Unilateral Trade Liberalization and Welfare Analysis:

Iceberg Trade Costs versus Tariffs

Türkmen Göksel

Additional information is available at the end of the chapter

Abstract

A large body of literature in international economics has tried to explain the effect of asymmetric changes in trade barriers in welfare of the liberalizing country, however, there is no consensus on this issue. In this paper, I focus on the implications of a decline in import costs in welfare of the liberalizing country. I utilize a version of computational general equilibrium model of international trade (based on Armington assumption) where countries are potentially asymmetric in terms of labor endowment, productivity, trade barriers etc. under two different specifications of trade costs: (i) standard iceberg cost formulation and (ii) tariffs. The model numerically proves that unilateral trade liberalization is welfare improving for the liberalizing country in Armington setup with iceberg costs. However, when using tariffs, I numerically show that there exists a positive optimal tariff rate which maximizes welfare. This result indicates that a reduction in tariffs may either benefit or immiserize the liberalizing country depending on the pre-liberalization value of tariff. In the literature, a simple formula has been driven which shows the gains from trade for the case of iceberg costs. I generalize this formula in Armington setup with tariffs and highlight the importance of revenue generating tariffs.

Keywords: unilateral trade liberalization, iceberg costs, tariffs, computational general equilibrium, welfare

1. Introduction

In this paper, I focus on the implications of a decline in import costs (in terms of both iceberg costs and tariffs) in welfare[1] of the liberalizing country. There is a vast literature on the effect of asymmetric changes in trade costs in welfare of the liberalizing country; however, there is no consensus on this issue. Moreover, Eaton and Kortum (2002) [1] derive a simple formula which shows the gains from trade and this formula is generalized by Arkolakis, Costinot, and Rodriguez-Clare (2012) [2] in the case of iceberg costs. I also generalize this formula in Armington setup with tariffs and highlight the importance of revenue generating tariffs.

In Melitz [3] setup with two large but possibly asymmetric economies, unilateral trade liberalization in terms of iceberg costs is welfare improving for the liberalizing country. Similarly, in a version of the Melitz [3] model for the case of a small economy, Demidova and Rodriguez-Clare [4] also establish that welfare increases for a country that unilaterally reduces importing trade barriers in terms of iceberg costs.

These results stand in sharp contrast to two different types of models. In the first category, Felbermayr and Jung [5] show that in a two-country Melitz [3] setup, unilateral liberalization of import tariffs lowers welfare of the liberalizing country. Demidova and Rodriguez-Clare [6] also show the existence of an optimal tariff in the small economy version of the Melitz [3] model suggesting that reduction in tariffs (compared to optimal level) lowers the welfare in the liberalizing country. As mentioned in [5], the reason behind this argument is that tariffs redistribute income across countries and this generates additional leverage to the selection effect in the models with firm-level heterogeneity.

In the second category, including [7–9], trade liberalization in home country results in a welfare loss. In this category, the difference arises from the presence of an outside sector that pins down the wages. However, these setups with outside sector ignore the general equilibrium forces that are crucial for the welfare analysis. Therefore, Demidova [7], Melitz and Ottaviano [8], Ossa [9] predict immiserization for the liberalizing country due to unilateral trade liberalization. Felbermayr and Jung [5] also point out that the assumption of a linear outside sector distorts the welfare predictions of the model: In a Melitz and Ottaviano [8] setup (due to a reduction in import costs), firms in liberalizing country relocate into the relatively more protected market (outside sector) from where they serve the liberalized economy. However, in Melitz [3] (without an outside sector) setup with Pareto assumption,[2] the wage adjustment is exactly such that the relocation channel is compensated.

This paper utilizes a version of computational general equilibrium model of international trade (based on Armington assumption) where countries are possibly asymmetric in terms of labor endowment, productivity, trade costs, etc., under two different specifications: iceberg costs and tariffs. This paper aims to compute the effects of unilateral trade liberalization in welfare of the

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[1]Given the class of models considered in this study, I use the terms welfare and real income interchangeably throughout the paper.

[2]This distributional assumption is widely used in the literature. Besides the analytical convenience of this distribution, Eaton et al. [10], among others, document that this distribution provides a reasonable approximation for the observed distribution of firm sizes.

liberalizing country in both specifications. To achieve this goal, I follow two main steps for each version. I first define and characterize the general equilibrium. In other words, I obtain a system of nonlinear equations which should be solved numerically. Second, after determining the parameters, I compute the equilibrium with numerical methods (using MATLAB). The model numerically proves that unilateral trade liberalization is welfare improving for the liberalizing country in Armington setup with iceberg costs. However, with tariffs, I numerically show that there exists a positive optimal tariff rate which maximizes welfare suggesting that a reduction in tariffs may either increase or decrease welfare of the liberalizing country depending on the pre-liberalization value of tariff.

This paper also discusses the extensions of a simple formula which is first derived by Eaton and Kortum [1] and then generalized by Arkolakis et al. [2]. These papers focus on welfare gains from trade relative to autarky in the case of iceberg costs. I generalize this formula in Armington setup with tariffs and highlight the important difference between these two formulas.

The next section presents two specifications of the model and characterizes the equilibrium for each case. Section 3 discusses the results of the numerical computations. Section 4 analytically analyzes the welfare gains from trade. Finally, Section 5 concludes.

