

ABSTRACT

Title of dissertation: TOP INCOME INEQUALITY,
AGGREGATE SAVING
AND THE GAINS FROM TRADE

Lixin Tang, Doctor of Philosophy, 2015

Dissertation directed by: Professor Nuno Limão
Department of Economics

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 dissertation, I study this interaction. More precisely, I study the relationship between international trade and income inequality, with a focus on the implications for aggregate saving and the gains from trade. I argue that accounting for the effects of international trade on income inequality among entrepreneurs can imply higher gains from trade for workers.

In the second chapter, I construct a dynamic model of international trade with incomplete markets. In the model, entrepreneurs face uninsurable idiosyncratic productivity risk, and thus save. Since the most productive entrepreneurs have the highest saving rate and are the ones that export, a reduction in trade costs increases their share of total profits and their savings, which leads to a large increase in the aggregate supply of capital and increased capital accumulation. I calibrate the model using US data and examine the effects of international trade on aggregate output, the

consumption of workers, and the consumption of entrepreneurs with heterogeneous productivity. In the model, international trade increases aggregate output by 2.5% and the wage of workers by 3.4%. 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 4.0%. Capital accumulation plays an important role in the model, accounting for 51.9% 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 1.8% while the increase in the wage of workers from trade is 2.7%. Therefore, the novel mechanism in my model increases the wage gains for workers by 25.9%, and the gains in aggregate output by 38.9%, compared to the complete markets benchmark.

In the third chapter, I test the key predictions of the model using country-level data. Using fixed-effects (FE) regressions in a large panel of countries, I find a significant and positive correlation between trade openness and the aggregate saving rate. I find a much weaker relationship between trade openness and the investment rate. Furthermore, I show that greater trade openness has a stronger effect on the aggregate saving rate in a country where the initial top 10% share of total income (before any changes in trade openness) is higher. This is in line with my model where the increase in the aggregate saving is driven by top income earners. Additionally, I build on the gravity-based instrumental-variable (IV) approach pioneered by Frankel

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

In the fourth chapter, I study the relationship between the household saving rate and openness in China through the lens of the framework outlined in the second chapter. I show that there has been a large increase in top income shares both among entrepreneurs and workers over the past 30 years in China. Additionally, there is a very significant and positive correlation between top income shares and the household saving rate across Chinese counties. Using the setting of the 1992 liberalization episode, I find that provinces with a greater increase in openness experienced a larger increase in the household saving rate during the period. Taken together, the evidence is supportive of the hypothesis that greater openness increases the household saving rate in China, by increasing the share of total income received by the highest-income households who also have the highest saving rate.

TOP INCOME INEQUALITY, AGGREGATE SAVING
AND THE GAINS FROM TRADE

by

Lixin Tang

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2015

Advisory Committee:
Professor Nuno Limão, Chair/Advisor
Professor John Haltiwanger
Professor Felipe Saffie
Professor John Shea
Professor Phillip Swagel

© Copyright by
Lixin Tang
2015

To my parents.

Acknowledgments

I am indebted to Nuno Limão for his patient guidance, encouragement and motivation. I thank John Haltiwanger, John Shea, Felipe Saffie and Phillip Swagel for their valuable feedback and advice, and for serving on the Dissertation Advisory Committee. I thank Yiqun Chen, Davin Chor, Ryan Decker, Pablo D'Erasmus, Rafael Dix-Carneiro, Jingting Fan, Jiandong Ju, Ethan Kaplan, Luca Opromolla, Felipe Saffie, John Shea, Luminita Stevens, Yoto Yotov and seminar participants at University of Maryland and the 2014 Midwest Economic Theory and Trade Conference for helpful comments. Thanks to Vickie Fletcher and Terry Davis for their help with administrative matters. I thank my classmates and friends at University of Maryland for their help and encouragement throughout the years. I have learned a lot from the numerous conversations with Jingting Fan.

I thank my parents and siblings, without whose unconditional support I could not possibly have completed this dissertation.

Table of Contents

List of Tables	vi
List of Figures	vii
1 Introduction	1
2 A Theory of International Trade and Top Income Inequality	11
2.1 Environment	11
2.1.1 Entrepreneurs	11
2.1.2 Workers	13
2.1.3 The Final Good Sector	14
2.1.4 Production of Differentiated Goods and International Trade	15
2.1.5 Capital Rental Market	16
2.1.6 Dynamic Budget Constraint	17
2.1.7 Timing of the Model	18
2.1.8 An Entrepreneur's Problem	19
2.1.9 Definition of a Stationary Competitive Equilibrium	20
2.2 Calibration	23
2.2.1 Complete Markets Benchmark (CM Benchmark)	25
2.3 Results	28
2.3.1 The Impact of International Trade on Inequality	28
2.3.1.1 Analytical Results	29
2.3.1.2 Numerical Results	31
2.3.2 The Impact of Trade on Aggregate Output	33
2.3.3 Welfare Gains from Trade	38
2.3.4 The Role of Risk Aversion	40
2.4 The Role of Capital	43
2.4.1 The NoK Model	44
2.4.2 The NoK CM Model	46
2.5 Models with Occupational Choice	50
2.6 Robustness and Extensions	57
2.6.1 Sunk Cost	57

2.6.2	Natural Borrowing Limits	59
2.6.3	Financial Frictions for Production	60
2.7	Conclusion	62
3	Cross-Country Evidence	63
3.1	Overview	63
3.2	Empirical Evidence in a Cross Section of Countries	65
3.3	Empirical Evidence in a Panel of Countries	73
3.3.1	Fixed-Effects Panel Regressions	73
3.3.2	The Role of Initial Top 10% Income Share	82
3.3.3	Fixed-Effects Panel Regressions with IV	86
3.4	Discussion	90
3.5	Conclusion	93
4	Openness, Inequality and the Chinese Saving Rate Puzzle	94
4.1	Introduction	94
4.2	Inequality in China	98
4.3	Inequality and the Household Saving Rate	106
4.3.1	Evidence from Household Surveys	106
4.3.2	Changes in Income Distribution and the Household Saving Rate: A Simple Exercise	110
4.4	Openness and the Household Saving Rate in China	111
4.4.1	Empirical Strategy	112
4.4.2	Results	114
4.5	Conclusion	125
5	Conclusion	126
2A	Computational Algorithm for the Full Model	128
2B	Proof of Propositions	130
2C	Decomposition Exercises	135
2C.1	Decomposition of Change in the Aggregate Saving Rate	135
2C.2	Decomposition of Change in the Target-Wealth-to-Profit Ratio	137
3A	Data Sources	139
3B	Robustness of Panel Regressions with IV	140

List of Tables

2.1	Calibration	25
2.2	The Effect of Trade on Inequality	31
2.3	The Impact of Trade on Aggregate Output	34
2.4	Welfare Gains from Trade	39
2.5	The Role of Coefficient of Relative Risk Aversion λ in the Full Model	42
2.6	Calibration of Models without Capital	48
2.7	Gains From Trade in Models without Capital	49
2.8	Income Inequality in a Model without Capital (NoK)	50
2.9	Calibration of Models with Occupational Choice	55
2.10	Gains from Trade in Models with Occupational Choice	56
2.11	Calibration: Extensions and Robustness	58
2.12	Robustness of Baseline Results	59
3.1	First Stages of 2SLS Cross-sectional Regressions	68
3.2	The Effects of Trade on Aggregate Saving and Investment	71
3.3	Robustness Checks on Cross-sectional Regression with IV	72
3.4	The Effect of Trade on Aggregate Saving and Investment	75
3.5	Robustness of Panel Fixed-Effects Panel Regressions:	80
3.6	Robustness of Fixed-Effects Panel Regressions:	81
3.7	The Role of Initial Top 10% Income Share	84
3.8	Results from Estimating a Panel Gravity Equation	87
3.9	The Effect of Trade on Aggregate Saving and Investment	88
4.1	Household Saving Rate and Inequality Across Chinese Counties	107
4.2	Income Distribution and Household Saving Rate	110
4.3	Household Saving Rate in China (1981-2000)	116
4.4	Household Saving Rate and Openness in China (1981-2000)	118
4.5	Household Saving Rate in China: Robustness of 2SLS Results	120
4.6	Investment Rate in China (1981-2000)	122
4.7	Investment Rate and Openness in China (1981-2000)	124
3A.1	Data Sources for the Empirical Exercises in Chapter 3	139

3B.1 Robustness of Fixed-Effects Panel Regressions with IV: Alternative Specifications	140
3B.2 Robustness of Fixed-Effects Regressions with IV	141

List of Figures

2.1 Average Saving Rate And Entrepreneur Productivity z	35
3.1 National Saving Rate and Trade Openness in 1985	67
3.2 Initial Top 10% Income Share and Marginal Effects of Openness . . .	85
4.1 Openness, Saving and Investment in China (1982-2011)	95
4.2 Top Income Shares in China (1986-2003)	100
4.3 Top Income Shares by Entrepreneur Status in China (1988-2009) . . .	102
4.4 Saving Rate by Household Income Quartile (1988-2007)	103
4.5 Saving Rate and Income Share by Income Decile	105

List of Abbreviations

2SLS	Two-Stage Least Squares
CDF	cumulative distribution function
CHFS	China Household Finance Survey
CHIP	China Household Income Project
CHNS	China Health and Nutrition Survey
CUHS	China Urban Household Surveys
CM Benchmark	Complete-Markets Benchmark
CRRA	Constant Relative Risk Aversion
FE	Fixed Effects
GDP	Gross Domestic Product
IV	Instrumental Variable
LIML	Limited Information Maximum Likelihood
PPP	Purchasing Power Parity
PWT	Penn World Table
UNU-WIDER	United Nations University World Institute for Development Economics Research
WDI	World Development Indicators

Chapter 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). A notable example is China, where the sum of exports and imports as a share of GDP increased from 5.3% in 1986 to 68.6% in 2005 (World Bank, 2012).

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

Although empirical studies have identified capital accumulation as an impor-

¹Data 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%.

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

In the second chapter, I develop a dynamic model of trade with incomplete markets. There are two types of households, workers and entrepreneurs. Entrepreneurs are ex-ante identical. They cannot undertake inter-temporal borrowing for consumption, but they are able to rent capital for production without constraints within a period.² They face uninsurable idiosyncratic income risk associated with their productivity and thus save.³ 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,

²Both assumptions are relaxed in the robustness checks in Section 2.6.

³Section 2.1.1 discusses the interpretations of entrepreneurs in my model, the importance of entrepreneurial income for the patterns of top income shares, and evidence of income risk for entrepreneurs.

which is both consistent with the data and crucial for the proposed mechanism in this dissertation. I conjecture that the proposed mechanism would continue to hold in a setup where the positive saving-income relationship was generated by a different mechanism, such as wealth-in-the-utility preferences as in Kumhof, Ranci re, and Winant (2014).⁴

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

I calibrate the model using US data and examine the effects of international trade on aggregate output, the consumption of workers, and the consumption of entrepreneurs with heterogeneous productivity.⁵ In the model, international trade

⁴In a dynastic model where agents are infinitely lived, as is the case in this dissertation, agents undertake saving for their “dynasties.” The saving motives in these models should be broadly interpreted as inclusive of bequest motives, which can be more explicitly modeled with finitely lived agents.

⁵I calibrate the model to the US economy to be comparable to other works in the literature, for example, Melitz and Redding (2013).

increases aggregate output by 2.5% and the wage of workers by 3.4%. 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 4.0%. Capital accumulation plays an important role in the model, accounting for 51.9% 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 1.8% while the increase in the wage of workers from trade is 2.7%. Therefore, the novel mechanism in my model increases the wage gains for workers by 25.9%, and the gains in aggregate output by 38.9%, compared to the complete markets benchmark. I then 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 top income inequality gives rise to higher aggregate output gains and higher wage gains. In fact, the model collapses to a variant of Chaney (2008) when I shut down both top 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 formula in Arkolakis, Costinot, and Rodriguez-Clare (2012).⁶

⁶Arkolakis et al. (2012) shows that in a wide class of trade models, the gains from trade for a country can be calculated from the same formula using two sufficient statistics, the import penetration ratio and the trade elasticity.

In the third chapter, I test the key predictions of the model using country-level data. Using fixed-effects regressions in a large panel of countries, I find a significant and positive correlation between openness and the aggregate saving rate. I find a much weaker relationship between openness and the investment rate. Additionally, I build on the gravity-based instrumental-variable (IV) approach pioneered by Frankel and Romer (1999) and extend it to a panel setting. I find a larger effect of trade openness on the aggregate saving rate in the fixed-effects panel regressions with IV than without IV. The results provide strong evidence that a supply-side channel of increased capital accumulation is operative following an increase in openness, while the demand-side channel is less evident in the data. I conduct a number of robustness checks to rule out alternative mechanisms for the saving-openness relationship. In particular, the results are robust to a rich set of control variables including capital account openness, alternative measures of the aggregate saving rate, and the exclusion of various subsets of countries. Furthermore, I show that greater trade openness has a stronger effect on the aggregate saving rate in a country where the initial top 10% share of total income (before any changes in trade openness) is higher. This is in line with the model where the increase in the aggregate saving is driven by top income earners.

