Trade and Welfare under Oligopolistic Competition: Reciprocal Dumping or Pro-Competitive Effects?*

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Abstract

We study the welfare consequences of reductions in trade costs in a general equilibrium model with symmetric firms and oligopolistic competition. We build on the nested CES model with a continuum of sectors in Atkeson and Burstein (2008), and derive formulas for the welfare consequences of a symmetric reduction in trade costs under different modes of competition (including Cournot and Bertrand competition). The framework collapses to a standard monopolistic competition model with symmetric firms – with an associated Arkolakis et al. (2012) welfare formula – when firms are of negligible size or when the within- and across-sector demand elasticities coincide. When the the within-sectoral substitution elasticity goes to infinity, our framework instead converges to a general equilibrium version of the Brander and Krugman (1983) 'reciprocal dumping' framework with homogeneous goods. We show that, starting from autarky, symmetric decreases in trade costs may reduce welfare, but only when the within-sectoral elasticity of substitution is high relative to both the cross-sectoral elasticity of substitution and the number of firms. In those cases, welfare is a U-shaped function of trade costs. When the degree of product differentiation within sectors is high enough or when the number of firms is large, welfare is instead monotonically decreasing in trade costs. We explore extensions of the model featuring heterogeneous firms and asymmetric countries.

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1 Introduction

Recent evidence points to a significant rise in market concentration across various sectors, particularly in the U.S. economy. Grullon et al. (2019) find that over the past few decades, market concentration has surged in over 75% of U.S. industries, coinciding with weaker competition and reduced new firm entry. Autor et al. (2020) further highlight that the share of revenue controlled by the largest firms has increased substantially in many industries, driven in part by 'superstar firms' dominating markets. Furthermore, Decker et al. (2016) and Covarrubias et al. (2020) have argued that, especially since 2000, the observed increase in concentration appears to have been driven by increasing barriers to entry and reduced business dynamism. A parallel empirical literature has also documented a notable increase in the average markups charged by firms (De Loecker et al., 2020; Diez et al., 2018). Some authors have furthered linked these higher average markups to increased industry concentration (Autor et al., 2020) and to reduced business dynamism, i.e., depressed entry and exit rates (Decker et al., 2016).[1]

Empirical trade economists have simultaneously unveiled a remarkable skewness in the distribution of exports, with a very small number of firms accounting for a very significant share of exports in various sectors. For instance, within four-digit industries, the largest French exporter accounts on average for 28% of an industry's exports (Gaubert and Itskhoki, 2021). Similarly, Ciliberto and Jäkel (2017) find that the largest exporter covers on average 47% of (four-digit) industry-level exports in Denmark, with the top 5 exporters in an industry accounting for 80% of Danish industry-level exports in 2007. Consistent with these findings, Freund and Pierola (2015) find in a sample of less developed economies that about one-third of the variation in the ratio of exports to GDP across countries and industries is due to *the* top firm in a sector, with the top five firms in a sector accounting for nearly 50% of the variation.

In this paper, we explore the welfare consequences of trade cost reductions in a model in which sectoral world trade flows are dominated by a *small* and *fixed* number of firms. In this environment, firms compete oligopolistically and earn positive profits both at home and in foreign markets due to the lack of competitive pressures from potential entrants. What is the impact of trade liberalization on the prices consumers pay for these firms' goods? Is trade necessarily pro-competitive? And how do the implications of trade liberalization for firms' profits shape the overall welfare effects of these liberalizations?

To seek answers to these questions, in section 2 we develop a general equilibrium model with multiple sectors in which a number of homogeneous firms engage in oligopolistic competition. More specifically, we build on the nested CES model in Atkeson and Burstein (2008), which features two countries and a continuum of symmetric sectors, each populated by a discrete number of firms producing a single variety. In section 3, we derive a formula for the welfare consequences of a symmetric reduction in trade costs. The formula applies to a wide range of market structures associated with arbitrary conjectural variations (see Amiti et al., 2019), encompassing the focal cases of Cournot and Bertrand competition with differentiated goods. The welfare consequences of trade cost reductions are shaped

[1] Admittedly, some of the micro-level results in this literature and their interpretation remain controversial, with certain studies finding conflicting evidence for some sectors (see, for instance, Grieco et al., 2024).

by the assumptions on market structure and by four key parameters: (i) the *cross-sectoral* elasticity of substitution (ρ) across the goods belonging to different sectors; (ii) the *within-sectoral* elasticity of substitution (σ) across the goods produced by different firms in the same sector; (iii) the number of firms (N) in each sector; and (iv) the initial (or baseline) level of trade costs (τ) from which the trade cost reduction takes place.

The framework collapses to a standard monopolistic competition model with symmetric firms when firms are of negligible size ($N \to \infty$) or when the within- and cross-sectoral elasticities of substitution coincide ($\rho = \sigma$). In those cases, we obtain the standard Arkolakis et al. (2012) formula relating the welfare effects of trade liberalization to the domestic trade share and the trade elasticity (pinned down by σ in those cases). Because reductions in trade costs necessarily decrease the domestic trade share, trade liberalizations always increase welfare in that case. A more plausible scenario, however, is one in which the within-sectoral substitution elasticity is higher than the cross-sectoral one, or $\sigma > \rho$. In that case, and depending on their market shares, firms will face a demand elasticity lower than σ but higher than ρ.

When the within-sectoral substitution elasticity goes to infinity ($\sigma \to \infty$) and firms compete à la Cournot, our framework converges to a general equilibrium version of the Brander and Krugman (1983) 'reciprocal dumping' framework with homogeneous goods and restricted entry. As is well known, in those circumstances, there is the possibility of a reduction in trade costs being detrimental to social welfare, particularly when the initial level of these trade costs is high.

In section 4, we show that this Brander-Krugman result is robust to assuming a large but bounded within-sectoral elasticity of substitution. More specifically, starting from autarky ($\tau \to \infty$), a small reduction in trade costs necessarily reduces welfare whenever the elasticity of demand (ε_d) perceived by *domestic* firms in their domestic market (which shapes domestic markups) is sufficiently lower than the within-sectoral elasticity of substitution (σ), or more precisely

$$\frac{\sigma}{\sigma - 1} > \frac{\varepsilon_d}{\sigma - \varepsilon_d}.$$

The firm-level domestic demand elasticity ε_d is an endogenous object that depends on the cross-sectoral and within-sectoral elasticities, the nature of competition (e.g., Cournot or Bertrand) and the number of firms in the industry. Nevertheless, regardless of market structure, the above condition collapses to a simple parametric condition when there is only one firm in each country (or $N = 1$).[2] For the cases of Cournot and Bertrand competition, we also obtain a parametric condition that applies for any arbitrary number N of firms, and losses from trade liberalization arise close to autarky when the within-sector elasticity of substitution is high relative to *both* the cross-sectoral elasticity of substitution *and* the number of firms.[3] Interestingly, for the case of Bertrand competition, losses can arise *only* when there is a single firm in each country, regardless of the relative size of the within- and cross-sectoral elasticities.

The intuition for why there may be losses from trade for high values of the within-sectoral elasticity

[2]Close to autarky, a domestic monopolist faces an elasticity of demand equal to the cross-sectional elasticity of substitution ($\varepsilon_d = \rho$), and thus the above condition reduces to $\sigma/(\sigma - 1) > \rho/(\sigma - \rho)$.

[3]We will sometimes refer to trade-cost reductions as 'trade liberalizations', but we do not consider the possibility that some of these trade costs are revenue-generating tariffs. Though not ideal, this is the same approach followed by the papers we most closely build on: Brander and Krugman (1983), Atkeson and Burstein (2008), and Arkolakis et al. (2012).

σ is related to the results in Brander and Krugman (1983). When goods are not too differentiated in the eyes of consumers, the social value of importing foreign goods is small, so reductions in trade costs will tend to produce small consumption gains from trade. At the same time, if market concentration is high, these same cost reductions will increase the net benefits of cross-hauling relatively homogeneous goods across countries, which is particularly detrimental to welfare when such 'reciprocal dumping' happens at high levels of trade costs. In the above condition, high levels of domestic market concentration are captured by a low level of the demand elasticity ε_d, which in turn is negatively related to the number of firms N in each market.[4]

In section 4, we also study the effects of trade cost reductions for the case in which the initial level of trade costs is very low ($\tau \to 1$). Close to this free-trade baseline, we show that trade cost reductions unambiguously increase welfare independently of parameter values, the nature of competition or the number of firms in each sector and country.

In section 5, we go beyond these limiting results and offer a full characterization of the welfare consequences of reductions in trade costs for arbitrary initial levels of these costs for the special (but preeminent) cases of Cournot and Bertrand competition. We show that in both of those cases, welfare is either monotonically decreasing in trade costs (when there are no losses from trade close to autarky) or a U-shaped function of trade costs (when there are losses from trade close to autarky). We also explore numerical simulations of the model for standard parameter values used in nested CES frameworks (Atkeson and Burstein, 2008). For the case of an international duopoly, with a single firm in each market, we find that in order for trade cost reductions to increase welfare relative to an initial autarky equilibrium, such reductions need to be quite substantial and require domestic trade shares no larger than 70%. When there are two or three of firms in each country, significant trade cost reductions are still needed in the case of Cournot competition.

Our baseline model is general equilibrium in nature and relies on several symmetry assumptions. In sections 6, 7, and 8, we relax some of these assumptions. First, in section 6, we introduce an additional 'outside' sector, featuring a homogeneous good produced under constant returns to scale by a competitive fringe of producers. With symmetric countries and reciprocal trade cost reductions, this extension has no impact on relative wages, but it regulates the importance for national income of the profits generated by firms in the 'inside' sectors. When the outside sector is large, trade cost reductions in inside sectors create little spillovers to the rest of the economy, thus reducing the general-equilibrium impacts of trade cost reductions. We show that losses from trade close to autarky are more likely the smaller the outside sector is, which corresponds to environments with a larger importance of firm profits for income. In the limit in which the 'inside' sectors become arbitrarily small, and these general-equilibrium forces are shut down, losses from trade can still occur for high values of the within-sectoral elasticity of substitution.