2. Model

I utilize a version of Armington model [11–13] with two different specifications. In the first specification, I assume that trade costs are in terms of standard iceberg formulation. However, in the second case, I assume that trade costs are in terms of tariffs and tariff revenue is redistributed to the consumers in a lump-sum fashion. In both versions, there are N countries indexed by $i, j = 1, \ldots, N$ where i and j denote exporters and importers, respectively. Each country has a population of measure L and I assume that all consumers are identical within countries. Armington setup is based on the assumption that each country produces a different good. Consumers in each country value not just domestically produced goods but also goods produced by foreign countries.

2.1. Model with iceberg costs

2.1.1. Demand

Country j maximizes the following constant elasticity of substitution (CES) utility function, U_j, over N goods each produced by a different country:

$$\max_{x_{ij}} U_j = \left(\sum_{i=1}^{N} \alpha_{ij}^{\frac{1}{\sigma}} x_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where x_{ij} is the consumption in country j of a good produced in country i. Therefore, x_{jj} denotes the consumption of domestic good. $\alpha_{ij} > 0$ is the demand parameter that reflects the preferences of country j toward goods produced in i. The elasticity of substitution across good varieties is given by $\sigma > 1$. A higher value of σ implies goods that are more substitutable. Each

consumer in country j has one unit of labor endowment which is in elastically supplied in a competitive labor market. Country j faces the following budget constraint:

$$\sum_{i=1}^{N} p_{ij} x_{ij} = w_j L_j \tag{2}$$

where p_{ij} is the price of a good produced in country i which is consumed by country j. Therefore, p_{jj} denotes the price of domestic good. w_j denotes the nominal wage in country j, and $w_j L_j$ is the total (nominal) income of country j.

The utility maximization subject to the budget constraint yields the following demand function of country j toward goods produced in i:

$$x_{ij} = \alpha_{ij} \left(\frac{p_{ij}}{P_j}\right)^{-\sigma} \frac{w_j L_j}{P_j} \tag{3}$$

where $P_j = (\sum_{i=1}^{N} \alpha_{ij} p_{ij}^{1-\sigma})^{\frac{1}{1-\sigma}}$ is the price index in country j. Note that the elasticity of substitution across good is defined as $\dfrac{\partial \ln\left(\frac{x_{ii}}{x_{ij}}\right)}{\partial \ln\left(\frac{p_{ii}}{p_{ij}}\right)}$. Using Eq. (3), I get the ratio of $\frac{x_{ii}}{x_{ij}}$ and by taking the logarithm of both sides, I obtain:

$$\ln\left(\frac{x_{ii}}{x_{ij}}\right) = -\sigma \ln\left(\frac{p_{ii}}{p_{ij}}\right) + (\sigma-1)\ln\left(\frac{P_i}{P_j}\right) + \ln\left(\frac{\alpha_{ii} w_i L_i}{\alpha_{ij} w_j L_j}\right) \tag{4}$$

Using Eq. (4), I simply get $\dfrac{\partial \ln\left(\frac{x_{ii}}{x_{ij}}\right)}{\partial \ln\left(\frac{p_{ii}}{p_{ij}}\right)} = -\sigma$. This result implies that the elasticity of substitution between good x_{ii} and x_{ij} is equal to σ.

2.1.2. Supply

Goods are produced in competitive markets. Labor is the only factor of production. In country i, there is a representative producer which has the constant returns to scale production technology: $y_{ij} = \phi_i l_{ij}$, where y_{ij} is the output produced in country i which is sold to country j, ϕ_i is the productivity level in country and l_{ij} is the labor amount used to produce good in country i in order to sell to country j. Hence, each country has potentially different productivity levels. τ_{ij} is the standard iceberg formulation of trade costs. $\tau_{ij} > 1$ implies that if one unit of good is shipped from country i to country j, only a fraction, $\frac{1}{\tau_{ij}}$, of the good arrives. There are no trade costs for domestic goods: $\tau_{ii} = 1$. Both production and trade costs are in terms of labor.

The profit maximization of a representative producer in country i when selling to country j is given by:

$$\max_{x_{ij}} p_{ij} x_{ij} - \frac{w_i x_{ij} \tau_{ij}}{\phi_i} \tag{5}$$

The profit maximization in competitive markets yields the following price rule:

$$p_{ij} = \frac{w_i \tau_{ij}}{\phi_i} \tag{6}$$

2.1.3. Equilibrium conditions

In order to fully characterize the equilibrium, one needs two more conditions. I first consider the labor market clearing condition. This condition implies that labor supply has to be equal to the total labor demand in country i. Hence, labor market clearing condition for country i can be written as:

$$L_i = \sum_{j=1}^{N} \frac{x_{ij} \tau_{ij}}{\phi_i} \tag{7}$$

Second equilibrium condition is the balanced trade condition. This condition implies that the value of total imports has to be equal to the value of total exports of country i. Balanced trade condition for country i can be written as:

$$\sum_{j=1(i \neq j)}^{N} p_{ij} x_{ij} = \sum_{j=1(i \neq j)}^{N} p_{ji} x_{ji} \tag{8}$$

