Entrepreneurial Income Inequality, Aggregate Saving and the Gains from Trade

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Abstract

I document three stylized facts relating trade openness, income equality among entrepreneurs and aggregate saving at the state and country level. I then develop a dynamic model of trade to account for these stylized facts. In the model, an increase in trade openness increases the share of total profits by the most productive entrepreneurs who have the highest saving rates, leading to increased capital accumulation and larger gains from trade. Quantitative analysis shows that the novel mechanism increases the real wage gains from trade by 25.0% and the gains in aggregate output by 36.8% than in a comparable benchmark.

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Key words: *top income shares, inequality, aggregate saving rate, capital accumulation, gains from trade*

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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 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). While 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. In this paper, I study this interaction, namely how income inequality among entrepreneurs affects the welfare gains from trade for the average worker.

Economists since Kuznets (1955) and Kaldor (1967) have hypothesized that higher income inequality increases capital accumulation, as higher-income households tend to have higher saving rates. Although older empirical studies using the Gini coefficient as the measure of income inequality have been inconclusive (e.g., Schmidt-Hebbel and Serven, 2000; Smith, 2001), recent studies of top income shares such as Piketty and Saez (2003) has renewed interests in the issue (e.g., Leigh and Posso, 2009). At the same time, a growing literature overwhelmingly finds that trade openness increases income inequality (e.g., Harrison, McLaren and McMillan, 2011; Ma, 2015). Together, these observations suggest possible effects of trade openness on aggregate saving and capital accumulation, via its effects on income inequality. This potential mechanism has not been studied empirically or theoretically. I study this potential mechanism in the context of income inequality among entrepreneurs.

In this paper, I first document three stylized facts. First, using data from states in the US, I show that trade openness is positively associated with greater income inequality among

[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%.

the high-income households. Second, using data from Survey of Consumer Finances (SCF), I show that among entrepreneurial households, households with higher income tend to have higher saving rates. Lastly, using fixed-effects regressions with at both the state level and the country level, I document a strongly positive correlation between openness and the aggregate saving rate. I find a positive but weaker relationship between openness and the investment rate.

To reconcile these three sets of stylized facts, 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 face uninsurable idiosyncratic income risk associated with their productivity and thus save. 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 novel mechanism in this paper.

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. An increase in trade openness increases the share of total profits received by exporters, and thus increases the total saving and the aggregate supply of capital in the economy via a mechanism similar to Kaldor (1967). 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, an increase in trade openness creates a large increase in the capital stock. Since the marginal product of labor is increasing in capital input, workers benefit from the large increase in capital accumulation and enjoy larger gains from trade than they would have otherwise.

I calibrate the model using US data. After using the SCF data to validate the model, I examine the effects of international trade on aggregate output, the consumption of workers, and the consumption of entrepreneurs with heterogeneous productivity. In the model, international trade increases aggregate output by 2.6% and the real wage of workers by 3.5%. On the other hand, while the aggregate consumption of entrepreneurs is unchanged by international trade, the increase in inequality of profits among entrepreneurs implies that the certainty-equivalent consumption of a typical entrepreneur actually decreases by 3.9%. In other words, while the *ex-post* most productive entrepreneurs gains from a decrease in trade costs, the *ex-ante* welfare of an average entrepreneur decreases due to greater dispersion of possible income realizations. Capital accumulation plays an important role in the model, accounting for 51.6% 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. In this complete markets benchmark, the increase in aggregate output due to international trade is 1.9% while the increase in the real wage of workers from trade is 2.8%. Therefore, the novel mechanism in this model increases the real wage gains for workers by 25.0%, and the gains in aggregate output by 36.8%, compared to the complete markets benchmark. I construct two additional benchmark models which abstract from capital accumulation, one with incomplete markets and the other with complete markets. I demonstrate that the interaction between capital accumulation and entrepreneurial income inequality gives rise to higher aggregate output gains and higher real wage gains. In fact, the model in this paper collapses to the Chaney (2008) model when I shut down both entrepreneurial income inequality and capital accumulation. The increase in aggregate output due to international trade in the complete markets benchmark without capital is 1.2%, which is the same as calculated from the sufficient-statistics formula in Arkolakis, Costinot and Rodriguez-Clare (2012) (henceforth "the ACR formula") using the relevant import penetration ratio and the trade elasticity.

My paper is related to the literature that aims to quantify the gains from trade (cf. Costinot and Rodriguez-Clare (2013)). I model entrepreneurial consumption, saving and capital accumulation in a dynamic framework. The focus on the role of capital accumulation is well supported by empirical evidence (Levine and Renelt, 1992; Wacziarg, 2001; Wacziarg and Welch, 2008). Nevertheless, most attempts to quantify gains from trade have abstracted from capital accumulation. Notable exceptions include Alessandria and Choi (2014), Anderson, Larch and Yotov (2015), Brooks and Pujolas (2016), and Ravikumar, Santacreu and Sposi (2017). Relative to these papers mentioned above, this paper emphasizes the capital response to a trade liberalization coming from savings by entrepreneurs, due to rising inequality.[2] 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 (Goldberg and Pavcnik, 2007; Harrison, McLaren and McMillan, 2011). A growing number of papers, including Haskel, Lawrence, Leamer and Slaughter (2012), Foellmi and Oechslin (2010) and Dinopoulos and Unel (2014), study the relationship between trade and the income share of superstars. Ma (2015) finds that the executive-to-worker pay ratio within the firms in the US is strongly associated with exporting and FDI activities of these firms. He concludes 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

[2] In the Solow (1956) growth model, an increase in aggregate TFP raises the marginal product of capital, and a trade liberalization would induce capital accumulation if it increases aggregate TFP (Baldwin, 1992). My model incorporates this demand-side mechanism.

attempts to shed light on the welfare implications of this increased inequality. Crucially, I show that there are non-trivial interactions between entrepreneurial income inequality and the gains from trade.

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 (Voitchovsky, 2005; Piketty, 2014; Acemoglu and Robinson, 2014; Aghion, Akcigit, Bergeaud, Blundell and Hmous, 2015). Kumhof, Rancière and Winant (2014) study the effects of increased top income shares on leverage and the probability of crises. 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 trade-induced increase in inequality among entrepreneurs (the high-income households) can have important welfare implications for the group of workers (the lower-income households), even if the income shares of these two groups do not change. The focus on welfare implication of inequality *within* the high-income households, namely the entrepreneurs, appears to be novel in the literature.

My paper makes three substantive contributions to the literature. First, I make an empirical contribution by documenting three important stylized facts relating trade openness, entrepreneurial inequality, and aggregate saving and investment. Second, I propose a novel mechanism linking entrepreneurial income inequality and the gains from trade and demonstrate that it is quantitatively relevant for the gains from trade.[3] Lastly, I study the welfare implications of income inequality among entrepreneurs. In the model, increased concentration of income among entrepreneurs contributes to larger welfare gains from trade for the rest of the population, the workers.

