A welfare ranking of multilateral reductions in real and tariff trade barriers when firms are heterogenous.

Philipp J.H. Schröder* Allan Sørensen†

August 10, 2011

Abstract

Trade liberalization comes about through reductions in various types of trade costs. This paper introduces, apart from real (also called frictional) variable and fixed export costs, two lump-sum redistributed tariffs into a Melitz (2003) model. We present comparable results for welfare effects and changes in industry structure by analyzing different liberalization channels with an equal effect on openness. The welfare ranking is sensitive to the degree of efficiency in tariff redistribution. Ad valorem tariffs moves from the least to the most preferred mode of liberalization as the fraction of tariffs wasted on rent-seeking activities moves from zero to unity. When not all tariff revenue is wasted on rent-seeking activities reductions in real variable trade costs are preferred to reductions in real fixed trade costs which again is preferred to an iceberg type unit tariff.

JEL: F12, F13, F15
Key Words: Real Trade Costs, Non-Tariff Barriers, Tariffs, Integration.

*Corresponding author: Aarhus University, Business and Social Sciences, Department of Economics and Business, Denmark. Tel.: +45 8948 6392, psc@asb.dk.
†Aarhus University, Business and Social Sciences, Department of Economics and Business, Denmark.
Acknowledgements: Philipp Schröder acknowledges financial support from the Danish Social Sciences Research Council (grant no. 275-06-0025) and the Tuborg Foundation. The usual disclaimer applies.
1 Introduction

Trade costs are large, richly linked to economic policy and have large welfare implications according to Anderson and Wincoop (2004). In their broad definition of trade costs they include costs like transportation costs, policy barriers (tariffs and nontariff barriers), information costs, contract enforcement costs, currency costs, legal costs and distribution costs. Reductions in these costs due to technological improvements and policy changes have occurred and will presumably continue and thereby increase gains from trade and welfare. However, as the trade costs are of rather different nature the welfare effects of trade liberalization presumably depends on which cost type is reduced. Almost needless to say this issue is highly relevant for policy making.

We address this issue by examining and comparing the welfare effects of various types of trade costs in an intra-industry trade model with heterogenous firms. The inclusion of heterogenous firms endogenizes average productivity through selection mechanism among firms with different productivities (see e.g. Melitz (2003)). These selection mechanisms are differently affected by different trade costs and therefore the heterogenous firm framework is able to identify and compare welfare effects from various trade costs running through average productivity that cannot be captured in settings with homogenous firms and thus constant average productivity.

The most widely noticed benefit from incorporating firm heterogeneity into models of intra-industry trade, e.g. Melitz (2003), is the ability to capture central stylized facts of modern international trade. This has resulted in a sizable empirical literature, see Greenaway and Kneller (2007) and Wagner (2007) for surveys. Equally important, but maybe less noticed, are the central contributions concerning novel effects of trade and economic integration, such as productivity gains from intra-industry reallocation due to trade opening. Accordingly, while the wake of a new consensus model of intra-industry trade has had ample consequences for the way economists conduct empirical research on trade and export behavior it has so far had only little impact on the way economists think about the policies surrounding international trade and economic integration.

The present paper therefore also contributes towards closing this gap by examining and comparing reductions in both real trade barriers and in tariff trade barriers in a heterogenous firm intra-industry trade model.\footnote{Schröder (2004) introduces a similar distinction into a Krugman (1980) model without firm heterogeneity. Accordingly no intra-industry reallocation and productivity effects are observed, and the presented welfare rankings are solely driven by changes in the number of varieties.} By real trade barriers, we mean costs that are real in terms of actually absorbing resources, such as administration costs, border formalities, transport costs and foreign regulation and safety standards, i.e., such trade costs burn up resources because e.g. firms have to employ staff to tackle these barriers. Real trade costs are what the existing models following Melitz (2003) capture when including iceberg costs and fixed export costs. On the other hand, tariff trade barriers, although very real for the individual firm, are unreal for the economy as a whole in the sense that they imply a reallocation of resources, that is, a tax that is imposed upon trade-active firms but eventually redistributed
to consumers. Tariffs have not previously been included into Melitz (2003)-type settings, probably because the redistribution of tariff revenues in a general equilibrium framework increases complexity. Our inclusion of redistributive tariffs can thus be seen as a methodical contribution of this paper. Since trade barriers are different in nature, they must have different effects on the economy, and removing the one or the other type of barrier during integration episodes will have different consequences for industry structure and welfare.

