Top Income Inequality, Aggregate Saving and the Gains from Trade

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Abstract

I study the implications of top income inequality for the gains from trade in a dynamic model. I argue that higher top income inequality among entrepreneurs can increase the gains from trade for workers. In the model, entrepreneurs face uninsurable idiosyncratic productivity risk, and thus save. Since the most productive entrepreneurs have the highest saving rate and are the ones that export, a reduction in trade costs increases their share of total profits and their savings, which leads to a large increase in the aggregate supply of capital. The welfare gains from trade for workers in the model are 6.4%, which are larger than in comparable benchmarks without top income inequality or capital accumulation. While the typical entrepreneur loses in consumption because of higher labor costs, aggregate consumption by entrepreneurs increases by 3.6%. Empirically, I find a strong relationship between trade openness and the national saving rate in a large sample of countries, consistent with the model. I find a much weaker relationship between trade openness and the investment rate.

1 Introduction

The global rise of inequality and the increased economic integration between countries are two of the most important developments in the world economy over the past 50 years. The share of total income

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received by the top 5% earners in the US increased from 20.9% to 33.1% between 1961 and 2005, while the income share of the top 0.1% increased from 2.1% to 7.8%.[1] Over the same period, global trade volume increased at an annual rate of 5.9% between 1950 and 2004 (Hummels, 2007). A notable example is China, where the sum of exports and imports as a share of GDP increased from 5.3% in 1986 to 68.6% in 2005 (World Bank, 2012).

Canonical studies of trade liberalization focus on its effects on aggregate income and on the distribution of income. The interaction between these two effects of trade liberalization has been less studied. I study that interaction in this paper. Specifically, I study how income inequality among high-income entrepreneurs (henceforth "top income inequality") affects the welfare gains from trade for the average worker.

Although empirical studies have identified capital accumulation as an important link between trade openness and economic performance (Levine and Renelt, 1992; Wacziarg and Welch, 2008), the recent literature trying to quantify the gains from trade has largely abstracted from capital accumulation. However, economists since Kuznets (1955) and Kaldor (1967) have hypothesized that higher inequality increases capital accumulation, as higher-income households tend to have higher saving rates. Therefore, a study of the relationship between top income inequality and gains from trade should include capital as a factor of production. In this paper, I propose a mechanism through which top income inequality affects the gains from trade, as a result of its effects on the aggregate saving rate and capital accumulation.

I develop a dynamic model of trade with incomplete markets. There are two types of households, workers and entrepreneurs. Entrepreneurs are ex-ante identical. They cannot undertake inter-temporal borrowing for consumption, but they are able to rent capital for production without constraints within a period. They face uninsurable idiosyncratic income risk associated with their productivity and thus save.[2] High-productivity entrepreneurs have higher current income than their long-term expected income and save aggressively for consumption-smoothing and precautionary reasons. On the other hand, low-productivity entrepreneurs have lower current income relative to their long-term expected income and dis-save from their wealth. The model provides a simple way of generating a positive relationship between the level of income and the saving rate, which is both consistent with the data and crucial for the proposed mechanism in this paper. I conjecture that the proposed mechanism would continue to hold in a setup

[1] Data are from the World Top Income Database (Alvaredo, Atkinson, Piketty, and Saez, 2011). The figures above do not include capital gains. Similar trends have been observed for other countries. For example, the top 5% income share in China increased from 9.8% to 17.8% between 1986 and 2003, while the top 0.1% income share increased from 0.5% to 1.2%.

[2] Section 2.1.1 discusses the interpretations of entrepreneurs in my model, the importance of entrepreneurial income for the patterns of top income shares, and evidence of income risk for entrepreneurs.

where the positive saving-income relationship was generated by a different mechanism, such as wealth-in-the-utility preferences as in Kumhof, Rancière, and Winant (2014).[3]

The ex-post heterogeneity in productivity among entrepreneurs translates into heterogeneity in exporting status, entrepreneurial income, consumption and saving. Exporting entrepreneurs have both the highest profit and the highest saving rate in the economy. A reduction in trade costs increases the share of total profits received by exporters, and thus increases the aggregate supply of capital in the economy. I refer to this channel as the supply-side channel of capital accumulation. On the other hand, a reduction in trade costs also increases the demand for capital, as exporters expand their production to serve foreign markets. I refer to this channel as the demand-side channel of capital accumulation. The supply-side channel is novel to this paper, while the demand-side channel is also found in previous work following Baldwin (1992). In equilibrium, a reduction in trade costs creates a large increase in the capital stock.

I calibrate the model using US data and examine the effects of international trade on aggregate output, the consumption of workers, and the consumption of entrepreneurs with heterogeneous productivity.[4] I find that the increase in consumption due to trade for workers in the model is 6.4%. On the other hand, although the aggregate consumption of entrepreneurs in stationary equilibrium increases by 3.6% as a result of trade, the increase in inequality of profits among entrepreneurs implies that the certainty-equivalent consumption of a typical entrepreneur actually decreases by 1.9%. Capital accumulation plays an important role in the model, accounting for 43.2% of the output gains from trade. To isolate the effects of the proposed mechanism, I construct a benchmark model with complete markets, in which firms with heterogeneous productivity are owned by a single entrepreneur. The welfare gains from trade for workers in my model are larger than those from the complete markets benchmark by 0.9 percentage points. Therefore, higher income inequality among entrepreneurs increases the gains from trade for workers in my model.

I test the key predictions of the model using country-level data. Using fixed-effects regressions in a large panel of countries, I find a strongly positive correlation between openness and the aggregate saving rate. I find a much weaker relationship between openness and the investment rate. Additionally, I find that trade openness has a stronger effect on the aggregate saving rate in a country with higher initial inequality. Lastly, I build on the gravity-based instrumental-variable (IV) approach pioneered by

[3] In a dynastic model where agents are infinitely lived, as is the case in this paper, agents undertake saving for their "dynasties." The saving motives in these models should be broadly interpreted as inclusive of bequest motives, which can be more explicitly modelled with finitely lived agents.

[4] I calibrate the model to the US economy to be comparable to other works in the literature, for example, Melitz and Redding (2013). The main qualitative conclusions of this paper do not change when I calibrate the model using data from China. See Section 3.4.

Frankel and Romer (1999) and extend it to a panel setting. I find a larger effect of trade openness on the aggregate saving rate in the fixed-effects panel regressions with IV than without IV. The results provide strong evidence that a supply-side channel of increased capital accumulation is operative following an increase in openness, while the demand-side channel is less evident in the data.

My paper is related to the literature that aims to quantify the gains from trade.[5] While nearly all quantification exercises rely on a static framework, I model entrepreneurial consumption, saving and capital accumulation in a dynamic framework. In their influential econometric analysis, Levine and Renelt (1992) find that the positive correlations between output growth and the investment rate, and between the investment rate and trade openness, are two of the only robust results in the empirical cross-country growth literature.[6] Wacziarg (2001) and Wacziarg and Welch (2008) show empirically that capital accumulation is a crucial channel through which trade openness affects economic growth. Despite this empirical evidence, most attempts to quantify gains from trade have abstracted from capital accumulation.[7] In the Solow (1956) growth model, an increase in aggregate TFP raises the marginal product of capital. A trade liberalization would induce capital accumulation if it increases aggregate TFP (Baldwin, 1992).[8] My model incorporates this demand-side mechanism into the framework of Melitz (2003), which does not include capital as a factor of production. More importantly, this paper emphasizes the capital response to a trade liberalization coming from the supply side, due to rising inequality. The emphasis on the supply-side channel is consistent with my empirical finding below, that greater trade openness is strongly associated with a higher aggregate saving rate, but not as strongly associated with the investment rate.

My paper is related to the large literature on the effects of international trade on inequality. Much of the literature has focused on wage inequality between workers.[9] Haskel, Lawrence, Leamer, and Slaughter (2012) argue that globalization contributes to inequality by increasing the income share of top income earners. The mechanism linking trade and top income inequality in my paper is closely related to Rosen's (1981) theory of superstars. Other papers on the relationship between trade and the income share

[5]See Costinot and Rodriguez-Clare (2013) for a review of relevant literature.

[6]Levine and Renelt (1992) do not use data on the aggregate saving rate in their analysis.

[7]Notable exceptions include Alessandria and Choi (forthcoming, 2014) and Alessandria, Choi, and Ruhl (2014). Alessandria et al. (2014) calculate the welfare gains from a cut in tariff in a model with rich trade adjustment dynamics, taking into account the transition period between steady states. They find larger gains from trade when accounting for the transition path than steady-state comparison of consumption. My paper abstracts from trade adjustment dynamics and emphasizes the role of saving by entrepreneurs.

[8]Relatedly, Eaton and Kortum (2001) argue that underdeveloped countries have a comparative disadvantage in producing capital goods, and that international trade facilitates capital accumulation in these countries by reducing the relative price of capital goods. The mechanism emphasized in this paper does not rely on patterns of comparative advantage.

[9]See Goldberg and Pavcnik (2007) and Harrison, McLaren, and McMillan (2011) for surveys of the literature. Goldberg and Pavcnik (2007) discuss how the literature on trade and inequality has been shaped by measurement issues.

of superstars include Foellmi and Oechslin (2010) and Dinopoulos and Unel (2014). In an interesting quantitative exercise, Ma (2013) finds that increased globalization accounts for about 33 percent of the observed increase in the top 0.01% income share in the US over the last two decades. These previous papers are primarily concerned with explaining the observed patterns of inequality. By contrast, my paper attempts to shed light on the welfare implications of this increased inequality.

The literatures on the effects of trade on inequality and on the welfare gains from trade have heretofore evolved largely independently. There are many papers that use microdata to examine the impact of a trade liberalization on different groups, for example by education level. While these studies arguably belong to both literatures, they do not emphasize the interaction between the effects of trade on the level of income and on the distribution of income. In the absence of any interaction between inequality and the gains from trade, one can take the headline results from both literatures, and assume a social welfare function to calculate the "the net welfare gains from trade," taking rising inequality as a cost of trade. My paper shows that there are non-trivial interactions between top income inequality and the gains from trade.[10] In contrast to the conventional view that rising inequality is a downside of free trade, I find that accounting for the increase in top income inequality implies higher gains from trade for the average worker.

Lastly, this paper is related to the research on top income shares and their aggregate implications (Piketty and Saez, 2003). Researchers have noted that top income shares may have different determinants and welfare implications than the traditional notions of income inequality such as skill premium. Fairness concerns and public policy implications are important motivations for the study of top income shares (Atkinson, Piketty, and Saez, 2011). Moreover, top income shares are crucial for aggregate welfare through their potential effects on social stability or political institutions (Piketty, 2014; Acemoglu and Robinson, 2014). Kumhof et al. (2014) study the effects of increased top income shares on leverage and the probability of crises. In their model, the top earners have a higher saving rate because they have wealth-in-the-utility preferences (Carroll, 2000), while the saving-income relationship in my model is generated by income fluctuations and borrowing constraints. In contrast to Kumhof et al. (2014), who focus on the effects of an exogenous increase of the income share of the top 5% on the probability of crises, I show that increased concentration within the group of entrepreneurs (the top earners) can have important welfare implications for the group of workers (the bottom earners), even if the income shares

[10]Other works, for example, Itskhoki (2009), have studied the trade-off between equity and efficiency in international trade and the policy implications.

of these two groups do not change.[11]

My paper makes three substantive contributions to the literature. First, I propose a novel mechanism linking top income inequality and the gains from trade and demonstrate that it is quantitatively relevant for the gains from trade.[12] Second, I help shed light on the welfare implications of top income inequality. I show that increased concentration at the top of income distribution can have positive welfare implications for the rest of the population.[13] Lastly, I make an empirical contribution by documenting a strong and positive relationship between trade openness and the aggregate saving rate.

In Section 2, I present the full model and the calibration strategy. Section 3 presents the key results from the calibration exercise. Further robustness checks and model extensions are relegated to the appendices. Section 4 presents the empirical results. Section 5 concludes.

2 Model

2.1 Environment

One goal of this paper is to propose a novel mechanism and demonstrate its quantitative relevance. Towards this end, I compare the results from the full model with those from comparable benchmark models. To facilitate the comparison, I deliberately keep the full model simple. I examine the robustness of the model to alternative assumptions, and extensions of the full model, in Appendix V.

2.1.1 Entrepreneurs

There are two symmetric countries. Each country has a unit mass of entrepreneurs who produce differentiated goods. Entrepreneurs are infinitely lived and differentiated by their productivity z. Productivity z is drawn from a time-invariant cumulative distribution function (CDF) $\mu(z)$. In each period, an entrepreneur receives a new draw of z from the CDF $\mu(z)$ with probability $(1-\gamma)$.

Entrepreneurs are risk averse and have the following utility function:

$$U(c) = E\Big(\sum_{t=0}^{\infty} \beta^t \frac{{c_t}^{1-\lambda}}{1-\lambda}\Big), \tag{1}$$

[11] Empirically, both the income share of the top 5% and the concentration of income within the top 5% in the US have increased between 1961 and 2005.

[12] A number of papers have noted a similar theoretical link between overall inequality and capital accumulation in a closed-economy context (Kuznets, 1955; Kaldor, 1967; Galor and Moav, 2004). The focus on top income inequality in this paper is motivated by the observation that wealth is extremely concentrated.

[13] As a concrete example, the bottom 95% in terms of income can have positive welfare gains, if the income share of the top 1% increases at the expense of the next 4%.

where β is the discount factor, λ is the coefficient of relative risk aversion, and c_t is the final good (the numeraire). I use the concept of stationary equilibrium in the analysis. From the perspective of an entrepreneur, in a stationary equilibrium, the only stochastic element in the economy is the evolution of idiosyncratic productivity z. As a result, in a stationary equilibrium, the expectation in Equation (1) is taken with respect to z.

Entrepreneurs in the model are intended to capture executives and entrepreneurs in the real world. Using data on US tax returns, Bakija, Cole, and Heim (2012) report that non-finance executives, managers and supervisors account for 40.9% of primary taxpayers in the top 0.1% of income tax-units in 2004. For about half of these executive households, the sum of self-employment, partnership and S-Corporation income is higher than salary income. Therefore, both executive income and entrepreneurial income are significant components of top income shares. Cagetti and De Nardi (2006) document that 68% of households in the top 5% of wealth are business owners or self-employed in the 1989 Survey of Consumer Finances data.

A crucial assumption is that these higher-income households face uninsurable income risk associated with the performance of firms. There is substantial evidence that income risk associated with entrepreneurial activities is particularly difficult to insure against. Guvenen (2007) analyzes the extent of risk sharing among stockholders (more wealthy individuals) and non-stockholders in the US. Using PSID data, he rejects perfect risk sharing among stockholders but does not reject perfect risk sharing among non-stockholders. Guvenen (2007) concludes that market incompleteness matters more for the wealthy, who face substantial entrepreneurial risk. Moreover, precautionary saving by entrepreneurs has been identified as an essential element to account for the extreme concentration of wealth in the right tail in US data (Quadrini, 2000; Cagetti and De Nardi, 2006). Lastly, Gentry and Hubbard (2004) find that entrepreneurial households have higher wealth-to-income ratios and higher saving rates than non-entrepreneurial households.

2.1.2 Workers

There is a unit measure of infinitely lived workers in each country. Each worker supplies a unit of labor and receives a wage. Since there is no idiosyncratic or aggregate income risk for workers in a stationary equilibrium, it is optimal for workers to simply consume their wages in each period. In other words, entrepreneurs account for all of the aggregate wealth in the economy.[14]

[14]Empirically, wealth is very concentrated. According to Saez and Zucman (2014), the top 10% households in terms of wealth accounted for 77.2% of total wealth in the US in 2012. Over the period 1986-2012, the average private saving rate

2.1.3 The Final Good Sector

Each country has a perfectly competitive final good sector. Throughout this paper, I use superscript * to denote prices, quantities and policy functions in the foreign country. A single representative firm in each country combines differentiated goods, produced domestically or imported, into the final good according to

$$Y = \Big(\int q(i)^{\frac{\sigma-1}{\sigma}} di \Big)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $q(i)$ is the amount of differentiated good i and $\sigma > 1$ is the elasticity of substitution in production. Taking the output price P and input prices $p(i)$ as given, the final good producer maximizes profit according to

$$\max_{q(i)} \Big\{ P \Big(\int q(i)^{\frac{\sigma-1}{\sigma}} di \Big)^{\frac{\sigma}{\sigma-1}} - \int p(i)q(i)di \Big\}. \tag{3}$$

The inverse demand function for variety i coming from the final good sector of a particular country is given by

$$p(i) = E^{\frac{1}{\sigma}} P^{1-\frac{1}{\sigma}} q(i)^{-\frac{1}{\sigma}} \tag{4}$$

where $E = \int p(i)q(i)di$ and $P = \Big(\int p(i)^{1-\sigma} di \Big)^{\frac{1}{1-\sigma}}$ are the aggregate expenditure and the price index in that country, respectively. Perfect competition and constant returns to scale in the production function imply zero profit in equilibrium for the representative final good firm. In equilibrium, $P^* = P = 1$ with symmetric countries.