[3]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; Bourguignon, 1981; Galor and Moav, 2004). Bertola, Foellmi and Zweimüller (2006) provides a comprehensive review of related literature. The focus on entrepreneurial income inequality in this paper is motivated by the observation that wealth is extremely concentrated.

In Section 2, I present the stylized facts. In Section 3, I present the full model and the calibration strategy. I evaluate the performance of the model by comparing non-targeted moments from the model against data from the SCF. Section 4 presents the key results from the calibration exercise. Further robustness checks and model extensions are relegated to the appendices. Section 5 concludes.

2 Stylized Facts

In this section, I document several stylized facts relating trade openness, income inequality among entrepreneurs, aggregate saving rate and investment rate. The empirical exercises make use of a number of data sources, including household-level data from the US, state-level aggregate data from the US and country-level data. Appendix A provides the details of data sources.

Stylized Fact 1 *In the US, increase in income inequality among high-income households within a state is positively associated with increasing trade openness at the state level.*

I first study the following specification

$$Inequality_{it} = \beta_0 + \beta_1 Openness_{it} + \beta_2 X_{it} + c_i + \mu_t + v_{it} \tag{1}$$

where $Inequality_{it}$ is the entrepreneurial income inequality of state i at time t, $Openness_{it}$ is the state-level trade openness, X_{it} is a vector of control variables, and c_i and μ_t are state and year fixed effects, respectively. I proxy for entrepreneurial income inequality within a state using the ratio between the top 0.1% income share and the top 10% income share, where the data on top income shares are constructed by Frank (2015) from Internal Revenue Services (IRS) income data. To measure state-level trade openness, I use the total value of export as a share of state GDP. Since total export at the state level is available from the Bureau of Economic Analysis (BEA) only starting 1999, I focus the analysis on the years between

1999 and 2013. I control for time-variant unobserved variables with state fixed effects. As control variables, I include in the vector X_{it} log GDP per capita, the share of finance sector in total GDP, and government size as measured by the share of public sector in total GDP.

Table 1: Top Income Inequality and Export/GDP Ratio across States

	(1)	(2)	(3)	(4)	(5)
Dependent Var.	Top 0.1% income share/Top 10% income share				Gini
Export/GDP	0.0983*	0.0970*	0.0981*	0.304*	0.0414
	(0.0530)	(0.0527)	(0.0521)	(0.174)	(0.0782)
ln GDP pc	0.112***	0.111***	0.116***	0.146***	-0.0406
	(0.0154)	(0.0173)	(0.0270)	(0.0444)	(0.0309)
Finance Sector Share		-0.0184	-0.0203	-0.0618	-0.272
		(0.0921)	(0.0892)	(0.115)	(0.203)
Government Size			0.0542	0.0116	0.314
			(0.183)	(0.343)	(0.231)
R^2	0.674	0.674	0.674	0.765	0.495
N Countries	51	51	51	51	51
N Observations	765	765	765	459	765

Robust standard errors are clustered at the state level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. Year and state fixed effects are included in all regressions. All regressions employ data from 1999 to 2013 except for Column (4), which drop data after 2007 (Great Trade Collapse).

The results of the fixed-effects regressions are presented in Table 1. As Column (1) of Table 1 shows, a one percent point increase in Export/GDP ratio is associated with 0.0983 percentage point increase in the top 0.1% share /top 10% share ratio. The coefficient of interest is statistically significant at 10% level. Columns (2) and (3) indicate that the results are robust to controlling for additional covariates. In Column 4, I exclude the years after 2007 in view of the unusual changes in international trade volumes during the Great Trade Collapse (Bems, Johnson and Yi, 2013). As Column (4) shows, exclusion of data from the years after the Great Trade Collapse increase the magnitude of the coefficient substantially. I repeat the analysis in Column (5) with the Gini coefficient as the dependent variable, and do not find a statistically significant relationship between the Export/GDP ratio and the Gini coefficient. This suggests that trade openness may have a larger effect on income inequality among high-income households than on income inequality in general.

To summarize, I find that increase in income inequality among high-income households within a state is positively associated with greater trade openness. This state-level evidence is complementary to the firm-level evidence in Ma (2015) that access to the global market is associated with a higher executive-to-worker pay ratio within firms in the US.

Stylized Fact 2 *In the US, the saving rate of entrepreneurial households is strongly increasing in household income.*

The well-known Kaldor hypothesis (Kaldor, 1967) rests on the assumption that rich households tend to have higher saving rate than lower-income households. This premise is empirically confirmed by Dynan et al. (2004) using US data. Does this relationship hold among entrepreneurial households in particular? To examine this question, I make use of data from the Survey of Consumer Finances (SCF), which is a triennial cross-sectional survey of U.S. families conducted by the Federal Reserve Bank, and is unique in its oversampling of rich households.

The empirical exercise below follows Dynan et al. (2004) closely. I use the 1983-1989 SCF panel data, which include 597 entrepreneurs households.[4] I classify a household as an entrepreneur household if they have or share ownership in a private-held business or at least one member of the household is self-employed.[5] I employ a median regression to examine the relationship between saving rate and income among entrepreneurial households. The household saving rate of an entrepreneur household is defined as the ratio between average annual change in total networth and average annual income over 1983-1989.[6] The entrepreneurial households are grouped according to quintiles of total income. I then conduct a median re-

[4]The SCF data contains little information on consumption, and it is not possible to construct household saving rate from the typical cross-sectional SCF data. Fortunately, the survey has contained a panel element over two periods, 1983-1989 and 2007-2009.

[5]This definition classifies 18.3% of households in the 2001 SCF data as entrepreneur households. These entrepreneur households account for 37.4% of total household income and 55.1% of total net worth. Ideally, I would like to include senior managers and executives of firms in the definition of entrepreneurs. However, detailed occupation information is not available in the public release of the SCF data. Including senior managers and executives of firms in the definition of entrepreneurs would increase these numbers substantially.

[6]More precisely, $\frac{\text{Networth}_{i,89}-\text{Networth}_{i,83}}{6\times(0.5*Y_{i,83}+0.5*Y_{i,89})}$, where $\text{Networth}_{i,t}$ and $Y_{i,t}$ are the total networth and total income of the entrepreneurial household i at year t respectively.

gression of the household saving rate on a full set of dummy variables for household quintile, without a constant term. I calculate the standard errors by bootstrapping the regression 500 times. As Table 2 shows, while the median saving rate of the households in the first and second quintiles are close to zero, it increases to 18.8% and 23.9% for the third and fourth quintiles respectively. The median saving rate for the fifth quintile is 53.6%, significantly higher than all the other quintiles. While the exercise above employed a median regression following Dynan et al. (2004) to reduce the influence of outliers, as an alternative approach, I calculate the average of the individual household saving rate, weighted by household income, for each income quintile. I find the same positive relationship between saving rate and household income (see Figure 1). Therefore, the saving rate of entrepreneur households is strongly increasing in household income.