Formally, we capture and compare different channels of economic integration by including four types of trade barriers in a $n + 1$ symmetric countries Melitz (2003) model under the assumption of Pareto distributed marginal productivities. First, we include real variable trade costs, i.e. the customary iceberg trade costs, which may represent for example transport costs. Although a useful and preferred modelling device in theoretical work, empirical studies have pointed at the importance of including additional empirically relevant formulations of trade costs, see Baier and Bergstrand (2001) or Hummels and Skiba (2004). Second, and in line with the heterogeneous firms trade literature, we include fixed cost of exporting which are homogeneous across firms, and also modeled as real trade costs. These fixed costs represent items such as implementing foreign standards or the costs caused by foreign red-tape. The fixed costs of exporting are a central element of the heterogeneous firms trade theory and are well established in the literature, e.g., Roberts and Tybout (1997), Das et al. (2007), Jørgensen and Schröder (2008). Third, we go beyond the existing literature and include tariff trade costs. We introduce a standard ad valorem tariff and a unit tariff and let the latter for purpose of comparison and tractability be modelled fully symmetric to the above iceberg cost apart from one crucial difference, namely that tariff revenues are redistributed. In particular we vary the degree of redistribution efficiency, say due to rent-seeking or administrative waste only part of the tariff revenue are actually redistributed. Moreover, we depart from previous studies of trade and welfare in heterogeneous firms settings by imposing a common measure of comparison. Multilateral reductions of the four barriers are compared for identical effects on economic integration, i.e. an equal increase in trade openness. This allows us not only to state the direction of welfare effects for different liberalization channels, as has been done in previous literature, e.g. Melitz (2003), Baldwin and Forslid (2010), Demidova and Rodriguez-Clare (2009), but also to compare their relative performance in terms of welfare and changes in industry structure for a given increase in trade openness. Moreover, openness is a suitable variable for empirical observation, bringing the model closer to empirical work. Optimal trade policies in settings with heterogeneous firms is an interesting but sofar underexplored research topic, see Cole (2010). This paper takes a first step by analysing, comparing and welfare ranking exogenous and multilateral changes in

---

2In Krugman (1980)-type intra-industry trade models without heterogeneity such redistributed tariffs have been implemented and analyzed by Gros (1987) and more recently by Jørgensen and Schröder (2005). Accordingly, intra-industry productivity reallocations have not been addressed.

3Analysis of unilateral optimal trade policies have only recently been conducted in the Melitz (2003) type framework. This is partly due to a significant loss of tractability when relative wages respond to trade policies. Recent examples are
trade policies and trade costs among symmetric countries.

For the empirically relevant situation, where all four types of barriers are present simultaneously and firms self-select into exporters and non-exporters we find that the welfare ranking depends on the degree of costly rent-seeking in allocation of the tariff revenue\(^4\) as the various modes of trade liberalization have heterogeneous impact on both industry structure and tariff revenue. In particular the ad valorem tariff moves from the least to the most preferred mode of trade liberalization as the fraction of tariff revenue wasted on rent seeking activities moves from zero to one. The driver behind this movement is that a reduction in the ad valorem tariff has the most advantageous effect on industry structure but is most costly in terms of lost tariff revenue. When rent-seeking activities absorbs all the tariff revenue we find equal welfare effects of the other modes of trade liberalization, whereas reductions in real variable trade costs is preferred to reductions in real fixed trade costs which again is preferred to reductions in the iceberg type unit tariff otherwise.

The rest of the paper is structured as follows. Section 2 introduces the model and includes the tariffs and rent-seeking activities. Section 3 presents the central welfare ranking and some results on industry structure. Section 4 concludes. Finally, an appendix contains all the proofs.

2 The Model

We consider the workhorse model of the new trade theory with heterogeneous firms, Melitz (2003), with the conventional assumption of Pareto distributed firm-specific productivities, see e.g. Helpman et al. (2004), Chaney (2007) and Eaton et al (2008). In the Melitz (2003) model the economy consists of \(n+1\) countries that are symmetric at aggregate levels including trade policies. Hence, we consider multilateral changes in trade policies/costs and thereby do not consider countries unilateral incentives to use policies to increase welfare at the expense of other countries, i.e. through e.g. terms of trade improvements.

