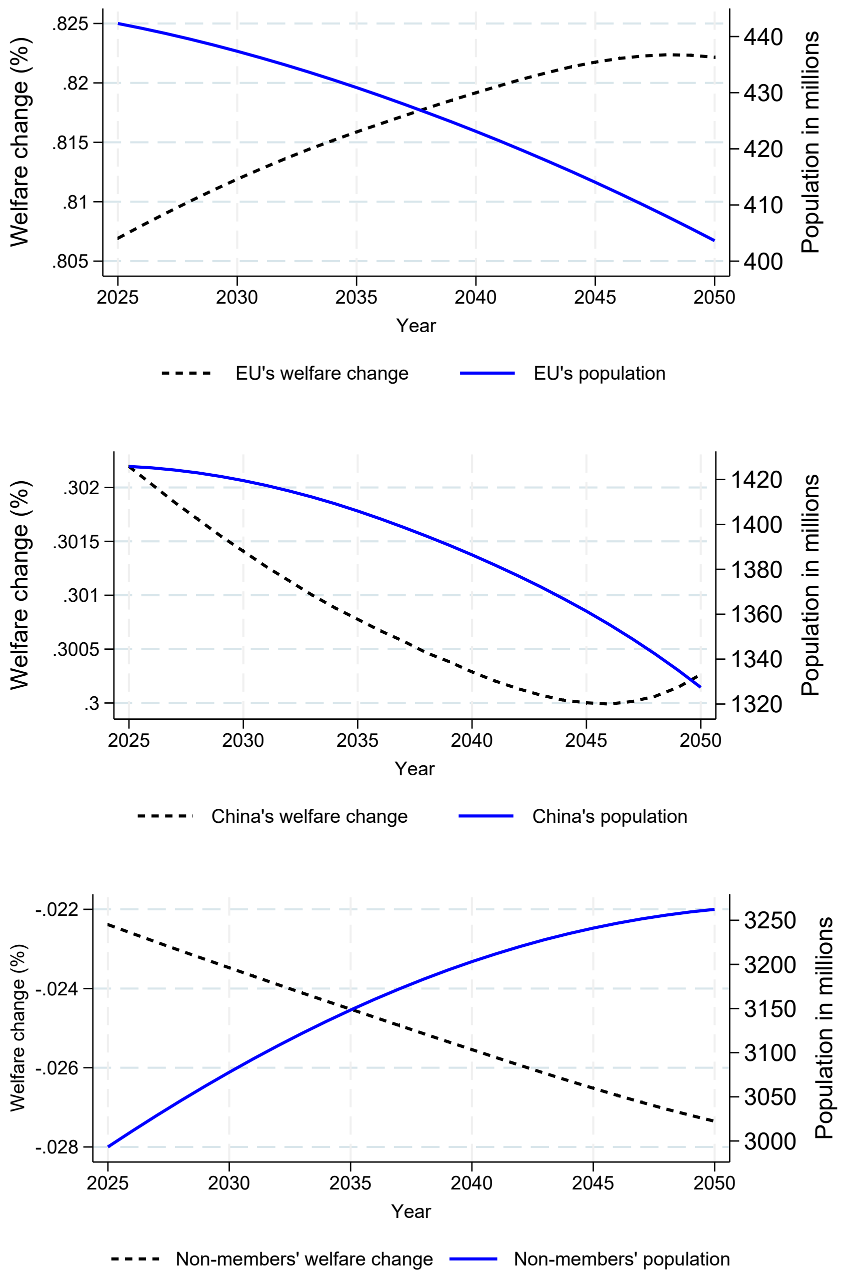

Figure 4: Robustness check—Different population projections: Per period welfare effects of a potential EU-China FTA against the projected populations for the three country groups in separate panels. Simulations use the sum of estimated trade cost elasticities of a medium-depth agreement from column (8) in Table 1, i.e., 0.639. We set the elasticity of substitution, σ, to 3.8, but instead of using use 'medium' population projections as in Figure 2, we use 'zero-migration' population projections. The non-members' welfare change is a population-weighted average.

