# Gains From Trade With Heterogeneous Agents Under Financial Constraints

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**Abstract**

We aim to quantify gains from trade in a general equilibrium setting with heterogeneous households with both trade frictions for firms and financial frictions for households. Households face idiosyncratic earning shocks but are constrained in their ability to save by savings fixed cost and minimum savings requirements. This is combined with a standard trade model with homogeneous firms in a two country setting where the firms rent capital and labor from domestic households. Iceberg costs of exporting is the exogenous shock that generates changes in trade volume, which in turn generates winners and losers from trade. Financial frictions are expected to generate lower gains from trade by limiting households' access to financial instruments.

**Keywords**: Gains from trade, inequality, financial access.

**Preliminary version, please do not circulate.**

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# 1 Introduction

It is well known that an increase in trade creates both winners and losers. While there are net gains at the aggregate in the standard trade models, the distributional impacts of an increase in trade can have consequences for the level of inequality. Of course, there are several papers that derive inequality implications in trade-based models.[1] However, there is evidence that households are constrained in their ability to access the financial markets compared to the extent assumed by the existing heterogeneous agent models. We begin by surmising, therefore, that realized aggregate gains may be lower compared to the existing research. In addition, distribution of these gains is also an important outcome of our model, which has implications for inequality.

Applied general equilibrium models of financial development with heterogeneous households and firms, as in Townsend [2010], generally abstract from trade. Some models in this literature consider international capital flow (Angeletos and Panousi [2011]), but trading in goods is generally not considered. Given the important role that trade plays in growth and development, it is important to analyze how change in trade frictions impacts aggregate outcomes and welfare in an environment in which households face financial frictions.

In this paper, on the household side, we model dynamic savings decisions of households who supply labor inelastically and face idiosyncratic labor productivity shock. On the firm side, we model the static trade problem of homogenous intermediate producers in different countries trading with each other. Each country completely specializes in the production of a single intermediate variety. Like in the standard trade models, we introduce an Armington aggregator to combine the intermediate goods in each country. Households's ability to save is constrained by a fixed cost to save as well as a minimum level of savings. We consider these to

[1] See Autor et al. [2015, 2013], Ebenstein et al. [2011], Topalova [2007], Goldberg and Pavcnik [2005, 2003], among others.

be the financial frictions facing households. Firms ability to trade, on the other hand, is constrained by the iceberg cost of trading. The equilibrium wage rate and interest rate in the economy are characterized by the savings fixed cost and iceberg trade costs that households face. The effects of relaxing trade frictions on welfare is mediated by the difficulty of access to savings.

There is a large literature discussing the lack of savings mechanism and opportunities due to high cost of access in developing economies, and there is a range of recent government policies and experiments that have been implemented aimed at reducing these costs to access savings (Jack and Suri [2014], Dupas et al. [2018]). In India too, recent advancements in increasing financial access at the village level have largely been a result of reduction in financial frictions akin to the ones we model.

In this paper, we abstract from the occupational/entrepreneur dynamic decision problem that has been the focus of important papers in macro-development literature on financial frictions (Buera et al. [2011, 2012]).

# 2 Model

We start by detailing a model with two countries. Within each country, there are heterogeneous households differing in labor productivities, an intermediate firm and a final good producer. Households supply labor inelastically, and their aggregated savings is employed by firms as capital in production.

## 2.1 Households

### 2.1.1 Preference

Households are risk-averse with respect to consumption within each time period, and utility over consumption is separable over time. Individual expected utility over lifetime sequence of consumption $c_t$, is $E\left[\sum_{t=0}^{\infty}\beta^t u\left(c_t\right)\right]$, where within each period, utility from consumption is $\log(c_t)$. $\beta$ is the discount factor. The expectation is over

realized values of labor supply shocks $z$.

