Heterogeneous Firms, the Structure of Industry, & Trade under Oligopoly *

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ABSTRACT: We develop a model with endogeneity in key features of industrial structure linked to heterogeneous cost structures under Cournot competition. We use the model to explore issues related to cross-country differences in industry structure and the impact of globalization on markups and pricing, concentration, and productivity. The model nests two workhorse trade models, the Brander & Krugman reciprocal dumping model and the Ricardian technology-based trade model, as special cases. We examine both free entry and limited entry (free exit) cases. The model generates clear testable predictions on the probability of zero trade flows and the pattern of export prices, and on cross-country and industry variations in industrial structure controlling for openness. Market prices decline as a result of trade liberalization, the least productive firms get squeezed out of the market, exporting firms gain market share, and more firms become trade oriented. In addition, depending on the strength of underlying cost heterogeneity, falling prices are consistent with both increasing and falling industry concentration following episodes of integration. Welfare rises with trade liberalization, unless trade costs decline from a prohibitive level in the short run free exit case. Variation across industries and markets in markups, concentration, and pricing structures is otherwise a function of market size and the variation in cost heterogeneity across industries.

Keywords: Industry structure and firm heterogeneity, Cournot competition, Composition effects of trade liberalization

JEL codes: L11, L13, F12

printdate: August 27, 2008

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1 Introduction

Research on the impact of globalization on firms has shown that the reallocation effects of trade are an important mechanism linking openness to productivity. Bernard and Jensen (2004) find that almost half of the rise of manufacturing total factor productivity in the USA between 1983 and 1992 is linked to a reallocation effect of resources towards more productive and trade oriented firms. Episodes of liberalization in developing countries also show the importance of changes in firm composition – composition effects (Tybout 2001).

A number of models of heterogeneous productivity have been put forward in the recent theoretical trade literature to explain composition effects of trade. A standard result is that processes of firm formation involving heterogeneous cost structures across firms imply beneficial reallocation effects from trade liberalization linked to rationalization of the population of firms. Less efficient firms producing for the domestic market are squeezed out by more efficient trading firms. For example, Melitz (2003) introduces heterogeneous productivity in a monopolistic competition framework with CES-preferences, while Bernard, et al (2003) include heterogeneous productivity in a model with Bertrand competition. Working with monopolistic competition models, Baldwin and Robert-Nicoud (2008) examine linkages between trade and growth given firm heterogeneity, while Ghironi and Melitz (2007) examine macroeconomic dynamics. In contrast, in this paper we explore heterogeneous productivity in a model with oligopoly characterized by Cournot competition. Basic aspects of market structure – markups, industrial concentration, relative firm positions, and prices for domestic and export markets – are endogenous. They depend on the interaction between the technology set, market size, and trade openness.

The model we develop is a two-country, multi-sector model of trade under Cournot competition.[1] The value added of this approach is threefold. First, the model is parsimonious, while generating a rich set of results linked to composition effects. This includes welfare effects of trade liberalization and the endogeneity of market structure. Moreover, we do not need to assume a specific distribution of productivity, as is the case with Bernard, et al (2003) and Melitz and Ottaviano (2008), to generate our results. Second, the model nests two workhorse trade models, the Brander and Krugman (1983) reciprocal dumping model and the Ricardian model, as special cases. Third, the model generates clear testable predictions on the probability of zero trade flows and export prices, as well as predictions about linkages between openness and industrial market structure across industries and countries. The pattern of zeros and unit values has emerged as a particularly important issue in the recent empirical trade literature. (See Baldwin and Harrigan 2007, Baldwin and Taglioni 2006). In the model developed here, a larger distance between countries leads to a higher probability of zero trade flows and lower fob export prices. The size of the importer country also influences the probability of zero trade flows and decreases the fob export price. A number of other results stand out. In the free entry case, falling trade costs raise welfare unambiguously. However, in the case without free entry, welfare increases as well only when certain conditions are placed on the distribution of costs. In addition, falling prices from trade liberalization can go hand and hand with increased firm concentration. Finally, we note the possibility of delocation effects with heterogeneous countries. Unilateral liberalization then leads to higher market prices in the liberalizing country. All results are derived without specifying a specific distribution of costs. Preferences are assumed to be CES.

[1]Van Long et al. (2007) also address firm heterogeneity in an oligopoly model. Their paper is focused on a different set of issues however, the interaction of trade and R&D.

The paper is organized as follows. In Section 2 we lay out the basic model. Section 3 goes into the case of trade without free entry and section 4 addresses the case of trade with free entry. Section 5 explores the heterogeneous countries case. Section 6 concludes.

2 The Basic Model

This section lays out the basics of the model without trade (or identically for an integrated or single global economy without trade costs). Industrial concentration emerges endogenously as a function of the degree of firm heterogeneity and market size, while the relationship of concentration to price depends on the cost structure of industry.

We start by assume that there are $Q+1$ sectors in the economy, oligopolistic Q sectors producing q_j and 1 sector producing z under conditions of perfect competition. In the first sections it is assumed that the Cournot sectors are symmetric. Later on this assumption is relaxed when asymmetries in national technology sets, country size, and policy are explored. Throughout it is assumed that there are sufficient sectors in the economy so that the effect of a price change on demand through the price index is negligible for firms. (There is no numeraire problem). There are L equal agents each supplying 1 unit of labor. All profit income from the Cournot sectors goes to the economic agents. The utility function of each agent is CES. The optimization problem of the consumer generates the following market demand functions in the Cournot sectors q_j and in the perfect competition sector z:

$$q_j = \frac{IP_U^{\sigma-1}}{p_j^{\sigma}} \tag{1}$$

$$z = IP_U^{\sigma-1} \tag{2}$$

The price of good z is normalized at 1 and I is the endogenous income of all agents, the sum of labor and profit income. P_U is the consumer price index, corresponding to one unit of utility:

$$P_U = \left[\sum_{j=1}^{Q} p_j^{1-\sigma} + 1\right]^{\frac{1}{1-\sigma}} = \left[Qp^{1-\sigma} + 1\right]^{\frac{1}{1-\sigma}} \tag{3}$$

Until we relax out symmetry assumptions, we will focus on one representative Cournot sector. (We will warn the reader when we drop these assumptions.) This means we can drop the sector index j for now. Labor is the only factor of production and there is a labor force of size L. One unit of labor is needed to produce one unit of the perfect competition good y. This means the wage is equal to 1. In the q sectors productivity is heterogeneous. One unit of labor can be transformed into $1/c_i$ units of q for the i-th firm which has marginal cost of production c_i. There are no fixed costs of production. Therefore the cost function of firm i is given by

$$C_i\left(q_i\right) = c_i q_i \tag{4}$$

There is Cournot competition between the different firms in the q-sectors. So, firms maximize profits towards quantity supplied, taking the quantity supplied by other firms as given. Profit of firm i is given by:

$$\pi_i = p q_i - c_i q_i \tag{5}$$

The first order condition is defined as:

$$\frac{\partial \pi_i}{\partial q_i} = p\left[1 - \frac{1}{\sigma}\frac{q_i}{q}\right] - c_i = 0 \tag{6}$$

With $q = \sum_{i=1}^{n} q_i$. n is the number of firms in the market. Using the first order condition, the second order condition can be written as follows (derivation in appendix A):

$$-\frac{1}{\sigma}\frac{p}{q}\left[\frac{(\sigma+1)\,c_i - (\sigma-1)\,p}{p}\right] < 0 \tag{7}$$

Using the definition for market share, $\theta_i = \frac{q_i}{q}$, the first order condition can be rewritten as:

$$p\left(1 - \frac{\theta_i}{\sigma}\right) = c_i \tag{8}$$

$$\theta_i = \sigma\frac{p - c_i}{p} \tag{9}$$

The marginal revenues on the LHS of equation (9) should be at least as large as the marginal costs on the RHS. The larger is market share θ_i, the lower is marginal revenue. So, for positive sales ($\theta_i \geq 0$) which are implicitly imposed, a firm can satisfy the FOC by just reducing its market share as long as its marginal cost is smaller than the market price. There is a cutoff cost level c^* with which a firm would just stay in the market. This cutoff cost level c^* is equal to the market price p. The highest cost firm staying in the market has a cost level equal or just below the cutoff cost level and selling an amount just above zero.

The equilibrium price and quantities sold can be found for a given number of firms. Below a free entry condition is added to endogenise the number of firms. Suppose for now there are n firms. Combining the demand equation in (1) with n first order conditions in equation (6) and with the equation for the sum of market shares, one can find the following solutions for the market price p, total sector sales q and sales of an individual firm q_i:

$$p = \frac{\sigma}{\sigma n - 1} \sum_{i=1}^{n} c_i = \frac{\sigma n}{\sigma n - 1} \bar{c} \tag{10}$$

$$q = \frac{IP_U^{\sigma-1}}{\bar{c}^\sigma} \left(\frac{\sigma n - 1}{\sigma n} \right)^\sigma \tag{11}$$

$$q_i = \sigma IP_U^{\sigma-1} \frac{\bar{c} - c_i}{\bar{c}^\sigma} \left(\frac{\sigma n - 1}{\sigma n} \right)^{\sigma-1} \tag{12}$$

with $\bar{c}$ the average cost of firms, $\bar{c} = \frac{1}{n} \sum\limits_{i=1}^{n} c_i$.

Using the fact that the price is equal to the cutoff cost level, the price equation (10) can be rewritten to solve for the number of firms as a function of the cutoff cost level and average cost:

$$n = \frac{1}{\sigma} \frac{c^*}{c^* - \bar{c}} \tag{13}$$

On the basis of equation (13) we make the following Proposition.

Proposition 1 *The cost structures and market structures of industries are related to the degree of heterogeneity. The less the degree of cost heterogeneity, the more competitive the structure of the industry.*

Equation (13) shows that an increase in the number of firms implies that the firm with the highest cost needs to have a cost parameter ever closer to average cost. Therefore, the cost levels of firms become ever closer to each other with more firms in the market. Proposition 1 highlights how the market structure and the cost structure in the model are interrelated. When we observe more competitive industries with more firms in equilibrium, this means the cost levels of firms should be closer to each other.[2]

[2] Working with a more restricted model without entry, Van Long and Soubeyran (1997) find similar results.

Next, free entry is allowed in the model. This will endogenise the number of firms n. Free entry is introduced like in Melitz (2003). Firms have to pay a sunk entry cost f_e to draw a cost parameter c_i randomly from a certain distribution of costs $F(c_i)$. Hence, uncertainty about productivity is a barrier to entry for firms. They start to produce when they can make positive operating profits. When they cannot make positive profits, they take their loss and leave the market immediately. Producing firms leave the market with a certain fixed death probability δ in each period or when market conditions have changed such that they cannot make positive profits anymore. The sunk entry costs use labor. As free entry leads to zero expected profits, all profit income on average is used to pay labor in the entry sector. Therefore, total income in the economy is fixed and equal to the amount of labor (with wages normalized at 1).

The entry and exit process described leads to a zero cutoff profit condition (ZCP) and a free entry condition (FE). Together these two conditions can be added to the 'no free entry' equilibrium equations, equations (10)-(12). The number of firms n can then be determined.

The ZCP can be derived from the fact that zero profit implies that price should be equal to marginal cost. The FOC in equation (6) shows that this firm will reduce market share to (just above) zero, to satisfy the first order condition and make non-negative profit. One finds as ZCP:

$$p = c^* \tag{14}$$

The FE is given by equalizing the ex ante expected profits from entry with the sunk entry cost:

$$F(c^*) \sum_{j=0}^{\infty} (1-\delta)^j \,\bar{\pi} = f_e \tag{15}$$

$$\tilde{\pi} = \frac{\delta f_e}{F(c^*)} \tag{16}$$

$\tilde{\pi}$ is the expected profit conditional upon entry. It can be written as:

$$\tilde{\pi} = \int_0^{c^*} [p(c)\, q(c) - cq(c)]\, \mu(c)\, dc = q \int_0^{c^*} \theta(c)\,(p-c)\, \mu(c)\, dc \tag{17}$$

They show that the variance of the cost distribution and the Herfindahl index of industry concentration are positively related in a model with Cournot competition: a larger variance leads to more industry concentration. From equation (13) above, it is clear that this result is more general, and holds with entry and exit.