Table 3: Robustness check: Counterfactual simulations of welfare change using a different population projection

Counterfactual scenarios	EU			China			Non-members of EU-China FTA		
	Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)
	2025	2050		2025	2050		2025	2050	
Population only (‘medium’ projection)	0.8	0.79	-1.3	0.3	0.31	3.3	-0.022	-0.023	4.5
Population only (‘zero-migration’ projection)	0.81	0.82	1.2	0.31	0.3	-3.2	-0.022	-0.027	22.7
Population and TFP (‘medium’ projection of pop)	0.84	1.04	23.8	0.29	0.26	-10.3	-0.023	-0.034	47.8
Population and TFP (‘zero-migration’ projection of pop)	0.84	1.03	22.6	0.3	0.26	-13.3	-0.023	-0.038	65.2
Population weighted average annual TFP growth in % (2025 - 2050)			0.44			1.49			0.45
Population growth in % (2025 - 2050) (‘medium’ projection)			-5.16			-7.57			10.21
Population growth in % (2025 - 2050) (‘zero-migration’ projection)			-8.75			-6.9			8.99
Population weighted average TFP growth in % (2025 - 2050)			12.07			46.84			12.44

Notes: This table summarises the welfare change results of the potential EU-China FTA using different population projection types and TFP projections. The simulations use the sum of estimated trade cost elasticities of a medium-depth agreement (0.639) from column (8) in Table 1. The trade elasticity σ is kept at 3.8. Simulations are done using both ‘medium’ and ‘zero-migration’ population projections. Population data is from United Nations (2022). The TFP growth projections are obtained using the LTGM-TFP, an Excel-based toolkit by Kim and Loayza (2019) at the World Bank. Annual averages are arithmetic averages.

5 Conclusion

In the coming decades, population is expected to shrink in both the EU, China, and other world regions, whereas in other parts of the world, population will continue to grow. Declining populations may lead to smaller markets, and make countries less attractive to do trade with. Policy makers voice concerns about a loss of importance on the world stage, which may lead to less influence and power to negotiate and sign trade agreements. While such concerns are routinely voiced by policy makers, interestingly, the academic literature on trade agreements has mostly abstracted from this debate.

We address this question head-on by analyzing the impact of a potential future free trade agreement between the EU and China while explicitly taking into account population and productivity projections. We incorporate these projections into an otherwise standard quantitative trade model that is used routinely in counterfactual simulations of potential trade policy initiatives.

We find that future welfare effects of FTAs do depend on the evolution of market sizes. However, in a different way than policy makers would probably expect: While we find only slight differences in the welfare effects of a EU-China FTA when taking into account current population projections between 2025 and 2050, things change when simultaneously also taking into account current TFP projections across countries. As the EU's market size increases by 7.46% between 2025 and 2050, the welfare effect of a potential EU-China FTA is 23.8% larger in 2050 compared to 2025. For China, a 32.53% increase of market size during this period results in a 13.3% reduction in the potential welfare increase caused by the FTA. These results are in line with terms-of-trade effects that imply that welfare effects are a function of country size.

Overall, our results transmit a clear message: Projected market size changes are important for the evaluations of future FTAs. These differences, however, are overwhelmingly determined by differences in the evolution of TFP across countries, not by changes in population size.

It seems that from this perspective, the purported demise of the economic influence of current major trading economies due to their shrinking populations seems to be greatly exaggerated. "Population anxiety" as described by the United Nations Population Fund (2023) seems to be misguided. Policy makers and the media therefore should refocus: Instead of worrying about population growth, if anything, they should worry about productivity growth.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT (`https://chatgpt.com/`) in order to improve the readability and language of the work of parts of the manuscript. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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For Online Publication
Appendix for “Market size and the evaluation of future trade agreements: The role of population and TFP growth”