2.1.4. Characterization of equilibrium

The equilibrium is characterized by N^2 demand equations, N labor market clearing conditions and $\frac{N^2-N}{2}$ balanced trade equations. Hence, in total, one needs $\frac{3N^2+N}{2}$ equations to characterize the equilibrium. In particular, for a two-country model ($N = 2$), the seven equilibrium equations are given by:

$$x_{11} = \alpha_{11} \left(\frac{p_{11}}{P_1}\right)^{-\sigma} \frac{w_1 L_1}{P_1} \tag{9}$$

$$x_{12} = \alpha_{12} \left(\frac{p_{12}}{P_2}\right)^{-\sigma} \frac{w_2 L_2}{P_2} \tag{10}$$

$$x_{22} = \alpha_{22} \left(\frac{p_{22}}{P_2}\right)^{-\sigma} \frac{w_2 L_2}{P_2} \tag{11}$$

$$x_{21} = \alpha_{21} \left(\frac{p_{21}}{P_1}\right)^{-\sigma} \frac{w_1 L_1}{P_1} \tag{12}$$

$$L_1 = \frac{x_{11} \tau_{11}}{\phi_1} + \frac{x_{12} \tau_{12}}{\phi_1} \tag{13}$$

$$L_2 = \frac{x_{21}\tau_{21}}{\phi_2} + \frac{x_{22}\tau_{22}}{\phi_2} \tag{14}$$

$$p_{21}x_{21} = p_{12}x_{12} \tag{15}$$

However, the given system has twelve unknown variables: eight prices $(p_{11}, p_{12}, p_{21}, p_{22}, w_1, w_2, P_1, P_2)$ and four consumption quantities $(x_{11}, x_{12}, x_{21}, x_{22})$, but only seven equations. By using the definition of price index $P_j = (\sum_{i=1}^{N}\alpha_{ij}p_{ij}^{1-\sigma})^{\frac{1}{1-\sigma}}$, the solution of profit maximization problem $p_{ij} = \frac{w_i\tau_{ij}}{\phi_i}$ and normalizing one of the prices, (p_{22}), to one, the equilibrium is characterized by a system of seven unknowns and seven equations:

$$x_{11} = \alpha_{11}p_{11}^{-\sigma}\frac{w_1L_1}{\alpha_{11}p_{11}^{1-\sigma} + \alpha_{21}\tau_{21}^{1-\sigma}} \tag{16}$$

$$x_{12} = \alpha_{12}(p_{11}\tau_{12})^{-\sigma}\frac{w_2L_2}{\alpha_{22} + \alpha_{12}(p_{11}\tau_{12})^{1-\sigma}} \tag{17}$$

$$x_{22} = \alpha_{22}\frac{w_2L_2}{\alpha_{22} + \alpha_{12}(p_{11}\tau_{12})^{1-\sigma}} \tag{18}$$

$$x_{21} = \alpha_{21}\tau_{21}^{-\sigma}\frac{w_1L_1}{\alpha_{11}p_{11}^{1-\sigma} + \alpha_{21}\tau_{21}^{1-\sigma}} \tag{19}$$

$$L_1 = \frac{x_{11}}{\phi_1} + \frac{x_{12}\tau_{12}}{\phi_1} \tag{20}$$

$$L_2 = \frac{x_{21}\tau_{21}}{\phi_2} + \frac{x_{22}}{\phi_2} \tag{21}$$

$$\tau_{21}x_{21} = p_{11}\tau_{12}x_{12} \tag{22}$$

Given the value of parameters and price normalization, one has to solve for three prices (p_{11}, w_1, w_2) and four consumption quantities $(x_{11}, x_{12}, x_{21}, x_{22})$. I use MATLAB in order to solve this nonlinear equation system.

2.2. Model with tariffs

2.2.1. Demand

Now, I assume that trade barriers are in terms of tariffs rather than iceberg trade costs. In this setup, tariff revenue from imports is redistributed to the consumers in a lump-sum fashion. The only change in country j's utility maximization problem is the budget constraint:

$$\sum_{i=1}^{N}p_{ij}x_{ij} = w_jL_j + T_j \tag{23}$$

where T_j represents the tariff revenue of country j.

The utility maximization subject to this new budget constraint yields the following demand equation:

$$x_{ij} = \alpha_{ij} \left(\frac{p_{ij}}{P_j}\right)^{-\sigma} \frac{w_j L_j + T_j}{P_j} \tag{24}$$

where $P_j = (\sum_{i=1}^{N} \alpha_{ij} p_{ij}^{1-\sigma})^{\frac{1}{1-\sigma}}$ is the price index in country j.

2.2.2. Supply

The only change in firm's problem is that τ_{ij} is treated as tariffs rather than iceberg costs. Tariffs are rebated lump sum to the consumers. The solution for profit maximization of a representative producer in country i when selling to country j in competitive markets is unchanged:

$$p_{ij} = \frac{w_i \tau_{ij}}{\phi_i} \tag{25}$$

2.2.3. Equilibrium conditions

In order to fully characterize the equilibrium, one needs three conditions: labor market clearing condition, the balanced trade condition and the tariff revenue that has to be fully redistributed to the consumers.

Labor market clearing implies that labor supply in country has to be equal to the total labor demand in country i:

$$L_i = \sum_{j=1}^{N} \frac{x_{ij}}{\phi_i} \tag{26}$$

Note that in contrast to the iceberg formulation, there are no additional production and employment for tariffs. Second equilibrium condition is the balanced trade condition. This condition implies that the value of total imports has to be equal to the value of total exports of country i. Balanced trade condition for country i can be written as

$$\sum_{j=1(i\neq j)}^{N} \frac{p_{ij} x_{ij}}{\tau_{ij}} = \sum_{j=1(i\neq j)}^{N} \frac{p_{ji} x_{ji}}{\tau_{ji}} \tag{27}$$

where dividing by τ_{ij} takes care of $p_{ij} x_{ij}$ being defined as inclusive of tariffs. Note that $p_{ij} x_{ij}$ is the value of imports of country j from i inclusive of tariffs. However, $\frac{p_{ij} x_{ij}}{\tau_{ij}}$ is the value of imports exclusive of tariffs.

