Structural Gravity and the Gains from Trade under Imperfect Competition[1]

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Abstract

We extend structural gravity models of trade flows to oligopoly and generalize the standard welfare formula for trade cost changes. We show that conventional estimates not only reflect trade costs but also market power. Our estimation procedure generalizes the standard gravity model and disentangles exogenous trade frictions and endogenous market power distortions. We use our estimated model to counterfactually increase trade costs by abolishing the European Single Market. We find that domestic markups in EU member countries increase by 2 to 6 percent. Welfare effects of trade liberalization are larger due to changes in competition among domestic and foreign firms.

JEL-Classification: F10, F12, F14, F15, F17.

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1 Introduction

The gravity equation is the most successful workhorse model in international trade as it explains trade patterns between countries remarkably well. It is routinely used to study the trade and welfare effects of geographical and cultural distance, trade agreements, trade policies, institutions as well as the effects of sporting events, sanctions and conflicts. Having started out as a purely empirical workhorse borrowed from physics, it is now well established in its structural form where the gravity equation is derived from a theoretical model which is consistent with general equilibrium constraints (for the path-breaking contributions, see Anderson, 1979, Anderson and van Wincoop, 2003, and Eaton and Kortum, 2002). It has been shown that a variety of models like Armington, Ricardo, Heckscher-Ohlin, monopolistic competition and models of heterogeneous firms all imply a gravity equation. In tandem with its theoretical foundations, best practices for estimating gravity equations have been established. Most recently, Allen et al. (2020) have shown how universal gravity is.[1]

A common feature of the theoretical frameworks underlying structural gravity models is that trade costs increase prices in export markets one-to-one, ruling out pricing-to-market. Given the counterfactual evidence on the pricing behavior of firms, we extend structural gravity to oligopolistic competition, while retaining all other features of typically used models. In particular, we develop a model where a domestic producer is allowed to have market power both in its domestic as well as its international markets. This model is the simplest possible extension of the widely used Armington (1969) model of product differentiation by country to oligopoly. Our model embeds the seminal oligopoly models of Brander and Krugman (1983) and Eaton and Grossman (1986) into a structural gravity model that allows us to conduct counterfactual welfare evaluations quantitative trade models and structural gravity are famous for.

Our framework has minimal data requirements as it only uses aggregate trade and production data, enabling the quantification of the third country and general equilibrium effects which take center stage in multi-country quantitative trade models. These effects

[1]Different theoretical foundations for the gravity equation can be found in Anderson and Yotov (2016), Arkolakis et al. (2012), Bergstrand (1985), Caliendo and Parro (2015), Chaney (2008), Chor (2010), Costinot et al. (2012), Deardorff (1998) and Helpman et al. (2008). Anderson (2011), Head and Mayer (2014) and Yotov et al. (2016) provide guidance on the estimation of structural gravity models. For a recent critical review of the structural gravity approach, see Carrère et al. (2020).

are crucial for the evaluation of multilateral trade liberalization via discriminatory trade agreements. We employ oligopoly models as in Amiti et al. (2019) and d'Aspremont and Dos Santos Ferreira (2016) and use the proportionality property between prices, markups and trade costs to derive a gravity equation. In particular, we show that if consumers have Dixit-Stiglitz (CES) preferences, gravity still holds for any oligopoly in prices or quantities. Thus, our results imply that researchers can still estimate trade costs using aggregate trade data and use their estimates to quantify the trade and welfare effects of changes in trade costs, if they are willing to (continue to) assume that preferences are of the Dixit-Stiglitz form. We show that the frictions estimated by standard gravity models are a combination of trade frictions and market power distortions in an oligopoly setting. We can use our estimated model to disentangle these trade and market power frictions, and we can do so for both price and quantity competition within the same framework.

Why is this important? International trade is driven by large firms: most firms do not export, and a small number of firms is responsible for a large fraction of exports.[2] Not allowing for the oligopolistic nature of today's international trade may lead to wrong quantifications of the effects of trade liberalization episodes and may therefore lead to wrong policy advice. This is particularly important as the motivation for economic integration via trade liberalization is often not only to reduce trade costs, but also to increase competition among exporters and domestic firms. An outstanding example for this is the creation of the European Single Market whose explicit aim is to increase competition.[3] Our paper offers guidance on how these effects can be estimated in a theory-consistent way in models of oligopolistic competition.[4]

Since the completion of the European Single Market was supposed to encourage compe-

[2]Bernard et al. (2007) find that only 4 percent of U.S. firms exported in 2000, and the top 10 percent of firms represent 96 percent of U.S. exports. This pattern is similar across the globe: in a sample of 32 countries, Freund and Pierola (2015) find that five firms account for a third of a country's exports.

[3]"The single market refers to the EU as one territory without any internal borders or other regulatory obstacles to the free movement of goods and services. A functioning single market stimulates competition and trade, improves efficiency, raises quality, and helps cut prices." See `https://ec.europa.eu/growth/single-market_en`.

[4]Other papers have focused on alternative demand systems. Our paper thus complements Arkolakis et al. (2019), Feenstra and Weinstein (2017), Mrázová and Neary (2014), Mrázová and Neary (2017), Mrázová and Neary (2020) and Novy (2013) who study the effects of trade costs for a wide variety of utility functions but assume that firms operate under monopolistic competition. See also Brooks and Pujolas (2019) who find a non-constant trade elasticity in a model with perfect competition and non-homothetic preferences.

tition, we use our estimated model to quantify these effects. For this purpose, we employ a national champions model in which each country hosts an arbitrary number of domestic firms that are active in all markets.[5] We counterfactually increase trade costs by abolishing the European Single Market, and we show that welfare effects are more pronounced than in standard models. We find that the interaction between endogenous markups and trade frictions makes a crucial difference such that a reduction in trade frictions has a stronger effect, even if the number of firms in a given market is large. As our framework nests models that assume monopolistic competition, we can compare the effects of the European Single Market implied by standard models with the Cournot and Bertrand industry equilibria of our model. Our baseline Armington-like assumption that each country hosts a single national champion implies that 43 firms will be active in each industry in our data set of 43 countries, and thus the competition effects we identify are a conservative estimate. We also demonstrate that significant differences in welfare effects remain even with a large number of domestic firms. We are not the first to estimate the effect of the European Single Market (see for example, Felbermayr et al., 2018, and Mayer et al., 2019, for recent studies), but these papers employ a standard structural gravity approach. Our study emphasizes the difference implied by oligopoly, also because several studies have found that the Single Market has reduced markups (see, Allen et al., 1998, and Badinger, 2007). Interestingly, it is not the difference between competition in prices and quantities — that is known to have opposite implications for strategic trade policy models — but the difference between oligopoly and monopolistic competition that matters most in terms of welfare implications.

To our knowledge, this is the first paper that integrates oligopolistic behavior into a structural gravity framework which allows to conduct counterfactual welfare analyses which take into account trade diversion effects, two central features of the quantitative trade theory literature.[6] Oligopoly has mostly been sidelined in quantitative multi-country models of trade, probably because of the detailed firm-level or scanner-level data typically

[5]If corresponding data are available, our model in principle also accommodates an oligopoly with several heterogeneous domestic firms, multi-product firms and endogenous entry. With information on market conduct, it can also allow for an economy with multiple sectors in which price competition prevails in some industries while other industries face binding capacity constraints.

[6]Breinlich et al. (2020) use a first-order approximation to proxy the impact of market power on trade elasticities in a gravity context, but their framework does not provide a method for counterfactual welfare analyses which takes into account trade diversion effects, a main focus of our paper.

used in the literature on competition effects which are not readily available for several countries.[7] In this vein, our paper is close to Amiti et al. (2019), Atkeson and Burstein (2008), Edmond et al. (2015), Gaubert and Itskhoki (2021) and Jaravel and Sager (2019) who use structural models and detailed data from one country to quantify the reallocation effects across firms and products of increasing competition. As such data are typically only available for one country, these papers have to assume away third country and trade diversion effects, i.e., they cannot answer questions about how changes in trade costs between two countries, e.g., due to a trade agreement between them, not only affect the trade agreement member countries but also their trade with non-members, as well as trade between non-members. These trade diversion effects are crucial for the evaluation of trade policies such as trade agreements, and they are at the heart of the gravity literature. Allowing for these effects is the crucial advantage of quantitative multi-country models which rely on aggregate data only. Because of these features, they remain the workhorse models in empirical international trade both for academic publications as well as evaluations of policies such as Brexit, even today, see, e.g., Carrère et al. (2020). The innovation of our paper is that we show how to allow for oligopolistic behavior using only aggregate data as used in such quantitative multi-country trade models. More generally, we show that strategic interactions in imperfectly competitive markets are important for aggregate evaluations of trade liberalization episodes. Standard quantitative trade models of monopolistic competition cannot directly address the pro-competitive effects of trade liberalization.[8]

Our model is consistent with the recent empirical findings of interdependent markups across markets and incomplete pass-through. Using Belgian firm-level data, Amiti et al. (2019) show that domestic and foreign prices co-move and that the pass-through of cost increases is incomplete.[9] Both results are in sharp contrast to models of monopolistic competition using CES demand structures. Their model exploits uniquely detailed data at the firm-product level for both Belgian and foreign firm sales in Belgium. While Amiti

[7] For an overview of the influence of oligopoly models on empirical trade studies, see Head and Spencer (2017). Head and Mayer (2019) compare the CES monopolistic competition approach with the random coefficients demand structures used in the industrial organization literature.

[8] In particular, Arkolakis et al. (2019) show that models that replace constant by variable markups may lead to lower gains from trade.

[9] Using the Global Exporter Database by the World Bank, a survey of exporters in multiple countries, Asprilla et al. (2019) provide reduced form evidence that firms adjust their markups after bilateral exchange rate shocks.

et al. (2019) focus on the total effect of cost shocks on firms' markups, we identify the individual effects of trade cost changes on markups. De Loecker et al. (2016) find that markups of Indian firms are heterogeneous, as well as their response to trade liberalization. De Loecker and Eeckhout (2018) report that world-wide, average markups have gone up, but they can only consider aggregate markups of firms but not across destinations. Both papers use a cost minimization approach and detailed firm-level data to estimate production functions. This allows them to infer production costs and ultimately markups without having to assume a specific market conduct. While these features are attractive for *ex post* single country studies of past liberalization episodes where these data are available, these approaches do not explicitly model consumer demand, making *ex ante* counterfactual analyses impossible, a key advantage of our more structural approach. Furthermore, we introduce oligopoly into the structural gravity literature, and thus a major innovation of our paper is that we can take third-country effects into account.

Our study also complements a series of papers by Holmes et al. (2014) and Hsu et al. (2020). They use the model of Bernard et al. (2003) which assumes Bertrand competition between firms from different countries that are heterogeneous in productivity but produce a homogeneous good. Instead, in line with Armington (1969), we model Bertrand competition between firms which produce differentiated varieties across countries with heterogeneous costs. We also consider Cournot competition (and monopolistic competition as the limiting case), and thus our paper complements Edmond et al. (2015) who study Cournot competition in an intermediate goods sector based on the model of Atkeson and Burstein (2008).

The remainder of this paper is organized as follows: Section 2 describes equilibrium prices and markups when firms compete strategically in terms of prices or quantity. Section 3 develops a welfare formula in the spirit of Arkolakis et al. (2012), while Section 4 derives the firm-level gravity equation for an exporting firm that is exposed to oligopolistic competition. Section 5 shows how trade cost and market power frictions can be disentangled empirically, and demonstrates to which extent not modeling imperfect competition may lead to a bias in the estimated welfare effects of trade agreements using the European Single Market as an example. Section 6 concludes.

2 Firm behavior under imperfect competition

This section scrutinizes oligopolistic competition among exporters and domestic firms if all countries have identical preferences where the upper tier utility function has a Cobb-Douglas form and the lower tier has a CES form, the standard setup used in quantitative trade models, see Costinot and Rodríguez-Clare (2014). We scrutinize oligopolistic competition by employing a model in which oligopolistic firms produce and export in a world in which n countries may trade with each other. Each country hosts a continuum of industries, and firms are large in the small, that is, they assume market power in their industry, but small in the large, that is, they take factor prices and incomes as given, as in the GOLE model by Neary (2016). We begin with considering the profits of a firm i that operates in industry k and produces at location $\ell(i)$. The set of firms in industry k that produce and export out of location j is denoted by $\mathcal{L}_{jk}$, and its aggregate number across all countries is given by m_k. Sales are subject to institutional or other geographical frictions that have the form of iceberg trade costs of size $\tau_{\ell(i)jk}$ where $\tau_{\ell(i)jk} \geq 1$ measures trade frictions of sales for exports from country $\ell(i)$ to country j.

In what follows, we will focus on the implications of oligopolistic competition as a more realistic alternative to monopolistic competition while we keep the standard assumptions for the demand side.[10] There are many industries, and following the canonical Dornbusch-Fischer-Samuelson (DFS) model (see Dornbusch et al., 1977 and Dornbusch et al., 1980), we consider a continuum of industries that are defined over the interval $[0, 1]$. In particular, we assume that the utility of a representative household in any country j is given by the Cobb-Douglas utility function $\ln W_j = \int_0^1 \alpha_k \ln U_{jk} dk, \int_0^1 \alpha_k = 1$, where U_{jk} denotes the subutility of the representative household in country j of goods produced in sector k. Country j's consumers will be served by the domestic firm and its foreign competitors in each industry, and the subutility is given by

$$U_{jk} = \left(\sum_{i \in M_{jk}} q_{ijk}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \qquad (1)$$

[10]These derivations bear some resemblance to results in Atkeson and Burstein (2008), but we also consider Bertrand competition and n countries. Our results on the conditions for strategic complementarity (see Lemma 1) are new.

where $\sigma > 1$;[11] q_{ijk} denotes the sales of firm i located at $\ell(i)$ to country j, so q_{ijk} is part of country j's internal trade if $\ell(i) = j$. M_{jk} is the set of all firms of industry k that serve country j. Note that all firms located in country j will serve at least country j, that is, $i \in M_{jk}$ if $i \in \mathcal{L}_{jk}$. Thus, local firms will always serve their own market, as we assume domestic trade to be frictionless. The aggregate expenditure for goods in this industry is given by E_{jk}. As is well-known, utility maximization implies that expenditure for goods produced by industry k for country j is given by $E_{jk} = \alpha_k Y_j$, where Y_j denotes country j's aggregate expenditure. For our analysis of strategic interaction, in order to save on notation, in this section, we drop the industry indexation k and consider a single industry for a target market j for which we also drop the indexation. Consequently, we write p_i for p_{ijk} and use a similar notation for all other variables and parameters in this part of the analysis. Without loss of generality, we assume that all m firms are active in the target country. Our model can easily be extended to endogenous entry which we discuss at the end of this section.

In the following, we scrutinize competition by prices. The case of competition by quantities is similar to Atkeson and Burstein (2008), and we have therefore relegated the details to Appendix A.1.[12] These are the classic oligopolistic model setups, where price competition assumes that firms face no capacity constraints and can serve any demand that will result from price competition. Quantity or capacity competition is a setup in which firms cannot change outputs in the short term. It depends on the nature of production whether firms are more likely to compete by prices or by quantities. In case of price competition, denoted by B for Bertrand, each firm i maximizes its operating profit, that is, $\pi_i^B(p_i, p_{-i}) = (p_i - \tau_{\ell(i)} c_{\ell(i)}) q_i(p_i, p_{-i})$ w.r.t. p_i, where p_{-i} is a $(m-1)$ price vector that denotes the prices of all other active rivals, and $c_{\ell(i)}$ denotes the marginal production cost at location $\ell(i)$. The first-order condition as an optimal response to the optimal pricing decisions of all rivals determines the Nash equilibrium in prices and reads

$$\forall i : \frac{\partial \pi_i^B}{\partial p_i}(p_i^*, p_{-i}^*) = q_i(p_i^*, p_{-i}^*) + \left(p_i^* - \tau_{\ell(i)} c_{\ell(i)}\right) \frac{\partial q_i}{\partial p_i}(p_i^*, p_{-i}^*) = 0, \tag{2}$$

[11] We assume a universal σ instead of σ_{jk} to ease notation. All derivations go through when allowing for an elasticity of substitution that is country- and industry-specific.

[12] We assume for now that markets are segmented such that each firm can set prices or quantities without any arbitrage constraint. Later on, we will show that the Nash equilibria for segmented markets are in fact immune against arbitrage and thus also qualify for Nash equilibria in integrated markets.

where p_i^* denotes the optimal price of firm i in country j, and p_{-i}^* denotes the $(m-1)$ vector of the optimal prices of all other firms. Since demand for firm i in country j is given by $q_i(p_i, p_{-i}) = Ep_i^{-\sigma} / \sum_{\iota=1}^m p_\iota^{1-\sigma}$, we can rewrite the first-order conditions in terms of markups, denoted by μ_i^B and μ_ι^B, respectively, and elasticities, denoted by ϵ_i^B and ϵ_ι^B, respectively:

$$\forall i : p_i^* = \mu_i^B \tau_{\ell(i)} c_{\ell(i)}, \mu_i^B = \frac{\epsilon_i^B}{\epsilon_i^B - 1} = \frac{\sigma - (\sigma-1)s_i^B}{(\sigma-1)(1-s_i^B)} \text{ because} \tag{3}$$
$$\epsilon_i^B = \sigma - (\sigma-1)\frac{\left(\mu_i^B \tau_{\ell(i)} c_{\ell(i)}\right)^{1-\sigma}}{\sum_{\iota=1}^m \left(\mu_\iota^B \tau_{\ell(\iota)} c_{\ell(\iota)}\right)^{1-\sigma}} = \sigma - (\sigma-1)s_i^B$$

where $s_i^B = (\mu_i^B \tau_{\ell(i)} c_{\ell(i)})^{1-\sigma} / \sum_{\iota=1}^m (\mu_\iota^B \tau_{\ell(\iota)} c_{\ell(\iota)})^{1-\sigma}$ denotes the market share of firm i in country j. Not surprisingly, the Nash equilibrium in prices converges to the monopolistic competition outcome if s_i^B approaches zero.[13] In general, s_i^B reduces the elasticity of demand for firm i, and this effect is the stronger, the stronger the trade *and* market power frictions of firm i relative to the ones of all firms located in all countries.