Households

Consider the representative household inelastically supplying \(L\) units of labour. The preferences of the household over a set of goods/varieties (\(\Omega\)) are given by the CES aggregate

\[
U = \left[ \int_{\omega \in \Omega} q(\omega)^{\sigma-1} d\omega \right]^{\frac{1}{\sigma}},
\]

where \(q(\omega)\) is consumption of variety \(\omega\) and \(\sigma > 1\) is the elasticity of substitution between any goods. Optimal demand for each variety takes the form

\[
q(\omega) = \left( \frac{p(\omega)}{P} \right)^{-\sigma} \frac{E}{P},
\]

\(^4\)We assume in the model that an exogenous given fraction \(1 - \chi \in [0, 1]\) of the tariff revenue is wasted on costly (in terms of labour) rent-seeking activities.
where $E$ denotes aggregate expenditures, $p (\omega)$ the price of variety $\omega$ and $P$ the price index of one unit of the composite good defined by

$$ P = \left[ \int_{\omega \in \Omega} p (\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}. \quad (2) $$

### Firms

Monopolistic firms face constant but heterogenous marginal costs. Firms face standard Dixit-Stiglitz (1977) innovation costs of developing a new variety ($F_E$).\(^5\) Innovation costs are sunk before each new variety is randomly associated with a variety-specific marginal productivity ($\varphi (\omega)$) and thus marginal costs. Production exhibits increasing returns as firms face fixed costs of production ($F$). Finally, firms face fixed market costs in each export markets ($F_X$). In addition, exporting firms also face variable real and tariff trade costs. Real variable trade costs are in line with the literature modeled by iceberg costs, $\tau \geq 1$, i.e. firms ship $\tau$ units for one unit to arrive at the export market. Accordingly, firm heterogeneity implies firm-specific unit costs of export. To emphasize the importance of real versus tariff costs we introduce a comparable unit tariff of $t_1 \varphi$ per unit of export.\(^6\) Total marginal costs of supplying one unit to the foreign market, including production costs, real trade costs and unit tariffs, thus become $\tau + t_1 \varphi$. Moreover, firms face a standard ad valorem tariff, $T > 0$.

Inserting demand (1) and utilizing that demand is identical across the symmetric countries, profit conditional on export status reads

$$ \pi (\varphi) = \begin{cases} (\frac{p}{P})^{-\sigma} \frac{E}{P} (p - \frac{1}{\varphi}) - F & \text{if pure domestic} \\ (\frac{p}{P})^{-\sigma} \frac{E}{P} (p - \frac{1}{\varphi}) + n (\frac{p_x}{P})^{-\sigma} \frac{E}{P} \left( \frac{p_x}{1+T} - \frac{1}{\varphi} (\tau + t) \right) - F - n F_X & \text{if exporting} \end{cases} $$

where $p (p_x)$ is the price charged in the domestic (export) market(s). Optimal pricing implies

$$ p = \frac{1}{\sigma - 1} \frac{\varphi}{\varphi} \quad (3) $$

$$ p_x = \frac{\tau + t}{\sigma - 1} \frac{1}{\varphi} (1 + T) \cdot $$

In order to obtain closed form solutions and thus to ensure tractability we follow the literature and assume that marginal productivities are drawn from a Pareto distribution (see e.g. Helpman, et al. (2004), Chaney (2007) and Eaton et al (2008)). The cumulative distribution function of marginal productivity is given by

$$ G (\varphi) = \begin{cases} 1 - \left( \frac{\varphi}{w} \right)^k & \text{if } \varphi \geq \varphi_0 > 0 \\ 0 & \text{if } \varphi < \varphi_0 \cdot $$

\(^5\) The costs consist of employing $F_E$ units of labour. However, as we set the wage $w$ to be the numeraire ($w \equiv 1$), the costs equal $F_E$.

\(^6\) This formulation of the tariff enhances tractability substantially. We must stress that it is simply the tariff equivalent of the real iceberg trade cost; other specifications are conceivable.
where $\phi_0$ and $k$ are scale and shape parameters.\footnote{The density of marginal productivities is given by}

The fixed costs of production and market access and the heterogeneous marginal productivities imply that firms self-select into groups of non-producing, pure domestic and exporting firms according to marginal productivities.

As is standard in the literature, we focus on steady state equilibria and assume zero discounting. With no discounting the present values of firms are kept finite by assuming that firms die with constant probability $\delta > 0$. Free entry ensures that firms enter until expected lifetime profits equal the costs of developing a new variety.

**Productivity thresholds**

Flow profits in the domestic ($\pi_D (\varphi)$) and in the export ($\pi_X (\varphi)$) markets are given by

$$\pi_D (\varphi) = B\varphi^{\sigma - 1} - F$$
$$\pi_X (\varphi) = B\varphi^{\sigma - 1} (1 + T)^{-\sigma} (\tau + t)^{1 - \sigma} - F_X,$$

where $B \equiv \frac{1}{\sigma - 1} \left( \frac{\sigma}{\sigma - 1} \right)^{-\sigma} P^{\sigma - 1} E$.