$\mu(c)$ is the truncated pdf of all firms producing, $\mu(c) = \frac{1}{F(c^*)} f(c)$.[3] Continuing the derivation, leads to the following FE:

$$\tilde{\pi} = \frac{LP_U^{\sigma-1}}{(c^*)^{\sigma}} \int_0^{c^*} \sigma \left(c^* - 2c + \frac{c^2}{c^*} \right) \mu(c)\, dc = \frac{\delta f_e}{F(c^*)} \tag{18}$$

$$\frac{LP_U^{\sigma-1}}{(c^*)^{\sigma}} \sigma \left(c^* - 2Ec + \frac{E(c)^2}{c^*} \right) = \frac{\delta f_e}{F(c^*)} \tag{19}$$

The expectation appearing in equation (19) is a truncated expectation, i.e. $Ec = E(c\,|c \leq c*)$. All expectations appearing in the remainder of the paper are the appropriate truncated expectations. Combining the FE and ZCP generates the following equation:

$$\frac{LP_U^{\sigma-1}}{(p)^{\sigma}} \sigma \left(p - 2Ec + \frac{E(c)^2}{p} \right) = \frac{\delta f_e}{F(p)} \tag{20}$$

The combined FE/ZCP equilibrium condition generates a stable price equilibrium. Rewriting equation (18) using average profit unconditional upon entry $\bar{\pi} = F(p)\,\tilde{\pi}$, gives:

$$\bar{\pi} = \frac{LP_U^{\sigma-1}}{(p)^{\sigma}} \sigma \int_0^{p} \left(p - 2c + \frac{c^2}{p} \right) f(c)\, dc = \delta f_e \tag{21}$$

Appendix A shows that the LHS of equation (21) rises in the market price from 0 to ∞ when the SOC is imposed, implying that there is a unique equilibrium.

The FE and ZCP can be used to solve for the cutoff cost level. An explicit solution requires the choice of an initial cost distribution. Once the cutoff cost level c^* is known the number of firms can be determined.

In steady state average cost is equal to expected cost, $\bar{c} = E(c\,|c \leq c^*)$. So, the number of firms is equal to:

$$n = \frac{p}{p - E(c\,|c \leq c^*)} = \frac{1}{1 - \frac{E(c|c \leq p)}{p}} \tag{22}$$

Equation (22) can be log differentiated with respect to the market price p and the number of firms n:

$$\hat{p} = -\frac{p - E(c\,|c \leq p)}{p} \frac{1}{1 - \varepsilon_{Ec,p}} \hat{n} \tag{23}$$

$\varepsilon_{Ec,p}$ is the elasticity of equilibrium average costs with respect to the equilibrium market

[3] Remember that q is the sum of sales of all firms in a Cournot sector

price. Equation (23) implies the following:

Proposition 2 *When the equilibrium average cost varies less than proportionally with market price (i.e. it falls slower with a corresponding drop in market price), a lower market price is coincident with a larger number of firms. Or equivalently, a lower market price is coincident with more firms when the average markup declines in equilibrium with falling market prices. When the average cost varies more than proportionally in equilibrium with lower market prices, a decreasing market price is coincident with less firms.*

Proposition 2 follows from equation (22). As the market price is equal to the cutoff cost level, the relation between the market price and the number of firms depends on the distribution of costs.[4] Intuitively, a lower market price can either be caused by more firms in the market or by more efficient firms in the market. When average costs respond less than proportionally to the market price, a lower market price is caused by more firms in the market. When average costs respond more than proportionally to the market price, a lower market price is caused by more efficient firms in the market. In this situation a lower market price can go along with less firms, because the least efficient firms are squeezed out of the market. A related result can be derived on the effect of market size L on the number of firms.

Proposition 3 *The number of firms rises in the size of the market L when equilibrium average costs decline less than proportionally with equilibrium market price.*

The combination of Propositions 1, 2 and 3 leads to the following corollaries about industrial market structure and market size.

Corollary 1 *The mix of price and concentration depends on the distribution of firm costs (from Proposition 1). While larger markets imply lower prices, larger markets will only have both more firms and lower prices as long as the equilibrium average cost varies less than proportionally with equilibrium market price (equation 23). Larger markets will have more concentration but also lower prices as long as the equilibrium average cost varies more than proportionally with market price (again as defined in equation 23).*

[4] With a Pareto distribution, the truncated mean is linear in the truncation point. Therefore, the number of firms will be fixed. Simulations show that with a lognormal distribution sensible results can be generated with a reasonable number of firms. Moreover, with a lognormal distribution the number of firms declines in the market price.

Corollary 2 *The relationship of markups to market size also depends on cost heterogeneity. Larger markets imply both larger markups and greater concentration when the equilibrium average cost varies more than proportionally with market price (as defined in equation 23), and otherwise they imply lower markups and less concentration if equilibrium average cost varies less than proportionally with market price. From Proposition 1, the latter case is more likely to hold in industries with lower cost heterogeneity (linked to the technical distribution of possible costs for a firm).*

From Corollary 2, a systematic variation between market size, markups, and concentration (for example in cross-country comparisons or markups and concentration) can be taken as an indirect indicator of cost heterogeneity.

The combined FE/ZCP in equation (21) can be totally differentiated towards p and L:

$$\frac{dp}{dL} = -\frac{L}{p} \frac{\int_0^p \frac{(p-c)^2}{p} f(c)\, dc}{\int_0^p ((\sigma+1)c - (\sigma-1)p) f(c)\, dc} < 0 \tag{24}$$

The denominator is positive by the SOC in equation (7). Equation (24) shows that a larger market leads to a lower market price. From Proposition 2 it is known that the number of firms rises in the equilibrium market price when the decline in equilibrium average cost is less than proportional to a decline in the equilibrium market price, which implies Proposition 2. Intuitively, a larger market can be served in two ways: through more firms or through an increase in the sales per firm. Depending on the distribution of costs one or the other dominates.[5] The number of firms can increase with a larger market, but the number of firms can also decrease with a larger market, when enough of the least efficient firms are squeezed out of the market. This result contrasts with the monopolistic competition model of Melitz, where the number of firms is linear in market size and the increase in market size is served through a proportional increase in the number of firms. Here, concentration is an indicator of underlying heterogeneity, as is price.

[5] With a Pareto distribution the number of firms is fixed, so the increase in sales as a result of the larger market is fully realized through more sales per firm. With a lognormal distribution, also the number of firms changes considerably.

3 International Trade without Free Entry: the Short Run

We next introduce international trade between two countries $s, r = H, F$ with markets effectively segmented by trading costs. The countries are symmetric in size and technology sets. In particular we now introduce iceberg trade costs τ in the Cournot sectors, meaning that marginal cost for production and delivery is increased at the rate τ relative to production and delivery for the domestic market. There are no fixed or beachhead trade costs, and the trading costs preclude return exports. We do not have free entry (we return to this in the next section) though existing firms can exit. This can be seen as a short-run or free-exit case. We focus on the impact of increased globalization (i.e. falling trade costs). Consistent with the empirical literature (Tybout 2001), increased globalization through falling trade costs means that average markups from domestic sales decline and average markups from exporting sales rise with falling trade costs.

Under our assumptions about trade costs, the equilibrium market price in the representative Cournot sector becomes:

$$p_s = \frac{\sigma n_s}{\sigma n_s - 1} \bar{c}_s \tag{25}$$

with $\bar{c}_s = \frac{1}{n_r} \left[\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xs}} \tau c_{ixs} \right]$ and $n_s = n_{ds} + n_{xs}$. In equation (25), there is a direct effect of trade liberalization on the market price: exporting firms have lower costs and therefore average costs decline. And there is an indirect effect, because firms producing for the domestic market can disappear and exporting firms can appear on the market. It can be shown that this indirect effect is 0 at the margin (see appendix B). Therefore, the relative change in the market price is equal to:

$$\widehat{P}_s = \frac{\sum_{i=1}^{n_{xs}} \tau c_{is}}{\sum_{i=1}^{n_{ds}} c_{is} + \sum_{i=1}^{n_{xs}} \tau c_{is}} \widehat{\tau} \tag{26}$$

Variables with a hat denote relative changes, $\widehat{x} = \frac{dx}{x}$. The elasticity of the market price with respect to trade costs, $\varepsilon_{p,\tau}$, is between 0 and 1:

$$\varepsilon_{p,\tau} = \frac{\sum_{i=1}^{n_{xs}} \tau c_{is}}{\sum_{i=1}^{n_{ds}} c_{is} + \sum_{i=1}^{n_{xs}} \tau c_{is}} \tag{27}$$

From equations (26) and (27) we make the following proposition:

Proposition 4 *With a decline in trade cost τ, the market price also declines.*

Equation (26) shows that a decline of trade costs τ drives down the market price. The domestic cutoff marginal cost is equal to the market price, so it also declines.

Several other Propositions can be made on the effect of trade liberalization.

Proposition 5 *Some of the least productive firms are squeezed out of the market with a decline in trade cost τ.*

How many firms are squeezed out of the market depends on the price distribution of the firms, i.e. it depends on how far the highest cost firms are from the old market price.

Proposition 6 *More of the remaining firms export with a decline in trade cost τ.*

More firms can enter the export market, as the exporting cutoff marginal cost rises when τ declines:

$$c^*_{xr} = \frac{P_s}{\tau} \tag{28}$$

$$\widehat{c}^*_{xr} = \widehat{P}_s - \widehat{\tau} = -\left(1 - \varepsilon_{p,\tau}\right)\widehat{\tau} \tag{29}$$

Proposition 7 *(Average) markups from domestic sales decline and (Average) markups from exporting sales rise with a decline in trade cost τ.*

Markups of all domestic sales decline, as the costs of the firms remain equal, whereas the market price declines. Markups of the exporting firms rise with trade liberalization, as the effect of the declining trade costs dominates the effect of the decrease in market price in the exporting market. Using the letter m to indicate markup, the following can be derived:

$$m_{ixs} = \frac{P_r}{\tau c_{is}} \tag{30}$$

$$\hat{m}_{ixs} = \hat{P}_r - \hat{\tau} = \left(\varepsilon_{p,\tau} - 1\right)\hat{\tau} \tag{31}$$

The effect on average domestic and exporting markups can be calculated as well. The markups of firms are weighted by market shares in calculating average markups, so as to give more weight to larger firms[6]:

$$\bar{m}_{ids} = \sum_{i=1}^{n_{ds}} \frac{p_s}{c_{is}} \theta_{ids} = \sum_{i=1}^{n_{ds}} \sigma \frac{p_s - c_{is}}{c_{is}} \tag{32}$$

$$\bar{m}_{ixs} = \sum_{i=1}^{n_{xs}} \frac{p_r}{\tau c_{is}} \theta_{ixs} = \sum_{i=1}^{n_{xs}} \sigma \frac{p_r - \tau c_{is}}{\tau c_{is}} \tag{33}$$

Relative changes of the average exporting and domestic markups are equal to:

$$\widehat{\bar{m}}_{ids} = \frac{\sum_{i=1}^{n_{ds}} \frac{p_s}{c_{is}}}{\sum_{i=1}^{n_{ds}} \frac{p_s}{c_{is}} \theta_{ids}} \varepsilon_{p,\tau} \hat{\tau} \tag{34}$$

$$\widehat{\bar{m}}_{ixs} = -\frac{\sum_{i=1}^{n_{ds}} \frac{p_r}{\tau c_{is}}}{\sum_{i=1}^{n_{ds}} \frac{p_r}{\tau c_{is}} \theta_{ixs}} \left(1 - \varepsilon_{p,\tau}\right) \hat{\tau} \tag{35}$$

So, average markups from domestic sales decline and average markups from exporting sales rise.[7] Declining markups in the domestic market fit well with empirical findings reported in Tybout (2001) from developing countries. Various studies find that more import competition goes along with declining markups.

As in almost any model of international trade (for example Armington) firms increase their market share on the exporting market and their market share is reduced in domestic markets. But the relative gain and loss of exporters and domestic producers displays an interesting pattern:

Proposition 8 *Large low cost firms lose less market share on the domestic market than small high cost firms and small high cost exporting firms gain more market share on the export market than large low cost firms*

Proposition 8 follows from totally differentiating the expressions for market shares:

$$d\theta_{ids} = \sigma \frac{c_{ids}}{p} \varepsilon_{p,\tau} \widehat{\tau} \tag{36}$$

[6] Implicitly it is assumed that the probability of firms to be in the market is equal for all marginal costs, i.e. that the distribution of costs is uniform.

[7] Indirect effects because domestic producing firms disappear from the market and exporting firms enter the market are 0, because the averages are weighted by market shares and market shares are zero for entering and exiting firms.

$$d\theta_{ixs} = \sigma \frac{c_{ixr}}{p} \left(\varepsilon_{p,\tau} - 1\right) \widehat{\tau} \tag{37}$$

Therefore small firms lose relatively more market share on the domestic market and small firms gain relatively more market share on the exporting market than large firms. So, more efficient big firms do not gain more from improved market access abroad than less efficient small firms. Essentially, big firms already have a strong position in an exporting market, so they cannot grow as much as a result of trade liberalization as small firms.[8]

Consider next the welfare effect of trade liberalization. This is complicated by the fact that income is endogenous as it depends on profit income in the imperfect competition sector. With free entry profit income is driven to zero, but in the no free entry case profit income is non-zero and varies.