We show in Appendix A.2 that the sufficient conditions are fulfilled for both the Bertrand equilibrium (3) and the Cournot equilibrium (A.2) in Appendix A.1 and that the industry equilibria exist and are unique.[14] The type of competition has an impact on market performance. We find:

Lemma 1. *(i) Prices are strategic complements in the sense of Bulow et al. (1985) in case of Bertrand competition. In case of Cournot competition, a firm i will increase (decrease) its output in response to an increase in rival output if $q_i^{(\sigma-1)/\sigma} > (<) \sum_{\iota \neq i} q_\iota^{(\sigma-1)/\sigma}$. (ii) For an identical market share, the markup is higher in case of Cournot competition than in case of Bertrand competition.*

Proof. For part (i), see Appendix A.3. For part (ii), $\epsilon_i^C < \epsilon_i^B$ and $\mu_i^C > \mu_i^B$ for the same market share s_i (see Appendix A.3) imply $(1-s_i)s_i(\sigma-1)^2 > 0$ which is true. □

[13] In case of complete symmetry in terms of trade frictions and production costs, i.e., $\tau_{\ell(i)} = \tau, c_{\ell(i)} = c, \forall i$, $s_i^B = 1/m$, implying $\epsilon_i^B = \sigma - (\sigma-1)/m$, also because symmetry implies equal markups $\mu_i^B = \mu^B$. This is, however, an unrealistic case in this context as it requires that either all trade is frictionless or that internal trade faces the same trade frictions as all external trade.

[14] Kreps and Scheinkman (1983) have shown that Cournot competition is strategically equivalent to a game in which firms commit to capacities first and compete by prices in the second stage in a homogeneous goods model. Our model features product differentiation such that we do not claim that one model can be the outcome of the other when a capacity investment stage is added.

Note that both prices and quantities are strategic neutrals in models of monopolistic competition due to its non-strategic nature, but they can be expected to respond in a strategic environment. Lemma 1 shows that firms are potentially more aggressive when competing in prices than in outputs. The reason is that a price decrease by one firm is always matched by a price decrease of other firms due to strategic complementarity, making competition more aggressive. In case of Cournot competition, an output increase may be moderated by output reductions of rival firms. However, a note of caution is in order. First, a firm may increase output in response to output increases if its initial output is already large to begin with. Second, the multilateral resistance terms, to be developed in Section 4, and their changes are different across competition modes.

A common feature of both competition modes is that the pass-through of trade frictions is not complete such that the markup decreases with the trade costs. In particular, we can show:

Proposition 1. *The markup of a firm decreases with its trade cost. Consequently, for both a Nash equilibrium in prices (Bertrand) and a Nash equilibrium in quantities (Cournot), any difference in a firm's equilibrium prices will be smaller than the difference in trade costs.*

Proof. See Appendix A.2. □

In models of monopolistic competition, the price charged for one destination is proportionate to the price charged to other destinations, and the degree of proportionality is determined by the trade friction only. In case of imperfect competition, an increase in trade frictions will be partially absorbed by firms.[15] It is now easy to see that this proportionality also holds under imperfect competition when both the trade friction *and* the market power distortion are taken into account, although we know from Proposition 1 that the degree of proportionality must be smaller than the pure trade friction. For this purpose, let us reintroduce the general setup, i.e., subscripts for industry k and destination market j, and write the equilibrium prices given by eqs. (3) and (A.2) as

[15] Proposition 1 also shows that the segmented market outcome is identical to the integrated market outcome if arbitrage traders are subject to the same frictions as goods producers as the price differences from one market to the other will always be smaller than the trade friction. Thus, eqs. (3) and (A.2) are also equilibria even if firms cannot exclude parallel trade, i.e., the resale of goods in one market that they delivered to another market.

$$p^*_{ijk} = \underbrace{\mu_{ijk}\tau_{\ell(i)jk}}_{\equiv t_{ijk}} c_{\ell(i)}, \tag{4}$$

where we have dropped the superscript B for Bertrand and C for Cournot, as eqs. (3) and (A.2) show how μ_{ijk} is determined in the two cases, and where we denote by t_{ijk} the combined trade and market power friction. It should have become clear now that the markups under both Bertrand and Cournot are not constant and depend on both the trade frictions and the market power frictions. Thus, our model is able to explain why markups differ across destinations.

Which markets will firms serve? Our model can also determine the extensive margin of trade, but we will follow the standard models by Anderson and van Wincoop (2003) and Eaton and Kortum (2002) which assume that firms serve all markets to stay as close as possible to these benchmarks. This is also in line with the aggregate data we use in our empirical application in Section 5, as we do not observe zero trade flows in our data set. In Appendix A.1, we describe how to incorporate the extensive margin in our model by developing M_{jk}, the set of firms of industry k that serve country j.

We have now described our model setup, which is as close as possible to the standard quantitative trade theory frameworks used in the literature which rely on aggregate data. The next section will determine the gains from trade liberalization under oligopoly, while we derive the gravity equation under oligopoly in Section 4.

3 The gains from trade

How does our model compare to standard quantitative models of trade for which Arkolakis et al. (2012) have shown that the gains from trade depend only on the change in the share of a country's expenditure on its own goods and the trade elasticity? In standard quantitative models of trade, this trade elasticity is regarded as an important measure to determine the welfare gains from trade (see, in particular, Arkolakis et al., 2012). In our model, the trade elasticity *at the firm level* does not play this important role. Proposition 1 has shown that $d\mu_{ijk}/d\tau_{\ell(i)jk} < 0$, and thus the trade elasticity at the firm level is given by

$$\zeta_{ijk} = (1-\sigma)\left(1 + \frac{d\mu_{ijk}/\mu_{ijk}}{d\tau_{\ell(i)jk}/\tau_{\ell(i)jk}}\right), \tag{5}$$

which is smaller in absolute terms than the monopolistic competition elasticity $1-\sigma$ since $d\mu_{ijk}/d\tau_{\ell(i)jk} < 0$. But this lower elasticity should not be taken to indicate that the welfare effects are smaller. The elasticity only shows how a single firm responds to a change of its market access conditions to a foreign country.[16] To describe the effect on the level of welfare in the economy, however, we have to take into account how rival firms respond to this change. Also note that the trade elasticity in our model is not constant but varies across country-pairs and depends on the level of bilateral trade costs and markups. We can generalize the welfare result derived by Arkolakis et al. (2012) to oligopoly. Following their notation, we denote the change of any variable z from its level z^0 before to the level z^1 after trade liberalization by $\widehat{z} \equiv z^1/z^0$, and we denote the share of country j's expenditure on goods produced by its domestic firm $\iota, \iota \in \mathcal{L}_{jk}$, in industry k by $\widehat{\lambda}_{\iota jk}$. We find:

Proposition 2. *Assume that each country uses only labor as factor of production and the endowment of labor is equal to L_j for country j. Let Π_j^{*0} $\left(\Pi_j^{*1}\right)$ denote the aggregate profit of all firms located in country j before (after) trade liberalization. The gains from trade liberalization under oligopoly are given by*

$$\widehat{W}_j = \widehat{Y}_j \prod_k \widehat{\Lambda}_{jk}^{\frac{\alpha_k}{1-\sigma}},$$

where

$$\Lambda_{jk} = \sum_{\iota \in \mathcal{L}_{jk}} \frac{\lambda_{\iota jk}}{\mu_{\iota jk}^{1-\sigma}}$$

and $\widehat{Y}_j = \left(L_j + \Pi_j^{*1}\right) / \left(L_j + \Pi_j^{*0}\right)$.

Proof. See Appendix A.4. □

[16] This result is similar to Edmond et al. (2015). They assume imperfect competition on the market for intermediate inputs while the final goods market is perfectly competitive, and they also find that the trade elasticity is smaller with variable markups.

Proposition 2 can be best understood by considering a country that hosts only a single domestic firm in each industry.[17] Let λ_{jjk} denote the domestic expenditures on the domestically produced good in industry k, and let μ_{jjk} denote the respective markup of the domestic firm in its home market. In this case, $\Lambda_{jk} = \lambda_{jjk}/\mu_{jjk}^{1-\sigma}$, and the welfare change is given by

$$\widehat{W}_j = \widehat{Y}_j \prod_k \left(\frac{\widehat{\lambda}_{jjk}^{\frac{1}{1-\sigma}}}{\widehat{\mu}_{jjk}} \right)^{\alpha_k}. \tag{6}$$

Eq. (6) shows that the gains from trade do not only depend on the change in domestic expenditures on the domestically produced goods, but also on the change in the domestic markup for domestically produced goods. In general, $\widehat{\Lambda}_{jk}$ summarizes both of these changes across domestic firms and industries. Proposition 2 shows that the welfare change can be measured by the change in GDP, $\widehat{Y}_j$, by the changes in expenditure shares for domestically produced goods and the changes in domestic markups for home consumers as summarized by $\widehat{\Lambda}_{jk}$ and by the elasticity $1/(1-\sigma)$, weighted by the respective expenditure shares. The welfare change would be the same as in Arkolakis et al. (2012) if (i) the domestic markups in the domestic market did not change, i.e. if $\widehat{\mu}_{jjk} = 1$, and (ii) real income did not change, i.e. if $\widehat{Y}_j = 1$. This holds for monopolistic competition models as the markup does not change for CES preferences and profit is either zero with free entry or a constant share of revenues otherwise. In our model, however, competition and strategic interaction are driving forces: first, a reduction in the expenditure share for the domestically produced good is due to a more aggressive pricing or output behavior of foreign firms, and second, competition changes the domestic markups in the domestic markets.

Thus, the gains from trade come about not only from the change in the share of country j's expenditure on its own goods, but also from the change in its own firms' markups for domestic consumers. For example, for given income effects, if trade liberalization leads to a decrease in $\widehat{\lambda}_{\iota jk}$, monopolistic competition will underestimate the gains from trade when competitive pressure will reduce the domestic markups of domestic firms at the same time. Furthermore, real income changes due to changes in domestic profits can either amplify

[17] Since the share of a country's expenditure on its own goods is equal to the market share in equilibrium if there is only one domestic firm in each country, we show in Appendix A.5 how one can also use the market share change to compute the change in welfare under this assumption.

or reduce the welfare gains, depending on whether domestic profits increase or decrease.[18] Note carefully that a reduction in trade costs does not necessarily imply lower profits: while import competition reduces domestic profits, easier access to foreign markets increases it, so it is not clear whether $\widehat{Y}_j$ is larger or smaller than unity.[19] Thus, Proposition 2 identifies two additional general equilibrium channels through which gains from trade may come about.

How large are the differences in the welfare effects of trade liberalization when comparing monopolistic competition and oligopoly? To gain intuition, we illustrate the difference in outcomes in a simple Krugman model in which two symmetric countries, each hosting a single firm, will reduce bilateral trade costs. This is a model in which each country hosts a single domestic firm that sells in the home and the foreign market, and thus $m = n = 2$. All industries are also completely symmetric and their marginal production costs are normalized to unity. This allows us to consider the whole economy as consisting of one industry only as all trade liberalization effects will be symmetric across industries and countries, and both firms will be active in both countries. We are interested in the effects of reducing bilateral and symmetric trade frictions for each exporter. We confine the analysis to price effects (and thus set $\widehat{Y}_j = 1$) to focus squarely on the impact of oligopoly behavior on welfare via its impact on consumer prices. We simulate the gains from trade from reducing $\tau_{\ell(1)2k} = \tau_{\ell(2)1k} = \tau$ to unity, i.e., free trade, for different levels of trade frictions to begin with.

Figures 1, 2 and 3 show the gains from trade liberalization measured by V as the ratio of welfare after to the welfare before trade liberalization on the vertical axis, and welfare is measured by the inverse of the price index in a country. τ on the horizontal axis gives the initial level of trade costs from which these trade costs are reduced to unity, so $V = 1$ for $\tau = 1$. Figure 1 assumes $\sigma = 3$, while Figures 2 and 3 assume $\sigma = 5$ and $\sigma = 7$, respectively. Each figure shows the three different modes of competition we consider: monopolistic competition, price competition (Bertrand) and quantity competition (Cournot). In case of monopolistic competition, the price setting behavior follows a simple markup behavior

[18] In this sense, Proposition 2 seems to be similar to the results of Arkolakis et al. (2019) who take into account incomplete pass-throughs and changes in the price indexes when preferences are not CES. The crucial difference is, however, that Proposition 2 deals with competition in an oligopoly framework that can include markup and profit changes as a result of strategic interactions.

[19] See, for example, Long et al. (2011) for a simple oligopoly model in which the size of these two effects depends on the initial level of trade costs.

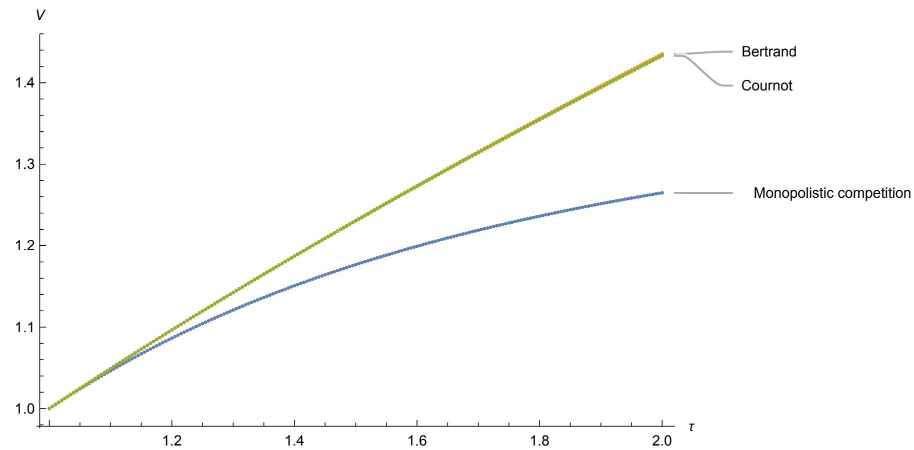

Figure 1: Welfare changes from trade liberalization in the Krugman model for $\sigma = 3$

of size $\sigma/(1-\sigma)$ while price competition and quantity competition price setting behavior is given by the Nash equilibria described by eqs. (3) and (A.2), respectively.

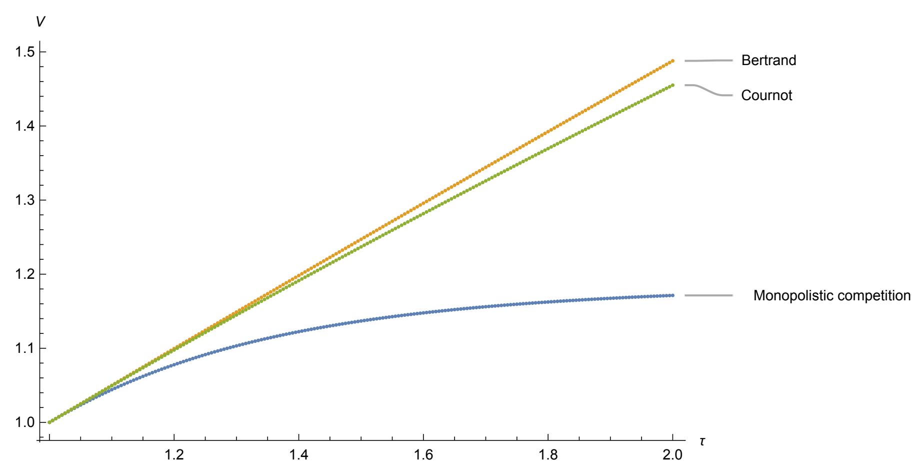

Figure 2: Welfare changes from trade liberalization in the Krugman model for $\sigma = 5$

All figures show that the gains from trade are much larger if the price setting behavior is modeled in an oligopolistic fashion and trade frictions are not too small to begin with. Figure 1 shows that the gains from trade under duopoly behavior are not too different for a relatively low elasticity of substitution. While a low elasticity of substitution may be regarded as a case where the monopolistic competition markup is a not too bad approximation for firm behavior, Figure 1 also shows that the difference in the gains from trade can mount up to 20 percent. For larger elasticities of substitution, these differences become more pronounced. Both Figure 2 and Figure 3 show that the gains from trade are larger under Bertrand than under Cournot competition. Price competition is more aggressive in our simple two country model although quantities are also strategic complements in this model with two firms when trade costs are non-zero (see Lemma 1). The difference between Bertrand and Cournot is not as striking as the difference between these two and monopolistic competition: Both figures show that the difference in welfare gains between duopoly and monopolistic competition can mount up to 40 percent. Note that Figures 1, 2 and 3 have illustrated the welfare *gains* from trade liberalization. It should be clear that the three different competition modes will imply different levels of welfare to begin with.