In section 7, we introduce firm heterogeneity into our framework. We do so while maintaining symmetry across sectors and countries in the size distribution of firms. We show that an increase in the mean-preserving spread in the distribution of firm sizes, which increase market concentration, tends to

[4] In section 2, we offer an alternative intuition for the losses-from-trade result based on how trade liberalization affects the distribution of markups among firms selling in a market.

increase the range of parameter values for which losses from trade occur close to autarky. Intuitively, even when an industry is populated by a large number of firms, when the firm size distribution becomes more and more skewed, the industry equilibrium will resemble more and more that of an oligopoly with a small number of small firms, for which we know that losses from trade close to autarky are disproportionately more likely. We illustrate this result via numerical simulations of the model, but we are in the process of calibrating the model to realistic distribution of firm sizes.

Finally, in section 8, we allow for asymmetries across countries. We develop two types of exercises. First, we consider the possibility that countries differ in their size or average productivity, thus generating endogenous relative wages, which will be affected by symmetric (or reciprocal) reductions in trade costs. Second, we consider cases in which countries are ex-ante identical, but wage differences arise because trade 'liberalization' is unilateral rather than reciprocal. Our (preliminary) results suggest that small and relatively less productive countries are more likely to suffer welfare losses from reciprocal reductions in trade costs than large or more productive countries. Furthermore, when a country unilaterally reduces the costs of selling into its market, this country experiences a welfare loss for a very wide range of parameter values, and often for *any* initial level of trade costs.

Contribution to the Literature As indicated above, our paper builds closely on the foundational papers that pioneered the analysis of trade under oligopolistic competition. Brander (1981) and Brander and Krugman (1983) introduced the concept of 'reciprocal dumping,' by which strategic interactions motivate firms from different countries to export to each other's markets despite the absence of comparative advantage or product-variety reasons for two-way trade. These insights helped launch a new field of research into strategic trade policy, with important contributions from Dixit (1984), Brander and Spencer (1985), Eaton and Grossman (1986), and Helpman and Krugman (1989), among others. Much of that literature, however, focused on partial equilibrium environments with homogeneous goods, in contrast to our general equilibrium environment with differentiated goods. Some authors, most notably Bernhofen (2001), Clarke and Collie (2003), and Friberg and Ganslandt (2008), considered oligopolistic settings with differentiated products, but did so in partial equilibrium models, and obtained very different results from us, as discussed in section 5.

A related literature, pioneered by Lerner (1934), advocates the study of market-power distortions in general equilibrium settings. This literature experienced a resurgence with Peter Neary's work on General Oligopolistic Equilibrium (GOLE) in the early 2000s (Neary, 2003; Leahy and Neary, 2013; Neary, 2016). This general equilibrium literature has shown that market power distortions are crucially affected by the dispersion of markups across sectors, rather than by their levels (see, for instance, Epifani and Gancia, 2011). In more recent years, a large body of work has emerged seeking to quantify the welfare implications of trade liberalization in models in which markups respond to trade due to strategic effects.[5] This branch of the literature, which includes the work of Eaton et al. (2012), Edmond et al. (2015), Gaubert et al. (2021), Gutiérrez (2023), Ding et al. (2024), and Graziano

[5]A parallel literature, to which we will compare our results in sections 3 and 5, studies models in which markups are affected by trade liberalization due to deviations from CES preferences, even in the absence of oligopolistic forces. Papers in this literature include Feenstra and Weinstein (2017), Arkolakis et al. (2019) and Zhelobodko et al. (2012), among many others.

(2024), has largely been focused on the quantification of rich frameworks, and has not concerned itself with deriving the type of analytical results that are at the core of our contribution.

Finally, in terms of our modeling approaches, our work is most closely related to the nested-CES demand structure in Atkeson and Burstein (2008), and the general approach of characterizing strategic (oligopolistic) interactions in pricing advocated in Amiti et al. (2019). We contribute to these papers by analytically characterizing the welfare implications of trade cost reductions in simple variants of their frameworks.

2 A Model of Reciprocal Dumping with Product Differentiation

In this section, we develop our baseline model of oligopolistic competition in general equilibrium with homogeneous firms, sectors and countries.

2.1 Setup

There are two countries, Home and Foreign, symmetric in all respects and indexed by i or j. Each country j has a representative consumer with preferences featuring a constant elasticity of substitution (CES) over the output of a continuum of sectors $k \in [0,1]$:

$$U_j = Q_j = \left(\int_0^1 \left(Q_j^k \right)^{(\rho-1)/\rho} dk \right)^{\rho/(\rho-1)}, \tag{1}$$

where Q_j^k is aggregate consumption of sector k in country $j = \{H, F\}$, and where ρ is the elasticity of substitution across sectors. In each sector k, there is a *discrete* number N of Home firms and a discrete number N of Foreign firms, with the output of these firms being differentiated in the eyes of consumers, as captured by the constant-elasticity-of-substitution (CES) aggregator:

$$Q_j^k = \left[\sum_{n=1}^{2N} \left(q_{nj}^k \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1. \tag{2}$$

The subscript n is used to index firms, so q_{nj}^k is the output of firm n in sector k sold in country j. Our nested CES preference structure with a continuum of symmetric sectors is identical to that in Atkeson and Burstein (2008), but we abstract from the consumption-leisure choice included in their model. Although the goods produced by different firms in an industry are imperfect substitutes for each other (so that $\sigma < \infty$), we naturally assume that they are more substitutable within sectors than across sectors, i.e., $1 < \rho < \sigma$.

Firms in all countries and sectors produce output according to a linear production function in labor with an associated constant marginal cost equal to c units of labor. Labor supply is equal to L in each country. By choice of numéraire, and given our symmetry assumptions, we set the wage rate to 1 in both countries. Firms incur an iceberg trade cost τ when selling abroad. We will later extend the framework to environments with heterogeneity in productivity across firms both within and across countries.

In terms of market structure, we follow Amiti et al. (2019) and derive expressions for a wide range of market structures associated with arbitrary conjectural variations. More specifically, we encompass all full-information simultaneous-move price-setting games, with Cournot and Bertrand competition as special cases.[6]

2.2 Equilibrium

In this section we describe the equilibrium of the model. Although we have imposed full symmetry across countries, sectors and firms, we express many equilibrium conditions for the more general case featuring asymmetries, so we can invoke these equations in later sections.

From the nested CES structure in (1) and (2), we obtain the following inverse demand function for firm n in sector k in country j:

$$\frac{p_{nj}^k}{P_j^k} = \left(\frac{q_{nj}^k}{Q_j^k}\right)^{-\frac{1}{\sigma}}. \tag{3}$$

In this expression, p_{nj}^k is the price firm n in sector k charges when selling in country j, while P_j^k is the price index of sector k in country j, which is in turn given by

$$P_j^k = \left[\sum_{n=1}^{2N}\left(p_{nj}^k\right)^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{4}$$

Finally, Q_j^k is aggregate consumption in country j of sector k output and satisfies

$$\frac{Q_j^k}{Q_j} = \left(\frac{P_j^k}{P_j}\right)^{-\rho}.$$

In this latter equation, P_j is the aggregate (ideal) price index in country j, i.e.,

$$P_j = \left[\int_0^1 \left(P_j^k\right)^{1-\rho} dk\right]^{1/(1-\rho)}.$$

and note that aggregate consumption Q_j satisfies $Q_j = I_j/P_j$, where I_j is income in country j, which is the sum of labor income and profits.

With these expressions in hand, we can write a firm's demand as

$$q_{nj}^k = I_j\left(P_j\right)^{\rho-1}\left(P_j^k\right)^{\sigma-\rho}\left(p_{nj}^k\right)^{-\sigma}. \tag{5}$$

Notice that, as long as there is a discrete number of firms, p_{nj}^k has a measurable (i.e., non-negligible) effect on P_j^k in (4), so firms do *not* face an isoelastic demand schedule. Because they know that by increasing output or by reducing prices, the price index P_j^k will fall, thus lowering their demand, firms have a lower incentive to cut prices (or increase production) than in the absence of oligopolistic forces.

[6] As shown in Amiti et al. (2019), one can cast a Cournot game as a game of price competition in which the conjectual variation function is such that it results in each firm taking the output of its competitors as given when choosing prices.

With non-atomistic firms, markups will thus be higher than when firms take their industry price index as given, and more so the larger the impact of a firm on the price index.

Given the demand function in (5), we can express the optimal price charged by a firm as

$$p_{nj}^k = \mu_{nj}^k c_{nj}^k, \tag{6}$$

where $c_{nj}^k = c$ when selling domestically and $c_{nj}^k = \tau c$ when selling abroad, and where

$$\mu_{nj}^k = \varepsilon\left(s_{nj}^k\right) / \left(\varepsilon\left(s_{nj}^k\right) - 1\right),$$

is the markup charged by firm n in market j. In this expression, $\varepsilon\left(s_{nj}^k\right)$ is the elasticity of demand perceived by the firm in that market, and s_{nj}^k is the firm's market share in sector k. Note that this *perceived* elasticity of demand is not only a function of the demand schedule but also of the conjectural variation associated with a given form of competition (see the Appendix). As is well known (see Atkeson and Burstein, 2008, for instance) for the case of Cournot competition, we obtain

$$\varepsilon\left(s_{nj}^k\right) = \left[\frac{1}{\sigma}\left(1 - s_{nj}^k\right) + \frac{1}{\rho}s_{nj}^k\right]^{-1}, \tag{7}$$

while for Bertrand competition, we instead obtain

$$\varepsilon\left(s_{nj}^k\right) = \sigma\left(1 - s_{nj}^k\right) + \rho s_{nj}^k. \tag{8}$$

Given the demand schedule in (5) and the optimal pricing rule in (6), profits of firm n in market j in sector k are given by

$$\pi_{nj}^k = \frac{1}{\varepsilon\left(s_{nj}^k\right)} I_j \left(P_j\right)^{\rho-1} \left(P_j^k\right)^{\sigma-\rho} \left(\mu_{nj}^k c_{nj}^k\right)^{1-\sigma}. \tag{9}$$

To close the model, we just need to ensure that income I_j is equal to labor income plus total profits Π_j, which given $w = 1$, imposes the additional equilibrium condition

$$I_j = L + \Pi_j = L + \int_0^1 \left(\sum_{n=1}^{N^k} \left(\pi_{nH}^k + \pi_{nF}^k\right)\right) dk. \tag{10}$$

3 A Welfare Formula For Symmetric Changes in Trade Costs

We begin our analysis by studying the welfare implications of symmetric changes in trade costs between Home and Foreign. More specifically, we consider changes in iceberg trade costs that are both symmetric across sectors and countries. Given the symmetry of the model, these changes do not affect wages (which we continue to set at 1), which is a key simplification for us to get neat analytical expressions for certain equilibrium objects. We shall also remove industry superindices k to keep the notation lighter, and we will only distinguish between **d**omestic firms (that do not incur trade costs when selling

to a given market j) and **f**oreign firms (which do incur those costs). Since all firms within those groups are symmetric, we will also drop n subscripts for the time being. As a result, s_d is the market share of domestic firms in a given market j, and s_f is the market share of foreign firms. More specifically, in our two-country symmetric model, s_d is the market share of Home firms at Home and of Foreign firms in Foreign, while s_f is the market share of Home firms in Foreign and of Foreign firms at Home.