In the fourth chapter, I study the relationship between the household saving and openness in China through the lens of the framework outlined in the second chapter. I show that there has been a large increase in top income shares both among entrepreneurs and workers over the past 30 years in China. Additionally, there is a very significant and positive correlation between top income shares and

the household saving rate across Chinese counties. Using the setting of the 1992 liberalization episode, I find that provinces with a greater increase in openness experienced a larger increase in the household saving rate during the period. Taken together, the evidence is supportive of the hypothesis that greater openness increases the household saving rate in China, by increasing the share of total income received by the highest-income households who also have the highest saving rate.

This study is related to the literature that aims to quantify the gains from trade (cf. Costinot and Rodriguez-Clare (2013)). While nearly all quantification exercises rely on a static framework, I model entrepreneurial consumption, saving and capital accumulation in a dynamic framework. In their influential econometric analysis, Levine and Renelt (1992) find that the positive correlations between output growth and the investment rate, and between the investment rate and trade openness, are two of the only robust results in the empirical cross-country growth literature.⁷ Wacziarg (2001) and Wacziarg and Welch (2008) show empirically that capital accumulation is a crucial channel through which trade openness affects economic growth. Despite this empirical evidence, most attempts to quantify gains from trade have abstracted from capital accumulation.⁸ In the Solow (1956) growth model, an increase in aggregate TFP raises the marginal product of capital. A trade liberalization would induce capital accumulation if it increases aggregate TFP

⁷Levine and Renelt (1992) do not use data on the aggregate saving rate in their analysis.

⁸Notable exceptions include Alessandria and Choi (forthcoming, 2014) and Alessandria, Choi, and Ruhl (2014). Alessandria, Choi, and Ruhl (2014) calculate the welfare gains from a cut in tariffs in a model with rich trade adjustment dynamics, taking into account the transition period between steady states. They find larger gains from trade when accounting for the transition path than steady-state comparison of consumption. This study abstracts from trade adjustment dynamics and emphasizes the role of saving by entrepreneurs.

(Baldwin, 1992).⁹ My model incorporates this demand-side mechanism into the framework of Melitz (2003), which does not include capital as a factor of production. More importantly, this study emphasizes the capital response to a trade liberalization coming from the supply side, due to rising inequality. The emphasis on the supply-side channel is consistent with my empirical finding in the third and fourth chapters, that greater trade openness is strongly associated with a higher aggregate saving rate, but not as strongly associated with the investment rate.

The current study 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.¹⁰ Haskel, Lawrence, Leamer, and Slaughter (2012) argue that globalization contributes to inequality by increasing the income share of top income earners. The mechanism linking trade and top income inequality in my study is closely related to Rosen's (1981) theory of superstars. Other studies on the relationship between trade and the income share of superstars include Foellmi and Oechslin (2010) and Dinopoulos and Unel (2014). In an interesting quantitative exercise, Ma (2013) finds that increased globalization accounts for about 33 percent of the observed increase in the top 0.01% income share in the US over the last two decades. These previous studies are primarily concerned with explaining the observed patterns of inequality. By contrast, my study attempts to shed light on the welfare implications of this

⁹Relatedly, Eaton and Kortum (2001) argue that underdeveloped countries have a comparative disadvantage in producing capital goods, and that international trade facilitates capital accumulation in these countries by reducing the relative price of capital goods. The mechanism emphasized in the second chapter does not rely on patterns of comparative advantage.

¹⁰See Goldberg and Pavcnik (2007) and Harrison, McLaren, and McMillan (2011) for surveys of the literature. Goldberg and Pavcnik (2007) discuss how the literature on trade and inequality has been shaped by measurement issues.

increased inequality.

The literatures on the effects of trade on inequality and on the welfare gains from trade have heretofore evolved largely independently. There are many studies that use micro-data to examine the impact of a trade liberalization on different groups, for example by education level. While these studies arguably belong to both literatures, they do not emphasize the interaction between the effects of trade on the level of income and on the distribution of income. In the absence of any interaction between inequality and the gains from trade, one can take the headline results from both literatures, and assume a social welfare function to calculate the “the net welfare gains from trade,” taking rising inequality as a cost of trade.¹¹ This dissertation shows that there are non-trivial interactions between top income inequality and the gains from trade.¹² In contrast to the conventional view that rising inequality is a downside of free trade, I find that accounting for the increase in top income inequality implies higher gains from trade for the average worker.

Lastly, this study 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 the skill premium.¹³ Fairness con-

¹¹Dollar et al. (2014) use a number of social welfare functions to evaluate the relative importance of changes in average income and inequality changes, for changes to overall social welfare. They find that changes in average income dominated inequality changes in terms of the effects on social welfare for a large number of countries over the past 40 years.

¹²Other works, such as Itskhoki (2009), have studied the trade-off between equity and efficiency in international trade and the policy implications.

¹³Using data from the Luxembourg Income Study for a sample of 25 developed countries, Voitchovsky (2005) finds that inequality in the top end of income distribution is positively associated with income growth, while inequality at the bottom end of income distribution is negatively associated with income growth.

cerns and public policy implications are important motivations for the study of top income shares (Atkinson, Piketty, and Saez, 2011). Moreover, top income shares are crucial for aggregate welfare through their potential effects on social stability or political institutions (Acemoglu and Robinson, 2014; Piketty, 2014). Kumhof, Rancière, and Winant (2014) study the effects of increased top income shares on leverage and the probability of crises. In their model, the top earners have a higher saving rate because they have wealth-in-the-utility preferences (Carroll, 2000), while the saving-income relationship in my model is generated by income fluctuations and borrowing constraints. In contrast to Kumhof et al. (2014), who focus on the effects of an exogenous increase of the income share of the top 5% on the probability of crises, I show that increased concentration within the group of entrepreneurs (the top earners) can have important welfare implications for the group of workers (the bottom earners), even if the income shares of these two groups do not change.¹⁴ The focus on welfare implication on inequality *within* the high-income earners appears to be novel in the literature.

This study makes four substantive contributions to the literature. First, I propose a novel mechanism linking top income inequality and the gains from trade and demonstrate that it is quantitatively relevant for the gains from trade.¹⁵ Second, I help shed light on the welfare implications of top income inequality. I show that

¹⁴Empirically, both the income share of the top 5% and the concentration of income within the top 5% in the US have increased between 1961 and 2005.

¹⁵A number of studies have noted a similar theoretical link between overall inequality and capital accumulation in a closed-economy context (Bourguignon, 1981; Galor and Moav, 2004; Kaldor, 1967; Kuznets, 1955). Bertola, Foellmi, and Zweimüller (2006) provides a comprehensive review of related literature. The focus on top income inequality in this dissertation is motivated by the observation that wealth is extremely concentrated.

increased concentration at the top of income distribution can have positive welfare implications for the rest of the population.¹⁶ Third, I make an empirical contribution by documenting a strong and positive relationship between trade openness and the aggregate saving rate at the country level. Lastly, I provide empirical findings to support a thesis regarding the Chinese saving rate puzzle.

The second chapter presents the theoretical model and the results from the calibration exercise. The third chapter presents the empirical results from a large sample of countries. The fourth chapter presents the empirical results from the liberalization experience of China. The fifth chapter concludes.

¹⁶As a concrete example, the bottom 95% in terms of income can have positive welfare gains, if the income share of the top 0.1% increases at the expense of the rest of the top 5%.

Chapter 2: A Theory of International Trade and Top Income Inequality

In this chapter, I present a dynamic model of trade with incomplete markets and the results from a calibration exercise. One goal of this dissertation is to propose a novel mechanism and demonstrate its quantitative relevance. Towards this end, I compare the results from the full model with those from comparable benchmark models. To facilitate the comparison, I deliberately keep the full model simple. I examine the robustness of the model to alternative assumptions, and extensions of the full model, in Section 2.6.

2.1 Environment

2.1.1 Entrepreneurs

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

Entrepreneurs are risk averse and have the following utility function:

$$U(c) = E\left(\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\lambda}}{1-\lambda}\right), \quad (2.1)$$

where β is the discount factor, λ is the coefficient of relative risk aversion, and c_t is the final good (the numeraire). I use the concept of stationary equilibrium in the analysis. From the perspective of an entrepreneur, in a stationary equilibrium, the only stochastic element in the economy is the evolution of idiosyncratic productivity z . As a result, in a stationary equilibrium, the expectation in Equation (2.1) is taken with respect to z .

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

A crucial assumption is that these higher-income households face uninsurable income risk associated with the performance of firms. Clementi and Cooley (2010) show that executive compensation is closely tied to innovations in shareholder wealth. There is also substantial evidence that income risk associated with

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

2.1.2 Workers

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

In reality, there is a lot of heterogeneity 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 mechanism similar to that in this paper. However, wealth is very concentrated empirically. According to Saez and Zucman (2014), the top 10% households in terms of wealth accounted for 77.2% of total wealth in the US in 2012. Over the period 1986-2012, the average private saving rate for the bottom 90% in wealth is 0%, compared to 22% for top 10% in wealth (Saez and Zucman, 2014). In view of these empirical findings, I abstract from worker heterogeneity and savings by workers. With this setup, the welfare of a worker is simply his wage, which is the marginal product of labor. This allows me to illustrate the interaction between income inequality among entrepreneurs and workers' welfare.

2.1.3 The Final Good Sector

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

$$Y = \left(\int q(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad (2.2)$$

where $q(i)$ is the amount of differentiated good i and $\sigma > 1$ is the elasticity of substitution in production. Taking the output price P and input prices $p(i)$ as

given, the final good producer maximizes profit according to

$$\max_{q(i)} \left\{ P \left(\int q(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} - \int p(i)q(i)di \right\}. \quad (2.3)$$

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

$$p(i) = E^{\frac{1}{\sigma}} P^{1-\frac{1}{\sigma}} q(i)^{-\frac{1}{\sigma}} \quad (2.4)$$

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

2.1.4 Production of Differentiated Goods and International Trade

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

$$q(i) = z(i)k(i)^{\alpha}l(i)^{1-\alpha}, \quad (2.5)$$

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

Only differentiated goods are tradable between the two countries. In order to export, firms incur a per-period fixed cost of f_X in units of labor.¹ 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 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 Section 2.6.1, I show that my results are robust to allowing for a sunk cost of exporting.

2.1.5 Capital Rental Market

Capital is immobile across countries.² Capital depreciates at rate δ . The capital rental market is perfectly competitive. For each unit of intermediated capital, a financial intermediary receives R in rental payment from entrepreneurs, pays out r as interest payment to depositors, and spends δ to replace the depreciated capital. Financial intermediaries are collectively owned by the entrepreneur population.

I assume that entrepreneurs cannot have negative wealth ($a \geq 0$). The no-

¹A 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 channel.

²With the assumption of symmetric countries, allowing capital mobility across countries does not affect any of the results presented in this chapter.

borrowing constraint ($a \geq 0$) and uninsurable idiosyncratic risk imply that entrepreneurs engage in precautionary saving. In Section 2.6.2, I examine the implications of relaxing the no-borrowing constraint. Entrepreneurs can rent any amount of capital within each period. That is, the rental of capital for production is not subject to financial frictions.³ Consequently, conditional on productivity, the demand for capital by a firm is not a function of entrepreneurial wealth a . Export status, factor inputs, sales and profits of firms can be written as functions of productivity z alone. In Section 2.6.3, I show that the results are robust to an alternative setting where the demand for capital by entrepreneurs is constrained by their wealth.

2.1.6 Dynamic Budget Constraint

The dynamic budget constraint of an entrepreneur is given by

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

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

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

³There is a large literature on the interactions between financial frictions and international trade. See for example Manova (2013).

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.

2.1.7 Timing of the Model

The timing of the model is given below.

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

2.1.8 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:

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

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

$$\bar{z}_X = \tau \cdot \left(\frac{w \cdot f_X}{\Phi \cdot E^*} \right)^{\frac{1}{\sigma-1}} R^\alpha w^{1-\alpha}, \quad (2.6)$$

where $\Phi = \left(\alpha^\alpha(1-\alpha)^{(1-\alpha)}\right)^{\sigma-1} \sigma^{-\sigma}(\sigma-1)^{(\sigma-1)}$. Equation (2.6) indicates that the export productivity cutoff is increasing in the fixed cost of exporting and factor prices, and is decreasing in foreign market size (E^*). Only entrepreneurs with $z \geq \bar{z}_X$ become exporters.