Welfare in country s is equal to utility in that country:

$$W_s = U_s = \frac{I_s}{P_{Us}} = \frac{L_s + \Pi_s}{P_{Us}} \tag{38}$$

Π_s is total profit income in the economy. Elaborating upon this equation (see appendix B) assuming that both countries are equal, one arrives at the following expression:

$$W = \frac{L\left(Qp + p^{\sigma}\right)}{p^{\sigma} + Q\tilde{c}} \frac{1}{P_U} \tag{39}$$

$\tilde{c}$ are the market share weighted average costs, $\tilde{c} = \sum_{i=1}^{n_d} c_i \theta_{id} + \sum_{i=1}^{n_x} \tau c_i \theta_{ix}$. Log-linearizing welfare towards trade costs τ from equation (39) and treating the price and the market share weighted average costs as endogenous, one finds (derivation in appendix B):

$$\hat{W} = \left[\frac{\sigma p^{\sigma}}{Qp + p^{\sigma}} - \frac{\sigma p^{\sigma}}{p^{\sigma} + Q\tilde{c}}\right] \hat{p} - \frac{Q}{p^{\sigma} + Q\tilde{c}} d\tilde{c} \tag{40}$$

The first term in (40) is the welfare gain through a decline in price. As expected the gain for the consumer from lower prices outweighs the loss of a lower profit income with lower prices. The second term measures the possible gain from trade liberalization of lower costs leading

[8] This set of results, related in particular to Proposition 8, has interesting political economy implications beyond the scope of this paper. As trade liberalization progresses, the dominant domestic firms gain relative domestic position (known as "standing" in the antidumping and trade safeguards literature). Assuming that lobbying efficiency is a function of industry concentration, increased concentration of firms with standing (i.e. the domestic industry) may increase their ability to organize and seek protection or relief against further drops in trade costs and foreign competition.

to a higher profit income. Elaborating on the cost effect, $d\tilde{c}$, one gets:

$$\begin{aligned}\hat{W} &= -\left[\frac{\sigma p^{\sigma}}{Qp+p^{\sigma}}-\frac{\sigma p^{\sigma}}{p^{\sigma}+Q\tilde{c}}\right]\hat{p} \\ &\quad -\frac{Q}{p^{\sigma}+Q\tilde{c}}\left[\sum_{i=1}^{n_d}c_i\theta_{id}\hat{\theta}_{id}+\sum_{i=1}^{n_x}\tau c_i\theta_{ix}\hat{\theta}_{ix}+\sum_{i=1}^{n_x}\tau c_i\theta_{ix}\hat{\tau}\right] \end{aligned} \tag{41}$$

$$\begin{aligned}\hat{W} &= -\left[\frac{\sigma p^{\sigma}}{Qp+p^{\sigma}}-\frac{\sigma p^{\sigma}}{p^{\sigma}+Q\tilde{c}}\right]\varepsilon_{p,\tau}\hat{\tau} \\ &\quad -\frac{Q}{p^{\sigma}+Q\tilde{c}}\left[\sum_{i=1}^{n_d}\sigma\frac{c_i^2}{p}\varepsilon_{p,\tau}-\sum_{i=1}^{n_x}\sigma\frac{\tau^2 c_i^2}{p}\left(1-\varepsilon_{p,\tau}\right)+\sum_{i=1}^{n_x}\tau c_i\theta_{ix}\right]\hat{\tau} \end{aligned} \tag{42}$$

Equation (41) and (42) can be interpreted as follows. In both equations is the first term on the RHS again the welfare gain from a lower market price. The second term on the RHS measures the effect on profit income through changed costs. In both (41) and (42) the first term between the second brackets measures the gain from the declining market share of domestic producing firms. The second term between the second brackets measures the loss from the rising market share of exporting firms. The third term measures the welfare gain from lower trade costs with trade liberalization.

Proposition 9 *Like in Brander and Krugman (1983) the welfare effect of trade liberalization <u>can</u> be negative at first when the tariff is reduced from a prohibitive level, due to the increased costs of cross-hauling associated with the first units traded. However, unlike Brander and Krugman, the welfare effect can also be positive when the tariff is reduced from a prohibitive level.*

Unlike in the model of Brander and Krugman (1983) the welfare effect of trade liberalization when the tariff is reduced from a prohibitive level is ambiguous. It depends on the cost structure of firms whether the welfare effect is positive or negative. It can be shown under what condition the welfare effect is negative in general, but this condition is cumbersome and does not lend itself to any interpretation. (See footnote 9 below for proof by example).[9]

[9] As proof of ambiguity, we can offer two examples to show that the welfare effect can go both ways. First an example of a negative welfare effect from trade liberalization. Suppose there are two identical countries with each three firms. They have marginal costs of 1, 1 and 2. The autarky market price will be 2. The iceberg trade costs are equal to 2. This implies that 2 firms can export, but with a market share of 0. Substitution elasticity σ is equal to 1. Equation (42) can be applied to show that a marginal reduction of the tariff decreases welfare with $\frac{1}{2}\frac{Q}{1+Q}$. An example where the welfare effect is positive is the following. Again there are two identical countries with each three firms. Marginal costs are 1, 2 and 3. The autarky market

The ambiguity vanishes for low trade costs.

Proposition 10 *The welfare effect of trade liberalization is unambiguously positive when the tariff is negligible or small, like in Brander and Krugman (1983)*

Proposition 10 follows immediately from equation (42). When the tariff is equal to 1, the first two terms between brackets in equation (42) are equal. So, only negative terms are left and therefore the welfare effect from trade liberalization is positive. Brander and Krugman (1983) only show that the welfare effect is positive when the tariff is negligible. In the present heterogeneous productivity model one can say more on when the welfare effect is positive. Elaborating upon equation (42), the following expression can be derived for the welfare effect of trade liberalization (see appendix B):

$$\begin{aligned} \hat{W} &= -\left[\frac{\sigma p^{\sigma}}{Qp+p^{\sigma}} - \frac{\sigma p^{\sigma}}{p^{\sigma}+Q\tilde{c}}\right]\hat{p} \\ &\quad -\frac{Q}{p^{\sigma}+Q\tilde{c}}\frac{\sigma n}{p^{2}(\sigma n-1)}\sum_{i=1}^{n_x}\tau c_i\left[n\mu_c\left(\mu_c+p-2\tau c_i\right)+(n-1)\,Var\left(c_i\right)\right]\hat{\tau} \end{aligned} \tag{43}$$

In equation (43) μ_c and $Var(c_i)$ are respectively the mean and variance of the marginal costs of domestic and exporting firms,

$$\mu_c = \frac{1}{n}\left[\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x}\tau c_i\right] \tag{44}$$

$$Var\left(c_i\right) = \frac{1}{n-1}\left(\sum_{i=1}^{n_d} c_i^2 + \sum_{i=1}^{n_x}\tau^2 c_i^2 - n\mu_c^2\right). \tag{45}$$

Note that the summation in equation (43) is over all the terms between brackets. It can also be shown that the welfare effect is positive when the following condition is satisfied:

$$\frac{Var\left(c_i\right)}{\mu_c^2} \geq \frac{n}{(\sigma n-1)(n-1)} \tag{46}$$

From equation (43) and (46) the following statements can be made:

price is 3. Iceberg trade costs are 3. So, only one firm can export. Furthermore, the substitution elasticity σ is 1, so utility is Cobb-Douglas. There are two sectors in the economy and the Cournot sector has CES-weight (Cobb-Douglas parameter) α. When the tariff is reduced from the prohibitive level, the welfare effect from equation (42) is equal to $(1-\alpha)\,\frac{5}{9}-\frac{4}{9}$ So, when the Cournot sector is small enough ($\alpha < 1/5$), the welfare effect of trade liberalization is positive.

Proposition 11 *The welfare effect of trade liberalization is positive when the exporting firms are efficient relative to average market costs. In particular, the welfare effect is unambiguously positive when all exporting firms have marginal costs inclusive of trade costs lower than the average of market price and average costs.*

Proposition 1 *The welfare effect of trade liberalization is positive when the coefficient of variation of the cost distribution is larger than the square root of* $\frac{n}{(\sigma n-1)(n-1)}$.

Proposition 11 follows from equation (43). When $\mu_c + p$ is larger than $2\tau c_i$ all terms in equation (43) will be negative and hence the welfare effect of trade liberalization will be positive. Intuitively, when the exporting firms are productive, their gain in market share at the expense of domestic producing firms represents a welfare gain. More productive firms replace less productive firms. But when the exporting firms' marginal costs inclusive of trade costs are larger than the marginal costs of the domestic producing firms, the shift in market share towards exporting firms can represent a loss. In some cases this loss can be larger than the welfare gain due to lower prices and lower trade costs, as shown by the example above.

Proposition 1 follows from (46). It can be interpreted as follows. When the variance of firms' costs is large relative to average firms' costs, the fraction of relatively inefficient exporting firms will be small. So, the welfare loss from an increasing market share of relatively inefficient exporting firms will be smaller than the welfare gain from a decreasing market share of domestic producing inefficient firms. The next section shows that the welfare effect from trade liberalization is unambiguously positive with free entry.

4 International Trade with Free Entry: the Long Run

In the free entry case, the welfare effect of trade liberalization depends entirely on the effect of liberalization on the market price as profit income remains zero. Showing that trade liberalization leads to a lower market price is sufficient to show that liberalization raises welfare. In this section we focus on market conditions with falling trade costs based on the combined ZCP and FE conditions. Trade liberalization does indeed lead to a lower market price and thus to higher welfare.

Firms can make profits from domestic and exporting sales, if they are productive enough to export. Average profit is defined as:

$$\tilde{\pi}_s = \tilde{\pi}_{ds} + \frac{F\left(c^*_{xs}\right)}{F\left(c^*_{ds}\right)}\tilde{\pi}_{xs} \tag{47}$$

$\tilde{\pi}_{ds}$ and $\tilde{\pi}_{xs}$are the expected profits from respectively domestic and exporting sales, conditional upon entry. There are two ZCP for domestic and exporting sales:

$$c^*_{ds} = p_s \tag{48}$$

$$c^*_{xs} = \frac{p_r}{\tau} \tag{49}$$

Elaborating on expected profits as in the closed economy case, generates the following equilibrium equations deriving from the ZCP and FE:

$$\delta f_e = \frac{L_s P_{Us}^{\sigma-1}}{p_s}\int_0^{p_s}\sigma\left(p_s - 2c + \frac{c^2}{p_s}\right)f\left(c\right)dc + \frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_0^{p_r}\sigma\left(p_r - 2c + \frac{c^2}{p_r}\right)f\left(c\right)dc \tag{50}$$

$$\begin{aligned}\frac{\delta f_e}{F\left(c^*_{ds}\right)} = {} & \frac{L_S P_{Us}^{\sigma-1}}{p_s}\sigma\left[p_s - 2Ec_{ds} + \frac{E\left(c_{ds}\right)^2}{p_s}\right] \\ & + \frac{F\left(\frac{p_r}{\tau}\right)}{F\left(p_s\right)}\left(\frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\sigma\left[p_r - 2\tau Ec_{xs} + \tau^2\frac{E\left(c_{xs}\right)^2}{p_r}\right]\right)\end{aligned} \tag{51}$$

To determine the impact of trade costs on the market price, one can totally differentiate the free entry condition in equation (50) towards the cutoff cost level (which equals the market price) and trade costs. Both the impact of sectoral trade liberalization and trade liberalization in all Cournot sectors can be addressed. The effect of sectoral trade liberalization on the market price is larger. Totally differentiating towards p and τ one finds the following expressions for the effect on market price of sectoral and economywide liberalization respectively(derivation in appendix C):

$$
\begin{aligned}
\hat{p} &= \frac{2\int\limits_0^{\frac{p}{\tau}} \tau c\left(1-\frac{\tau c}{p}\right) f(c)\,dc}{A+B}\hat{\tau} = \varepsilon_{p,\tau,sect,FE}\hat{\tau} && (52)\\
\hat{p} &= \frac{2\int\limits_0^{\frac{p}{\tau}} \tau c\left(1-\frac{\tau c}{p}\right) f(c)\,dc}{A+B+C}\hat{\tau} = \varepsilon_{p,\tau,nat,FE}\hat{\tau} && (53)\\
A &= \int\limits_0^{p} \theta_d(c)\left((\sigma+1)c-(\sigma-1)p\right) f(c)\,dc\\
B &= \int\limits_0^{\frac{p}{\tau}} \theta_x(c)\left((\sigma+1)\tau c-(\sigma-1)p\right) f(c)\,dc\\
C &= \frac{Qp^{1-\sigma}}{Qp^{1-\sigma}+1}\left(\bar{\pi}_d+\bar{\pi}_x\right)
\end{aligned}
$$

$\varepsilon_{p,\tau,sect,FE}$ and $\varepsilon_{p,\tau,nat,FE}$ are the elasticities of the market price with respect to trade costs in the free entry case with sectoral and nationwide trade liberalization respectively. By the SOC in equation (7) the denominator in both equations is positive and hence the fraction is positive as well. This gives rise to the following Proposition:

Proposition 12 *Trade liberalization or otherwise falling trade costs τ leads to a lower market price and higher welfare in the free entry case.*

Welfare rises when the market price of q declines as income is fixed with free entry.[10] Hence, welfare rises in this model as a result of trade liberalization. By Proposition 2 a lower market price goes along with more or less firms in the market depending on how much average costs decline when the market price declines. This result can be combined with Proposition 12. The implication is that the lower market price as a result of trade liberalization can go along with more but also with less firms in the market, depending on how many of the least efficient firms are squeezed out of the market. Hence, the conventional insight of the reciprocal dumping model that trade liberalization leads to lower market prices, because there are more firms in the market has to be relaxed. Trade liberalization can also lead to less firms in the market and still decrease market prices, because enough of the least efficient firms are squeezed out of the market.