Following the literature, we focus on the empirically relevant equilibria in which there is partitioning of firms into exiters, non-exporters and exporters and that all exporting firms also supply the domestic market. Only the most productive firms find it worth while paying the fixed export market costs. Let $\varphi^*$ and $\varphi_X^*$ be the thresholds such that firms with $\varphi \geq \varphi_X^*$ are exporters, firms with $\varphi \in [\varphi^*, \varphi_X^*)$ are domestic firms, and firms with $\varphi < \varphi^*$ do not produce. The partitioning constraint – i.e. the parameter restriction ensuring this partitioning – becomes when all for trade barriers are present $(1 - T)^{-\sigma} (\tau + t)^{1 - \sigma} F_X > F$. Then we have that $\pi_D (\varphi^*) = F$ and $\pi_X (\varphi_X^*) = 0$ which can be rewritten as

$$B (\varphi^*)^{\sigma - 1} = F$$
$$B (\varphi_X^*)^{\sigma - 1} = (1 + T)^{\sigma} (\tau + t)^{1 - \sigma} F_X.$$

implying that $\varphi_X^* = \varphi^* \left( \frac{(1 + T)^{\sigma} (\tau + t)^{1 - \sigma} F_X}{F} \right)^{\frac{1}{\sigma - 1}}$. As there is free entry, firms enter the industry until the expected value of the stream of profits equals the investment costs (entry costs). This free entry condition

$$\int_{\varphi^*}^{\infty} \pi_D (\varphi) dG (\varphi) + n \int_{\varphi_X^*}^{\infty} \pi_X (\varphi) dG (\varphi) = \delta F_E$$

We assume that $k > \sigma - 1$ to bound expected profits prior to entry from above.
pins down the two thresholds to

$$\varphi^* = \varphi_0 \left( \frac{(\sigma - 1)}{k - (\sigma - 1)} \frac{F_k}{\delta F_E} \right)^{\frac{1}{\bar{\sigma}}} \left( 1 + n(\tau + t)^{-k} (1 + T)^{-k \bar{\sigma} - 1} \left( \frac{F_X}{F} \right)^{1 - k \bar{\sigma} - 1} \right)^{\frac{1}{\bar{\sigma}}}$$  \hspace{1cm} (4)

$$\varphi^X = \varphi^*(\tau + t) (1 + T)^{\frac{k}{\bar{\sigma} - 1}} \left( \frac{F_X}{F} \right)^{\frac{1}{\bar{\sigma} - 1}}$$

Both thresholds are invariant to the level of aggregate demand. However, aggregate demand determines the mass of active firms ($M$).

**Aggregation with redistributed tariffs**

A key difference between real and tariff trade costs in general equilibrium is that we explicitly model and include the revenues generated by the tariffs barrier via a lump-sum redistribution scheme to households. Accordingly, closing the model we depart for convenience from the standard labour market clearing condition and instead evoke the expenditure-sales clearing condition.\(^8\) Aggregate expenditure on goods, $E$, of households is the sum of wage earnings and the tariff revenue less waste and spending on rent-seeking activities.\(^9\) The fraction $1 - \chi \in [0, 1]$ of tariff revenue is assumed to be wasted on costly (in terms of labour) rent-seeking activities and accordingly only the fraction $\chi \in [0, 1]$ of the tariff revenue reenters households demand for goods.\(^10\) Aggregate tariff revenue reads

$$TR = M \int_{\varphi^*}^{\infty} E \left( \frac{p_x(\varphi)}{P} \right)^{-\sigma} \left( \frac{t}{\varphi} + \frac{T}{1 + T} p_x(\varphi) \right) \mu(\varphi) d\varphi$$

$$= Mn(\sigma - 1) F \left( \frac{t}{\varphi} + \frac{T}{\sigma - 1} \right) \frac{k}{k - (\sigma - 1)} (\tau + t)^{-k} (1 + T)^{-k \bar{\sigma} - 1} \left( \frac{F_X}{F} \right)^{1 - k \bar{\sigma} - 1}$$

where $\mu(\varphi) = \frac{g(\varphi)}{1 - G(\varphi^*)}$ is the distribution function for active firms. Aggregate sales read

$$R = M \int_{\varphi^*}^{\infty} p(\varphi) \left( \frac{p(\varphi)}{P} \right)^{-\sigma} E \mu(\varphi) d\varphi + nM \int_{\varphi^*}^{\infty} p_x(\varphi) \left( \frac{p_x(\varphi)}{P} \right)^{-\sigma} E \mu(\varphi) d\varphi$$

$$= M \sigma F \frac{k}{k - (\sigma - 1)} \left( 1 + n(\tau + t)^{-k} (1 + T)^{1 - k \bar{\sigma} - 1} \left( \frac{F_X}{F} \right)^{1 - \frac{k}{\bar{\sigma} - 1}} \right).$$

\(^8\)Obviously, the equilibrium number of firms can also be determined from the full employment condition.

\(^9\)Following the literature we assume zero discounting. This assumption implies zero return to savings and thereby no capital income.