October 18, 2024

A Country-level results

Table A.1: Country-level results

Exporter (ISO 3-digit code)	EU member (= 1)	Average annual population growth in % (2025 - 2050)	Average annual TFP growth in % (2025 - 2050)	Population in 2025 (in 000's)	Population in 2050 (in 000's)	Welfare change in % in 2025 with only pop. growth	Welfare change in % in 2025 with pop. and TFP growth	Welfare change in % in 2050 with only pop. growth	Welfare change in % in 2050 with pop. and TFP growth
AUS	0	0.71	0.17	26,829	32,109	0.04	0.05	0.04	0.06
AUT	1	-0.03	0.29	8,986	8,933	0.35	0.36	0.33	0.41
BEL	1	0.12	0.29	11,730	12,094	0.66	0.69	0.61	0.71
BGR	1	-0.94	0.18	6,592	5,214	0.81	0.87	0.87	1.34
BRA	0	0.22	0.02	218,232	230,972	-0.01	-0.01	-0.01	0.00
CAN	0	0.61	0.04	39,269	45,801	-0.02	-0.01	-0.03	-0.01
CHE	0	0.37	-0.01	8,878	9,744	-0.16	-0.16	-0.19	-0.18
CHN	0	-0.33	1.49	1,424,864	1,316,946	0.30	0.30	0.31	0.26
CYP	1	0.35	0.23	1,273	1,391	1.50	1.61	1.29	2.02
CZE	1	0.03	0.51	10,507	10,573	0.75	0.79	0.68	0.88
DEU	1	-0.21	0.34	83,229	79,064	1.15	1.15	1.14	1.33
DNK	1	0.31	0.12	5,954	6,439	1.21	1.28	1.11	1.50
ESP	1	-0.28	0.40	47,449	44,340	0.52	0.60	0.53	0.81
EST	1	-0.46	0.46	1,317	1,175	1.25	1.35	1.28	1.84
FIN	1	-0.07	0.31	5,552	5,465	0.97	1.00	0.93	1.22
FRA	1	0.05	0.36	64,943	65,863	0.91	0.95	0.83	1.15
GBR	0	0.20	0.36	68,073	71,660	0.08	0.10	0.05	0.16
GRC	1	-0.46	0.55	10,283	9,173	0.81	0.91	0.83	1.26
HRV	1	-0.69	0.18	3,976	3,347	0.60	0.67	0.65	1.15
HUN	1	-0.46	0.72	9,924	8,838	0.99	1.08	1.03	1.34
IDN	0	0.47	1.81	280,914	316,968	-0.04	-0.05	-0.04	-0.08
IND	0	0.55	0.25	1,448,211	1,668,475	-0.03	-0.03	-0.03	-0.04
IRL	1	0.44	0.50	5,105	5,718	0.93	0.83	0.91	0.34
ITA	1	-0.45	0.52	58,610	52,428	0.52	0.54	0.56	0.70
JPN	0	-0.64	-0.01	122,299	104,140	-0.02	-0.02	-0.01	-0.02

Table A.1 continued from previous page

Exporter (ISO 3-digit code)	EU member (= 1)	Average annual population growth in % (2025 - 2050)	Average annual TFP growth in % (2025 - 2050)	Population in 2025 (in 000's)	Population in 2050 (in 000's)	Welfare change in % in 2025 with only pop. growth	Welfare change in % in 2025 with pop. and TFP growth	Welfare change in % in 2050 with only pop. growth	Welfare change in % in 2050 with pop. and TFP growth
KOR	0	-0.49	0.01	51,718	45,989	-0.02	-0.02	-0.02	-0.02
LTU	1	-0.80	0.65	2,680	2,196	0.63	0.71	0.75	1.09
LUX	1	0.63	0.51	665	780	0.77	0.83	0.60	0.91
LVA	1	-0.89	0.82	1,800	1,440	0.93	1.00	1.00	1.40
MEX	0	0.39	1.06	129,850	143,734	-0.03	-0.02	-0.03	-0.07
MLT	1	-0.11	0.33	538	523	2.13	2.45	2.00	3.16
NLD	1	0.04	0.31	17,697	17,912	1.59	1.70	1.49	2.04
NOR	0	0.55	0.20	5,535	6,356	-0.45	-0.51	-0.46	-0.78
POL	1	-0.52	0.75	39,869	35,039	0.56	0.60	0.61	0.77
PRT	1	-0.39	0.66	10,211	9,288	0.56	0.61	0.56	0.81
ROU	1	-0.44	0.54	19,508	17,500	0.46	0.52	0.46	0.78
RUS	0	-0.30	0.80	143,720	133,354	-0.03	-0.02	-0.02	-0.02
SVK	1	-0.35	0.86	5,663	5,198	0.59	0.62	0.60	0.67
SVN	1	-0.22	0.47	2,118	2,007	0.68	0.72	0.67	0.94
SWE	1	0.41	0.19	10,704	11,882	0.66	0.69	0.57	0.74
TUR	0	0.40	1.20	86,479	95,744	-0.07	-0.08	-0.09	-0.21
TWN	0	-0.26	1.49	23,963	22,515	0.01	0.01	0.01	0.01
USA	0	0.35	0.16	342,716	375,085	0.00	0.00	0.00	0.01