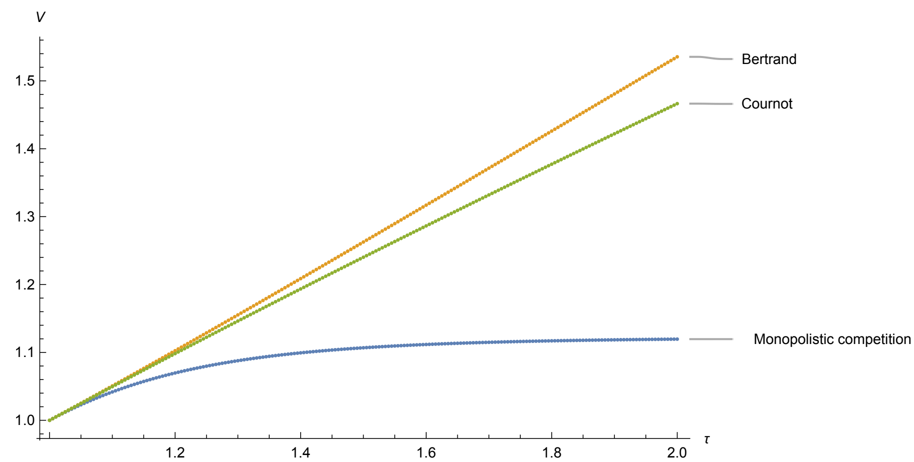

Figure 3: Welfare changes from trade liberalization in the Krugman model for $\sigma = 7$

4 Gravity under imperfect competition

While our simple example from the previous section helps to gain intuition, it may be held against this exercise that we assume a duopoly, and the differences between the three competition modes should become smaller with an increase in the number of firms. To explore this issue further and to be able to take our model to the data, we now develop the gravity equation under oligopoly, returning to a setting with n countries. For this exercise, we assume that each country hosts a single national firm in each industry to which we refer to as the national champions' model.[20] Consequently, we can now refer to i also as the country where firm i is located, and $n = m$ holds. This will allow us to estimate the gravity equation using aggregate trade data only. Consider a firm in industry k that is located in country i and serves country j. From eq. (4), we can compute sales, denoted by x^*_{ijk}, as

$$x^*_{ijk} = p^*_{ijk} q^*_{ijk} = \left(\frac{p^*_{ijk}}{P_{jk}} \right)^{1-\sigma} E_{jk} = \frac{E_{jk}}{P^{1-\sigma}_{jk}} {t_{ijk}}^{1-\sigma} c_i^{1-\sigma}, \tag{7}$$

if $x^*_{ijk} > 0$, that is, if firm i of industry k is actively serving country j. $t_{ijk} = \mu_{ijk}\tau_{ijk}$ measures both the distortions that originate from market power and from trade frictions, and

$$P_{jk} = \left(\sum_{i=1}^{n} {p^*_{ijk}}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{8}$$

is the price index in the target market j. Aggregate sales of country i in industry k are equal to the sum of all trade, including to itself, i.e., $Y_{ik} = \sum_{j=1}^{n} x^*_{ijk}$. Let I_{ijk} denote an indicator variable for which $I_{ijk} = 1$ if $i \in M_{jk}$ and $I_{ijk} = 0$ otherwise. Hence we can write

$$Y_{ik} = \sum_{j=1}^{n} x^*_{ijk} = \sum_{j=1}^{n} \frac{I_{ijk} E_{jk}}{P^{1-\sigma}_{jk}} {p_{ijk}}^{1-\sigma} = c_i^{1-\sigma} \sum_{j=1}^{n} \frac{I_{ijk} E_{jk}}{P^{1-\sigma}_{jk}} {t_{ijk}}^{1-\sigma}. \tag{9}$$

Solving eq. (9) for $c_i^{1-\sigma} = Y_{ik} Q_{ik}^{\sigma-1}$ and plugging $c_i^{1-\sigma}$ into eq. (7), we can now write trade flows from country i to j in industry k as

$$x^*_{ijk} = \frac{Y_{ik} E_{jk}}{Y_k^W} \left(\frac{t_{ijk}}{Q_{ik} P_{jk}} \right)^{1-\sigma} = \frac{Y_{ik} E_{jk}}{Y_k^W} \left(\frac{\mu_{ijk} \tau_{ijk}}{Q_{ik} P_{jk}} \right)^{1-\sigma}, \quad \text{with} \tag{10}$$

$$Q_{ik}^{1-\sigma} = \sum_{j=1}^{n} I_{ijk} \frac{E_{jk}}{Y_k^W} \left(\frac{t_{ijk}}{P_{jk}} \right)^{1-\sigma} \quad \text{and} \quad P_{jk}^{1-\sigma} = \sum_{i=1}^{n} \frac{Y_{ik}}{Y_k^W} \left(\frac{t_{ijk}}{Q_{ik}} \right)^{1-\sigma}, \tag{11}$$

where Q_{ik} is the outward multilateral resistance term and Y_k^W are world sales of industry k. As in other gravity models, the outward multilateral resistance term measures the exposure of the firm in country i in industry k to frictions. In our context producers do

[20] We later extend this model to an arbitrary number of (symmetric) national champions, i.e., domestic firms, in each country. We explore the quantitative implications in our empirical application in the following section. For details, see Section A.10 in the Appendix.

not only face trade frictions, but also market power frictions from rival firms. P_{jk} can be interpreted as the inward multilateral resistance term which measures the impact of all frictions for consumers in country j, but again these frictions now include both trade and market power frictions.

Equation (10) is the gravity equation under imperfect competition. It has a striking resemblance with the standard gravity equation from Anderson and van Wincoop (2003), however, with a key difference. Bilateral trade flows not only depend on bilateral trade costs τ_{ijk} as in standard gravity models but also on markups charged by firms via the term μ_{ijk}. From the perspective of our model, commonly estimated gravity equations do not specify the trade cost function τ_{ijk} but specify the combined effect of markups and trade costs t_{ijk}. Alternatively, standard gravity equations do not control for the bilateral varying markup, and hence the markup term μ_{ijk} ends up in the error term of the regression. As markups depend on the level of trade costs (see Proposition 1), there exists a correlation between the error term and the regressors used to specify the trade cost equation, and hence estimated trade cost parameters will be biased. In this sense, this bias is similar to the bias introduced when omitting the multilateral resistance terms in standard gravity regressions: without properly controlling for the multilateral resistance terms, trade cost estimates are biased as they depend on the level of trade costs. We will demonstrate the empirical relevance of this omitted variable bias in our empirical application in the next section where we explore the welfare effects of trade (de-)liberalization using real world data by estimating our model for a large number of asymmetric competitors and where we show that the differences are still substantial.

5 Estimating the welfare and competition effects of the European Single Market

Proponents of market integration not only focus on its reduction of trade frictions, but also on how it increases competition between firms. For example, the formation of the European Single Market had the main purpose to enhance competition within Europe by reducing non-tariff trade barriers, as tariffs had already been abolished before. It is therefore the ideal setting to use our model to quantify the relative importance of trade cost and competition effects. We show in this section that quantitative trade models that do not take into account imperfect competition may underestimate the gains from trade liberalization. Thus, we show that including market power and in particular the change in market power leads to larger welfare effects. We do so by estimating the parameters of our quantitative oligopoly trade model and comparing our results to those of a conventional structural gravity approach. We then use our model to counterfactually abolish the European Single Market. As we want to focus squarely on the competition effects of trade liberalization, for our counterfactual simulations, we use a conditional general equilibrium analysis in the language of structural gravity modeling (or what Head and Mayer, 2014, call the modular trade impact): we take into account the direct effect of frictions (which on its own would be a partial equilibrium analysis only) and the third-country effects as they arise from a change in the multilateral resistance terms. We keep aggregate income and wages fixed so that we neither have to take a stance on the operation of labor markets nor on ultimate international firm ownership structures to calculate changes in aggregate profits.[21] We compare the results of Bertrand and Cournot oligopoly behavior with the standard monopolistic competition result in order to demonstrate the differences in welfare implications.

We estimate our model using trade data from the World Input-Output Database (WIOD).[22] A key advantage of WIOD is that it contains domestic trade data which allow us to calculate domestic market shares and markups. The use of domestic trade data has become standard in the structural gravity literature, see Heid et al. (2021). We use aggregate trade data between the 43 countries included in WIOD for the years 2000 to 2014. When doing so, we assume that many symmetric industries exist, that is, $\alpha_k = 1, \forall k$, such that the aggregate data are representative for each industry; the same assumption is implicitly made by perfect and monopolistic competition models using aggregate data. The innovation is that we now allow for market power such that each country hosts a national champion, making it 43 competitors for Bertrand and Cournot competition. Thus, we assume that $M_{jk} = \{1, \ldots, n\}, \forall j, k$, which may seem a too large number of competitors, but this guarantees that the competition effects of trade (de-)liberalization we estimate are conservative. In particular, we estimate eq. (10) by specifying the combined trade and

[21]Note that the difference between the modular trade impact we use and the full general equilibrium trade impact which endogenizes wages is typically negligible, see the discussion on p. 170 in Head and Mayer (2014). Still, in Appendix A.6, we show how our model can be extended by including a labor market clearing condition to do a full general equilibrium analysis if one is willing to take a stance on factor mobility across sectors.

[22]For a detailed description of the data, see Timmer et al. (2015).

market power frictions as

$$t_{ijt}^{1-\sigma} = \mu_{ijt}^{1-\sigma}\tau_{ijt}^{1-\sigma} = \mu_{ijt}^{1-\sigma}\exp(\beta_1 EU_{ijt} + \beta_2 RTA_{ijt} + \xi_{ij}) = \mu_{ijt}\exp(\mathbf{x}'_{ijt}\boldsymbol{\beta}), \tag{12}$$

where we have introduced a time index as subscript t. Hence we estimate

$$X_{ijt} = \mu_{ijt}^{1-\sigma}\exp(\eta_{it} + \nu_{jt} + \beta_1 EU_{ijt} + \beta_2 RTA_{ijt} + \xi_{ij} + u_{ijt}), \tag{13}$$

where η_{it} and ν_{jt} are exporter×year and importer×year fixed effects to control for the multilateral resistance terms in eq. (10), and ξ_{ij} is a directional bilateral fixed effect to control for the endogeneity of trade policy as suggested by Baier and Bergstrand (2007) as well as to control for standard gravity regressors such as, e.g., distance. Note that η_{it} and ν_{jt} also control for changes in a countries' overall productivity level over time which, via its impact on a countries' production cost, c_i, not only affects markups but also may influence a country's decision to join an RTA or the EU. EU_{ijt} is a dummy which is one for all international trade flows between member countries of the European single market (EU and EEA), and RTA_{ijt} is a dummy which is one for all international trade flows where the country pair is part of a regional trade agreement (including the EU, i.e., the effect of the EU common market is $\beta_1 + \beta_2$). For EU_{ijt} and RTA_{ijt}, we use Mario Larch's Regional Trade Agreements Database, see Egger and Larch (2008).[23] In the following, we sometimes refer to the EU as a short hand for the trade effect of the European Single Market where it is understood that the European Single Market also comprises the European Economic Area (EEA) countries. In our main results, we have opted to not include Switzerland in the European Single Market as it does not fully implement its four freedoms of the European Single Market and has access to the EU market only via a bilateral trade agreement with the EU.[24] For similar reasons, we ignore the customs union between the EU and Turkey. We present results which include both Switzerland and Turkey in the definition of EU_{ijt} in Appendix A.7.1. We estimate eq. (13) using PPML following the suggestion by Santos

[23] The data set can be downloaded at `https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`. We use the version from 07 November 2018. Note that we set $EU_{ijt} = 0$ for domestic trade flows of EU member countries, to be consistent with RTA_{ijt} which also is equal to 0 for domestic trade flows. This implies that EU_{ijt} and RTA_{ijt} identify the international trade effects of these agreements, relative to domestic trade. Being real models, gravity models only allow to identify the international trade cost reducing effect of policies by comparing international to domestic trade. For a more detailed discussion of gravity regressions with domestic trade flows, see Heid et al. (2021).

[24] See background on this at `https://www.europarl.europa.eu/factsheets/en/sheet/169/the-european-economic-area-eea-switzerland-and-the-north`.

Silva and Tenreyro (2006) using the `ppmlhdfe` Stata package by Correia et al. (2020) and use $\mu_{ijt}^{1-\sigma}$ as an exposure variable.[25] Following the recommendation by Egger and Tarlea (2015), we use Cameron et al. (2011) multiway clustered standard errors across exporters and importers. Note that this also controls for autocorrelation in the error term due to, for example, serially correlated changes in a country's overall productivity.

The question remains how to measure $\mu_{ijt}^{1-\sigma}$. For a given value of σ, the market share of each active firm is given by

$$s_{ijt} \equiv \frac{X_{ijt}}{\sum_{\iota \in N_{jt}} X_{\iota jt}} = \frac{t_{ijt}^{1-\sigma} c_{it}^{1-\sigma}}{\sum_{\iota \in N_{jt}} t_{\iota jt}^{1-\sigma} c_{\iota t}^{1-\sigma}} < 1. \tag{14}$$

From the first-order conditions, we know that $\mu_{ijt} = \epsilon_{ijt}/(\epsilon_{ijt} - 1)$ where

$$\epsilon_{ijt} = \begin{cases} \sigma - (\sigma - 1)s_{ijt} & \text{for Bertrand,} \\ \frac{\sigma}{1+(\sigma-1)s_{ijt}} & \text{for Cournot} \end{cases} \tag{15}$$

due to eq. (3) for Bertrand competition and eq. (A.2) for Cournot competition in Appendix A.1 which lead to

$$\mu_{ijt}^{B} = \frac{\sigma - (\sigma - 1)s_{ijt}^{B}}{(\sigma - 1)\left(1 - s_{ijt}^{B}\right)} \quad \text{and} \quad \mu_{ijt}^{C} = \frac{\sigma}{(\sigma - 1)\left(1 - s_{ijt}^{C}\right)}, \tag{16}$$

where the superscript B and C denotes the mode of competition. Equation (16) shows that the monopolistic competition markup $\sigma/(\sigma-1)$ is smaller by factor $1 - s_{ijt}^{C}$ than the Cournot markup. For the same level of trade costs and hence market shares, both markups are larger than $\sigma/(\sigma-1)$, but note that different markups across competition modes imply different estimated trade frictions for the same country-pair. Importantly, eq. (16) allows us to calculate markups directly from the observed market shares in the trade data for a given value of σ, and hence we can estimate the adjusted gravity equation (13).[26] Also

[25] This can be easily done with `ppmlhdfe` by using its `exposure` option. When estimating a log-linearized eq. (13) by OLS, one can use the transformed dependent variable $\ln X_{ijt} - \ln \mu_{ijt}^{1-\sigma}$ to implement our estimation approach. For the OLS regressions, we use the `reghdfe` Stata package by Correia (2017).

[26] Note that our model can also accommodate multi-product firms and cannibalization effects which are found important in the industrial organization literature; see Head and Mayer (2019) and the references cited therein. In Appendix A.8, we generalize the elasticity eq. (15) such that our model could easily be applied to multi-product firms if firm-product market share data, including domestic market shares, were available for a large set of countries. For a general modeling of multi-product firms using an aggregative games approach, see Nocke and Schutz (2018).

note that in standard gravity models the markup μ_{ijt} does not vary across destinations or origins and hence is captured by the fixed effects. Hence our estimation procedure nests the standard gravity model in a monopolistic competition framework for which $\mu_{ijt} = \mu, \forall i, j, t$, and is strictly more general. To calculate $\mu_{ijt}^{1-\sigma}$, we use $\sigma = 5.03$, the preferred estimate of the literature survey in Head and Mayer (2014). This value is also close to the value 4.927 reported by Gaubert and Itskhoki (2021) who structurally estimate σ using detailed French firm-level data in a two country oligopoly model.[27] However, we also conduct robustness checks setting $\sigma = 3.8$, the median value of the the metastudy by Bajzik et al. (2020). These results are reported in Appendix A.7.3 which shows that our findings are largely insensitive to the choice of σ.

We present regression results in Table 1. Columns (1) to (3) show results for a log-linearized gravity equation regression using OLS for comparison, whereas the remaining columns use PPML. Column (1) is the standard log-linearized gravity which assumes monopolistic competition (MC), i.e., constant markups. According to this specification, RTAs increase trade by approximately 13 percent.[28] The EU's trade creating effect in addition to the 13 percent of a standard RTA is 21 percent. In column (2), we use our adjusted gravity estimation and use the Bertrand markups. Results are similar to column (1) albeit we estimate slightly larger EU and RTA effects. In column (3), results increase further for both regressors. Remember that log-linearized gravities suffer from inconsistent estimates due to the heteroskedasticity of the trade data. We therefore prefer the PPML estimates in the remaining columns. Column (4) is again the benchmark gravity estimation which is the current best practice specification used in the literature. Now we find that typical RTAs increase trade on average by 15 percent. The EU now increases trade by 53 percent more than the typical RTA. In column (5), using our adjusted gravity estimation under Bertrand competition, we find an even larger trade-creating effect of the EU of 92 percent. Similarly, the effect of the typical RTA increases to 42 percent. Under Cournot competition, the estimated coefficients become even larger, with the EU increasing trade 183 percent more than the typical trade agreement with an effect of 67 percent. These increasing effects are due to the fact that markups under Cournot compe-

[27]Note that their two country structural framework only distinguishes sales between two markets, domestic sales versus sales to the rest of the world, and hence abstracts from the third country effects we focus on.

[28]In the following, we calculate marginal effects of dummy variables as $\exp(\beta_k - 1) \times 100$.

tition are higher *ceteris paribus* than under Bertrand competition (with markups being lowest under monopolistic competition). Controlling for the effect of $\mu_{ijt}^{1-\sigma}$ becomes the more important the larger the markup: we estimate an RTA trade effect which is roughly three times larger than RTA effects estimated with conventional methods under Bertrand competition, and even larger under Cournot competition. In columns (7) to (9), we repeat the estimations from columns (4) to (6) but now also control for time-varying border effects, $INTER_{ijt}$, as suggested by Bergstrand et al. (2015) and Baier et al. (2019) to control for time trends in globalization-induced general reductions of international trade costs. Controlling for these general trends reduces the estimated trade effects of both the EU and trade agreements considerably. Using our new method, we still find sizeable trade effects of RTAs (+22 percent in column (8) and +26 percent in column (9)), and the EU increases trade 50 percent more than the typical RTA under Bertrand competition (+89 percent under Cournot competition).

We use the estimated trade cost coefficients from columns (7) to (9) of Table 1 to calculate trade costs for the year 2014, the most recent year in our data set, and simulate our model.[29] We follow the literature and set $\tau_{iit} = 1, \forall i, t$, such that domestic trade is frictionless. We proxy unit costs c_{it} by GDP per worker using GDPs in current U.S.-$ (PPP) from the Penn World Tables 9.0, see Feenstra et al. (2015), as provided in Gurevich and Herman (2018). Labor force data are from the World Bank's World Development Indicators (accessed 20 December 2019).[30] As a robustness check, we redo our counterfactual simulations using GDP per capita. We present results in the Appendix in Section A.7.2. Results remain similar.

As our counterfactual, we abolish the European Single Market. In terms of our trade cost specification, this means that we switch off the EU_{ijt} dummy as well as the according values of the RTA_{ijt} dummy for the member countries of the European Single Market. We then calculate the endogenous, model-consistent markups implied by the fitted trade costs for the corresponding competition mode. This allows us to construct model-consistent t_{ij} for both the baseline and counterfactual scenario. Armed with these, we can solve the system of inward and outward multilateral resistance terms from eq. (11) for the baseline and counterfactual scenario, and calculate welfare and markup changes. We do these

[29] We describe our simulation procedure in detail in Appendix A.9.

[30] For Taiwan, we use labor force data from National Statistics of the Republic of China (Taiwan), `https://eng.stat.gov.tw/ct.asp?xItem=12683&ctNode=1609&mp=5` (accessed 20 December 2019).

Table 1: Trade cost parameter estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			PPML					
	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot
EU_{ijt}	0.187***	0.212***	0.267***	0.426***	0.651***	1.041***	0.332***	0.404***	0.635***
	(0.063)	(0.064)	(0.065)	(0.053)	(0.072)	(0.122)	(0.069)	(0.089)	(0.142)
RTA_{ijt}	0.122***	0.137***	0.160***	0.136***	0.352***	0.515***	0.065**	0.200***	0.228**
	(0.044)	(0.044)	(0.045)	(0.041)	(0.033)	(0.041)	(0.029)	(0.069)	(0.094)
$INTER_{ijt}$	NO	NO	NO	NO	NO	NO	YES	YES	YES
N	27735	27735	27735	27735	27735	27735	27735	27735	27735

Notes: †MC: Monopolistic competition. Table reports regression coefficients of estimating the adjusted gravity equation from eq. (13) by OLS in logs using `reghdfe` and by PPML in levels using `ppmlhdfe`. All regressions include exporter×year, importer×year and directional bilateral fixed effects. Cameron et al. (2011) standard errors are robust to multiway clustering across exporters and importers. For comparison, we present standard gravity estimates in columns (1), (4), and (7). Columns (2), (5) and (8) use μ_{ijt}^{B} from eq. (16) and columns (3), (6) and (9) use μ_{ijt}^{C}. ** significant at the 5% level, *** significant at the 1% level.

simulations for both Bertrand and Cournot competition as well as the benchmark of monopolistic competition.