\(^10\)This formulation captures in a simple way that rent-seeking activities increase with the rents to be seeked (the tariff revenue).
The equilibrium condition $E = L + \chi TR = R$ determines the mass of firms/varieties

$$M = \frac{L k - (\sigma - 1)}{k \sigma}$$

$$\times \left[ 1 + \left[ 1 - \chi \left( \frac{t}{\tau + t} \frac{1}{1 + T} \frac{\sigma - 1}{\sigma} + \frac{T}{1 + T} \right) \right] n(\tau + t)^{-k} (1 + T)^{1-k} \varphi^{1-k} \left( \frac{F_X}{F} \right)^{1-k} \right]^{-1}. \tag{5}$$

Finally, using the price index (2)\textsuperscript{11}, the optimal prices (3), the thresholds (4) and the mass of firms (5) welfare becomes

$$W = \frac{R}{P} = (\sigma - 1) F \left( \frac{L}{\sigma F} \right)^{\frac{\sigma}{\sigma - 1}}$$

$$\times \left[ 1 + n(\tau + t)^{-k} (1 + T)^{1-k} \varphi^{1-k} \left( \frac{F_X}{F} \right)^{1-k} \right]^{\frac{\sigma}{\sigma - 1}} \varphi^*$$

$$= \hat{W} \left( 1 + n(\tau + t)^{-k} (1 + T)^{1-k} \varphi^{1-k} \left( \frac{F_X}{F} \right)^{1-k} \right)^{-\frac{1}{k}}$$

$$\times \left[ 1 + n(\tau + t)^{-k} (1 + T)^{1-k} \varphi^{1-k} \left( \frac{F_X}{F} \right)^{1-k} \right]^{\frac{\sigma}{\sigma - 1}},$$

where $\hat{W} = (\sigma - 1) \varphi_0 \left( \frac{L}{\sigma F} \right)^{\frac{\sigma}{\sigma - 1}} F \left( \frac{L}{\sigma F} \right)^{\frac{1}{k}} > 0$. The degree of rent-seeking activities, $1 - \chi$, has no effect on the industry structure but decreases welfare as disposable income and thereby consumption decreases.\textsuperscript{12} However, more rent-seeking also decreases welfare indirectly, as the smaller demand cf. (5) decreases the mass of varieties which in turn decreases welfare due to love of variety. We state:

**Lemma 1.** A larger degree of tariff redistribution $\chi$ has no effect on the thresholds but increases welfare through increased disposable income and an increased number of varieties.

\textsuperscript{11}The price index becomes

$$P = M^{\frac{1}{\sigma - 1}} \left( \frac{k}{k - (\sigma - 1)} \right)^{\frac{1}{\sigma - 1}} \left[ 1 + n(\tau + t)^{-k} (1 + T)^{1-k} \varphi^{1-k} \left( \frac{F_X}{F} \right)^{1-k} \right]^{\frac{1}{\sigma - 1}}$$

\textsuperscript{12}Rent-seeking activities affects market size but due to constant elasticities of demand market size has no impact on the industry structure.
3 Trade liberalization, welfare and industry structure

The above specification presents a version of the Melitz (2003) framework extended to include tariffs that are redistributed to households and thus matter in general equilibrium. Inspection of (6) leads to a first result on trade liberalization channels and welfare:

**Lemma 2.** Trade liberalization through reductions in either real variable trade costs \((\tau)\), real fixed trade costs \((F_X)\), unit tariffs \((t)\) or ad valorem tariffs \((T)\) increases welfare.

Next, we will address the question of how different types of trade liberalization rank in terms of their effect on welfare. To fix the scale of changes in the different trade costs, we compare changes in trade costs yielding the same effect on a standard measure of economic integration, namely openness \((\Theta)\) defined by import plus exports relative to GDP.\(^\text{13}\) In the present setting this measure becomes

\[
\Theta = 2 \frac{n(\tau + t)^{-k} (1 + T)^{1-k} \frac{F_X}{T} \left(1 + \frac{k}{\sigma - 1}\right) \frac{1}{\sigma - 1}}{1 + n(\tau + t)^{-k} (1 + T)^{1-k} \frac{F_X}{T} \left(1 + \frac{k}{\sigma - 1}\right) \frac{1}{\sigma - 1}} \in (0, 2).
\]

(7)

As expected trade liberalization in any dimension increases openness:

**Lemma 3.** Openness \((\Theta)\) increases in trade liberalization irrespective of the source, i.e. it increases through reductions in real variable trade costs \((\tau)\), unit tariffs \((t)\), ad valorem tariffs \((T)\) or fixed trade costs \((F_X)\).