Notes: Population data is from United Nations (2022). The TFP growth projections are obtained using the LTGM-TFP, an Excel-based toolkit from the World Bank by Kim and Loayza (2019). To obtain the per-period welfare effects of potential EU-China FTA using population and TFP projections, the simulations use the estimated long-run total estimated trade cost elasticities of a medium-depth agreement from column (8) in Table 1, i.e., 0.639. We set the elasticity of substitution, σ, to 3.8, and use 'medium' population projections. Annual averages are arithmetic averages.

B Alternative gravity estimates

Table A.2: Structural gravity estimates of the elasticity of trade to FTAs by deepness without lags

Dependent variable: X_{ijt}	PPML(standard)				PPML(unbiased)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$FTA_{ij,t}$	0.296***		0.269***		0.352***		0.320***	
	(0.053)		(0.049)		(0.052)		(0.048)	
$FTA_{ij,t}^{Deep}$		0.456***		0.426***		0.515***		0.481***
		(0.053)		(0.054)		(0.068)		(0.064)
$FTA_{ij,t}^{Medium}$		0.201***		0.176***		0.232***		0.201***
		(0.034)		(0.036)		(0.071)		(0.062)
$FTA_{ij,t}^{Shallow}$		0.133		0.114		0.148		0.126
		(0.104)		(0.102)		(0.124)		(0.125)
$INTLBRDR_{ij} \times \mathbf{I}(t = 2002)$			-0.127***	-0.122***			-0.121***	-0.116***
			(0.040)	(0.040)			(0.005)	(0.016)
$INTLBRDR_{ij} \times \mathbf{I}(t = 2006)$			0.021	0.020			0.021	0.019
			(0.016)	(0.016)			(0.022)	(0.024)
$INTLBRDR_{ij} \times \mathbf{I}(t = 2010)$			0.034*	0.033*			0.033	0.031
			(0.019)	(0.019)			(0.021)	(0.020)
$INTLBRDR_{ij} \times \mathbf{I}(t = 2014)$			0.083***	0.084***			0.081***	0.083***
			(0.023)	(0.023)			(0.021)	(0.020)

Notes: This table reports panel gravity estimates with data on merchandise trade of 43 countries, from 2000 to 2014. Total number of observations are 27,735. Exporter-time (it), importer-time (jt), and exporter-importer (ij) fixed effects are included in all specifications but not reported for brevity. Columns 1 to 4 are estimated using the standard `ppmlhdfe` STATA command by Correia et al. (2020) and 5 to 8 are estimated using the `ppml_fe_bias` STATA command by Weidner and Zylkin (2021). Columns 1, 3, 5, and 7 are estimated by pooling FTAs regardless of their deepness. Columns 2, 4, 6, and 8 are estimated by grouping trade agreements into clusters based on deepness. Multi-way clustered standard errors by Cameron et al. (2011) given in parentheses. *** p <0.01, ** p <0.05, * p <0.10.