2.1.4 Production of Differentiated Goods and International Trade

I assume monopolistic competition for producers of differentiated goods. Additionally, there is no firm entry or exit. An entrepreneur with productivity $z(i)$ produces a variety i of differentiated goods according to

$$q(i) = z(i)k(i)^{\alpha} l(i)^{1-\alpha}, \tag{5}$$

where $k(i)$ and $l(i)$ are capital input and labor input in production, respectively. When feasible, I omit the index i from the notation in what follows.

Only differentiated goods are tradable between the two countries. In order to export, firms incur a per-period fixed cost of f_X in units of the final good.[15] There is no sunk cost of exporting. Lastly, there

for the bottom 90% in wealth is 0%, compared to 22% for the wealth top 10%.(Saez and Zucman, 2014).

[15] Costinot and Rodriguez-Clare (2013) note that under this specification, as aggregate TFP increases following a decrease in variable trade costs, the amount of resources devoted to fixed costs is reduced. This creates another source for gains from

is an iceberg variable cost of trade, $\tau \geq 1$. Exporters have to ship τ units for every unit of goods sold in the other country.

I do not specify a sunk cost of exporting for two reasons. First, this assumption allows me to derive analytical results on the effect of international trade on inequality. Second, as I will make clear below, the absence of sunk costs facilitates the construction and calibration of a benchmark alternative model which has a representative entrepreneur. In Appendix V.(a), I show that my results are robust to allowing for a sunk cost of exporting.

2.1.5 Capital Rental Market

Capital is immobile across countries.[16] Capital depreciates at rate δ. The capital rental market is perfectly competitive. For each unit of intermediated capital, a financial intermediary receives R in rental payment from entrepreneurs, pays out r as interest payment to depositors, and spends δ to replace the depreciated capital. Financial intermediaries are collectively owned by the entrepreneur population.

I assume that entrepreneurs cannot have negative wealth ($a \geq 0$). The no-borrowing constraint ($a \geq 0$) and uninsurable idiosyncratic risk imply that entrepreneurs engage in precautionary saving. In Appendix V.(b), I examine the implications of relaxing the no-borrowing constraint. Entrepreneurs can rent any amount of capital within each period. That is, the rental of capital for production is not subject to financial frictions.[17] Consequently, conditional on productivity, the demand for capital by a firm is not a function of entrepreneurial wealth a. Export status, factor inputs, sales and profits of firms can be written as functions of productivity z alone. In Appendix V.(c), I show that the results is robust to allowing for the demand for capital by entrepreneurs to be constrained by their wealth.

2.1.6 Dynamic Budget Constraint

The dynamic budget constraint of an entrepreneur is given by

$$c + a' = \max\{\pi^D(z), \pi^X(z)\} + (1 + r)a,$$

trade. A possible alternative is to specify this fixed cost in units of labor. However, specifying the fixed cost in units of the final good facilitates the decomposition of output gains from trade in Section 3.2.1.

[16] With the assumption of symmetric countries, allowing capital mobility across countries does not affect any of the results presented in this paper.

[17] There is a large literature on the interactions between financial frictions and international trade. See for example Manova (2013).

where $a \geq 0$ is the beginning-of-period wealth of the entrepreneur and r is the interest rate received by depositors. The profit functions $\pi^j(z)$, $j = D, X$, where D and X denote domestic producer and exporters respectively, are defined as

$$\begin{aligned} \pi^D(z) &= \max_{k,l,q^D} \left\{ E^{\frac{1}{\sigma}} \left((q^D)^{1-\frac{1}{\sigma}} \right) - R \cdot k - w \cdot l \right\} \\ & s.t \quad q^D = z k^\alpha l^{1-\alpha} \end{aligned}$$

and

$$\begin{aligned} \pi^X(z) &= \max_{k,l,q^D,q^X} \left\{ E^{\frac{1}{\sigma}} (q^D)^{1-\frac{1}{\sigma}} + E^{*\frac{1}{\sigma}} P^{*1-\frac{1}{\sigma}} (q^X)^{1-\frac{1}{\sigma}} - R \cdot k - w \cdot l - f_X \right\} \\ & s.t \quad q^D + \tau q^X = z k^\alpha l^{1-\alpha} \end{aligned}$$

where q^D and q^X are total domestic sales and total export sales respectively.

2.1.7 Timing of the Model

The timing of the model is given below.

1. Entrepreneurs enter a period with wealth a and observe productivity z. An entrepreneur's state is given by the pair (a, z). Entrepreneurs deposit their wealth a with financial intermediaries.[18]

2. Entrepreneurs choose export status $e(z) \in \{0, 1\}$, capital input $k(z)$ and labor input $l(z)$ for the current period. Financial intermediaries rent out capital to firms. Each worker supplies one unit of labor.

3. Production of differentiated goods takes place. Capital depreciates at rate δ during production.

4. Production and sales of the final good take place. Simultaneously, entrepreneurs receive revenue; pay capital rentals and wages to the financial intermediaries and workers; receive their deposits including interest payment, $(1 + r)a$, from financial intermediaries; and purchase and consume the final good $c(a, z)$. Each worker receives and consumes a wage.

5. Entrepreneurs enter the next period with wealth $a'(a, z)$.

[18] It is not inconsistent for an entrepreneur to be both a lender (depositor) and a renter of capital, since the interest rate is the same for lenders and renters.

Note that entrepreneur decisions $e(z)$, $a'(a,z)$, $c(a,z)$, $k(z)$ and $l(z)$ can be made simultaneously (instead of sequentially) after productivity z is observed, since there is no uncertainty within a period.

2.2 An Entrepreneur's Problem

Since there is no aggregate risk in this model, the domestic wage w, interest rate r, capital rental rate R, aggregate price index P, and total expenditure E are time-invariant in a stationary equilibrium, as are the corresponding variables in the foreign country. An entrepreneur chooses export status $e(z)$, asset position $a'(a,z)$, consumption $c(a,z)$, variable labor input $l(z)$, capital input $k(z)$, domestic sales $q^D(z)$ and export sales $q^X(z)$ (for exporters only).

An entrepreneur chooses consumption c and assets a' to maximize expected utility, subject to the budget constraint:

$$\begin{aligned} v(a,z) = & \max_{c,a' \geq 0} \tfrac{c^{1-\lambda}}{1-\lambda} + \beta\{\gamma v(a',z) + (1-\gamma)E_{z'}\big(v(a',z')\big)\} \\ \text{s.t.} \quad & c + a' \leq max\{\pi^D(z), \pi^X(z)\} + (1+r)a. \end{aligned}$$

As is well known, the fixed cost of exporting f_X introduces a productivity cutoff $\bar{z}_X$ for participation in exporting, given by the solution to $\pi^D(\bar{z}_X) = \pi^X(\bar{z}_X)$. The cutoff $\bar{z}_X$ is given by

$$\bar{z}_X = \tau \cdot \Big(\frac{f_X}{\Phi \cdot E^*}\Big)^{\frac{1}{\sigma-1}} R^\alpha w^{1-\alpha}, \tag{6}$$

where $\Phi = \Big(\alpha^\alpha(1-\alpha)^{(1-\alpha)}\Big)^{\sigma-1}\sigma^{-\sigma}(\sigma-1)^{(\sigma-1)}$. Equation (6) indicates that the export productivity cutoff is increasing in the fixed cost of exporting and factor prices, and is decreasing in foreign market size (E^*). Only entrepreneurs with $z \geq \bar{z}_X$ become exporters.

2.3 Definition of a Stationary Competitive Equilibrium with International Trade

The definition of a stationary competitive equilibrium with international trade includes an invariant distribution of entrepreneurs over the (a,z) space, a set of prices, and a set of policy functions in each country satisfying a list of equilibrium conditions. I state the equilibrium conditions for the domestic economy below. Analogous conditions hold for the foreign economy.

1. Given aggregate variables w, R, r, P, E, and the corresponding variables in the foreign country, the policy functions $c(a,z)$, $a'(a,z)$, $e(z)$, $l(z)$, $k(z)$, $q^D(z)$ and $q^X(z)$ solve an entrepreneur's

optimization problem.

2. Each worker supplies one unit of labor and optimally chooses to consume his wage each period.

3. Financial intermediaries make zero profit in equilibrium. This implies

$$R = r + \delta.$$

4. The markets for capital rental, labor and the final good clear. Trade balances.

   (a) Capital rental market clearing implies

$$\int_z \int_a k(z) G(da, dz) \quad = K = \quad \int_z \int_a a'(a, z) G(da, dz).$$

   Both integrals are taken over the entire entrepreneur population. The left-hand side gives the total demand for capital while the right hand side gives the total supply of capital in the economy. The letter K denotes the stock of capital in a stationary equilibrium.

   (b) Labor market clearing implies

$$\int_z \int_a l(z) G(da, dz) \quad = \quad 1$$

   The integral on the left-hand side is taken with respect to the entire entrepreneur population and represents labor demand. The right-hand side of the equation gives the total labor supply (normalized to 1).

   (c) Trade balance implies

$$\int_{e(z)=1} \int_a p(z) q^X(z) G(da, dz) = \int_{e^*(z)=1} \int_a p^*(z) q^{X*}(z) G^*(da, dz).$$

   The integrals in the equation above are taken with respect to all exporters in the home country and in the foreign country respectively.

   (d) Market clearing for the final good in the domestic economy implies

$$\int_z \int_a c(a, z) G(da, dz) + w + \delta \cdot K + \int_{\{e(z)=1\}} \int_a G(da, dz) \cdot f_X \quad = \quad Y \tag{7}$$

In a stationary equilibrium, the final good is either consumed or used to replace depreciated capital. The first integral on the left-hand side is taken with respect to the entrepreneur population. The second term is total consumption by workers. The first two terms are thus the total consumption in the economy. The third term on the left-hand side gives the depreciation of capital while the fourth term gives the final good used to cover the fixed cost of exporting. Finally, Y is the total output of the final good in the economy.

5. The joint distribution of wealth a and entrepreneurial productivity z is a fixed point of the equilibrium mapping

$$G(a,z) = \gamma \int_{\tilde{z}\leq z} \int_{a'(\tilde{a},\tilde{z})\leq a} G(d\tilde{a},d\tilde{z}) + (1-\gamma)\mu(z) \int_{\tilde{z}} \int_{a'(\tilde{a},\tilde{z})\leq a} G(d\tilde{a},d\tilde{z}) \tag{8}$$

for all (a,z). Equation (8) states that for any point (a,z), the CDF at this point (LHS) should be equal to the CDF at the same point next period (RHS). Consider a point $(\bar{a},\bar{z})$. The CDF at $(\bar{a},\bar{z})$ this period is given by $G(\bar{a},\bar{z})$. The CDF in the following period consists of two components. For the γ fraction in the population whose entrepreneur productivity z remains unchanged, I integrate over the entrepreneurs with $z \leq \bar{z}$ whose policy functions place them at $a' \leq \bar{a}$. For the $(1-\gamma)$ fraction in the entrepreneur population who receive a new z, I integrate over all entrepreneurs whose policy functions place them at $a' \leq \bar{a}$. The integral is multiplied by $\mu(\bar{z})$ since only a fraction $\mu(\bar{z})$ will have $z \leq \bar{z}$ after the redraw of z.

2.4 Calibration

I calibrate the model to US data at annual frequency. The calibration follows closely Buera and Shin (2013) and Melitz and Redding (2013). The model is solved numerically using parallel computing. The computational algorithm is described in detail in Appendix I. Table 1 summarizes the parameter choices and target moments in the calibration exercise.

Following Buera and Shin (2013), I set the coefficient of relative risk aversion λ at 1.5, the share of capital in production α at 0.333, and the one-year depreciation rate of capital δ at 0.06. Following Melitz and Redding (2013), I set the elasticity of substitution σ at 4.0. The implied markup for differentiated goods is 33.3%.

The model specifies an exogenous distribution of entrepreneurial productivity. Following Chaney (2008), I assume that productivity follows a Pareto distribution. The cumulative distribution function

(CDF) for entrepreneurial productivity is given by

$$\mu(z) = Pr(Z \leq z) = 1 - z^{-\eta}, \ z \geq 1,$$

where η is the shape parameter that governs the dispersion of entrepreneurial productivity. There is a one-to-one mapping between entrepreneurial productivity and domestic sales. As shown in di Giovanni and Levchenko (2013), the distribution of domestic sales is given by

$$Pr(S > s) = B \cdot s^{\zeta},$$

where B is some constant, and $\zeta = \frac{\eta}{\sigma-1}$ is the tail parameter of the Pareto distribution of firm sales. Following Melitz and Redding (2013), I set the tail index of the firm sales distribution to $\zeta = 1.3$. The implied shape parameter η for productivity is $\eta = \zeta \times (\sigma - 1) = 3.9$.

I set the discount factor β at 0.928 to match an annual interest rate of 3.0%.[19] I choose $\gamma = 0.814$ to match the persistence of firm productivity reported in Foster, Haltiwanger, and Syverson (2008).[20] In this model, as in Melitz (2003), the ratio of export revenue to total sales for exporters is fixed at $\frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}$. In the data, across all exporters in U.S manufacturing, the share of exports in total shipments was 14.0% in 2002 (Bernard, Jensen, Redding, and Schott, 2007). To match this ratio, I set the variable trade cost τ to 1.83. I choose $f_X = 0.060$ to match the Export/GDP ratio of 10.0% for the US in 2002.

In the counter-factual experiment, I increase the variable trade cost to infinity to shut down international trade. This allows us to infer the realized gains from trade in the US. I refer to the economy matching the observed level of trade as "Trade" and the counter-factual economy as "Autarky".

2.5 Complete Markets Benchmark (CM Benchmark)

One goal of this paper is to demonstrate that entrepreneurial income inequality plays a critical role for the gains from trade. It is instructive to describe a benchmark model in which markets are complete, and to compare the results from the benchmark model to the full model. Towards this end, I introduce a representative entrepreneur in each country who receives the income of all the firms, while allowing the firms with heterogeneous productivity to make profit-maximizing decisions independently. This aggre-

[19]In this class of models, the discount factor β needed to match a reasonable interest rate is typically small. For example, Buera and Shin (2013) use $\beta = 0.904$ to match an interest rate of 4.5%.

[20]Using simulated data on firm productivity, with $\zeta = 1.3$ and $\gamma = 0.814$, I find that the standard deviation of the logarithm of productivity is 0.256, which is close to the value of 0.260 reported in Foster et al. (2008).

Table 1: Calibration Parameters

Panel A: Parameters Taken from Prior Literature		Full Model	CM Benchmark
Parameter	Symbol	Value	Value
Coefficient of Risk Aversion	λ	1.500	-
Share of Capital in Production	α	0.333	0.333
Capital Depreciation Rate	δ	0.060	0.060
Elasticity of Substitution	σ	4.000	4.000
Persistence of Firm Productivity	γ	0.814	-
Shape Parameter of Sales Distribution	ζ	1.300	1.300

Panel B: Parameters Calibrated to Match Data Moments		Full Model		CM Benchmark	
Target Moment	US Data	Parameter	Model	Parameter	Model
Interest Rate	3.00%	$\beta = 0.929$	3.00%	$\beta = 0.971$	3.00%
Export/GDP Ratio	10.00%	$f_X = 0.110$	9.94%	$f_X = 0.110$	9.94%
Export to Sales Ratio	14.00%	$\tau = 1.83$	14.00%	$\tau = 1.83$	14.00%

"Full Model" refers to the model described in Section 2.1; "CM Benchmark" refers to the complete markets benchmark described in Section 2.5.

gates away the idiosyncratic risks. I refer to the benchmark model with complete markets as the "CM benchmark." In the CM benchmark, firms are heterogeneous, but entrepreneurial income, consumption and saving are homogeneous.