Given homothetic preferences, welfare in country j is simply given by

$$W_j = \frac{I_j}{P_j}.$$

Thus, the log change in welfare following a given change in the environment is equal to the resulting log change in income minus the log change in the aggregate price index, or $d\log W_j = d\log I_j - d\log P_j$.

3.1 Effect on the Price Index

Building on Amiti et al. (2019), we show in the Appendix that the (total) change in the price index following a bilateral reduction in trade costs can be written as

$$d\log P_j = \frac{S_f\Omega_f}{S_d\Omega_d + S_f\Omega_f} d\log\tau, \tag{11}$$

where S_f is the aggregate market share of foreign firms (i.e., $S_f = Ns_f$) when selling in j, S_d is the joint market share of domestic firms in their own market (j in this case), and the term Ω_i is given by

$$\Omega_i = \frac{1-s_i}{1-s_i+\Gamma_i}, \tag{12}$$

with

$$\Gamma_i \equiv -\frac{\partial\log(\mu_i)}{\partial\log(p_i)}. \tag{13}$$

The variable Γ_i captures the markup elasticity of a firm with respect to its own price. Note that this partial derivative takes into account that by changing a firm's price, this affects the firm's market share, and thus its demand elasticity. Yet, it is still a partial derivative in the sense that it takes other firms' strategies as given.[7]

In models in which markups are constant, this elasticity is zero ($\Gamma_i = 0$), thus implying $\Omega_i = 1$: the log change in the price index is then simply the market share of foreign companies S_f times the log change in trade costs, or $d\log P_j = S_f d\log\tau$. This result can be expressed in an alternative familiar form by noting that the relative demand equation (3), together with $S_d + S_f = 1$, implies $(1-\sigma)\,d\log\tau = d\log(S_f/S_d) = -(1/(1-S_d))\log S_d$. Hence, the log change in the price index

[7] We can alternatively express

$$\Gamma_i \equiv -\frac{\partial\log(\varepsilon(s_i)/(\varepsilon(s_i)-1))}{\partial\log p_i},$$

where $\varepsilon(s_i)$ is the elasiticity of demand perceived by a firm, which is shaped by the conjectural variation associated with a given form of competition.

becomes

$$d \log P_j = S_f d \log \tau = \frac{1}{\sigma - 1} \log S_d, \tag{14}$$

which corresponds to the well-known Arkolakis et al. (2012) formula for the gains from trade in economies in which firms charge constant markups.

When markups are endogenous, a change in trade costs does not only induce a change in the marginal cost of selling goods for foreign firms, but it also leads to a change in the markups charged by both foreign and domestic firms. Equation (11) summarizes how these endogenous changes in markups – via the terms Ω_d, Ω_f, Γ_d and Γ_f in equations (12) and (13) – shape the response of a country's aggregate price index to changes in trade costs.

Moving beyond the general formula in (11), Amiti et al. (2019) show that whenever preferences are of the nested CES form in (1) and (2), Γ_d and Γ_f admit an analytical solution (as a function of a firm's market s_i) whenever firms compete à la Cournot or à la Bertrand. More specifically, with Cournot competition we have

$$\Gamma_i = \frac{(\sigma - \rho)(\sigma - 1)}{\sigma(\rho - 1) + (\sigma - \rho)(1 - s_i)} (1 - s_i) s_i, \tag{15}$$

while with Bertrand, we obtain

$$\Gamma_i = \frac{(\sigma - \rho)(\sigma - 1)}{(s_i \rho + (1 - s_i)\sigma)(s_i \rho + (1 - s_i)\sigma - 1)} (1 - s_i) s_i, \tag{16}$$

for $i = d, f$.

In both cases, we have that Γ_i goes to 0 whenever firms become negligible ($s_i = 0$), in which case their demand elasticity is constant and given by σ, or whenever firms are monopolists in their sector ($s_i = 1$), in which case their demand elasticity is also constant but given by ρ. Outside these extreme cases, i.e., $s_i \in (0, 1)$, markups are affected by changes in marginal costs and by changes in the prices charged by a firm's competitors.

We can also use expressions (15) and (16) to show that, under a natural scenario of 'home bias', decreases in trade costs generate disproportionately larger reductions in the price index under oligopoly than under monopolistic competition. More specifically:

Proposition 1. Starting from a common aggregate market share S_f, a reduction in trade costs τ reduces the aggregate price index by more under Cournot or Bertrand competition than under monopolistic competition if and only if domestic firms have higher market shares than foreign firms ($s_d > s_f$).

The proof is relegated to the Appendix but it simply amounts to comparing equations (11) and (14) and showing that

$$\frac{S_f \Omega_f}{S_d \Omega_d + S_f \Omega_f} > S_f,$$

if and only if $s_d > s_f$.

The fact that models with oligopolistic competition produce larger reductions in consumer prices in response to reductions in trade costs than models with monopolistic competition is not new: Jaravel

and Sager (2019) derive a formula analogous to (11) (see their Corollary 2.2) and show that, for plausible parameter values, their large estimated impact of increased imports from China on U.S. consumer prices is consistent with models with strategic price setting, while these same estimates are too large to be rationalized by models featuring monopolistic competition. Importantly, they argue that this is not just driven by the fact that canonical models of monopolistic competition feature constant markups. Even models with variable elasticities of substitution, such as Arkolakis et al. (2019), would generate too small reductions in US prices when calibrated with conventional parameter values. Intuitively, in models without strategic price effects, trade cost reductions lead to a decline in domestic markups (the so-called pro-competitive effect from trade) but an increase in foreign markups, with an overall effect that is theoretically ambiguous (see Arkolakis et al., 2019). Although with Bertrand or Cournot competition, trade cost reductions also constitute a force towards higher foreign markups, strategic complementarities in pricing induce a larger reduction in domestic prices, and a more tamed increase in foreign prices, thus *necessarily* resulting in a disproportionate decline in the aggregate price index (relative to the case of monopolistic competition) when $s_d > s_f$.

3.2 Effect on Income

Let us now turn to the impact of trade cost changes on income, as determined by equation (10). Because wages worldwide are normalized to 1 in our symmetric world economy, incomes changes are purely shaped by changes in firms' profits. In the Appendix, we show that we can express the log change in income in any country j as

$$d\log I_j = \frac{1}{1-\Psi} N \sum_{i=d,f} \left(\frac{s_i}{\varepsilon_i}\right) \left[d\log s_i - d\log \varepsilon_i\right] \tag{17}$$

where the term Ψ is given by

$$\Psi = \frac{\Pi}{L+\Pi} = N \sum_{i=d,f} \frac{s_i}{\varepsilon_i}, \tag{18}$$

and corresponds to the ratio of aggregate profits to income. In these expressions, $s_i = s_d$ for domestic firms in j and $s_i = s_f$ for foreign firms selling in j, while the term $\varepsilon_i = \mu_i/(\mu_i - 1)$ is firm i's *perceived* demand elasticity determining markups (see equations (7) and (8) for the Cournot and Bertrand cases). Clearly, income and profits are higher, the higher are market shares and the higher are markups of a given country's firms in both their domestic market and in the foreign market.

Expression (17) for the log change in income holds generally in any model with symmetric countries, firms and sectors, and constant marginal costs, regardless of the shape of preferences (other than the existence of differentiable firm-level demand elasticity). In the Appendix, we further demonstrate that whenever preferences are of the nested CES form in (1) and (2), we can further express the log change in the ratio s_i/ε_i as

$$\frac{d\log s_d - d\log \varepsilon_d}{d\log \tau} = \left(\varepsilon_d - 1 + (\sigma - \varepsilon_d)\,\Omega_d\right)\left(1 - \frac{S_d\Omega_d}{S_d\Omega_d + S_f\Omega_f}\right) \tag{19}$$

for domestic firms, and

$$\frac{d\log s_f - d\log \varepsilon_f}{d\log \tau} = -\left(\varepsilon_f - 1 + (\sigma - \varepsilon_f)\Omega_f\right)\left(1 - \frac{S_f\Omega_f}{S_d\Omega_d + S_f\Omega_f}\right) \tag{20}$$

for foreign firms.

Note that because $\sigma \geqslant \varepsilon_d > 1$ (at least in the Cournot and Bertrand cases), the right-hand-side of equation (19) is necessarily positive, implying that decreases in trade costs necessarily reduce the profits of domestic firms in their own market. Conversely, because $\sigma \geqslant \varepsilon_f \geqslant 1$, the right-hand-side of equation (20) is necessarily negative: this implies that decreases in trade costs necessarily increase the profits of foreign firms (or the profits of firms from Home in foreign markets). The balance of these two effects is ambiguous. For instance, for the limiting case of monopolistic competition in which $\varepsilon_d = \varepsilon_f = \sigma$ and $\Omega_d = \Omega_f = 1$, these two effects exactly offset each other and we have $d\log I_j = 0$.