2.1.9 Definition of a Stationary Competitive Equilibrium

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

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

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

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

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

$$\int_z \int_a c(a, z) G(da, dz) + w + \delta \cdot K = Y \quad (2.7)$$

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

$$G(a, z) = \gamma \int_{\bar{z} \leq z} \int_{a'(\bar{a}, \bar{z}) \leq a} G(d\bar{a}, d\bar{z}) + (1 - \gamma) \mu(z) \int_{\bar{z}} \int_{a'(\bar{a}, \bar{z}) \leq a} G(d\bar{a}, d\bar{z}) \quad (2.8)$$

for all (a, z) . Equation (2.8) states that for any point (a, z) , the CDF at this point (LHS) should be equal to the CDF at the same point next period (RHS). Consider a point (\bar{a}, \bar{z}) . The CDF at (\bar{a}, \bar{z}) this period is given by $G(\bar{a}, \bar{z})$. The CDF in the following period consists of two components. For the γ fraction in the population whose entrepreneur productivity z remains unchanged, I integrate over the entrepreneurs with $z \leq \bar{z}$ whose policy functions place them

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

2.2 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 2A. Table 2.1 summarizes the parameter choices and target moments in the calibration exercise.

Following Buera and Shin (2013), I set the coefficient of relative risk aversion λ at 1.5, the share of capital in production α at 0.333, and the one-year depreciation rate of capital δ at 0.06. I set the elasticity of substitution σ at 5.0, which is close to the estimates by Simonovska and Waugh (2014). The implied markup for differentiated goods is 25%.

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

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

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 of entrepreneur in the model. Empirically, income follows a Pareto distribution with a tail parameter of around 1.7 for the US over 1991-2000 (Alvaredo et al., 2011). I set the tail index of the firm sales distribution to $\zeta = 1.5$. The implied shape parameter η for productivity is $\eta = \zeta \times (\sigma - 1) = 6.0$. 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.⁴ 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, Jensen, Redding, and Schott, 2007). To match this ratio, I set the variable trade cost τ to 1.57. I choose $f_X = 0.090$ to match the import penetration ratio of 7.0% for the US in 2000.

In the counter-factual experiment, I increase the variable trade cost to infinity

⁴In the following description, it is understood that the moments are affected by the parameters jointly, but some moments may be more sensitive to changes in certain parameters.

Table 2.1: Calibration

Panel A: Parameters Taken from Prior Literature					
Parameter	Symbol	Full Model		CM Benchmark	
		Value	Value	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					
Target Moment	US Data	Full Model		CM Benchmark	
		Parameter	Model	Parameter	Model
Interest Rate	3.0%	$\beta = 0.952$	3.0%	$\beta = 0.971$	3.0%
Import Penetration Ratio	7.0%	$f_{EX} = 0.09$	7.0%	$f_{EX} = 0.09$	7.0%
Export to Sales Ratio	14.0%	$\tau = 1.57$	14.0%	$\tau = 1.57$	14.0%

“Full Model” refers to the model described in Section 2.1; “CM Benchmark” refers to the complete markets benchmark described in Section 2.2.1

to shut down international trade. This allows us to infer the realized gains from trade in the US. I refer to the economy matching the observed level of trade as “Trade” and the counter-factual economy as “Autarky”.

2.2.1 Complete Markets Benchmark (CM Benchmark)

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

decisions independently. This 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 $\mu(z)$. The representative entrepreneur maximizes

$$\max_{c_t, a_t} \sum_{t=0}^{\infty} \beta^t u(c_t) \quad (2.9)$$

where $u'(\cdot) > 0$ and $u''(\cdot) < 0$,⁵ subject to the dynamic budget constraint

$$c_t + a_{t+1} = \int \max\{\pi^D(z), \pi^X(z)\} \mu(dz) + (1+r)a_t \quad (2.10)$$

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

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

⁵Note 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.

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

1. The policy functions maximize the utility of the representative entrepreneur.
2. Each firm maximizes profit each period.
3. Workers optimally choose to consume their wage each period.
4. All markets clear.
5. Trade balances.

To solve the model, I obtain the first-order conditions for the maximization problem given by Equations (2.9) and (2.10). I obtain the stationary equilibrium by imposing $c_t = \bar{c}$ and $a_t = \bar{a}$ for any t . It is straightforward to show that $r = \frac{1}{\beta} - 1$ in any stationary equilibrium. This contrasts with the full model in which the equilibrium interest rate is affected by a myriad of parameters, including the probability of expiration of ideas γ , capital share α , discount factor β and coefficient of relative risk aversion λ .

It is instructive to consider the static problem of finding the equilibrium wage to clear markets, taking the interest rate as exogenous. For a given equilibrium interest rate and a given set of parameter values on the production side, the optimization problem faced by firms in the benchmark model is the same as in the full model.⁶ By choosing a different value of β for the benchmark model so that

⁶The parameters on the production side are α , δ , σ , ζ , f_X and τ .

the equilibrium interest rate is identical across the two models, the labor market in the benchmark model can be cleared using the equilibrium wage from the full model. I target an equilibrium interest rate of 3.00% for the full model. To have the same interest rate in the CM benchmark, I simply set $\beta = \frac{1}{1+0.0300} = 0.971$. This procedure produces an identical equilibrium wage and target moments across the two models. This feature of the calibration allows for an appropriate comparison across the two models.

To summarize, I construct the CM benchmark by assuming that all firms in a country are owned by one representative entrepreneur. Each firm makes exporting and input decisions independently to maximize income. The rest of the CM benchmark is essentially identical to the full model. The same set of parameter values, other than the value of β , can be used to calibrate both models to the US data.⁷ The details on the calibration of the CM benchmark are presented in Table 2.1.

2.3 Results

2.3.1 The Impact of International Trade on Inequality

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

⁷As noted earlier, the exact functional form of static utility does not matter for stationary equilibrium in the CM benchmark. The absence of sunk costs implies that the parameter γ , which governs the persistence of firm productivity, does not matter in the CM benchmark.

2.3.1.1 Analytical Results

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

Proof: See Appendix 2B.

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

$$\frac{\int_{z_x}^{\infty} \left(\frac{z}{z_{min}}\right)^{\sigma-1} \pi^D(z_{min}) \mu(dz)}{\int_{z_{min}}^{\infty} \left(\frac{z}{z_{min}}\right)^{\sigma-1} \pi^D(z_{min}) \mu(dz)} = \frac{\int_{z_x}^{\infty} z^{\sigma-1} \mu(dz)}{\int_{z_{min}}^{\infty} z^{\sigma-1} \mu(dz)} \quad (2.11)$$

where $\pi^D(\cdot)$ is defined earlier and z_{min} is the minimum possible z (normalized to 1 in the calibration). This ratio is preserved if we consider profits from domestic sales alone in an economy with trade. Given the fixed cost of exporting, if there are any exporters in the economy, they must first come from the top $x\%$. When moving to trade, there is an additional term involving profits from export sales added to both the denominator and the numerator of Equation (2.11). The proof in Appendix 2B demonstrates that the numerator in Equation (2.11) necessarily increases proportionally more than the denominator when a country opens up to trade. A corollary of Proposition 1 is that the Gini coefficient of profits among entrepreneurs is minimized at Autarky.

It is important to emphasize that Proposition 1 considers only the distribution of profit income among entrepreneurs. The distribution of interest income is deter-

mined by dynamic factors such as the persistence of profit income and risk aversion, so it is difficult to examine analytically.

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

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

Proof: See Appendix 2B.

With constant mark-up and Cobb-Douglas production, total *variable* profit, total cost of capital rental and total cost of *variable* labor input are fixed in proportion across all firms, regardless of the level of trade cost. However, as more firms start to export, more labor is used to cover the fixed cost of exporting. As a result, total labor income increases relative to total entrepreneurial income. Also, since the markup of price over marginal cost is constant, the percentage markup of price over average cost is lower at exporting firms, as a result of the fixed cost of exporting. Therefore, compared to Autarky, total profit (net of the fixed cost of exporting) as a share of total sales is lower in an economy with any positive level of trade ($\tau < \infty$). Therefore, in moving from Autarky ($\tau = \infty$) to any positive level of trade ($\tau < \infty$), the share of total income received by the workers increases.

2.3.1.2 Numerical Results

Section 2.3.1.1 presents some analytical results concerning the effects of trade on income inequality. However, Proposition 1 does not consider the distribution of interest income. Since the distribution of interest income is a function of the equilibrium wealth distribution, it is difficult to provide analytical results concerning the effect of trade on the distribution of overall entrepreneurial income. I turn to numerical results.

Table 2.2: The Effect of Trade on Inequality

Panel A. Income Inequality among Entrepreneurs		
	Autarky	Trade
Share of Total Entrepreneurial Income		
Top 1%	18.8%	20.1%
Top 2-5%	18.6%	19.4%
Top 5-20%	23.0%	22.7%
Top 20-50%	21.8%	20.9%
Bottom 50%	17.9%	17.0%
Gini Coefficient	0.538	0.558
Panel B. Income Distribution Between Workers and Entrepreneurs		
	Autarky	Trade
Workers Share of Total Income	64.7%	65.4%

“Autarky” refers to the economy when the variable cost of trade is set to infinity;

“Trade” refers to the economy calibrated to match the observed level of trade in the US.

As shown in Panel A of Table 2.2, international trade increases the share of overall entrepreneurial income received by the most productive entrepreneurs. Moving from Autarky to Trade, the share of overall entrepreneurial income received

by the top 1% increases from 18.8% to 20.1%, while the share received by the top 5% (including the top 1%) increases from 37.4% to 39.5%. On the other hand, the share of overall entrepreneurial income received by the bottom 50% decreases from 17.9% to 17.0%. 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 2.2, are modest. Total income of an entrepreneur is the sum of profit income π and interest income $a \cdot r$, which are positively correlated in the model. Moving from Autarky to Trade, the interest rate r decreases from 3.15% to 3.00%. 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 2.3.3, I show that this modest increase in top income inequality can nevertheless have large welfare implications for the workers.

Panel B of Table 2.2 presents the results on the distribution of income between the entrepreneurs and the workers. Moving from Autarky to Trade, the share of total income received by workers increases from 64.7% to 65.4%. This is consistent with Proposition 2. However, the central mechanism of this chapter linking inequality to saving is driven by income inequality among entrepreneurs, rather than by inequality between workers and entrepreneurs. In fact, an increase in the workers' share works against the proposed mechanism, since workers do not save at all in the model.

2.3.2 The Impact of Trade on Aggregate Output

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

$$Y = \text{TFP} \cdot K^\alpha \quad (2.12)$$

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

$$\text{TFP} = L_v^{1-\alpha} \left(\int_{e(z)=0} z^{\sigma-1} \mu(dz) + (1 + \tau^{1-\sigma}) \int_{e(z)=1} z^{\sigma-1} \mu(dz) \right)^{\frac{1}{\sigma-1}}, \quad (2.13)$$

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 (2.12), we have

$$\frac{\Delta Y}{Y} \approx \frac{\Delta \text{TFP}}{\text{TFP}} + \alpha \frac{\Delta K}{K}. \quad (2.14)$$

Equation (2.14) shows that the change in aggregate output can be decomposed

into contributions from the increase in aggregate TFP and from the increase in the capital stock. The percentage contributions from the increase in TFP and from capital accumulation are given by $(\frac{\Delta TFP}{TFP}/\frac{\Delta Y}{Y})$ and $(\alpha \cdot \frac{\Delta K}{K}/\frac{\Delta Y}{Y})$, respectively.

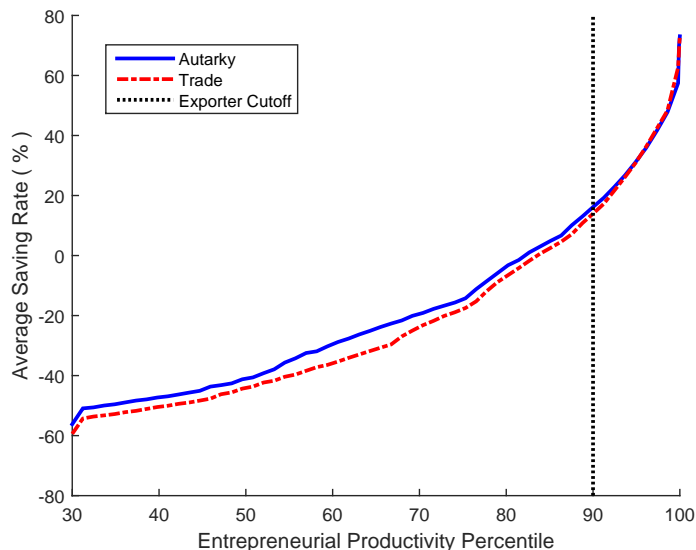
Table 2.3: The Impact of Trade on Aggregate Output

	Change in Aggregate Output		Decomposition	
	(1)	(2)	(3)	(4)
Model	Full Model	CM Benchmark	Full Model	CM Benchmark
TFP	1.2%	1.2%	48.1%	66.7%
Capital	3.9%	1.8%	51.9%	33.3%
Output	2.5%	1.8%	100.0%	100.0%

“Full Model” refers to the model described in Section 2.1; “CM Benchmark” refers to the complete markets benchmark described in Section 2.2.1.