[10] $U = \frac{L}{P_U}$, $\hat{U} = -\frac{Qp^{1-\sigma}}{1+Qp^{1-\sigma}}\hat{p}$

The various effects of trade liberalization described in the section on 'no free entry' can also be examined in the free entry case. The following effects of trade liberalization are found:

Proposition 13 *The least productive firms get squeezed out of the market with falling trade costs τ in the free entry case.*

Proposition 13 follows from the fact that the cutoff cost level is equal to the market price. A lower market price implies that the highest cost producers have to leave the market. Next, the effect on market shares from domestic and exporting sales is calculated.

Proposition 14 *Market shares from domestic sales decline and market shares from exporting sales rise with declining trade costs τ in the free entry case.*

Log-differentiating the expressions for market shares, defined implicitly in equations (9) and using equation (52) gives:

$$\widehat{\theta}_{id} = \frac{1}{\sigma}\frac{c_i}{p-c_i}\hat{p} = \frac{1}{\sigma}\frac{c_i}{p-c_i}\varepsilon_{p,\tau,FE}\hat{\tau} \tag{54}$$

$$\widehat{\theta}_{ix} = \frac{1}{\sigma}\frac{\tau c_i}{p-\tau c_i}\left(\hat{p}-\widehat{\tau}\right) = -\frac{1}{\sigma}\frac{\tau c_i}{p-\tau c_i}\left(1-\varepsilon_{p,\tau,FE}\right)\hat{\tau} \tag{55}$$

The market share from domestic sales declines for all firms. Therefore, the market share from exporting sales should rise, either because more firms can export or because the market share of firms that already exported should rise. The market share of firms that enter the exporting market is zero. Therefore, the market share of firms already exporting should rise. Applying this line of reasoning, equation (55) implies that the elasticity of the market price with respect to iceberg trade costs in equations (52) and (53) is smaller than 1. This result is useful in the remainder.

Proposition 15 *The elasticity of the market price with respect to trade costs is between 0 and 1.*

Proposition 15 can immediately be used in the following two Propositions.

Proposition 16 *More of the remaining firms are able to export with declining trade cost τ in the free-entry case.*

The exporting cutoff cost level c_x^* is equal to $\frac{p}{\tau}$. Log-differentiating shows that the exporting cutoff cost level declines with trade liberalization, implying that more firms can export:

$$\hat{c}_x^* = \hat{p} - \hat{\tau} = (\varepsilon_{p,\tau,FE} - 1)\,\hat{\tau} \tag{56}$$

Proposition 17 *Markups from domestic sales decline and markups from exporting sales rise for remaining individual firms with declining trade cost τ in the free entry case.*

Markups from domestic sales and exporting sales are equal to $\frac{p}{c}$ and $\frac{p}{\tau c}$, respectively. Log differentiating shows that markups from domestic sales decline and markups from exporting sales rise with trade liberalization:

$$\hat{m}_d = \hat{p} = \varepsilon_{p,\tau,FE}\hat{\tau} \tag{57}$$

$$\hat{m}_x = \hat{p} - \hat{\tau} = (\varepsilon_{p,\tau,FE} - 1)\,\hat{\tau} \tag{58}$$

While we have clear results for individual firms, the impact on the average across firms depends on the underlying structure of cost distributions, much like the closed economy case in Section 2. Basically, market expansion through globalization with falling trade costs τ is analogous to market expansion in the closed economy case. We summarize this point with the following proposition:

Proposition 18 *While deeper integration through falling trade cost τ implies falling prices, the impact on average markups across firms and average firm size (whether they rise or fall on average) depends on the underlying distribution of costs.*

Average markups from domestic and exporting sales weighted by market shares are defined, respectively, as:

$$\bar{m}_d = \int_0^p \frac{p}{c}\sigma\frac{p-c}{p}\mu(c)\,dc = \int_0^p \sigma\frac{p-c}{c}\frac{f(c)}{F(p)}dc \tag{59}$$

$$\bar{m}_x = \int_0^{\frac{p}{\tau}} \frac{p}{\tau c}\sigma\frac{p-\tau c}{p}\mu(c)\,dc = \int_0^{\frac{p}{\tau}} \sigma\frac{p-\tau c}{\tau c}\frac{f(c)}{F\left(\frac{p}{\tau}\right)}dc \tag{60}$$

Log-differentiating these expressions shows that average markups from domestic sales decline and average markups from exporting sales rise:

$$\widehat{\bar{m}}_d = \frac{\sigma}{\tau}\left[\int_0^p \frac{p}{c}\mu(c)\,dc - \frac{f(p)\,p}{F(p)}\int_0^p \frac{p-c}{p}\mu(c)\,dc\right]\varepsilon_{p,\tau,FE} \tag{61}$$

$$\widehat{\bar{m}}_x = \frac{\sigma}{\tau}\left[\int_0^{\frac{p}{\tau}} \frac{p}{\tau c}\mu(c)\,dc - \frac{f\left(\frac{p}{\tau}\right)\frac{p}{\tau}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}} \frac{p-\tau c}{p}\mu(c)\,dc\right](\varepsilon_{p,\tau,FE}-1) \tag{62}$$

The terms in $\frac{f(p)p}{F(p)}$ represent the increased probability weight of all firms in the market, when the cutoff point declines as a result of trade liberalization. Basically, as in the closed or integrated economy case, the effect of trade liberalization (which is somewhat analogous to market expansion) on average domestic and exporting markups is ambiguous and depends on the cost distribution of productivities. As in the closed economy case, larger or more integrated markets imply lower prices, but these lower prices may involve lower or higher average markups. It depends on the structure of cost heterogeneity.

Similarly, as in the case of the closed or integrated economy, we find a similar result for average firm size (and hence for concentration as well). Average firm size from domestic sales and exporting sales is defined, respectively, as:

$$\begin{aligned}\bar{r}_d &= \int_0^p pq_d(c)\,\mu(c)\,dc = \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\int_0^p \theta_d(c)\,\mu(c)\,dc \\ &= \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\int_0^p \sigma\frac{p-c}{p}\mu(c)\,dc = P_U^{\sigma-1}L\sigma\int_0^p\left(\frac{1}{p^{\sigma-1}}-\frac{c}{p^\sigma}\right)\mu(c)\,dc \end{aligned}\tag{63}$$

$$\begin{aligned}\bar{r}_x &= \int_0^{\frac{p}{\tau}} pq_x(c)\,\mu(c)\,dc = \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\int_0^{\frac{p}{\tau}} \theta_x(c)\,\mu(c)\,dc \\ &= \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\int_0^{\frac{p}{\tau}} \sigma\frac{p-\tau c}{p}\mu(c)\,dc = P_U^{\sigma-1}L\sigma\int_0^{\frac{p}{\tau}}\left(\frac{1}{p^{\sigma-1}}-\frac{\tau c}{p^\sigma}\right)\mu(c)\,dc \end{aligned}\tag{64}$$

Differentiating these expressions towards trade costs generates:

$$\frac{\partial\bar{r}_d}{\partial\tau} = \tau\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\left[\sigma\int_0^p(1-\theta_d(c))\,\mu(c)\,dc - \frac{f(p)\,p}{F(p)}\int_0^p\sigma\frac{p-c}{p}\mu(c)\,dc\right]\varepsilon_{p,\tau,FE} \tag{65}$$

$$\frac{\partial \bar{r}_x}{\partial \tau} = -\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{1}{\tau}\left[\int_0^{\frac{p}{\tau}}\left[\left(1-\theta_x(c)\right)\left(1-\varepsilon_{p,\tau}\right)+\frac{\sigma-1}{\sigma}\theta_x(c)\right]\mu(c)\,dc\right]$$
$$+\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{f\left(\frac{p}{\tau}\right)\frac{p}{\tau^2}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}}\sigma\frac{p-\tau c}{p^{\sigma}}\mu(c)\,dc\left[1-\varepsilon_{p,\tau,FE}\right] \tag{66}$$

So, like with average markups, the effect on average domestic and exporting firm sales depends on the distribution of costs.

5 Asymmetric Countries

So far we have focused on strict symmetry across countries in terms of technology sets and size. In this section the symmetry assumptions are relaxed. Three sets of results are derived. First, we show that unilateral liberalization can lead to higher prices in the liberalizing country in the long run. Second, the impact of country size and distance on the probability of zero trade and on exporting unit values is derived. Third, we present the Ricardian model with productivity differences as a nested model of the present framework.

The setup in this section is as follows. There are two countries $s, r = H, F$. The countries display differences in country size, in trade costs and in their technology sets (cost distributions). Productivity differences are modeled by a different lower frontier for the marginal cost distribution, $\underline{c}_s \neq \underline{c}_r$. The combined FE/ZCP conditions in both countries become:

$$\delta f_e = \frac{L_s P_{Us}^{\sigma-1}}{p_s^{\sigma}}\int_{\underline{c}_s}^{p_s}\sigma\left(p_s-2c+\frac{c^2}{p_s}\right)f_s(c)\,dc$$
$$+\frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_{\underline{c}_s}^{\frac{p_r}{\tau_{sr}}}\sigma\left(p_r-2\tau_{sr}c+\frac{\tau_{sr}^2 c^2}{p_r}\right)f_s(c)\,dc \tag{67}$$

$$\delta f_e = \frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_{\underline{c}_r}^{p_r}\sigma\left(p_r-2c+\frac{c^2}{p_r}\right)f_r(c)\,dc$$
$$+\frac{L_s P_{Us}^{\sigma-1}}{p_s^{\sigma}}\int_{\underline{c}_r}^{\frac{p_s}{\tau_{rs}}}\sigma\left(p_r-2\tau_{rs}c+\frac{\tau_{rs}^2 c^2}{p_s}\right)f_r(c)\,dc \tag{68}$$

5.1 asymmetries in trade costs

Unilateral liberalization can be studied using the above two equations. Assuming that the two countries are equal in all respects except their trade costs, one can log-linearize the above system of equations towards market prices p_s, p_r and trade costs τ_{sr}, τ_{rs}. Appendix D shows that this leads to the following result:

$$\hat{p}_r = \frac{2}{\sigma} \frac{\left(\frac{q_s}{q_r} dc_{ds} dc_{x\tau r} \hat{\tau}_{rs} - dc_{xr} dc_{x\tau s} \hat{\tau}_{sr}\right)}{dc_{ds} dc_{dr} - dc_{xs} dc_{xr}} \tag{69}$$

$$\hat{p}_s = \frac{2}{\sigma} \frac{\left(\frac{q_r}{q_s} dc_{ds} dc_{x\tau s} \hat{\tau}_{sr} - dc_{xs} dc_{x\tau r} \hat{\tau}_{rs}\right)}{dc_{ds} dc_{dr} - dc_{xs} dc_{xr}} \tag{70}$$

dc_{ds}, dc_{dr}, dc_{xs}, dc_{xr}, $dc_{x\tau s}$ and $dc_{x\tau r}$ are respectively the marginal effects on expected profit from domestic and exporting price changes and from trade liberalization in country s and r, defined as follows:

$$dc_{ds} = \int_0^{p_s} \theta_{ds} \left((\sigma+1) c - (\sigma-1) p_s \right) f(c)\, dc \tag{71}$$

$$dc_{xs} = \int_0^{\frac{p_s}{\tau_{sr}}} \theta_{xs} \left((\sigma+1) c - (\sigma-1) p_r \right) f(c)\, dc \tag{72}$$

$$dc_{x\tau s} = \int_0^{\frac{p_r}{\tau_{sr}}} \theta_{xs}(c)\, \tau_{sr} c f(c)\, dc \tag{73}$$

The variables in r are defined accordingly. The marginal effects from domestic price changes on expected profit dc_{ds} and dc_{dr} are larger than the marginal effects from exporting prices on expected profit dc_{xs} and dc_{xr}, because the domestic market shares θ_d are larger than the exporting market shares θ_x and the integration frontier is larger for the domestic cost variables than for the exporting cost variables.