3.3 Overall Effect

Putting all the pieces together, we can express the log change in welfare resulting from a log change in trade costs as

$$\frac{d\log W_j}{d\log \tau} = \left[\frac{\left(\varepsilon_d - 1 + (\sigma - \varepsilon_d)\,\Omega_d\right)\frac{S_d}{\varepsilon_d} - \left(\varepsilon_f - 1 + (\sigma - \varepsilon_f)\Omega_f\right)\frac{\Omega_d}{\Omega_f}\frac{S_d}{\varepsilon_f}}{1 - \frac{S_d}{\varepsilon_d} - \frac{S_f}{\varepsilon_f}} - 1\right]\frac{S_f\Omega_f}{S_d\Omega_d + S_f\Omega_f}. \tag{21}$$

Although this expression is cumbersome and entails many terms, it can be reduced to a function of the aggregate market shares S_d and S_f, and the parameters N, σ, and ρ for specific market structures,

The Special Case of Monopolistic Competition Whenever firms do not internalize the effect of their pricing on their industry's price index, we naturally have $\varepsilon_i = \sigma$, which immediately implies $\Gamma_i = 0$ and $\Omega_i = 1$ for both domestic and foreign firms.[8] Equation (21) then reduces to

$$d\log W_j = -S_f d\log \tau = -\frac{1}{\sigma - 1} d\log S_d,$$

which is identical to the formula in Arkolakis et al. (2012). This is not surprising since we saw that this formula captures the effect of trade costs on the consumer price index in equation (4), while we also noted that the effect of trade costs on profits is zero with constant markups. An important implication of this result is that, because a reduction in τ necessarily decreases S_d and increases S_f, it necessarily increases welfare, or $d\log W_j/d\log \tau < 0$ for any τ. Thus, no reduction in trade costs can be welfare-reducing in a world with constant markups ($N \to \infty$ or $\sigma = \rho$).

In the next section, we will study the effects of trade cost changes in economies in which markups are variable due to strategic pricing effects. Are there still positive gains from trade associated with *any* trade cost reduction in the presence of strategic effects? The results in Brander and Krugman (1983)

[8] This monopolistic competition limit applies when $N \to \infty$, but with our nested CES preference structure, it also applies when $\sigma = \rho$.

suggest that the answer may be "No" whenever the varieties produced by different firms are perfect substitutes ($\sigma \to \infty$), at least when firms compete à la Cournot and provided that the initial level of trade costs is large. Is this result robust to general equilibrium environments in which firms' output is partly differentiated? Can there be losses from trade under Bertrand competition with product differentiation?

4 Gains from Trade Close to Free Trade and to Autarky

In this section, we study the effects of trade cost reductions on welfare for two limiting cases. First, we study trade-cost reductions around free trade ($\tau \to 1$), and we then we analyze the polar opposite of arbitrarily large trade costs ($\tau \to \infty$).

4.1 Gains from Trade Close to Free Trade

Given our symmetry assumptions, whenever trade is free, we naturally have $s_d = S_d/N = S_f/N = s_f = s$, $\varepsilon_d = \varepsilon_f = \varepsilon$, and $\Omega_d = \Omega_f = \Omega$, so equation (21) simplifies to

$$\left.\frac{d\log W_j}{d\log \tau}\right|_{\tau\to 1} = -\frac{1}{2}.$$

It then follows that, for sufficiently low τ, reductions in trade costs increase welfare regardless of how market structure is modelled. Intuitively, close to free trade, the loss of profits for domestic firms in their home market is exactly offset by the increase in their profits abroad ($d\log I_j = 0$), and the only net effect is the consumption gains from accessing foreign goods at a lower cost (with an associated market share of 1/2).

In sum, for sufficiently low trade costs, trade liberalization is necessarily welfare enhancing regardless of the nature of competition. Is this still true for larger initial levels of trade costs?

4.2 Gains from Trade Close to Autarky

Following the approach in Brander and Krugman (1983), we now study the effects of trade cost reductions in the limiting case in which the initial trade costs are arbitrarily large, therefore implying $s_f = S_f \to 0$. In terms of the variables Γ_f and Ω_f developed in the last section, the fact that foreign firms are of negligible size implies $\varepsilon_f = \sigma$, and thus $\Gamma_f = 0$ and $\Omega_f = 1$. On the other hand, the values of ε_d, Γ_d and Ω_d remain a function of market structure among domestic producers. Plugging in these values for ε_f, Γ_f and Ω_f into equation (21), we obtain

$$\frac{d\log W_j}{d\log \tau} = \left[\frac{\left(\varepsilon_d - 1 + (\sigma-\varepsilon_d)\,\Omega_d\right)\frac{S_d}{\varepsilon_d} - (\sigma-1)\,\Omega_d\frac{S_d}{\sigma}}{1-\frac{S_d}{\varepsilon_d}-\frac{S_f}{\sigma}} - 1\right]\frac{S_f}{S_d\Omega_d + S_f}.$$

When $S_f \to 0$ and $S_d \to 1$, the last term in this expression converges to 0, while the first term in brackets converges to

$$\Omega_d \frac{\sigma - \varepsilon_d - (\sigma - 1)\frac{\varepsilon_d}{\sigma}}{\varepsilon_d - 1}, \tag{22}$$

which takes a bounded value since $\varepsilon_d > 1$. Therefore, as $\tau \to \infty$, $dW_j/d\log\tau \to 0$, and the effect of trade costs on welfare eventually vanishes.

Nevertheless, equation (22) indicates that this convergence to 0 occurs from *below*, thus implying $d\log W_j/d\log\tau \leqslant 0$ for very large τ, if and only if

$$\frac{\sigma}{\sigma - 1} \leqslant \frac{\varepsilon_d}{\sigma - \varepsilon_d}. \tag{23}$$

In other words, when condition (23) is violated, reductions in trade costs necessarily *reduce* welfare when they take place starting at arbitrarily large trade costs. Given our nested CES preference structure, ε_d is necessarily bounded above by σ and bounded below by ρ (at least in the Cournot and Bertrand cases). The former case arises when domestic firms are infinitesimally small (i.e., $N \to \infty$), and in that case, condition (23) necessarily holds and we *cannot* have losses from trade close to autarky. Conversely, when $\varepsilon_d = \rho$, losses from trade are certainly possible when ρ is low relative to σ, and they are ensured when $\rho = 1$ (provided, of course, that $\sigma > \rho$). We summarize this as follows:

Proposition 2. Close enough to autarky ($\tau \to \infty$), a small reduction in trade costs τ reduces welfare whenever the perceived elasticity of demand ε_d faced by firms is sufficiently lower than σ, implying $\sigma/(\sigma - 1) > \varepsilon_d/(\sigma - \varepsilon_d)$.

The intuition for why there may be losses from trade for high values of σ is related to the results in Brander and Krugman (1983). When goods are not too differentiated in the eyes of consumers, the social value of importing foreign goods is not particularly high, so changes in the environment – such as reductions in trade costs – that increase the cross-hauling of relatively homogeneous goods are socially inefficient. Such two-way trade in largely homogeneous good is enhanced by high levels of market power of domestic firms, which by increasing domestic prices makes exporting appealing to foreign firms. In our model, high levels of domestic market power are captured by low levels of the demand elasticity ε_d, which are negatively related to the number of firms N in each market, as discussed below. Conversely, for lower values of σ or higher values of ε_d, variety gains from trade dominate these Brander-Krugman effects, and welfare increases with trade-cost reductions even when starting with arbitrarily large trade costs. Interestingly, only firms' perceived elasticity of demand in their own domestic market matters for this result. Consequently, only domestic market structure shapes the possibility of losses from trade close to autarky (although, of course, market structure is symmetric across countries in our model).

Although our results relate to those in Brander and Krugman (1983), it is important to stress an important difference between their framework and ours. In particular, their model is partial equilibrium, featuring a perfectly competitive outside sector that pins down wages. Instead, we have developed a general equilibrium model with oligopolistic competition in all sectors. As first pointed out by Lerner (1934), how market power distorts economies is quite different in partial and general equilibrium

models, with the absolute level of markups mattering in partial equilibrium, but the dispersion of markups across sectors mattering in general equilibrium (see also, Neary, 2003, Epifani and Gancia, 2011, or Edmond et al., 2015). Indeed, in our model with symmetric market structure in all sectors, the autarkic equilibrium is in fact efficient, as it features zero dispersion in markups.

This observation motivates an alternative intuition for our main result in Proposition 2: for $\tau = 0$ and for $\tau \to \infty$, markup inefficiencies vanish as all active producers in a market charge the same markup. For intermediate levels of τ, the equilibrium of our symmetric model is isomorphic to that of a closed economy with a measure N of '*domestic*' firms with marginal cost of c and an equal number N of '*exporting*' firms with marginal cost τc. In such an equilibrium, domestic producers tend to have higher market shares than exporting firms, and thus charge higher markups. It thus follows that, when lowering τ from an arbitrarily large value, this gives rise to market power distortions, and if they are not counterbalanced by increased variety gains from trade (which are higher, the lower is σ), then welfare necessarily goes down when trade costs are reduced from these arbitrarily large levels.

To further unpack the result in Proposition 2, we next briefly discuss three specific examples in which we can express condition (23) as a simple function of exogenous parameters.

Domestic Monopolist When there is only one domestic firm ($N = 1$) in each market, the perceived elasticity of demand faced by this firm when $\tau \to \infty$ and $s_d = S_d = 1$ is given by $\varepsilon_d = \rho$, and condition (23) reduces to

$$\frac{\sigma}{\sigma - 1} \leqslant \frac{\rho}{\sigma - \rho}, \tag{24}$$

which as mentioned above is necessarily violated when ρ is sufficiently close to one.

Cournot Oligopoly When firms compete in quantities and each domestic firm holds a market share that converges to $s_d = 1/N$ as $\tau \to \infty$, so equation (7) indicates that

$$\varepsilon_d = \left[\frac{1}{\sigma}\left(1 - \frac{1}{N}\right) + \frac{1}{\rho}\frac{1}{N}\right]^{-1},$$

which plugging into condition (23) results in

$$\frac{\sigma}{\sigma - 1} \leqslant N\frac{\rho}{\sigma - \rho}.$$

It is clear that this condition can still be violated for low values of ρ or N, but the larger N is, the harder it is that it becomes violated. Hence, in relatively competitive environments with a larger value of N, losses from trade are less likely to materialize. In fact, a sufficient condition for there to be welfare gains from trade-cost reductions around autarky is $\sigma < N$.