Finally, tariff revenue in country j is given by:

$$T_j = p_{ij} x_{ij} (\tau_{ij} - 1) \tag{28}$$

2.2.4. Characterization of equilibrium

Consider a two-country $(N = 2)$ case. Normalizing one of the prices, p_{22}, to one, the equilibrium is characterized by a system of nine unknowns and nine equations:

$$x_{11} = \alpha_{11} p_{11}^{-\sigma} \frac{w_1 L_1 + T_1}{\alpha_{11} p_{11}^{1-\sigma} + \alpha_{21} \tau_{21}^{1-\sigma}} \tag{29}$$

$$x_{12} = \alpha_{12} (p_{11} \tau_{12})^{-\sigma} \frac{w_2 L_2 + T_2}{\alpha_{22} + \alpha_{12} (p_{11} \tau_{12})^{1-\sigma}} \tag{30}$$

$$x_{22} = \alpha_{22} \frac{w_2 L_2 + T_2}{\alpha_{22} + \alpha_{12} (p_{11} \tau_{12})^{1-\sigma}} \tag{31}$$

$$x_{21} = \alpha_{21} \tau_{21}^{-\sigma} \frac{w_1 L_1 + T_1}{\alpha_{11} p_{11}^{1-\sigma} + \alpha_{21} \tau_{21}^{1-\sigma}} \tag{32}$$

$$L_1 = \frac{x_{11}}{\phi_1} + \frac{x_{12}}{\phi_1} \tag{33}$$

$$L_2 = \frac{x_{21}}{\phi_2} + \frac{x_{22}}{\phi_2} \tag{34}$$

$$p_{22} x_{21} = p_{11} x_{12} \tag{35}$$

$$T_1 = p_{22} x_{21} (\tau_{21} - 1) \tag{36}$$

$$T_2 = p_{11} x_{12} (\tau_{12} - 1) \tag{37}$$

Given the value of parameters and price normalization, one has to solve for three prices (p_{11}, w_1, w_2), four consumption quantities $(x_{11}, x_{12}, x_{21}, x_{22})$ and tariff revenue for both countries, T_1 and T_2.

3. Numerical exercises: unilateral trade liberalization

3.1. Iceberg costs

Consider two symmetric countries: home (country 1) and foreign (country 2). Main goal of this section is to compute the effects of unilateral trade liberalization (at home) in welfare. In a benchmark model, I assume that $\tau_{12} = \tau_{21} = 1.2$. In the counterfactual analysis, I set import barriers in terms of iceberg costs for home country (τ_{21}) to 1 keeping τ_{12} unchanged. **Table 1** presents the parameter values which are used in numerical computations.

For the trade elasticity, I follow Anderson and Van Wincoop [14]. Anderson and Van Wincoop [14] suggest that the value for trade elasticity (ε) lies in the range of $[-10, -5]$ after a

comprehensive review of the existing literature. In our Armington setup, trade elasticity, ε, is equal to one minus elasticity of substitution across goods, $1-\sigma$.[3] In the numeric computations, I choose a value of 8 for σ in order to match $\varepsilon = -7$.

	Benchmark model	Counterfactual analysis
L_1	1	1
L_2	1	1
ϕ_1	1	1
ϕ_2	1	1
σ	8	8
α_{11}	0.6	0.6
α_{12}	0.4	0.4
α_{21}	0.4	0.4
α_{22}	0.6	0.6
τ_{11}	1	1
τ_{12}	1.2	1.2
τ_{21}	1.2	1
τ_{22}	1	1

Table 1. Parameter values.

Table 2 presents the computation results of both exercises: benchmark model and counterfactual analysis.

Computation results in **Table 2** imply that unilateral reduction in iceberg costs in country 1 increases the welfare in country 1. The mechanism is as follows: A decrease in import trade barriers in country 1 reduces the price of the imported good in country 1 which yields an increase in imports from country 2. To restore trade balance nominal wages in country should fall and this causes a decline in the price of domestic goods. The reduction in both prices (domestic and import) yields a reduction in aggregate price index in country 1 as well. The decrease in price index dominates the decrease in nominal wages and therefore, real income (welfare) in country 1 is increasing. Moreover, the unilateral reduction in iceberg costs in country 1 causes an increase in real income of country 2. However, the increase in country 2 is smaller than the increase in country 1.

Figure 1 depicts the welfare changes associated with unilateral trade liberalization (in terms of iceberg costs) in country 1 keeping $\tau_{12} = 1.2$ unchanged.

In **Figure 1**, I conclude that trade liberalization (in the case of iceberg costs) monotonically increases the welfare of the liberalizing country.

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[3]This result is proven in Section 4.