We present results in Table 2.[31] The first three columns of the table show the change in welfare from abolishing the European Single Market for monopolistic, Bertrand and Cournot competition, whereas the last two columns show the percentage change in the markup charged by domestic firms in their respective home country for Bertrand and Cournot competition. Under monopolistic competition, markups are unaffected by any change in trade costs. The monopolistic competition column shows the welfare effects of a conventional structural gravity model. As expected, members of the European Single Market see a reduction in their welfare when it is abolished, whereas most non-members gain.[32] This result is true for the benchmark monopolistic competition model as well as for our new gravity model using Bertrand or Cournot competition. Importantly, welfare effects are about 50 to 100 percent larger in absolute terms than in the benchmark model. This implies that standard welfare quantifications substantially underestimate the gains from trade liberalization episodes.

Generally, welfare effects are larger for Cournot competition than for Bertrand competition. However, this ranking is not true in all cases: for large economies of the European Single Market like France, Germany and Italy, welfare losses under Cournot competition are smaller than under Bertrand competition.[33] What is the reason for this pattern? First, price competition implies that the removal of the European Single Market increases prices of foreign firms serving a domestic market and the price of the national champion. With Cournot competition, the response of the national champion to the decline in foreign supply depends on its initial market share. As Lemma 1 has shown, a large output to begin with may lead to a decline in domestic output, aggravating the welfare loss from reduced

[31] As we allow for asymmetric trade costs and unbalanced trade, we have to normalize the multilateral resistance terms, see Anderson and Yotov (2010). We follow the suggestion by Yotov et al. (2016), p. 72, and normalize by the value of the inward multilateral resistance term P_j for a country which should hardly be affected by our counterfactual exercise. We choose South Korea for our normalization.

[32] An exception is China that loses from removing the European Single Market. The reason is that China is already a large exporter to Europe. Removing the Single Market leads to trade diversion in the aggregate, implying less exports from European countries and more exports from non-European countries to any European country. However, since aggregate imports decline, imports from large exporters may decline since an already large import level can be substituted out easier at the margin, overcompensating the trade diversion effect. Furthermore, China does not have an RTA with Europe but other non-member countries do.

[33] Also Norway loses less under Cournot than under Bertrand competition.

Table 2: Welfare and markup changes of removing the European Single Market (in %)

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.6	1.1	0.0	0.0
Austria	-5.3	-7.7	-10.3	0.3	3.8
Belgium	-4.4	-7.3	-10.1	0.2	1.9
Bulgaria	-4.0	-7.0	-9.0	6.6	13.5
Brazil	0.0	0.4	2.8	0.0	0.0
Canada	0.2	0.9	2.7	-0.0	0.0
Switzerland	1.3	2.3	3.6	0.0	0.0
China	-0.2	-0.5	-0.9	-0.0	-0.0
Cyprus	-5.0	-8.4	-9.2	4.7	9.5
Czech Republic	-4.4	-6.9	-8.9	1.4	7.1
Germany	-1.3	-1.1	-0.2	0.2	2.7
Denmark	-4.4	-7.1	-10.0	0.5	4.4
Spain	-1.9	-2.4	-4.5	2.3	10.6
Estonia	-4.6	-7.4	-10.0	0.9	5.4
Finland	-3.2	-4.5	-5.3	0.8	7.3
France	-2.9	-3.3	-3.1	0.5	4.2
United Kingdom	-2.0	-2.5	-3.2	0.5	4.1
Greece	-2.7	-4.3	-6.8	2.1	9.7
Croatia	-4.7	-7.3	-8.5	2.9	8.5
Hungary	-4.4	-6.6	-8.4	1.3	5.9
Indonesia	-0.1	0.0	0.1	-0.0	0.0
India	-0.1	0.1	1.1	-0.0	0.0
Ireland	-3.4	-4.3	-6.2	0.2	1.7
Italy	-1.6	-0.8	-0.1	0.8	8.0
Japan	-0.0	0.0	0.2	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	-0.0
Lithuania	-3.8	-6.4	-8.8	0.9	5.3
Luxembourg	-5.3	-8.5	-11.0	0.2	1.4
Latvia	-3.9	-6.4	-8.7	1.2	5.6
Mexico	0.1	0.8	2.4	0.0	0.0
Malta	-5.4	-8.5	-9.4	2.9	8.4
Netherlands	-3.6	-5.2	-7.2	0.1	1.0
Norway	-4.1	-5.5	-4.4	0.2	3.2
Poland	-2.9	-4.5	-6.3	2.8	10.8
Portugal	-4.2	-6.9	-8.6	5.1	12.5
Romania	-2.8	-4.5	-6.6	4.5	12.4
Russia	0.2	0.6	3.3	0.0	0.0
Slovakia	-3.2	-5.0	-6.3	1.4	5.9
Slovenia	-5.3	-6.8	-7.7	1.1	6.3
Sweden	-4.2	-6.3	-7.9	0.5	5.1
Turkey	0.3	0.7	3.0	0.0	0.0
Taiwan	0.1	0.2	0.6	0.0	0.0
United States	0.1	0.6	2.4	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1: Monopolistic competition uses parameters from column (7), Bertrand competition from column (8), and Cournot from column (9).

Table 3: Average changes of markups (in %)

	Bertrand	Cournot
all countries		
average across all markets	0.01	0.03
average across all export markets	-0.01	-0.07
average across all domestic markets	1.10	4.33
EU members		
average across all EU domestic markets	1.62	6.42
average across all EU export markets	-0.03	-0.17
average across all non-EU export markets	-0.00	0.00
non-EU members		
average across all non-EU domestic markets	0.00	0.00
average across all EU export markets	0.01	0.02
average across all non-EU export markets	0.00	-0.00

Notes: Table reports simple average changes in markups of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1: Bertrand competition from column (8), and Cournot from column (9).

foreign supply. If the domestic market share is not too large to begin with, an increase in domestic output will moderate the aggregate foreign supply reduction. Furthermore, the market share distribution under Cournot is not the same than under Bertrand to begin with. While Lemma 1 gives us some guidance on the effects under different competition modes, our results demonstrate that the degree of heterogeneity across competition modes depends on the empirical application, particularly on trade costs and market shares across all markets. We also observe that the welfare losses for Germany and Italy are smaller under oligopolistic competition although domestic markups increase, implying that the impact of trade diversion patterns on welfare effects may differ across competition modes. This also demonstrates that it is essential to model imperfect competition in a consistent structural general equilibrium model which allows for third country effects.

We see similar heterogeneity in the markup changes. Abolishing the European Single Market shields domestic firms from foreign competition and hence allows them to increase their domestic markups. This effect is more pronounced under Cournot competition. Markup changes can be substantial: without the European Single Market, domestic markups in Bulgaria would be 13.5 percent larger. Similarly, other countries at the periphery of the European Single Market like Spain, Poland, Portugal and Romania all see

Table 4: Welfare and markup changes of removing the European Single Market (in %) using the same monopolistic competition trade costs

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.2	0.2	0.0	-0.0
Austria	-5.3	-5.3	-5.2	0.2	0.9
Belgium	-4.4	-4.1	-4.1	0.1	0.4
Bulgaria	-4.0	-4.4	-4.3	3.5	4.6
Brazil	0.0	0.0	0.1	0.0	-0.0
Canada	0.2	0.1	0.1	0.0	0.0
Switzerland	1.3	1.2	1.0	0.0	0.0
China	-0.2	-0.1	-0.1	0.0	-0.0
Cyprus	-5.0	-4.8	-4.5	2.6	4.0
Czech Republic	-4.4	-4.4	-4.4	0.7	2.3
Germany	-1.3	-1.5	-1.8	0.1	0.3
Denmark	-4.4	-4.4	-4.4	0.2	1.0
Spain	-1.9	-2.0	-2.7	0.6	1.9
Estonia	-4.6	-4.4	-4.1	0.5	1.9
Finland	-3.2	-3.3	-3.6	0.4	1.6
France	-2.9	-2.9	-3.2	0.2	0.8
United Kingdom	-2.0	-2.1	-2.5	0.2	0.8
Greece	-2.7	-2.8	-3.3	0.9	2.5
Croatia	-4.7	-4.8	-4.8	1.7	3.3
Hungary	-4.4	-4.2	-4.1	0.8	2.3
Indonesia	-0.1	-0.0	-0.0	0.0	0.0
India	-0.1	0.1	0.1	0.0	0.0
Ireland	-3.4	-3.3	-3.5	0.1	0.5
Italy	-1.6	-1.8	-2.3	0.2	0.9
Japan	-0.0	-0.1	-0.1	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-3.8	-3.7	-3.7	0.5	1.9
Luxembourg	-5.3	-5.3	-5.2	0.1	0.4
Latvia	-3.9	-3.9	-3.9	0.7	2.3
Mexico	0.1	0.1	0.0	-0.0	0.0
Malta	-5.4	-5.0	-4.9	1.2	3.0
Netherlands	-3.6	-3.4	-3.5	0.0	0.3
Norway	-4.1	-4.0	-3.9	0.1	0.3
Poland	-2.9	-3.2	-3.8	1.3	3.1
Portugal	-4.2	-4.6	-4.9	1.9	3.4
Romania	-2.8	-3.5	-4.1	2.4	4.2
Russia	0.2	0.2	0.2	0.0	0.0
Slovakia	-3.2	-3.4	-3.7	0.9	2.4
Slovenia	-5.3	-5.1	-5.0	0.6	2.1
Sweden	-4.2	-4.2	-4.3	0.2	1.1
Turkey	0.3	0.2	0.2	-0.0	-0.0
Taiwan	0.1	0.0	0.0	0.0	0.0
United States	0.1	0.0	-0.1	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1, column (7), i.e., we use the same trade costs consistent with conventional structural gravity models for all competition modes.

their domestic markups increase by more than 10 percent. Hence our model confirms one of the central motivations behind the creation of the European Single Market: to increase competition in EU member countries' domestic markets. From this perspective, particularly peripheral EU countries benefit from the competition effects of the European Single Market, in line with results by Badinger (2007). Conventional structural gravity models must remain silent on this.

The reduction in trade costs between EU members increases welfare in non-member states, but their domestic markups practically do not change. Table 2 does not show markup changes in the export markets of firms. We provide summary statistics of the markup changes across different markets in Table 3. The first three rows show the average of markup changes across all markets, for both EU members and non-members, where the average is the simple average across all countries. On average, markups in the world hardly change (0.01 percent under Bertrand and 0.03 percent under Cournot). Markups fall slightly across export markets, but the majority of the markup changes happen in domestic markets. The next three rows of Table 3 show the markup changes for EU member countries. On average, the domestic markup of EU member country firms increases between 1.62 and 6.42 percent, depending on the competition mode. Even within the EU, markups in their export markets only fall by 0.03 to 0.17 percent after the increase of trade costs among themselves. Markups EU member firms charge in non-member countries remain effectively constant. The last three rows of the table show the average markup changes of non-EU members. Non-EU members slightly increase their markups within EU member states but their other markups remain essentially constant. This implies that the welfare gains for non-EU members of abolishing the European Single Market stem overwhelmingly from the trade diversion caused by the exogenous change in trade costs, not from endogenous markup changes. For EU member states, the welfare changes are the combined effect of exogenous trade cost changes and endogenous markup changes.

Table 2 illustrates that the welfare effects of trade (de-)liberalization episodes are quite different from those of conventional monopolistic competition models. The difference in welfare results stems from two sources: (1) the different competition modes imply different price and output responses, and (2) the different competition modes imply different trade cost parameter estimates.[34] Therefore, a natural question is how would welfare effects

[34]This is reminiscent of the discussion in Simonovska and Waugh (2014) who stress that different trade models imply different parameter estimates, particularly trade elasticities, and hence different welfare

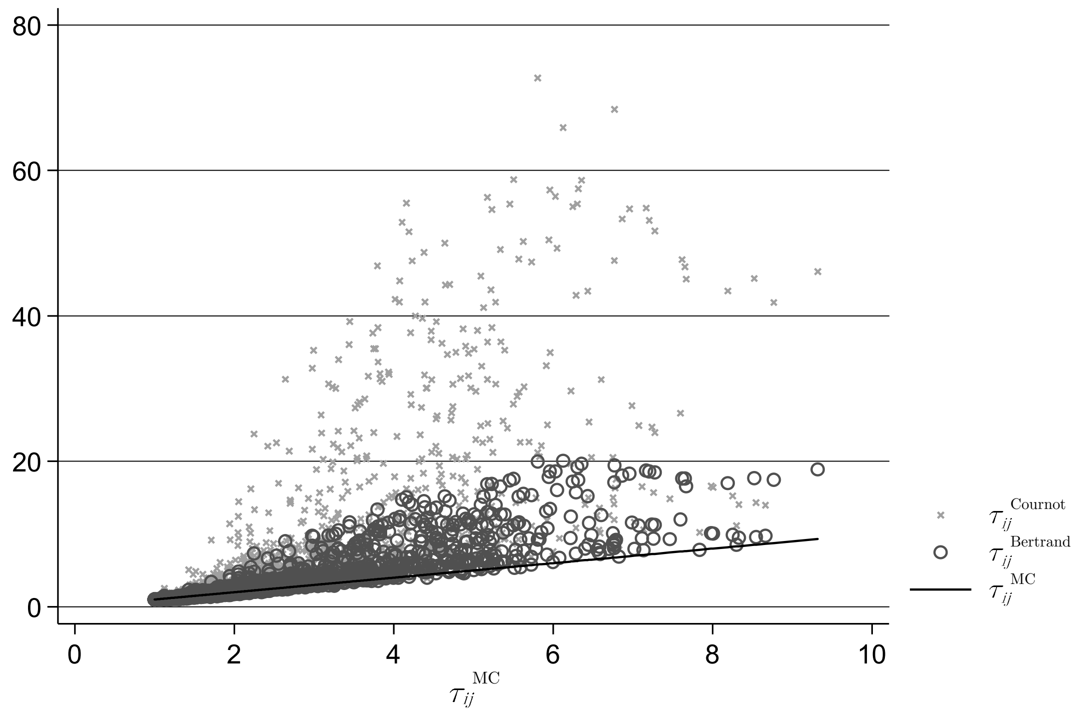

Figure 4: Comparison of estimated trade costs across different modes of competition

differ across the different competition modes if the underlying trade cost parameters were the same. We therefore redo the simulations underlying Table 2 but use the same trade cost parameters for all three competition modes. We use the trade cost parameters from the conventional gravity estimation, i.e., for monopolistic competition. We present results of these counterfactuals in Table 4, which is organized in the same way as Table 2, and the results are the same in the monopolistic competition column. Welfare changes across the different competition modes are now more similar. Still sizeable differences remain, with many EU member countries suffering from a 10 to 20 percent larger welfare loss when abolishing the European Single Market. At the same time, Germany and Italy now lose more under oligopolistic competition. What becomes clear when comparing Tables 2 and 4 is that differences in welfare effects stem mostly from differences in the estimated trade costs, and subsequent differences in implied trade diversion effects. Figure 4 shows

effects.

the different estimated trade costs for all country pairs for the three different competition modes: estimated trade costs under Bertrand competition are larger than under monopolistic competition, and trade costs implied by Cournot competition are even larger. Also the spread in trade costs increases, from monopolistic to Bertrand to Cournot competition. The intuition for this lies in the negative relationship between markups and trade costs: under monopolistic competition, the whole variance in trade flows has to come from trade costs (conditional on importer- and exporter-specific determinants), whereas under Bertrand and Cournot competition, trade costs can vary more as markups can adjust accordingly. As markups react more under Cournot than under Bertrand competition, the variance of trade costs is also larger under Cournot than under Bertrand. This highlights the importance of using estimated trade costs which are consistent with the underlying model when conducting counterfactual simulations.

Estimated trade costs depend on the markups which are functions of the number of firms serving a given market. In our national champions model, we have one domestic firm per country which serves all markets. A natural question therefore is how our welfare quantifications change when we allow for more than one national champion. We extend our model to allowing for an arbitrary number of domestic firms which all have the same production costs. Hence, in every destination market, the market share of the sole national champion is now equally shared amongst all national champions.[35] We reestimate the trade cost parameters with these new market shares for a given number of domestic firms, obtain the model-implied trade costs and markups and quantify the welfare effects of removing the European Single market. We show the average welfare effect for an European Single Market member as a function of the number of national champions in Figure 5 for the three competition modes. To illustrate, with three national champions, there are 3×43 [countries in our data set] $= 129$ firms competing in each market. Not surprisingly, differences in welfare effects between monopolistic competition and oligopoly vanish faster with Bertrand competition than with Cournot competition. It becomes clear that there are sizable differences in the welfare effects of the European Single Market under oligopoly compared to the monopolistic competition benchmark even when we allow for more than one domestic firm per country, i.e., our larger welfare gains are not an artefact of the single national champion model. Overall, our results stress the importance of taking into

[35]See Appendix A.10 for the derivation of the gravity equation for the model with an arbitrary number of national champions. More detailed results are available upon request.

account the endogenous adjustments of markups when evaluating episodes of trade (de-)liberalization.