Bertrand Oligopoly When firms compete in prices and each domestic firm holds a market share that converges to $s_d = 1/N$ when $\tau \to \infty$, these domestic firms perceive a demand elasticity equal to

(see equation (8))

$$\varepsilon_d = \sigma\left(1 - \frac{1}{N}\right) + \rho\frac{1}{N},$$

which plugging into condition (23) results in

$$\frac{\sigma}{\sigma - 1} \leqslant \frac{\rho + (N-1)\,\sigma}{\sigma - \rho}.$$

This condition is again more likely to be violated when N and ρ are low, but we can in fact derive a much stronger implication: when $N \geqslant 2$, this condition *cannot possibly* be violated.[9] Therefore, whenever firms compete in prices, trade-cost reductions starting from autarky can reduce welfare *only* in the presence of a domestic monopolist.

It is intuitive that losses from trade cannot occur for high values of N, but why are they possible for $N = 1$? This result might puzzle some readers because, in partial equilibrium, oligopolistic settings with homogeneous goods, such as the ones in Brander (1981) or Brander and Krugman (1983), losses cannot occur under price competition. Intuitively, in those settings, consumers only purchase from the least-cost provider of the good, so wasteful two-way trade cannot possibly emerge. When the domestic monopolist has a cost advantage, a decrease in trade costs simply reduces their (limit) price, thereby increasing output and reducing market-power distortions. Why does our model not deliver this result for $\sigma \to \infty$? The reason for this goes back to the important distinction between monopoly distortions under partial equilibrium and under general equilibrium.[10] In a general equilibrium model with homogeneous goods and symmetric Bertrand competition across sectors, reductions in trade costs would not generate welfare gains, because a pro-competitive expansion in output in all sectors is inconsistent with labor-market clearing. In fact, as long as domestic market shares are equal to one, welfare is in fact insensitive to trade costs. With a bounded elasticity of substitution across goods ($\sigma < \infty$), reduction in trade costs do affect the distribution of markups and thus welfare, and as in the case of Cournot competition, these monopoly distortions are higher for intermediate levels of trade costs than under free trade or under arbitrarily large trade costs. For sufficiently high levels of σ, these distortions are large enough to dominate the variety gains from trade, and welfare can indeed be reduced by trade-cost reductions. Conversely, for low values of σ, the consumption gains from being able to access differentiated foreign varieties at a lower trade cost are large enough to counterbalance the markup distortions, and welfare is higher, the lower are trade costs.

In this section, we have focused on the characterization of the welfare effects of local reductions in trade costs starting from arbitrarily large values for these trade costs. In the next section, we provide a full characterization of the welfare effects of reductions in trade costs for any starting values of τ for the special cases of Cournot and Bertrand oligopolies.

[9] Note that the right-hand-side term increases in N, and when $N = 2$, $\frac{\sigma}{\sigma-1} < \frac{\sigma}{\sigma-\rho} + \frac{\rho}{\sigma-\rho}$, which necessarily holds since $\rho > 1$.

[10] The results in Kucheryavyy (2012) indicate that the reason for this distinction is not a discontinuity at $\sigma = +\infty$. More specifically, Kucheryavyy (2012) demonstrates continuity of the equilibrium of a nested-CES model à la Atkeson and Burstein (2008) as the elasticity of substitution between goods goes to infinity. Note that the introduction of product differentiation also addresses the technical difficulties that motivated the work of Ben-Zvi and Helpman (1992).

5 Full Characterization for Cournot and Bertrand Competition

In this section, we go beyond the limiting result obtained in the last section and characterize the impact of an infinitessimal change in τ for *any* starting level of those trade costs. To be able to do so analytically, we however restrict attention to the cases of Cournot and Bertrand competition. The key idea is that, for these two focal market structures, we can exploit equations (7)–(8) and (15)–(16) to express the general change in welfare in equation (21) as an explicit function of the market share $s_f = S_f/N$ of foreign firms, and the parameters N, σ, and ρ. Because s_f is necessarily monotonically decreasing in τ, how changes in welfare vary with τ can then be inferred from how welfare varies with the value of s_f.

5.1 Cournot Competition

Given equations (11) and (12), we can express the term governing the impact of trade costs on the aggregate price index as a function of s_f and parameters

$$\frac{S_f \Omega_f}{S_d \Omega_d + S_f \Omega_f} = \frac{s_f \frac{1-s_f}{1-s_f+\Gamma\left(s_f\right)}}{\left(\frac{1}{N} - s_f\right) \frac{s_f}{s_f+\Gamma\left(\frac{1}{N}-s_f\right)} + s_f \frac{1-s_f}{1-s_f+\Gamma\left(s_f\right)}}, \tag{25}$$

where the function $\Gamma\left(s_f\right)$ is defined in equation (15).

In the Appendix, we derive an analogous equation for the log change in income in equation (17) as a function of s_f, N, σ and ρ, by plugging (15) into equations (18)–(20). Analysis of these two equations then delivers the following result:

Proposition 3. When firms compete à la Cournot, the following two results apply:

a) If $\frac{\sigma}{\sigma-1} \leqslant N\frac{\rho}{\sigma-\rho}$, welfare is monotonically decreasing in τ, and thus trade cost reductions always increase welfare.

b) If $\frac{\sigma}{\sigma-1} > N\frac{\rho}{\sigma-\rho}$, there is a threshold trade cost level $\widehat{\tau} \in (1, \infty)$ such that welfare is monotonically decreasing in τ for $\tau < \widehat{\tau}$, but is monotonically increasing in τ for $\tau > \widehat{\tau}$.

This result generalizes our limiting result in the previous section. First, if $\sigma/\left(\sigma-1\right) < N\rho/\left(\sigma-\rho\right)$, not only are there gains from trade-cost reductions for very large values of τ, but there can be *no* losses from trade liberalization for *any* value of trade costs. Thus, as in the case monopolistic competition, welfare is monotonically decreasing in trade costs in this region of the parameter space.

Conversely, if $\sigma/\left(\sigma-1\right) > N\rho/\left(\sigma-\rho\right)$, welfare is a U-shaped function of trade costs, first decreasing with trade costs but eventually increasing in them for sufficiently large trade costs. As already explained in the last section, losses from trade cost reductions are less likely the more competitive are sectors, as measured by N, and there cannot be losses from trade when $\sigma < N$.

Our results complement and qualify existing results on the theoretical literature on the welfare effects of trade liberalization in economies with oligopoly power. Naturally, the possibility of losses

from trade is related to the classical results in Brander (1981) and Brander and Krugman (1983), but we show that their result crucially depends on a high degree of substitutability across varieties within industries; when varieties are sufficiently differentiated, trade-cost reductions always increase welfare.

We are not the first to introduce product differentiation in models of trade with Cournot competition, but previous contributions, most notably Bernhofen (2001) and Friberg and Ganslandt (2008), did so in partial equilibrium models. As we have argued above, how monopoly distortions interact with trade liberalization is markedly different in partial and general equilibrium models. For these reasons, our results are quite distinct from those of previous papers: for instance, Bernhofen (2001) finds that losses from trade are *more* likely the larger is N, while Friberg and Ganslandt (2008) show that trade can reduce welfare for *any* level of product differentiation. Both of these results are in sharp contrast to our Proposition 3.[11]

As mentioned before, our results also contrast with those obtained in monopolistic competition models with constant markups, for which the formula in Arkolakis et al. (2012) applies and there are necessarily gains from symmetric trade cost reductions. In monopolistic competition models with variable markups, it is well understood that trade liberalization may well reduce welfare due to its impact on the distribution of markups. For instance, Kokovin et al. (2022) show that reductions in trade costs have a non-monotonic effect on welfare, and necessarily reduce welfare close to autarky, while increasing welfare close to free trade. Although our results resonate with theirs, we find conditions under which welfare is monotonically decreasing with trade costs, and we also provide a more complete characterization showing that, for high levels of within-industry substitutability, welfare is necessarily a U-shaped function of trade costs.

5.2 Bertrand Competition

The case of Bertrand competition can be similarly analyzed, starting with the same equation (25), but with the relevant formula for $\Gamma(s_f)$ now being given by equation (16). This leads again to a (cumbersome) formula for log changes in income as a function of s_f, N, σ and ρ. In the Appendix, we prove the following result:

Proposition 4. When firms compete à la Bertrand, the following two results apply:

a) If $\frac{\sigma}{\sigma-1} \leqslant \frac{\rho+(N-1)}{\sigma-\rho}$, welfare is monotonically decreasing in τ, and thus trade liberalization always increases welfare.

b) If $\frac{\sigma}{\sigma-1} > \frac{\rho+(N-1)}{\sigma-\rho}$, there is a threshold trade cost level $\widehat{\tau} \in (1, \infty)$ such that welfare is monotonically decreasing in τ for $\tau < \widehat{\tau}$ and is monotonically increasing in τ for $\tau > \widehat{\tau}$.

The result is largely analogous to the one obtained under Cournot competition, and indeed the two Propositions coincide for the special case $N = 1$, but for $N > 1$ they differ in the following important way.

[11] As explained in the introduction, our work is also related to a more recent literature (Edmond et al., 2015; Gaubert et al., 2021; Gutiérrez, 2023; Ding et al., 2024) that has studied the welfare effects of trade liberalization with oligopoly in general equilibrium framework. But this literature has been less concerned with deriving analytical results, and has instead studied quantitatively the nature of oligopolistic distortions and how they are shaped by trade liberalization.

Corollary 1. When firms compete à la Bertrand and $N \geqslant 2$, then welfare is monotonically decreasing in τ.

In other words, under Bertrand competition, there can only be losses from trade-cost reductions when there is a single firm in each market. In such a case, the welfare effects of trade liberalization are qualitatively analogous to those under Cournot competition, with welfare being a U-shaped function of trade costs.