	Benchmark model (I)	Counterfactual analysis (II)	(II)/(I)
p_{11}	1	0.9202	0.9202
p_{12}	1.2	1.1043	0.9202
p_{21}	1.2	1	0.8333
p_{22}	1	1	1
w_1	1	0.9202	0.9202
w_2	1	1	1
P_1	1.0498	0.9461	0.9012
P_2	1.0498	1.0324	0.9834
Welfare$_1$	0.9526	0.9726	1.0210
Welfare$_2$	0.9526	0.9686	1.0167
Exports/GDP$_1$	15.69%	27.14%	1.7297
Imports/GDP$_1$	15.69%	27.14%	1.7297
Exports/GDP$_2$	15.69%	24.98%	1.5920
Imports/GDP$_2$	15.69%	24.98%	1.5920

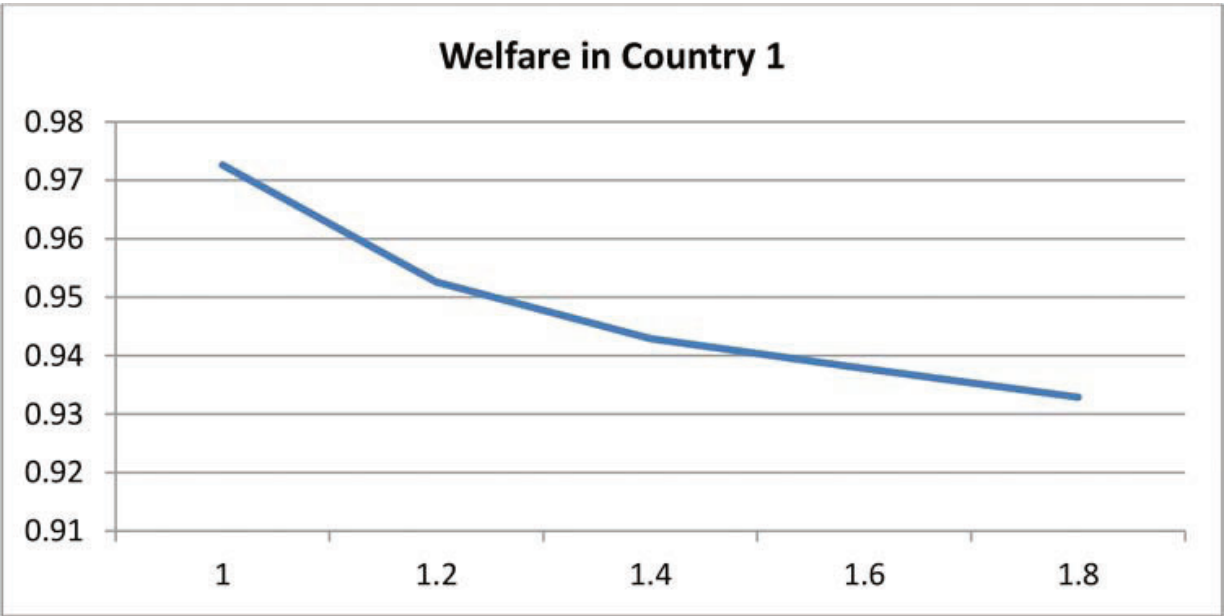**Table 2.** Computation results.

Figure 1. Welfare changes associated with unilateral trade liberalization (in terms of iceberg costs) in country 1.

3.2. Tariffs

Using the same parameters in **Table 1** for the benchmark and counterfactual analyses, **Table 3** presents the computation results of both exercises in the case of tariffs. Exports and imports values are presented in both ways (inclusive and exclusive in tariffs).

	Benchmark model (I)	Counterfactual analysis (II)	(II)/(I)
p_{11}	1	0.9092	0.9092
p_{12}	1.2	1.0910	0.9091
p_{21}	1.2	1	0.8333
p_{22}	1	1	1
w_1	1	0.9092	0.9092
w_2	1	1	1
P_1	1.0498	0.9377	0.8932
P_2	1.0498	1.0292	0.9803
Welfare$_1$	0.9781	0.9696	0.9913
Welfare$_2$	0.9781	1.0167	1.0394
Exports/GDP$_1$	13.07%	25.51%	1.9517
Imports/GDP$_1$	13.07%	25.51%	1.9517
Exports/GDP$_2$	13.07%	22.16%	1.6954
Imports/GDP$_2$	13.07%	22.16%	1.6954
Exports/GDP$_1$*	15.68%	25.51%	1.6269
Imports/GDP$_1$*	15.68%	25.51%	1.6269
Exports/GDP$_2$*	15.68%	22.16%	1.4132
Imports/GDP$_2$*	15.68%	22.16%	1.4132
Tariff revenue$_1$	0.0268	0	0
Tariff revenue$_2$	0.0268	0.0464	1.7313
Tariff revenue$_1$/GDP$_1$	2.61%	0%	0
Tariff revenue$_2$/GDP$_2$	2.61%	4.43%	1.6973
Tariff multiplier$_1$	1.0268	1	0.9738
Tariff multiplier$_2$	1.0268	1.0464	1.0190

* Inclusive of tariffs.

**Table 3.** Computation results.

In contrast to the iceberg cost formulation, unilateral trade liberalization causes a welfare loss in the liberalizing country 1. However, this result depends on pre-liberalization value of tariffs. **Figure 2** shows the welfare changes associated with unilateral trade liberalization in country 1 (in terms of tariffs) keeping $\tau_{12} = 1.2$ unchanged.

Figure 2 also implies that there exists an optimal positive tariff rate (which maximizes welfare) which is around 20% in our case.