Table 2: Household Saving Rate and Income Quintile of Entrepreneur Households

Income Quintile	
Quintile 1	2.209
	(4.899)
Quintile 2	-1.99932
	(3.428)
Quintile 3	18.796***
	(6.759)
Quintile 4	23.897***
	(1.851)
Quintile 5	53.564***
	(3.871)
N Households	597
Pseudo R^2	0.025

This table reports the results from a median regression of household saving rate on income quintile. Bootstrapped standard errors are shown in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The income quintiles are weighted by sampling probability; the median regression is unweighted.

Given that entrepreneurial households with higher income tend to have higher saving rate, following the argument in Kaldor (1967), one would expect that higher income inequality among entrepreneurs to increase the aggregate saving rate in the economy. I examine this hypothesis, again using data from U.S. states. As before, I use the ratio between the top 0.1%

income share and the top 10% income share to proxy for entrepreneurial income inequality.[7] I construct the aggregate saving rate of each state as $\frac{\text{Income}_{it} - \text{Expenditure}_{it}}{\text{Income}_{it}}$, where Income_{it} and Expenditure_{it} are total household income and total personal consumption expenditure at the state level, respectively. As Table 3 shows, aggregate saving rate is positively associated with inequality at the top of the income distribution, at 1% significance level.

Table 3: Saving Rate and Top Income Inequality across States

	(1)	(2)	(3)
Dependent Var.	Aggregate Saving Rate		
Top Income Inequality	0.314***	0.315***	0.314***
	(0.0749)	(0.0745)	(0.0734)
ln GDP pc	0.178***	0.182***	0.207***
	(0.0245)	(0.0264)	(0.0414)
Finance Sector Share		0.0810	0.0714
		(0.147)	(0.141)
Government Size			0.243
			(0.252)
R^2	0.584	0.585	0.587
N states	51	51	51
N observations	765	765	765

Robust standard errors are clustered at the state level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. Year and state fixed effects are included in all regressions. All regressions employ data from 1999 to 2013.

Stylized Fact 3 *At both the state level and the country level, there is a strongly positive association between trade openness and aggregate saving rate. There is also a positive but weaker relationship between trade openness and aggregate investment rate at the country level.*

In the empirical exercises above, I have found a positive association between trade openness and income inequality among high-income households, and a positive association between income inequality among high-income households and aggregate saving rate, using

[7] The current exercise focuses on income inequality among the rich households while the previous literature on income inequality and saving considers income inequality among the general population. The departure is motivated by the observation that saving is dis-proportionally done by high-income households.

data from states of the US. A natural question is whether there is a positive relationship between trade openness and aggregate saving rate. I address this question in two ways.

First, I investigate this relationship again using state-level data from the US. Table 4 in the appendix relates aggregate saving rate to the Export/GDP ratio at the state level. I find a positive and statistically significant (at 10% level) relationship between the aggregate saving rate of a state and the Export/GDP ratio.

Table 4: Saving Rate and Export/GDP ratio at the State Level

Dependent Var.	Aggregate Saving Rate		
	(1)	(2)	(3)
Export/GDP	0.123*	0.130*	0.136*
	(0.0709)	(0.0670)	(0.0687)
ln GDP pc	0.216***	0.221***	0.250***
	(0.0269)	(0.0295)	(0.0438)
Finance Sector Share		0.0903	0.0803
		(0.158)	(0.152)
Government Size			0.280
			(0.254)
Within R^2	0.547	0.548	0.550
N Countries	51	51	51
N Observations	765	765	765

Robust standard errors are clustered at the state level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. Year and state fixed effects are included in all regressions. All regressions employ data from 1999 to 2013.

A disadvantage of our state-level regressions is the short time span, as a result of the limited time coverage of the export series at the state level. Therefore, I investigate the relationship between openness and the aggregate saving rate at the country level. The use of country-level data is advantageous for two reasons. First, data are more easily available for more observations and for longer period of time. Moreover, since data for aggregate investment rate are available at the country level, I can also test the relationship between aggregate investment rate and trade openness. The equation of interest is

$$S_{it} = \beta_0 + \beta_1 Openness_{it} + \beta_2 X_{it} + c_i + \mu_t + v_{it} \tag{2}$$

where S_{it} is the aggregate saving rate, or the aggregate investment rate, in country i at time t, $Openness_{it}$ is the Trade/GDP ratio, X_{it} is a vector of control variables, and c_i and μ_t are country and time fixed effects, respectively. 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 Great Trade Collapse.

Panel A of Table 5 presents the results from fixed-effects panel regressions on the saving rate. Column (1) presents my baseline results from the sample of countries. I control for income by including the log of GDP per capita and its square. Additionally, I control for financial development using the Credit/GDP ratio. I lag the income terms and the Credit/GDP ratio by five years since they are potentially endogenous with respect to the saving rate. According to Column (1), a one-percentage-point increase in the Trade/GDP ratio raises the aggregate saving rate by 0.0918 percentage point. The coefficient is statistically significant at 1%. According to the point estimate in Column (1), the aggregate saving rate increases by 0.221 standard deviation for a one-standard-deviation increase in the Trade/GDP ratio.[8] 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 predicted average national saving rate would have been 21.5% instead of 17.1%.

Column (1) demonstrates 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 (2) of Table 5, 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.

The strong correlation between the Trade/GDP ratio and the saving rate may be driven

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

Table 5: The Effect of Trade on Aggregate Saving and Investment

Fixed-Effects Panel Regressions

	(1) Baseline	(2) Lag-Lead	(3) Inv/Sav
Panel A.		**Aggregate Saving Rate**	
Trade/GDP	0.0918***	0.0811**	0.0592*
	(0.0330)	(0.0313)	(0.0331)
Trade/GDP (Lag)		-0.00679	
		(0.0314)	
Trade/GDP (Lead)		0.0395	
		(0.0495)	
Investment Rate			0.653***
			(0.0797)
Within R^2	0.120	0.127	0.320
Panel B.		**Aggregate Investment Rate**	
Trade/GDP	0.0499***	0.0604***	0.0180
	(0.0151)	(0.0190)	(0.0166)
Trade/GDP (Lag)		0.0126	
		(0.0183)	
Trade/GDP (Lead)		-0.0213	
		(0.0266)	
Saving Rate			0.348***
			(0.0702)
Within R^2	0.149	0.170	0.343
N Countries	110	106	110
N Observations	556	452	556

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 baseline controls in Column (1) include log GDP per capita and its square (both lagged), and the Credit/GDP ratio (lagged); Column (2) controls for the five-year lag and lead of the Trade/GDP ratio, in addition to the baseline controls; Column (3) ("Inv/Sav") controls for the investment rate in the saving regression, and for the saving rate in the investment regression, in addition to the baseline controls.

by demand-side factors, as a higher return to investment after a trade liberalization induces households to save more. In Column (3), I control for the aggregate investment rate. The results show that, conditional on the aggregate 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 saving-openness relationship is solely driven by higher returns to investment.