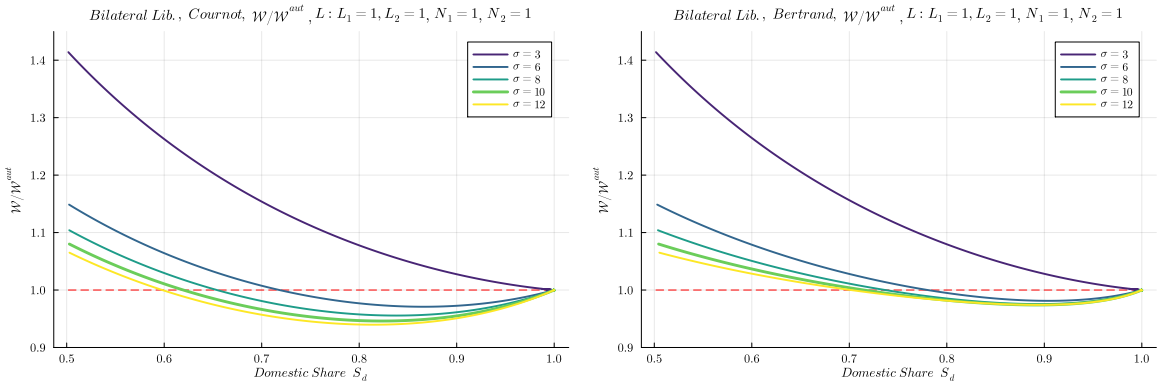
As for the case of Cournot competition, our results with Bertrand competition are also distinct from those in the existing literature. More specifically, Clarke and Collie (2003) and Friberg and Ganslandt (2008) studied the welfare consequences of trade-cost reductions in partial equilibrium models with product differentiation, but both papers derived very different results. More specifically, Clarke and Collie (2003) develop a partial-equilibrium linear demand model in which, under an international Bertrand duopoly, losses from trade cannot occur under *any* degree of product differentiation. Friberg and Ganslandt (2008) extend their framework to an arbitrary number of firms in each country, and show that welfare is a U-shaped function of trade costs, but that losses from trade can only occur if firms produce sufficiently close substitutes or if the number of firms is sufficiently large. These partial-equilibrium results stand in sharp contrast to our general-equilibrium insights: we find that losses from trade can *only* occur under an international Bertrand duopoly, and only when products within industries are sufficiently differentiated.

5.3 Numerical Simulations

We next illustrate our results numerically for various values of the three key parameters of the model (σ, ρ, and N), and for values of trade costs ranging from free trade $\tau = 1$ to autarky $\tau \to \infty$. We do not attempt (at this point) to produce a carefully calibrated exercise, but we adopt, as our benchmark, the calibrated values of σ and ρ in Atkeson and Burstein (2008), namely $\sigma = 10$ and $\rho = 2$. In the following graphs, in the Y-axis, we plot welfare levels ($W = I/P$) relative to the welfare of the country under autarky (W^{aut}), while in the X-axis we plot the aggregate domestic share S_d which is a monotonic function of τ. In the Appendix, we include plots with τ on the X-axis, which we refer to at times in the main text.

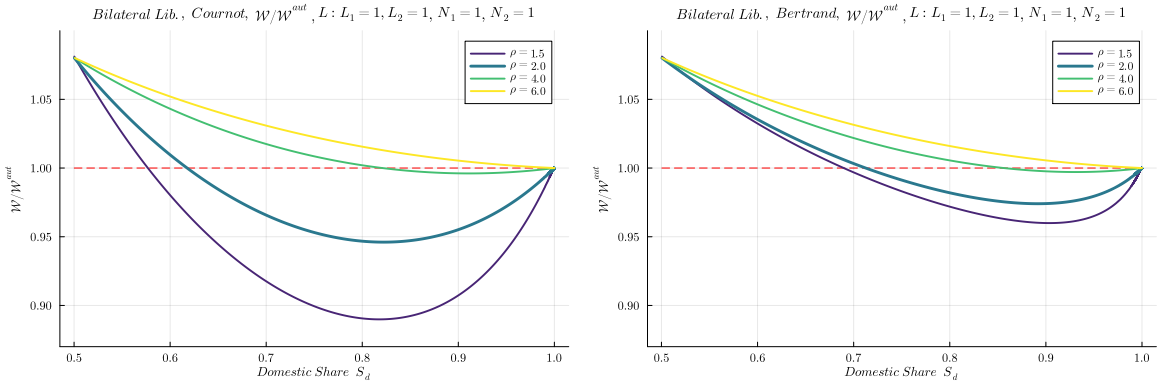
In Figure 1, we start by focusing on the case in which there is a single firm in each country, or $N = 1$. For the baseline case with $\sigma = 10$ and $\rho = 2$, the key condition (23) is violated (since $\frac{\sigma}{\sigma-1} = \frac{10}{9} > \frac{2}{8} = \frac{\rho}{\sigma-\rho}$) and, in line with Propositions 3 and 4, welfare levels are lower with trade than under autarky for values of S_d close to 1, which are associated with high levels of trade costs. Interestingly, for this baseline case, welfare levels with trade remain lower than under autarky for a significant interval of domestic market shares. In other words, with a monopolist in each country, it does not take much 'home bias' to generate losses from trade. In the Cournot case, we have losses from trade for all $S_d > 0.62$, while in the Bertrand case, the same is true for all $S_d > 0.71$. As we show in the Appendix, given the high value of σ, the range of trade costs for which losses from trade occur is very large, and gains from trade only materialize if (roughly) $\tau < 1.2$, regardless of market structure (see Figure A.1 in the Appendix).

Figure 1: Welfare and trade costs for $N = 1$, $\rho = 2$ and various σ



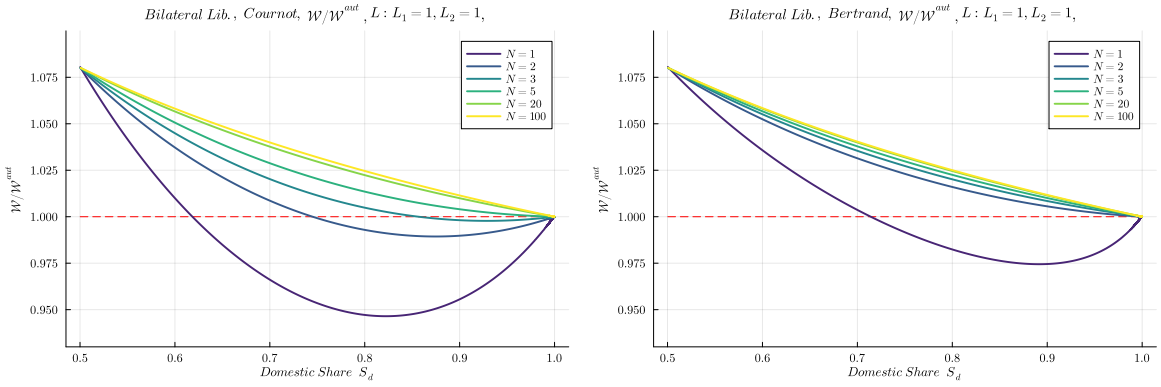
(a) Cournot **(b)** Bertrand

Figure 2: Welfare and trade costs for $N = 1$, $\sigma = 10$ and various ρ



(a) Cournot **(b)** Bertrand

Figure 3: Welfare and trade costs for $\sigma = 10$, $\rho = 2$, and various N



(a) Cournot **(b)** Bertrand

In Figures 1 and A.1 we further explore the implications of changing the value of σ while keeping constant $\rho = 2$ and $N = 1$. As expected, the range of domestic shares and trade costs for which we observe losses from trade (relative to autarky) is lower the lower σ is, and for $\sigma = 3$, condition (23) is satisfied and welfare is monotonically decreasing in τ, as predicted by Propositions 3 and 4.

In Figures 2 and Appendix Figure A.2, we further explore the robustness of the results to variation in ρ holding σ constant at 10. Naturally, the range of trade costs with losses from trade is lower the higher ρ is, and this range is essentially negligible (though still positive) when $\rho = 6$.

Figures 1 and 2 appear to indicate that the possibility of welfare-reducing trade is far more than a theoretical curiosity. Nevertheless, the case with a monopolist in each country is representative of very few industries. Figure 3 plots welfare relative to autarky for various values of N, ranging from $N = 1$ to $N = 100$. As expected, the range of trade costs for which losses from trade exist is lower the higher N, but we still get losses from trade when $N = 4$ in the Cournot case. As noted in Corollary 1, in the Bertrand case, losses from trade can only materialize if $N = 1$.

6 Modulating the General Equilibrium Effects

As explained in previous sections, one of the ways in which our work departs from Brander and Krugman (1983) is in considering the general equilibrium impact of uniform changes in trade costs in all sectors of the economy. More specifically, Brander and Krugman (1983) consider a partial equilibrium model in which an industry's demand only depends on a sector's price, wages are pinned down by an outside sector, and profits only affect welfare via their direct impact on income. Conversely, in our model, both profits and wages are endogenous, and trade costs affect the demand for goods not only via price effects, but also via income effects, potentially generating pecuniary spillovers across sectors. In this section, we develop a simple extension of our framework to study the robustness of our main results to alternative environments in which general equilibrium effects are of varying magnitude.

In particular, we consider the case in which the representative consumer in each country j allocates a share α of their spending to the continuum of sectors $k \in [0, 1]$ modelled above, and the remaining share $1 - \alpha$ to an 'outside' sector. Formally, we replace (1) with

$$U_j = Q_j = \left(Q_j^{out}\right)^{1-\alpha} \left(\int_0^1 \left(Q_j^k\right)^{(\rho-1)/\rho} dk \right)^{\alpha\rho/(\rho-1)},$$

where Q_j^{out} is consumption of the outside sector. The output of this outside sector is assumed to be produced one to one with labor in all countries, with producers in that sector behaving competitively. Given our symmetry assumptions, the wage in both countries can be normalized to 1, resulting in a unit price worldwide for that outside sector's output (even though this good is not traded in equilibrium).

Although the parameter α does not affect the relative wages in the two countries, the economy-wide effects of changes in trade costs applying to goods in the 'inside' sectors *will* be modulated by this parameter. First, on the consumption side, the impact of changes in trade costs on the ideal price

index of consumers, is given by

$$d\log P_j = \alpha \frac{S_f \Omega_f}{S_d \Omega_d + S_f \Omega_f} d\log \tau,$$

and, thus, it is naturally larger, the larger α is. When $\alpha = 1$, we obtain equation (11), while when $\alpha \to 0$, the effects of changes in trade costs in the inside sectors become negligible.