Columns (1) and (2) of Table 2.3 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 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 2.3 present the decomposition of the output gains from trade for both models. Capital accumulation plays a more important role in the full model than in the CM benchmark. Increased capital accumulation accounts for 51.9% of the output gains from trade in the full model, compared to 33.3% in the CM benchmark. It is also important to

Figure 2.1: Average Saving Rate And Entrepreneur Productivity z



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

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 3.9% increase in the capital stock as we move from Autarky to Trade. The capital stock increases through two channels. First, the reduction in variable trade costs increases the demand for capital, as exporters expand their production to serve foreign markets. This is analogous to the increase in the demand for labor in Melitz (2003).

Second, the reduction in trade costs increases the supply of capital. Figure 2.1 shows that the average saving rate of entrepreneurs in the full model is strongly increasing in entrepreneurial productivity z .^{8,9} 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.¹⁰ 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 3.00% 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 3.00%. The capital stock increases by 1.8%, substantially less than the 3.4% increase in the full model. This confirms the quantitative importance of the supply-side channel emphasized in this chapter.

In principle, there are two mechanisms by which moving from Autarky to Trade can affect aggregate saving. First, moving to trade increases the income share of the

⁸I define an entrepreneur's saving rate as $\frac{a' - a}{y}$, where $y = \pi + a \cdot r$ is the entrepreneur's overall income. The average saving rate for a given z is calculated as the total saving of entrepreneurs (sum of $(a' - a)$) with a given z (but different a), divided by their total income.

⁹Dynan, Skinner, and Zeldes (2004) document a steep positive relationship between the saving rate and income. They find some evidence that the relationship is in part driven by uncertainty with respect to income, as is the case in this chapter. Carroll (2000) argues that the saving behavior of the rich is best explained by a model in which wealth enters the utility function of individuals directly. In his model, individuals regard accumulation of wealth as an end in itself. I conjecture that the supply-side channel of capital accumulation would remain if I instead used the approach of Carroll (2000) to generate a positive relationship between the saving rate and income.

¹⁰The 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.

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.¹¹ 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. Appendix 2C provides details of the experiments above, as part of a decomposition exercise on the change in the aggregate saving rate.¹²

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

¹¹It 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) .

¹²In a stationary equilibrium, the aggregate saving rate of entrepreneurs is 0. A crucial point is that capital depreciation takes place inside financial intermediaries in this model, and entrepreneurs earn only the net return of saving. This is proven in Appendix 2C. 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*.

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 Appendix 2C.

2.3.3 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 2.3.1, international trade affects the distribution of income among entrepreneurs, as well as the distribution of income between workers and entrepreneurs. It is important to examine the effects of trade on the welfare of workers and of entrepreneurs separately.¹³

In both models, workers face no income risk and simply consume their wage each period. A natural measure of workers' welfare is the equilibrium wage. In contrast to workers, entrepreneurs are heterogeneous and face idiosyncratic income risk. I measure the welfare of entrepreneurs in two ways. The first measure of entrepreneur welfare is simply the aggregate consumption of all entrepreneurs. The second measure of welfare is the certainty-equivalent consumption of a typical entrepreneur. Since there is no consumption heterogeneity in the CM benchmark, certainty-equivalent consumption is the same as aggregate consumption. For the

¹³To consider aggregate welfare, I would need to take a stand on the relative weights of entrepreneurs and workers in the social welfare function. I do not pursue this approach.

full model, certainty-equivalent consumption is calculated in two steps. First, I calculate the average utility of entrepreneurs in a stationary equilibrium.¹⁴ 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 2.4: Welfare Gains from Trade

Model	Full Model	CM Benchmark
Consumption of Workers		
Wage	3.4%	2.7%
Entrepreneurial Consumption		
Aggregate	0.0%	0.0%
Certainty-Equivalent	-4.0%	-

“Full Model” refers to the model described in Section 2.1; “CM Benchmark” refers to the complete markets benchmark described in Section 2.2.1.

Table 2.4 presents the effects of international trade on welfare. Consider the results from the full model. The increase in the wage is 3.4%. Interestingly, aggregate entrepreneurial consumption is unchanged by international trade. The change in aggregate consumption for entrepreneurs is zero by numerical rounding and would change under different levels of openness.¹⁵ There is a 4.0% decrease of certainty-

¹⁴Stationary equilibrium implies that I only have to look at a single period.

¹⁵If I keep more decimal places, the increase in aggregate entrepreneurial consumption is 0.003%

equivalent consumption for entrepreneurs. Intuitively, the distribution of consumption among entrepreneurs becomes more dispersed when moving from Autarky to Trade.

The differences between the two models in the responses of output and the capital stock translate into differences in welfare gains for workers. In the CM benchmark, the increase in the wage is only 2.7%, lower than that in the full model. Therefore, the novel mechanism in my model increases the wage gains for workers by 25.9%, compared to the complete markets benchmark. As in the full model, aggregate entrepreneur consumption in the CM benchmark is unchanged from international trade.

2.3.4 The Role of Risk Aversion

The saving behavior of entrepreneurs plays a very important role in the full model. A critical parameter governing saving behavior is λ , the coefficient of relative risk aversion. In the calibration of the full model, I set λ at 1.5. To understand the role of λ in the model, I vary the value of λ . Since a larger value of λ drives down the equilibrium interest rate, to maintain an equilibrium interest rate of 3.0%, I pick a different value of the discount factor β for each value of λ . In other words, I use different combinations of λ and β to obtain the same target interest rate of 3.0% while maintaining all other parameter values as given in Table 2.1. First, I set λ to 1.0, which corresponds to the log utility function. To match the target interest rate, I set β to 0.959. I then set λ to 2.0. To match the target interest rate, I set β and 0.038% under the full model and CM benchmark respectively.

at 0.945.

The gains from trade implied by different values of λ and β for the full model are presented in Table 2.5. The baseline results implied by $\lambda = 1.5$, $\beta = 0.952$ are reproduced in Column (2) for easy comparison. The impact of trade on aggregate TFP and aggregate entrepreneurial consumption are identical across the different combinations of λ and β .

Column (1) presents gains from trade assuming less risk aversion ($\lambda = 1.0$, $\beta = 0.959$). The percentage increase in the capital stock due to trade is now smaller at 3.3%. The smaller increase in capital stock translates into smaller output gains from trade (2.3%) and smaller wage gains for workers (3.3%). However, certainty-equivalent entrepreneurial consumption decreases by only 3.3% instead of 4.0%, as lower risk aversion implies that entrepreneurs do not suffer as large a loss in expected utility due to increased income dispersion under trade.

Column (3) of Table 2.5 presents the results when I assume more risk aversion ($\lambda = 2.0$, $\beta = 0.945$). The percentage increase in the capital stock due to trade is now higher, at 4.7%. The output gains from trade and wage gains are also higher, while certainty-equivalent entrepreneurial consumption decreases by a larger percentage (4.4%) than in the baseline calibration.

As in Section 2.3.2, I conduct two experiments to analyze the change in the aggregate saving rate of entrepreneurs. First, I fix the average saving rate of each z group at Autarky and change the income shares of each group to the income shares under Trade. This results in an increase of 1.68, 1.72, and 1.80 percentage points in the aggregate saving rate among entrepreneurs, for $\lambda = 1.0, 1.5$, and 2.0,

Table 2.5: The Role of Coefficient of Relative Risk Aversion λ in the Full Model

	(1)	(2)	(3)
	Parameter Values		
λ	1.00	1.50	2.00
β	0.959	0.952	0.945
	Percentage Change in Aggregate Output		
TFP	1.2%	1.2%	1.2%
Capital	3.3%	3.9%	4.7%
Output	2.3%	2.5%	2.8%
	Consumption of Workers		
Wage	3.3%	3.4%	3.7%
	Entrepreneurial Consumption		
Aggregate	0.0%	0.0%	0.0%
Certainty-Equivalent	-3.3%	-4.0%	-4.4%

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

respectively. Second, I fix the income shares of each z group under Autarky and change the average saving rate of each group to the saving rate under Trade. This results in a decrease of 1.79, 1.83 and 1.93 percentage points in the aggregate saving rate for $\lambda = 1.0, 1.5,$ and 2.0 , respectively. This confirms the finding above that the change in income shares among entrepreneurs is behind the large increase in the supply of capital. The value of λ affects the magnitude of the increase in the supply of capital, by changing the slope of the saving-income relationship.

Overall, Table 2.5 shows that the degree of risk aversion matters for our evaluation of the realized gains from trade, through its effects on capital accumulation. A larger value of λ corresponds to a larger increase in the capital stock and a

greater increase in output, but at the cost of greater welfare loss for entrepreneurs. The intuition is that a higher λ implies a steeper saving-income relationship for entrepreneurs.

2.4 The Role of Capital

Section 2.3 demonstrates the implications of entrepreneurial income inequality for gains from trade by contrasting the full model with the CM benchmark. The mechanism linking entrepreneurial income inequality and gains from trade is capital accumulation. In this section, I further investigate this point by repeating the quantitative exercise in two models without capital.

I modify the full model by assuming labor is the only factor of production. I refer to the resulting model as the “NoK” model. Similarly, I modify the CM benchmark and I refer to the resulting model as the “NoK CM” model. I then compare the gains from trade under these two modified models. In the absence of capital, heterogeneity in entrepreneurial income affects the size of welfare gains for entrepreneurs, but it does not affect the size of output gains or welfare gains for workers. Therefore, the interaction of capital and the heterogeneity in entrepreneurial income explains the sizable differences between the full model and the CM benchmark reported in Table 2.3 and Table 2.4.

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

$$q(i) = z(i)l, \tag{2.15}$$

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

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

2.4.1 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

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

The profit functions $\pi^j(z)$, $j = D, X$, are defined as

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

and

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

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

A stationary competitive equilibrium with international trade is defined as an invariant distribution $G(\cdot)$ 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.

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

(b) Trade balances.

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

(c) The final good market clears.

$$\int_z \int_a c(a, z) G(da, dz) + w = Y$$

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

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

for all (a, z) .

2.4.2 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

$$\max_{c_t, a_t} \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{2.16}$$

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

$$c_t + a_{t+1} = \int \max\{\pi^D(z), \pi^X(z)\} \mu(dz) + a_t \quad (2.17)$$

where $\pi^D(z)$ and $\pi^X(z)$ are the profit functions of a domestic firm and an exporting firm respectively.

I use the same strategy as in Section 2.2 to calibrate both the NoK model and the NoK CM model. Table 2.6 provides the details. The number of parameters is reduced to six in the NoK model. The parameter values are identical to those in Table 2.1, 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.

Results

Table 2.7 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.

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

$$1 - \lambda_{ii}^{-\frac{1}{\varepsilon}} \quad (2.18)$$

Table 2.6: Calibration of Models without Capital

Panel A: Parameters Taken from Prior Literature					
Parameter	Symbol	NoK Model		NoK CM Model	
		Value	Value	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 Firm Sales Distribution	ζ	1.500		1.500	
Panel B: Parameters Calibrated to Match Data Moments					
Target Moment	US Data	NoK Model		NoK CM Model	
		Parameter	Model	Parameter	Model
Import Penetration Ratio	7.0%	$f_{EX} = 0.060$	7.0%	$f_{EX} = 0.060$	7.0%
Export to Sales Ratio	14.0%	$\tau = 1.57$	14.0%	$\tau = 1.57$	14.0%

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.

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 (2.18) yields an output gain from trade of 1.2%. This is the same as the output gain of 1.2% 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 2.7. 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

Table 2.7: Gains From Trade in Models without Capital

	(1)	(2)	(3)	(4)
Model	NoK	NoK CM	Full	CM
TFP	1.2%	1.2%	1.2%	1.2%
Capital	-	-	3.9%	1.8%
Output	1.2%	1.2%	2.5%	1.8%
Consumption of Workers				
Wage	1.8%	1.8%	3.4%	2.7%
Entrepreneurial Consumption				
Aggregate	-1.3%	-1.3%	0.0%	0.0%
Certainty-Equivalent	-4.6%	-	-4.0%	-

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. The “Gains from Trade” numbers are the percentage differences in the relevant measure between “Autarky” and “Trade,” where “Autarky” refers to the economy in stationary equilibrium when variable cost of trade is set to infinity and “Trade” refers to the economy in stationary equilibrium.

gains, wage gains for workers, and aggregate entrepreneurial consumption gains are all lower in the NoK CM benchmark than the corresponding numbers in the CM benchmark.