Equation (26) shows that in the short run unilateral liberalization leads to a lower market price in the importing country. Equations (69) and (70) show that unilateral liberalization in country s , i.e. a negative τ_{rs}, decreases the market price in the exporting country s and increases the market price in the importing country r in the long run. This gives rise to the following Proposition:

Proposition 19 *Unilateral liberalization causes a decreasing market price in the liberalizing (importing) country in the short run. In the long run, however, the market price in the importing country increases and the market price in the exporting country decreases. Hence, the welfare effect of unilateral liberalization is negative in the importing country and positive in the exporting country.*

The short-run effect of unilateral liberalization is as one would expect. The long-run impact is due to industrial delocation effects.[11] Due to unilateral liberalization in country s, expected profit rises in country r. Therefore, there will be more entry in country r. At the same time, the decreasing market price in country s reduces entry in that country. The effect of this entry and exit is that the market price in the exporting country s declines and the market price in the importing country r rises.[12]

5.2 asymmetric size, distance, and zero trade flows

We next focus on the impact of distance and importer country size on the probability of zero trade and on export prices. We concentrate on country r as the importer country. First consider the effect of a change in distance. We take as proxy a change in trade costs. Equations (69) and (70) show the effect of lower trade costs on market prices. Equalizing the change in trade costs, i.e. $\hat{\tau}_{rs} = \hat{\tau}_{sr} = \hat{\tau}$, one finds:

$$\hat{p}_r = \frac{2}{\sigma} \frac{\frac{q_s}{q_r} dc_{ds} dc_{x\tau r} - dc_{xr} dc_{x\tau s}}{dc_{ds} dc_{dr} - dc_{xs} dc_{xr}} \hat{\tau} = \varepsilon_{p_r\, \tau, UC} \hat{\tau} \tag{74}$$

$$\hat{p}_s = \frac{2}{\sigma} \frac{\frac{q_r}{q_s} dc_{dr} dc_{x\tau s} - dc_{xs} dc_{x\tau r}}{dc_{ds} dc_{dr} - dc_{xs} dc_{xr}} \hat{\tau} = \varepsilon_{p_s\, \tau, UC} \hat{\tau} \tag{75}$$

Unless country sizes differ a lot leading to strong delocation effects, market prices decline with lower trade costs in the importing country r. Using the same reasoning as in the equal country case, one can prove that the elasticity of price wrt trade costs, $\varepsilon_{p_r\, \tau, UC}$, has to be

[11] With a different model, but also characterized by cost heterogeneity, Melitz and Ottaviano (2008) obtain a similar result.

[12] Mathematically, the reason for the declining market price in the exporting country s and the rising market price in the importing country r is the following: the marginal effect on expected profit of a changing domestic price, as represented by c_{dr} and c_{ds}, is larger than the effect on expected profit of a changing price in the export market, represented by c_{xr} and c_{xs}. Therefore, when the expected profit from exports in country s rise due to unilateral liberalization in country r, the FE can be restored by decreasing prices in the export market r and/or in the domestic market s. The prices in the two markets should go in opposite directions, however, because the FE in foreign should also be satisfied. Because the marginal effect of domestic price changes is larger, the domestic price (in s) has to decrease and the exporting price (in r) has to rise. With decreasing export prices (in r) and rising domestic prices (in s), the FE's could never be satisfied.

between 0 and 1. Market shares of domestic producers in country r and exporters from country s can be log differentiated to get:

$$\widehat{\theta}_{idr} = \frac{1}{\sigma}\frac{c_{ir}}{p_r - c_{ir}}\hat{p}_r = \frac{1}{\sigma}\frac{c_{i_r}}{p_r - c_{ir}}\varepsilon_{p_r\,\tau,UC}\hat{\tau} \tag{76}$$

$$\widehat{\theta}_{ixs} = \frac{1}{\sigma}\frac{\tau c_{is}}{p_r - \tau c_{is}}\left(\hat{p}_r - \widehat{\tau}\right) = -\frac{1}{\sigma}\frac{\tau c_{is}}{p_r - \tau c_{is}}\left(1 - \varepsilon_{p_r\,\tau,UC}\right)\hat{\tau} \tag{77}$$

When distance becomes smaller, the market price in country r, p_r, declines (if there are no strong delocation effects). As a result the domestic market shares in the importing country, θ_{idr} decline. Hence, the θ_{ixs} have to rise to get a total market share of 1 and therefore $0 < \varepsilon_{p_r\,\tau,UC} < 1$. This implies that p_r/τ will decline, as the denominator τ declines at a larger rate than the numerator p_r. p_r/τ is both the export price and the cutoff cost value for exports from country s to country r. When the cutoff cost value of exports declines, the probability of zero trade rises. It becomes more likely that no firm is able to export profitably. Therefore, we have the following result:

Proposition 20 *A lower distance between trading partners leads to both a lower probability of zero trade flows and a lower fob export price.*

Consider next the effect of importing country size on the probability of zero trade flows and export price. The combined FE/ZCP equations, (68) and (67), are log differentiated wrt p_r, p_s and L_r, leading to[13]:

$$\hat{p}_r = -\frac{d_{cds}\bar{\pi}_{dr} - d_{crx}\bar{\pi}_{sx}}{\left(d_{cdr}d_{cds} - d_{crx}d_{csx}\right)q_r}\hat{L}_r \tag{78}$$

$$\hat{p}_s = -\frac{d_{csx}\bar{\pi}_{dr} - d_{cdr}\bar{\pi}_{sx}}{\left(d_{cdr}d_{cds} - d_{crx}d_{csx}\right)q_s}\hat{L}_r \tag{79}$$

d_{cdr}, d_{cxr}, d_{cds} and d_{cxs} are respectively the marginal effects on expected profit from domestic and exporting price changes in country r and country s, as defined in equations (71) and (72) for country s. As the effect of domestic price changes on expected profit are larger, because market shares in the domestic market are larger, the denominator in both equations (78) and (79) is positive. When productivity differences between the two countries are not too large, expected profits from domestic sales of producers in country r, $\bar{\pi}_{dr}$ are larger than

[13]Derivation available upon request. The derivation is similar to the log differentiation wrt p_r, p_s and τ discussed in appendix D.

expected profits from exporting sales of exporters from country s, $\bar{\pi}_{sx}$. This implies that the numerator is also positive. Hence, the market price in country r decreases in its market size. The fob price of exporters from country s, p_r/τ, also decreases. Therefore, we have the following result:

Proposition 21 *A larger market size of the importing country leads to a higher probability of zero trade flows and lower fob export prices.*

Baldwin and Harrigan (2007) compare different models of international trade on their predictions of the effect of distance and importing country size on the probability of zero trade flows and fob prices. From table 1 in their paper it is clear that the Cournot model in this paper generates the same predictions as the Melitz and Ottaviano (2008) model in this regard. The predictions are different from the model proposed by Baldwin and Harrigan (2007), which seems to align with the empirical findings presented in their paper. However, whereas the model of Baldwin and Harrigan (2007) contains product differentiation and quality differences, the oligopoly model in this paper describes a setting with homogeneous products. Therefore, the predictions from this model should be tested with data from homogeneous goods sectors and not with a dataset of all sectors as Baldwin and Harrigan (2007) do. Intuitively, the different predictions can be clearly explained from the different modeling setups. Baldwin and Harrigan (2007) adapt the Melitz firm heterogeneity model to allow for quality differences. More productive firms charge higher instead of lower prices, because they sell higher quality products involving also higher marginal costs. The probability of zero trade flows rises with distance in our model and in Baldwin and Harrigan (2007). A larger distance makes it in both models more likely that trade costs are too high and that no firm is productive enough to sell profitably in the export market. The probability of zero trade flows rises in importing country size in our model and declines in importing country size in Baldwin and Harrigan (2007). The intuition in our model is that a larger market leads to tougher competition, more entry of firms and lower prices. Henceforth, it becomes harder to export to that market. The model of Baldwin and Harrigan (2007) features fixed export costs. In a larger market it is easier to earn these fixed costs back and therefore also the less productive firms with lower quality and lower price can sell in the market profitably.[14]

[14] A larger market also implies a lower price index and therefore less sales for an individual firm, making it more difficult to sell profitably in the export market. Apparently the direct effect of market size dominates.

A larger distance leads to higher fob export prices in Baldwin and Harrigan (2007) and lower export prices in our model. In both models a larger distance makes it harder to export and therefore only more productive firms can export. In our model with homogeneous goods more productive firms charge lower prices, whereas in Baldwin and Harrigan (2007) they charge higher prices, because the quality of the good is larger. Finally, the export price declines in both models in the importing country size. The reason is different, however. In our model prices are lower in a larger market due to intenser competition and for given trade costs this leads to lower export prices as well. In Baldwin and Harrigan (2007) it is easier to earn back the fixed export costs in a larger market. Therefore, also lower quality, lower price exporters can sell profitably and the average export price will be lower. It could be an interesting exercise to see if the predictions of Baldwin and Harrigan (2007) on the probability of trade zeros and export zeros carry through in a sample of sectors with homogeneous goods or if our model of oligopoly predicts better.

5.3 technology asymmetries

With technological asymmetries, the Ricardian comparative advantage can be treated as a nested case of the present model. Comparative advantage is introduced in this case as follows. There are two types of sectors, country s has a comparative advantage in the A sectors and country r has a comparative advantage in the B sectors. Comparative advantage is modeled by the integration frontiers of the initial distribution of productivities. As only the lower integration frontiers $\underline{c}$ appears in the relevant ZCP and FE equations, attention can be restricted to these. The following assumptions are made to define comparative advantage:

$$\underline{c}_{sA} < \underline{c}_{rA} \tag{80}$$

$$\underline{c}_{sB} > \underline{c}_{rB} \tag{81}$$

$\underline{c}_{sA}$ is the lower integration frontier in country s in the A sectors, i.e. in the sectors in which country s has a comparative advantage. To show that Ricardian comparative advantage is a nested case of the model, the distribution of productivities within a country is squeezed, i.e. the heterogeneity of firms is reduced. The productivity differences between countries

An effect of market size on profit margins is absent in the model of Baldwin and Harrigan (2007) , because they work with CES and thus fixed markups.

remain. When the within country distribution of productivities collapses to a single point, the model converges either to a Ricardian model with perfect competition or a Brander and Krugman (1983) Cournot model with specialization, depending on whether the sunk entry costs disappear or not.

Before the distribution of productivities is narrowed, the following relations between the lower integration frontiers, market prices and trade costs apply:

$$\underline{c}_{sA} < \underline{c}_{rA} < p_{rA}/\tau < p_{rA} \tag{82}$$

$$\underline{c}_{sA} < \underline{c}_{rA} < p_{sA}/\tau < p_{sA} \tag{83}$$

The focus in the discussion is on sector A, because sector B is just its mirror image with a comparative advantage for country r. Equation (82) ensures that at least some firms in country s can export in their comparative advantage sector A and that at least some firms in country r can produce for the domestic market. Equation (83) guarantees that some firms in country r can also export in their comparative disadvantage market A and that firms in country s can sell in their domestic market in their comparative advantage sector A. Hence, there is two-way trade in sector A.

Next, suppose that the distribution of productivities becomes more homogenous. This can be seen as a narrowing of the distribution of productivities. The lower integration frontier moves up and the upper integration frontier moves down. However, only the lower integration frontier appears in the combined ZCP/FE condition, so mathematically a more homogenous productivity distribution comes down to an increase in the lowest cost.

Uncertainty about productivity is a barrier to entry for firms. The sunk entry costs are dependent on uncertainty about the prospective productivity. Firms have to incur research costs to get rid of the uncertainty about their productivity. This interpretation of the sunk entry costs implies that a squeezing of the productivity distribution decreases the sunk entry costs. The combined ZCP/FEs in a S sector are given in equations (67) and (68) (with symmetric trade costs). Log differentiating these expressions towards market prices, the lower integration frontiers and the sunk entry costs shows what happens when the distributions of productivities become more homogenous:

$$q_s \int_{\underline{c}_s}^{p_s} \theta_{ds} \left((\sigma+1) c - (\sigma-1) p_s \right) f_s dc \hat{p}_s + q_r \int_{\underline{c}_s}^{\frac{p_r}{\tau}} \theta_{xs} \left((\sigma+1) \tau c - (\sigma-1) p_r \right) f_s dc \hat{p}_r$$

$$-\sigma q_s \underline{c}_s \left(p_s - 2\underline{c}_s + \frac{\underline{c}_s^2}{p_s} \right) f\left(\underline{c}_s\right) \hat{c}_s + q_r \underline{c}_s \left(p_r - 2\tau \underline{c}_s + \frac{\tau^2 \underline{c}_s^2}{p_r} \right) f\left(\underline{c}_s\right) \hat{c}_s = \delta f_e \hat{f}_e \qquad (84)$$

$$q_r \int_{\underline{c}_r}^{p_r} \theta_{dr} \left((\sigma+1) c - (\sigma-1) p_r \right) f_r dc \hat{p}_r + q_s \int_{\underline{c}_r}^{\frac{p_r}{\tau}} \theta_{xr} \left((\sigma+1) \tau c - (\sigma-1) p_s \right) f_r dc \hat{p}_s$$

$$-\sigma q_r \underline{c}_r \left(p_r - 2\underline{c}_r + \frac{\underline{c}_r^2}{p_r} \right) f\left(\underline{c}_r\right) \hat{c}_r + q_s \underline{c}_r \left(p_s - 2\tau \underline{c}_r + \frac{\tau^2 \underline{c}_r^2}{p_s} \right) f\left(\underline{c}_r\right) \hat{c}_r = \delta f_e \hat{f}_e \qquad (85)$$

The effect of squeezing the distribution of productivities on market prices depends on the size of the change in the sunk entry cost f_e. When this change is small, the market prices will have to rise to keep on satisfying the free entry condition.