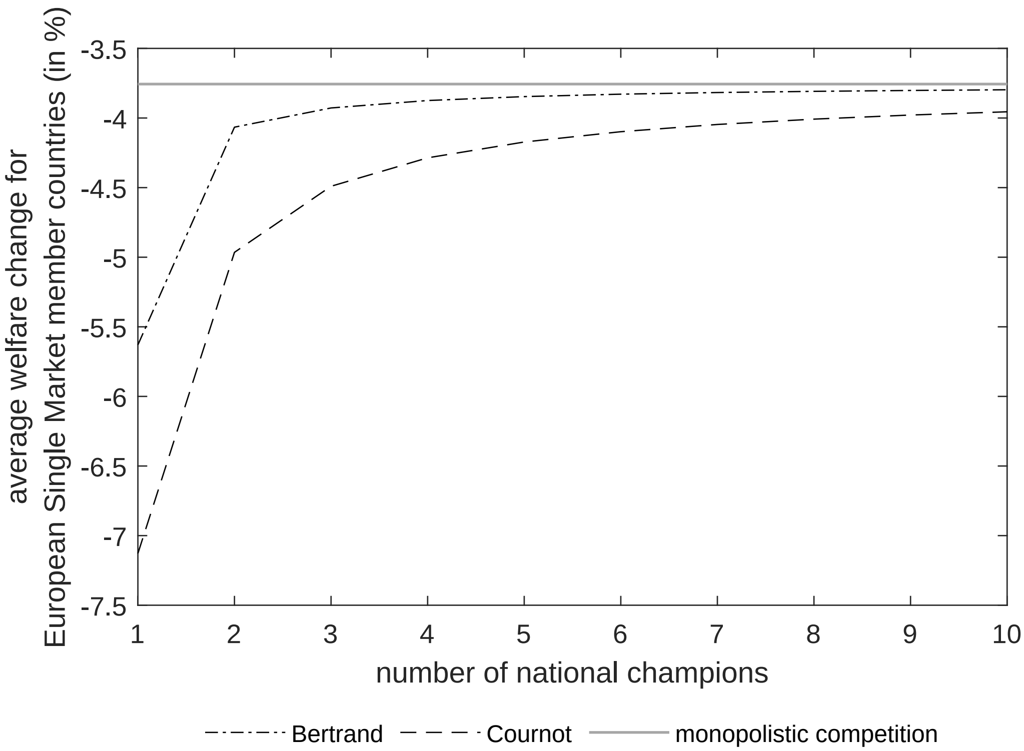

Figure 5: Comparison of welfare effects of removing the European Single Market for different number of national champions

6 Concluding remarks

This paper has shown that the structural gravity model can be extended to oligopolistic competition. Oligopolistic competition makes market power endogenous, but we could show that it is possible to empirically disentangle trade and market power frictions. Thus, the structural gravity model is much more universal and not restricted to models of perfect or monopolistic competition. This is an important development as many markets are dominated by large firms, and thus empirical analyses should allow for strategic interactions and market power. We have included price and quantity competition as an alternative to monopolistic competition in an otherwise standard quantitative trade model. In general, however, more complex modes of competition, for example competition among multi-product firms, could also be accommodated if according data were available.

Furthermore, this paper has addressed the concern that recent quantitative models do not take these market power effects into account and may thus not exactly model the purpose of market integration policies (or their opposite, protectionism). The reason is that these models employ orthogonal reaction functions and are thus limited in estimating pro-competitive effects. We have developed a simple empirical strategy to take into account these effects at both the estimation and counterfactual simulation stage. The data requirements for our approach are identical to standard quantitative trade models: we only rely on aggregate trade data to calculate market shares and markups. We have applied our approach to a standard data set of aggregate bilateral trade flows and evaluated the European Single Market which had the explicit purpose of intensifying competition among EU member countries by lowering non-tariff trade barriers. We have found that models ignoring competition effects underestimate the welfare effects of the European Single Market in particular and of the gains from trade in general.

We could also outline that welfare effects may come about through changes in profits across countries, in addition to changes in price indices as in standard models. While standard models cannot accommodate these changes, since profits are either zero due to perfect competition or free entry or are a fraction of revenues, our model could show how these changes may affect a country's welfare. This is an important innovation in times in which large firms are dominant players in many industries. We hope that our framework will enable future research to take into account strategic firm responses when estimating and quantifying aggregate trade policy effects.

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Appendix for "Structural Gravity and the Gains from Trade under Imperfect Competition"

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A.1 Cournot competition and the extensive margin

In case of quantity competition, denoted by C for Cournot, each firm maximizes its operating profit $\pi_i^C(q_i, q_{-i}) = (p_i(q_i, q_{-i}) - \tau_{\ell(i)} c_{\ell(i)}) q_i$ w.r.t. q_i, and the first-order conditions determine the Nash equilibrium in quantities:

$$\forall i : \frac{\partial \pi_i^C}{\partial q_i}(q_i^*, q_{-i}^*) = p_i(q_i^*, q_{-i}^*) - \tau_{\ell(i)} c_{\ell(i)} + \frac{\partial p_i}{\partial q_i}(q_i^*, q_{-i}^*) q_i^* = 0, \tag{A.1}$$

where q_i^* denotes the optimal supply of firm i in country j, and q_{-i}^* denotes the $(m-1)$ vector of the optimal supplies of all other firms. The inverse demand function for firm i is given by $p_i(q_i, q_{-i}) = E q_i^{-\frac{1}{\sigma}} / \sum_{\iota=1}^m q_\iota^{\frac{\sigma-1}{\sigma}}$. As in the case of Bertrand competition presented in the main text, we can rewrite the first-order condition in terms of mark-ups, denoted by μ_i^C, and elasticities, denoted by ϵ_i^C, now as they follow from the Nash equilibrium in quantities:

$$\begin{aligned} \forall i : p_i(q_i^*, q_{-i}^*) = \mu_i^C \tau_{\ell(i)} c_{\ell(i)}, \mu_i^C = \frac{\epsilon_i^C}{\epsilon_i^C - 1} = \frac{\sigma}{(\sigma-1)\left(1 - s_i^C\right)} \text{ because} \\ \epsilon_i^C = \frac{\sigma}{1 + (\sigma-1) \frac{\left(\mu_i^C \tau_{\ell(i)} c_{\ell(i)}\right)^{1-\sigma}}{\sum_{\iota=1}^m \left(\mu_\iota^C \tau_{\ell(\iota)} c_{\ell(\iota)}\right)^{1-\sigma}}} = \frac{\sigma}{1 + (\sigma-1) s_i^C}, \end{aligned} \tag{A.2}$$

where $s_i^C = (\mu_i^C \tau_{\ell(i)} c_{\ell(i)})^{1-\sigma} / \sum_{j=1}^n (\mu_j^C \tau_j c_j)^{1-\sigma}$ is the market share of firm i such that the Nash equilibrium in quantities converges to the monopolistic competition outcome for s_i^C approaching zero, too.

Not all countries are served by all countries in detailed product-level data (see Armenter and Koren, 2014). Let F_{ijk} denote the fixed cost of exporting to country j that a firm i in industry k has to bear where $F_{ijk} = 0$ if $i \in \mathcal{L}_{jk}$, but $F_{ijk} > 0$ if $i \notin \mathcal{L}_{jk}$: a firm will always serve its own domestic market, but exporters have to be able to recover their fixed costs. As common in the industrial organization literature, firms in each industry play a two-stage game: in the first stage, they decide on the export decision, and if they enter, they invest F_{ijk}, and in the second stage, they compete as described above either with prices or quantities. Thus, a firm i for which $(\mu_{ijk} - 1)\tau_{\ell(i)jk} c_{\ell(i)} \geq (<) F_{ijk}$ holds, will (will not) be active in country j, and the set of active firms is given by

$$M_{jk} = \{i | i \in \mathbb{N}, 1 \leq i \leq m_k \text{ and } (\mu_{ijk} - 1)\tau_{\ell(i)jk} c_{\ell(i)} \geq F_{ijk}\}. \tag{A.3}$$

A.2 Sufficient conditions, comparative static results, existence and uniqueness of the industry equilibrium

For our proofs, we employ the concept of aggregative games. Aggregative games are characterized by the property that the profit of each firm can be expressed such that it depends on the firm's own action and an aggregate of all firms' actions only.[1] We follow Anderson et al. (2020) to prove sufficiency, existence and uniqueness of the industry equilibrium and to demonstrate that pass-through is incomplete, that is, that the markup decreases with the trade friction. We proceed by showing that all four assumptions required by Anderson et al. (2020) are fulfilled for our industry equilibrium. We denote by a_i firm i's action, by $A_{-i} = \sum_{j \neq i} a_j$ the aggregate of all other firms' actions and by $A = a_i + A_{-i}$ the aggregate of all firms' actions for the Bertrand game, so the profit of firm i can be written as

$$\begin{aligned}\left(p_i - \tau_{\ell(i)} c_{\ell(i)}\right) q_i(\cdot) &= \left(p_i - \tau_{\ell(i)} c_{\ell(i)}\right) \frac{E p_i^{-\sigma}}{\sum_{j=1}^{n} p_j^{1-\sigma}} = \left(a_i^{\frac{1}{1-\sigma}} - \tau_{\ell(i)} c_{\ell(i)}\right) \frac{E a_i^{-\frac{\sigma}{1-\sigma}}}{A_{-i} + a_i} \\ &= \widetilde{\pi}_i^B (A_{-i} + a_i, a_i),\end{aligned} \tag{A.4}$$

where we have set $a_i = p_i^{1-\sigma}$. Expression (A.4) shows that the Bertrand game is an aggregative game, and that (A.4) strictly decreases with A_{-i} which fulfills Assumption 1 of Anderson et al. (2020). Furthermore, $\widetilde{\pi}_i^B(A_{-i} + a_i, a_i)$ is twice differentiable and strictly quasi-concave in a_i. Defining profit as a function of A and a_i, that is,

$$\breve{\pi}_i^B(A, a_i) = \left(a_i^{\frac{1}{1-\sigma}} - \tau_{\ell(i)} c_{\ell(i)}\right) \frac{E a_i^{-\frac{\sigma}{1-\sigma}}}{A}, \tag{A.5}$$

shows that $\breve{\pi}_i^B(A, a_i)$ is also twice differentiable and strictly quasi-concave in a_i. Furthermore, maximization of $\breve{\pi}_i^B(A, a_i)$ w.r.t. a_i is the same exercise as in monopolistic competition models in which A is regarded as constant by the firm, and we know that the sufficient conditions are fulfilled in this setup. Thus, $\breve{\pi}_i^B(A, a_i)$ is strictly concave at the maximum, and hence Assumption 2 of Anderson et al. (2020) is fulfilled if the profit function $\widetilde{\pi}_i^B(A_{-i} + a_i, a_i)$ can be shown to be strictly concave at the profit maximum. To

[1] The concept of aggregative games was first developed by Cornes and Hartley (2007) for public goods games and has been generalized and extended to other applications, see for example Acemoglu and Jensen (2013), Anderson et al. (2020), Córchon (1994) and Martimort and Stole (2012). Nocke and Schutz (2018) develop an aggregative games approach for multi-product firms.

show this, we do not use the first-order condition (2), but the markup equation (3). Let $b_i = (\mu_i \tau_{\ell(i)} c_{\ell(i)})^{1-\sigma}$ such that

$$\mu_i^B = \frac{b_i^{\frac{1}{1-\sigma}}}{\tau_{\ell(i)} c_{\ell(i)}} \text{ and } \mathcal{B}_{-i} = \sum_{j \neq i} b_j$$

so that we can write the markup equation (3) as an implicit function

$$\Psi(\cdot) = \frac{b_i^{\frac{1}{1-\sigma}}}{\tau_{\ell(i)} c_{\ell(i)}} - \frac{b_i + \mathcal{B}_{-i}\sigma}{(\sigma - 1)\mathcal{B}_{-i}} = 0.$$

Differentiation yields

$$\frac{\partial \Psi(\cdot)}{\partial b_i} = -\frac{\mathcal{B}_{-i} b_i^{\frac{1}{1-\sigma}} + b_i \tau_{\ell(i)} c_{\ell(i)}}{(\sigma - 1) b_i \mathcal{B}_{-i} \tau_{\ell(i)} c_{\ell(i)}} < 0, \frac{\partial \Psi(\cdot)}{\partial \mathcal{B}_{-i}} = \frac{b_i}{\mathcal{B}_{-i}^2 (\sigma - 1)} > 0, \frac{\partial \Psi(\cdot)}{\partial \tau_{\ell(i)}} = -\frac{b_i^{\frac{1}{1-\sigma}}}{\tau_{\ell(i)}^2 c_{\ell(i)}} < 0$$

and shows that (i) the profit function is strictly concave at the profit maximum, (ii) $\partial \Psi(\cdot)/\partial b_i - \partial \Psi(\cdot)/\partial \mathcal{B}_{-i} < 0$ and (iii) that an increase in the trade friction makes the firm less aggressive. Thus, Assumptions 2 and 3 of Anderson et al. (2020) are also fulfilled.

We now turn to the existence and the uniqueness of the Bertrand equilibrium. As shown by Anderson et al. (2020), continuity of the best response functions implies also continuity of the aggregate of the best response functions. If the individual strategy spaces are compact intervals, an equilibrium exists as an implication of Brouwer's fixed point theorem. The problem with Bertrand games in a CES environment is that compactness warrants to allow $p_i = 0$, implying a non-continuity of the profit function. Anderson et al. (2020) show that a condition on the aggregate of all best response functions guarantees the existence of an equilibrium, and this condition is fulfilled for CES demand functions.[2] As for uniqueness, we now turn to inclusive best reply functions and replace $b_i + \mathcal{B}_{-i}$ by $\mathcal{B}$. Solving for $\mathcal{B}$ and treating $\mathcal{B}$ as the inclusive inverse best reply function of b_i yields

$$\mathcal{B}(b_i) = b_i + \frac{b_i \tau_i c_{\ell(i)}}{(\sigma - 1) b_i^{\frac{1}{1-\sigma}} - \sigma \tau_{\ell(i)} c_{\ell(i)}}.$$

Since

[2]See eq. (2) in Anderson et al. (2020) which requires $(\sum_{i=1}^n r_i(\mathcal{B}))/\mathcal{B} >> 1$ for small $\mathcal{B}$ where $r_i(\mathcal{B})$ denotes the inclusive best reply function of firm i and $\mathcal{B} = b_i + \mathcal{B}_{-i}$.

$$\frac{d\mathcal{B}(b_i)}{db_i} = 1 + \frac{\sigma\tau_{\ell(i)}c_{\ell(i)}\left(b_i^{\frac{1}{1-\sigma}} - \tau_{\ell(i)}c_{\ell(i)}\right)}{\left((\sigma-1)b_i^{\frac{1}{1-\sigma}} - \sigma\tau_{\ell(i)}c_{\ell(i)}\right)^2}$$

and

$$\frac{d\mathcal{B}(b_i)}{db_i} - \frac{\mathcal{B}(b_i)}{b_i} = \frac{\tau_{\ell(i)}c_{\ell(i)}b_i^{\frac{1}{1-\sigma}}}{\left((\sigma-1)b_i^{\frac{1}{1-\sigma}} - \sigma\tau_{\ell(i)}c_{\ell(i)}\right)^2} > 0,$$

Assumption 4 of Anderson et al. (2020) is fulfilled and thus the Nash equilibrium is unique.[3] Furthermore, since $\partial\Psi(\cdot)/\partial\tau_{\ell(i)} < 0$, $b_i/\mathcal{B}$ must strictly decrease. Since $s_i = b_i/\mathcal{B}$ is the firm's market share, the markup can also be written as a function of the market share, that is,

$$\mu^B(s_i^B) = \frac{\sigma - (\sigma-1)s_i^B}{(\sigma-1)(1-s_i^B)}, \frac{d\mu^B(s_i^B)}{ds_i^B} = \frac{1}{(\sigma-1)(1-s_i^B)^2} > 0, \tag{A.6}$$

where the derivative shows that the markup increases monotonically with the market share. Thus, a decline in market share (e.g., caused by an increase in trade costs) reduces the markup, and hence the difference in equilibrium prices between two markets will be smaller than the difference in trade costs to serve these two markets. Hence, (A.6) proves Proposition 1 for the Bertrand game.

We now turn to the Cournot game for which profits can be written as

$$\begin{aligned}(p(\cdot) - \tau_{\ell(i)}c_{\ell(i)})q_i &= \left(\frac{Eq_i^{-\frac{1}{\sigma}}}{\sum_{j=1}^n q_j^{\frac{\sigma-1}{\sigma}}} - \tau_{\ell(i)}c_{\ell(i)}\right)q_i = \left(\frac{Ea_i^{-\frac{1}{\sigma-1}}}{A_{-i} + a_i} - \tau_{\ell(i)}c_{\ell(i)}\right)a_i^{\frac{\sigma}{\sigma-1}} \\ &= \widetilde{\pi}_i^C(A_{-i} + a_i, a_i),\end{aligned} \tag{A.7}$$

where we now have set $a_i = q_i^{(\sigma-1)/\sigma}$. Expression (A.7) shows that the Cournot game is also an aggregative game, and that (A.7) strictly decreases with A_{-i} so Assumption 1 of

[3] Anderson et al. (2020) use the inclusive best reply function $r_i(\mathcal{B})$, and their slope condition thus reads $dr_i(\mathcal{B})/d\mathcal{B} < r_i(\mathcal{B})/\mathcal{B}$. Since the inclusive best reply function is strictly monotone, we can use the inverse best reply function as we can solve explicitly for $\mathcal{B}$, but not for b_i.