### 2.1.2 Financial Frictions

Given individual specific uninsurable labor supply shocks, we allow households to save to smooth consumption over time. There are two country $i$ and household $h$ specific fixed costs associated with savings: $\left\{\psi_{ih}^{S}, \psi_{ih}^{M}\right\}$. In each period, if a household decides to save, a fixed account maintenance cost of $\psi_{ih}^{M}$ has to be paid. If the the level of savings upon entering a period is 0, and a household decides to save, an additional set-up fixed cost of $\psi_{ih}^{S}$ has to be paid to create a bank account. These fixed costs represent the average pecuniary and non-pecuniary costs associated with traveling to the bank, bank fees and other costs. Households face an interest rate $r$. The one-period return on savings when households save small amounts could be negative due to the fixed costs, which in effect generates a wedge in effective return to savings and firms' borrowing interest rate.

Given these, the households' problem is subject to the following budget constraint every period:

$$\begin{aligned} c + a' =& (1 + r_i) \cdot a + z \cdot w_i \\ &+ \psi_{ih}^{M} \cdot \mathbf{1}\{a' > 0\} + \psi_{ih}^{S} \cdot \mathbf{1}\{a = 0 \text{ and } a' > 0\} \end{aligned} \tag{1}$$

where households provide inelastic labor supply normalized to 1 and face idiosyncratic labor supply shock $z$.

### 2.1.3 Recursive Formulation of Households' Problem

Households maximize their life-time utility functions by choosing sequences of consumption and savings position, subject to a sequence of budget constraints and savings fixed costs. At the beginning of a period, the state-space $s$ of the household includes savings from last period $a$ and realized labor supply shock $z$. In equations 2 and 3, a household chooses consumption $c$ and savings $a'$, subject to period budget

constraint:

$$v_{ih}(a,z) = \max_{c,\,a' >= 0} \; u(c) + \beta \int v_{ih}(a',z')\, f(z'|z) dz' \tag{2}$$

$$\text{s.t.: } c = (1+r_i)\cdot a - a' + z\cdot w_i + \psi_{ih}^{M}\cdot \mathbf{1}\{a'>0\} + \psi_{ih}^{S}\cdot \mathbf{1}\{a=0 \text{ and } a'>0\} \tag{3}$$

## 2.2 Firms

We will consider the case of homogeneous production technology. There are two sectors within each country. The first sector produces a single intermediate good, while the second produces a non-traded final good by combining the intermediates from both the countries.

### 2.2.1 Intermediate Firm

The intermediate sector in a country operates under perfect competition and the production technology is Cobb-Douglas,

$$y_i = K_i^{\alpha} L_i^{1-\alpha} \tag{4}$$

where $y_i$ is the total output of the intermediate good, $K_i$ and $L_i$ are capital and labor employed in production in country $i$, and $\alpha$ is the share of intermediate sector's expenditure in capital. Because the output must either be consumed locally or consumed abroad, the market clearing condition for the intermediate sector is,

$$y_i = y_{ii} + y_{ij} \tag{5}$$

where $y_{ij}$ denotes the quantity of intermediate good produced in $i$ and shipped to $j$.

**Trade cost:** Intermediate good shipped across a border incurs an iceberg-type proportional shipping cost $\tau_{ij} \geq 1$: a quantity of $\tau_{ij}$ need to be shipped from $i$ for

one unit of that good to arrive in $j$. In other words, only $y_{ij}/\tau_{ij}$ units arrive in $j$ when a quantity $y_{ij}$ is exported from $i$. We treat this as the real costs associated with shipping goods across borders. The iceberg cost for domestically sold goods is normalized to zero, hence $\tau_{ii} = 1$.

**Intermediate Firm Problem**: The intermediate firm maximizes profits given its prices in the two markets, and the prices of its inputs.

$$\pi_i = \max_{K_i, L_i} \; p_{ii} y_{ii} + p_{ij} \frac{y_{ij}}{\tau_{ij}} - w_i L_i - (r_i + \delta) K_i$$