Suppose that the distribution of productivities becomes concentrated in one point. Then two questions remain. First, does the model converge to a Ricardian comparative advantage model with perfect competition or a Brander and Krugman Cournot model? Second, will there be full specialization across countries? To address the first question, where the model converges to depends on what happens with sunk entry costs. When some sunk entry costs remain, because uncertainty about productivity is not the only source of the sunk costs, the model remains Cournot. The market price becomes higher than marginal costs to cover the sunk entry costs and the number of firms is limited. When uncertainty is the only source of sunk costs and so when there are no sunk costs left when the distribution of productivities collapses to a single point, the model converges to a perfect competition Ricardian model. Marginal cost will be equal to the market price and the number of firms becomes infinite as is clear from equation (13).[15]

Proposition 22 *When the distribution of productivities becomes concentrated in one point the model either converges to a Brander & Krugman Cournot model or a Ricardian perfect competition model depending on the presence of sunk (or fixed) costs. Two-way trade emerges either from cost heterogeneity or the presence of sunk (or fixed) entry costs.*

[15] It should be noted that there are no wage differences in the present model. Modeling wage differences, possibly along the line of the Dornbusch-Fischer-Samuelson model of Ricardian trade with a continuum of goods and technology asymmetries, constitutes a possible extension of the present model

Whether there will be full specialization depends on the relation between market prices and marginal cost levels that emerges. There will be full specialization when:

$$\underline{c}_{rA} < p_{sA}/\tau < \underline{c}_{sA} \tag{86}$$

$$c_{rA} < p_{rA} < \tau \underline{c}_{sA} \tag{87}$$

The model converges either to a Cournot model or a Ricardian perfect competition model depending on the presence of sunk costs. There is no strict link between the appearance of full specialization and the type of market competition that emerges. There can be full specialization with Cournot competition when productivity differences are large enough. Also, the Ricardian model does not imply full specialization. A country could still produce for its own market in the Ricardian model in its comparative disadvantage sector when trade costs are large enough. But two way trade is only possible with Cournot competition. Moreover, full specialization is more likely in the Ricardian model without fixed costs, because market prices become equal to marginal costs (inclusive of trade costs) in that case.

Proposition 23 *When the distribution of productivities collapses to a single point, full specialization is more likely with lower trade costs, a larger cost difference between countries and the absence of sunk costs.*

6 Summary and Conclusions

We have developed a model of trade with endogeneity in key features of market structure linked to heterogeneous cost structures under Cournot competition. This approach leads to a set of results familiar from the recent Bertrand and Chamberlinian monopolistic competition literature with cost heterogeneity. Market prices decline, the least productive firms get squeezed out of the market and exporting firms gain market share when trade costs fall. These results hold in cases with and without free entry. Welfare rises in both cases with trade liberalization, unless the trade barriers decline from a prohibitive level in the short run. With asymmetric countries, the Brander & Krugman's (1983) reciprocal dumping model and the Ricardian comparative advantage model can be nested as special cases. Furthermore, delocation effects are present in the asymmetric trade cost case: unilateral liberalization leads in the long run to higher prices in the liberalizing country, because firms delocate to the other country. Possible extensions of the model are the introduction of wage differences between the two countries, political economy applications (as domestic industry concentration is endogenous to the evolution of trade policy), and specifying a distribution of costs enabling simulations with the model with more countries and more sectors.

The model provides insight into zero trade flows and the pattern of export prices. The probability of zero trade flows rises with distance and with the size of the importer country, while fob export prices decrease with distance and with the size of the importer country. The model also offers insight into cross-country differences in markups, concentration, and prices across industries controlling for different degrees of openness. In particular, the variation across industries and countries in markups, concentration, and pricing structures is also a function of country or market size and the variation in cost heterogeneity across industries.

References

BALDWIN, RICHARD AND JAMES HARRIGAN (2007). "Zeros, Quality and Space: Trade Theory and Trade Evidence." NBER Working Paper No. 13214

BALDWIN, RICHARD AND FRÉDÉRIC ROBERT-NICOUD(2008). "Trade and Growth with Heterogeneous Firms." *Journal of International Economics* 74(1): 21-34.

BALDWIN, RICHARD AND DARIA TAGLIONI (2007). "Gravity for Dummies and Dummies for Gravity Equations." CEPR Discussion Paper No. 5850.

BERNARD, ANDREW B., JONATHAN EATON, J. BRADFORD JENSEN, AND SAMUEL KORTUM (2003). "Plants and Productivity in International Trade." *American Economic Review* 93(4): 1268-1290.

BERNARD, ANDREW B. AND J. BRADFORD JENSEN (2004). "Exporting and Productivity in the USA." *Oxford Review of Economic Policy* 20(3).

BRANDER, JAMES AND PAUL KRUGMAN (1983). "A 'Reciprocal Dumping' Model of International Trade." *Journal of International Economics* 15: 313-321.

GHIRONI, F. AND MARC J. MELITZ(2007). "International Trade and Macroeconomic Dynamics with Heterogeneous Firms." *American Economic Review* 97(2): 356-361.

MELITZ, MARC J. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71(6): 1695-1725.

MELITZ, MARC J. AND GIANMARCO I.P. OTTAVIANO (2008), "Market Size, Trade, and Productivity," *Review of Economic Studies* 75(1): 295-316.

TYBOUT, JAMES R. (2001). "Plant and Firm-Level Evidence on New Trade Theories." in: Harrigan J. (ed.), *Handbook of International Economics* 38, Basil-Blackwell. Also: NBER Working Paper No. 8414.

VAN LONG, NGO AND ANTOINE SOUBEYRAN (1997), "Cost Heterogeneity, Industry Concentration and Strategic Trade Policies." *Journal of International Economics* 43: 207-220.

Appendix A Basic Model

The appendices show how to derive equations from the main text.

Equation 7: SOC

Differentiating the FOC in equation 6 with respect to firm sales q_i leads to:

$$\frac{\partial^2 \pi_i}{\partial q_i^2} = -\frac{2p}{\sigma q} + \frac{(\sigma+1)\,p}{\sigma^2 q}\theta_i \tag{A.1}$$

Substituting the first order condition, $\theta_i = \sigma \frac{p-c_i}{p}$ into (A.1), generates equation (7) in the main text:

$$\begin{aligned}
\frac{\partial^2 \pi_i}{\partial q_i^2} &= -\frac{1}{\sigma}\frac{p}{q}\left[2 - \frac{\sigma+1}{\sigma}\theta_i\right] = -\frac{1}{\sigma}\frac{p}{q}\left[2 - \frac{\sigma+1}{\sigma}\sigma\frac{p-c_i}{p}\right] \\
&= -\frac{1}{\sigma}\frac{p}{q}\frac{2p - (\sigma+1)\,p + (\sigma+1)\,c_i}{p} = -\frac{1}{\sigma}\frac{p}{q}\frac{(\sigma+1)\,c_i - (\sigma-1)\,p}{p}
\end{aligned}$$

Combined FEZCP leads to stable equilibrium

Average profit unconditional upon entry in equation (21) can be differentiated with respect to the market price:

$$\begin{aligned}
\frac{\partial \bar{\pi}}{\partial p} &= \sigma L P_u^{\sigma-1} \int_0^p \left(\frac{-(\sigma-1)}{p^\sigma} + \sigma\frac{2c}{p^{\sigma+1}} - (\sigma+1)\frac{c^2}{p^{\sigma+2}}\right) f(c)\,dc \\
&= \frac{\sigma L P_u^{\sigma-1}}{p^\sigma} \int_0^p \left(-(\sigma-1) + \sigma\frac{2c}{p} - (\sigma+1)\frac{c^2}{p^2}\right) f(c)\,dc \\
&= \frac{\sigma L P_u^{\sigma-1}}{p^\sigma} \int_0^p \left(1 - \frac{c}{p}\right)\left(\frac{(\sigma+1)\,c - (\sigma-1)\,p}{p}\right) f(c)\,dc > 0
\end{aligned} \tag{A.2}$$

The integrand in (A.2) is positive by the SOC in equation (7), hence average profit unconditional upon entry rises in the market price. This reflects two opposite forces: firstly, a decline in the market price leads to larger market sales in the entire industry and thus a larger profit conditional upon entry. Secondly, a decline in market price decreases the average profit margin (weighted by the market share θ and by the probability μ). This is due to a decline in the profit margin $p - c$ and to the declining market share. The second effect dominates the first effect. Hence, the model generates a stable equilibrium market price.

Appendix B The Limited Entry Case

Equation 26: Direct and indirect effect of trade liberalization in short-run free exit case

The market price is defined in equation (25)

$$p_s = \frac{\sigma}{\sigma\left(n_{ds} + n_{xr}\right) - 1}\left(\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr}\right) \tag{B.1}$$

Totally differentiating equation (B.1) with respect to p and τ, one finds:

$$\begin{aligned} dp_s \quad = \quad & \sum_{i=1}^{n_{xr}} c_{ixr} d\tau + \frac{\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr} + \sum_{j=1}^{\Delta \exp} \tau c_{jxr} - \sum_{j=1}^{\Delta dom} c_{jdr}}{n_s - 1 + \Delta \exp - \Delta dom} \\ & - \frac{\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr}}{n_s - 1} \end{aligned} \tag{B.2}$$

$\Delta \exp$ is the number of exporting firms that are entering the market because of the change in tariffs and Δdom is the number of domestic producing firms that have to leave the market. These firms that are entering the export market and leaving the domestic market all have marginal costs (inclusive of trade costs for the exporters) equal to the market price.

Therefore, equation (B.2) can be written as:

$$
\begin{aligned}
dp_s &= \sum_{i=1}^{n_{xt}} c_{ixr} d\tau + \frac{\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr} + (\Delta \exp - \Delta dom)\, p}{n_s - 1 + \Delta \exp - \Delta dom} - \frac{\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr}}{n_s - 1} \\
&= \sum_{i=1}^{n_{xr}} c_{ixr} d\tau \\
&\quad + \frac{\left(\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr} + (\Delta \exp - \Delta dom)\, p\right)(n_{s-1})}{(n_s - 1 + \Delta \exp - \Delta dom)(n_s - 1)} \\
&\quad - \frac{\left(\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr}\right)(n_s - 1 + \Delta \exp - \Delta dom)}{(n_s - 1 + \Delta \exp - \Delta dom)(n_s - 1)} \\
&= \sum_{i=1}^{n_{xr}} c_{ixr} d\tau \\
&\quad + \frac{(\Delta \exp - \Delta dom)\, p\,(n_{s-1}) - \left(\sum_{i=1}^{n_{ds}} c_{ids} + \sum_{i=1}^{n_{xr}} \tau c_{ixr}\right)(\Delta \exp - \Delta dom)}{(n_s - 1 + \Delta \exp - \Delta dom)(n_K - 1)} \\
&= \sum_{i=1}^{n_{xr}} c_{ixr} d\tau
\end{aligned}
$$

So, the effect through a change in the number of firms is zero. The direct effect remains which is positive. Using relative changes, one arrives at equation (26) in the main text.