Anderson et al. (2020) is fulfilled. Furthermore, $\widetilde{\pi}_i^C(A_{-i}+a_i, a_i)$ is twice differentiable and strictly quasi-concave in a_i. Defining profit as a function of A and a_i, that is,

$$\breve{\pi}_i^C(A, a_i) = \left(\frac{E a_i^{-\frac{1}{\sigma-1}}}{A} - \tau_{\ell(i)} c_{\ell(i)} \right) a_i^{\frac{\sigma}{\sigma-1}} \tag{A.8}$$

shows that $\breve{\pi}_i^C(A, a_i)$ is also twice differentiable and strictly quasi-concave in a_i. Furthermore, maximization of $\breve{\pi}_i^C(A, a_i)$ w.r.t. a_i is again the same exercise as in monopolistic competition models in which A is regarded as constant by the firm, and we know that the sufficient conditions are fulfilled in this setup. Thus, $\breve{\pi}_i^C(A, a_i)$ is strictly concave at the maximum, and hence Assumption 2 of Anderson et al. (2020) is fulfilled if the profit function $\widetilde{\pi}_i^C(A_{-i}+a_i, a_i)$ can be shown to be strictly concave at the profit maximum, and we also show this by using the markup equation (A.2) instead of the first-order condition (A.1). We use b_i, $\mathcal{B}_{-i}$ and $\mathcal{B}$ as above and can write the markup equation (A.2) as an implicit function

$$\Omega(\cdot) = \frac{b_i^{\frac{1}{1-\sigma}}}{\tau_{\ell(i)} c_{\ell(i)}} - \frac{\sigma(b_i + \mathcal{B}_{-i})}{(\sigma-1)\mathcal{B}_{-i}} = 0.$$

Differentiation yields

$$\frac{\partial \Omega(\cdot)}{\partial b_i} = -\frac{\mathcal{B}_{-i} b_i^{\frac{1}{1-\sigma}} + \sigma b_i \tau_{\ell(i)} c_{\ell(i)}}{(\sigma-1) b_i \mathcal{B}_{-i} \tau_{\ell(i)} c_{\ell(i)}} < 0, \frac{\partial \Omega(\cdot)}{\partial \mathcal{B}_{-i}} = \frac{\sigma b_i}{\mathcal{B}_{-i}^2(\sigma-1)} > 0, \frac{\partial \Omega(\cdot)}{\partial \tau_{\ell(i)}} = -\frac{b_i^{\frac{1}{1-\sigma}}}{\tau_{\ell(i)}^2 c_{\ell(i)}} < 0$$

and shows that (i) the profit function is strictly concave at the profit maximum, (ii) $\partial\Psi(\cdot)/\partial b_i - \partial\Psi(\cdot)/\partial\mathcal{B}_{-i} < 0$ and (iii) that an increase in the trade friction makes the firm less aggressive. Thus, Assumptions 2 and 3 are also fulfilled. Furthermore, the best response functions are continuous, implying also continuity of the aggregate of the best response functions, and the individual strategy line is compact, such that a Nash equilibrium exists. Uniqueness were guaranteed if outputs were strategic substitutes, but Lemma 1 shows that this is not true in general. We can again prove uniqueness by solving for $\mathcal{B}$ and treating $\mathcal{B}$ as the inclusive inverse best reply function of b_i which yields

$$\mathcal{B}(b_i) = b_i \left(\frac{1}{1 - \frac{\sigma \tau_{\ell(i)} c_{\ell(i)}}{\sigma-1} b_i^{\frac{1}{\sigma-1}}} \right).$$

Since

$$\frac{d\mathcal{B}(b_i)}{db_i} = \frac{1-(\sigma-2)\sigma\left(b_i^{\frac{1}{\sigma-1}}\tau_{\ell(i)}c_{\ell(i)}-1\right)}{\left(1+\sigma\left(b_i^{\frac{1}{\sigma-1}}\tau_{\ell(i)}c_{\ell(i)}-1\right)\right)^2}$$

and

$$\frac{d\mathcal{B}(b_i)}{db_i} - \frac{\mathcal{B}(b_i)}{b_i} = \frac{\sigma b_i^{\frac{1}{\sigma-1}}\tau_{\ell(i)}c_{\ell(i)}}{\left(1+\sigma\left(b_i^{\frac{1}{\sigma-1}}\tau_{\ell(i)}c_{\ell(i)}-1\right)\right)^2} > 0,$$

Assumption 4 of Anderson et al. (2020) is fulfilled and thus the Nash equilibrium is also unique for Cournot competition. Again, since $\partial\Omega(\cdot)/\partial\tau_{\ell(i)} < 0$, the market share $s_i = b_i/\mathcal{B}$ must strictly decrease. Rewriting the markup as a function of the market share implies

$$\mu^C(s_i^C) = \frac{\sigma}{(\sigma-1)(1-s_i^C)}, \frac{d\mu^C(s_i^C)}{ds_i^C} = \frac{\sigma}{(\sigma-1)(1-s_i^C)^2} > 0, \tag{A.9}$$

where the derivative shows that the markup increases monotonically with the market share. Thus, a decline in the market share (e.g., caused by an increase in trade costs) reduces the markup, and hence the difference in equilibrium prices between two markets will be smaller than the difference in trade costs to serve these two markets. Hence (A.9) proves Proposition 1 for the Cournot game.

A.3 Strategic complements and substitutes

In what follows, we consider firm i competing against firm $j \neq i$ in country j. For Bertrand competition, the first-order condition for firm i can be written as

$$\psi_i^B(\cdot) = 1 - \frac{(p_i - \tau_{\ell(i)}c_{\ell(i)})}{p_i}\sigma + (\sigma-1)(p_i - \tau_{\ell(i)}c_{\ell(i)})\frac{p_i^{-\sigma}}{\sum_j p_j^{1-\sigma}} = 0. \tag{A.10}$$

Strategic complementarity requires that $\partial\psi_i^B(\cdot)/\partial p_j > 0$ which is true:

$$\frac{\partial\psi_i^B(\cdot)}{\partial p_j} = (1-\sigma)^2(p_i - \tau_{\ell(i)}c_{\ell(i)})\frac{p_i^{-\sigma}p_j^{-\sigma}}{(\sum_\iota p_\iota^{1-\sigma})^2} > 0. \tag{A.11}$$

For Cournot competition, we use the aggregative games approach of Appendix A.2. Differentiation of $\widetilde{\pi}_i^C(A_{-i}+a_i, a_i)$ in eq. (A.7) w.r.t. a_i yields the first-order condition for firm i as

$$\psi_i^C(\cdot) = \frac{\sigma a_i^{\frac{1}{\sigma-1}} \left(\frac{E a_i^{-\frac{1}{\sigma-1}}}{a+A_{-i}} - c_{\ell(i)}\tau_{\ell(i)} \right)}{\sigma - 1} - a_i^{\frac{\sigma}{\sigma-1}} \left(\frac{E a_i^{-\frac{1}{\sigma-1}}}{(a_i + A_{-i})^2} + \frac{E a_i^{-\frac{\sigma}{\sigma-1}}}{(\sigma-1)(a_i + A_{-i})} \right) = 0. \tag{A.12}$$

Strategic complementarity (substitutability) requires that $\partial\psi_i^C(\cdot)/\partial A_{-i} > (<)0$. We find:

$$\frac{\partial \psi_i^C(\cdot)}{\partial A_{-i}} = \frac{E(a_i - A_{-i})}{(a_i + A_{-i})^3}. \tag{A.13}$$

Thus, whether Cournot competition implies strategic complementarity or strategic substitutability depends on the relative size of firms' outputs: if the output of firm i is large (small) such that

$$q_i^{(\sigma-1)/\sigma} > (<) \sum_{\iota \neq i} q_\iota^{(\sigma-1)/\sigma}, \tag{A.14}$$

firm i will increase (decrease) its output with an increase in rival output, and hence quantities are strategic complements (substitutes).

A.4 Proof of Proposition 2

As in Arkolakis et al. (2012), we assume that labor is the only factor of production with an endowment of size L_i in each country. Without loss of generality, we assume that one unit of labor is needed to produce one unit of output in each industry. The labor market is perfectly competitive. Let w_i denote the equilibrium wage rate, so the price index in country j for industry k is given by

$$P_{jk} = \left(\sum_{i \in M_{jk}} {p_{ijk}^*}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} = \left(\sum_{i=1}^{n} (w_i t_{ijk})^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{A.15}$$

Furthermore,

$$x_{ijk}^* = p_{ijk}^* q_{ijk}^* = \left(\frac{p_{ijk}^*}{P_{jk}}\right)^{1-\sigma} E_{jk} = \frac{E_{jk}}{P_{jk}^{1-\sigma}} (w_i t_{ijk})^{1-\sigma} = \frac{\alpha_k Y_j}{P_{jk}^{1-\sigma}} (w_i t_{ijk})^{1-\sigma}. \tag{A.16}$$

Let λ_{ijk} denote the expenditure share in country j on goods produced by firm i as a fraction of expenditures in industry k:

$$\lambda_{ijk} = \frac{x_{ijk}^*}{\alpha_k Y_j} = \frac{(w_i t_{ijk})^{1-\sigma}}{P_{jk}^{1-\sigma}} \Leftrightarrow (w_i t_{ijk})^{1-\sigma} = \lambda_{ijk} P_{jk}^{1-\sigma}.$$

As in Arkolakis et al. (2012), we consider a potential shock in all other countries except in country j, and we also use country j's wage rate as the numeraire. In Arkolakis et al. (2012), profits are a constant share of revenues, and therefore Arkolakis et al. (2012) can show that $d \ln Y_j = d \ln w_j = 0$ holds in their setup (see also Dekle et al., 2007). This is not true in an oligopoly setup where

$$Y_j = L_j + \Pi_j^*, \Pi_j^* = \sum_{\theta=1}^{n} \sum_{\iota \in \mathcal{L}_{jk}} \int_0^1 \pi_{\iota\theta k}^* dk \tag{A.17}$$

defines the income of the representative household with $w_j = 1$ used as the numeraire; $\pi_{\iota\theta k}^*$ is the maximized profit of an industry k firm located in country j selling to all other countries including the home country. Note that $d \ln Y_j \neq d \ln w_j$ also precludes solving our model in changes as in Dekle et al. (2007). In eq. (A.17), $\pi_{\iota\theta k}^*$ denotes the maximized profit of the firm ι in industry k that is located in country j and sells in country θ. Thus, Π_j^* denotes the aggregate profits of all firms that are located in country j. Consequently, welfare changes come about through changes in income due to profit changes and due to changes in the price indexes. As for the price index changes, totally differentiating eq. (A.15) yields

$$d \ln P_{jk} = \sum_{i \in M_{jk}} \lambda_{ijk} (d \ln w_i + d \ln t_{ijk}). \tag{A.18}$$

As above, let $\iota \in \mathcal{L}_{jk}$ denote a firm that has its location in country j. Since

$$\frac{\lambda_{ijk}}{\lambda_{\iota jk}} = \left(\frac{w_i t_{ijk}}{w_j t_{\iota jk}}\right)^{1-\sigma},$$

$$\ln \lambda_{ijk} - \ln \lambda_{\iota jk} = (1-\sigma)(\ln w_i + \ln t_{ijk} - \ln w_j - \ln t_{\iota jk}).$$

Since w_j is the numeraire, $d\ln w_j = 0$. Contrary to Arkolakis et al. (2012), however, we cannot assume that $d\ln t_{\iota jk} = 0$, but only that $d\ln \tau_{\ell(\iota)jk} = 0$. Therefore,

$$d\ln\lambda_{ijk} - d\ln\lambda_{\iota jk} = (1-\sigma)(d\ln w_i + d\ln t_{ijk} - d\ln t_{\iota jk}),$$

where $d\ln t_{\iota jk} = d\ln\mu_{\iota jk}$ is the relative change in the domestic markup charged by a firm ι located in country j. Solving for $d\ln w_i + d\ln t_{ijk}$ leads to

$$d\ln w_i + d\ln t_{ijk} = \frac{d\ln\lambda_{ijk} - d\ln\lambda_{\iota jk}}{1-\sigma} + d\ln\mu_{\iota jk}. \tag{A.19}$$

Using eqs. (A.18) and (A.19) and aggregating over all firms located in country j implies

$$d\ln P_{jk} = \sum_{\iota\in\mathcal{L}_{jk}} \left(\frac{d\ln\lambda_{\iota jk}}{\sigma-1} + d\ln\mu_{\iota jk}\right), \tag{A.20}$$

because $\sum_{i\in M_{jk}}\lambda_{ijk} = 1$ and thus $\sum_{i\in M_{jk}} d\ln\lambda_{ijk} = \sum_{i\in M_{jk}}(d\lambda_{ijk}/\lambda_{ijk}) = 0$. The overall consumer price index in our model is given by $P_j = \prod_k P_{jk}^{\alpha_k}$. We define

$$d\ln\Lambda_{jk} = \sum_{\iota\in\mathcal{L}_{jk}} \left(d\ln\lambda_{\iota jk} + (\sigma-1)d\ln\mu_{\iota jk}\right) \tag{A.21}$$

as the combined and weighted relative change in domestic expenditures and domestic markups. Equation (A.20) then leads to the differential equation $dP_{jk}/d\Lambda_{jk} = -P_{jk}/[(1-\sigma)\Lambda_{jk}]$ whose solution is

$$P_{jk} = \mathcal{C}\Lambda_{jk}^{-\frac{1}{1-\sigma}},$$

where $\mathcal{C}$ is a constant. Let the superscript 1 (0) denote after (before) the change. Since

$$\widehat{U}_{jk} = \frac{U_{jk}^1}{U_{jk}^0} = \frac{E_{jk}^1}{E_{jk}^0}\frac{P_{jk}^0}{P_{jk}^1} = \frac{Y_j^1}{Y_j^0}\left(\frac{\Lambda_{jk}^0}{\Lambda_{jk}^1}\right)^{\frac{1}{1-\sigma}} = \widehat{Y}_j\widehat{\Lambda}_{jk}^{\frac{1}{1-\sigma}}, \widehat{W}_j = \widehat{Y}_j\prod_k \widehat{\Lambda}_{jk}^{\frac{\alpha_k}{1-\sigma}}. \tag{A.22}$$

Furthermore, eq. (A.21) can be solved for levels such that

$$\Lambda_{jk} = \sum_{\iota\in\mathcal{L}_{jk}} \left(\lambda_{\iota jk}\mu_{\iota jk}^{\sigma-1}\right) = \sum_{\iota\in\mathcal{L}_{jk}} \frac{\lambda_{\iota jk}}{\mu_{\iota jk}^{1-\sigma}}. \tag{A.23}$$

Using eqs. (A.17), (A.22) and (A.23) implies Proposition 2.

A.5 Using market shares for welfare changes

In the national champions' model,

$$d \ln \Lambda_{jk} = d \ln \lambda_{jjk} + (\sigma - 1) d \ln \mu_{jjk} = d \ln s_{jjk} + (\sigma - 1) d \ln \mu_{jjk},$$

as the expenditure share in country j on goods produced by the national champion of country j is exactly s_{jjk}. The change in Λ_{jk} determines the change in welfare for $\widehat{Y}_j = 1$ (see Proposition 2 and Appendix A.4). We can now use eqs. (A.6) and (A.9), respectively, to compute $d\mu_{jjk}/\mu_{jjk}$ and determine $d \ln \Lambda_{jk}$. In case of Bertrand competition,

$$d \ln \Lambda_{jk} = d \ln s^B_{jjk} \left(1 + \frac{s^B_{jjk}(\sigma - 1)}{(1 - s^B_{jjk})((1 - s^B_{jjk})\sigma + s^B_{jjk})} \right),$$

which shows that the effect of a reduction in domestic expenditure leads to an additional welfare effect due to the reduction in the markup. The same is true for Cournot competition for which we find

$$d \ln \Lambda_{jk} = d \ln s^C_{jjk} \left(1 + \frac{s^C_{jjk}(\sigma - 1)}{1 - s^C_{jjk}} \right).$$

A.6 Additional general equilibrium conditions

We make the same assumptions as in Appendix A.4 and include a perfectly competitive labor market, but we confine the analysis to the national champion model. The first-order condition for Bertrand reads $q_{ijk}(\cdot) + (p^*_{ijk} - c_i \tau_{ijk}) \partial q_{ijk}(\cdot)/\partial p_{ijk} = 0$ and the one for Cournot reads $p_{ijk}(\cdot) - c_i \tau_{ijk} + q^*_{ijk} \partial p_{ijk}(\cdot)/\partial q_{ijk} = 0$. Both can be rewritten to compute the maximized profit as $\pi^*_{ijk} = (p_{ijk} - c_i \tau_{ijk}) q_{ijk} = -q^2_{ijk} \partial p_{ijk}/\partial q_{ijk} = (p_{ijk} q_{ijk})/\epsilon_{ijk} = x^*_{ijk}/\epsilon_{ijk}$ because $\partial p_{ijk}/\partial q_{ijk} = -p_{ijk}/(q_{ijk}\epsilon_{ijk})$. Without loss of generality, we ignore fixed costs and assume universal activity of each firm,[4] and thus our income equation can be written as

$$Y_i = w_i L_i + \sum_{j=1}^{n} \int_0^1 \pi^*_{ijk} dk = w_i L_i + \sum_{j=1}^{n} \int_0^1 \frac{x^*_{ijk}}{\epsilon_{ijk}} dk. \tag{A.24}$$

[4]Fixed costs can be included and activities can be endogenized by specifying market entry conditions in the spirit of eq. (A.3) that determine which firms enter which market and carry a corresponding fixed entry cost.

We now develop the market clearing condition. Sales are given by

$$x^*_{ijk} = \left(\frac{p^*_{ijk}}{P_{jk}}\right)^{1-\sigma} E_{jk}.$$

if $x^*_{ijk} > 0$. Aggregation yields

$$Y_{ik} = \sum_{\iota=1}^{n} x^*_{i\iota k} = {p^*_{ijk}}^{1-\sigma} \sum_{\iota=1}^{n} I_{i\iota k} \left(\frac{1}{P_{jk}} \frac{t_{i\iota k}}{t_{ijk}}\right)^{1-\sigma} E_{\iota k}$$

where we have factored out ${p^*_{ijk}}^{1-\sigma}$. Division by $Y_k^W = \sum_{i=1}^{n} Y_{ik}$ and using the outward resistance term leads to

$$\left(\frac{p^*_{ijk}}{t_{ijk}} Q_{ik}\right)^{1-\sigma} = (w_i Q_{ik})^{1-\sigma} = \frac{Y_{ik}}{Y_k^W}$$

and

$$\forall i : w_i = \frac{1}{Q_{ik}} \left(\frac{Y_{ik}}{Y_k^W}\right)^{\frac{1}{1-\sigma}}. \tag{A.25}$$

Note that $Y_i = \sum_{j=1}^{n} \int_0^1 x^*_{ijk} dk$, i.e., GDP equals aggregate sales, so the income definition can be rewritten as

$$w_i L_i = \sum_{j=1}^{n} \int_0^1 x^*_{ijk} \left(1 - \frac{1}{\epsilon_{ijk}}\right) dk.$$

Labor demand is equal to $\sum_{j=1}^{n} \int_0^1 \tau_{ijk} q^*_{ijk} dk$, and since $q^*_{ijk} = x^*_{ijk}/p^*_{ijk} = x^*_{ijk}/(t_{ijk} c_i)$, we find that the firm labor demand is given by

$$\tau_{ijk} q^*_{ijk} = \frac{x^*_{ijk}}{\mu_{ijk} c_i} = \frac{x^*_{ijk}}{\frac{\epsilon_{ijk}}{\epsilon_{ijk}-1} c_i} = \frac{x^*_{ijk}}{c_i} \left(1 - \frac{1}{\epsilon_{ijk}}\right), \tag{A.26}$$

where the last terms follow from eqs. (3) and (A.2). Equation (A.26) shows that adding up over all firm labor demand meets the labor endowment.

A.7 Additional results on the European Single Market counterfactual

A.7.1 Including Switzerland and Turkey in the European Single Market Dummy

In our results presented in Section 5 of the main body of the text, Switzerland is not considered to be part of the European Single Market as it only implements part of the four freedoms of the EU within bilateral agreements with the EU. Table A.1 presents regression results when including Switzerland in the EU_{ijt} dummy, and Tables A.2 and A.3 show results of abolishing the European Single Market when Switzerland is considered part of the single market.