From the pricing equation defined shortly in 8, we know that the price charged in the foreign market, $p_{ij}$ is given by the iceberg cost times the domestic price $p_{ii}$. Hence the firm problem can be rewritten as,

$$\pi_i = \max_{K_i, L_i} \; p_{ii} y_i - w_i L_i - (r_i + \delta) K_i$$

where $y_i$ is intermediate firm's total output given in 4. This implies the following first order conditions with respect to capital and labor, respectively,

$$r_i + \delta = p_{ii} \cdot \alpha \left( \frac{L}{K} \right)^{1-\alpha} \tag{6}$$

$$w_i = p_{ii} \cdot (1 - \alpha) \left( \frac{K}{L} \right)^{\alpha} \tag{7}$$

**Prices**: Intermediate firms take their prices in the two markets as given, which equals the marginal cost of production. Hence,

$$p_{ij} = \tau_{ij} \cdot A \cdot (r_i + \delta)^{\alpha} \cdot w_i^{1-\alpha} \tag{8}$$

where $p_{ij}$ is the price of intermediate from $i$ in market $j$, $A = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$ is a Cobb-Douglas constant, and $w$ and $r$ are wage and rental rates (nominal) respectively.

### 2.2.2 Final Good Producer

The final good producers in each country aggregates intermediates via an Armington aggregator:

$$Y_i^{\frac{\sigma-1}{\sigma}} = \lambda^{\frac{1}{\sigma}} y_{ii}^{\frac{\sigma-1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \left(\frac{y_{ji}}{\tau}\right)^{\frac{\sigma-1}{\sigma}} \tag{9}$$

Where $Y_i$ is the output of final good in country $i$, $y_{ji}$ is the intermediate good exported from $j$ to $i$, parameter $\lambda \in [0,1]$ is the share of expenditure on the intermediate from the same country, and $\sigma$ is the elasticity of substitution between the intermediate varieties.

Given the production function, the demand for an intermediate variety in country $i$ given its price is,

$$y_i^d = \left(\frac{p_i}{P_i}\right)^{-\sigma} Y_i$$

where $P_i = \left[\lambda p_i^{1-\sigma} + (1-\lambda) p_{ji}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ is the aggregate price in $i$. The final good in country 1 is set to be the numeraire in our exercises.

## 2.3 Stationary Competitive Equilibrium

We now define a stationary recursive Competitive Equilibrium for this economy with two countries.

Given iceberg costs, the proportion $P_{ih}$ of households facing different fixed costs $\Psi_{ih}$, a Recursive Competitive Equilibrium are the values and policy functions for the household $v_{ih}(a,z)$, $a_{ih}(a,z)$, interest rate $r$, as well as stationary measure $\mu$, such that:

1. In country $i$, for household $h$ facing $\Psi_{ih}$, the value function $v_{ih}$ solves equation 2 and $a_{ih}$ is the associated policy function.

2. In country $i$, interest rate $r$ clears:

$$\sum_h P_{ih} \int a_{ih}(a,z) d\mu_{ih}(da, dz) = K_i$$

3. In country $i$, the first order conditions for the intermediate producer in equations 6 and 7 are satisfied.

4. In country $i$, the budget constraint 1 is satisfied for every household.

5. Relative value of the aggregate prices in the two economies adjust to result in balanced trade between them.

In this stationary equilibrium, the measure $\mu$–the weighted sum of $\mu_{ih}$–over state space is invariant with respect to the Markov process induced by the labor supply shocks and exogenous fraction of households with different savings fixed costs, and the policy functions.

For policy experiment, welfare in aggregate village economy is measured by a social welfare function in the steady state that is Utilitarian with equal weights assigned to all households. All welfare analysis is based on stationary steady state.

# 3 Exercises

In the first set of exercises, we forgo the fixed costs of saving, and consider the interaction of an Aiyagari economy with a standard trade model with two symmetric countries. We treat this first best case in the context of financial constraints as our benchmark case for comparison with cases where households face additional financial constraints. Our goal is to conduct exercises with the benchmark economy and an economy with additional constraints and derive implications for policy.

We compute and report important statistics regarding the wealth and consumption inequalities, as well as other level statistics such as consumption, output, and capital stock, in our set of benchmark exercises.

## 3.1 Model Parameterization

Because our benchmark economy features symmetric countries, there are seven parameters. There is the discount factor $\beta$, and the fixed costs $\psi^M$ and $\psi^S$ on the household side of the model. On the firms' side, there is the capital share parameter $\alpha$, iceberg cost $\tau$, capital depreciation rate $\delta$, and the elasticity of substitution between intermediate varieties $\sigma$.