Equation 39: Welfare in free exit case

Welfare is defined in equation (38) of the main text as:

$$U_s = \frac{I_s}{P_{Us}} = \frac{L + \Pi_s}{P_{Us}} \tag{B.3}$$

Labor income is fixed. All Cournot-sectors are equal. Therefore total profit Π is equal to:

$$\Pi_s = Q\pi_s = Q\left(p_s q_{ds} + p_M q_{xs} - \sum c_{is} q_{ids} - \sum \tau c_{is} q_{ixs}\right) \tag{B.4}$$

π_s is profit income in one Cournot-sector. To proceed one needs to assume that the two countries are equal. This implies that (B.4) can be rewritten as:

$$\begin{aligned}
\frac{\Pi}{Q} &= p\left(q_d+q_x\right)-\sum_{i=1}^{n_d} c_i q_{id}-\sum_{i=1}^{n_x} c_i \tau q_{ix} \\
\frac{\Pi}{Q} &= pq-q\sum_{i=1}^{n_d} c_i \theta_{id}-q\sum_{i=1}^{n_x} c_i \tau \theta_{ix} \\
\frac{\Pi}{Q} &= \frac{IP_U^{\sigma-1}}{p^{\sigma-1}}\left(\frac{p-\sum_{i=1}^{n_d} c_i \theta_{id}+\sum_{i=1}^{n_x} c_i \tau \theta_{ix}}{p}\right) && \text{(B.5)}\\
\frac{\Pi}{Q} &= (L+\Pi)\frac{P_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right) && \text{(B.6)}
\end{aligned}$$

The term $\sum_{i=1}^{n_d} c_i\theta_{id}+\sum_{i=1}^{n_x} c_i\tau\theta_{ix}$ in (B.5) represents the market share weighted average of costs, $\tilde{c}$. Therefore, $\left(p-\sum_{i=1}^{n_d} c_i\theta_{id}-\sum_{i=1}^{n_x} c_i\tau\theta_{ix}\right)$ is defined as the market share weighted average profit per unit of sales, $\tilde{\pi}$. Solving for $L+\Pi$ from (B.6) yields:

$$\begin{aligned}
\frac{\Pi}{Q}-\Pi\frac{P_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right) &= L\frac{P_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right) \\
\Pi\left(1-\frac{QP_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right)\right) &= QL\frac{P_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right) \\
\Pi &= \frac{QL\frac{P_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right)}{1-\frac{QP_U^{\sigma-1}}{p^{\sigma}}\left(p-\tilde{c}\right)} \\
L+\Pi &= \frac{L}{1-\frac{QP_U^{\sigma-1}(p-\tilde{c})}{p^{\sigma}}} && \text{(B.7)}
\end{aligned}$$

Substituting equation (B.7) into equation (B.3), one finds the following expression for welfare, equation (39) in the main text:

$$\begin{aligned}
W &= \frac{L}{1-\frac{QP_U^{\sigma-1}(p-\tilde{c})}{p^{\sigma}}}\frac{1}{P_U}=\frac{L}{1-\frac{Q(p-\tilde{c})}{(Qp^{1-\sigma}+1)p^{\sigma}}}\frac{1}{P_U}=\frac{L}{1-\frac{Q(p-\tilde{c})}{Qp+p^{\sigma}}}\frac{1}{P_U} \\
W &= \frac{L\left(Qp+p^{\sigma}\right)}{p^{\sigma}+Q\tilde{c}}\frac{1}{P_U} && \text{(B.8)}
\end{aligned}$$

Equation 40: Relative Welfare Change in free exit case

Log-differentiating equation (B.8) with respect to trade costs τ, treating the market price p, the price index P_U and average costs $\tilde{c}$ as endogenous generates equation (40) in the main text:

$$\begin{aligned}
\hat{W} &= \frac{Qp+\sigma p^{\sigma}}{Qp+p^{\sigma}}\hat{p}-\frac{\sigma p^{\sigma}\hat{p}+Qd\tilde{c}}{p^{\sigma}+Q\tilde{c}}-\hat{P}_U \\
&= \left(\frac{Qp+\sigma p^{\sigma}}{Qp+p^{\sigma}}-\frac{\sigma p^{\sigma}}{p^{\sigma}+Q\tilde{c}}\right)\hat{p}-\frac{Q}{p^{\sigma}+Q\tilde{c}}d\tilde{c}-\frac{Qp^{1-\sigma}}{Qp^{1-\sigma}+1}\hat{p} \\
\hat{W} &= \left(\frac{\sigma p^{\sigma}}{p^{\sigma}+Qp}-\frac{\sigma p^{\sigma}}{p^{\sigma}+Q\tilde{c}}\right)\hat{p}-\frac{Q}{p^{\sigma}+Q\tilde{c}}d\tilde{c} \qquad \text{(B.9)}
\end{aligned}$$

Equation 43 and 46: Conditions for positive welfare effect of trade liberalization

Starting from equation (B.9), one can elaborate on the term $d\tilde{c}$. Using equations (9), (36), (37), $d\tilde{c}$ can be rewritten as follows:

$$d\tilde{c}=\sum_{i=1}^{n_d}c_i\frac{p-c_i}{p}\frac{c_i}{p-c_i}\varepsilon_{p,\tau}\hat{\tau}+\sum_{i=1}^{n_x}\tau c_i\frac{p-\tau c_i}{p}\frac{\tau c_i}{p-\tau c_i}\left(\varepsilon_{p,\tau}-1\right)\hat{\tau}+\sum_{i=1}^{n_x}\tau c_i\frac{p-\tau c_i}{p}\hat{\tau} \qquad \text{(B.10)}$$

Using equation (27) one can substitute for the price elasticity in equation (B.10) to get:

$$\begin{aligned}
d\tilde{c} &= \sum_{i=1}^{n_d}\sigma\frac{c_i^2}{p}\frac{\sum\limits_{i=1}^{n_x}\tau c_i}{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}\hat{\tau}+\sum_{i=1}^{n_x}\sigma\frac{\tau^2c_i^2}{p}\frac{\sum\limits_{i=1}^{n_x}\tau c_i}{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}\hat{\tau}-2\sum_{i=1}^{n_x}\sigma\frac{\tau^2c_i^2}{p}\hat{\tau}+\sum_{i=1}^{n_x}\sigma\frac{p\tau c_i}{p}\hat{\tau}d\tilde{c} \\
&\quad \sigma\sum_{i=1}^{n_d}\frac{c_i^2}{p}\frac{\sum\limits_{i=1}^{n_x}\tau c_i}{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}\hat{\tau}+\sigma\sum_{i=1}^{n_x}\frac{\tau^2c_i^2}{p}\frac{\sum\limits_{i=1}^{n_x}\tau c_i}{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}\hat{\tau} \\
&\quad -\sigma\left(2\sum_{i=1}^{n_x}\frac{\tau^2c_i^2}{p}-\sum_{i=1}^{n_x}\frac{p\tau c_i}{p}\right)\frac{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}{\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i}\hat{\tau} \\
d\tilde{c} &= \frac{1}{p\left(\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i\right)}*
\end{aligned}$$

$$\left[\sigma\sum_{i=1}^{n_d}c_i^2\sum_{i=1}^{n_x}\tau c_i\hat{\tau}+\sigma\sum_{i=1}^{n_x}\tau^2c_i^2\sum_{i=1}^{n_x}\tau c_i\hat{\tau}-\sigma\left(2\sum_{i=1}^{n_x}\tau^2c_i^2-p\sum_{i=1}^{n_x}\tau c_i\right)\left(\sum_{i=1}^{n_d}c_i+\sum_{i=1}^{n_x}\tau c_i\right)\hat{\tau}\right] \qquad \text{(B.11)}$$

Next, $p=\frac{\sigma}{\sigma n-1}\left(\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i\right)$, $\mu_c=\frac{1}{n}\left(\sum\limits_{i=1}^{n_d}c_i+\sum\limits_{i=1}^{n_x}\tau c_i\right)$, also implying that, $p=\frac{\sigma n}{\sigma n-1}\mu_c$ can be used to rewrite (B.11) as:

$$d\tilde{c}=\frac{\sigma n}{p^2\left(\sigma n-1\right)}\left[\left(\sum_{i=1}^{n_d}c_i^2+\sum_{i=1}^{n_x}\tau^2c_i^2\right)\sum_{i=1}^{n_x}\tau c_i\hat{\tau}-\left(2\sum_{i=1}^{n_x}\tau^2c_i^2-p\sum_{i=1}^{n_x}\tau c_i\right)n\mu_c\hat{\tau}\right] \qquad \text{(B.12)}$$

The following expression on the variance of costs is used:

$$Var\left(c_i\right) = \frac{1}{n-1}\left(\sum_{i=1}^{n_d} c_i^2 + \sum_{i=1}^{n_x} \tau^2 c_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right)^2\right) = \frac{1}{n-1}\left(\sum_{i=1}^{n_d} c_i^2 + \sum_{i=1}^{n_x} \tau^2 c_i^2 - n\mu_c^2\right) \tag{B.13}$$

Substituting equation (B.13) into equation (B.12) leads to the following expression:

$$d\tilde{c} = \frac{\sigma^2 n}{p^2\left(\sigma n - 1\right)}\left[\left(\left(n-1\right) Var\left(c_i\right) + n\mu_c^2\right)\sum_{i=1}^{n_x} \tau c_i \hat{\tau} - \left(2\sum_{i=1}^{n_x} \tau^2 c_i^2 - p\sum_{i=1}^{n_x} \tau c_i\right) n\mu_c \hat{\tau}\right] \tag{B.14}$$

Bringing the summation of $\sum\limits_{i=1}^{n_x} \tau c_i$ outside the brackets in equation (B.14) gives the final expression for $d\tilde{c}$ in equation (43) in the main text:

$$d\tilde{c} = \frac{\sigma n}{p^2\left(\sigma n - 1\right)}\sum_{i=1}^{n_x} \tau c_i \left[n\mu_c\left(\mu_c + p - 2\tau c_i\right) + \left(n-1\right) Var\left(c_i\right)\right]\hat{\tau}$$

Inequality (46) can be derived as follows. The $d\tilde{c}$ part of the welfare change in equation (B.9) can be written as:

$$\begin{aligned}
d\tilde{c} &= \sum_{i=1}^{n_d} c_i \theta_{id} \hat{\theta}_{id} + \sum_{i=1}^{n_x} \tau c_i \theta_{ix} \hat{\theta}_{ix} + \sum_{i=1}^{n_x} \tau c_i \theta_{ix} \hat{\tau} \\
d\tilde{c} &= \sum_{i=1}^{n_d} \sigma \frac{c_i^2}{p} \hat{p} + \sum_{i=1}^{n_x} \sigma \frac{\tau^2 c_i^2}{p}\left(\hat{p} - \hat{\tau}\right) + \sum_{i=1}^{n_x} \sigma \tau c_i \frac{p - \tau c_i}{p} \hat{\tau} \\
d\tilde{c} &= \frac{1}{p}\sum_{i=1}^{n_d} \sigma c_i^2 \frac{\sum\limits_{i=1}^{n_x} \tau c_i}{\sum\limits_{i=1}^{n_d} c_i + \sum\limits_{i=1}^{n_x} \tau c_i}\hat{\tau} - \sum_{i=1}^{n_x} \sigma \tau^2 c_i^2 \frac{\sum\limits_{i=1}^{n_d} c_i}{\sum\limits_{i=1}^{n_d} c_i + \sum\limits_{i=1}^{n_x} \tau c_i}\hat{\tau} + \sum_{i=1}^{n_x} \sigma \tau c_i \left(p - \tau c_i\right) \frac{\sum\limits_{i=1}^{n_d} c_i + \sum\limits_{i=1}^{n_x} \tau c_i}{\sum\limits_{i=1}^{n_d} c_i + \sum\limits_{i=1}^{n_x} \tau c_i}\hat{\tau} \\
d\tilde{c} &= \frac{1}{p}\frac{\sigma}{\sum\limits_{i=1}^{n_d} c_i + \sum\limits_{i=1}^{n_x} \tau c_i}\left(\sum_{i=1}^{n_d} c_i^2 \sum_{i=1}^{n_x} \tau c_i \hat{\tau} - \sum_{i=1}^{n_x} \tau^2 c_i^2 \sum_{i=1}^{n_d} c_i \hat{\tau} + \sum_{i=1}^{n_x} \tau c_i \left(p - \tau c_i\right)\left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right)\hat{\tau}\right)
\end{aligned}$$

$$d\tilde{c} = \frac{\sigma}{p^2\left(n-1\right)}\left(\sum_{i=1}^{n_d} c_i^2 \sum_{i=1}^{n_x} \tau c_i \hat{\tau} - \sum_{i=1}^{n_x} \tau^2 c_i^2 \sum_{i=1}^{n_d} c_i \hat{\tau} + \left(p\sum_{i=1}^{n_x} \tau c_i - \sum_{i=1}^{n_x} \tau^2 c_i^2\right)\left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right)\hat{\tau}\right) \tag{B.15}$$

The third term between brackets in equation (B.15), the gain through lower trade costs, should be positive as $p \geq \tau c_i\ \forall i$. This generates the following condition:

$$\sum_{i=1}^{n_x} \tau^2 c_i^2 \sum_{i=1}^{n_d} c_i \leq p\sum_{i=1}^{n_x} \tau c_i \left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right) - \sum_{i=1}^{n_x} \tau^2 c_i^2 \sum_{i=1}^{n_x} \tau c_i \tag{B.16}$$

Substituting the condition in (B.16) into the first two terms of $d\tilde{c}$ in equation (B.15) one can proceed as follows:

$$
\begin{aligned}
d\tilde{c} &\geq \left[\sum_{i=1}^{n_d} c_i^2 \sum_{i=1}^{n_x} \tau c_i - p \sum_{i=1}^{n_x} \tau c_i \left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right) + \sum_{i=1}^{n_x} \tau^2 c_i^2 \sum_{i=1}^{n_x} \tau c_i\right] \hat{\tau} \\
d\tilde{c} &\geq \sum_{i=1}^{n_x} \tau c_i \left[\left(\sum_{i=1}^{n_d} c_i^2 + \sum_{i=1}^{n_x} \tau^2 c_i^2\right) - p\left(\sum_{i=1}^{n_d} c_i + \sum_{i=1}^{n_x} \tau c_i\right)\right] \hat{\tau} \\
d\tilde{c} &\geq \sum_{i=1}^{n_x} \tau c_i \left[(n-1) Var(c_i) + n\mu_c^2 - pn\mu_c\right] \hat{\tau} \\
d\tilde{c} &\geq \sum_{i=1}^{n_x} \tau c_i \left[(n-1) Var(c_i) + n\mu_c (\mu_c - p)\right] \hat{\tau} \\
d\tilde{c} &\geq \sum_{i=1}^{n_x} \tau c_i \left[(n-1) Var(c_i) + n\mu_c \left(\mu_c - \frac{\sigma n}{\sigma n - 1}\mu_c\right)\right] \hat{\tau} \\
d\tilde{c} &\geq \sum_{i=1}^{n_x} \tau c_i \left[(n-1) Var(c_i) + \frac{\sigma n}{\sigma n - 1}\mu_c^2\right] \hat{\tau} \qquad \text{(B.17)}
\end{aligned}
$$

So, from the inequality in (B.17) $d\tilde{c}$ is positive whenever $\frac{Var(c_i)}{\mu_c^2} \geq \frac{\sigma n}{(n-1)(\sigma n-1)}$, condition (46) in the main text.