As in the full model, firms are differentiated by productivity z, drawn from the CDF $\mu(z)$. The representative entrepreneur maximizes

$$\max_{c_t, a_t} \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{9}$$

where $u'(.) > 0$ and $u''(.) < 0$,[21] subject to the dynamic budget constraint

$$c_t + a_{t+1} = \int \max\{\pi^D(z), \pi^X(z)\}\mu(dz) + (1+r)a_t \tag{10}$$

where $\pi^D(z)$ and $\pi^X(z)$ are the profit functions of a domestic firm and an exporting firm respectively. The production function for differentiated goods implies that the interest rate r approaches infinity when $a = 0$. Therefore, the representative entrepreneur holds a positive level of assets to smooth consumption over time. The absence of sunk costs implies that the production side is essentially static: it is irrelevant whether a particular entrepreneur's productivity z is stochastic, as long as the distribution of z is constant over time.

[21]Note that this is more general than the CRRA utility function in the full model. The exact functional form of utility does not matter for the complete markets benchmark.

The final good sector, the differentiated goods sector and the capital rental market are identical to their counterparts in the full model.

I consider the stationary equilibrium for the benchmark model. A stationary competitive equilibrium with international trade is defined as a set of prices and policy functions such that

1. The policy functions maximize the utility of the representative entrepreneur.

2. Each firm maximizes profit each period.

3. Workers optimally choose to consume their wage each period.

4. All markets clear.

5. Trade balances.

To solve the model, I obtain the first-order conditions for the maximization problem given by Equations (9) and (10). I obtain the stationary equilibrium by imposing $c_t = \bar{c}$ and $a_t = \bar{a}$ for any t. It is straightforward to show that $r = \frac{1}{\beta} - 1$ in any stationary equilibrium. This contrasts with the full model in which the equilibrium interest rate is affected by a myriad of parameters, including the probability of expiration of ideas γ, capital share α, discount factor β and coefficient of relative risk aversion λ.

It is instructive to consider the static problem of finding the equilibrium wage to clear markets, taking the interest rate as exogenous. For a given equilibrium interest rate and a given set of parameter values on the production side, the optimization problem faced by firms in the benchmark model is the same as in the full model.[22] By choosing a different value of β for the benchmark model so that the equilibrium interest rate is identical across the two models, the labor market in the benchmark model can be cleared using the equilibrium wage from the full model. I target an equilibrium interest rate of 3.00% for the full model. To have the same interest rate in the CM benchmark, I simply set $\beta = \frac{1}{1+0.0300} = 0.971$. This procedure produces an identical equilibrium wage and target moments across the two models. This feature of the calibration allows for an appropriate comparison across the two models.

To summarize, I construct the CM benchmark by assuming that all firms in a country are owned by one representative entrepreneur. Each firm makes exporting and input decisions independently to maximize income. The rest of the CM benchmark is essentially identical to the full model. The same set of parameter values, other than the value of β, can be used to calibrate both models to the US data.[23]

[22]The parameters on the production side are α, δ, σ, ζ, f_X and τ.

[23]As noted earlier, the exact functional form of static utility does not matter for stationary equilibrium in the CM benchmark. The absence of sunk costs implies that the parameter γ, which governs the persistence of firm productivity, does not matter in the CM benchmark.

The details on the calibration of the CM benchmark are presented in Table 1.

3 Results

3.1 The Impact of International Trade on Inequality

Before presenting the results on gains from trade in this model, I first examine the effects of trade on inequality. Although the model is dynamic in nature, the production decisions of entrepreneurs are static. This allows us to derive some analytical results.

3.1.1 Analytical Results

Proposition 1: Moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$, $e(z) = 1$ for some z), the profit share of the top $x\%$ of entrepreneurs strictly increases for any $x \in (0, 100)$, for any non-degenerate CDF function $\mu(z)$.

Proof: See Appendix II.

The intuition of the proof is straightforward. Define z_x as $\mu(z_x) = 1 - \frac{x}{100}$. In Autarky, the profit share of the top $x\%$ of entrepreneurs is given by

$$\frac{\int_{z_x}^{\infty}(\frac{z}{z_{min}})^{\sigma-1}\pi^D(z_{min})\mu(dz)}{\int_{z_{min}}^{\infty}(\frac{z}{z_{min}})^{\sigma-1}\pi^D(z_{min})\mu(dz)} = \frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dz)}{\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dz)} \tag{11}$$

where $\pi^D(.)$ is defined earlier and z_{min} is the minimum possible z (normalized to 1 in the calibration). This ratio is preserved if we consider profits from domestic sales alone in an economy with trade. Given the fixed cost of exporting, if there are any exporters in the economy, they must first come from the top $x\%$. When moving to trade, there is an additional term involving profits from export sales added to both the denominator and the numerator of Equation (11). The proof in Appendix II demonstrates that the numerator in Equation (11) necessarily increases proportionally more than the denominator when a country opens up to trade. A corollary of Proposition 1 is that the Gini coefficient of profits among entrepreneurs is minimized at Autarky.

It is important to emphasize that Proposition 1 considers only the distribution of profit income among entrepreneurs. The distribution of interest income is determined by dynamic factors such as the persistence of profit income and risk aversion, so it is difficult to examine analytically.

The effects of trade on the inequality between workers and entrepreneurs are summarized by the following proposition.

Proposition 2: Consider the special case of the model in which there is no capital depreciation ($\delta = 0$). Moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$, $e(z) = 1$ for some z), the share of total income received by the workers increases.

Proof: See Appendix II.

With Cobb-Douglas production, the ratio between the total cost of capital rental (RK) and total cost of labor (w) is constant, regardless of the level of trade costs. On the other hand, since the markup of price over marginal cost is constant, the percentage markup of price over average cost is lower at exporting firms, as a result of the fixed cost of exporting. Therefore, compared to Autarky, total profit (net of the fixed cost of exporting) as a share of total sales is lower in an economy with any positive level of trade ($\tau < \infty$).[24] Therefore, in moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$), the share of total income received by the workers increases.

3.1.2 Numerical Results

Section 3.1.1 presents some analytical results concerning the effects of trade on income inequality. However, Proposition 1 does not consider the distribution of interest income. Since the distribution of interest income is a function of the equilibrium wealth distribution, it is difficult to provide analytical results concerning the effect of trade on the distribution of overall entrepreneurial income. I turn to numerical results.

As shown in Panel A of Table 2, international trade increases the share of overall entrepreneurial income received by the most productive entrepreneurs. Moving from Autarky to Trade, the share of overall entrepreneurial income received by the top 1% increases from 31.0% to 32.6%, while the share received by the top 5% (including the top 1%) increases from 50.5% to 52.6%. On the other hand, the share of overall entrepreneurial income received by the bottom 50% decreases from 12.8% to 11.9%. The Gini coefficient among entrepreneurs increases, from 0.654 under Autarky to 0.675 under Trade.

The effects of trade openness on income inequality among entrepreneurs, as presented in Panel A of Table 2, are modest. Total income of an entrepreneur is the sum of profit income π and interest income $a \cdot r$, which are positively correlated in the model. Moving from Autarky to Trade, the interest rate r decreases from 3.2% to 3.0%. As a result, the increase in the inequality of profit income for entrepreneurs is partially offset by a decrease in the equilibrium interest rate, in the sense that interest income does

[24] This argument does not apply to comparisons between different finite levels of the trade cost. See Appendix II for details.

not increase proportionally with profit income for the exporters. In Section 3.2, I show that this modest increase in top income inequality can nevertheless have large welfare implications for the workers.

Table 2: Income Inequality and Trade Openness

Panel A. Income Inequality among Entrepreneurs		
	Autarky	Trade
Share of Total Entrepreneurial Income		
Top 1%	31.0%	32.6%
Top 2-5%	19.5%	20.0%
Top 5-20%	20.3%	20.1%
Top 20-50%	16.4%	15.4%
Bottom 50%	12.8%	11.9%
Gini Coefficient	0.654	0.675
Panel B. Income Distribution Between Workers and Entrepreneurs		
	Autarky	Trade
Workers' Share of Total Income	59.8%	60.4%

"Autarky" refers to the economy when the variable cost of trade is set to infinity; "Trade" refers to the economy calibrated to match the observed level of trade in the US.

Panel B of Table 2 presents the results on the distribution of income between the entrepreneurs and the workers. Moving from Autarky to Trade, the share of total income received by workers increases from 59.8% to 60.4%. This is consistent with Proposition 2. However, the central mechanism of this paper linking inequality to saving is driven by income inequality among entrepreneurs, rather than by inequality between workers and entrepreneurs. In fact, an increase in the workers' share works against the proposed mechanism, since workers do not save at all.

3.2 Gains from Trade

3.2.1 The Impact of Trade on Aggregate Output

The model implies an aggregate production function for the final good as follows:

$$Y = \text{TFP} \cdot K^{\alpha} L^{1-\alpha} = \text{TFP} \cdot K^{\alpha} \tag{12}$$

where Y, TFP, K and L are the aggregate output of the final good, aggregate total factor productivity (TFP), aggregate capital stock, and total labor input, respectively. The last equality follows because the size of the labor force is normalized to 1.

Aggregate TFP is the weighted harmonic mean of productivity over all firms, given by

$$\text{TFP} = \Big(\int_{e(z)=0} z^{\sigma-1}\mu(dz) + (1+\tau^{1-\sigma}) \int_{e(z)=1} z^{\sigma-1}\mu(dz) \Big) \Big\}^{\frac{1}{\sigma-1}}. \tag{13}$$

The first integral is taken with respect to non-exporting firms while the second integral is taken with respect to exporting firms. Moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$, $e(z) = 1$ for some z), the aggregate TFP in the economy increases, since high-productivity entrepreneurs increase their production relative to the non-exporters (Melitz, 2003).

From Equation (12), we have

$$\frac{\Delta Y}{Y} \approx \frac{\Delta \text{TFP}}{\text{TFP}} + \alpha \frac{\Delta K}{K}. \tag{14}$$

Equation (14) shows that the change in aggregate output can be decomposed into contributions from the increase in aggregate TFP and from the increase in the capital stock. The percentage contributions from the increase in TFP and from capital accumulation are given by $(\frac{\Delta TFP}{TFP} / \frac{\Delta Y}{Y})$ and $\big(\alpha \cdot \frac{\Delta K}{K} / \frac{\Delta Y}{Y}\big)$, respectively.

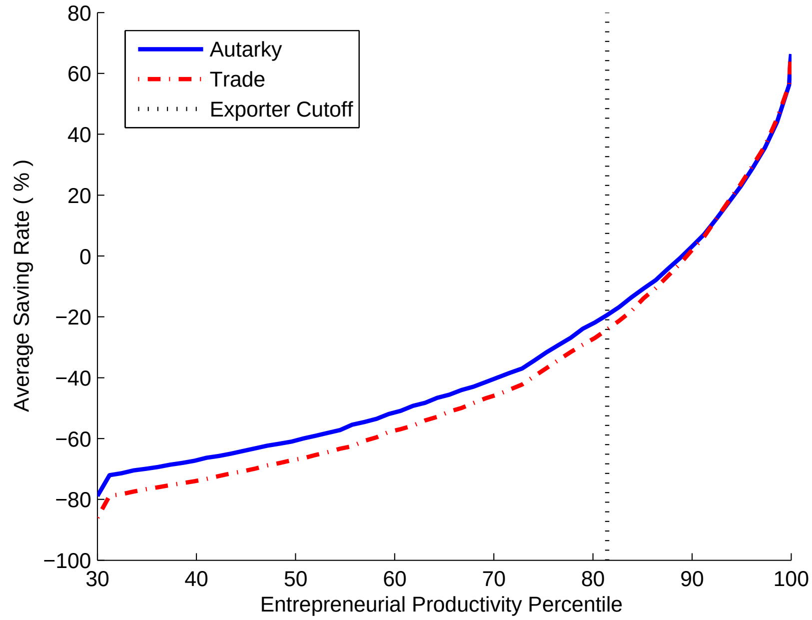
Table 3: The Impact of Trade on Aggregate Output

	Change in Aggregate Output		Decomposition	
	(1)	(2)	(3)	(4)
Model	Full Model	CM Benchmark	Full Model	CM Benchmark
TFP	3.6%	3.6%	56.8%	66.8%
Capital	8.3%	5.3%	43.2%	33.2%
Output	6.3%	5.4%	100.0%	100.0%

"Full Model" refers to the model described in Section 2.1; "CM Benchmark" refers to the complete markets benchmark described in Section 2.5.

Columns (1) and (2) of Table 3 summarize the impact of trade on aggregate output. In the full model, when we move from Autarky to Trade, aggregate output increases by 6.3%. In the CM benchmark, aggregate output increases by 5.4%, 0.9 percentage points less than in the full model. Crucially, the percentage change in aggregate TFP is identical across the two models. The difference in output gains from trade is solely driven by the difference in capital accumulation. Columns (3) and (4) of Table 3 present the decomposition of the output gains from trade for both models. Capital accumulation plays a more important role in the full model than in the CM benchmark. Increased capital accumulation accounts for 43.2% of the output gains from trade in the full model, compared to 33.2% in the CM benchmark. It is also important to note that the contribution of capital accumulation to the output gains

Figure 1: Average Saving Rate And Entrepreneur Productivity z



I define an entrepreneur's saving rate as $\frac{a'-a}{y}$, where $y = \pi + a \cdot r$ is the entrepreneur's overall income. Average saving rate is calculated as the total saving of entrepreneurs (sum of $(a' - a)$) with a given z (but different a), divided by their total income. The figure starts at the 30th percentile of productivity, as I group the entrepreneurs in the first three productivity deciles together when solving the model numerically.

from trade is quantitatively large in both models. The decomposition exercise shows the importance of explicitly accounting for capital accumulation in attempts to quantify the gains from trade.

In the full model, there is an 8.3% increase in the capital stock as we move from Autarky to Trade. The capital stock increases through two channels. First, the reduction in variable trade costs increases the demand for capital, as exporters expand their production to serve foreign markets. This is analogous to the increase in the demand for labor in Melitz (2003).

Second, the reduction in trade costs increases the supply of capital. Figure 1 shows that the average saving rate of entrepreneurs in the full model is strongly increasing in entrepreneurial productivity z.[25,26] High-productivity entrepreneurs have higher current income than their long-term expected in-

[25] I define an entrepreneur's saving rate as $\frac{a'-a}{y}$, where $y = \pi + a \cdot r$ is the entrepreneur's overall income. The average saving rate for a given z is calculated as the total saving of entrepreneurs (sum of $(a' - a)$) with a given z (but different a), divided by their total income.

[26] Dynan, Skinner, and Zeldes (2004) document a steep positive relationship between the saving rate and income. They find some evidence that the relationship is in part driven by uncertainty with respect to income, as is the case in this paper. Carroll (2000) argues that the saving behavior of the rich is best explained by a model in which wealth enters the utility function of individuals directly. In his model, individuals regard accumulation of wealth as an end in itself. I conjecture that the supply-side channel of capital accumulation would remain if I instead used the approach of Carroll (2000) to generate a positive relationship between the saving rate and income.

come and save aggressively for consumption-smoothing and precautionary reasons. On the other hand, low-productivity entrepreneurs have lower current income relative to their long-term expected income and dis-save from their wealth. Since greater trade openness increases the share of profits received by the most productive entrepreneurs, there is a substantial increase in the aggregate supply of capital in the economy. Consequently, the interest rate in equilibrium decreases from 3.2% to 3.0% to as we move from Autarky to Trade. In contrast, in the CM Benchmark, the equilibrium interest rate is the same for Autarky and Trade at 3.0%. The capital stock increases by 5.4%, substantially less than the 8.3% increase in the full model. This confirms the quantitative importance of the supply-side channel emphasized in this paper.