Table 1: Benchmark Parameter Values

| **Parameter** | **Description** | **Value** |
|---|---|---|
| $\beta$ | Discount factor | 0.96 |
| $\alpha$ | Capital share in output | 0.36 |
| $\delta$ | Capital depreciation rate | 5% |
| $\sigma$ | Elasticity of substitution | 2 |
| $\psi^M$ | Saving fixed cost | 0 |
| $\psi^S$ | Saving set-up costs | 0 |
| $\tau$ | Export iceberg cost | [1.05,2.5] |

We assign plausible parameter values based on existing research. So $\beta = 0.96$, $\alpha = 0.36$, $\delta = 0.05$, and $\sigma = 2$ in the benchmark case. As mentioned earlier, we consider a case without any financial frictions, so $\psi^M = \psi^S = 0$.

We conduct experiments which mimics cases with different trade regimes brought about by changes in import tariffs. In our model, this corresponds to varying our policy variable, which is the iceberg cost parameter $\tau$. We consider cases in which the iceberg cost varies between 1.05 and 2.5, which covers tariffs that range from 5% to 150%. Table 1 lists the parameters and their values in the benchmark model.

## 3.2 Idiosyncratic shock

We consider a case where the idiosyncratic shock can take only two possible values-high and low. We arbitrarily set these values to be 0.1 and 1.0 respectively. In addition, we impose very high persistence in the dynamics. Given today's realization

of the shock, a household will expect to realize the same value 90% of the time, and get a different value only 10% of the time. We build our grid for the shock, and the transition probability matrix to reflect these features.

## 3.3 Results

We present the results from our benchmark set of exercises in Figure 3.3. The x-axis in each of the subplots represents different trade regimes such that going to the right on the axis represents an increase in the iceberg cost, and lower trade. Each of the simulated data point in the figure represents a unique stationary competitive equilibrium for a particular value of the iceberg cost.

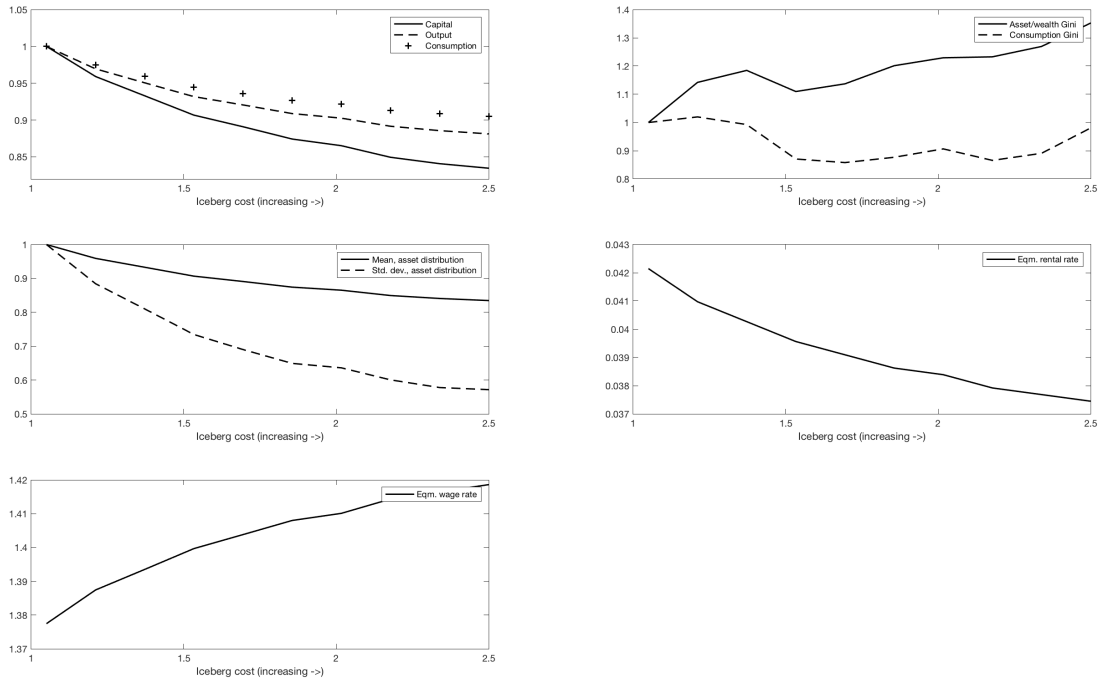


Figure 1: Plots of various model variables and moments under different trade regimes. Going to the right on the X-axis represents a regime with higher iceberg costs, and therefore lower trade.