3.3. Discussion: iceberg costs versus tariffs

Numerical solutions suggest that in Armington setup, iceberg cost and tariff formulations give the different welfare implications. Therefore, the type of trade barrier plays a crucial role in

computing the welfare gains due to trade liberalization. This result can be generalized (see [1, 3, 15, 16] for details).
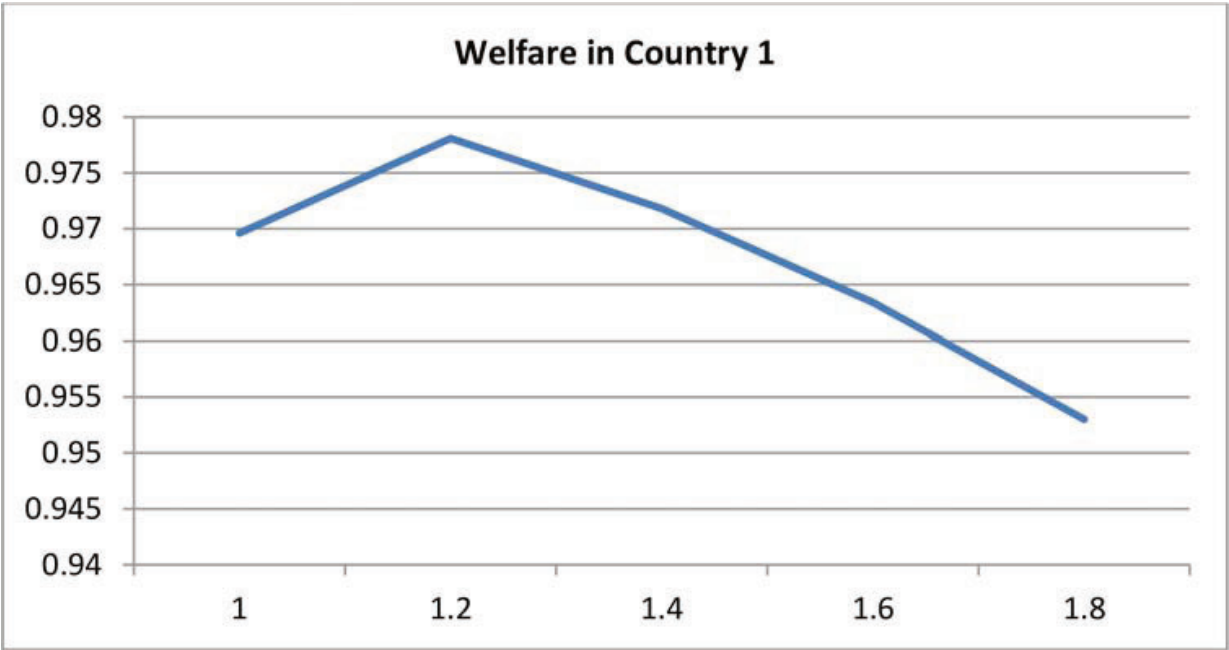
Figure 2. Welfare changes associated with unilateral trade liberalization (in terms of tariffs) in country 1.

Similar to my findings, Felbermayr and Jung [5] show that in a two-country Melitz [3] setup, unilateral liberalization of import tariffs lowers welfare of the liberalizing country. Demidova and Rodriguez-Clare [6] also show the existence of an optimal tariff in the small economy version of the Melitz [3] model, suggesting that reduction in tariffs (compared to optimal level) lowers the welfare in liberalizing country.

4. Gains from trade: welfare analysis

Eaton and Kortum [1] show that welfare gains from trade are function of only two elements in the case of iceberg costs: (i) the share of expenditure on domestic goods, which is equal to one minus the import penetration ratio and (ii) trade elasticity (an elasticity of imports with respect to variable iceberg trade costs). This result is generalized by Arkolakis et al. [2] for a large class of trade models, including the one used in this paper (version of Armington model), Eaton and Kortum [1], Krugman [15] and Melitzs [3] models in the case of iceberg costs.[4] This generalized result implies that although recent quantitative trade models can explain a wider set of micro-

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[4]The Frechet and the Parteo distributions are considered for productivities in Eaton and Kortum [1] and Melitz [3] frameworks, respectively.

level facts, all type of models mentioned above calculate the exact same amount of gains from trade in the case of iceberg costs. In summary, welfare gains from trade liberalization do not depend on the different models microstructure.[5]

However, this paper argues that the result generalized by Arkolakis et al. [2] is only true in the case of iceberg costs, but not in the tariff formulation, since the formula generalized by Arkolakis et al. [2] ignores the tariff redistribution.

Section 4.1 derives the simple formula which is generalized by Arkolakis et al. [2] in the case of iceberg costs. Section 4.2 extends the simple formula in the case of tariffs and highlights the important difference between two formulas.

4.1. Simple formula for the gains from trade: iceberg cost formulation

Arkolakis et al. [2] generalized a simple formula for the gains from trade for a large set of trade models including Armington [11], Krugman [15], Eaton and Kortum [1] and Melitz [3] models in the case of iceberg costs. In order to compute the gains from trade by this simple formula, one only needs two elements: (i) the share of expenditure on domestic goods (λ_{jj}) and (ii) elasticity of imports with respect to iceberg costs, $(1-\sigma)$.

Using our model in Section 3, let's first show that trade elasticity (elasticity of imports with respect to iceberg costs) which is defined as $\frac{\partial \ln(X_{ij}/X_{jj})}{\partial \ln \tau_{ij}}$ is equal to $(1-\sigma)$. Second, one can write the share of expenditure on domestic goods, λ_{jj}, just in terms of prices. Finally, one can relate these two elements with welfare (real income) definition $W_j = \frac{w_j}{P_j}$ in country j.