Second, the change in aggregate income is now given by

$$d\log I_j = \frac{\alpha}{1 - \alpha N \sum_{i=d,f} \frac{s_i}{\varepsilon_i}} N \sum_{i=d,f} \left(\frac{s_i}{\varepsilon_i}\right) \left[d\log s_i - d\log \varepsilon_i\right],$$

which is also increasing in α. This is for two reasons. First, as in the case of the price index, the importance of the inside sectors for aggregate welfare increases proportionally with α. Second, a higher α translates into a higher ratio of profits to labor income because the outside sector generates no profits. This latter effect is key for the results below and reflects a pecuniary externality, by which increasing profits in some sectors of the economy increase income and generate higher sales and income in other sectors of the economy.

Given this pecuniary externality, the change in welfare is analogous to the one in equation (21), and given by

$$\frac{d\log W_j}{d\log \tau} = \left[\frac{\left(\varepsilon_d - 1 + (\sigma - \varepsilon_d)\,\Omega_d\right) \frac{S_d}{\varepsilon_d} - \left(\varepsilon_f - 1 + (\sigma - \varepsilon_f)\Omega_f\right) \frac{\Omega_d}{\Omega_f} \frac{S_d}{\varepsilon_f}}{1 - \alpha \frac{S_d}{\varepsilon_d} - \alpha \frac{S_f}{\varepsilon_f}} - 1 \right] \frac{\alpha S_f \Omega_f}{S_d \Omega_d + S_f \Omega_f},$$

which again goes to 0 when $S_f \to 0$. Yet, such convergence is from below (thus implying gains from trade even as $\tau \to \infty$) if and only if

$$\frac{\sigma}{\sigma - 1} \leqslant \frac{\varepsilon_d}{\sigma - \varepsilon_d} + (1 - \alpha) \frac{\sigma}{\Omega_d \left(\sigma - \varepsilon_d\right)\left(\sigma - 1\right)}. \tag{26}$$

Clearly, this condition is *more* likely to hold than the analogous condition (23) applying when $\alpha = 1$, and thus the more significant are general equilibrium effects (and associated pecuniary externalities), the *more* likely it is that losses from trade liberalization may occur. In other words, the losses from trade in Brander-Krugman type partial-equilibrium environments persist and are even *magnified* in general equilibrium environments.

The above condition (26) is a function of two endogenous objects: the perceived elasticity of demand ε_d of firms in the inside sectors, and the term Ω_d capturing the response of domestic prices to marginal cost reductions of foreign firms. Whenever market structure takes the form of Bertrand or Cournot competition, it is straightforward to express condition (23) as solely a function of σ, ρ, and α. For instance, in the Cournot monopolist case ($N = 1$), we have $\varepsilon_d = \rho$, and losses from trade-cost reductions close to autarky occur if and only if

$$\frac{\sigma}{\sigma - 1} > \frac{\rho}{\sigma - \rho} + (1 - \alpha) \left[\frac{\sigma}{\left(\sigma - \rho\right)\left(\sigma - 1\right)} + \frac{1}{\rho - 1} \right].$$

Simple differentiation indicates that this condition is more likely to hold the larger is σ, and when $\sigma \to \infty$, this condition necessarily holds whenever $\rho > 2 - \alpha$.[12] Thus, losses from trade liberalization continue to occur when the within-sectoral elasticity is sufficiently high, provided that ρ is higher than $2 - \alpha$. In the case of a domestic Bertrand monopolist, losses from trade cost reductions occur if and only if

$$\frac{\sigma}{\sigma - 1} > \frac{\rho}{\sigma - \rho} + (1 - \alpha)\left[\frac{\sigma}{(\sigma - \rho)(\sigma - 1)} + \frac{\sigma}{\rho(\rho - 1)}\right],$$

a condition that can again be satisfied even for $\alpha = 0$.[13]

7 Heterogeneous Firms

In this section, we extend our analysis to the case of heterogeneous firms. To simplify the analysis, we maintain the other symmetry assumptions in the model: countries and industries are symmetric in all respects, so the distribution of firm size is also symmetric across countries and sectors. Our main result is that in the presence of firm heterogeneity, the likelihood that welfare losses from reductions in trade costs occur close to autarky is increasing in the dispersion in the distribution of firm productivities. The intuition as follows: the larger firm productivity dispersion is, the higher the relative size of the largest firms in an industry, and the closer the industry equilibrium will be to one with a small number of firms. As a result, and in contrast to Corollary 1, we show that losses from trade can occur under Bertrand competition even when the number of firms in each country is higher than two.

7.1 General Formula and Limiting Case

Consider the case in which there are N producers in each country and sector, but their marginal costs and sizes are different, with $\sum_{n=1}^{N} s_{ni} = S_i$ for $i = d, f$.

As we show in the Appendix, equation (21) generalizes to

$$\frac{d \log W_j}{d \log \tau} = \left[\frac{\sum_{n=1}^{N}\left(\frac{s_{nd}}{\varepsilon_{nd}}\right)(\varepsilon_{nd} - 1 + (\sigma - \varepsilon_{nd})\Omega_{nd}) - \sum_{n=1}^{N}\left(\frac{s_{nf}}{\varepsilon_{nf}}\right)(\varepsilon_{nf} - 1 + (\sigma - \varepsilon_{nf})\Omega_{nf})\frac{S_d\Omega_d}{S_f\Omega_f}}{1 - \sum_{i=H,F}\sum_{n}\frac{s_{ni}}{\varepsilon_{ni}}} - 1\right] \times \frac{S_f\Omega_f}{S_d\Omega_d + S_f\Omega_f}.$$

where

$$\Omega_{ni} \equiv \frac{1 - s_{ij}}{1 - s_{ij} + \Gamma_{ij}},$$

[12] Define $f(\sigma, \rho) = \frac{\rho}{\sigma - \rho} + (1 - \alpha)\left[\frac{\sigma}{(\sigma - \rho)(\sigma - 1)} + \frac{1}{\rho - 1}\right] - \frac{\sigma}{\sigma - 1}$. Then note

$$\frac{\partial f(\sigma, \rho)}{\partial \sigma} = -\frac{\left(\sigma^2 - \rho\right)(\rho - \alpha)}{(\sigma - 1)^2(\sigma - \rho)^2} < 0,$$

and $\lim_{\sigma \to \infty} f(\sigma, \rho) = -(\rho - 2 + \alpha)/(\rho - 1)$.

[13] Nevertheless, how this condition is shaped by σ is more complex, especially when ρ is very small.

and

$$\Omega_i = \sum_n \frac{s_{ni}}{S_i} \Omega_{ni}.$$

When $s_{ni} = S_i/N$ for $i = d, f$, this expression naturally coincides with (21).

How does the presence of firm heterogeneity shape the possibility of decreases in trade cost reducing welfare close to autarky? When $\tau \to \infty$, it will be the case that $S_d \to 1$, and $s_f = S_f \to 0$. Consequently, we can show that $d \log W_j / d \log \tau$ is negative if and only if

$$\sum_{n=1}^{N} s_{nd} \left(\frac{\sigma - \varepsilon_{nd}}{\varepsilon_{nd}} - \frac{\sigma - 1}{\sigma} \right) \Omega_{nd} \leqslant 0,$$

which generalizes our formula in equation (23) when firms within an industry have heterogeneous productivities.

The left-hand-side term is a sum of a nonlinear function of all firms' market shares. Because ε_{nd} is decreasing in firm size s_{nd}, this nonlinear function is typically convex. As a result, increases in the variance of firm sizes tend to make this condition less likely to hold.[14] We will illustrate this result below via numerical simulations, but we can provide a stark version of this result as follows. Suppose there are only two firms ($N = 2$) with domestic market shares θ and $1 - \theta$ under autarky, then:

Proposition 5. Even when there are gains from trade as $\tau \to \infty$ for the case of symmetric firms ($\theta = 1/2$), whenever $\frac{\sigma}{\sigma - 1} > \frac{\rho}{\sigma - \rho}$, there are losses from trade for sufficiently high or low θ.

A corollary of this result is that losses from trade may occur even under Bertrand competition when $N = 2$ provided that the variance in domestic market shares is sufficiently high. We have illustrated this result for the special case $N = 2$, but the same result applies more broadly. As the variance in firm sizes grows, the larger firm in an industry becomes disproportionately larger, so eventually, what matters for the possibility of there existing losses from trade under autarky is condition (24) applying to the case of a domestic monopolist.

Numerical Simulations We next illustrate the role of productivity dispersion in shaping the welfare effects of trade-cost reductions. Our approach is analogous to the simulations presented in section 5.3, plotting welfare levels relative to autarky in the Y-axis, and the aggregate domestic share S_d in the X-axis. For simplicity, we focus throughout on the calibrated values in Atkeson and Burstein (2008), namely $\sigma = 10$ and $\rho = 2$.

Figure 4 presents results for the case of 5 firms ($N = 5$) and various mean-preserving distributions of productivity. When all firms are homogenous, the key condition (23) is satisfied, and welfare is monotonically decreasing in trade costs: trade liberalizations always increase welfare in that case. But as the dispersion in productivity grows, the possibility of losses close to autarky quickly arises, and the range of trade costs for which losses occur is larger the larger dispersion is, in line with Proposition 5.[15]

[14] For the case of Cournot competition, one can show that this function is necessarily convext for all s_{nd} if σ is below a certain threshold.

[15] To be precise, Proposition 5 relates losses from trade to a mean-preserving spread in the size distribution of firms, whereas Figure 4 plots gains from trade for various mean-preserving spread in the distribution of firm productivities.

We are currently exploring a calibration of the model to match the observed distribution of Danish exporters.

8 Country Asymmetries

In this final section, we extend our results to an environment in which the Home and Foreign country are no longer symmetric. The main novel aspect of the analysis is that wages differ across countries, and changes in trade costs affect relative wages. The expressions for welfare changes as a function of trade costs thus incorporate additional terms related to those wage movements.

We will not present these equations here for the time being because we have not been able to derive any sharp theoretical results. Instead, we present numerical simulations for two types of exercises. In both cases, we assume full symmetry across sectors and homogeneous firms within sectors, but we first consider the possibility that countries differ in their size or firm productivity, and we later consider cases in which countries are ex-ante identical, but wage differences arise because trade 'liberalization' is unilateral rather than reciprocal.