We present the model endogenous variables (consumption, output and capital stock) in the top left subplot. The inequality measures (wealth and consumption gini coefficients) are in the top right subplot. The statistics on the asset distribution (mean and standard deviation) are in the first subplot in the second row. We plot

the equilibrium rental rate and wage in the second subplot on row two and the subplot on row three respectively. All the variables except the wage and rental rates have been normalized to the case with iceberg cost = 5%.

Broadly, the results are in line with models which feature only aggregate variables. For instance, low trade regimes are characterized by low levels of aggregate consumption, output, and capital stocks. An increase of 145 percentage points (pp) in the iceberg cost in the model results in a 13pp reduction in output and a 10pp reduction in aggregate consumption. In addition, the fact that output falls much more than consumption is in line with the permanent income hypothesis.

Average asset holdings also see a drop of about 17pp, which lines up with the fall in the aggregate capital stock.[2] Qualitatively, the result can be explained as follows. Regimes with greater iceberg costs are associated with higher aggregate price levels and lower demand. This lowers the returns to capital, and thus savings or asset holdings go down. The asset distribution gets tighter in regimes with less trade.

More interestingly, the inequality measures indicate a drop in wealth inequality when there is more trade. On the other hand, we find little or no effect of trade on consumption inequality. We believe these could be artifacts of the way the asset grid is setup.

**Implications for further research**

Figure 3.3 shows that an increase in the iceberg cost is associated with a decrease in returns to asset holdings and an increase in wage rate. We can hypothesize the effects of introducing financial frictions in the form of fixed costs of saving looking at this relationship between wage and rental rates.

Now consider an economy where households face a fixed cost of saving ($\psi^M > 0$) such that every household faces the same $\psi^M$. Such a friction reduces households' willingness to save. In such a case, liberalizing trade could have much less positive

[2]Because the total population is fixed, the change in aggregate capital stock must line up with average asset holdings when borrowing is not allowed.

effects on savings- in other words, the plot with mean of asset holdings against export iceberg cost could be flatter.

On the other hand, we could introduce heterogeneity in $\psi_{ih}^M$ over households $h$ for a given country $i$. Ignoring any resulting asymmetry across countries, the plots for wage and rental rates in Figure 3.3 have important implications for thinking about inequality. If some households face higher frictions than others (consider high and low values for $\psi^M$), the households facing higher $\psi^M$ could be affected negatively by opening up to trade because their wage falls (Figure , row three), but at the same time they are unable to take full advantage of an increase in returns to assets. If such frictions have very high persistence, opening up to trade could have negative welfare implications of a more permanent nature for the high cost households.

# 4 Conclusions

We present preliminary evidence on the effect of trade on the aggregate outcomes as well as on wealth and consumption inequalities. We combine an Aiyagari economy with a standard trade structure with homogeneous intermediate firms. Trade is governed by a single policy parameter- iceberg cost of exporting. In this paper, we consider a benchmark economy with no financial frictions, although our model can handle such frictions.

Our simulations generate the aggregate patterns generated in standard trade models with homogeneous households- we observe increases in consumption, output, and capital stock in regimes with more trade. Contrary to popular belief, however, we find that more trade reduces wealth inequality. In addition, while rental rates are higher in high trade regimes, wage rates are lower.

Based on the observed patterns in wage and rental rates as the iceberg cost is varied, we derive a preliminary understanding of what introducing additional frictions will entail. We believe that such costs will invariably limit households'

limit to borrow and hence realized gains will be lower. In addition, if there is heterogeneity in such frictions, households with higher realized values of savings costs could have negative welfare effects from trade.

Of course, the results in this paper are preliminary and further analyses are needed to derive a better understanding of the interaction between trade regimes, welfare, and inequality.

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