From the openness measure (7) it follows that trade liberalizations of equal impact on openness must satisfy

\[
\begin{align*}
\frac{dt}{d\tau} &= \frac{d\tau}{dT} = \frac{1 + T}{\tau + t} \frac{k}{k - \frac{\sigma}{\sigma - 1} - 1} d\tau \\
\frac{dF_X}{d\tau} &= \frac{F_X}{\tau + t} \frac{k}{k - \frac{1}{\sigma - 1} - 1} d\tau
\end{align*}
\]

(8)\(\text{ }\) (9)\(\text{ }\) (10)

For latter reference it is useful to rewrite the exit threshold as

\[
\phi_\Theta^* = \phi_0 \left(\frac{1}{k - \frac{\sigma - 1}{\sigma - 1}} \frac{F}{F_E} \right)^{\frac{1}{\sigma - 1}} \left(1 + \frac{1}{1 + T} \frac{\Theta}{2 - \Theta}\right)^{\frac{1}{\sigma - 1}}
\]

(11)

and noting that

\(^{13}\)Another conceivable measure would be the share of imports in GDP. All results stated are robust also for such specification.
Lemma 4. Trade liberalization in any dimension increases the exit threshold. The impact on the exit threshold of trade liberalizations with equal impact on openness is stronger for a reduction in the ad valorem tariff than reductions in the other trade costs.

It is convenient for tractability to express welfare in terms of the openness measure:

\[ W = W_\Theta = \tilde{W} \left( 1 + \frac{1}{1+T} \frac{\Theta}{2-\Theta} \right)^{\frac{1}{1+\Theta}} \left( 1 + \left[ 1 - \chi \left( \frac{t}{\tau+t} + \frac{T}{1+T} \right) \right] \frac{\Theta}{2-\Theta} \right)^{\frac{1}{\sigma-1}} \] (12)

The change in welfare from changing \( x \) for \( x = t, T, \tau, F_X \) follows from (12) and reads

\[ dW = \frac{\partial W_\Theta}{\partial \Theta} d\Theta + \frac{\partial W_\Theta}{\partial x} dx \]

and as we rank modes of trade liberalization for given changes in the openness measure we only need to rank \( \frac{\partial W_\Theta}{\partial x} dx \) for \( x = t, T, \tau, F_X \). We are now in a position to rank the welfare gains from increasing openness arising from reductions in the four types of trade costs.

Proposition 1. For trade liberalizations with a given effect on openness, \( \Theta \), it follows:

1) When all tariff revenue is wasted on rent-seeking activities reductions in iceberg trade costs, fixed trade costs and unit tariffs all have the same impact on welfare.

2) When only part of tariff revenue is wasted on rent-seeking activities reductions in iceberg trade costs (\( \tau \)) are preferred to reductions in fixed trade costs (\( F_X \)) which again is preferred to reductions in unit tariffs (\( t \)).

3) Reductions in ad valorem tariffs moves from the least to the most preferred mode of trade liberalization as the degree of rent-seeking moves from zero to one.

Figure 1 illustrates the discontinuity in the productivity measures caused by the presence of fixed costs. Both when computing productivity for total sales (panel a) and productivity for units of output (panel b), the measures stating average productivity display a fall in productivity when moving from non-exporting status to export active. The theoretical marginal productivity measures do not feature this discontinuity, since they exclude fixed costs. Moreover, marginal productivity computed from total sales turns out to be constant and to depend only on the mark-up. The reason for this is that in the sales based measure the price and volume effects driven by \( \varphi \) off-set each other.

When all tariff revenue is wasted on rent-seeking activities, i.e. \( \chi = 0 \), the tariff revenue play no role and from the welfare expression (6) it follows that trade liberalization only affects welfare through the exit threshold and thus the industry
structure. From the exit threshold (11) and Lemma 3 it follows that reductions in fixed trade costs, iceberg trade cost and unit tariffs having the same effect on openness also have the same impact on the exit threshold. This in turn ensures identical welfare gains and explains result 1 in Proposition 1. As expected iceberg costs and unit tariffs have the same effect on welfare since the entire tariff revenue is wasted in rent-seeking activities and the unit tariff is modelled as the tariff equivalent of the iceberg costs. The equivalent welfare effect from reductions in fixed and iceberg trade costs is sensitive to the assumption of Pareto distributed marginal productivities but is never the less both interestingly and surprisingly.