C Counterfactual welfare analysis for different parameters

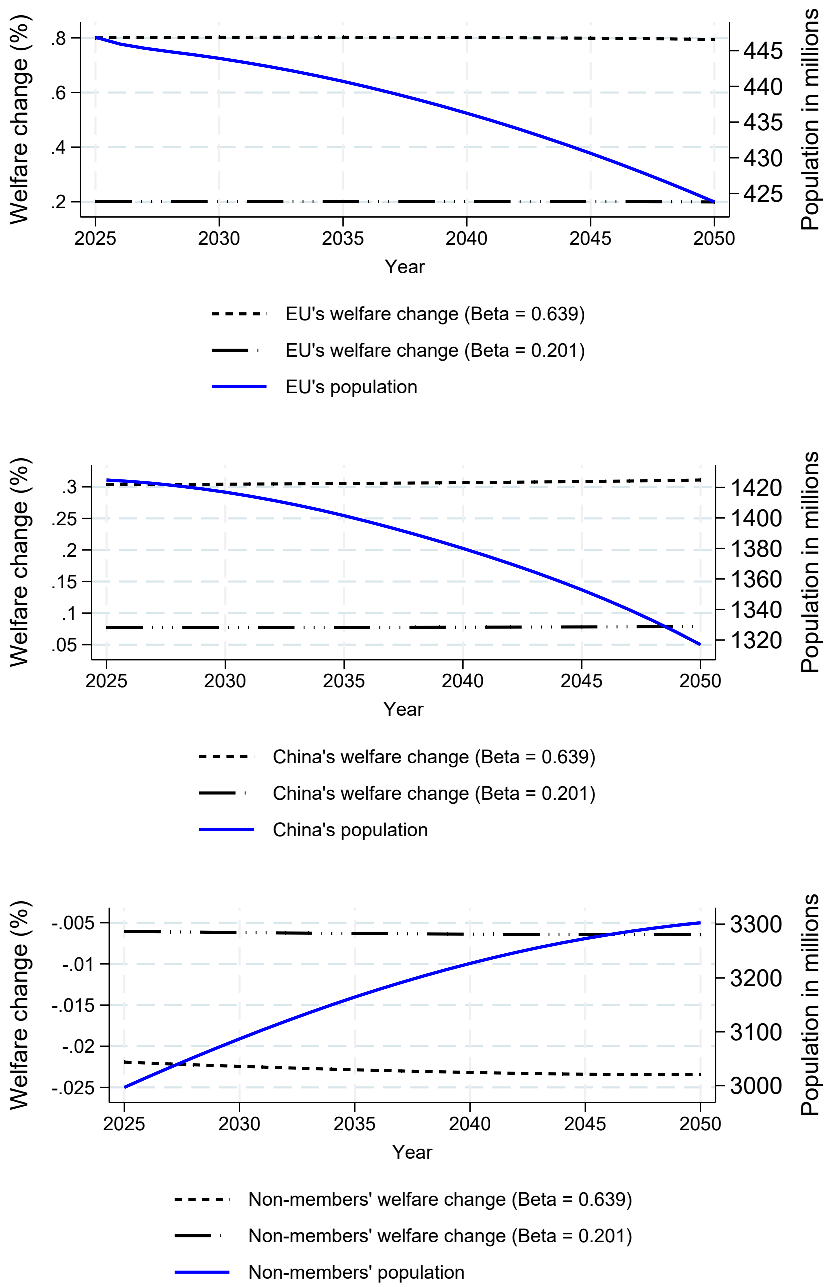

Figure A.1: Robustness check—Different FTA effect estimates: Per period welfare effects against the projected populations for the three country groups in separate panels. Simulations use two different estimates of trade cost elasticities (βs) of a medium-depth agreement: The dashed line uses the long-run effect, i.e., Total $FTA_{ij,t}^{Medium}$ from column (8) of Table 1, i.e., $\beta = 0.639$; and the dashed-dotted line uses the coefficient of $FTA_{ij,t}^{Medium}$ from column (8) of Table A.2, i.e., $\beta = 0.201$. In both cases, we set $\sigma = 3.8$, and use 'medium' population projections. The non-members' welfare change is a population-weighted average.