Appendix C Free Entry Case

Equation 52: Effect of sectoral trade liberalization on market price in free entry case

Assuming equal countries, the combined FE/ZCP condition, equation (50) is given by:

$$
\frac{LP_U^{\sigma-1}}{p^\sigma} \int_0^p \sigma \left(p - 2c + \frac{c^2}{p}\right) f(c)\, dc + \frac{LP_U^{\sigma-1}}{p^\sigma} \int_0^p \sigma \left(p - 2c + \frac{c^2}{p}\right) f(c)\, dc = \delta f_e \qquad \text{(C.1)}
$$

Totally differentiating equation (C.1) towards p and τ and considering the effect through the market share as negligibly small, one can calculate the effect of sectoral liberalization as:

$$
\begin{aligned}
& \sigma L P_u^{\sigma-1} \int_0^p \left(-\frac{(\sigma-1)}{p^\sigma} + \frac{2\sigma c}{p^{\sigma+1}} - \frac{(\sigma+1)\,c^2}{p^{\sigma+2}} \right) f(c)\, dcdp \\
+ \quad & \sigma L P_u^{\sigma-1} \int_0^{\frac{p}{\tau}} \left(-\frac{(\sigma-1)}{p^\sigma} - \frac{2\tau c}{p^\sigma} \frac{(\sigma+1)\,\tau^2 c^2}{p^{\sigma+2}} \right) f(c)\, dcdp \\
- \quad & \left[L P_u^{\sigma-1} \int_0^{\frac{p}{\tau}} \left(\frac{2c}{p^\sigma} - \frac{2\tau c^2}{p^{\sigma+1}} \right) f(c)\, dc \right] d\tau = 0 \qquad \text{(C.2)}
\end{aligned}
$$

Equation (C.2) can be rewritten as:

$$
\begin{aligned}
& \int_0^p \sigma \left(1 - \frac{c}{p}\right) \left(\frac{(\sigma+1)\,c - (\sigma-1)\,p}{p} \right) f(c)\, dcdp \\
& \int_0^{\frac{p}{\tau}} \sigma \left(1 - \frac{\tau c}{p}\right) \left(\frac{(\sigma+1)\,\tau c - (\sigma-1)\,p}{p} \right) f(c)\, dcdp - \left[\int_0^{\frac{p}{\tau}} \left(2c - \frac{2\tau c^2}{p} \right) f(c)\, dc \right] d\tau = 0 \qquad \text{(C.3)}
\end{aligned}
$$

Using the definition of market shares and multiplying by $\frac{p}{\tau}$ generates equation (52) in the main text.

Equation 53: Effect of economywide trade liberalization on market price in the free entry case

The effect of economywide liberalization, also takes into account the effect through the price index P_U. Totally differentiating the combined ZCP/FE in equation (C.1) towards p and τ considering P_U as endogenous leads to:

$$
\begin{aligned}
& \left[\sigma L P_u^{\sigma-1} \int_0^p \left(-\frac{(\sigma-1)}{p^\sigma} + \frac{2\sigma c}{p^{\sigma+1}} - \frac{(\sigma+1)\,c^2}{p^{\sigma+2}} \right) f(c)\, dc \right] dp \\
& + \left[\sigma L P_u^{\sigma-1} \int_0^{\frac{p}{\tau}} \left(-\frac{(\sigma-1)}{p^\sigma} - \frac{2\tau c}{p^\sigma} - \frac{(\sigma+1)\,\tau^2 c^2}{p^{\sigma+2}} \right) f(c)\, dc \right] dp \\
& + \frac{(\sigma-1)\, L P_U^{\sigma-2}}{p^\sigma} \frac{\partial P_U}{\partial p} \frac{L P_U^{\sigma-1}}{p^\sigma} \left(\int_0^p \left(p - 2c + \frac{c^2}{p} \right) f(c)\, dc + \int_0^p \left(p - 2c + \frac{c^2}{p} \right) f(c)\, dc \right) dp \\
& - \left[L P_u^{\sigma-1} \int_0^{\frac{p}{\tau}} \left(\frac{2c}{p^\sigma} - \frac{2\tau c^2}{p^{\sigma+1}} \right) f(c)\, dc \right] d\tau = 0 \qquad \text{(C.4)}
\end{aligned}
$$

One can calculate $\frac{\partial P_U}{\partial p} = P_U \frac{Qp^{-\sigma}}{Qp^{1-\sigma}+1}$. Furthermore, the unconditional profits from domestic and exporting sales can be defined as $\bar{\pi}_d = F(p)\,\tilde{\pi}_d$ and $\bar{\pi}_x = \frac{F\left(\frac{p}{\tau}\right)}{F(p)}\tilde{\pi}_x$. Rewriting the first term as in the sectoral liberalization derivation, one arrives at the following expression with A, B and C defined as in the main text:

$$\hat{p} = \frac{2\int_0^{\frac{p}{\tau}} \tau c\left(1-\frac{\tau c}{p}\right) f(c)\,dc}{A+B+C}\hat{\tau} \tag{C.5}$$

Equations 65 and 66: Derivatives of average revenues with respect to trade costs

Average domestic and exporting revenues are defined in the main text in equations (63) and (64). Differentiating these expressions towards trade costs leads to:

$$\begin{aligned}\frac{\partial \bar{r}_d}{\partial \tau} \;=\;& \left[P_U^{\sigma-1}L\sigma\int_0^p\left(-\frac{\sigma-1}{p^\sigma}+\frac{\sigma c}{p^{\sigma+1}}\right)\mu(c)\,dc - \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{f(p)}{F(p)}\int_0^p \sigma\frac{p-c}{p}\mu(c)\,dc\right]\frac{\partial p}{\partial \tau}\\ &+\tau\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\left[\sigma\int_0^p(1-\theta_d(c))\,\mu(c)\,dc - \frac{f(p)\,p}{F(p)}\int_0^p\sigma\frac{p-c}{p}\mu(c)\,dc\right]\varepsilon_{p,\tau}\end{aligned} \tag{C.6}$$

$$\begin{aligned}\frac{\partial \bar{r}_x}{\partial \tau} \;=\;& P_U^{\sigma-1}L\sigma\left[\int_0^{\frac{p}{\tau}}\left(-\frac{(\sigma-1)}{p^\sigma}+\sigma\frac{\tau c}{p^{\sigma+1}}\right)\mu(c)\,dc - \frac{f\left(\frac{p}{\tau}\right)\frac{1}{\tau}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}}\sigma\frac{p-\tau c}{p^\sigma}\mu(c)\,dc\right]\frac{\partial p}{\partial \tau}\\ &-P_U^{\sigma-1}L\sigma\left[\int_0^{\frac{p}{\tau}}\frac{c}{p^\sigma}\frac{f(c)}{F\left(\frac{p}{\tau}\right)}dc + \frac{f\left(\frac{p}{\tau}\right)\frac{p}{\tau^2}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}}\frac{p-\tau c}{p^\sigma}\mu(c)\,dc\right]\end{aligned}$$

$$\begin{aligned}=\;& \frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{1}{\tau}\left[\int_0^{\frac{p}{\tau}}\left(1-\sigma\frac{p-\tau c}{p}\right)\mu(c)\,\frac{\partial p}{\partial \tau}\frac{\tau}{p} - \int_0^{\frac{p}{\tau}}\frac{\tau c}{p}\mu(c)\,dc\right]\\ &-\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{f\left(\frac{p}{\tau}\right)\frac{p}{\tau^2}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}}\sigma\frac{p-\tau c}{p^\sigma}\mu(c)\,dc\,[\varepsilon_{p,\tau}-1]\end{aligned}$$

$$= \quad -\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{1}{\tau}\left[\int_0^{\frac{p}{\tau}}\left[(1-\theta_x(c))(1-\varepsilon_{p,\tau})+\frac{\sigma-1}{\sigma}\theta_x(c)\right]\mu(c)\,dc\right]$$

$$-\frac{P_U^{\sigma-1}L}{p^{\sigma-1}}\frac{f\left(\frac{p}{\tau}\right)\frac{p}{\tau^2}}{F\left(\frac{p}{\tau}\right)}\int_0^{\frac{p}{\tau}}\sigma\frac{p-\tau c}{p^{\sigma}}\mu(c)\,dc\,[\varepsilon_{p,\tau}-1] \tag{C.7}$$

Appendix D Asymmetric Countries Case

Equations 69 and 70: Effects of unilateral trade liberalization on market prices

The combined FE/ZCP's in country s and r are given by:

$$\frac{L_s P_{Us}^{\sigma-1}}{p_s^{\sigma}}\int_{\underline{c}_s}^{p_s}\left(p_s-2c+\frac{c^2}{p_s}\right)f_s(c)\,dc+\frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_{\underline{c}_s}^{\frac{p_r}{\tau_{sr}}}\left(p_r-2\tau_{sr}c+\frac{\tau_{sr}^2c^2}{p_r}\right)f_s(c)\,dc=\delta f_e \tag{D.1}$$

$$\frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_{\underline{c}_r}^{p_r}\left(p_r-2c+\frac{c^2}{p_r}\right)f_r(c)\,dc+\frac{L_s P_{Us}^{\sigma-1}}{p_s^{\sigma}}\int_{\underline{c}_r}^{\frac{p_s}{\tau_{rs}}}\left(p_s-2\tau_{rs}c+\frac{\tau_{rs}^2c^2}{p_s}\right)f_r(c)\,dc=\delta f_e \tag{D.2}$$

Totally differentiating equation (D.1) towards p_s, p_r and τ_{sr} gives:

$$\frac{\sigma L_s P_{Us}^{\sigma-1}}{p_s^{\sigma}}\int_0^{p_s}\left(1-\frac{c}{p_s}\right)\left(\frac{(\sigma+1)c-(\sigma-1)p_s}{p_s}\right)f(c)\,dc\,dp_s$$

$$+\frac{\sigma L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}\int_0^{\frac{p_r}{\tau_{sr}}}\left(1-\frac{\tau_{sr}c}{p_r}\right)\left(\frac{(\sigma+1)\tau_{sr}c-(\sigma-1)p_r}{p_r}\right)f(c)\,dc\,dp_r$$

$$-\frac{L_r P_{Ur}^{\sigma-1}}{p_r^{\sigma}}2\int_0^{\frac{p_r}{\tau_{sr}}}\left(c-\frac{2\tau_{sr}c^2}{p_r}\right)f(c)\,dc\,d\tau_{sr}=0 \tag{D.3}$$

Rewriting equation (D.3) in terms of relative changes and adding the equivalent expression for the other country, one arrives at:

$$q_s\int_0^{p_s}\theta_{ds}(c)\left((\sigma+1)c-(\sigma-1)p_s\right)f(c)\,\hat{p}_s$$

$$+q_r\int_0^{\frac{p_r}{\tau_{sr}}}\theta_{xs}(c)\left((\sigma+1)\tau_{sr}c-(\sigma-1)p_r\right)f(c)\,dc\hat{p}_r-\frac{2q_r}{\sigma}\int_0^{\frac{p_r}{\tau_{sr}}}\tau_{sr}c\theta_{xs}(c)f(c)\,dc\hat{\tau}_{sr}=0 \tag{D.4}$$

$$q_r \int_0^{p_r} \theta_{dr}(c)\left((\sigma+1)c-(\sigma-1)p_r\right) f(c)\,\hat{p}_r$$

$$+q_s \int_0^{\frac{p_s}{\tau_{rs}}} \theta_{xr}(c)\left((\sigma+1)\tau_{rs}c-(\sigma-1)p_s\right) f(c)\,dc\hat{p}_K - \frac{2q_s}{\sigma}\int_0^{\frac{p_s}{\tau_{rs}}} \tau_{rs}c\theta_{xr}(c) f(c)\,dc\hat{\tau}_{rs} = 0 \tag{D.5}$$

Defining the marginal effects dc_{ds}, dc_{dr}, dc_{xs}, dc_{xr}, $dc_{x\tau s}$ and $dc_{x\tau r}$ as in the main text, equations (D.4) and (D.5) can be solved for $\hat{p}_s$, $\hat{p}_r$ as a function of $\hat{\tau}_{sr}$ and $\hat{\tau}_{rs}$, leading to equations (69) and (70) in the main text.