In principle, there are two mechanisms by which moving from Autarky to Trade can affect aggregate saving. First, moving to trade increases the income share of the most productive entrepreneurs, who have higher saving rates. Second, moving to trade increases income uncertainty which may encourage additional precautionary saving for any given level of income.

To shed light on the mechanism behind the increase in the supply of capital, I group the entrepreneurs by their productivity z and conduct two counter-factual experiments.[27] First, I fix the average saving rate of each z group at its level under Autarky, and change the income shares of each group to the income shares under Trade. This results in an increase of 2.55% in the aggregate saving rate among entrepreneurs. Second, I fix the income shares of each z group under their levels under Autarky, and change the average saving rate of each group to the saving rate under Trade. This results in a decrease of 2.69% in the aggregate saving rate. The decomposition exercise suggests that the change in income shares among entrepreneurs, rather than increases in the saving rates for given levels of z, is behind the increase in the supply of capital. Appendix III provides details of the experiments above, as part of a decomposition exercise on the change in the aggregate saving rate.[28]

I conduct an additional decomposition exercise on the change in the aggregate target-wealth-to-profit ratio, where the target wealth of an entrepreneur with productivity z is his steady-state wealth if the entrepreneur were to receive the same z forever. The decomposition exercise shows that the change in profit shares among entrepreneurs, rather than an increase in the individual-level target-wealth-to-profit

[27]It is not possible to match the entrepreneurs by (a, z) between Autarky and Trade because the joint distribution of (a, z) is an endogenous object. Therefore, I group the entrepreneurs by z instead of by (a, z).

[28]In a stationary equilibrium, the aggregate saving rate of entrepreneurs is 0. A crucial point is that capital depreciation takes place inside financial intermediaries in this model, and entrepreneurs earn only the net return of saving. This is proven in Appendix III. In the model, by changing income shares of entrepreneurs, international trade increases the aggregate saving rate of entrepreneurs in a *partial-equilibrium* sense. In *general equilibrium*, the aggregate saving rate of entrepreneurs returns to 0 through the equilibrium adjustment of the interest rate. The *partial-equilibrium* increase in the aggregate saving rate is reflected in the higher capital stock in *general equilibrium.*

ratio, is behind the increase in the aggregate capital stock. The details of the decomposition exercise are also presented in Appendix III.

3.2.2 Welfare Gains from Trade

Having quantified the effect of trade openness on aggregate output, I examine the welfare implications of trade. In both models, welfare gains from trade may differ from output gains because some final good is used to replace depreciated capital. Moreover, as shown in Section 3.1, international trade affects the distribution of income among entrepreneurs, as well as the distribution of income between workers and entrepreneurs. It is important to examine the effects of trade on the welfare of workers and of entrepreneurs separately.[29]

In both models, workers face no income risk and simply consume their wage each period. A natural measure of workers' welfare is the equilibrium wage. In contrast to workers, entrepreneurs are heterogeneous and face idiosyncratic income risk. I measure the welfare of entrepreneurs in two ways. The first measure of entrepreneur welfare is simply the aggregate consumption of all entrepreneurs. The second measure of welfare is the certainty-equivalent consumption of a typical entrepreneur. Since there is no consumption heterogeneity in the CM benchmark, certainty-equivalent consumption is the same as aggregate consumption. For the full model, certainty-equivalent consumption is calculated in two steps. First, I calculate the average utility of entrepreneurs in a stationary equilibrium.[30] This is the expected utility of an entrepreneur chosen randomly from the economy at any point in time. Second, I use the static utility function to back out the "certainty equivalent" consumption that corresponds to the expected utility from the first step. The resulting welfare measure is expressed in units of the final good. Compared to aggregate consumption, certainty-equivalent consumption takes the distributional effects of trade into consideration.

Table 4 presents the effects of international trade on welfare. Consider the results from the full model. The increase in the wage is 6.4%. The increase in aggregate entrepreneurial consumption is more modest at 3.6%. In terms of certainty-equivalent consumption, there is in fact a 1.8% decrease for the entrepreneurial sector. Intuitively, although average consumption of entrepreneurs increases, the distribution of consumption among entrepreneurs becomes more dispersed when moving from Autarky to Trade. The calibration exercise shows that the increase in average consumption is not enough to offset

[29] To consider aggregate welfare, I would need to take a stand on the relative weights of entrepreneurs and workers in the social welfare function. I do not pursue this approach.

[30] Stationary equilibrium implies that I only have to look at a single period.

Table 4: Welfare Gains from Trade

Model	Full Model	CM Benchmark
Consumption of Workers		
Wage	6.4%	5.4%
Entrepreneurial Consumption		
Aggregate	3.6%	3.6%
Certainty-Equivalent	-1.9%	-

"Full Model" refers to the model described in Section 2.1; "CM Benchmark" refers to the complete markets benchmark described in Section 2.5.

the increase in dispersion of consumption.

The differences between the two models in the responses of output and the capital stock translate into differences in welfare gains for workers. In the CM benchmark, the increase in the wage is only 5.3%, lower than that in the full model. The increase in aggregate entrepreneur consumption in the CM benchmark is similar to that in the full model.[31]

3.3 The Role of Risk Aversion

The saving behavior of entrepreneurs plays a very important role in the full model. A critical parameter governing saving behavior is λ, the coefficient of relative risk aversion. In the calibration of the full model, I set λ at 1.5. To understand the role of λ in the model, I vary the value of λ. Since a larger value of λ drives down the equilibrium interest rate, to maintain an equilibrium interest rate of 3.0%, I pick a different value of the discount factor β for each value of λ. In other words, I use different combinations of λ and β to obtain the same target interest rate of 3.0% while maintaining all other parameter values as given in Table 1. First, I set λ to 1.0, which corresponds to the log utility function. To match the target interest rate, I set β to 0.944. I then set λ to 2.0. To match the target interest rate, I set β at 0.913.

The gains from trade implied by different values of λ and β for the full model are presented in Table 5. The baseline results implied by $\lambda = 1.5$, $\beta = 0.929$ are reproduced in Column (2) for easy comparison. The impact of trade on aggregate TFP and aggregate entrepreneurial consumption are virtually identical across the different combinations of λ and β.

Column (1) presents gains from trade assuming less risk aversion ($\lambda = 1.0$, $\beta = 0.944$). The percentage increase in the capital stock due to trade is now smaller at 7.6%. The smaller increase in capital

[31] Aggregate consumption is identical to certainty-equivalent consumption in the CM benchmark, since there is no consumption heterogeneity among entrepreneurs in the CM benchmark. For this reason, I do not report the change in certainty-equivalent consumption.

stock translates into smaller output gains from trade (6.1%) and smaller wage gains for workers (6.1%). However, certainty-equivalent entrepreneurial consumption decreases by only 1.0% instead of 1.9%, as lower risk aversion implies that entrepreneurs do not suffer as large a loss in expected utility due to increased income dispersion under trade.

Column (3) of Table 5 presents the results when I assume more risk aversion ($\lambda = 2.0$, $\beta = 0.913$). The percentage increase in the capital stock due to trade is now higher, at 8.8%. The output gains from trade and wage gains are also higher, while certainty-equivalent entrepreneurial consumption decreases by a larger percentage (2.4%) than in the baseline calibration.

Table 5: The Role of Coefficient of Relative Risk Aversion λ in the Full Model

	(1)	(2)	(3)
	Parameter Values		
λ	1.0	1.5	2.0
β	0.944	0.929	0.913
Percentage Change due to Trade			
TFP	3.6%	3.6%	3.6%
Capital	7.6%	8.3%	8.8%
Output	6.1%	6.3%	6.5%
Consumption of Workers			
Wage	6.1%	6.4%	6.6%
Entrepreneurial Consumption			
Aggregate	3.6%	3.6%	3.6%
Certainty-Equivalent	-1.0%	-1.9%	-2.4%

Column (1) presents the results when a log utility function is used. For each alternative value of λ, the parameter β is re-calibrated to match a real interest rate of 3.00%.

Overall, Table 5 shows that the degree of risk aversion matters for our evaluation of the realized gains from trade, through its effects on capital accumulation. A larger value of λ corresponds to a larger increase in the capital stock and a greater increase in output. The intuition is that a higher λ implies a steeper saving-income relationship for entrepreneurs.

As in Section 3.2.1 and in Appendix III, I conduct two experiments to analyze the change in the aggregate saving rate of entrepreneurs. First, I fix the average saving rate of each z group at Autarky and change the income shares of each group to the income shares under Trade. This results in an increase of 2.46, 2.55, and 2.60 percentage points in the aggregate saving rate among entrepreneurs, for $\lambda = 1.0, 1.5,$ and 2.0, respectively. Second, I fix the income shares of each z group under Autarky and change the average saving rate of each group to the saving rate under Trade. This results in a decrease of 2.59, 2.69 and 2.75 percentage points in the aggregate saving rate for $\lambda = 1.0, 1.5,$ and 2.0, respectively.

This confirms the finding above that the change in income shares among entrepreneurs is behind the large increase in the supply of capital. The value of λ affects the magnitude of the increase in the supply of capital, by changing the slope of the saving-income relationship.

3.4 Robustness and Extensions

In this paper, I focus on the comparison between Autarky and an economy calibrated to match the observed level of trade in the US. The comparison reveals the realized gains from trade, which are of much interest in the trade literature. In Appendix IV, I consider two additional policy experiments where I further reduce the variable trade cost. The supply-side channel of capital adjustment appears to be less important when the countries are already quite open to trade. In the baseline calibration, with a relatively small fixed cost of exporting, a further decrease in the variable trade cost induces export entry by less productive firms, and the increase in the export of the country is shared by more firms. This limits the increase in top income inequality and consequently the response in the supply of capital. In ongoing work, I calibrate the full model to China. Data moments for China differ from those for US in two crucial respects: first, the Export/GDP ratio is higher in China; second, conditional in exporting, firms in China export a greater fraction of total sales. I calibrate a higher fixed cost of exporting and a lower variable cost for China, compared to the trade costs in the baseline calibration using US data. With a high calibrated fixed cost of exporting, a further decrease in the variable trade cost induces a large increase in the capital stock, even when the Trade/GDP ratio is relatively high.

In Appendix V, I examine the robustness of the calibration results. In the first robustness check, I introduce a sunk cost of exporting. In the second, I relax the borrowing constraints for entrepreneurs by introducing a natural borrowing limit. In the third robustness check, I introduce a limited-enforcement financial constraint on the production side, such that the production policy functions include wealth a as an additional argument. Lastly, I calibrate the productivity process using a log-normal AR(1) process. The results are robust to the introduction of a sunk cost, a natural borrowing limit on the consumption side, or financial constraints on the production side. On the other hand, a fat-tailed distribution of firm sales appears to be crucial for the results. In an economy where productivity has a log-normal distribution, entrepreneurs with the highest productivity and the highest saving rate account for less of the total saving. As a result, the trade-induced redistribution of profits to the most productive entrepreneurs has a much smaller effect on the aggregate supply of capital.

In Appendix VI, I present versions of the model without capital, "NoK" and "NoK CM," which correspond to the full model and the CM benchmark, respectively. I then compare the gains from trade under these two variants of the model. In the absence of capital, heterogeneity in entrepreneurial income affects the size of welfare gains for entrepreneurs, but it does not affect the size of output gains or welfare gains for workers. Therefore, the interaction of capital and the heterogeneity in entrepreneurial income explains the sizable differences between the full model and the CM benchmark reported in Table 3 and Table 4.

In the full model, I assume no entry or exit into entrepreneurship. This allows me to examine the welfare implication of international trade for workers and entrepreneurs separately. In particular, the setup enables me to isolate the welfare implications of top income inequality for workers. On the other hand, the exit of the least productive firms resulting from greater trade openness is another important source of TFP gains in the standard Melitz (2003) model. In *Online Appendix II*, I describe a version of the model with occupational choice as well as its associated complete markets benchmark. Agents are endowed with productivity z and choose to be a worker, a domestic producer, or an exporter of differentiated goods, subject to fixed costs of producing or exporting. In each period, the agents with the lowest z choose to be workers, while those with the highest z become exporters. The results in Table 3 and Table 4 are robust to the introduction of occupational choice into the model, although it is no longer possible to examine the welfare of workers and entrepreneurs separately.

4 Empirical Evidence

4.1 Overview

The theoretical model provides a number of testable hypotheses. For instance, the model predicts that reduced barriers to international trade increase top income inequality. Despite recent efforts to construct top income shares for a number of countries (Piketty and Saez, 2003), the sample of countries with top income data remains too small for analysis using panel regressions.[32] Testing the relationship between top income inequality and trade openness using micro data on trade liberalization episodes is hindered by poor coverage of high-income households in typical household survey data.

The model also predicts a strong relationship between the individual-level saving rate and income

[32] The World Top Income Database by Alvaredo, Atkinson, Piketty, and Saez (2011) covers 25 countries. I attempt to use the top income database to analyze the effects of trade openness on top income inequality in a panel of countries. I find that the results are sensitive to exclusion of certain countries (For example, Singapore). Roine, Vlachos, and Waldenstrom (2009) study the correlates of top income inequality using a sample of 14 countries and do not find a positive correlation between trade openness and top income shares. However, they do not attempt to establish causality.

among entrepreneurs (the top of the income distribution of the whole population). According to Dynan et al. (2004), the median saving rate is 51.2% for households in the top 1% of income, and 37.2% for the households in the top 5% of income (inclusive of the top 1%) in the 1983-89 US Survey of Consumer Finances (SCF) data.[33] Using 2012 data from the China Household Finances Survey (CHFS), Gan (2013) calculates that the average saving rate is 72.2% for households in the top 5% of income and 45.2% for households in the top 10% of income in China, compared to an average saving rate of 31.8% for the entire sample. Clearly, if the saving rate is a function of a household's position in the income distribution, as in my model (Figure 1), shifting of income shares towards the individuals at the top of the income distribution can increase the aggregate saving rate substantially.

In view of the evidence on the saving-income relationship, if openness increases top income inequality, there should be a positive relationship between the aggregate saving rate and openness. I focus on testing this hypothesis in a panel of countries. An important advantage of this approach is that data on the aggregate saving rate is more widely available than data on top income shares. To begin, I use fixed-effects regressions to study the relationship between openness and the saving rate in a panel of countries. To distinguish the supply-side channel from the demand-side channel, I also examine the relationship between the aggregate investment rate and trade openness. If the saving-openness relationship is driven primarily by higher returns to investment, we would expect the investment-openness relationship to be stronger than the saving-openness relationship, since at least some of the increased investment following an increase in openness would be financed by capital inflows. Next, to address the endogeneity of trade openness, I follow Frankel and Romer (1999) and Alcalá and Ciccone (2004) and employ the gravity-based IV approach in a cross section of countries. I find that trade openness has a large positive effect on the aggregate saving rate in a cross section of countries. Finally, I employ the gravity-based instrumental-variable (IV) approach pioneered by Frankel and Romer (1999) in a panel setting, and find larger effects of trade openness on the saving rate than in the simple fixed-effects regressions.

4.2 Fixed-Effects Panel Regressions

This section analyzes the effects of trade openness on the national saving rate in a panel of countries. The equation of interest is

$$S_{it} = \beta_0 + \beta_1(\text{Trade/GDP})_{it} + \beta_2 X_{it} + c_i + \mu_t + v_{it} \tag{15}$$

[33] Relatedly, using tax returns data, Saez and Zucman (2014) calculate that the average saving rate is 36% for the top 1% in wealth and 22% for the top 10% in wealth over the period 1986-2012 for the US.

where S_{it} is the national saving rate in country i at time t, $(\text{Trade/GDP})_{it}$ is the Trade/GDP ratio (the openness ratio), X_{it} is a vector of control variables, and c_i and μ_t are country and time fixed effects, respectively.

My main measure of national saving is the gross national saving rate from the World Development Index (WDI), which is defined as national income plus net transfers less consumption, as a percentage of gross national income. The empirical results are robust to the use of the net national saving rate, which accounts for depreciation, or the private saving rate as the dependent variable. To distinguish the supply-side channel of capital from the demand-side channel in the data, I also examine a specification analogous to Equation (15) but with the gross investment rate as the dependent variable. I use gross fixed capital formation as a percentage of GDP, available from the WDI database, as the investment measure.