For the first step, let's write the equation for imports of country j from country i:

$$x_{ij} = \alpha_{ij} \left(\frac{p_{ij}}{P_j} \right)^{-\sigma} \frac{w_j L_j}{P_j} \qquad (38)$$

Let's multiply both sides by p_{ij} in order to get the value of imports (rather than quantities) of country j from country i which is denoted by X_{ij}:

$$X_{ij} = \alpha_{ij} \left(\frac{p_{ij}}{P_j} \right)^{1-\sigma} w_j L_j \qquad (39)$$

Let's derive X_{ij}/X_{jj} by using the equality of $p_{ij} = \frac{w_i \tau_{ij}}{\phi_i}$ (recall that $\tau_{jj} = 1$):

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[5]Arkolakis et al. [2] discuss some extensions of their result. Adding multiple sectors, tradable intermediate goods or multiple factors of production into the model can change the validity of their result. In particular, Balistreri et al. [17] add a second non-tradable sector and they show that models with perfect and monopolistic competition no longer have the same welfare implications.

$$\frac{X_{ij}}{X_{jj}} = \frac{\alpha_{ij}}{\alpha_{jj}} \left(\frac{w_i}{w_j} \frac{\phi_j}{\phi_i} \tau_{ij} \right)^{1-\sigma} \tag{40}$$

Taking the natural logarithm of both sides of Eq. (40), I obtain:

$$ln\left(\frac{X_{ij}}{X_{jj}}\right) = ln\left(\frac{\alpha_{ij}}{\alpha_{jj}}\right) + (1-\sigma)ln\left(\frac{w_i}{w_j}\frac{\phi_j}{\phi_i}\right) + (1-\sigma)ln(\tau_{ij}) \tag{41}$$

By using Eq. (41), after the simple math, I get:

$$\frac{\partial ln\left(\frac{X_{ij}}{X_{jj}}\right)}{\partial ln\tau_{ij}} = (1-\sigma) \tag{42}$$

Hence, the trade elasticity (elasticity of imports with respect to iceberg costs) is equal to one minus elasticity of substitution across good varieties.

For the second step, I use the definition $\lambda_{jj} \equiv \frac{X_{jj}}{\sum_{i=1}^{N} X_{ij}}$. Using Eq. (39) and $\sum_{i=1}^{N} X_{ij} = w_j L_j$ equality, I can rewrite this equation as follows:

$$\lambda_{jj} = \frac{\alpha_{jj}\left(\frac{p_{jj}}{P_j}\right)^{1-\sigma} w_j L_j}{w_j L_j} = \alpha_{jj}\left(\frac{p_{jj}}{P_j}\right)^{1-\sigma} \tag{43}$$

After solving for $\frac{p_{jj}}{P_j}$, I obtain:

$$\frac{p_{jj}}{P_j} = \left(\frac{\lambda_{jj}}{\alpha_{jj}}\right)^{\frac{1}{1-\sigma}} \tag{44}$$

For the final step, let's define welfare in country j, W_j, which is measured by the real income $\frac{w_j}{P_j}$. Using the $p_{jj} = \frac{w_j}{\phi_j}$ result (recall that $\tau_{jj} = 1$), I can rewrite the real income as:

$$\frac{w_j}{P_j} = \frac{p_{jj}\phi_j}{P_j} \tag{45}$$

Finally, by substituting $\frac{p_{jj}}{P_j} = \left(\frac{\lambda_{jj}}{\alpha_{jj}}\right)^{\frac{1}{1-\sigma}}$ into the Eq. (45), I get W_j as follows:

$$W_j = \frac{w_j}{P_j} = \lambda_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j \tag{46}$$

Welfare gains from trade can be shown as the change in welfare before and after trade:

$$\frac{\hat{W}_j}{W_j} = \frac{\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j}{\lambda_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j} = \left(\frac{\hat{\lambda}_{jj}}{\lambda_{jj}}\right)^{\frac{1}{1-\sigma}} \tag{47}$$

where $\hat{W}_j$ and W_j denote welfare after and before trade, respectively. Since I focus on trade liberalization, I assume that there is no change in other parameters such as α_{jj} and ϕ_j. I conclude that to compute the change in welfare due to trade liberalization, one only needs to know the change in share of expenditure on domestic goods and trade elasticity, $\varepsilon = 1-\sigma$.

Let's apply our formula to the numerical exercise in Section 3.1 for country 1. 0.1569 and 0.2714 are the share of imports to GDP before and after unilateral trade liberalization (reduction in τ_{21} from 1.2 to 1), respectively. Hence, I get $1 - 0.1569 = 0.8431$ before trade liberalization and $1 - 0.2714 = 0.7286$ after trade liberalization as the share of expenditures on domestic goods. In Section 3, I assume that the elasticity of substitution across good is eight suggesting a value of -7 ($\varepsilon = 1-8 = -7$) for the trade elasticity. Now, let's substitute these values into our simple formula:

$$\frac{\hat{W}_j}{W_j} = \left(\frac{\hat{\lambda}_{jj}}{\lambda_{jj}}\right)^{\frac{1}{1-\sigma}} = \left(\frac{0.7286}{0.8431}\right)^{\frac{1}{1-8}} = 1.0210 \tag{48}$$

National income in country 1 increased by 2.1% due to unilateral trade liberalization which is the same result I obtain in **Table 2**.

4.2. Simple formula for the gains from trade: tariff formulation

This section extends the simple formula derived by Arkolakis et al. [2]. In this section, I assume that trade barriers are in the form of tariffs rather than iceberg costs. In order to compute the gains from trade by the extended formula, one needs three elements rather than two: (i) the share of expenditure on domestic goods (λ_{jj}), (ii) elasticity of imports with respect to tariffs ($1-\sigma$) and (iii) a tariff multiplier (β_j).