In Panel B of Table 5, I repeat the analysis with the aggregate investment rate as the dependent variable. According to Column (1), the aggregate investment rate increases by 0.166 standard deviations following a one-standard-deviation increase in the Trade/GDP ratio, compared to an increase of 0.221 standard deviation for the national saving rate. Column (2) shows that the investment rate is positively correlated with contemporaneous trade openness but is not correlated with past or future trade openness. Column (3) shows that conditional on the saving rate, there is no statistically significant relationship between trade openness and the aggregate investment rate.

A comparison of the results from Panel A and Panel B of Table 5 can offer some insight on the saving-openness relationship. 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. As Table 5 shows, the results suggest 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 A1.

To address the endogeneity of trade openness, in a companion paper (Tang, 2015) 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 Frankel and Romer (1999) instrumental-variable (IV) approach in a panel setting, and find larger effects of trade openness on the saving rate than in the simple fixed-effects regressions.

Summary

I have documented three stylized facts. First, trade openness increases income inequality among the high-income households. Second, the household saving rate is increasing in household income, among the SCF sample of entrepreneurs. Lastly, I find that the aggregate saving rate is positively associated with trade openness both at the state and country level. Taken together, these stylized facts suggest a mechanism whereby a trade-induced increase in entrepreneurial income inequality raises aggregate saving, leading to higher capital accumulation. Can this mechanism be incorporated in a formal model? What are the welfare implications of such a mechanism? I construct a model of international trade to address these questions in the next section.

3 Model

In this section, I develop a dynamic model of trade with incomplete markets to jointly explain the stylized facts described above. The model formalizes the novel mechanism that an increase in trade openness raises aggregate saving and capital accumulation, via its effects on income inequality among entrepreneurs. I then study the welfare implications of the model. To demonstrate its quantitative relevance of the proposed mechanism implied by the model, 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 Online Appendix V.

3.1 Environment

3.1.1 Entrepreneurs

There are two symmetric countries. Throughout this paper, I use superscript * to denote prices, quantities and policy functions in the foreign country. 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:

$$U(c) = E\Big(\sum_{t=0}^{\infty} \beta^t \frac{{c_t}^{1-\lambda}}{1-\lambda}\Big), \tag{3}$$

where β is the discount factor, λ is the coefficient of relative risk aversion, and c_t is the final good (the numeraire). 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 (3) is taken with respect to z.

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.

3.1.2 The Final Good Sector

Each country has a perfectly competitive final good sector. A single representative firm in each country combines differentiated goods, produced domestically or imported, into the final good according to

$$Y = \Big(\int q(i)^{\frac{\sigma-1}{\sigma}} di\Big)^{\frac{\sigma}{\sigma-1}}, \tag{4}$$

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

$$\max_{q(i)} \Big\{ P\Big(\int q(i)^{\frac{\sigma-1}{\sigma}} di \Big)^{\frac{\sigma}{\sigma-1}} - \int p(i)q(i)di \Big\}. \tag{5}$$

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

$$p(i) = E^{\frac{1}{\sigma}} P^{1-\frac{1}{\sigma}} q(i)^{-\frac{1}{\sigma}} \tag{6}$$

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.

3.1.3 Production of Differentiated Goods and International Trade

Producers of differentiated goods operates under monopolistic competition. An entrepreneur with productivity $z(i)$ produces a variety i of differentiated goods according to

$$q(i) = z(i)k(i)^{\alpha} l(i)^{1-\alpha}, \tag{7}$$

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 cost of f_X in units of labor.[9] There is no sunk cost of exporting. Lastly, there is an iceberg variable cost of trade, $\tau \geq 1$. Exporters have to ship τ units for

[9] A possible alternative is to specify this fixed cost in final goods. However, 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 trade. I abstract from this additional chanel.

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 Online Appendix V.1, I show that my results are robust to allowing for a sunk cost of exporting.

3.1.4 Capital Rental Market

Capital is immobile across countries and depreciates at rate δ per year. 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. Entrepreneurs can rent any amount of capital within each period. That is, the rental of capital for production is not subject to financial frictions. 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. Since there is a large literature on the interactions between financial frictions and international trade (Manova, 2013), I show that the results are robust to an alternative setting where the demand for capital by entrepreneurs is constrained by their wealth in Online Appendix V.3.

3.1.5 Dynamic Budget Constraint

The dynamic budget constraint of an entrepreneur is given by

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

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

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

and

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

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

3.1.6 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.

2. Entrepreneurs choose export status $e(z) \in \{0, 1\}$, capital input $k(z)$ and *variable* 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 $a'(a, z)$.

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.

3.2 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:

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

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 $\pi^D(\bar{z}_X) = \pi^X(\bar{z}_X)$. An entrepreneur become an exporter if and only if $z \geq \bar{z}_X$, where the cutoff $\bar{z}_X$ is given by

$$\bar{z}_X = \tau \cdot \left(\frac{w \cdot f_X}{\Phi \cdot E^*}\right)^{\frac{1}{\sigma-1}} R^\alpha w^{1-\alpha}, \tag{8}$$

where $\Phi = \left(\alpha^\alpha(1-\alpha)^{(1-\alpha)}\right)^{\sigma-1} \sigma^{-\sigma}(\sigma-1)^{(\sigma-1)}$. Equation (8) 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^*).

3.3 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

$$\int_z \int_a l(z)G(da,dz) + f_X \cdot \int_{e(z)=1} \int_a G(da,dz) \quad = \quad 1$$

The first integral on the left-hand side is taken over the entire entrepreneur population and gives total demand for variable labor input. The second integral is taken over all exporting entrepreneurs and gives total labor used as fixed costs of exporting. 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

$$\int_z \int_a c(a,z)G(da,dz) + w + \delta \cdot K \quad = \quad Y \tag{9}$$

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. 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

$$G(a, z) = \gamma \int_{\tilde{z} \le z} \int_{a'(\tilde{a}, \tilde{z}) \le a} G(d\tilde{a}, d\tilde{z}) + (1-\gamma)\mu(z) \int_{\tilde{z}} \int_{a'(\tilde{a}, \tilde{z}) \le a} G(d\tilde{a}, d\tilde{z}) \quad (10)$$

for all (a, z). Equation (10) 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).[10]

3.4 Complete Markets Benchmark (CM Benchmark)

To investigate the role of entrepreneurial income inequality for the gains from trade, it is instructive to construct a benchmark model in which markets are complete, and to compare the results from the benchmark model to the full model. 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 aggregates 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

[10] 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, the integration is taken over the entrepreneurs with $z \le \bar{z}$ whose policy functions place them at $a' \le \bar{a}$. For the $(1-\gamma)$ fraction in the entrepreneur population who receive a new z, the integration is taken over all entrepreneurs whose policy functions place them at $a' \le \bar{a}$. The integral is multiplied by $\mu(\bar{z})$ since only a fraction $\mu(\bar{z})$ will have $z \le \bar{z}$ after the redraw of z.