The conventional openness ratio (the Trade/GDP ratio) is defined as the sum of exports and imports over GDP, where each term is calculated based on the nominal exchange rate. Alcalá and Ciccone (2004) argue that the real openness ratio, defined as the real sum of exports and imports over purchasing power parity (PPP) GDP, is theoretically preferred to the conventional measure. According to the model in Alcalá and Ciccone (2004), greater trade openness can reduce the price level in the tradable sector relative to the price level in the non-tradable sector as a result of a productivity increase in the tradable sector. This may cause a distortion in the conventional openness ratio. While Alcalá and Ciccone (2004) do not adjust the sum of exports and imports for PPP prices, presumably due to data availability, the most recent Penn World Table (Mark 8.0) (Feenstra, Inklaar, and Timmer, 2013) has made this adjustment possible. I use the *real* openness ratio from PWT (Mark 8.0), which adjusts the sum of exports and imports for PPP prices, throughout this paper. I provide a summary of the main variables and data sources for the empirical exercise in Table A10.

To reduce the influence of outliers, I group the years 1961-2005 into nine non-overlapping five-year intervals and use the averages of yearly data in the regressions. I exclude the years after 2005 in view of the global recession starting in 2007. I exclude countries whose population in 1961 is smaller than 1.5 million, because the aggregate variables of small states are more prone to large fluctuations.[34] The final sample includes 111 countries.

Panel A of Table 6 presents the results from fixed-effects panel regressions on the saving rate. Column

[34] Mankiw, Romer, and Weil (1992) argue that the determination of real income in small countries may be dominated by idiosyncratic factors, and they exclude small countries from one of their samples in their test of the Solow growth model. The population cutoff of 1.5 million for small states in this paper is taken from the World Bank (`http://www.worldbank.org/en/country/smallstates/overview`).

Table 6: The Effect of Trade on Aggregate Saving and Investment

Fixed-Effects Panel Regressions

	(1) No-Covar	(2) Lag-Y	(3) Fin-Dev	(4) Lag-Lead	(5) Inv/Sav
Panel A.			Gross National Saving Rate		
Trade/GDP	0.0744***	0.107***	0.107***	0.0907**	0.0773*
	(0.0262)	(0.0396)	(0.0392)	(0.0384)	(0.0409)
Trade/GDP (Lag)				0.00809	
				(0.0232)	
Trade/GDP (Lead)				0.0685	
				(0.0566)	
Investment Rate					0.617***
					(0.0930)
Within R^2	0.0930	0.165	0.166	0.201	0.358
Panel B.			Gross Investment Rate		
Trade/GDP	0.0125	0.0463***	0.0479***	0.0572***	0.00797
	(0.0143)	(0.0151)	(0.0157)	(0.0203)	(0.0183)
Trade/GDP (Lag)				0.00610	
				(0.0194)	
Trade/GDP (Lead)				-0.00635	
				(0.0274)	
Saving Rate					0.374***
					(0.0892)
Within R^2	0.0466	0.157	0.161	0.180	0.354
N Countries	111	111	111	107	111
N Observations	567	567	567	461	567

Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. I group the years 1961-2005 into nine five-year intervals and use the averages of yearly data in the regressions. Time and country fixed effects are included in all regressions. Column (1) ("No-Covar") includes only time and country fixed effects as controls; Column (2) ("Lag-Y") adds log income and its square (both lagged) as controls; Column (3) ("Fin-Dev") additionally controls for the Credit/GDP ratio (lagged); Column (4) controls for the five-year lag and lead of the Trade/GDP ratio, in addition to the controls in Column (3); Column (5) ("Inv/Sav") controls for the investment rate in the saving regression, and for the saving rate in the investment regression, in addition to the controls in Column (3).

(1) includes the Trade/GDP ratio as the only right-hand-side variable aside from the fixed effects. A one-percentage-point increase in the Trade/GDP ratio is associated with a 0.0744 percentage point increase in the aggregate saving rate. The coefficient is statistically different from zero at the 1% significance level. In Column (2), I control for income by including the log of GDP per capita and its square. Since GDP per capita is most likely endogenous with respect to the saving rate, I lag these two variables by five years. The coefficient on trade openness remains positive and significant. In Table A8, I show that the results are robust to controlling for current income instead of lagged income.

Financial development is another potentially important omitted variable. In Column (3), I control for financial development using the Credit/GDP ratio. I lag the Credit/GDP ratio by five years since this measure is potentially endogenous with respect to the saving rate. Column (3) is my preferred panel specification. According to Column (3), a one-percentage-point increase in the Trade/GDP ratio raises the aggregate saving rate by 0.107 percentage point. The coefficient is statistically significant at 1%. According to the point estimate in Column (3), the gross national saving rate increases by 0.255 standard deviation for a one-standard-deviation increase in the openness measure.[35] As an example, if Bulgaria (Trade/GDP ratio at 33.0%) had the same level of openness as Austria (Trade/GDP ratio at 81.3%) over the period 1996 to 2000, its average national saving rate would have been 18.8% instead of 13.7%.

Columns (1)-(3) demonstrate a strong correlation between trade openness and the saving rate. However, a higher level of openness may be a result rather than a cause of a higher aggregate saving rate. For example, a positive shock to the national saving rate may allow a country to build up infrastructure conducive to international trade, resulting in a higher measured level of openness. To address this issue, I include the five-year lag and lead of the Trade/GDP ratio in the panel regression. As shown in Column (4) of Table 6, the coefficient on the contemporaneous Trade/GDP ratio remains positive and statistically significant. On the other hand, the coefficients on past and future trade openness are not statistically significant. This provides some evidence in favor of the proposed mechanism.

The theoretical model emphasizes the importance of the supply-side channel of capital accumulation. However, the strong correlation between the Trade/GDP ratio and the saving rate may be driven by demand-side factors, as a higher return to investment after a trade liberalization induces households to save more. In Column (5), I control for the gross investment rate in the regression. The results show that, conditional on the gross investment rate, there is still a strong and positive correlation between the Trade/GDP ratio and the national saving rate. This is not what we would expect to find if the

[35] I remove the country and year fixed-effects before calculating the standard deviations of the Trade/GDP ratio and the gross national saving rate.

saving-openness relationship is solely driven by a higher return to investment.

In Panel B of Table 6, I repeat the analysis with the gross investment rate as the dependent variable. The coefficient on the Trade/GDP ratio is positive and statistically significant at 1% in Columns (2) and (3), but it is not statistically significant in Column (1). According to Column (3), the gross investment rate increases by 0.165 standard deviations following a one-standard-deviation increase in the Trade/GDP ratio, compared to an increase of 0.255 standard deviation for the national saving rate. Column (4) shows that the investment rate is positively correlated with contemporaneous trade openness but is not correlated with past or future trade openness. Column (5) shows that conditional on the saving rate, there is no statistically significant relationship between trade openness and the gross investment rate. A comparison of the results from Panel A and Panel B of Table 6 suggests that the supply-side channel of capital accumulation dominates the demand-side channel.

I find that the results are robust to the introduction of additional regressors and modifications of the baseline specification. The details of the robustness checks are presented in Table A8. Another concern is that the results in Table 6 are driven by a handful of countries. The World Bank classifies countries into seven regions: East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa. To address the concern of outlier countries, I drop each region one by one from the full sample and repeat the analysis in each column of Table A9. The results are robust to the exclusion of any single region.

The Role of Initial Top Income Inequality

The fixed-effects regressions above establish a strong correlation between trade openness and the aggregate saving rate. Since trade openness increases the aggregate saving rate through its effects on top income inequality in the model, it is interesting to examine the role of initial top income inequality on the saving-openness relationship. The equation of interest is

$$S_{it} = \beta_0 + \beta_1(\text{Trade/GDP})_{it} + \beta_2\text{Inequality}_i \cdot (\text{Trade/GDP})_{it} + \beta_3 X_{it} + c_i + \mu_t + v_{it}, \tag{16}$$

where Inequality_i is a proxy for initial entrepreneurial income inequality. As in Column (3) of Table 6, I control for lagged income and financial development. The coefficient β_1 shoud be interpreted jointly with the coefficient on the interaction β_2. The marginal effect on the aggregate saving rate of an increase in the Trade/GDP ratio is given by $(\beta_1 + \beta_2\text{Inequality}_i)$.

I use data on top 10% income share from the UNU-WIDER World Income Inequality Database (UNU-WIDER, 2014) as a proxy for initial entrepreneurial income inequality.[36] Ideally, I would like to use data on top 10% income shares from a single cross section in 1960 to capture the difference in initial inequality before any changes in trade openness. However, data availability for top 10% income shares varies across years and countries. For the countries without data for 1960, I use data closest to 1960. Since UNU-WIDER has data going back to 1867, the years with data closest to 1960 may be before 1960, after 1960 or both.[37] This procedure allows me to retain the largest possible number of countries in the sample.

Table 7: Differential Effects of Openness on Aggregate Saving and Investment:

the Role of Initial Inequality

	(1) All	(2) 20-Year	(3) 10-Year
Panel A.	Gross National Saving Rate		
Trade/GDP	0.0174	-0.0882	-0.128
	(0.0909)	(0.0909)	(0.0874)
Initial Inequality × Trade/GDP	0.00239	0.00447*	0.00574**
	(0.00233)	(0.00230)	(0.00235)
Within R^2	0.181	0.176	0.189
Panel B.	Gross Investment Rate		
Trade/GDP	0.0122	-0.00436	-0.00834
	(0.0396)	(0.0540)	(0.0506)
Initial Inequality × Trade/GDP	0.00135	0.00216	0.00215
	(0.00111)	(0.00139)	(0.00136)
Within R^2	0.185	0.227	0.259
N Countries	107	58	44
N Observations	551	364	281

Robust standard errors are clustered at country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. I group the years 1961-2005 into non-overlapping 5-year intervals and use the averages of yearly data in the regressions. I control for log income and its square (both lagged), and the Credit/GDP ratio (lagged). Time and country fixed effects are included in all regressions. Column (1) ("All years") includes all countries for which we have data; Column (2) ("20-Years") restricts the sample to countries for which the data on initial inequality (top 10% income shares) come from 1951-1970; Column (3) ("10-Years") restricts the sample to countries for which the data on initial inequality (top 10% income shares) come from 1956-1965.

The results are presented in Panel A of Table 7. Column (1) presents the results when all countries

[36] As discussed earlier, data on top 0.1% income shares are available only for a small number of countries. Data from the World Top Income Database show that there is a strong correlation between the top 10% income share in the cross section and the (top 0.1% income share)/(top 10% income share) ratio, which is a more ideal proxy for initial entrepreneurial income inequality.

[37] As an example, data for a country may be available for 1958 and 1962 but not available for 1960. In this case, I take the average between the 1958 and 1962 data.

with available data are included in the sample. The point estimate of β_2 is positive but statistically insignificant. A problem with the results in Column (1) is the use of data from different years to proxy for the cross-sectional difference in top income inequality between countries. In Column (2), I conduct the same analysis for countries for which the data on top 10% income shares come from a 20-year window between 1951 and 1970. This reduces the number of countries in the sample to 58. Among the countries used in the regression, for a one-percentage-point increase in the Trade/GDP ratio, the marginal effects on the national saving rate range from -0.002 to 0.177 percentage points, where the negative values are not statistically different from zero. The point estimate of β_2 is positive and statistically significant at 10%. According to Column (2), for a one-percentage-point increase in the initial top 10% income share, the marginal effect on the national saving rate of a one-percentage-point increase in the Trade/GDP ratio is 0.004 percentage points higher. Column (3) further limits the analysis to countries for which the data on top 10% income shares come from a 10-year window between 1956 and 1965. The point estimate for β_2 increases slightly and is now statistically significant at 5%. The results suggest that the level of initial top income inequality plays an important role for the saving-openness relationship.

Panel B of Table 7 repeats the analysis with the gross investment rate as the dependent variable. The coefficient on the additional interaction term $\text{Inequality}_i(\text{Trade/GDP})_{it}$ is positive but is statistically insignificant in all three columns. This is reminiscent of the results in Table 6 that the saving-openness relationship is stronger than the investment-openness relationship.

4.3 Fixed-Effects Panel Regressions with IV

A concern about the fixed-effects results presented above is that openness might be endogenous with respect to saving. For example, a strong economy overall could simultaneously boost saving and trade. Alternatively, an increase in domestic saving could allow domestic firms to invest in export operations. To address issues of endogeneity, I follow Frankel and Romer (1999) and Alcalá and Ciccone (2004) in using gravity variables as instruments for trade openness. First, I find a large effect of trade openness on the aggregate saving rate but an insignificant effect on the investment rate when I instrument for openness in a cross section of countries. The details of the cross-section exercise are relegated to *Online Appendix III*. Next, I extend the gravity-based methodology of Frankel and Romer (1999) to a panel setting.[38] To construct my instrument, I run the following panel regression on the bilateral trade share:

$$\log(\frac{\text{Trade}_{ij\tau}}{\text{GDP}_{i\tau}}) = \gamma_0 + \gamma_1 \text{Freight}_\tau \cdot \ln(Dist_{ij}) + \gamma_2 X_{ij} + \gamma_3 Z_{ij\tau} + u_\tau + \epsilon_{ij\tau} \quad (17)$$

where $\text{Trade}_{ij\tau}$ is the sum of exports and imports between country i and country j, Freight_τ is an index of shipping costs (common to all countries) from Hummels (2007), $\ln(Dist_{ij})$ is the log of bilateral distance between the two countries, X_{ij} is a vector of geography variables (including $\ln(Dist_{ij})$), $Z_{ij\tau}$ are the time-varying gravity terms related to population, and u_τ is a year fixed effect.[39] Specifically, X_{ij} includes bilateral distance, total land area, landlocked status, bordering status, and the interaction of bordering status with all other geographic features; and $Z_{ij\tau}$ includes population and its interaction with bordering status. These gravity terms follow Frankel and Romer (1999) closely.

I estimate Equation (17) using fixed-effects panel regression.[40] I then aggregate the predicted bilateral trade shares (unlogged) from Equation (17) over trade partners to obtain the predicted trade share for country i in year τ. The predicted trade shares are then averaged over nine five-year intervals and employed as an IV for the Trade/GDP ratio in Equation (15).[41] Aside from the year fixed effect in Equation (17), the resulting predicted trade shares are time-varying for two reasons. First, the gravity terms involving population are time varying. Second, advances in shipping technology, as reflected in the decrease in the index of shipping costs, increase bilateral trade more for country pairs with greater bilateral distance. In other words, $\gamma_1 < 0$ in Equation (17). In practice, both sources of time variation are necessary to have a relatively strong first stage in the 2SLS regression. Since the population size of a country may have a direct effect on its national saving rate, I include log of population as a control variable in the 2SLS regression in addition to the standard controls in Column (3) of Table 6. The identifying assumption is that the shipping cost index (common to all countries), and the populations of a country's trade partners, are exogenous with respect to its gross national saving rate and gross investment rate.

Since the sample is reduced by the use of trade flow data, I report the fixed-effects OLS estimates for the smaller sample in Column (1) of Table 8. The results from the fixed-effects 2SLS regressions are

[38] Feyrer (2009) and Felbermayr and Gröschl (2013) use gravity-based IV in a panel setting to study the relationship between income and trade openness. Feyrer (2009) exploits the fact that improvement in aircraft technology increases bilateral trade more for country pairs with relatively short air routes compared to sea routes. Felbermayr and Gröschl (2013) use natural disasters as a source of exogenous variation.

[39] I experiment with a specification with bilateral fixed effects to control for all time-invariant factors. I find that the 2SLS results from the resulting IV are very sensitive to exclusions of particular subsamples.

[40] I also experiment with the Poisson Pseudo Maximum Likelihood estimator (PPML) proposed in Santos Silva and Tenreyro (2006), and find the resulting instrument to be too weak.

[41] Since I have bilateral trade data from 1962 to 2000, the average predicted trade shares for 1962-1965 are used in place of the average for 1961-1965.