Table 2.8 summarizes the effects of trade on income inequality among entrepreneurs in the NoK model. The results are similar to those from the full model. Importantly, trade increases income inequality among entrepreneurs. To see the effects of entrepreneurial income inequality in models without capital, I compare

Table 2.8: Income Inequality in a Model without Capital (NoK)

Panel A. Inequality within the Entrepreneur Sector		
Share of total entrepreneurial income		
	Autarky	Trade
Top 1%	20.2%	22.1%
Top 2-5%	16.6%	17.4%
Top 5-20%	21.7%	20.9%
Top 20-50%	20.9%	19.9%
Bottom 50%	20.6%	19.7%
Gini Coefficient	0.498	0.521
Panel B. Inequality between Entrepreneurs and Workers		
	Autarky	Trade
Workers Share of Total	80.0%	80.5%

“Autarky” refers to the economy in stationary equilibrium when variable cost of trade is set to infinity; “Trade” refers to the economy in stationary equilibrium calibrated to the observed level of trade in the US

Column (1) and Column (2) of Table 2.7. 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).

2.5 Models with Occupational Choice

In the full model, I assume no entry or exit into entrepreneurship. This allows me to examine the welfare implications of international trade for workers and

entrepreneurs separately. In particular, the setup enables me to isolate the welfare implications of top income inequality for workers. On the other hand, the exit of the least productive firms resulting from greater trade openness is another important source of TFP gains in the standard Melitz (2003) model. In this section, I describe a version of the model with occupational choice as well as its associated complete markets benchmark.

The Occupation Model

There are two symmetric countries. In each country, there is a unit measure of infinitely-lived individuals, who are heterogeneous in their wealth a . Each individual is endowed with one unit of productive labor, which is differentiated by the quality of entrepreneurial idea z . Individuals have the following utility function:

$$U(c) = E\left(\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\lambda}}{1-\lambda}\right), \quad (2.19)$$

In each period, individuals choose to work for a wage w , or work as a producer of differentiated goods. Individuals have to pay a fixed cost f_D , in terms of labor, to operate a firm each period. An individual with an entrepreneurial idea of quality $z(i)$ can produce a variety i of differentiated goods according to

$$q(i) = z(i)k^\alpha l^{1-\alpha}. \quad (2.20)$$

The quality of an entrepreneurial idea z is drawn from a time-invariant cumulative

distribution function (CDF) $\mu(z)$. Entrepreneurial ideas expire with a probability of $(1 - \gamma)$ in each period. In the case of expiration of ideas, a new value of z is drawn from the CDF $\mu(z)$. I denote an individual's occupational choice as $o \in \{W, D, X\}$, where W , D and X correspond to workers, domestic producers and exporters, respectively. The specification of the final good market, the differentiated goods market, international trade, and the capital rental market are the same as in the full model.

A stationary competitive equilibrium with international trade is similar to the definition in Section 2.1.9, with the key modifications described below.

1. Given aggregate variables w, R, r, P, E , and the corresponding variables in the foreign country, individual policy functions, $c(a, z)$, $a'(a, z)$, $o(z)$, $l(z)$, $k(z)$, $q^D(z)$ and $q^X(z)$, solve an individual's optimization problem. The additional policy function $o(z) \in \{W, D, X\}$ is the occupational choice function of an individual, which is characterized by

$$\max\{w, \pi^D(z), \pi^X(z)\}.$$

2. The labor market clears.

$$\begin{aligned} \int_{o(z)=W} \int_a G(da, dz) &= \int_z \int_a l(z) G(da, dz) \\ + \int_{o(z) \in \{D, X\}} \int_a G(da, dz) \cdot f_D &+ \int_{o(z)=X} \int_a G(da, dz) \cdot f_X \end{aligned}$$

The integral on the left hand side is taken over all workers $\{(a, z) \mid o(z) = W\}$,

and gives the total labor supply. The first integral on the right-hand side is taken with respect to the entire population while the next two integrals gives total labor used as fixed costs of operation and fixed costs of exporting, respectively. Note that $l(z) = 0$ if $o(z) = W$, since workers have zero demand for labor.

3. The market for the final good clears.

$$\int_z \int_a c(a, z) G(da, dz) + \delta \cdot K = Y$$

The first integral on the left-hand side is taken with respect to the whole population. This term is the total consumption in the economy. The other terms on the left-hand side give the total depreciation of capital, the total fixed cost of operation and the total fixed cost of exporting, respectively. Finally, Y is the total output of the final good.

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

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

For any point (a, z) , the CDF at this point (LHS) should be equal to the CDF at the same point next period (RHS).

The Occupation CM Model

There is one representative agent in each country. The representative agent of a country owns a unit measure of productive labor. As in the benchmark model, productive labor is differentiated by the quality of the entrepreneurial idea z , which is drawn from the CDF $\mu(z)$. The representative agent maximizes

$$\max_{c_t, a_t} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\lambda}}{1-\lambda}, \quad (2.21)$$

subject to the dynamic budget constraint

$$c_t + a_{t+1} = \int \max\{w, \pi^D(z), \pi^X(z)\} d\mu(z) + (1+r)a_t. \quad (2.22)$$

The final good sector, the differentiated goods sector and the capital rental market are the same as before. Each unit of productive labor makes production decisions independently to maximize income. A stationary competitive equilibrium with international trade is defined accordingly.

I calibrate the Occupation and the Occupation CM models following a strategy similar to that in Section 2.2. The additional parameter to be calibrated is f_D , the fixed cost of operating a firm. I target this parameter to match the share of entrepreneurs in the population. According to the 2004 data from the Bureau of Labor Statistics, the total number of firms with payroll in the US is 5.9 million while total non-farm payroll employment is 132 million. I take the ratio of these

two numbers (4.5%) as the targeted share of entrepreneurs in the population. Table 2.9 provides the details on the calibration of other parameters.

Table 2.9: Calibration of Models with Occupational Choice

Panel A: Parameters Taken from Prior Literature					
Parameter	Symbol	“Occupation”		“Occupation CM”	
		Value	Value	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					
Target Moment	US Data	“Occupation”		“Occupation CM”	
		Parameter	Model	Parameter	Model
Interest Rate	3.0%	$\beta = 0.952$	3.0%	$\beta = 0.971$	3.0%
Export/GDP Ratio	7.0%	$f_{EX} = 1.700$	7.0%	$f_{EX} = 1.700$	7.0%
Export to Sales Ratio	14.0%	$\tau = 1.57$	14.0%	$\tau = 1.57$	14.0%
Percentage of Entrepreneurs in Population	4.5%	$f_D = 1.250$	4.5%	$f_D = 1.250$	4.5%

“Occupation” refers to a model with occupational choice while “Occupation CM” refers to its associated complete markets benchmark.

Table 2.10 summarizes the gains from trade from both the Occupation and Occupation CM models. Moving from Autarky to Trade, the TFP increase in the Occupation model (1.2%) is slightly larger than in the Occupation CM model (1.0%). In the Occupation model, the change in the equilibrium interest rate affects the occupational choice of individuals by affecting the cost of capital and the profitability of operating a firm. As in Section 2.3.3, the increase in capital stock is much larger

Table 2.10: Gains from Trade in Models with Occupational Choice

	“Occupation”	“Occupation CM”
The Effect of Trade on Aggregate Output		
TFP	1.2%	1.0%
Capital	3.9%	1.5%
Output	2.5%	1.5%
The Effect of Trade on Consumption and Welfare		
Wage	2.5%	1.4%
Welfare	1.8%	1.4%
Workers Consumption	2.7%	-
Entrepreneurial Consumption	-1.8%	-

The “Gains from Trade” numbers are the percentage differences in the relevant measure between “Autarky” and “Trade”, where “Autarky” refers to the economy in stationary equilibrium when the variable cost of trade is set to infinity and “Trade” refers to the economy in stationary equilibrium calibrated to the observed level of trade in the US.

in the Occupation model (3.9%) than in the Occupation CM model (1.5%). The difference in capital accumulation again contributes to differences in gains from trade in terms of output, wages and welfare, where the welfare measure is the certainty-equivalent consumption of a randomly-chosen individual in the economy. Lastly, moving from Autarky to Trade in the Occupation model, the total consumption by workers each period increases by 2.7% while the total consumption by entrepreneurs decreases by 1.8%. I do not provide these numbers for the Occupation CM model because incomes from all units of productive labor are pooled together in that model.

Therefore, the results in Table 2.3 and Table 2.4 in Section 2.3 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.

2.6 Robustness and Extensions

In this section, I examine the robustness of the baseline 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.

2.6.1 Sunk Cost

I first examine an alternative assumption on the fixed cost of exporting. In addition to the per-period fixed cost of exporting f_X , I assume that firms which did not export the previous period have to pay a sunk cost of exporting of f_{sunk} units of labor. As a result, the previous export status of the firm is a state variable. Table 2.11 provides the details of the calibration. For simplicity, I set $f_{sunk} = 4 \cdot f_X$ in the calibration. The results are reported in Column (1) in Table 2.12. The results can be compared to Columns (4) and (5), which reproduce results from the full model and from the CM benchmark, respectively. A comparison of Columns (1) and (4) indicates that the quantitative results are broadly robust to the alternative specification of the fixed cost of exporting.

Table 2.11: Calibration: Extensions and Robustness

Panel A: Parameters Taken from Prior Literature						
Model		(1)	(2)	(3)	(5)	(6)
Parameter	Symbol	Sunk Value	NBL Value	K-Friction Value	Full Value	CM Value
Coefficient of Risk Aversion	λ	1.500	1.500	1.500	1.500	1.500
Share of Capital in Production	α	0.333	0.333	0.333	0.333	0.333
Capital Depreciation Rate	δ	0.060	0.060	0.060	0.060	0.060
Elasticity of Substitution	σ	5.000	5.000	5.000	5.000	5.000
Persistence of Firm Productivity	γ	0.814	0.814	0.814	0.814	0.814
Shape Parameter of Sales Distribution	ζ	1.500	1.500	1.500	1.500	1.500
Panel B: Parameter Calibrated to the Model						
Target Moment	Data	Sunk Parameter	NBL Parameter	K-Friction Parameter	Full Model Parameter	CM Parameter
Interest Rate	3.0%	$\beta = 0.952$	$\beta = 0.892$	$\beta = 0.952^a$	$\beta = 0.952$	$\beta = 0.971$
Import Penetration Ratio	7.0%	$f_{EX} = 0.051$	$f_{EX} = 0.091$	$f_{EX} = 0.058$	$f_{EX} = 0.09$	$f_{EX} = 0.09$
		$f_{sunk} = 0.204$	-	-	-	-
Export to Sales Ratio	14.0%	$\tau = 1.57$	$\tau = 1.57$	$\tau = 1.57$	$\tau = 1.57$	$\tau = 1.57$
Credit/GDP Ratio (Counter-factual)	60.00%	-	-	$\phi = 0.23$	-	-

^a β is taken from the full model. It is not re-calibrated to match the interest rate.

“Sunk” refers to a modification of the full model with sunk cost of exporting. “NBL” refers to a version of the model where there is a “Natural Borrowing Limit”. “K-Frictions” refers to a version of the model with financial frictions on the production side.

Table 2.12: Robustness of Baseline Results

	(1)	(2)	(3)	(4)	(5)
Model	Sunk	NBL	K-Frictions	Full Model	CM
TFP	1.3%	1.2%	0.9%	1.2%	1.2%
Capital	4.1%	3.4%	2.4%	3.9%	1.8%
Output	2.6%	2.3%	1.7%	2.5%	1.8%
Consumption of Workers					
Wage	3.5%	3.3%	3.0%	3.4%	2.7%
Entrepreneurial Consumption					
Aggregate	0.2%	0.0%	-1.1%	0.0%	0.0%
Certainty-Equivalent	-4.0%	-2.8%	-2.8%	-4.0%	-

“Sunk” refers to a modification of the full model with a sunk cost of exporting.

“NBL” refers to a version of the model with a “Natural Borrowing Limit”. “K-

Frictions” refers to a version of the model with financial frictions on the production

side. Columns (4) and (5) reproduce key results from Tables 2.3 and 2.4.