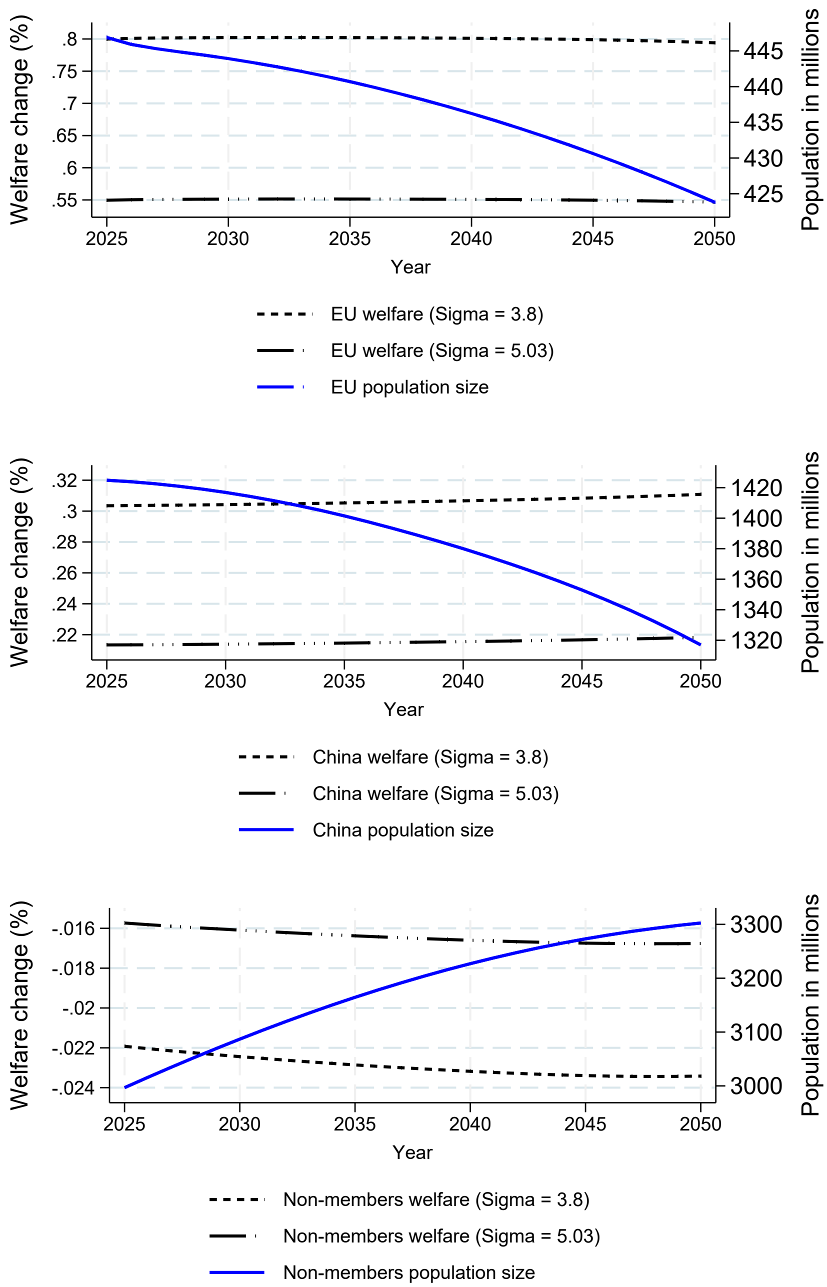

Figure A.2: Robustness check—Different σ values: Per period welfare effects against the projected populations for the three country groups in separate panels. Simulations use two different σ values, 3.8 and 5.03. In both cases, we use the estimated long-run total trade cost elasticity of a medium-depth agreement from column (8) in Table 1, 0.639, and 'medium' population projections. The non-members' welfare change is a population-weighted average.