Table 8: The Effect of Trade on Aggregate Saving and Investment

Fixed-Effects Panel Regressions with IV

	FE-OLS	FE-2SLS
Panel A.	Gross National Saving Rate	
Trade/GDP	0.110***	0.221**
	(0.0411)	(0.0952)
Panel B.	Gross Investment Rate	
Trade/GDP	0.0546***	-0.0479
	(0.0188)	(0.0679)
Panel C.	First Stage of 2SLS	
Predicted Trade Share		1.879**
		(0.743)
Excluded IV F-Stat		6.399
N Countries	83	83
N Observations	441	441

Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. I group the years 1961-2000 into eight five-year intervals and use the averages of yearly data in the regressions. Time and country fixed effects are included in all regressions. The control variables are log income and its square (both lagged), the Credit/GDP ratio (lagged) and log population. The instrument in 2SLS regressions is the predicted trade share from a panel gravity regression (see text).

presented in Column (2). The first-stage F-statistic for the excluded instrument is 6.4, lower than the rule-of-thumb critical value of 10. According to the 2SLS results, a one-percentage-point increase in the Trade/GDP ratio raises the national saving rate by 0.228 percentage point, larger than the increase of 0.118 percentage point in the fixed-effects OLS regression. On the other hand, I do not find a positive effect of trade openness on the gross investment rate in the 2SLS regression. Table B7 and Table B8 in *Online Appendix IV* show that the results are robust to additional controls, and exclusion of any single region from the sample, respectively.[42]

4.4 Discussion

To summarize the empirical results so far, I find a strong relationship between openness and the saving rate in a cross section and a panel of countries. I find a much weaker relationship between openness and the investment rate. Taken together, these results provide strong evidence that a supply-side channel of increased capital accumulation is operative following an increase in trade openness. The finding of a robust positive relationship between openness and the aggregate saving rate is consistent with the theoretical results in Section 3. However, the mechanism emphasized in the theoretical model is not the only potential explanation for the observed saving-openness relationship.

One plausible alternative explanation is that trade openness decreases the labor share of income.[43] If the saving rate of labor income is lower than that of capital income, a decrease in the labor share of income can increase the aggregate saving rate. Another related explanation is that the increased income share for the very top group ("the exporters") comes at the expense of smaller income shares for low-income groups ("the workers"), rather than for other high-income groups ("the domestic producers"). For example, a change in the competitive environment, resulting from increased trade openness, may allow superstar entrepreneurs to charge higher markups.[44] To distinguish the proposed mechanism from alternative explanations, I use data on the labor share of income from Karabarbounis and Neiman (2014) as an additional control in the fixed-effects panel regression.[45] The results are presented in Column (9) of Table A8. Although the sample is substantially reduced, the coefficient on the Trade/GDP ratio remains positive and statistically significant. This provides some evidence in favor of the proposed mechanism.

[42] The coefficient on trade openness is positive but statistically insignificant when I additionally control for the trade balance in the 2SLS regression of the national saving rate.

[43] Harrison (2005) studies the relationship between globalization and the labor share of income. Her results suggest that rising trade openness reduces the labor share of income.

[44] Using data from Slovenia, De Loecker and Warzynski (2012) find that exporters charge higher markups on average, and markups increase upon export entry.

[45] Karabarbounis and Neiman (2014) provide data on the labor share of income in the corporate sector, and the overall labor share. I use the overall labor share of income, as this variable is available for a larger number of countries.

Another explanation is that the income shares of various groups are independent of trade openness, but trade openness increases the saving rate of certain income groups. Since the saving rate of low income groups has a small effect on the aggregate saving rate, the saving rate of high income groups should increase at least moderately for this alternative explanation to be plausible. In the theoretical results in Section 3, I do not find an increase in the saving rate for exporters. However, to distinguish empirically the proposed mechanism from the alternative explanation, we would need to examine the entire distribution of income and saving rates in a country before and after a trade shock. I leave this for future research.

Capital Flows Across Countries

For simplicity, I have assumed in the theoretical model that capital is immobile across countries, so that $S = I$ holds for each country.[46] While Levine and Renelt (1992), Wacziarg (2001) and Wacziarg and Welch (2008) find a positive relationship between trade openness and the investment rate, I find this relationship to be statistically weaker than the relationship between trade openness and the saving rate. I do not find a significant relationship between trade openness and the investment rate in some specifications. On the one hand, this supports my emphasis on the supply-side channel of capital accumulation. On the other hand, the weaker relationship between trade openness and the investment rate suggests that some of the trade-induced increase in saving flows abroad.

If capital is mobile across countries in the model, some of the trade-induced increase in saving in a country may flow abroad and result in higher investment in the recipient country. Workers in the recipient country would benefit from higher wages through a higher marginal productivity of labor. In other words, with capital flows across countries, the positive welfare effect of a trade-induced increase in saving in one country may be shared with workers in different countries.[47] Therefore, relaxation of the $S = I$ assumption has implications for the distribution of gains from trade between countries. However, a quantitative analysis of distributional effects between countries is beyond the scope of this paper.

[46] Feldstein and Horioka (1980) documents a strong relationship between domestic saving and investment. Bai and Zhang (2010) use a model with financial frictions to explain the Feldstein-Horioka puzzle.

[47] In the extreme case of small economies with perfect capital account openness, the trade-induced increase in the aggregate saving rate would have no impact on the investment rate, or additional welfare gains for workers, in the domestic economy.

5 Conclusion

I propose a mechanism linking top income inequality and the gains from trade, through the effects of trade on aggregate saving. I calibrate the model to US data and show that the supply-side channel of capital accumulation is quantitatively relevant for the evaluation of the gains from trade. I test the key predictions from the model using country-level data and find strong support for the proposed mechanism.

While the empirical results suggest that the proposed mechanism is relevant for a typical country, the mechanism is particularly interesting when we consider the recent experience of China. China's recent integration into the global economy coincided with a rise in top income shares (Piketty and Qian, 2009) and a rise in the aggregate saving rate (Yang, 2012). Gan (2013) and Lin (2012) argue that the rise in income inequality is an important reason behind the high household saving rate in China. In ongoing work, I use the distance from the coast to instrument for changes in the trade openness of Chinese provinces, and find that greater openness has positive and statistically significant effects on both the household saving rate and the investment rate of a province. When the full model in this paper is calibrated using data from China, a decrease in the variable trade cost increases the aggregate supply of capital in the economy. Therefore, the model in this paper provides a framework to quantitatively examine the rise in the aggregate saving rate in China.

To focus on the interaction between top income inequality and the gains from trade for the average worker, I have abstracted from workers heterogeneity. Introducing worker heterogeneity would allow me to consider a setting where workers differentially benefit from the increase in capital accumulation according to their skill levels. Lastly, as discussed earlier, allowing for international capital flows would allow me to examine the distribution of the gains from trade between countries. I leave these interesting topics for future research.

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Appendix

Appendix I Computational Algorithm for the Full Model

The computational algorithm used in this paper is an extension of the nested fixed-point algorithm of Aiyagari (1994) and is similar to the algorithms used in Buera and Shin (2013). The assumptions of differentiated goods and constant returns to scale introduce a complication. Specifically, the total expenditure E on differentiated goods enters the maximization problem of firms. For each economy, I need to solve for equilibrium prices r and w, and aggregate expenditure E on differentiated goods.

I set the price of the final good to be 1. To start, I discretize the asset space a and the space for entrepreneur productivity z. I set the number of points in the asset space to be 3001 and the number of points in the space for z to be 60.

1. The total expenditure on differentiated goods is given by

$$E = \frac{w}{1-\alpha} \cdot \frac{\sigma}{\sigma - 1}. \tag{18}$$

   Since the final good producer makes zero profit, E is also the total expenditure on the final good.

2. Start with interest rate r and wage w. Calculate aggregate expenditure E from r and w using Equation (18).

3. For the set of prices r and w, and expenditure E, get the policy functions $a'(a, z)$, $o'(z)$ and $c(a, z)$. This is carried out with a value function iteration routine.

4. Guess the joint distribution of assets (a) and entrepreneur productivity (z) . Use the policy functions from Step 2, and the transition matrix of z, to obtain a new joint distribution the subsequent period. Continue the process until the maximum difference between the joint distributions from two consecutive periods is smaller than a given convergence criteria.

5. Check market clearing conditions. If markets do not clear at this point, update r and w with the bisection method. Repeat Steps 2 to 4 until all markets clear.

Appendix II Proof of Propositions

Proposition 1: Moving from Autarky $(\tau = \infty)$ to any positive level of trade, for any $x \in (0, 100)$, the profit share of the top $x\%$ of entrepreneurs increases. This holds true for any non-degenerate CDF function $\mu(z)$.

Lemma (1): If $f(x) > 0 \ \forall x \in (z, \infty)$, and $\sigma > 1$, then

$$\frac{d\left(\frac{\int_z^\infty x^{\sigma-1} f(x)dx}{\int_z^\infty f(x)dx}\right)}{dz} > 0.$$

Proof:

$$\begin{aligned}\frac{d\left(\frac{\int_z^\infty x^{\sigma-1} f(x)dx}{\int_z^\infty f(x)dx}\right)}{dz} &= \frac{\int_z^\infty f(x)dx \cdot \Big(-z^{\sigma-1}f(z)\Big) - \int_z^\infty x^{\sigma-1} f(x)dx \cdot (-f(z))}{(\int_z^\infty f(x)dx)^2} \\ &= \frac{f(z) \cdot \int_z^\infty (x^{\sigma-1} - z^{\sigma-1}) f(x)dx}{(\int_z^\infty f(x)dx)^2} \\ &> 0\end{aligned}$$

The following algebraic properties are useful in the proofs.

Property (1). If $\frac{A}{B} > \frac{C}{D}$, and $B > D > 0$, then $\frac{A-C}{B-D} > \frac{A}{B}$.

Property (2). If $\frac{A}{B} > \frac{C}{D}$, $B > 0$, and $D > 0$, then $\frac{A+C}{B+D} > \frac{C}{D}$.

Property (3). If $A < B$, $B > 0$ and $C > 0$, then $\frac{A}{B} > \frac{A+C}{B+C}$.

Proof of Proposition 1.

Define z_x as $\mu(z_x) = 1 - \frac{x}{100}$. In Autarky, the profit share of the top x% of entrepreneurs is given by

$$\frac{\int_{z_x}^\infty z^{\sigma-1} \pi^D(z_{min})\mu(dz)}{\int_{z_m}^\infty z^{\sigma-1} \pi^D(z_{min})\mu(dz)} = \frac{\int_{z_x}^\infty z^{\sigma-1}\mu(dz)}{\int_{z_m}^\infty z^{\sigma-1}\mu(dz)}$$

where $\pi^D(.)$ is defined earlier. Constant-returns-to-scale (CRS) production and the demand function imply that $\frac{\pi^D(z)}{\pi^D(z_{min})} = \frac{z^{\sigma-1}}{z_{min}^{\sigma-1}}$. The profit from exporting activities for a firm with productivity z is given by $\tau^{1-\sigma}\pi^D(z) - f_X$. Recall that $\bar{z}_X$ is the productivity cutoff for exporting.

Case 1: $z_x > \bar{z}_X$.

By Lemma (1),

$$\frac{\int_{z_x}^\infty z^{\sigma-1}\mu(dx)}{\int_{z_x}^\infty \mu(dx)} > \frac{\int_{\bar{z}_X}^\infty z^{\sigma-1}\mu(dx)}{\int_{\bar{z}_X}^\infty \mu(dx)}$$

which implies

$$\frac{\int_{z_x}^\infty \mu(dx)}{\int_{\bar{z}_X}^\infty \mu(dx)} < \frac{\int_{z_x}^\infty z^{\sigma-1}\mu(dx)}{\int_{\bar{z}_X}^\infty z^{\sigma-1}\mu(dx)}$$

$$\frac{\frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{z_x}^{\infty}\mu(dx)}{\frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{\bar{z}_X}^{\infty}\mu(dx)} < \frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx)},$$

where $\pi_T^D(.)$ is the domestic profit function. Since exporters export only if export revenue is greater than the fixed cost of exporting, $\tau^{1-\sigma}\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) > f_X\int_{z_x}^{\infty}\mu(dx)$. From Property (1),

$$\frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{z_x}^{\infty}\mu(dx)}{\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx)}$$

Since $\bar{z}_X > z_{min}$,

$$\frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{z_x}^{\infty}\mu(dx)}{\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)}$$

From Property (2), I obtain

$$\frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) + \int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{z_x}^{\infty}\mu(dx)}{\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx) + \int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - \frac{f_X}{\pi_T^D(z_{min})}\tau^{\sigma-1}\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)},$$

$$\frac{\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{z_x}^{\infty}\mu(dx)}{\pi_T^D(z_{min})\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\pi_A^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\pi_A^D(z_{min})\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)},$$

where $\pi_A^D(.)$ is the profit function of a firm in Autarky. The left-hand side of the above equation gives the share of total profit received by the top $x\%$ of firms in Trade, while the right-hand side gives the corresponding share in Autarky.

Case 2: $z_x \leq \bar{z}_X$.

Since exporters export only if export revenue is greater than fixed cost of exporting,

$$\tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx) > 0$$

Furthermore, since $z_x > z_{min}$,$\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) < \int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)$.

From Property (3),

$$\frac{\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx)}{\pi_T^D(z_{min})\int_{z_{min}} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\pi_T^D(z_{min})\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)}$$

$$\frac{\pi_T^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx)}{\pi_T^D(z_{min})\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx) + \tau^{1-\sigma}\pi_T^D(z_{min})\int_{\bar{z}_X}^{\infty} z^{\sigma-1}\mu(dx) - f_X\int_{\bar{z}_X}^{\infty}\mu(dx)} > \frac{\pi_A^D(z_{min})\int_{z_x}^{\infty} z^{\sigma-1}\mu(dx)}{\pi_A^D(z_{min})\int_{z_{min}}^{\infty} z^{\sigma-1}\mu(dx)}.$$

The left-hand side of the above equation gives the share of total profit received by the top $x\%$ of firms in Trade, while the right-hand side of the above equation gives the corresponding share in Autarky.

Proposition 2: Consider the special case of the model in which there is no capital depreciation ($\delta = 0$). Moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$, $e(z) = 1$ for some z), the share of total income received by workers increases.

Proof: The total wage bill in the economy is w while the total cost of capital rental before depreciation is RK. As is well-known, $\frac{w}{RK} = \frac{1-\alpha}{\alpha}$ with Cobb-Douglas production. Therefore, with $\delta = 0$, $rk = RK = w\frac{\alpha}{1-\alpha}$.

Denote the equilibrium wages in Autarky and under Trade as w_A and w_T. With the CES monopolistic framework, total entrepreneurial profit in Autarky is given by $\frac{\sigma}{\sigma-1}\frac{w_A}{1-\alpha}$. Denoting the fraction of exporters under Trade as pctX, $0 < \text{pctX} < 1$, total entrepreneurial profit in Autarky is given by $\frac{\sigma}{\sigma-1}\frac{w_T}{1-\alpha} - \text{pctX} \cdot f_X$.

In Autarky, the share of total income received by workers is given by

$$\frac{w_A}{\frac{w_A}{1-\alpha} + \frac{\sigma}{\sigma-1}\frac{w_A}{1-\alpha}} = (1-\alpha)\frac{\sigma-1}{2\sigma-1} \tag{19}$$

Analogously under Trade,

$$\frac{w_T}{\frac{w_T}{1-\alpha} + \frac{\sigma}{\sigma-1}\frac{w_T}{1-\alpha} - \text{pctX} \cdot f_X} \tag{20}$$

The value in Equation (20) is lower than that in Equation (19) by inspection. Note that this argument does not apply to comparisons between two different but finite levels of trade costs, since the wage and fraction of exporters pctX are endogenous in the model.

Appendix III Decomposition of Saving Rates and Target Wealth to Income Ratio

Appendix III.(a) A decomposition of the change in aggregate saving rate by entrepreneurs.

Proposition: In a stationary equilibrium, the aggregate saving rate of entrepreneurs is zero.