2.6.2 Natural Borrowing Limits

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

$$a > -\frac{\pi^D(z_{min})}{r}. \quad (2.23)$$

Inequality (2.23) requires an entrepreneur to be able to keep up with the interest payment on her loans while maintaining positive consumption, even if the entrepreneur receives the lowest possible productivity z_{min} forever. Table 2.11 provides the details

of the calibration. As reported in Column (2) of Table 2.12, while the specification of a natural borrowing limit reduces the contribution of capital accumulation to output gains from trade, there is still a large increase of the capital stock of 3.4% when moving from Autarky to Trade.

2.6.3 Financial Frictions for Production

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

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

$$\max_l \{ E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} - w \cdot l \} - Rk + (1+r)a \geq (1-\phi) \left\{ \max_l \{ E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} - w \cdot l \} + (1-\delta) \cdot k \right\} \quad (2.24)$$

where $q^D(z) = zk^\alpha l^{1-\alpha}$. Equation (2.24) states that a non-exporter must end up with more resources by fulfilling credit and rental obligations (left-hand side) than by defaulting (right-hand side). Equation (2.24) can be reduced to

$$\phi \cdot \max_l \left\{ E^{\frac{1}{\sigma}} (q^D(z))^{1-\frac{1}{\sigma}} - w \cdot l \right\} - k \cdot \left[R + (1-\phi)(1-\delta) \right] + (1+r)a \geq 0, \quad (2.25)$$

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

Analogously,

$$\phi \cdot \max_l \left\{ E^{\frac{1}{\sigma}} q^D(z)^{1-\frac{1}{\sigma}} + E^{*\frac{1}{\sigma}} q^X(z)^{1-\frac{1}{\sigma}} - w \cdot l - w \cdot f_X \right\} - k \cdot \left[R + (1-\phi)(1-\delta) \right] + (1+r)a \geq 0, \quad (2.26)$$

which implies a capital rental limit $\bar{k}^X(a, z; \phi)$ for exporters. Entrepreneurs hire capital subject to Equations (2.25) and Equation (2.26), and there is no default in equilibrium.

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

I calibrate the additional parameter ϕ to match the total private credit to GDP ratio. In the calibration of the full model ($\phi = 1$), the credit to GDP ratio is 189%, compared to the figure of 162% for the US in 2000. Keeping the other parameters constant, I calibrate the financial development parameter ϕ to match a Credit/GDP ratio of 60%, which is the level of financial development studied in Buera and Shin (2013), and change the fixed cost of exporting f_X to maintain an import penetration ratio of 7%. The introduction of the enforcement constraint decreases the demand for capital and the equilibrium interest rate. I do not change β to maintain $r = 3.00\%$. The strategy of calibrating ϕ after calibrating other parameters to the US benchmark follows Buera and Shin (2013). Lastly, I increase the variable cost τ to infinity to obtain the equilibrium under Autarky. The details

of the calibration are presented in Column (3) of Table 2.11 while the results are presented in Table 2.12. Moving from Autarky to Trade, TFP increases by 0.9%, smaller than the increase of 1.2% in the full model. The capital stock increases by 2.4%, which is larger than the increase in the CM benchmark, when we take into account the smaller increase in TFP in the K-Frictions model. Therefore, the mechanism emphasized in this study is robust to the introduction of financial frictions on the production side.

2.7 Conclusion

In this chapter, I construct a dynamic model of international trade with incomplete markets. I propose a mechanism through which accounting for the effects of international trade on top income inequality implies higher gains from trade for workers. I show that the proposed mechanism is quantitatively important by contrasting the full model with alternative models without top income inequality or without capital. Additionally, the baseline calibration results are robust to various model extensions. I examine the empirical relevance of the theory in the next two chapters.

Chapter 3: Cross-Country Evidence

3.1 Overview

The theoretical model in the previous chapter provides a number of testable hypotheses. The model predicts an increase in labor productivity resulting from reallocation of market shares across firms. This is confirmed by empirical studies such as Frankel and Romer (1999), Alcalá and Ciccone (2004), Pavcnik (2002) and Trefler (2004). Additionally, the model predicts that reduced barriers to international trade increase inequality *within* the top of the income distribution. Despite recent efforts to construct top income shares for a number of countries (Piketty and Saez, 2003), the sample of countries with top income data remains too small for analysis using panel regressions.¹ Testing the relationship between top income inequality and trade openness using micro data on trade liberalization episodes is hindered by poor coverage of high-income households in typical household survey data.

The model also predicts a strong relationship between the individual-level

¹The World Top Income Database by Alvaredo, Atkinson, Piketty, and Saez (2011) covers 25 countries. I attempt to use the top income database to analyze the effects of trade openness on top income inequality in a panel of countries. I find that the results are sensitive to exclusion of certain countries (for example, Singapore). Roine, Vlachos, and Waldenstrom (2009) study the correlates of top income inequality using a sample of 14 countries and do not find a positive correlation between trade openness and top income shares. However, they do not attempt to establish causality.

saving rate and income among entrepreneurs (the top of the income distribution of the whole population). According to Dynan et al. (2004), the median saving rate is 51.2% for households in the top 1% of income, and 37.2% for the households in the top 5% of income (inclusive of the top 1%) in the 1983-89 US Survey of Consumer Finances (SCF) data.² If the saving rate is a function of a household's position in the income distribution, as in my model (Figure 2.1), a shift of income shares towards the individuals at the top of the income distribution can increase the aggregate saving rate substantially.

In view of the evidence on the saving-income relationship, if openness increases top income inequality, there should be a positive relationship between the aggregate saving rate and openness. I test this hypothesis using data in a large number of countries. An important advantage of this approach is that data on the aggregate saving rate is more widely available than data on top income shares. To begin, I study the relationship between aggregate saving and trade openness in a cross section of countries using the IV approach pioneered by Frankel and Romer (1999). I find that trade openness has a large positive effect on the aggregate saving rate in a cross section of countries. I then use fixed-effects regressions to study the relationship between openness and the saving rate in a panel of countries. To distinguish the supply-side channel from the demand-side channel, I also examine the relationship between the aggregate investment rate and trade openness. If the saving-openness relationship is driven primarily by higher returns to investment, we would expect

²On a related note, using tax returns data, Saez and Zucman (2014) calculate that the average saving rate is 36% for the top 1% in wealth and 22% for the top 10% in wealth over the period 1986-2012 for the US.

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. Finally, I extend the gravity-based IV approach pioneered by Frankel and Romer (1999) to a panel setting, and find larger effects of trade openness on the saving rate than in the simple fixed-effects regressions.

3.2 Empirical Evidence in a Cross Section of Countries

The baseline cross-sectional regression is

$$S_i = \beta_0 + \beta_1(\text{Trade/GDP})_i + \beta_2\text{Institution}_i + \beta_3X_i + u_i \quad (3.1)$$

where S_i is the gross national saving rate for country i , $(\text{Trade/GDP})_i$ is the Trade/GDP ratio, Institution_i is a measure of institutional quality, and X_i is a vector of control variables, respectively. The proxy of institutional quality, adapted by Alcalá and Ciccone (2004) from Kaufmann, Kraay, and Zoido-Lobaton (1999), is designed to measure government effectiveness, rule of law and graft. Following Alcalá and Ciccone (2004), I control for the log of population and the log of total land area to capture any scale effects. Lastly, I include continent dummies in all regressions.

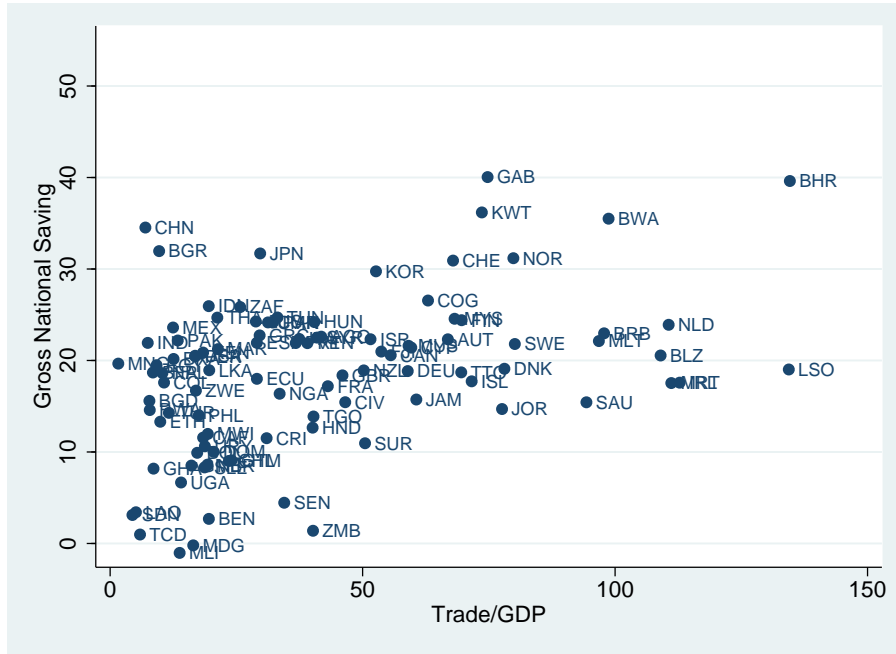
The conventional openness ratio (the Trade/GDP ratio) is defined as the sum of exports and imports over GDP, where each term is calculated based on the nominal exchange rate. Alcalá and Ciccone (2004) argue that the real openness ratio,

defined as the sum of real exports and real imports over purchasing power parity (PPP) GDP, is theoretically preferred to the conventional measure. According to the model in Alcalá and Ciccone (2004), greater trade openness can reduce the price level in the tradable sector relative to the price level in the non-tradable sector as a result of a productivity increase in the tradable sector. This may cause a distortion in the conventional openness ratio. While Alcalá and Ciccone (2004) do not adjust the sum of exports and imports for PPP prices, presumably due to data availability, the most recent Penn World Table (Mark 8.0) (Feenstra, Inklaar, and Timmer, 2013) has made this adjustment possible. I use the *real* openness ratio from PWT (Mark 8.0), which adjusts the sum of exports and imports for PPP prices, throughout this chapter. I provide a summary of the main variables and data sources for the empirical exercise in Appendix 3A.

Trade openness can be correlated with many variables, such as income level and factor endowment. In a cross-section OLS regression with the aggregate saving rate as the dependent variable, it is difficult to sufficiently control for all potential variables. Additionally, reverse causality is also a concern. For example, a higher saving rate may allow a country to develop its tradable sector and have a higher level of openness. I employ the Frankel and Romer (1999) gravity approach to construct an instrument for trade openness. In the first step, I run a gravity regression to relate bilateral trade flows to variables capturing geography and population.³ For each country, I aggregate the predicted values of this gravity equation across all

³Specifically, the geography terms in the estimated gravity equation include bilateral distance, total land area, landlocked status and bordering status. Bordering status is interacted with all other geographic features and population. This follows Frankel and Romer (1999) exactly.

Figure 3.1: National Saving Rate and Trade Openness in 1985



WDI Database

trade partners. The resulting variable is used as an instrument for trade openness.

I instrument for institutional quality using the population share speaking one of five primary European languages since birth and distance from equator, following Hall and Jones (1999) and Alcalá and Ciccone (2004). Hall and Jones (1999) argue that these two variables capture the historical influence of European countries on institutional quality. I focus on data from 1985 to facilitate comparison with Frankel and Romer (1999) and Alcalá and Ciccone (2004), both of which use data from 1985.

My main measure of national saving is the gross national saving rate from the World Development Index (WDI), which is defined as national income plus net transfers less consumption, as a percentage of gross national income. Figure 3.1 plots the gross national saving rate against the Trade/GDP ratio in 1985 for the 99

countries for which I have data on all variables in Equation (3.1).⁴ Figure 3.1 shows a strong and positive correlation between the gross national saving rate and trade openness.

Table 3.1: First Stages of 2SLS Cross-sectional Regressions

	(1)	(2)
	Trade/GDP	Institution
Predicted Trade Share	0.595*** (0.143)	0.00883* (0.00444)
European Languages	6.968 (8.870)	0.837*** (0.257)
Distance to Equator	0.184 (0.203)	0.0276*** (0.00638)
Log Population	-5.495* (3.267)	0.0455 (0.0530)
Log Area	2.495 (2.665)	0.00878 (0.0553)
Excluded IV F-stat	9.813	15.96
R^2	0.494	0.726
N	84	84

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The data are from 1985. The variable “Predicted Trade Share” is constructed using population and geography as determinants of bilateral trade flows in the gravity equation. We then aggregate the predicted values for each country. The variable “European Languages” refers to the population share speaking one of five primary European languages since birth.