Applying the similar steps with the previous section (the case of iceberg costs), I obtain the same equation for $\frac{p_{jj}}{P_j}$ in the case of tariffs:

$$\frac{p_{jj}}{P_j} = \left(\frac{\lambda_{jj}}{\alpha_{jj}}\right)^{\frac{1}{1-\sigma}} \tag{49}$$

However, in the case of tariff, total income in country j is $X_j = w_j L_j + T_j$ rather than just $w_j L_j$. Now, let's drive the tariff multiplier, β_j, for country j. By definition, I have:

$$X_j \equiv X_j \tag{50}$$

Multiplying RHS by $\frac{w_j L_j}{w_j L_j}$ I obtain:

$$X_j \equiv X_j \frac{w_j L_j}{w_j L_j} \tag{51}$$

Since I know that $w_j L_j = X_j - T_j$

$$X_j \equiv X_j \frac{w_j L_j}{X_j - T_j} \tag{52}$$

Hence, I have:

$$X_j = \beta_j w_j L_j \tag{53}$$

where $\beta_j = \frac{X_j}{X_j - T_j}$ is the tariff multiplier. Since $X_j - T_j < X_j$ with positive tariff revenues, multiplier β_j takes values >1. I can rewrite β_j as $\left(1 - \frac{T_j}{X_j}\right)^{-1}$ which is the inverse of one minus the share of tariffs in total income. Hence, it is enough to know the share of tariffs in total income in order to compute the tariff multiplier. Given the tariff multiplier, the real income is equal to $\beta_j \frac{w_j}{P_j}$. Using the $p_{jj} = \frac{w_j}{\phi_j}$ result (recall that $\tau_{jj} = 1$), one can rewrite the real wage as:

$$\beta_j \frac{w_j}{P_j} = \beta_j \frac{p_{jj} \phi_j}{P_j} \tag{54}$$

Finally, by substituting $\frac{p_{jj}}{P_j} = \left(\frac{\lambda_{jj}}{\alpha_{jj}}\right)^{\frac{1}{1-\sigma}}$ into Eq. (54), I get W_j as follows:

$$W_j = \beta_j \frac{w_j}{P_j} = \beta_j \lambda_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j \tag{55}$$

Welfare gains from trade can be shown as the change in welfare before and after trade:

$$\frac{\hat{W}_j}{W_j} = \frac{\hat{\beta}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j}{\beta_j \lambda_{jj}^{\frac{1}{1-\sigma}} \alpha_{jj}^{\frac{1}{\sigma-1}} \phi_j} = \frac{\hat{\beta}_j}{\beta_j} \left(\frac{\hat{\lambda}_{jj}}{\lambda_{jj}}\right)^{\frac{1}{1-\sigma}} \tag{56}$$

where $\hat{W}_j$ and W_j denote welfare after and before trade, respectively. Since I focus on trade liberalization, I assume that there is no change in other parameters such as α_{jj} and ϕ_j. I conclude that to compute the change in welfare due to trade liberalization, one only needs to know changes in share of expenditure on domestic goods, trade elasticity and the tariff multiplier.

Let's apply our formula to the numerical exercise in Section 3.2 for country 1. 0.1568 and 0.2551 are the share of imports to GDP (inclusive of tariffs) before and after unilateral trade liberalization (reduction in τ_{21} from 1.2 to 1), respectively, in the case of tariffs. Hence, I get $1 - 0.1568 = 0.8432$ before trade liberalization and $1 - 0.2551 = 0.7449$ after trade liberalization as the share of expenditures on domestic goods. In Section 3, I assume that the elasticity of substitution

across good is 8 suggesting a value of −7 for the trade elasticity. Now, let's substitute these values into our simple formula and I obtain:

$$\frac{\hat{W}_j}{W_j} = \left(\frac{\hat{\lambda}_{jj}}{\lambda_{jj}}\right)^{\frac{1}{1-\sigma}} \frac{\hat{\beta}_j}{\beta_j} = \left(\frac{0.7449}{0.8432}\right)^{\frac{1}{1-8}} \frac{1}{1.0268} = 0.9913 \tag{57}$$

National income in country 1 decreased due to unilateral trade liberalization which is the same result I obtain in **Table 3**.

5. Conclusion

Although there is a fairly sizable literature in international trade, there is no general agreement on the implications of unilateral trade liberalization in welfare of the liberalizing country. This paper studies the effects of a decline in import costs (in terms of both iceberg cost and tariffs) in welfare of the liberalizing country. Based on Armington model, I numerically show that unilateral trade liberalization is welfare improving for the liberalizing country in the case of iceberg costs. However, in the tariff case, I numerically show that there exists a positive optimal tariff rate which maximizes welfare, suggesting that a reduction in tariffs may either increases or decreases welfare of liberalizing country depending on the pre-liberalization value of tariff.

Moreover, this paper also discusses the welfare gains from trade with a simple equation which is derived by Eaton and Kortum [1] and generalized by Arkolakis et al. [2] in the case of iceberg costs. I generalize this formula in Armington setup with tariffs and highlight the importance of revenue-generating tariffs.

Author details

Türkmen Göksel

Address all correspondence to: tgoksel@ankara.edu.tr

Department of Economics, Ankara University, Turkey

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