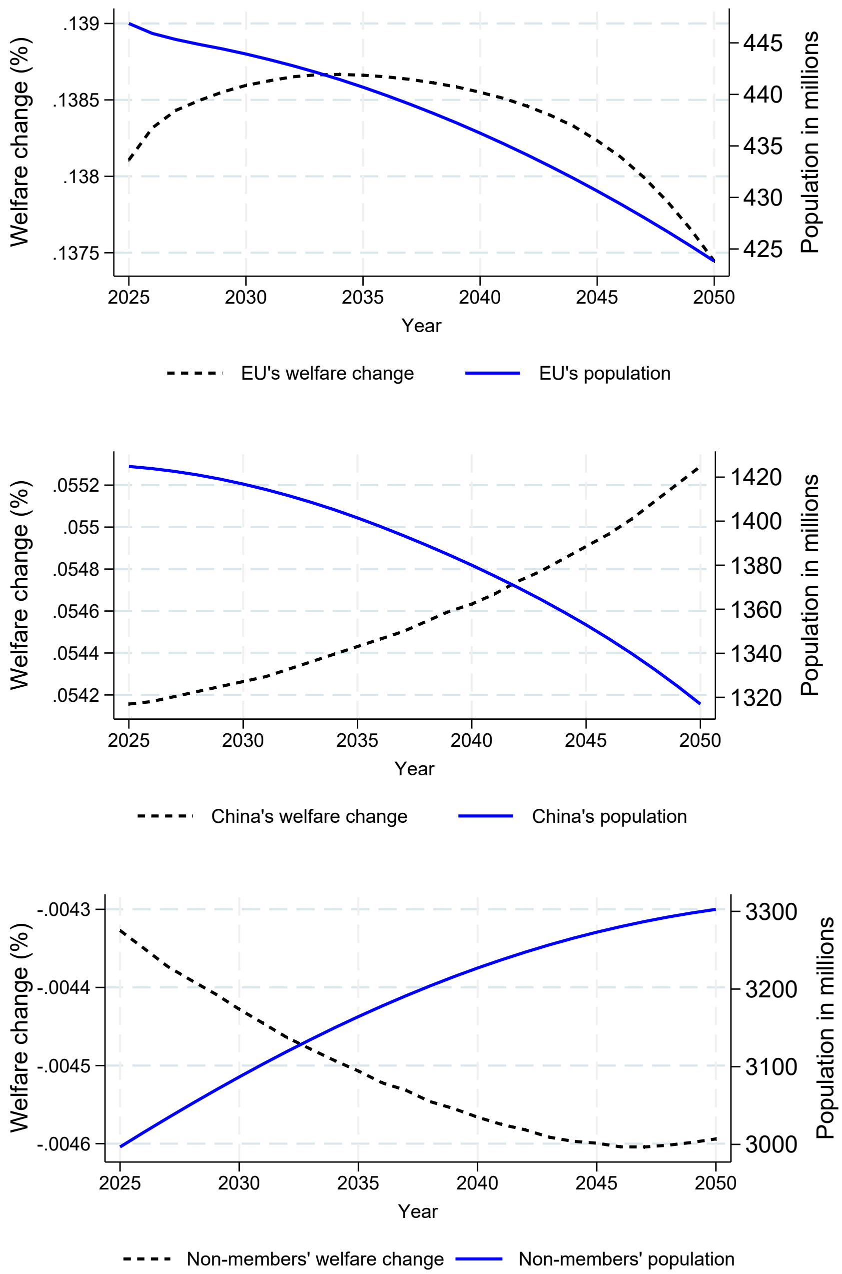

Figure A.3: Robustness check—Different FTA effect estimates and σ values: Per period welfare effects against the projected populations for the three country groups in separate panels. Simulations use the short-run estimated trade cost elasticity of a medium-depth agreement from column (8) in Table A.2, i.e., 0.201. We set $\sigma = 5.03$, and use 'medium' population projections. The non-members' welfare change is a population-weighted average.

Table A.3: Summary of counterfactual simulations of welfare change

Counterfactual scenarios		EU			China			Non-members of EU-China FTA		
		Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)	Welfare change (percentage points)		Change (%)
		2025	2050		2025	2050		2025	2050	
Population only (‘medium’ projection)	$\beta = 0.639$ $\sigma = 3.8$	0.8	0.79	-1.3	0.3	0.31	3.3	-0.022	-0.023	4.5
Population only (‘zero-migration’ projection)		0.81	0.82	1.2	0.31	0.3	-3.2	-0.022	-0.027	22.7
Population and TFP (‘medium’ projection of pop)		0.84	1.04	23.8	0.29	0.26	-10.3	-0.023	-0.034	47.8
Population and TFP (‘zero-migration’ projection of pop)		0.84	1.03	22.6	0.3	0.26	-13.3	-0.023	-0.038	65.2
Population only (‘medium’ projection)	$\beta = 0.201$ $\sigma = 5.03$	0.138	0.143	-3.6	0.05	0.06	20.0	-0.004	-0.005	25.0
Population and TFP (‘medium’ projection of pop)		0.14	0.17	21.4	0.053	0.049	-7.5	-0.004	-0.01	150.0
Population weighted average annual TFP growth in % (2025 - 2050)				0.44			1.49			0.45
Population growth in % (2025 - 2050) (‘medium’ projection)				-5.16			-7.57			10.21
Population growth in % (2025 - 2050) (‘zero-migration’ projection)				-8.75			-6.9			8.99
Population weighted average TFP growth in % (2025 - 2050)				12.07			46.84			12.44

Notes: This table summarises the welfare change results of different counterfactual simulations that vary depending on the estimated trade cost parameters β, σ (elasticity of substitution) and population projections. Simulations use either the estimated long-run total trade cost elasticities of a medium-depth agreement (0.639) from column (8) in Table 1 or the short-run trade cost elasticity of a medium-depth agreement (0.201) from column (8) in Table A.2. Population data is from United Nations (2022). The TFP growth projections are obtained using the LTGM-TFP, an Excel-based toolkit by Kim and Loayza (2019) at the World Bank. Annual averages are arithmetic averages.