I exclude small countries with a population of less than 1.5 million in the

⁴Singapore and Bahamas appear to be outliers in terms of openness and are excluded from Figure 3.1 and the regression analysis. Inclusion of these two countries would strengthen the results.

regression analysis. The resulting sample includes 84 countries. The first-stage regressions are presented in Table 3.1. The Stock-Yogo test for weak instruments suggests that the instruments are weak.⁵ To alleviate weak-instrument-bias concerns, I re-estimate all specifications using the Limited Information Maximum Likelihood (LIML) Estimator. The results from LIML are very similar to the 2SLS estimates.⁶

The OLS results are reported in Column (1) of Table 3.2. Consistent with Figure 3.1, the national saving rate is positively correlated with trade openness at 5% significance level. The results from the 2SLS regressions for saving are presented in Column (2) of Table 3.2. The specification follows the baseline in Alcalá and Ciccone (2004) closely.⁷ According to the point estimate, a one-percentage-point increase in the Trade/GDP ratio raises the national saving rate by 0.209 percentage point. Interestingly, the point estimate is close to the value of 0.221 from the fixed-effects panel IV regression presented below (Section 3.3.3). However, the coefficient on the Trade/GDP ratio is statistically significant at 10%. Institutional quality does not appear to have a significant effect on the aggregate saving rate.

In Columns (4)-(6) of Table 3.2, I repeat the regression with the investment rate as the dependent variable. If the saving-openness relationship is driven primarily by a higher return to investment, we would expect the investment-openness relationship to be stronger than the saving-openness relationship, since at least some

⁵With two endogenous variables, the usual rule-of-thumb F-Statistic of 10 does not apply. The Stock-Yogo test does not reject the null that the quality of the instruments is of the lowest level.

⁶The Limited Information Maximum Likelihood (LIML) estimator is more robust in over-identified models. It is less efficient but also less biased than 2SLS (Angrist and Pischke, 2008, p.213).

⁷In Alcalá and Ciccone (2004), the dependent variable of interest is log output per worker. Since they are interested in estimating the elasticity of productivity with respect to openness, they use the log of real openness (instead of its level).

of the investment would be financed by capital inflows. I use gross fixed capital formation as a percentage of GDP, available from the WDI database, as the investment measure. I do not find a positive effect of trade openness on the investment rate in the 2SLS results in Column (5) which is my preferred specification. I interpret the results as supportive of the supply-side channel of capital accumulation.

To provide a comparison to the trade-growth literature, Columns (7)-(9) of Table 3.2 repeat the regressions with log of GDP per capita as the dependent variable. In the 2SLS results in Column (8), the coefficient on the Trade/GDP ratio is 0.0148, with a P-value of 0.128. A one-percentage-point increase in the Trade/GDP ratio raises GDP per capita by 1.48%. The log of GDP per capita increases by 0.279 standard deviation, compared to an increase of 0.677 standard deviation for the gross national saving rate, if the openness measure increases by one standard deviation. Therefore, the estimated effect of trade openness on the aggregate saving rate is large. According to my model, a higher aggregate saving rate (Column (2) of Table 3.2) contributes substantially to higher income (Column (8) of Table 3.2).

Table 3.2: The Effects of Trade on Aggregate Saving and Investment

Cross-sectional Regressions with IV

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Saving			Investment			Income		
	OLS	2SLS	LIML	OLS	2SLS	LIML	OLS	2SLS	LIML
Trade/GDP	0.0904**	0.209*	0.210*	0.0106	-0.132	-0.143	0.0142***	0.0148	0.0148
	(0.0391)	(0.120)	(0.122)	(0.0627)	(0.127)	(0.134)	(0.00476)	(0.00972)	(0.00974)
Institutional Quality	0.553	-0.938	-0.971	2.262*	5.789*	6.027*	0.656***	0.805***	0.805***
	(1.348)	(2.561)	(2.594)	(1.336)	(3.192)	(3.353)	(0.152)	(0.239)	(0.240)
R^2	0.368	0.286	0.284	0.320	0.157	0.133	0.787	0.782	0.782
N	84	84	84	84	84	84	84	84	84

The dependent variables are the gross national saving rate (Columns (1)-(3)), the gross investment rate (Columns (4)-(6)) and log of GDP per capita (Columns (7)-(9)), respectively. Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The data are from 1985. I instrument for the Trade/GDP ratio and institutional quality. The instruments used are predicted trade shares (Frankel and Romer, 1999), the population share speaking one of five primary European languages since birth, and distance from the equator. All regressions include log population, log total land area, and continental dummies as right-hand side variables.

Table 3.3: Robustness Checks on Cross-sectional Regression with IV

	(1)	(2)	(3)
	D-graph	No-Oil	10-Years
Panel A.	Gross National Saving Rate		
Trade/GDP	0.180*	0.190*	0.281**
	(0.0984)	(0.114)	(0.126)
Institutional Quality	-3.454	-1.136	-2.278
	(3.792)	(2.527)	(2.823)
Panel B.	Gross Investment Rate		
Trade/GDP	-0.134	-0.121	0.0588
	(0.118)	(0.128)	(0.112)
Institutional Quality	6.285	5.814*	2.245
	(4.548)	(3.305)	(2.902)
N	84	81	84

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The basic specification follows Column (1) of Table 3.2. Column (1) controls for young and old age dependency ratios; Column (2) excludes major oil exporters in the sample; Column (3) uses data averaged over 1981-1990.

I subject the baseline cross-sectional IV regressions to a number of robustness checks. Results are shown in Table 3.3. The results are robust to controlling for age dependency ratios and exclusion of the major oil exporters from the sample. To address the concern that the results might be driven by data anomalies from one particular year, I show that the results are similar if I use the 1981-1990 averages of variables.

3.3 Empirical Evidence in a Panel of Countries

3.3.1 Fixed-Effects Panel Regressions

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

$$S_{it} = \beta_0 + \beta_1(\text{Trade/GDP})_{it} + \beta_2 X_{it} + c_i + \mu_t + v_{it} \quad (3.2)$$

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

I continue to use the gross national saving rate from the World Development Index (WDI) as the main measure of national saving. To distinguish the supply-side channel of capital from the demand-side channel in the data, I also examine a specification analogous to Equation (3.2) but with the gross investment rate as the dependent variable.

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.⁸ The final

⁸Mankiw, 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 chapter is taken from the World Bank (<http://www.worldbank.org/en/country/>)

sample includes 111 countries.

Panel A of Table 3.4 presents the results from fixed-effects panel regressions on the saving rate. Column (1) includes the Trade/GDP ratio as the only right-hand-side variable aside from the fixed effects. A one-percentage-point increase in the Trade/GDP ratio is associated with a 0.0744 percentage point increase in the aggregate saving rate. The coefficient is statistically different from zero at the 1% significance level. In Column (2), I control for income by including the log of GDP per capita and its square. Since GDP per capita is most likely endogenous with respect to the saving rate, I lag these two variables by five years. The coefficient on trade openness remains positive and significant. In Table 3.5, I show that the results are robust to controlling for current income instead of lagged income.

Financial development is another potentially important omitted variable. In Column (3), I control for financial development using the Credit/GDP ratio. I lag the Credit/GDP ratio by five years since this measure is potentially endogenous with respect to the saving rate. Column (3) is my preferred panel specification. According to Column (3), a one-percentage-point increase in the Trade/GDP ratio raises the aggregate saving rate by 0.107 percentage point. The coefficient is statistically significant at 1%. According to the point estimate in Column (3), the gross national saving rate increases by 0.255 standard deviation for a one-standard-deviation increase in the openness measure.⁹ 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 [smallstates/overview](#)).

⁹I remove the country and year fixed-effects before calculating the standard deviations of the Trade/GDP ratio and the gross national saving rate.

Table 3.4: The Effect of Trade on Aggregate Saving and Investment

Fixed-Effects Panel Regressions

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

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

the period 1996 to 2000, its predicted average national saving rate would have been 18.8% instead of 13.7%.

Columns (1)-(3) demonstrate a strong correlation between trade openness and the saving rate. However, a higher level of openness may be a result rather than a cause of a higher aggregate saving rate. For example, a positive shock to the national saving rate may allow a country to build up infrastructure conducive to international trade, resulting in a higher measured level of openness. To address this issue, I include the five-year lag and lead of the Trade/GDP ratio in the panel regression. As shown in Column (4) of Table 3.4, the coefficient on the contemporaneous Trade/GDP ratio remains positive and statistically significant. On the other hand, the coefficients on past and future trade openness are not statistically significant. This provides some evidence in favor of the proposed mechanism.

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

In Panel B of Table 3.4, I repeat the analysis with the gross investment rate as the dependent variable. The coefficient on the Trade/GDP ratio is positive and

statistically significant at 1% in Columns (2) and (3), but it is not statistically significant in Column (1). According to Column (3), the gross investment rate increases by 0.165 standard deviation following a one-standard-deviation increase in the Trade/GDP ratio, compared to an increase of 0.255 standard deviation for the national saving rate. Column (4) shows that the investment rate is positively correlated with contemporaneous trade openness but is not correlated with past or future trade openness. Column (5) shows that conditional on the saving rate, there is no statistically significant relationship between trade openness and the gross investment rate.

I find that the results in Table 3.4 are robust to the introduction of additional regressors and modifications of the baseline specification. The details of the robustness checks are presented in Table 3.5. One important concern with the baseline results is that the coefficient on Trade/GDP is simply picking up the effects of capital account openness. In Column (1) of Table 3.5, 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. However, the coefficient on trade openness remains positive and significant.¹⁰

In the baseline panel regression, I lag the income terms by five years, as the current income level is clearly endogenous with respect to the saving rate in the model. In Column (2), I use current income terms in place of lagged income terms, despite the endogeneity concerns. In Column (3), I control for the GDP growth rate.

¹⁰Neither controlling for capital account openness nor changing the sample of countries have an impact on baseline results.

In Column (4), I include old and young dependency ratios as additional regressors to capture the effects of demographic changes. Column (5) includes the inflation rate as an additional regressor. The results in Table 3.5 are in line with those presented in Table 3.4.

The national accounting identity implies that $S - I = X - M$, where S , I , X and M are saving, investment, exports and imports, respectively. This may suggest controlling for the trade balance. In Column (6) of Table 3.5, I include the trade surplus as an additional regressor. The point estimate of the coefficient on the Trade/GDP ratio decreases to 0.0664 but remains statistically significant at 1%. Since I am holding $(S - I)$ constant in this regression, the results in Column (6) are consistent with the finding that a substantial part of the openness-induced saving translates into higher investment.

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

Another concern is that the results in Table 3.4 are driven by a handful of countries. The World Bank classifies countries into seven regions: East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa. To address the

concern of outlier countries, I drop each region one by one from the full sample and repeat the analysis in each column of Table 3.6. The results are robust to the exclusion of any single region. In each column of Table 3.6, I drop a different region from the full sample and repeat the baseline panel regression. As shown in Table 3.6, the results are robust to the exclusion of any single region.

Table 3.5: Robustness of Panel Fixed-Effects Panel Regressions:
Alternative Specifications

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

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

Table 3.6: Robustness of Fixed-Effects Panel Regressions:

Exclusion of Subsamples

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

Column (1) reproduces Column (3) of Table 3.4. Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively.

3.3.2 The Role of Initial Top 10% Income Share

The fixed-effects regressions above establish a strong correlation between trade openness and the aggregate saving rate. In the model, trade openness has a positive effect on the aggregate saving through its effects on entrepreneurial saving. It is interesting to examine how the saving-openness relationship is affected by the share of total income received by entrepreneurs. If the increase in the aggregate saving rate in Table 3.4 is driven by increased inequality among entrepreneurs (high-income earners), greater trade openness should have a larger effect on the aggregate saving rate in a country where entrepreneurs account for a greater share of total income.

The equation of interest is

$$S_{it} = \beta_0 + \beta_1(\text{Trade/GDP})_{it} + \beta_2\text{Top10\%}_i \cdot (\text{Trade/GDP})_{it} + \beta_3X_{it} + c_i + \mu_t + v_{it}, \quad (3.3)$$

where Top10\%_i is the share of total income received by entrepreneurs. As in Column (3) of Table 3.4, I control for lagged income and financial development. The coefficient β_1 should be interpreted jointly with the coefficient on the interaction β_2 . The marginal effect on the aggregate saving rate of an increase in the Trade/GDP ratio is given by $(\beta_1 + \beta_2\text{Top10\%}_i)$.

I use data on top 10% income share from the UNU-WIDER World Income Inequality Database (UNU-WIDER, 2014) as a proxy for the share of total income received by entrepreneurs. Ideally, I would like to use data on top 10% income shares from a single cross section in 1960 to capture the difference in initial inequality before

any changes in trade openness. However, data availability for top 10% income shares varies across years and countries. For the countries without data for 1960, I use data closest to 1960. Since UNU-WIDER has data going back to 1867, the years with data closest to 1960 may be before 1960, after 1960 or both.¹¹ This procedure allows me to retain the largest possible number of countries in the sample.