Proof: From the budget constraint of an entrepreneur, we have

$$c(a,z) + a'(a,z) = \max\{\pi^D(z), \pi^X(z)\} + (1+r)a.$$

We then integrate this budget constraint over all a and z,

$$\int_a\int_z c(a,z)dadz + \int_a\int_z a'(a,z)dadz = \int \max\{\pi^D(z), \pi^X(z)\}dz + \int ada + r\int ada.$$

Denoting the aggregate quantities with C,K',Π and K, respectively, we have

$$C + K' = \Pi + K + rK.$$

In a stationary equilibrium, we have $K = K'$. Therefore, we have $C = \Pi + rK$. The left hand side is consumption while the right hand side is total income, which consists of total profit income and total interest income. The aggregate saving rate of entrepreneurs is given by $SR_s = \frac{\Pi + rK - C}{\Pi + rK} = 0$, {s=A, T}. Therefore, when we compare the stationary equilibria under Autarky and under Trade, the aggregate saving rate by entrepreneurs is necessarily the same at 0.[48]

Let the average saving rate of entrepreneurs with productivity z be $sr_s(z) = \frac{y_s(z) - c_s(z)}{y_s(z)}$. Then the aggregate saving rate equals $SR = \frac{\int y_s(z) - c_s(z)\mu(dz)}{\int y_s(z)\mu(dz)} = \int sr_s(z) \cdot share^y_s(z)\mu(dz)$ where $y_s(z)$ is the average income of all entrepreneurs with productivity z,[49] and $share^y(z) = \frac{y_s(z)}{\int y_s(z)\mu(dz)}$. Following Olley and Pakes (1996),

$$\begin{aligned} SR_T - SR_A = &\int sr_A(z)\big(share^y_T(z) - share^y_A(z)\big)\mu(dz) \\ &+ \int \big(sr_T(z) - sr_A(z)\big)share^y_A(z)\mu(dz) \\ &+ \int \big(sr_T(z) - sr_A(z)\big)\big(share^y_T - share^y_A(z)\big)\mu(dz) \end{aligned} \tag{21}$$

The first term in Equation (21) is the "between" change in the saving rate, which is the change in the saving rate if we hold the average saving rate of all entrepreneurs of a given z fixed at its level under Autarky, but change the income shares to their levels under Trade. The second term is the "within" change in the saving rate, which is the change in the saving rate if we fix the income share of all entrepreneurs at a given z at its level under Autarky, but change the saving rates to their levels under Trade. In the baseline calibration of the full model, I find the "between" change to be 2.55 percentage points and the "within" change to be -2.69 percentage points. The last term is a co-variance term relating changes in income shares to changes in the individual saving rate. The covariance term is 0.14 percentage point in

[48]Moving from Autarky to Trade, the gross saving rate of the economy increases. The aggregate capital stock in the economy is K. In each period, δK amount of capital is depreciated, and the same amount must be saved to maintain the capital stock at K. Therefore, the gross saving rate of the economy in steady state is given by $\frac{\delta K}{Y}$. Since K increases more proportionally than Y from Autarky to Trade in the calibration exercise, the gross saving rate $\frac{\delta K}{Y}$ is higher under Trade than under Autarky. It is helpful to note that the replacement of depreciated capital is carried out by financial intermediaries instead of by entrepreneurs in the model, and entrepreneurs earn the net return of saving r (instead of "$R = r + \delta$").

[49]The average is taken over entrepreneurs with different a. I am grouping the entrepreneurs by z instead of by (a, z) because the joint distribution of (a, z) is an endogenous object. It is not possible to match the entrepreneurs by (a, z) between the equilibria under Autarky and under Trade.

the current application.

Appendix III.(b) Decomposition based on the Target-Wealth-to-Profit Ratio

Recall that $a'_s(a, z)$,$s = \{A, T\}$ is the asset policy function of an entrepreneur with asset a and productivity z, where the subscript s is added to emphasize that the policy function is dependent on the trade regime, and A and T denote "Autarky" and "Trade" respectively. Define $a^*_s(z)$ to be such that $a'_s(a^*_s(z), z) = a^*_s(z)$. The target wealth $a^*_s(z)$ of an entrepreneur is the steady state asset holding if the entrepreneur were to receive the same z forever.[50] Let the profit of an entrepreneur with productivity z be $\pi_s(z)$, $s = \{A, T\}$. The target-wealth-to-profit ratio $m_s(z) = \frac{a^*_s(z)}{\pi_s(z)}$, $s = \{A, T\}$, is a measure of the incentiveto save at each productivity level.[51,52]

Let $M_s = \frac{\int a^*_s(z)\mu(dz)}{\int \pi_s(z)\mu(dz)}$, $s = \{A, T\}$ be the aggregate target-wealth-profit ratio. In the calibration exercise, $M_A = 11.9$ and $M_T = 12.3$. Define $share^{\pi}_s(z) = \frac{\pi_s(z)}{\int \pi_s(z)\mu(dz)}$, $s = \{A, T\}$. I obtain

$$M_s = \frac{\int a^*_s(z)\mu(dz)}{\int \pi_s(z)\mu(dz)} = \int \frac{\pi_s(z)}{\int \pi_s(z)\mu(dz)} \cdot \frac{a^*_s(z)}{\pi_s(z)}\mu(dz) = \int share^{\pi}_s(z) m_s(z)\mu(dz) \tag{22}$$

Following Olley and Pakes (1996), I obtain the following decomposition formula:

$$\begin{aligned} M_T - M_A = &\int \Big(share^{\pi}_T(z) - share^{\pi}_A(z)\Big) \cdot m_A(z)\mu(dz) \\ &+ \int share^{\pi}_A(z) \cdot \Big(m_T(z) - m_A(z)\Big)\mu(dz) \\ &+ \int \Big(share^{\pi}_T(z) - share^{\pi}_A\Big) \cdot \Big(m_T(z) - m_A(z)\Big)\mu(dz) \end{aligned} \tag{23}$$

The first term Equation (23) is the "between" change, which is the change in M if we fix $m_s(z)$ at its level under Autarky but change the profit shares to their levels under Trade. The second term is the "within" change, which is the change in M if we keep the profit shares at their levels under Autarky, but change $m_s(z)$ to its level under Trade. The last term is a co-variance term relating changes in profit shares to changes in the target-wealth-to-profit ratio. In my baseline calibration, the "between" component,

[50] CRRA utility guarantees that $a^*_s(z)$ is bounded for all z (Krueger, 2012). Numerically, $a^*_s(z)$ is obtained by starting at $a = 0$ and iterating on the asset policy function $a'_s(a, z)$ until $a'_s(a, z) = a$.

[51] The actual wealth-to-profit ratio at a given z is not a good measure of incentive to save for entrepreneurs. For example, if an entrepreneur receives a low productivity draw after a long series of high productivity draws, the wealth-to-profit ratio would be very high, even though this entrepreneur would be actively dis-saving at the low z state. The ratio between aggregate target wealth and actual aggregate wealth is 1.09 and 1.08 under Autarky and Trade, respectively.

[52] I conduct an similar decomposition exercise based on the target-wealth-to-income ratio $\frac{a^*_s(z)}{y_s(z)}$, $s = \{A, T\}$, where $y_s(z)$ is the average total income of entrepreneurs with productivity z. This alternative approach produces similar results. I present the results based on $\pi_s(z)$ because some interest income in $y_s(z)$ is derived from wealth accumulated under different values of z.

the "within" component and the covariance term account for 172%, -68% and 4% of the change in the aggregate target-wealth-to-profit ratio between Autarky and Trade, respectively.

Appendix IV Further Trade Liberalizations

In this paper, I focus on the comparison between Autarky and an economy calibrated to match the observed level of trade in the US. The comparison reveals the realized gains from trade, which are of much interest in the trade literature. I consider two additional policy experiments. First, we lower the variable trade cost τ to have a target Export/GDP ratio of 25% by setting $\tau = 1.38$. Second, we consider the extreme scenario in which the variable trade cost τ is eliminated by setting τ to 1.00. With the assumption of two symmetric countries, the Export/GDP ratio is 50% at $\tau = 1.0$. I compute the stationary equilibria of the models with $\tau = 1.38$ and $\tau = 1.00$, referring to these economies as "More Trade"($\tau = \tau_{MT}$) and "Free Trade"($\tau = \tau_{FT}$) respectively. Table A1 presents the results on inequality, while Table A2 presents the results on output and welfare gains from trade. The supply-side channel of capital adjustment appears to be more important when countries are initially less open to trade. In the policy experiment of moving from "Trade" to "Free Trade", the increase in capital is quite similar between the full model and the CM benchmark. As shown in Table A1, the effect of further trade liberalizations on the income shares of the most productive entrepreneurs is small. In the calibration, the fixed cost of exporting is relatively small, and further trade liberalization results in export entry by less productive firms. This quickly drives up the equilibrium wage, and limits the increase in top income inequality. As a result, the difference in the response in capital between the full model and the CM benchmark is smaller. In ongoing work where I calibrate the full model to China, with a higher calibrated fixed cost of exporting, additional trade liberalization results in a greater increase in the capital stock than in the CM benchmark.

Appendix V Robustness and Extensions of the Calibration Exercise

In this section, I examine the robustness of the results from the baseline calibration of the full model. The results are robust to alternative specifications of the fixed cost of exporting or borrowing limits. On the other hand, having a a fat-tailed distribution of firm sales appears to be crucial for the results.

Table A1: Further Trade Liberalization: Results on Inequality

Panel A. Income Inequality Among Entrepreneurs				
	Autarky	Trade	More Trade	Free Trade
Top 1%	31.0%	32.6%	31.8%	31.6%
Top 2-5%	19.5%	20.0%	20.9%	20.7%
Top 5-20%	20.3%	20.1%	21.3%	21.6%
Top 20-50%	16.4%	15.4%	15.3%	15.6%
Bottom 50%	12.8%	11.9%	10.7%	10.5%
Gini Coefficient	0.654	0.675	0.691	0.691
Panel B. Income Inequality between Workers and Entrepreneurs				
	Autarky	Trade	More Trade	Free Trade
Workers Share of Total	59.8%	60.4%	61.2%	61.7%

"Autarky" refers to the economy in stationary equilibrium with a variable trade cost of infinity; "Trade" refers to the economy in stationary equilibrium calibrated to the observed level of trade in the US; "More Trade" refers to the economy in stationary equilibrium in which the trade cost is calibrated to match an Export/GDP ratio of 25%; "Free Trade" refers to the economy in stationary equilibrium with no variable trade cost ($\tau = 1.0$).

Table A2: Further Trade Liberalizations: Results on Output and Welfare

	Trade to More Trade		Trade to Free Trade	
	(1)	(2)	(3)	(4)
Model	Full Model	CM Benchmark	Full Model	CM Benchmark
Production				
TFP	6.4%	6.4%	21.7%	21.7%
Capital	11.5%	9.7%	33.9%	34.2%
Output	10.6%	9.7%	34.1%	34.2%
Worker's Wage	10.6%	9.7%	34.1%	34.2%
Entrepreneurial Consumption				
Aggregate	7.0%	6.6%	27.3%	27.2%
Certainty-Equiv.	1.7%	-	20.2%	-

"Full Model" refers to the model described in Section 2.1; "CM Benchmark" refers to the complete markets benchmark described in Section 2.5. The numbers give the percentage differences in the relevant measure between economies with different variable trade costs. "Trade" refers to the economy in stationary equilibrium calibrated to the observed level of trade in the US; "More Trade" refers to the economy in stationary equilibrium in which the trade cost is calibrated to match an Export/GDP ratio of 25%; "Free Trade" refers to the economy in stationary equilibrium with no variable trade cost ($\tau = 1.0$).

Appendix V.(a) Sunk Cost

I first examine an alternative assumption on the fixed cost of exporting. In addition to the per-period fixed cost of exporting f_X, I assume that firms which did not export the previous period have to pay a sunk cost of exporting of f_{sunk} units of labor. As a result, the previous export status of the firm is a state variable. Table A3 provides the details of the calibration. For simplicity, I set $f_{sunk} = 4 \cdot f_X$ in the calibration. The results are reported in Column (1) in Table A4. The results can be compared to Columns (4) and (5), which reproduce results from the full model and from the CM benchmark, respectively. A comparison of Columns (1) and (4) indicates that the results are robust to the alternative specification of the fixed cost of exporting.

Appendix V.(b) Natural Borrowing Limits

I have assumed so far that entrepreneurs cannot borrow ($a \geq 0$). To examine the role of the zero-borrowing assumption, I study a version of the model with a natural borrowing limit. Specifically, I assume

$$a > -\frac{\pi^D(z_{min})}{r}. \tag{24}$$

Inequality (24) requires an entrepreneur to be able to keep up with the interest payment on her loans while maintaining positive consumption, even if the entrepreneur receives the lowest possible productivity, z_{min}, forever. Table A3 provides the details of the calibration. As reported in Column (2) of Table A4, while the specification of a natural borrowing limit reduces the contribution of capital accumulation to output gains from trade, there is still a large increase of the capital stock of 6.1% when moving from Autarky to Trade.

Table A3: Calibration: Extensions and Robustness

Panel A: Parameters Taken from Prior Literature							
		(1)	(2)	(3)	(4)	(5)	(6)
	Model	Sunk	NBL	K-Friction	LogN AR1	Full	CM
Parameter	Symbol	Value	Value	Value	Value	Value	Value
Coefficient of Risk Aversion	λ	1.500	1.500	1.500	1.500	1.500	1.500
Share of Capital in Production	α	0.333	0.333	0.333	0.333	0.333	0.333
Capital Depreciation Rate	δ	0.060	0.060	0.060	0.060	0.060	0.060
Elasticity of Substitution	σ	4.000	4.000	4.000	4.000	4.000	4.000
Persistence of Firm Productivity	γ	0.814	0.814	0.814	-	0.814	0.814
Shape Parameter of Sales Distribution	ζ	1.300	1.300	1.300	-	1.300	1.300
Lognormal AR1 Process:	ρ	-	-	-	0.814	-	-
	σ_z	-	-	-	0.260	-	-

Panel B: Parameter Calibrated to the Model							
		Sunk	NBL	K-Friction	LogN AR1	Full Model	CM
Target Moment	Data	Parameter	Parameter	Parameter	Parameter	Parameter	Parameter
Interest Rate	3.00%	$\beta = 0.929$	$\beta = 0.943$	$\beta = 0.929$*	$\beta = 0.960$	$\beta = 0.929$	$\beta = 0.971$
Export/GDP Ratio	10.00%	$f_{EX} = 0.07$	$f_{EX} = 0.11$	$f_{EX} = 0.08$	$f_{EX} = 0.14$	$f_{EX} = 0.110$	$f_{EX} = 0.110$
		$f_{sunk} = 0.28$	-	-	-	-	-
Export to Sales Ratio	14.00%	$\tau = 1.83$	$\tau = 1.83$	$\tau = 1.83$	$\tau = 1.83$	$\tau = 1.83$	$\tau = 1.83$
Credit/GDP Ratio (Counter-factual)	60.00%	-	-	$\phi = 0.25$	-	-	-

“Sunk” (described in Appendix V.(a)) refers to a modification of the full model with sunk cost of exporting. “NBL” (Appendix V.(b)) refers to a version of the model where there is a “Natural Borrowing Limit”. “K-Frictions” (Appendix V.(c)) refers to a version of the model with financial frictions on the production side. “LogN AR1” (Appendix V.(d)) refers to a version of the model with lognormal AR(1) productivity process. *β is taken from the full model. It is not re-calibrated to match the interest rate.

Table A4: Robustness of Calibration Results

Model	(1) Sunk	(2) NBL	(3) K-Frictions	(4) LogN AR1	(5) Full Model	(6) CM Benchmark
TFP	3.5%	3.6%	3.2%	3.6%	3.6%	3.6%
Capital	8.5%	7.4%	6.5%	5.8%	8.3%	5.3%
Output	6.3%	6.1%	5.4%	5.6%	6.3%	5.4%
Worker's Wage	6.4%	6.1%	5.4%	5.6%	6.4%	5.4%
Entrepreneurial Consumption						
Aggregate	3.6%	3.6%	2.2%	1.4%	3.6%	3.6%
Certainty-Equivalent	-2.0%	-3.9%	-1.5%	0.0%	-1.9%	-

"Sunk" refers to a modification of the full model with sunk cost of exporting. "NBL" refers to a version of the model with a natural borrowing limit. "K-Frictions" refers to a version of the model with financial frictions on the production side. "LogN AR1" refers to a version of the model with a lognormal AR(1) productivity process. Columns (5) and (6) reproduce key results from Tables 3 and 4.