Finally, Turkey has a customs union with the EU but does not otherwise participate in the European Single Market. Table A.4 presents regression results when, in addition to Switzerland, we also include Turkey in the EU_{ijt} dummy, and Tables A.5 and A.6 show results of abolishing the European Single Market when considering both Switzerland and Turkey part of the single market. Now, as expected, Switzerland (and Turkey) lose from abolishing the European Single Market. Results for other countries remain similar.

Table A.1: Trade cost parameter estimates, including Switzerland in EU_{ijt}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			PPML					
	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot
EU_{ijt}	0.177**	0.203**	0.258***	0.426***	0.650***	1.040***	0.331***	0.401***	0.631***
	(0.064)	(0.065)	(0.066)	(0.054)	(0.073)	(0.123)	(0.069)	(0.089)	(0.143)
RTA_{ijt}	0.121**	0.137**	0.160**	0.136***	0.352***	0.515***	0.065*	0.200**	0.228*
	(0.044)	(0.044)	(0.046)	(0.041)	(0.033)	(0.041)	(0.029)	(0.069)	(0.094)
$INTER_{ijt}$	NO	NO	NO	NO	NO	NO	YES	YES	YES
N	27735	27735	27735	27735	27735	27735	27735	27735	27735

Notes: †MC: Monopolistic competition. Table reports regression coefficients of estimating the adjusted gravity equation from eq. (13) by OLS in logs using `reghdfe` and by PPML in levels using `ppmlhdfe`. All regressions include exporter×year, importer×year and directional bilateral fixed effects. Cameron et al. (2011) standard errors are robust to multiway clustering across exporters and importers. For comparison, we present standard gravity estimates in columns (1), (4), and (7). Columns (2), (5) and (8) use μ^B_{ijt} from eq. (16) and columns (3), (6) and (9) use μ^C_{ijt}. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table A.2: Welfare and markup changes of removing the European Single Market (in %), including Switzerland in EU_{ijt}

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.6	1.2	-0.0	0.0
Austria	-5.5	-8.0	-10.6	0.3	3.8
Belgium	-4.4	-7.4	-10.3	0.2	1.9
Bulgaria	-4.1	-7.2	-9.2	6.6	13.5
Brazil	0.0	0.4	3.0	0.0	0.0
Canada	0.2	1.0	2.8	0.0	0.0
Switzerland	-4.2	-5.5	-5.8	0.7	5.8
China	-0.2	-0.6	-1.0	0.0	0.0
Cyprus	-5.1	-8.5	-9.5	4.7	9.5
Czech Republic	-4.5	-7.1	-9.0	1.4	7.1
Germany	-1.5	-1.3	-0.4	0.2	2.6
Denmark	-4.5	-7.2	-10.1	0.5	4.4
Spain	-2.0	-2.5	-4.7	2.3	10.6
Estonia	-4.6	-7.5	-10.1	0.9	5.3
Finland	-3.3	-4.6	-5.4	0.8	7.3
France	-3.0	-3.5	-3.4	0.5	4.2
United Kingdom	-2.1	-2.6	-3.3	0.5	4.1
Greece	-2.9	-4.5	-7.2	2.1	9.7
Croatia	-4.8	-7.4	-8.6	2.9	8.5
Hungary	-4.4	-6.7	-8.5	1.3	5.9
Indonesia	-0.1	0.0	0.1	-0.0	-0.0
India	-0.1	0.1	1.2	0.0	0.0
Ireland	-3.5	-4.5	-6.4	0.2	1.7
Italy	-1.7	-0.9	0.1	0.8	8.0
Japan	-0.0	0.0	0.2	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-3.8	-6.4	-8.9	0.9	5.3
Luxembourg	-5.4	-8.6	-11.1	0.2	1.4
Latvia	-4.1	-6.7	-9.1	1.2	5.6
Mexico	0.1	0.8	2.5	0.0	0.0
Malta	-5.5	-8.7	-9.6	2.9	8.3
Netherlands	-3.7	-5.3	-7.3	0.1	1.0
Norway	-4.0	-5.5	-4.3	0.2	3.1
Poland	-2.9	-4.6	-6.3	2.8	10.7
Portugal	-4.3	-7.0	-8.8	5.1	12.5
Romania	-2.9	-4.7	-6.7	4.4	12.4
Russia	0.2	0.6	3.3	0.0	0.0
Slovakia	-3.3	-5.1	-6.4	1.4	5.9
Slovenia	-5.4	-6.9	-7.8	1.1	6.3
Sweden	-4.2	-6.4	-8.0	0.5	5.1
Turkey	0.3	0.7	3.1	0.0	0.0
Taiwan	0.1	0.2	0.6	0.0	0.0
United States	0.1	0.7	2.6	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table A.1: Monopolistic competition uses parameters from column (7), Bertrand competition from column (8), and Cournot from column (9).

Table A.3: Welfare and markup changes of removing the European Single Market (in %), including Switzerland in EU_{ijt} using the same monopolistic competition trade costs

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.3	0.2	0.0	0.0
Austria	-5.5	-5.5	-5.4	0.2	0.9
Belgium	-4.4	-4.2	-4.2	0.1	0.4
Bulgaria	-4.1	-4.5	-4.4	3.5	4.6
Brazil	0.0	0.0	0.1	-0.0	0.0
Canada	0.2	0.1	0.1	0.0	0.0
Switzerland	-4.2	-4.3	-4.5	0.2	1.0
China	-0.2	-0.1	-0.1	-0.0	0.0
Cyprus	-5.1	-4.9	-4.6	2.6	4.0
Czech Republic	-4.5	-4.5	-4.5	0.7	2.3
Germany	-1.5	-1.6	-2.0	0.1	0.3
Denmark	-4.5	-4.4	-4.5	0.2	1.0
Spain	-2.0	-2.1	-2.8	0.6	1.9
Estonia	-4.6	-4.4	-4.1	0.5	1.9
Finland	-3.3	-3.4	-3.6	0.4	1.6
France	-3.0	-3.0	-3.3	0.2	0.8
United Kingdom	-2.1	-2.2	-2.5	0.2	0.8
Greece	-2.9	-2.9	-3.4	0.9	2.5
Croatia	-4.8	-4.9	-4.9	1.7	3.3
Hungary	-4.4	-4.2	-4.1	0.8	2.3
Indonesia	-0.1	-0.0	-0.0	0.0	0.0
India	-0.1	0.1	0.1	-0.0	-0.0
Ireland	-3.5	-3.4	-3.6	0.1	0.5
Italy	-1.7	-1.9	-2.4	0.2	0.9
Japan	-0.0	-0.1	-0.1	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-3.8	-3.7	-3.8	0.5	1.9
Luxembourg	-5.4	-5.3	-5.3	0.1	0.4
Latvia	-4.1	-4.0	-4.0	0.7	2.3
Mexico	0.1	0.1	0.0	0.0	0.0
Malta	-5.5	-5.1	-4.9	1.2	3.0
Netherlands	-3.7	-3.4	-3.5	0.0	0.3
Norway	-4.0	-3.9	-3.9	0.1	0.3
Poland	-2.9	-3.3	-3.9	1.3	3.1
Portugal	-4.3	-4.7	-5.0	1.9	3.4
Romania	-2.9	-3.5	-4.1	2.4	4.2
Russia	0.2	0.1	0.1	0.0	0.0
Slovakia	-3.3	-3.4	-3.8	0.9	2.4
Slovenia	-5.4	-5.2	-5.0	0.6	2.1
Sweden	-4.2	-4.2	-4.4	0.2	1.1
Turkey	0.3	0.2	0.2	-0.0	0.0
Taiwan	0.1	0.1	0.0	0.0	0.0
United States	0.1	-0.0	-0.1	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table A.1, column (7), i.e., we use the same trade costs consistent with conventional structural gravity models for all competition modes.

Table A.4: Trade cost parameter estimates, including Switzerland and Turkey in EU_{ijt}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS			PPML					
	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot
EU_{ijt}	0.169**	0.199**	0.258***	0.433***	0.675***	1.081***	0.338***	0.425***	0.667***
	(0.061)	(0.063)	(0.065)	(0.055)	(0.073)	(0.122)	(0.069)	(0.089)	(0.143)
RTA_{ijt}	0.120*	0.135**	0.159**	0.135**	0.352***	0.514***	0.065*	0.200**	0.229*
	(0.045)	(0.044)	(0.046)	(0.041)	(0.033)	(0.042)	(0.029)	(0.069)	(0.094)
$INTER_{ijt}$	NO	NO	NO	NO	NO	NO	YES	YES	YES
N	27735	27735	27735	27735	27735	27735	27735	27735	27735

Notes: †MC: Monopolistic competition. Table reports regression coefficients of estimating the adjusted gravity equation from eq. (13) by OLS in logs using `reghdfe` and by PPML in levels using `ppmlhdfe`. All regressions include exporter×year, importer×year and directional bilateral fixed effects. Cameron et al. (2011) standard errors are robust to multiway clustering across exporters and importers. For comparison, we present standard gravity estimates in columns (1), (4), and (7). Columns (2), (5) and (8) use μ^B_{ijt} from eq. (16) and columns (3), (6) and (9) use μ^C_{ijt}. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table A.5: Welfare and markup changes of removing the European Single Market (in %), including Switzerland and Turkey in EU_{ijt}

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.4	0.7	1.3	0.0	0.0
Austria	-5.6	-8.3	-10.8	0.3	3.9
Belgium	-4.6	-7.7	-10.6	0.2	1.9
Bulgaria	-4.5	-7.9	-9.7	6.9	14.1
Brazil	0.0	0.5	3.3	0.0	-0.0
Canada	0.2	1.1	3.1	0.0	0.0
Switzerland	-4.2	-5.6	-5.9	0.7	6.0
China	-0.2	-0.6	-1.1	-0.0	-0.0
Cyprus	-5.6	-9.2	-10.0	4.9	9.8
Czech Republic	-4.6	-7.3	-9.2	1.4	7.4
Germany	-1.6	-1.4	-0.3	0.2	2.8
Denmark	-4.6	-7.5	-10.3	0.5	4.5
Spain	-2.0	-2.6	-4.7	2.4	11.1
Estonia	-4.8	-7.7	-10.4	1.0	5.6
Finland	-3.4	-4.7	-5.4	0.9	7.7
France	-3.1	-3.6	-3.3	0.5	4.4
United Kingdom	-2.3	-2.8	-3.3	0.5	4.3
Greece	-2.7	-4.3	-7.1	2.2	10.1
Croatia	-5.0	-7.7	-8.8	3.0	8.8
Hungary	-4.5	-6.9	-8.6	1.4	6.2
Indonesia	-0.1	0.1	0.1	-0.0	-0.0
India	-0.1	0.1	1.3	-0.0	0.0
Ireland	-3.6	-4.7	-6.6	0.2	1.8
Italy	-1.8	-0.8	0.5	0.8	8.3
Japan	-0.0	0.0	0.3	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-4.0	-6.7	-9.1	1.0	5.5
Luxembourg	-5.5	-8.8	-11.4	0.2	1.5
Latvia	-4.2	-7.0	-9.3	1.3	5.8
Mexico	0.2	0.9	2.8	0.0	0.0
Malta	-5.9	-9.3	-10.0	3.0	8.7
Netherlands	-3.8	-5.5	-7.4	0.1	1.1
Norway	-4.0	-5.6	-4.3	0.2	3.3
Poland	-3.0	-4.7	-6.4	2.9	11.2
Portugal	-4.4	-7.3	-9.0	5.3	13.0
Romania	-3.1	-4.8	-6.8	4.6	12.9
Russia	0.2	0.7	3.6	0.0	0.0
Slovakia	-3.3	-5.2	-6.5	1.5	6.2
Slovenia	-5.6	-7.2	-8.0	1.1	6.5
Sweden	-4.3	-6.6	-8.1	0.5	5.3
Turkey	-1.3	-2.8	-6.6	3.9	13.0
Taiwan	0.1	0.2	0.7	0.0	0.0
United States	0.1	0.8	2.8	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table A.4: Monopolistic competition uses parameters from column (7), Bertrand competition from column (8), and Cournot from column (9).

Table A.6: Welfare and markup changes of removing the European Single Market (in %), including Switzerland and Turkey in EU_{ijt} using the same monopolistic competition trade costs

Country	**$\%\Delta W_j$**			**$\%\Delta \mu_{jj}$**	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.4	0.3	0.3	0.0	0.0
Austria	-5.6	-5.6	-5.6	0.2	0.9
Belgium	-4.6	-4.3	-4.3	0.1	0.5
Bulgaria	-4.5	-5.0	-4.9	3.6	4.8
Brazil	0.0	0.0	0.1	0.0	-0.0
Canada	0.2	0.1	0.1	0.0	0.0
Switzerland	-4.2	-4.3	-4.5	0.2	1.0
China	-0.2	-0.1	-0.1	0.0	0.0
Cyprus	-5.6	-5.4	-5.0	2.7	4.2
Czech Republic	-4.6	-4.6	-4.6	0.7	2.3
Germany	-1.6	-1.7	-2.1	0.1	0.3
Denmark	-4.6	-4.6	-4.6	0.2	1.1
Spain	-2.0	-2.2	-2.9	0.6	2.0
Estonia	-4.8	-4.5	-4.3	0.5	1.9
Finland	-3.4	-3.5	-3.8	0.4	1.6
France	-3.1	-3.1	-3.5	0.2	0.8
United Kingdom	-2.3	-2.3	-2.7	0.2	0.8
Greece	-2.7	-2.8	-3.5	0.9	2.6
Croatia	-5.0	-5.0	-5.1	1.7	3.4
Hungary	-4.5	-4.3	-4.2	0.8	2.3
Indonesia	-0.1	-0.0	-0.0	0.0	0.0
India	-0.1	0.1	0.1	-0.0	-0.0
Ireland	-3.6	-3.5	-3.7	0.1	0.5
Italy	-1.8	-1.9	-2.5	0.2	1.0
Japan	-0.0	-0.1	-0.1	-0.0	-0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-4.0	-3.9	-3.9	0.5	2.0
Luxembourg	-5.5	-5.4	-5.4	0.1	0.5
Latvia	-4.2	-4.2	-4.2	0.8	2.4
Mexico	0.2	0.1	0.0	0.0	0.0
Malta	-5.9	-5.5	-5.3	1.3	3.1
Netherlands	-3.8	-3.5	-3.6	0.0	0.3
Norway	-4.0	-3.9	-3.9	0.1	0.3
Poland	-3.0	-3.4	-4.0	1.4	3.2
Portugal	-4.4	-4.8	-5.1	1.9	3.6
Romania	-3.1	-3.8	-4.5	2.5	4.3
Russia	0.2	0.2	0.3	0.0	0.0
Slovakia	-3.3	-3.5	-3.9	0.9	2.4
Slovenia	-5.6	-5.4	-5.2	0.7	2.2
Sweden	-4.3	-4.4	-4.5	0.2	1.2
Turkey	-1.3	-1.6	-2.4	0.9	2.5
Taiwan	0.1	0.1	0.0	0.0	0.0
United States	0.1	-0.0	-0.1	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table A.4, column (7), i.e., we use the same trade costs consistent with conventional structural gravity models for all competition modes.

A.7.2 Using GDP per capita as unit cost proxy

In our results presented in Section 5 of the main body of the text, we use GDP per worker to proxy unit production cost c_{jt}. In this section, we present counterfactual results which use GDP per capita as our production cost measure. GDPs in current U.S.-$ (PPP) and population data are from the Penn World Tables 9.0, see Feenstra et al. (2015), as provided in Gurevich and Herman (2018). In Table A.7, we present results from abolishing the European Single Market for the different competition forms using the respective estimated trade costs. In Table A.8, we use the estimated trade costs from monopolistic competition for all three competition modes. Results remain similar.

Table A.7: Welfare and markup changes of removing the European Single Market (using GDP per capita for unit cost) (in %)

Country	$\%\Delta \mathbf{W}_j$			$\%\Delta \boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.6	1.1	0.0	0.0
Austria	-5.3	-7.7	-10.3	0.2	3.2
Belgium	-4.4	-7.3	-10.0	0.3	2.6
Bulgaria	-4.0	-7.0	-9.0	6.7	13.6
Brazil	0.0	0.4	2.8	-0.0	0.0
Canada	0.2	0.9	2.7	0.0	0.0
Switzerland	1.3	2.3	3.6	0.0	0.0
China	-0.2	-0.6	-0.9	0.0	0.0
Cyprus	-5.0	-8.1	-8.7	2.1	6.7
Czech Republic	-4.4	-6.9	-8.8	1.2	6.9
Germany	-1.3	-1.0	0.1	0.1	2.1
Denmark	-4.4	-7.1	-9.9	0.4	4.0
Spain	-1.9	-2.3	-4.3	2.0	10.3
Estonia	-4.6	-7.4	-10.0	0.9	5.3
Finland	-3.2	-4.5	-5.4	0.9	7.5
France	-2.9	-3.3	-3.3	0.6	4.8
United Kingdom	-2.0	-2.4	-3.0	0.4	3.7
Greece	-2.7	-4.5	-6.9	2.8	10.6
Croatia	-4.7	-7.4	-8.7	3.3	8.8
Hungary	-4.4	-6.6	-8.4	1.6	6.5
Indonesia	-0.1	0.0	0.1	0.0	0.0
India	-0.1	0.1	1.0	0.0	0.0
Ireland	-3.4	-4.3	-6.2	0.2	1.8
Italy	-1.6	-1.0	-1.2	1.2	9.3
Japan	-0.0	0.0	0.3	-0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-3.8	-6.4	-8.8	1.0	5.4
Luxembourg	-5.3	-8.5	-11.1	0.2	1.4
Latvia	-3.9	-6.4	-8.7	1.4	5.7
Mexico	0.1	0.8	2.4	0.0	0.0
Malta	-5.4	-8.4	-9.4	2.9	8.5
Netherlands	-3.6	-5.2	-7.2	0.1	0.8
Norway	-4.1	-5.5	-4.2	0.1	2.7
Poland	-2.9	-4.6	-6.4	3.0	11.0
Portugal	-4.2	-6.7	-8.4	4.6	12.2
Romania	-2.8	-4.5	-6.5	4.5	12.5
Russia	0.2	0.6	3.4	0.0	0.0
Slovakia	-3.2	-5.0	-6.3	1.3	5.7
Slovenia	-5.3	-6.8	-7.6	0.9	6.0
Sweden	-4.2	-6.2	-7.7	0.4	4.5
Turkey	0.3	0.7	2.8	-0.0	0.0
Taiwan	0.1	0.2	0.7	0.0	0.0
United States	0.1	0.7	2.5	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1: Monopolistic competition uses parameters from column (7), Bertrand competition from column (8), and Cournot from column (9). The difference to Table 2 in the main text is that this table uses GDP per capita as our proxy for country-specific unit costs, see Section A.9 for details.