Turning to the case with limited rent-seeking activities, i.e. $\chi > 0$, tariff revenue matters. Tariff revenue can be written as

$$TR_\Theta = L \frac{\left(\frac{1}{\tau + t} \frac{1}{1+T} \frac{1}{\sigma^2} + \frac{T}{1+T}\right) \frac{\Theta}{2-\Theta}}{1 + \left(1 - \chi \left(\frac{1}{\tau + t} \frac{1}{1+T} \frac{1}{\sigma^2} + \frac{T}{1+T}\right)\right) \frac{\Theta}{2-\Theta}}$$

(13)

and comparing the effect on tariff revenue of the various modes of trade liberalization we find

**Lemma 5.** For trade liberalizations yielding an equal increase in openness ($\Theta$) reductions in real trade costs implies higher tariff revenue than reductions in tariffs. Among tariffs the unit tariff is preferred on a tariff revenue scale to the ad valorem tariff. Among real trade costs the iceberg trade cost is preferred on a tariff revenue scale to the fixed cost of exporting.
That reductions in real trade costs are preferred to reductions in tariffs in terms of tariff revenue is hardly surprising. However, the rankings among real trade costs and among tariffs are less obvious.

Reductions in fixed trade costs, iceberg trade costs and unit tariffs yield identical welfare gains through changes in the industry structure, cf. Lemma 3. However, according to Lemma 4 they have a heterogenous effects on tariff revenue which therefore determines the welfare ranking, i.e. result 2 of Proposition 1.

The final result of Proposition 1 states that the ad valorem tariff moves from the least to the most preferred mode of trade liberalization as the degree of rent-seeking moves from zero to one. To understand this recall from Lemma 3 that a lower ad valorem tariff yields the largest impact on the exit threshold and thus generates the most favorable intra-industry reallocations. This clearly makes ad valorem tariffs the most preferred mode when all tariff revenue is wasted. Turning to tariff revenue we have that the ad valorem tariff is most costly in terms of tariff revenue. A smaller degree of rent-seeking makes tariff revenue increasingly important and the ranking of the ad valorem tariff therefore gradually deteriorates and eventually becomes the least preferred mode.

Turning to the industry structure we have above derived and ranked the effects on the exit threshold from various modes of trade liberalization, cf. Lemma 3. For the degree of international engagement of firms we find non-surprisingly that trade liberalization increases the fraction of firms exporting. However, we can again compare various modes of trade liberalization for a given impact on openness and find that

**Proposition 2.** Trade liberalization increases the fraction of firms exporting. The fraction of firms exporting increases most as trade liberalization occurs through reductions in fixed costs of exporting followed by reductions in the ad valorem tariff. The iceberg costs and the iceberg type tariff have equal impacts on the fraction of firms exporting.

And finally to complete the characterization of the industry structure we can turning to the mass of (domestic) firms:

**Proposition 3.** Trade liberalization reduces the mass of active (domestic) firms. When all tariff revenue is wasted on rent-seeking activities all modes of trade liberalization have the same effect on the mass of active (domestic) firms. Otherwise more (domestic) firms are active when liberalization occurs through reductions in real trade costs. For real costs reductions most (domestic) firms are active when liberalization occurs through lower iceberg trade costs. For lower tariffs most (domestic) firms are active when the unit tariff is reduced.
4 Conclusion

This paper takes the recent advances of intra-industry trade models with heterogeneous firms into the arena of policy questions in international economics. We examine and compare the welfare effects of four distinct channels of multilateral trade liberalization (economic integration). In particular we have compared reductions in real variable trade costs (iceberg costs), real fixed export costs and lump-sum redistributed unit and ad valorem tariffs in a Melitz (2003) type model, along a criterion of equal effect on trade openness. Our key findings are i) the welfare ranking is sensitive to the degree of efficiency in tariff redistribution as ad valorem tariffs moves from the least to the most preferred mode of liberalization as the fraction of tariffs wasted on rent-seeking activities moves from zero to unity and ii) when only parts of tariff revenue is wasted reductions in real variable trade costs are preferred to reductions in real fixed trade costs which again is preferred to an iceberg type unit tariff. These findings are driven by the fact that various modes of trade liberalization have different effects on the industry structure (including aggregate productivity) and on the number of varieties available to the consumers. Moreover the paper stresses that the preferred mode of trade liberalization may depend on the degree of rent-seeking activities and thereby indirectly on strength of institutions.