$\mu(z)$. The representative entrepreneur maximizes

$$\max_{c_t, a_t} \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{11}$$

where $u'(.) > 0$ and $u''(.) < 0$,[11] subject to the dynamic budget constraint

$$c_t + a_{t+1} = \int \max\{\pi^D(z), \pi^X(z)\}\mu(dz) + (1+r)a_t \tag{12}$$

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.

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.

[11]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.

To solve the model, I obtain the first-order conditions for the maximization problem given by Equations (11) and (12). 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.

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. The details on the calibration of the CM benchmark are presented in Table 6.

4 Quantitative Analysis

4.1 Calibration

I calibrate the model to US data at annual frequency. The model is solved numerically using parallel computing. The computational algorithm is described in detail in Appendix C. Table 6 summarizes the parameter choices and target moments.

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. I set the elasticity of substitution σ at 5.0, which is the average estimate for differentiated goods in Broda and Weinstein (2006).

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. Melitz and Redding (2013) uses a value of 1.3 for the tail parameter. However, γ also governs the income distribution among entrepreneur in the model. Empirically, income follows a Pareto distribution with a tail parameter of around 1.7 for the US population over 1991-2000 (Alvaredo et al., 2011). As a compromise, I set the tail index of the firm sales distribution to $\zeta = 1.5$. The resulting income distribution among entrepreneurs matches the 2001 SCF data (See Panel A of Table 7). I choose $\gamma = 0.814$ to match the persistence of firm productivity reported in Foster, Haltiwanger and Syverson (2008).

I calibrate the remaining parameters to match a number of moments from the US economy. I set the discount factor β at 0.952 to match an annual interest rate of 3.0%. 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 et al., 2007). To match this ratio, I set the variable trade cost τ to 1.57. I choose $f_X = 0.088$ to match the import penetration ratio of 7.0% for the US in 2000, which is used in the headline calculation in Arkolakis et al. (2012)

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".

Table 6: Calibration

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	5.000		5.000	
Persistence of Firm Productivity	γ	0.814		-	
Shape Parameter of Sales Distribution	ζ	1.500		1.500	
Panel B: Parameters Calibrated to Match Data Moments					
		Full Model		CM Benchmark	
Target Moment	US Data	Parameter	Model	Parameter	Model
Interest Rate	3.00%	$\beta = 0.952$	3.03%	$\beta = 0.971$	3.03%
Import Penetration Ratio	7.00%	$f_{EX} = 0.088$	7.06%	$f_{EX} = 0.088$	7.06%
Export to Sales Ratio	14.00%	$\tau = 1.57$	14.00%	$\tau = 1.57$	14.00%

"Full Model" refers to the model described in Section 3.1; "CM Benchmark" refers to the complete markets benchmark described in Section 3.4

4.2 Calibration of the CM Benchmark Model

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 (α, δ, σ, ζ, f_X and τ), the optimization problem faced by firms in the benchmark model is the same as in the full model. 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. Since I have targeted an equilibrium interest rate of 3.00% for the full model, I simply set $\beta = \frac{1}{1+0.0300} = 0.971$ to have the same interest rate in the CM benchmark. 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.

4.3 Model Validation

Before proceeding to the main results, I evaluate the model by comparing non-targeted moments of the model with the SCF data.

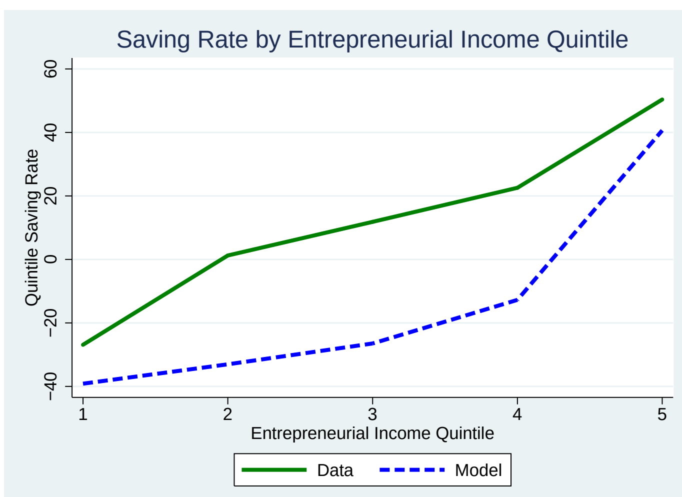
Table 7: Comparison of Inequality Between Model and Data

Panel A. Income			Panel B. Wealth		
Share of Total Entrepreneurial Income			Share of Total Entrepreneurial Wealth		
	Model	2001 SCF Data		Model	2001 SCF Data
Quintile 1	5.2%	2.7%	Quintile 1	0.0%	0.4%
Quintile 2	7.2%	5.7%	Quintile 2	1.0%	2.4%
Quintile 3	10.0%	9.8%	Quintile 3	4.7%	5.9%
Quintile 4	15.4%	16.0%	Quintile 4	12.5%	12.8%
Quintile 5	62.2%	65.8%	Quintile 5	81.7%	78.4%
Top 10%	49.8%	52.2%	Top 10%	67.8%	64.3%
Top 5%	39.5%	39.7%	Top 5%	55.5%	49.1%
Gini Coefficient	0.557	0.614	Gini Coefficient	0.798	0.751

I compare the income and wealth distribution in the model against the 2001 SCF data. Table 7 presents the income and wealth distribution from both the SCF data and the model. As shown in Panel A of Table 7, the income distribution in the model matches the data well. However, the Gini coefficient among entrepreneur of 0.558 in the model is somewhat lower than the value of 0.614 in the data. In Panel B, I examine the wealth distribution among entrepreneurs, which is not targeted in the calibration. The differences between the model and the data in share of total wealth are small for all five wealth quintiles. On the other hand, the model over-predicts the share of total wealth held by the top 5% entrepreneurs, with a value of 55.5% in the model compared to 49.1% in the data. Overall, the wealth distribution in the model matches the data well.