Table A.8: Welfare and markup changes of removing the European Single Market using the same monopolistic competition trade costs (using GDP per capita for unit cost) (in %)

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.3	0.3	0.2	0.0	-0.0
Austria	-5.3	-5.3	-5.3	0.1	0.6
Belgium	-4.4	-4.2	-4.2	0.1	0.5
Bulgaria	-4.0	-4.4	-4.3	3.2	4.3
Brazil	0.0	0.0	0.1	0.0	0.0
Canada	0.2	0.1	0.1	-0.0	0.0
Switzerland	1.3	1.2	1.0	0.0	0.0
China	-0.2	-0.1	-0.1	-0.0	0.0
Cyprus	-5.0	-4.8	-4.6	1.0	2.6
Czech Republic	-4.4	-4.4	-4.5	0.6	2.0
Germany	-1.3	-1.4	-1.8	0.0	0.2
Denmark	-4.4	-4.4	-4.5	0.2	0.8
Spain	-1.9	-2.0	-2.6	0.4	1.6
Estonia	-4.6	-4.4	-4.1	0.4	1.7
Finland	-3.2	-3.3	-3.6	0.3	1.5
France	-2.9	-3.0	-3.3	0.1	0.8
United Kingdom	-2.0	-2.2	-2.4	0.1	0.6
Greece	-2.7	-2.9	-3.4	0.9	2.5
Croatia	-4.7	-4.9	-4.9	1.8	3.3
Hungary	-4.4	-4.3	-4.1	0.9	2.4
Indonesia	-0.1	-0.0	0.0	0.0	0.0
India	-0.1	0.2	0.2	0.0	0.0
Ireland	-3.4	-3.4	-3.5	0.1	0.4
Italy	-1.6	-1.8	-2.4	0.2	1.2
Japan	-0.0	-0.1	-0.1	-0.0	-0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-3.8	-3.7	-3.7	0.5	1.9
Luxembourg	-5.3	-5.3	-5.2	0.1	0.4
Latvia	-3.9	-3.9	-3.9	0.7	2.2
Mexico	0.1	0.1	0.0	0.0	-0.0
Malta	-5.4	-5.1	-5.0	0.9	2.6
Netherlands	-3.6	-3.5	-3.5	0.0	0.2
Norway	-4.1	-4.0	-3.9	0.0	0.2
Poland	-2.9	-3.3	-3.9	1.3	3.0
Portugal	-4.2	-4.5	-4.9	1.3	3.0
Romania	-2.8	-3.5	-4.1	2.2	3.9
Russia	0.2	0.2	0.2	0.0	0.0
Slovakia	-3.2	-3.4	-3.7	0.7	2.2
Slovenia	-5.3	-5.2	-5.0	0.4	1.8
Sweden	-4.2	-4.2	-4.3	0.2	0.9
Turkey	0.3	0.3	0.4	-0.0	0.0
Taiwan	0.1	0.0	0.0	0.0	0.0
United States	0.1	0.0	-0.0	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1, column (7), i.e., we use the same trade costs consistent with conventional structural gravity models for all competition modes. The difference to Table 4 in the main text is that this table uses GDP per capita as our proxy for country-specific unit costs, see Section A.9 for details.

A.7.3 Robustness checks for $\sigma = 3.8$

In our results presented in Section 5 of the main body of the text, we set $\sigma = 5.03$, the preferred estimate of the literature survey in Head and Mayer (2014). In Table A.9, we present parameter estimates using $\sigma = 3.8$, the median value of the metastudy by Bajzik et al. (2020). In Table A.10 we present results for the same counterfactual as in the main text but using $\sigma = 3.8$. Results remain quite similar.

Table A.9: Robustness check: trade cost parameter estimates using $\sigma = 3.8$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		OLS				PPML			
	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot	MC†	Bertrand	Cournot
EU_{ijt}	0.187***	0.209***	0.242***	0.426***	0.621***	0.857***	0.332***	0.401***	0.546***
	(0.063)	(0.064)	(0.064)	(0.053)	(0.070)	(0.100)	(0.069)	(0.084)	(0.116)
RTA_{ijt}	0.122***	0.135***	0.149***	0.136***	0.306***	0.397***	0.065**	0.165***	0.177**
	(0.044)	(0.044)	(0.045)	(0.041)	(0.031)	(0.035)	(0.029)	(0.057)	(0.070)
$INTER_{ijt}$	NO	NO	NO	NO	NO	NO	YES	YES	YES
N	27735	27735	27735	27735	27735	27735	27735	27735	27735

Notes: †MC: Monopolistic competition. Table reports regression coefficients of estimating the adjusted gravity equation from eq. (13) by OLS in logs using `reghdfe` and by PPML in levels using `ppmlhdfe`. All regressions include exporter×year, importer×year and directional bilateral fixed effects. Cameron et al. (2011) standard errors are robust to multiway clustering across exporters and importers. For comparison, we present standard gravity estimates in columns (1), (4), and (7). Columns (2), (5) and (8) use μ^B_{ijt} from eq. (16) and columns (3), (6) and (9) use μ^C_{ijt}. We set $\sigma = 3.8$, the median value of the meta study by Bajzik et al. (2020). In Table 1 in the main text, we use $\sigma = 5.03$, the preferred value of the meta study by Head and Mayer (2014). ** significant at the 5% level, *** significant at the 1% level.

Table A.10: Robustness check: welfare and markup changes of removing the European Single Market using $\sigma = 3.8$ (in %)

Country	$\%\Delta\mathbf{W}_j$			$\%\Delta\boldsymbol{\mu}_{jj}$	
	Monop. Comp.	**Bertrand**	**Cournot**	**Bertrand**	**Cournot**
Australia	0.4	0.8	1.2	0.0	-0.0
Austria	-7.5	-10.3	-12.5	0.6	4.2
Belgium	-6.2	-9.7	-12.3	0.5	2.5
Bulgaria	-5.7	-9.0	-10.8	7.5	14.0
Brazil	0.0	0.4	1.8	0.0	-0.0
Canada	0.3	1.2	2.5	0.0	0.0
Switzerland	1.9	3.1	4.3	0.0	0.0
China	-0.3	-0.7	-1.3	0.0	0.0
Cyprus	-7.2	-10.9	-12.8	5.1	10.4
Czech Republic	-6.3	-9.2	-10.9	1.9	6.9
Germany	-1.9	-1.6	-1.2	0.3	2.6
Denmark	-6.3	-9.4	-12.2	1.0	4.9
Spain	-2.7	-3.5	-5.4	3.3	10.7
Estonia	-6.5	-9.8	-12.0	1.3	5.0
Finland	-4.6	-6.1	-6.9	1.4	6.8
France	-4.1	-4.7	-4.8	0.8	4.2
United Kingdom	-2.9	-3.4	-4.3	0.9	4.0
Greece	-3.9	-5.8	-8.0	3.1	9.8
Croatia	-6.7	-9.7	-10.8	3.3	8.5
Hungary	-6.2	-8.7	-10.4	1.6	5.5
Indonesia	-0.1	-0.0	-0.1	-0.0	-0.0
India	-0.1	0.1	0.7	0.0	0.0
Ireland	-4.8	-6.2	-8.3	0.5	2.5
Italy	-2.4	-1.6	-1.8	1.5	7.9
Japan	-0.1	0.0	0.2	0.0	0.0
Korea, South	0.0	0.0	0.0	0.0	0.0
Lithuania	-5.4	-8.3	-10.4	1.2	4.9
Luxembourg	-7.6	-11.3	-13.5	0.5	2.4
Latvia	-5.6	-8.5	-10.5	1.5	5.1
Mexico	0.2	1.0	2.2	0.0	-0.0
Malta	-7.7	-11.3	-13.3	3.8	9.3
Netherlands	-5.2	-7.5	-9.7	0.3	1.6
Norway	-5.8	-7.6	-7.4	0.6	4.3
Poland	-4.1	-6.0	-7.5	3.5	10.5
Portugal	-6.0	-9.1	-10.8	6.3	13.2
Romania	-4.0	-6.0	-7.7	5.3	12.7
Russia	0.3	0.8	2.3	0.0	0.0
Slovakia	-4.6	-6.5	-7.7	1.7	5.5
Slovenia	-7.6	-9.3	-10.2	1.6	6.0
Sweden	-5.9	-8.4	-10.1	0.9	4.9
Turkey	0.4	0.9	2.3	0.0	0.0
Taiwan	0.1	0.2	0.4	-0.0	0.0
United States	0.1	0.8	2.2	0.0	0.0

Notes: Table reports welfare changes of removing the European Single Market in percent. Estimated trade cost parameters used are from Table 1 in this letter. Monopolistic competition uses parameters from column (7), Bertrand competition from column (8), and Cournot from column (9). We set $\sigma = 3.8$, the median value of the meta study by Bajzik et al. (2020). In Table 2 in the manuscript, we use $\sigma = 5.03$, the preferred value of the meta study by Head and Mayer (2014).

A.8 Extension to multi-product firms

Let the set of all produced varieties be denoted by $\mathcal{V}$, and the subset that is produced by firm i is given by $\mathcal{V}_i \subset \mathcal{V}$. In case of price competition, firm i maximizes its operating profit in country j, that is, $\pi_i^B(\cdot) = \sum_{i\in\mathcal{V}_i}(p_i - \tau_{\ell(i)}c_i)q_i(\cdot)$ w.r.t. to all p_i, leading to the first-order conditions

$$\forall i \in \mathcal{V}_i : q_i(\cdot) + \left(p_i^* - \tau_{\ell(i)}c_{\ell(i)}\right)\sum_{\theta\in\mathcal{V}_i}\frac{\partial q_\theta}{\partial p_i}(\cdot) = 0.$$

The first-order conditions can be rewritten in terms of markups as in the main text, except that

$$\widetilde{\epsilon}_i^B = \sigma - (\sigma - 1)\sum_{\theta\in\mathcal{V}_i} s_\theta \tag{A.27}$$

replaces the elasticity. It is now the sum of market shares that determines the overall elasticity and reduces, *ceteris paribus*, the elasticity compared to a single-product firm. The reason is the cannibalization effect that the firm wants to reduce.

In case of quantity competition, firm i maximizes its operating profit $\pi_i^C(\cdot) = \sum_{i\in\mathcal{V}_i}(p_i(\cdot) - \tau_{\ell(i)}c_{\ell(i)})q_i$ w.r.t. q_i, leading to the first-order conditions

$$\forall i \in \mathcal{V}_i : p_i(\cdot) - \tau_{\ell(i)}c_{\ell(i)} + \sum_{\theta\in\mathcal{V}_i}\frac{\partial p_\theta}{\partial q_i}(\cdot)q_\theta = 0.$$

Again, the first-order conditions can be rewritten in terms of markups as in the main text, except that

$$\widetilde{\epsilon}_i^C = \frac{\sigma}{1 + (\sigma - 1)\sum_{\theta\in\mathcal{V}_i} s_\theta} \tag{A.28}$$

replaces the elasticity.

A.9 Description of the solution of the model for the counterfactual simulations

In the following, we describe the solution method used for the counterfactual simulations presented in Section 5 of the main text. After estimating our gravity given by eq. (13) using aggregate trade flows from WIOD, including domestic trade, we calculate model-consistent scaled trade costs as $\tau_{ijt}^{1-\sigma} = \exp(\mathbf{x}'_{ijt}\boldsymbol{\beta})$ for the last year 2014 in our data set and solve for τ_{ijt} using $\sigma = 5.03$ as recommended by Head and Mayer (2014).[5] We can then use eqs. (3) and (A.2) to solve for the matrix of markups μ_{ijt} consistent with the calculated trade costs for the case of Bertrand and Cournot competition, respectively. Note that for our counterfactual simulations, we use the markup eqs. (3) and (A.2) to allow for country-specific unit costs c_{jt} which we proxy by GDP per worker.[6] For monopolistic competition, all markups in all markets are given by $\sigma/(\sigma-1)$. With the model-consistent trade cost and markup matrices, we can then calculate model-consistent $t_{ijt} = \mu_{ijt}\tau_{ijt}$ and solve the system of (scaled) multilateral resistance terms in eq. (11).

For given trade costs and markups, i.e., for given values of t_{ijt}, the system of multilateral resistance terms in eq. (11) is identical to the system of equations in Anderson and van Wincoop (2003), and hence their discussion concerning existence and uniqueness of the equilibrium applies in our setting. Particularly, the solution to the system of equations in (11) is only defined up to scale; for a lucid discussion, see Anderson and Yotov (2010). We follow the suggestion by Yotov et al. (2016), p. 72, and normalize by the value of the inward multilateral resistance term P_j for a country which should hardly be affected by our counterfactual exercise. We choose South Korea for our normalization.[7]

For the counterfactual, we change the exogenous trade cost matrix τ_{ijt}, solve for the en-

[5]We set $\tau_{iit} = 1, \forall i, t$, and $\tau_{ijt} = 1$ if our estimated trade cost is below unity. The functional form used in the literature, $\tau_{ijt}^{1-\sigma} = \exp(\mathbf{x}'_{ijt}\boldsymbol{\beta})$, does not enforce fitted trade costs to be larger than 1. This happens only for 49 country pairs (2.7 percent of all country pairs), mostly neighboring countries in Europe (e.g., Austria, Belgium, Germany) where international trade costs may be particularly low as the geographical distance between two countries is smaller than the average distance within a large country like Germany or France. This is then picked up by the bilateral fixed effect ξ_{ij}, leading to fitted $\tau_{ijt} < 1$ in some cases.

[6]See Section A.7.2 for counterfactual simulation results using GDP per capita as our unit cost proxy. Results remain similar.

[7]For numerical stability, we follow Anderson (2011) and actually solve eq. (11) for $\mathbb{P}_j \equiv Y_j/Y^W P_j^{\sigma-1}$ and $\mathbb{Q}_i \equiv E_i/Y^W P_i^{\sigma-1}$. For an explicit depiction of eq. (11) in this form, see Appendix B in Heid and Larch (2016).

dogenous markups in the counterfactual scenario, again using eqs. (3) and (A.2), and then solve for the corresponding counterfactual multilateral resistance terms using eq. (11). We use observed sales and expenditure in our trade data to calculate E_j/Y_t^W and Y_i/Y_t^W.We then calculate welfare changes in country j as $\%\Delta W_j = (P_j^0/P_j^1 - 1) \times 100$ where we use the superscript 1 to denote the counterfactual and 0 the baseline scenario. Hence our welfare changes are equivalent to what Head and Mayer (2014) call the Modular Trade Impact.

A.10 Model extension to an arbitrary number of national champions

In the main text, the quantification of the welfare effects focusses on our model with one national champion, i.e., one domestic firm per country. In Figure 5 in the main text we show the average welfare effect of removing the European Single Market for European Single Market member countries when we allow for more than one national champion per country. In the following, we derive the gravity equation for this generalized model. If we allow for N_f symmetric national champions in each country, sales of each individual firm are still given by eq. (7). As all national champions from one country are symmetric, they all charge the same prices, hence, $p_{ijkf} = p_{ijk} \,\forall\, f \in N_f$, and markups. For the same level of trade costs, markups are different as in the case of Bertrand competition, the market share of any individual firm in the model with N_f national champions, $\tilde{s}_{ijf}^B$, is given by $\tilde{s}_{ijf}^B = s_{ijf}^B/N_f$, where s_{ijf}^B is the market share of the single national champion in the main text, and similarly for Cournot competition. Therefore, the systems of equations given by eq. (3) and eq. (A.2) still determine the markups across all destinations when replacing s_{ijf}^B by $\tilde{s}_{ijf}^B$ and s_{ijf}^C by $\tilde{s}_{ijf}^C$.

Aggregate sales from country i to country j in industry k are given by

$$x_{ijk} = N_f \frac{E_{jk}}{P_{jk}^{1-\sigma}} {t_{ijk}}^{1-\sigma} c_i^{1-\sigma}. \tag{A.29}$$

Aggregate sales can then be written as

$$Y_{ik} = \sum_{j=1}^{n} x_{ijk}^* = \sum_{j=1}^{n} N_f \frac{I_{ijk} E_{jk}}{P_{jk}^{1-\sigma}} {p_{ijk}}^{1-\sigma} = c_i^{1-\sigma} \sum_{j=1}^{n} N_f \frac{I_{ijk} E_{jk}}{P_{jk}^{1-\sigma}} {t_{ijk}}^{1-\sigma}, \tag{A.30}$$

which we can solve for $c_i^{1-\sigma} = Y_{ik}\tilde{Q}_{ik}^{\sigma-1}$, where $\tilde{Q}_{ik}^{\sigma-1}$ is the outward multilateral resistance term. $\tilde{Q}_{ik}^{\sigma-1}/N_f = Q_{ik}^{\sigma-1}$ as defined in the main text, and hence we can derive a similar gravity equation as in the main text:

$$x_{ijk}^* = \frac{Y_{ik}E_{jk}}{Y_k^W}\left(\frac{t_{ijk}}{\tilde{Q}_{ik}\tilde{P}_{jk}}\right)^{1-\sigma} = \frac{Y_{ik}E_{jk}}{Y_k^W}\left(\frac{\mu_{ijk}\tau_{ijk}}{\tilde{Q}_{ik}\tilde{P}_{jk}}\right)^{1-\sigma}, \quad \text{with} \tag{A.31}$$

$$\tilde{Q}_{ik}^{1-\sigma} = \sum_{j=1}^{n} I_{ijk}\frac{E_{jk}}{Y_k^W}\left(\frac{t_{ijk}}{\tilde{P}_{jk}}\right)^{1-\sigma} \quad \text{and} \quad \tilde{P}_{jk}^{1-\sigma} = \sum_{i=1}^{n}\frac{Y_{ik}}{Y_k^W}\left(\frac{t_{ijk}}{\tilde{Q}_{ik}}\right)^{1-\sigma}. \tag{A.32}$$

Note that as multilateral resistance terms are only defined up to scale, see Anderson and van Wincoop (2003), in the case of constant markups as in monopolistic competition, the number of national champions does not affect the equilibrium.

To bring our model to the data, we calculate the market shares of each of the N_f national champions from the data, estimate the trade cost parameters and then solve for the model-consistent markups and welfare in both the baseline and counterfactual scenario as described in Appendix A.9.

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