Appendix V.(c) Financial Frictions for Production

I assume that capital rental by firms is limited by imperfect enforceability of contracts. Entrepreneurs can default on their contracts after productionhas taken place. In case of default,entrepreneurs can keep a fraction $(1-\phi)$ of capital and revenue net of labor costs and export fixed costs, but they lose their financial assets deposited with the financial intermediary. In the following period, entrepreneurs regain access to financial markets despite the history of default. The parameter ϕ, $0 \leq \phi \leq 1$, indexes financial development of an economy.

The capital input k for a domestic producer with wealth a and productivity z must satisfy

$$\max_l \{E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} - w \cdot l\} - Rk + (1+r)a \geq (1-\phi)\Big\{ \max_l \{E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} - w \cdot l\} + (1-\delta)\cdot k \Big\} \tag{25}$$

where $q^D(z) = zk^\alpha l^{1-\alpha}$. Equation (25) states that a non-exporter must end up with more resources by fulfilling credit and rental obligations (left-hand side) than by defaulting (right-hand side). Equation (25) can be reduced to

$$\phi \cdot \max_l \Big\{ E^{\frac{1}{\sigma}} \big(q^D(z)\big)^{1-\frac{1}{\sigma}} - w \cdot l \Big\} - k \cdot \Big[R + (1-\phi)(1-\delta) \Big] + (1+r)a \geq 0, \tag{26}$$

which implies a capital rental limit $\bar{k}^d(a, z; \phi)$ for a non-exporter with state (a, z). Analogously,

$$\phi \cdot \max_l \Big\{ E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} + E^{*\frac{1}{\sigma}} q^X(z)^{1-\frac{1}{\sigma}} - w \cdot l - f_X \Big\} - k \cdot \Big[R + (1-\phi)(1-\delta) \Big] + (1+r)a \geq 0, \tag{27}$$

which implies a capital rental limit $\bar{k}^X(a, z; \phi)$ for exporters. Entrepreneurs hire capital subject to Equations (26) and Equation (27), and there is no default in equilibrium.

The other features of the model are the same as the full model. With the financial constraints, the production policy functions are now written as $q^D(a, z)$, $q^X(a, z)$, $k(a, z)$, $l(a, z)$ and $e(a, z)$. The stationary equilibrium is defined anagolously. The full model in this paper corresponds to the special case where $\phi = 1$.

I calibrate the additional parameter ϕ to match the total private credit to GDP ratio. In the calibration of the full model ($\phi = 1$), the credit to GDP ratio is 189%, compared to the figure of 162% for the US in 2000. Keeping the other parameters constant, I calibrate the financial development parameter ϕ to match a Credit/GDP ratio of 60%, which is the level of financial development studied in Buera and Shin (2013), and the fixed cost of exporting f_X to maintain a Trade/GDP ratio of 10%. The introduction of the enforcement constraint decreases the demand for capital and the equilibrium interest rate. The strategy of calibrating ϕ after calibrating other parameters to the US benchmark follows Buera and Shin (2013). Lastly, I increase the variable cost τ to infinity to obtain the equilibrium under Autarky. The details of the calibration are presented in Column (3) of Table A3 while the results are presented in Table A4. Moving from Autarky to Trade, TFP increases by 3.2%, smaller than the increase of 3.6% in the full model. The capital stock increases by 6.5%, which is larger than the increase in the CM benchmark, when we take into account the smaller increase in TFP in the K-Frictions model. Therefore, the mechanism emphasized in this paper is robust to the introduction of financial frictions on the production side.

Appendix V.(d) Log-normal AR(1) Productivity Process

To examine the implications of the fat-tailed firm sales distribution for the quantitative results, I alternatively assume that entrepreneur productivity $z_t(i)$ follows a log-normal AR(1) productivity process:

$$\log(z_t(i)) = \rho \log\big(z_{t-1}(i)\big) + e_t(i)$$

where $0 \leq \rho < 1$, $e_t(i)$ is *i.i.d* across time and firms, and $e_t(i) \sim N\Big(0,\ \sigma_z^2(1-\rho^2)\Big)$. The cross-sectional distribution of firm productivity is $z(i) \sim logN\Big(0, \sigma_z^2\Big)$. I choose ρ and σ_z^2 so that firm productivity has the same persistence and standard deviation as in the full model. Table A3 provides the details of the calibration. As reported in Column (4) of Table A4, with a log-normal AR(1) productivity process, the contribution of capital accumulation to gains from trade is much smaller. Table A4 indicates that the trade-induced change in top income shares among entrepreneurs is much smaller compared to that in the full model. Therefore, the fat-tailed Pareto distribution of firm sales is crucial for the quantitative results of this paper. In an economy where productivity has a log-normal distribution, entrepreneurs with the highest productivity and the highest saving rate account for less of the total saving. As a result, the trade-induced redistribution of profits to the most productive entrepreneurs has a much smaller effect on the aggregate supply of capital.

Table A5: Income Inequality with Lognormal AR1 Productivity

Panel A. Inequality within the Entrepreneur Sector		
	Autarky	Trade
Top 1%	5.1%	5.4%
Top 2-5%	11.7%	12.3%
Top 5-20%	26.7%	27.2%
Top 20-50%	31.6%	31.1%
Bottom 50%	24.9%	24.0%
Gini Coefficient	0.369	0.385
Panel B. Inequality between Sectors		
	Autarky	Trade
Workers Share of Total	60.0%	61.0%

"Autarky" refers to the economy in which the variable cost of trade is set to infinity; "Trade" refers to the economy calibrated to match the observed level of trade in the US.

Appendix VI The Role of Capital

Section 3 demonstrates the implications of entrepreneurial income inequality for gains from trade by contrasting the full model with the CM benchmark. The mechanism linking entrepreneurial income inequality and gains from trade is capital accumulation. In this section, I further investigate this point by repeating the quantitative exercise in two models without capital.

I modify the full model by assuming labor is the only factor of production. I refer to the resulting model as the "NoK" model. Similarly, I modify the CM benchmark and I refer to the resulting model as the "NoK CM" model.

The NoK model differs from the full model in the following ways. First, labor is the only factor of production. An entrepreneur with productivity $z(i)$ can produce a variety i of differentiated goods according to

$$q(i) = z(i)l, \tag{28}$$

where l is variable labor input in production. Second, there are no financial intermediaries. Lastly, the final good is assumed to be non-perishable. In other words, there is a technology that allows entrepreneurs to transform a unit of the final good today into a future unit of the final good. Entrepreneurs can hold a non-negative amount of the final good as savings ($a \geq 0$). As a result, in the stationary equilibrium of the NoK model, entrepreneurs hold a buffer-stock of the final good. Other features of the NoK model are similar to the full model.

To construct the NoK CM model, I introduce a representative entrepreneur in each country into the NoK model. The representative entrepreneur in each country receives the profit of all the firms, while allowing each firm to make decisions independently to maximize profit. The NoK CM model is entirely static and resembles Chaney (2008). The details of the NoK model and the NoK CM model are relegated to *Online Appendix I*.

Results

Table A6 reports the results from the NoK and NoK CM models. For ease of comparison, Columns (3) and (4) reproduce the results from the full model and the CM model, respectively.

Table A6: Gains From Trade in Models without Capital

	(1)	(2)	(3)	(4)
Model	NoK	NoK CM	Full	CM
TFP	3.6%	3.6%	3.6%	3.6%
Capital	-	-	8.3%	5.3%
Output	3.6%	3.6%	6.3%	5.4%
Consumption of Workers				
Wage	3.6%	3.6%	6.4%	5.4%
Entrepreneurial Consumption				
Aggregate	1.2%	1.2%	3.6%	3.6%
Certainty-Equivalent	-4.4%	-	-1.8%	-

The "NoK" Model (described in *Online Appendix I.(a)*) refers to a modification of the full model which do not include capital in the production function. The "NoK CM" Model (described in *Online Appendix I.(b)*) refers to a version of the model with complete markets where there is no capital.

Since the NoK CM model is similar to the class of models studied in Arkolakis et al. (2012), it is interesting to compare the results. Arkolakis et al. (2012) show that in a wide class of models, the gains from trade can be summarized by the formula

$$1 - \lambda_{ii}^{-\frac{1}{\varepsilon}} \tag{29}$$

where λ_{ii} is the share of expenditure on the domestic good and $\varepsilon < 0$ is the elasticity of trade flows with respect to the variable trade cost. As derived in Chaney (2008), the elasticity of trade with respect to variable trade cost in this model is given by $-\eta = -(\sigma - 1)\zeta$. I have set $\eta = (\sigma - 1)\zeta = 3.9$ and $\lambda_{ii} = 0.90$ in the calibration. The formula in Equation (29) yields an output gain from trade of 2.7%. This is close to the output gain of 3.6% shown in Column (2).

To see the role of capital in models without heterogeneity in entrepreneurial income, I compare Column (2) and Column (4) of Table A6. Although the aggregate TFP gains are the same in the CM benchmark and the NoK CM benchmark, capital accumulation in the CM model amplifies the output gains. As a result, the output gains, wage gains for workers, and aggregate entrepreneurial consumption gains are all lower in the NoK CM benchmark than the corresponding numbers in the CM benchmark.

Table A7: Income Inequality and Trade Openness in a Model without Capital (NoK)

Panel A. Inequality within the Entrepreneur Sector		
	Autarky	Trade
Top 1%	32.8%	35.0%
Top 2-5%	17.3%	18.1%
Top 5-20%	18.9%	18.4%
Top 20-50%	16.2%	15.0%
Bottom 50%	14.8%	13.6%
Gini Coefficient	0.623	0.650
Panel B. Inequality between Sectors		
	Autarky	Trade
Workers Share of Total	75.0%	75.4%

"Autarky" refers to the economy when the variable cost of trade is set to infinity; "Trade" refers to the economy calibrated to match the observed level of trade in the US.

Table A7 summarizes the effects of trade on income inequality among entrepreneurs in the NoK model. The results are similar to those from the full model. Importantly, trade increases income inequality among entrepreneurs. To see the effects of entrepreneurial income inequality in models without capital, I compare Column (1) and Column (2) of Table A6. The numbers in Column (1) and Column (2) are identical. In summary, in the absence of capital accumulation, heterogeneity in entrepreneur income affects our assessment of welfare gains for entrepreneurs, but does not affect the size of output gains or welfare gains for workers. The interaction of capital and the heterogeneity in entrepreneurial income contributes to the sizable differences between Column (3) and Column (4).

Appendix VII Robustness of Fixed-Effects Panel Regressions

In Table A8, I conduct a number of robustness checks for the fixed-effects panel regressions reported in Table 6.

An important concern is that the coefficient on Trade/GDP is simply picking up the effects of capital account openness. In Column (1), I include the Quinn Index (Quinn and Toyoda, 2008) as an additional regressor to control for capital account openness. The sample of countries is reduced substantially by data availability.

In the baseline panel regression, I lag the income terms by five-years, as the current income level is clearly endogenous with respect to the saving rate in the model. In Column (2), I use current income terms in place of lagged income terms, despite the endogeneity concerns. In Column (3), I control for the GDP growth rate. In Column (4), I include old and young dependency ratios as additional regressors to capture the effects of demographic changes. Column (5) includes the inflation rate as an additional regressor. The results in Table A8 are in line with those presented in Table 6.

The national accounting identity implies that $S - I = X - M$, where S, I, X and M are saving, investment, exports and imports, respectively. This may suggest controlling for the trade balance. In Column (6) A8, I include the trade surplus as an additional regressor. The point estimate of the coefficient on the Trade/GDP ratio decreases to 0.0664 but remains statistically significant at 1%. Since I am holding $(S - I)$ constant in this regression, the results in Column (6) are consistent with the finding that a substantial part of the openness-induced saving translates into higher investment.

Another concern is that the relationship between the gross national saving rate and openness is working through public saving, while my model is about the private saving rate. To alleviate this concern, Column (7) includes total government expenditure as a share of GDP. Additionally, Column (8) uses data on the private saving rate from Loayza, Schmidt-Hebbel, and Serven (2000) as the dependent variable. Although the sample is substantially reduced, the coefficient on the Trade/GDP ratio remains positive and statistically significant.

In each column of Table A9, I drop a different region from the full sample and repeat the baseline panel regression. As shown in Table A9, the results are robust to the exclusion of any single region.

Table A8: Robustness of Panel Fixed-Effects Panel Regressions:

Alternative Specifications

	(1) K-Open	(2) Current-Y	(3) Growth	(4) D-graph	(5) Inflation	(6) Balance	(7) Gov-Size	(8) P-saving	(9) L-Share
Panel A:	Gross National Saving Rate								
Trade/GDP	0.0865**	0.0875**	0.0892**	0.105**	0.107***	0.0825***	0.102***	0.0593*	0.0547**
	(0.0337)	(0.0347)	(0.0350)	(0.0406)	(0.0391)	(0.0283)	(0.0361)	(0.0310)	(0.0262)
Panel B:	Gross Investment Rate								
Trade/GDP	0.0502***	0.0344**	0.0375***	0.0467***	0.0472***	0.0694***	0.0488***		0.00103
	(0.0172)	(0.0151)	(0.0140)	(0.0160)	(0.0156)	(0.0178)	(0.0148)		(0.0191)
N Countries	73	111	111	111	111	111	111	61	83
N Observations	444	567	566	567	566	567	565	300	250

Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. I group the years 1961-2005 into nine five-year intervals and use the averages of yearly data in the regressions. Time and country fixed effects are included in all regressions. The standard set of control variables include log of income and its square (both lagged) and the Credit/GDP ratio (lagged). Column (1) controls for capital account openness; Column (2) replaces the lagged income terms with current income terms; Column (3) controls for the GDP growth rate; Column (4) controls for old and young dependency ratios; Column (5) controls for the inflation rate; Column (6) controls for the trade balance; Column (7) controls for total government expenditure as a share of GDP; Column (8) uses the private saving rate as the dependent variable; Column (9) controls for the labor share of income.

Table A9: Robustness of Fixed-Effects Panel Regressions:

Exclusion of Subsamples

Subsample Excluded	(1) None	(2) E. Asia & Pacific	(3) Europe & C. Asia	(4) L. America & Caribbean	(5) M. East & N. Africa	(6) N. America	(7) S. Asia	(8) S.S. Africa
Panel A:	Gross National Saving Rate							
Trade/GDP	0.107***	0.0865*	0.153***	0.110**	0.0827**	0.107***	0.101**	0.111**
	(0.0392)	(0.0501)	(0.0330)	(0.0437)	(0.0323)	(0.0397)	(0.0385)	(0.0445)
Panel B:	Gross Investment Rate							
Trade/GDP	0.0479***	0.0604***	0.0556**	0.0421**	0.0405***	0.0496***	0.0440***	0.0433***
	(0.0157)	(0.0180)	(0.0269)	(0.0165)	(0.0146)	(0.0160)	(0.0151)	(0.0147)
N Countries	111	97	71	96	102	109	106	85
N Observations	567	495	405	471	519	551	535	426

Column (1) reproduces Column (3) of Table 6. Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively.

Table A10: Data Sources for Variables Used in the Empirical Exercises

Variables	Sources
Gross National Saving Rate	WDI
Gross Investment Rate	WDI
("Gross Fixed Capital Formation, as % of GDP")	
GDP per capita	WDI
Population	WDI
Age Dependency Ratios	WDI
Credit/GDP Ratio	WDI
Inflation	WDI
GDP Growth	WDI
Government Expenditure	WDI
Capital Account Openness	Quinn and Toyoda (2008)
Labor Share of Income	Karabarbounis and Neiman (2014)
Private Saving Rate	Loayza, Schmidt-Hebbel, and Serven (2000)
Top 10% Income Share	UNU-WIDER (2014)
Institutional Quality	Kaufmann, Kraay, and Zoido-Lobatón (1999)
	(As adapted by Alcalá and Ciccone (2004).)
Trade/GDP (PPP)	PWT (Mark 8.0.)
(Sum of PPP export and PPP import over PPP GDP)	
European Languages	Hall and Jones (1999); IV for institutional quality
(Population share speaking one of five European Languages at birth)	
Bilateral Trade Flows	Feenstra, Lipsey, Deng, Ma, and Mo (2005)
Geography Variables	CEPII
(Used in estimating the gravity equation)	