The paper demonstrates that the model family following Melitz (2003) can straightforwardly be extended beyond the simple iceberg trade costs assumption, by including redistributed tariffs, while remaining highly tractable. These extensions are of relevance to applications in policy modeling and for taking the model back to data and episodes of real world economic integration. Taking our findings beyond the narrow formal framework in which they are derived, they have implications for the understanding and analysis of real world integration episodes. First, studies assessing the welfare gains from tariff liberalizations as managed within WTO, NAFTA or the European customs union will tend to overstate the gains from liberalization if tariff cuts are modeled as iceberg cost reductions. Second, the findings of the present paper have implications for the sequencing of trade liberalization. While the largest welfare gains for sufficiently efficient tariff redistribution are to be harvested by reductions in real trade costs, these parameters rarely feature on the political agenda; in contrast the central weight in post World War II trade policy has been on tariff cuts. The reason for this is, of course, that many of the parameters determining real trade costs are outside the realm of traditional political negotiations. Transport technologies, costs of information flows, and costs of conducting business across borders are much less subject to politics as they are subject to technological advance and possibility. Still, issues such as time wasted in transit and border controls, common standards, and demands of foreign regulation and red-tape may clearly be influenced by international agreements. The present paper has shown that the largest gains from trade are to be harvested when tackling these types of real trade barriers.
Appendix: Proofs

Proof of Lemma 1: Follows by inspection of (4) and the derivatives of the welfare expression (6) with respect to $\chi$.

Proof of Lemma 2: Follows directly from the derivatives of the welfare expression (6) with respect to the various trade costs.

Proof of Lemma 3: Follows directly from the derivatives of openness (7) with respect to the various trade costs.

Proof of Lemma 4: That trade liberalization in any dimension increases the exit threshold follows directly from the partial derivatives of (4). The ranking among trade liberalizations with an equal impact on openness ($\Theta$) follows from the derivatives of (11) yielding $\frac{\partial c_0}{\partial T} = \frac{\partial c_0}{\partial F_X} = \frac{\partial c_0}{\partial T} = 0$ and $\frac{\partial c_0}{\partial T} < 0$, where $\frac{dF_X}{dT} = \frac{dT}{dT}$ and $\frac{dT}{dT}$ follows from (8)-(10).

Proof of Proposition 1: Apply (8)-(10) to obtain $\frac{\partial W_{\Theta}}{\partial F_X} = 0$, $\frac{\partial W_{\Theta}}{\partial T} = -1 + 1 - \chi_l \left[ \frac{1}{\tau} \left( \frac{1 + \tau}{1 + \sigma + \tau} \right) \right] \leq 0$, $\frac{\partial W_{\Theta}}{\partial T} = 1 - \chi_l \left[ \frac{1}{\tau} \left( \frac{1 + \tau}{1 + \sigma + \tau} \right) \right] \leq 0$ and $\frac{\partial W_{\Theta}}{\partial T} = W_{\Theta} \left[ 1 + \tau + \frac{2}{\tau} \right] k \frac{\tau - \chi}{\tau - 1}$ for $x = t, \tau, F_X$ and $\frac{\partial W_{\Theta}}{\partial T} \bigg|_{\chi = 1} > \frac{\partial W_{\Theta}}{\partial T} \bigg|_{\chi = 1} > \frac{\partial W_{\Theta}}{\partial T} \bigg|_{\chi = 1}$ which proves the third result.

Proof of Proposition 2: It follows from (13) that $\frac{\partial T^{R_\Theta}}{\partial T} < \frac{\partial T^{R_\Theta}}{\partial F_X} = 0 < \frac{\partial T^{R_\Theta}}{\partial T} < \frac{\partial T^{R_\Theta}}{\partial T} \frac{dT}{dT}$, where $\frac{dF_X}{dT} = \frac{dT}{dT}$ and $\frac{dT}{dT}$ follows from (8)-(10).

Proof of Proposition 3: The first follows directly from noting that $\frac{\partial p_{x,\Theta}}{\partial F_X} = \left( \frac{\tau}{\tau} \right)^{-k} \left( \frac{1}{\tau} \right) F_X \left( \frac{1}{\tau} \right)$ and by using Lemma 2. The rest follows from applying that $\frac{\partial p_{x,\Theta}}{\partial F_X} = \left( \frac{\tau}{\tau} \right)^{-k} \frac{1}{\tau} F_X \left( \frac{1}{\tau} \right)$ and the ranking comes from noting that $\frac{\partial p_{x,\Theta}}{\partial F_X} = 0$, $\frac{\partial p_{x,\Theta}}{\partial T} = -M_{\Theta} \left[ 1 - \chi_l \left( \frac{1 + \tau}{1 + \sigma + \tau} \right) \right] \leq 0$, $\frac{\partial p_{x,\Theta}}{\partial T} = M_{\Theta} \left[ \frac{2}{\tau} \right] \left( \frac{1}{\tau} \right) \left( \frac{1}{\tau} \right)$ for $x = t, \tau, F_X$ and $\frac{\partial p_{x,\Theta}}{\partial T} \bigg|_{\chi = 1} > \frac{\partial p_{x,\Theta}}{\partial T} \bigg|_{\chi = 1} > \frac{\partial p_{x,\Theta}}{\partial T} \bigg|_{\chi = 1}$ which proves the third result.
References