D Derivations

In this subsection, we derive Equations (5) and (10) in the main text.

Plugging $p_{ij} = \tau_{ij} Y_i / A_i L_i$ into Equations (4) and (3) yields the gravity equation:

$$X_{ij} = \frac{(Y_i \tau_{ij})^{1-\sigma} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{1-\sigma} \chi_{lj}} E_j, \tag{A.1}$$

where we have defined $\chi_{ij} \equiv (L_i A_i / \psi_{ij})^{\sigma-1}$.

Under balanced trade, $Y_i = E_i$, and noting that $Y_i = \sum_j X_{ij}$ (income of i is the sum of all its sales), we can sum up Equation (A.1) over all countries to receive

$$Y_i = \sum_{j=1}^{n} \frac{(Y_i \tau_{ij})^{1-\sigma} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{1-\sigma} \chi_{lj}} Y_j. \tag{A.2}$$

Variables in the counterfactual scenario are denoted by using a prime; then counterfactual income is given by $Y_i' = \hat{Y}_i Y_i$, where $\hat{Y}_i \equiv Y_i'/Y_i$. We can then write counterfactual income by using Equation (A.2) in changes as

$$\hat{Y}_i Y_i = \sum_{j=1}^{n} \frac{(\hat{Y}_i Y_i \hat{\tau}_{ij} \tau_{ij})^{1-\sigma} \hat{\chi}_{ij} \chi_{ij}}{\sum_{l=1}^{n} (\hat{Y}_l Y_l \hat{\tau}_{lj} \tau_{lj})^{1-\sigma} \hat{\chi}_{lj} \chi_{lj}} \hat{Y}_j Y_j. \tag{A.3}$$

where $\hat{x} \equiv x'/x$ denotes the ratio of a variable before and after the change, and the prime denotes the counterfactual situation after the change. Equation (A.3) is Equation (5) in the main text.

Define $\lambda_{ij} \equiv X_{ij} / \sum_l X_{lj} = X_{ij}/E_j$, the expenditure share of j on goods from i. Plugging in Equation (A.1) into the definition of λ_{ij}, we receive

$$\lambda_{ij} = \frac{(Y_i \tau_{ij})^{1-\sigma} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{1-\sigma} \chi_{lj}}, \tag{A.4}$$

and we can accordingly write the expenditure share in the counterfactual scenario, λ_{ij}', as

$$\hat{\lambda}_{ij} \lambda_{ij} = \frac{(\hat{Y}_i Y_i \hat{\tau}_{ij} \tau_{ij})^{1-\sigma} \hat{\chi}_{ij} \chi_{ij}}{\sum_{l=1}^{n} (\hat{Y}_l Y_l \hat{\tau}_{lj} \tau_{lj})^{1-\sigma} \hat{\chi}_{lj} \chi_{lj}}, \tag{A.5}$$

which simplifies to

$$\hat{\lambda}_{ij} = \frac{(\hat{Y}_i \hat{\tau}_{ij})^{1-\sigma} \hat{\chi}_{ij}}{\sum_{l=1}^{n} \lambda_{lj} (\hat{Y}_l \hat{\tau}_{lj})^{1-\sigma} \hat{\chi}_{lj}}, \tag{A.6}$$

where we have used $E_j = Y_j$ and Equation (A.1). Setting $\hat{\tau}_{ij} = 1$ and using the explicit time notation used in the main text, i.e. writing out the ratio of expenditure shares across time periods T and $T+S$, $\tilde{\lambda}_{ij,T+S}$, instead across counterfactual versus baseline scenarios, $\hat{\lambda}_{ij}$, renders Equation (A.6) identical to Equation (10) in the main text.

Following Arkolakis et al. (2012), we can express the welfare change in country j due to a change in trade costs, $\hat{\tau}_{ij}$, as:

$$\hat{W}_j = \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}, \tag{A.7}$$

where $\lambda_{jj} = X_{jj}/E_j$ is the fraction of expenditure on domestically produced goods. Allowing for exogenous additive trade deficits, Baier et al. (2019) provide the Stata package `gegravity` that calculates $\hat{W}_j$ for given $\hat{\tau}_{ij}$ using the counterfactual expenditure shares, $\lambda_{ij,T+S}$, and income levels, $Y_{j,T+S}$ in all future periods $T+S$.