I compare the saving rates by entrepreneurial income quintile between the model and the data. From the SCF data, I group these households into quintiles of total income. I calculate the aggregate household saving rate of an income quintile as $\frac{\text{Networth}_{89} - \text{Networth}_{83}}{6 \times (0.5 * Y_{83} + 0.5 * Y_{89})}$, where Networth_t and Y_t are the total networth and total income of all households in an income quintile at year t respectively. In other words, I calculate the weighted average of the individual household saving rate for each income quintile, where the weights are given by income. I simulate the model for six years and follow the above definition closely to produce the model counterparts. Figure 1 presents the aggregate saving rate by income quintile for the model and the data. The quintile saving rates from the SCF data are depicted by the solid green line, while the model counterparts of these saving rates are depicted by the dashed blue line. As Figure 1 shows, the model is able to produce a positive relationship between saving rate and income. The correlation for quintile saving rates between the data and the model is 0.903. On the other hand, the quintile saving rates appear to be systematically lower in the model than in the data. This is due to the fact that the aggregate saving rate of all entrepreneurs is necessarily zero in a stationary equilibrium in the model and entrepreneurs earn only the net return of saving, while it does not have to be zero in the data (See Online Appendix II). Overall, the model reproduces the key dimensions of the quintile saving rates in the SCF data.

Figure 1: Aggregate Saving Rate by Entrepreneurial Income Decile:
Model and Data



Source: 1983-1989 panel of the SCF. Quintile saving rate is defined as change in total quintile networth over total quintile income.

4.4 The Impact of International Trade on Inequality

I examine the effects of trade openness on entrepreneurial income inequality. I focus on the numerical results in this section and relegate the analytical results to Online Appendix I. As shown in Panel A of Table 8, international trade increases the share of overall entrepreneurial income received by the most productive entrepreneurs. Moving from Autarky to Trade, the share of total entrepreneurial income received by the bottom 40% decreases from 17.9% to 17.0%. The share of total entrepreneurial income received by the 3rd and 4th income quintiles also decreases. On the other hand, the share of total entrepreneurial income received by the top 5% increases from 37.3% to 39.5%. The Gini coefficient among entrepreneurs increases, from 0.538 under Autarky to 0.558 under Trade.

The effects of trade openness on income inequality among entrepreneurs, as presented in Panel A of Table 8, 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 3.15% to 3.03%. 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 not increase proportionally with profit income for the exporters. In Section 4.5, I show that this modest increase in entrepreneurial income inequality can nevertheless have large welfare implications for the workers.

I also examine 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 64.6% to 65.4%. This is consistent with Proposition 2 in Online Appendix I. 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 novel mechanism in this paper, since workers do not save at all in the model.

Panel B of Table 8 presents the effects of trade on the wealth distribution among entrepreneurs. Moving from Autarky to Trade, the share of total wealth held by the first four

Table 8: The Effects of Trade on Income and Wealth Inequality

Panel A. Income Share of Total Entrepreneurial Income			Panel B. Wealth Share of Total Entrepreneurial Wealth		
	Autarky	Trade		Autarky	Trade
Quintile 1	5.5%	5.2%	Quintile 1	0.0%	0.0%
Quintile 2	7.6%	7.2%	Quintile 2	1.2%	1.0%
Quintile 3	10.5%	10.0%	Quintile 3	5.2%	4.7%
Quintile 4	16.1%	15.4%	Quintile 4	13.1%	12.5%
Quintile 5	60.3%	62.2%	Quintile 5	80.4%	81.7%
Top 10%	47.5%	49.8%	Top 10%	66.2%	67.8%
Top 5%	37.3%	39.5%	Top 5%	53.9%	55.5%
Gini Coefficient	0.536	0.557	Gini Coefficient	0.786	0.798

"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.

wealth quintiles all decreases. On the other hand, the share of total wealth received by the 5th wealth quintile increases from 80.4% to 81.7%. The share of total wealth held by the top 5% increases from 53.9% to 55.5%. The Gini coefficient for wealth among entrepreneurs increases, from 0.786 under Autarky to 0.798 under Trade. Therefore, international trade increases wealth inequality among entrepreneurs in the model modestly.

4.5 Gains from Trade

4.5.1 The Impact of Trade on Aggregate Output

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

$$Y = \text{TFP} \cdot K^{\alpha} \tag{13}$$

where Y, TFP, and K are the aggregate output of the final good, aggregate total factor productivity (TFP) and aggregate capital stock respectively. Aggregate TFP is in turn given by

$$\text{TFP} = L_v^{1-\alpha}\Big(\int_{e(z)=0} z^{\sigma-1}\mu(dz) + (1+\tau^{1-\sigma})\int_{e(z)=1} z^{\sigma-1}\mu(dz)\Big)\Big\}^{\frac{1}{\sigma-1}}, \tag{14}$$

where L_v denotes total labor used as variable input, and the second term is the weighted harmonic mean of productivity over all firms. The first integral of the second term 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 (13), we have

$$\frac{\Delta Y}{Y} \approx \frac{\Delta \text{TFP}}{\text{TFP}} + \alpha \frac{\Delta K}{K}. \tag{15}$$

Equation (15) 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 $\left(\alpha \cdot \frac{\Delta K}{K}/\frac{\Delta Y}{Y}\right)$, respectively.

Table 9: 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	1.23%	1.23%	48.4%	66.7%
Capital	3.95%	1.85%	51.6%	33.3%
Output	2.55%	1.85%	100.0%	100.0%

"Full Model" refers to the model described in Section 3.1; "CM Benchmark" refers to the complete markets benchmark described in Section 3.4.

Columns (1) and (2) of Table 9 summarize the impact of trade on aggregate output. In the full model, when we move from Autarky to Trade, aggregate output increases by 2.5%. In the CM benchmark, aggregate output increases by 1.8%, 0.7 percentage points less than in the full model. Therefore, the novel mechanism in my model increases the gains in aggregate output by 38.9%, compared to the complete markets benchmark. 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 9 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 51.6% of the output gains from trade in the full model, compared to 33.3% in the CM benchmark. It is also important to note that the contribution of capital accumulation to the output gains 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 a 4.0% 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. As shown earlier in Figure 1, the household saving rate of entrepreneurs in the full model is strongly increasing in income. This is consistent with the second stylized fact in Section 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.[12] 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 3.15% to 3.03% 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 3.03%. The capital stock increases by 1.9%, substantially less than the 4.0% increase in the full model. This confirms the quantitative importance of the supply-side channel emphasized in this paper.

[12]The positive relationship between the saving rate and current income also plays an important role in Buera, Kaboski and Shin (2012) and Buera, Kaboski and Shin (2014) who use a heterogeneous-agent model with occupational choice to evaluate the aggregate implications of micro-finance and asset granting programs respectively.