Asymmetric Country Fundamentals Figure 5 illustrates the implications of size differences across countries. More specifically, we consider our baseline international duopoly ($N = 1$) case with $\sigma = 10$ and $\rho = 2$, and let country 2 (Foreign) be larger in population than country 1 (Home). Because domestic expenditure shares S_d will now vary across countries even if other parameters are identical across countries, we plot our results as a function of the common trade cost level τ. As is clear from the figure, losses from trade occur for a much wider range of trade costs for the small country than for the large one.

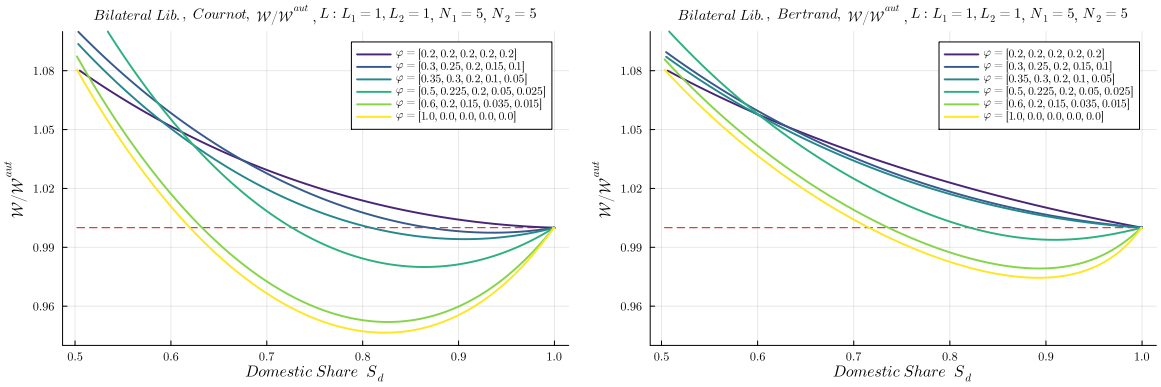
Figure 6 shows the results for the case of asymmetries in productivity. The results are analogous. The less productive country is more likely to lose from trade (for high values of τ) than the more productive country.

Unilateral Liberalization [IN PROGRESS]

9 Conclusion

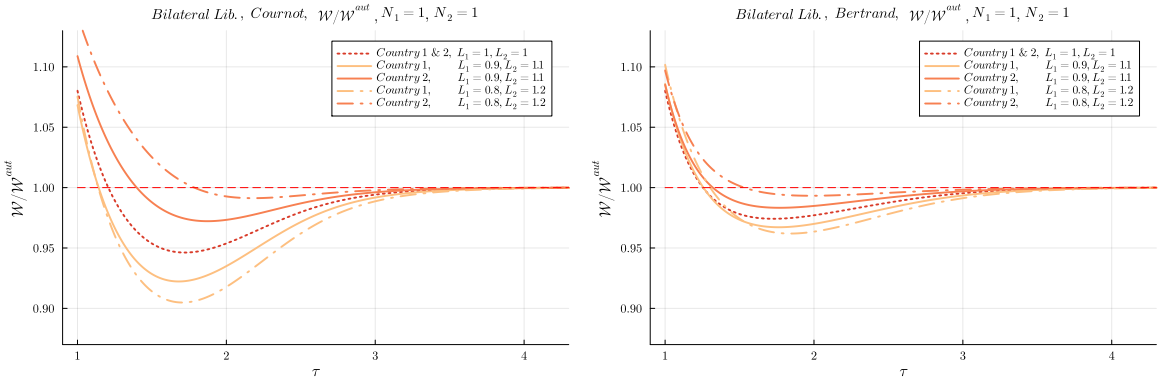
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Figure 4: Welfare and trade costs for $N = 5$ heterogeneous firms



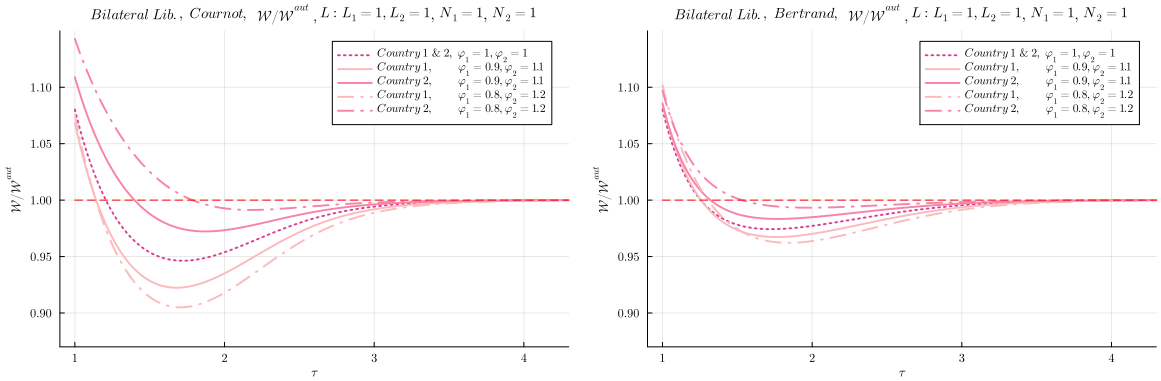
(a) Cournot **(b)** Bertrand

Figure 5: Welfare and trade costs with asymmetric population



(a) Cournot **(b)** Bertrand

Figure 6: Welfare and trade costs with asymmetric productivity



(a) Cournot **(b)** Bertrand

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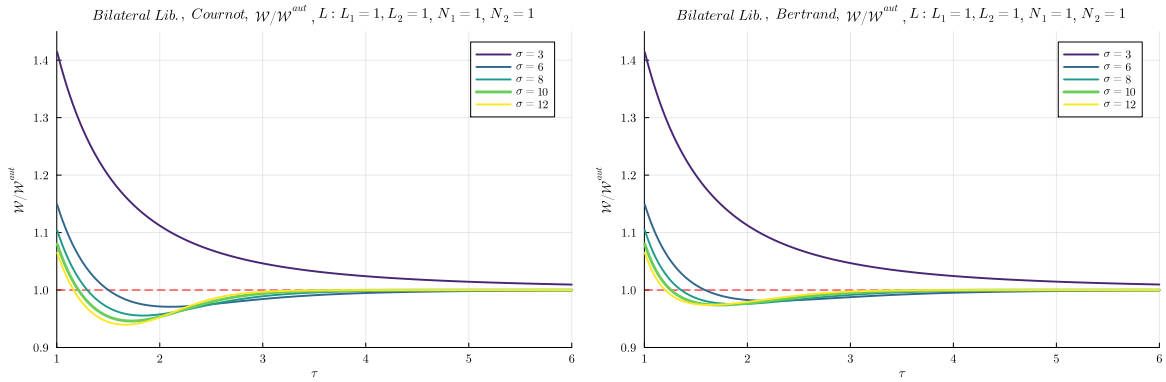
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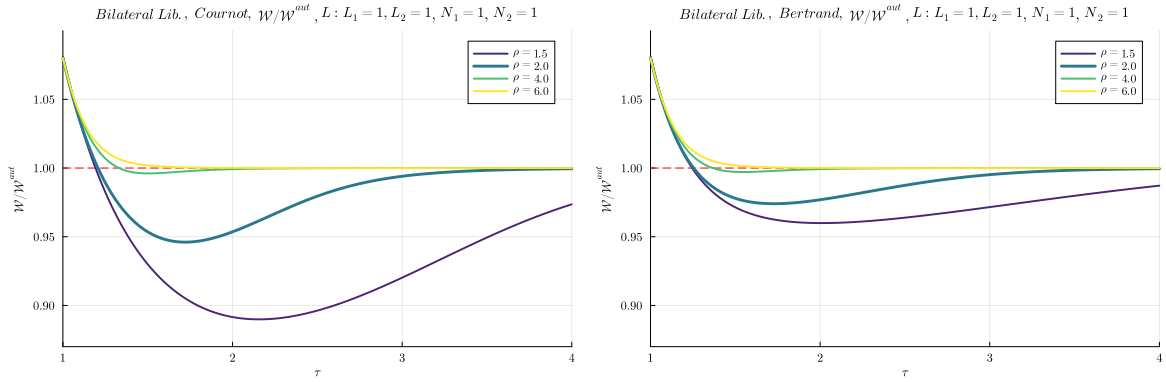
A Appendix Figures

Figure A.1: Welfare and trade costs for $N = 1$, $\rho = 2$ and various σ



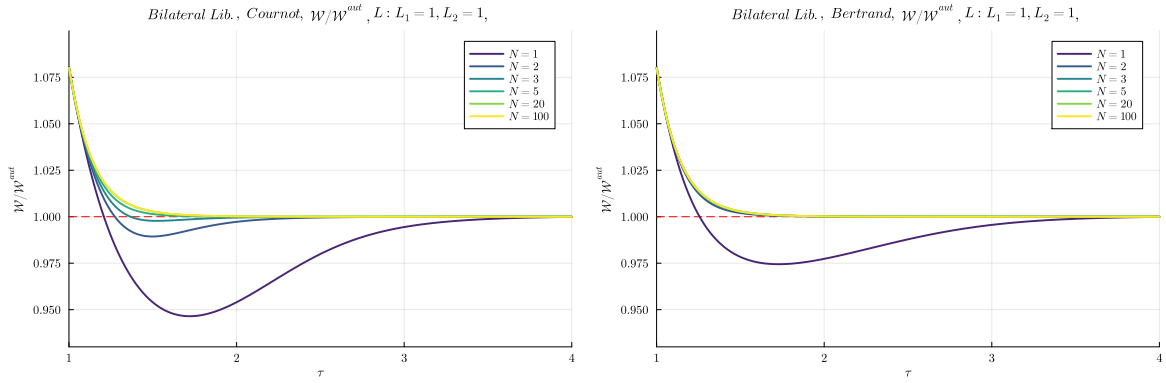
(a) Cournot **(b)** Bertrand

Figure A.2: Welfare and trade costs for $N = 1$, $\sigma = 10$ and various ρ



(a) Cournot **(b)** Bertrand

Figure A.3: Welfare and trade costs for $\sigma = 10$, $\rho = 2$, and various N



(a) Cournot **(b)** Bertrand