In principle, there are two possible 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.[13] 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 1.72% 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 1.83% 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. Online Appendix II provides details of the experiments above, as part of a decomposition exercise on the change in the aggregate saving rate.[14]

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

[13] 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).

[14] In a stationary equilibrium, the aggregate saving rate of all entrepreneurs is zero. 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 Online Appendix II. 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*.

Appendix II.

4.5.2 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 4.4, 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. I do not consider aggregate welfare, since doing so would require me to take a stand on the relative weights of entrepreneurs and workers in the social welfare function.

In both models, workers face no income risk and simply consume their wage each period. A natural measure of workers' welfare is the equilibrium real 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. 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 10 presents the effects of international trade on welfare. Consider the results from the full model. The increase in the real wage is 3.5%. On the other hand, while

Table 10: Welfare Gains from Trade

Model	Full Model	CM Benchmark
Consumption of Workers		
Real Wage	3.48%	2.78%
Entrepreneurial Consumption		
Aggregate	0.02%	0.14%
Certainty-Equivalent	-3.85%	-

"Full Model" refers to the model described in Section 3.1; "CM Benchmark" refers to the complete markets benchmark described in Section 3.4.

aggregate entrepreneurial consumption is unchanged by international trade, there is a 3.9% decrease of certainty-equivalent consumption for entrepreneurs. Intuitively, the distribution of consumption among entrepreneurs becomes more dispersed when moving from Autarky to Trade. In other words, while the *ex-post* most productive entrepreneurs gains from a decrease in trade costs, the *ex-ante* welfare of an average entrepreneur decreases due to greater dispersion of possible income realizations.

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 real wage is only 2.8%, lower than that in the full model. Since the marginal product of labor is increasing in capital input, workers benefits from the large increase in capital accumulation and enjoys larger gains from trade in the full model than in the CM benchmark. Therefore, the novel mechanism in my model increases the real wage gains for workers by 25.0%, compared to the CM benchmark. Lastly, as in the full model, aggregate entrepreneur consumption in the CM benchmark is unchanged from international trade.

4.6 Robustness and Extensions

A crucial assumption is that these higher-income households face uninsurable income risk associated with the performance of firms. This is well supported by empirical studies. Clementi and Cooley (2010) show that executive compensation is closely tied to innovations in shareholder wealth. Guvenen (2007) analyzes the extent of risk sharing among households in the

US and finds that market incompleteness matters more for the wealthy households, who face substantial entrepreneurial risk. Quadrini (2000) and Cagetti and De Nardi (2006) find that precautionary saving by entrepreneurs to be an essential element to account for the extreme concentration of wealth in the right tail in US data.

The model assumes labor to be homogeneous. In reality, there is a lot of heterogenity among workers, and there is extensive evidence that trade openness increases wage inequality (Goldberg and Pavcnik, 2007; Harrison et al., 2011). To the extent that the saving rate is also increasing in income among workers, an increase in wage inequality can increase the aggregate saving by workers and capital accumulation through a similar mechanism. I abstract from worker heterogeneity and savings by workers in view of the fact that wealth is very concentrated empirically. With this setup, the welfare of a worker is simply his real wage, which is the marginal product of labor. This allows me to illustrate the interaction between income inequality among entrepreneurs and workers' welfare. In Online Appendix III, I describe a version of the model with occupational choice in which an agent choose to be a worker or an entrepreneur, and workers can have significant wealth. 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 9 and Table 10 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. The main conclusions of this paper are not changed by the model extension.

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 Online Appendix IV, I consider two additional policy experiments where I further reduce the variable trade cost and find similar results.

In Online Appendix V, I examine the robustness of the baseline calibration results to alternative modeling choices. 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. The baseline results are robust to these alternatives.

4.7 The Role of Capital

By contrasting the full model with the CM benchmark, Section 4 shows that entrepreneurial income inequality affects the magnitude of the gains from trade. The mechanism linking entrepreneurial income inequality and gains from trade is capital accumulation. 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

$$q(i) = z(i)l, \tag{16}$$

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. The details of the models and associated calibration are provided in Appendix D.

Table 11 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 11: Gains From Trade in Models without Capital

	(1)	(2)	(3)	(4)
Model	NoK	NoK CM	Full	CM
TFP	1.23%	1.23%	1.23%	1.23%
Capital	-	-	3.95%	1.85%
Output	1.23%	1.23%	2.55%	1.85%
Consumption of Workers				
Real Wage	1.85%	1.85%	3.48%	2.78%
Entrepreneurial Consumption				
Aggregate	-1.28%	-1.28%	0.02%	0.14%
Certainty-Equivalent	-4.61%	-	-3.85%	-

The "NoK" Model refers to a modification of the full model which does not include capital in the production function. The "NoK CM" Model 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

$$1 - \lambda_{ii}^{-\frac{1}{\varepsilon}} \tag{17}$$

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 the variable trade cost in this model is given by $-\eta = -(\sigma - 1)\zeta$. I have set $\eta = (\sigma - 1)\zeta = 6.0$ and $\lambda_{ii} = 0.93$ in the calibration. The formula in Equation (17) yields an output gain from trade of 1.22%. This is identical (other than rounding errors) to the output gain of 1.23% 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 11. 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, real 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.

To see the effects of entrepreneurial income inequality in models without capital, I compare Column (1) and Column (2) of Table 11. 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).

5 Conclusion

This paper starts by documenting three stylized facts relating trade openness, entrepreneur income inequality, aggregate saving rate and investment rate. First, trade openness is positively associated with greater income inequality among the high-income households across the states of the US. Second, among entrepreneurial households in the US, households with higher income have higher saving rate. Lastly, at both the state and the country level, there is a positive correlation between trade openness and the aggregate saving rate. There is also a positive but weaker correlation between trade openness and the investment rate at the country level. These stylized facts point to a potential mechanism whereby greater trade openness increases aggregate saving and capital accumulation, via its effects on income inequality. I construct a formal model of international trade to reconcile these facts and to study the welfare implications of the mechanism.

I find that accounting for the effect of trade openness on entrepreneurial income inequality implies greater welfare gains from trade for workers, via a supply-side channel of capital accumulation. In this sense, the benefits of trade for workers and greater inequality among entrepreneurs are inseparable. It is also interesting to note that the *ex-ante* welfare of an average entrepreneur decreases due to the greater dispersion of possible income realizations. Therefore, although greater trade openness in the model increases income inequality, as in previous studies, this paper also suggests that the welfare implications may be more nuanced than previously thought. Further research is needed to advance our understanding of this topic.

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Appendix A Data Appendix

Data used in state-level empirics

Data on top income shares for each US state are taken from Frank (2015). The Frank (2015), which extends Frank (2009), are based on Internal Revenue Service (IRS) income data (available at `http://www.shsu.edu/eco_mwf/inequality.html`). Frank (2015) also provides data on education attainment by state. Data on export from each stata are taken from International Trade Administration (available at `http://tse.export.gov/tse/tsehome.aspx`). Lastly, data on aggregate GDP, sector-level GDP, and population are available from Bureau of Economic Analysis (BEA).

Data used in country-level regressions

Sample of Countries 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. 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`). The final sample includes 110 countries.

Variables My main measure of aggregate saving rate 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 GDP. 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.I use gross fixed capital formation as a percentage of GDP, available from the WDI database, as the investment measure. Since Alcalá and Ciccone (2004) argue that the real openness ratio, defined as the sum of real exports and real imports over purchasing power parity (PPP) GDP, is theoretically preferred to the conventional measure (the sum of exports and imports over GDP using the nominal exchange rate), I use the *real* openness ratio from PWT (Mark 8.0), which adjusts the sum of exports and imports for PPP prices. Most of the other country-level variables, including aggregate saving rate, aggregate investment rate, GDP per capita, population, age dependency ratio, the Credit/GDP ratio and government expenditure share, are taken from WDI database. To supplement the WDI database, I take the measure of capital account openness from Quinn and Toyoda (2008), data on labor share of total income from Karabarbounis and Neiman (2014) and data on private saving rate from Loayza et al. (2000a), respectively.

Appendix B More on the Stylized Facts

Appendix B1 Saving Rate and Trade Openness across Countries

In Table A1, I conduct a number of robustness checks for the fixed-effects panel regressions reported in Table 5.

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 Column (2), I control for the GDP growth rate. In Column (3), I include old and young dependency ratios as additional regressors to capture the effects of demographic changes.

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 (4) of Table A1, I include the trade surplus as an additional regressor. The point estimate of the coefficient on the Trade/GDP ratio decreases to 0.0715 but remains statistically significant at 1%. Since I am holding $(S - I)$ constant in this regression, the results in Column (4) are consistent with the finding that a substantial part of the openness-induced saving translates into higher investment.

Table A1: Robustness of Panel Fixed-Effects Panel Regressions:

Alternative Specifications

	(1) K-Open	(2) Growth	(3) D-graph	(4) Balance	(5) Gov-Size	(6) L-Share	(7) P-saving
Panel A:			Aggregate Saving Rate				
Trade/GDP	0.0762**	0.0769**	0.0870***	0.0715***	0.0872***	0.0706*	0.0522*
	(0.0323)	(0.0304)	(0.0326)	(0.0253)	(0.0311)	(0.0416)	(0.0273)
Panel B:			Aggregate Investment Rate				
Trade/GDP	0.0461***	0.0400***	0.0479***	0.0660***	0.0507***	-0.00536	
	(0.0145)	(0.0143)	(0.0154)	(0.0162)	(0.0147)	(0.0254)	
N Countries	73	110	110	110	110	82	61
N Observations	437	554	556	556	554	247	293

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) controls for the GDP growth rate; Column (3) controls for old and young dependency ratios; Column (4) controls for the trade balance; Column (5) controls for total government expenditure as a share of GDP; Column (6) controls for the labor share of income; Column (7) uses the private saving rate as the dependent variable.

Another concern is that the relationship between the aggregate saving rate and openness is working through public saving, while my model is about the private saving rate. To alleviate this concern, Column (5) includes total government expenditure as a share of GDP. Column (6) use data on the labor share of income from Karabarbounis and Neiman (2014) as an additional control. Column (7) uses data on the private saving rate from Loayza, Schmidt-Hebbel and Serven (2000b) as the dependent variable. Although the sample size is substantially reduced, the coefficient on the Trade/GDP ratio is positive and statistically significant for both Columns (6) and (7).

Appendix C 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. Start with a guess of L_v which is the total variable labor input. The total expenditure on differentiated goods can be expressed as

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

   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 $a'(a,z)$, $e(z)$ 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 for the labor market and capital rental market. 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.

6. Check that $E = Y$. If $E \neq Y$, update L_v and repeat Steps 1 to 5.

Appendix D Models without capital

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).

Appendix D1 The NoK Model

An entrepreneur produces a variety i of differentiated goods according to $q(i) = z(i)l$. The dynamic budget constraint of an entrepreneur is given by

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

where $\pi^D(z)$ $\pi^X(z)$ are defined without choice of capital but otherwise analogous as before.

A stationary competitive equilibrium with international trade is defined as an invariant distribution $G(.)$ of entrepreneurs over the (a, z) space, a set of prices, and a set of policy functions such that:

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

2. The markets for labor and the final good clear. Trade balances.

(a) Labor market clears.

(b) Trade balances.

(c) The final good market clears.

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

$$G(a,z) = \gamma \int_{\tilde{z}\leq z} \int_{a'(\tilde{a},\tilde{z})\leq a} G(d\tilde{a},d\tilde{z}) + (1-\gamma)\mu(z) \int_{\tilde{z}} \int_{a'(\tilde{a},\tilde{z})\leq a} G(d\tilde{a},d\tilde{z}) \tag{19}$$

for all (a,z).

Appendix D2 The NoK CM Model

There is one representative entrepreneur in each country. The representative entrepreneur owns all firms in the country. Other features of the NoK CM model are the same as in the NoK model. The representative entrepreneur maximizes

$$\max_{c_t,a_t} \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{20}$$

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

$$c_t + a_{t+1} = \int \max\{\pi^D(z), \pi^X(z)\}\mu(dz) + a_t. \tag{21}$$

I use the same strategy as in Section 4.1 to calibrate both the NoK model and the NoK CM model. Table A2 provides the details. The number of parameters is reduced to six in the NoK model. The parameter values are identical to those in Table 6, except for the fixed cost of exporting f_X, which is set to 0.060. The NoK CM model has only four parameters and the parameter values are the same as those used for the NoK model.

Table A2: Calibration of Models without Capital

Panel A: Parameters Taken from Prior Literature					
		NoK Model		NoK CM Model	
Parameter	Symbol	Value		Value	
Coefficient of Risk Aversion	λ	1.500		-	
Elasticity of Substitution	σ	5.000		5.000	
Persistence of Firm Productivity	γ	0.814		-	
Shape Parameter of Sales Distribution	ζ	1.500		1.500	
Panel B: Parameters Calibrated to Match Data Moments					
		NoK Model		NoK CM Model	
Target Moment	US Data	Parameter	Model	Parameter	Model
Import Penetration Ratio	7.00%	$f_{EX} = 0.060$	7.06 %	$f_{EX} = 0.060$	7.06%
Export to Sales Ratio	14.00%	$\tau = 1.57$	14.00%	$\tau = 1.57$	14.00%

The “NoK” Model refers to a modification of the full model which does not include capital in the production function. The “NoK CM” Model refers to a version of the model with complete markets where there is no capital.