The results are presented in Panel A of Table 3.7. Column (1) presents the results when all countries with available data are included in the sample. The point estimate of β_2 is positive but statistically insignificant. A problem with the results in Column (1) is the use of data from different years to proxy for the cross-sectional difference in top income inequality between countries. In Column (2), I conduct the same analysis for countries for which the data on top 10% income shares come from a 20-year window between 1951 and 1970. This reduces the number of countries in the sample to 58. The point estimate of β_2 is positive and statistically significant at 10%. Figure 3.2 plots the marginal effects of a percentage point increase in the openness ratio on the national saving rate, against the initial top 10% income share. Among the countries in the sample, a one-percentage-point increase in the Trade/GDP ratio effects the national saving rate by -0.002 to 0.177 percentage points, depending on the level of inequality where the negative values are not statistically different from zero. According to Column (2), a one-percentage-point increase in the initial top 10% income share increases the marginal effect on the national saving rate of a one-percentage-point increase in the Trade/GDP ratio by 0.004 percentage points.

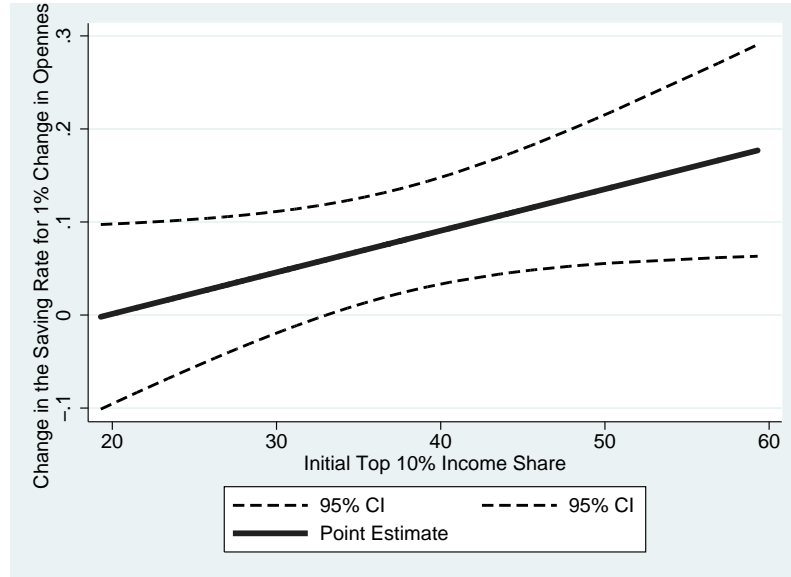
¹¹As an example, data for a country may be available for 1958 and 1962 but not available for 1960. In this case, I take the average between the 1958 and 1962 data.

Table 3.7: The Role of Initial Top 10% Income Share
The Effects of Openness on Saving and Investment

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

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

Figure 3.2: Initial Top 10% Income Share and Marginal Effects of Openness



WDI Database

Column (3) further limits the analysis to countries for which the data on top 10% income shares come from a 10-year window between 1956 and 1965. The point estimate for β_2 increases slightly and is now statistically significant at 5%. The results suggest that the share of total income received by entrepreneurs plays an important role for the saving-openness relationship.

Panel B of Table 3.7 repeats the analysis with the gross investment rate as the dependent variable. The coefficient on the interaction term between inequality and trade openness is positive but is statistically insignificant in all three columns. This is reminiscent of the results in Table 3.4 that the saving-openness relationship is stronger than the investment-openness relationship.

3.3.3 Fixed-Effects Panel Regressions with IV

A concern about the fixed-effects results presented above is that openness might be endogenous with respect to saving. For example, a strong economy overall could simultaneously boost saving and trade. Alternatively, an increase in domestic saving could allow domestic firms to invest in export operations. To address issues of endogeneity, I again follow Frankel and Romer (1999) and Alcalá and Ciccone (2004) in using gravity variables as instruments for openness, as in the previous cross-section analysis. Here, I extend the gravity-based methodology of Frankel and Romer (1999) to a panel setting.¹² To construct my instrument, I run the following panel regression on the bilateral trade share:

$$\log\left(\frac{\text{Trade}_{ij\tau}}{\text{GDP}_{i\tau}}\right) = \gamma_0 + \gamma_1 \text{Freight}_\tau \cdot \ln(\text{Dist}_{ij}) + \gamma_2 X_{ij} + \gamma_3 Z_{ij\tau} + u_\tau + \epsilon_{ij\tau} \quad (3.4)$$

where $\text{Trade}_{ij\tau}$ is the sum of exports and imports between country i and country j , Freight_τ is an index of shipping costs (common to all countries) from Hummels (2007), $\ln(\text{Dist}_{ij})$ is the log of bilateral distance between the two countries, X_{ij} is a vector of geography variables (including $\ln(\text{Dist}_{ij})$), $Z_{ij\tau}$ are the time-varying gravity terms related to population, and u_τ is a year fixed effect.¹³ Specifically, X_{ij} includes bilateral distance, total land area, landlocked status, bordering status,

¹²Feyrer (2009) and Felbermayr and Gröschl (2013) use gravity-based IV in a panel setting to study the relationship between income and trade openness. Feyrer (2009) exploits the fact that improvement in aircraft technology increases bilateral trade more for country pairs with relatively short air routes compared to sea routes. Felbermayr and Gröschl (2013) use natural disasters as a source of exogenous variation.

¹³I experiment with a specification with bilateral fixed effects to control for all time-invariant factors. I find that the 2SLS results from the resulting IV are very sensitive to exclusions of particular subsamples.

and the interaction of bordering status with all other geographic features; and $Z_{ij\tau}$ includes population and its interaction with bordering status. These gravity terms follow Frankel and Romer (1999) closely.

Table 3.8: Results from Estimating a Panel Gravity Equation

	Log (Bilateral Trade /GDP _i)
Log Distance	-0.836*** (0.0154)
Freight Cost Index * Log Distance	-0.0938*** (0.00970)
Log Population (Country i)	-0.175*** (0.00358)
Log Population (Country j)	0.948*** (0.00349)
Log Population * Border Status (Country i)	-0.189*** (0.0243)
Log Population * Border Status (Country j)	-0.0640*** (0.0241)
R^2	0.359
Observations	334663

Robust standard errors are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The panel gravity equation also include total land area, landlocked status, bordering status and its interaction with total land area and with landlocked status, and year dummies.

I estimate Equation (3.4) using fixed-effects panel regression.¹⁴ I then aggregate the predicted bilateral trade shares (unlogged) from Equation (3.4) over trade partners to obtain the predicted trade share for country i in year τ . The predicted trade shares are then averaged over nine five-year intervals and employed as an IV

¹⁴I also experiment with the Poisson Pseudo Maximum Likelihood estimator (PPML) proposed in Santos Silva and Tenreyro (2006), and find the resulting instrument to be too weak.

Table 3.9: The Effect of Trade on Aggregate Saving and Investment

Fixed-Effects Panel Regressions with IV

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

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

for the Trade/GDP ratio in Equation (3.2).¹⁵ Aside from the year fixed effect in Equation (3.4), the resulting predicted trade shares are time-varying for two reasons. First, the gravity terms involving population are time varying. Second, advances in shipping technology, as reflected in the decrease in the index of shipping costs, increase bilateral trade more for country pairs with greater bilateral distance. In other words, $\gamma_1 < 0$ in Equation (3.4). The results are reported in Table 3.8. The key coefficient of interest γ_1 is negative and statistically negative from 0 at 1%. Bilateral distance has a strong and negative effect on bilateral trade, and the effect is stronger when the cost of shipping is higher. The Freight Cost Index from Hummels (2007) decreases from a value of 2.03 in 1962 to the normalized value of 1.00 in 2000. Therefore, the effect of distance on bilateral trade has decrease by 11.5% over the period according to the estimates. This is the key variation I exploit in the IV strategy. Additionally, population is also a strong predictor of bilateral trade.¹⁶ In practice, both sources of time variation are necessary to have a relatively strong first stage in the 2SLS regression. Since the population size of a country may have a direct effect on its national saving rate, I include log of population as a control variable in the 2SLS regression in addition to the standard controls in Column (3) of Table 3.4. The identifying assumption is that the shipping cost index (common to all countries), and the populations of a country's trade partners, are exogenous with respect to its gross national saving rate and gross investment rate.

Since the sample is reduced by the use of trade flow data, I report the fixed-

¹⁵Since I have bilateral trade data from 1962 to 2000, the average predicted trade shares for 1962-1965 are used in place of the average for 1961-1965.

¹⁶In Table 3.8, the populations of Country i and Country j have different effects on bilateral trade shares. This is consistent with the cross-section estimates in Frankel and Romer (1999).

effects OLS estimates for the smaller sample in Column (1) of Table 3.9. The results from the fixed-effects 2SLS regressions are presented in Column (2). The first-stage F-statistic for the excluded instrument is 6.4, lower than the rule-of-thumb critical value of 10. According to the 2SLS results, a one-percentage-point increase in the Trade/GDP ratio raises the national saving rate by 0.228 percentage point, larger than the increase of 0.118 percentage point in the fixed-effects OLS regression. On the other hand, I do not find a positive effect of trade openness on the gross investment rate in the 2SLS regression. Table 3B.1 and Table 3B.2 in Appendix 3B show that the results are robust to additional controls, and exclusion of any single region from the sample, respectively.¹⁷

3.4 Discussion

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

¹⁷The coefficient on trade openness is positive but statistically insignificant when I additionally control for the trade balance in the 2SLS regression of the national saving rate.

One plausible alternative explanation is that trade openness decreases the labor share of income.¹⁸ If the saving rate of labor income is lower than that of capital income, a decrease in the labor share of income can increase the aggregate saving rate. Another related explanation is that the increased income share for the very top group (“the exporters”) comes at the expense of smaller income shares for low-income groups (“the workers”), rather than for other high-income groups (“the domestic producers”). For example, a change in the competitive environment, resulting from increased trade openness, may allow superstar entrepreneurs to charge higher markups.¹⁹ To distinguish the proposed mechanism from alternative explanations, I use data on the labor share of income from Karabarbounis and Neiman (2014) as an additional control in the fixed-effects panel regression.²⁰ The results are presented in Column (9) of Table 3.5. Although the sample is substantially reduced, the coefficient on the Trade/GDP ratio remains positive and statistically significant. This provides some evidence in favor of the proposed mechanism.

Another explanation is that the income shares of various groups are independent of trade openness, but trade openness increases the saving rate of certain income groups. Since the saving rate of low income groups has a small effect on the aggregate saving rate, the saving rate of high income groups should increase at least moderately for this alternative explanation to be plausible. In the theoretical

¹⁸Harrison (2005) studies the relationship between globalization and the labor share of income. Her results suggest that rising trade openness reduces the labor share of income.

¹⁹Using data from Slovenia, De Loecker and Warzynski (2012) find that exporters charge higher markups on average, and markups increase upon export entry.

²⁰Karabarbounis and Neiman (2014) provide data on the labor share of income in the corporate sector, and the overall labor share. I use the overall labor share of income, as this variable is available for a larger number of countries.

results in Section 2.3, I do not find an increase in the saving rate for exporters. However, to distinguish empirically the proposed mechanism from the alternative explanation, we would need to examine the entire distribution of income and saving rates in a country before and after a trade shock. I leave this for future research.

Capital Flows Across Countries

For simplicity, I have assumed in the theoretical model that capital is immobile across countries, so that $S = I$ holds for each country.²¹ While Levine and Renelt (1992), Wacziarg (2001) and Wacziarg and Welch (2008) find a positive relationship between trade openness and the investment rate, I find this relationship to be statistically weaker than the relationship between trade openness and the saving rate. I do not find a significant relationship between trade openness and the investment rate in some specifications. On the one hand, this supports my emphasis on the supply-side channel of capital accumulation. On the other hand, the weaker relationship between trade openness and the investment rate suggests that some of the trade-induced increase in saving flows abroad.

If capital is mobile across countries in the model, some of the trade-induced increase in saving in a country may flow abroad and result in higher investment in the recipient country. Workers in the recipient country would benefit from higher wages through a higher marginal productivity of labor. In other words, with capital flows across countries, the positive welfare effect of a trade-induced increase in saving

²¹Feldstein and Horioka (1980) documents a strong relationship between domestic saving and investment. Bai and Zhang (2010) use a model with financial frictions to explain the Feldstein-Horioka puzzle.

in one country may be shared with workers in different countries.²² Therefore, relaxation of the $S = I$ assumption has implications for the distribution of gains from trade between countries. However, a quantitative analysis of distributional effects between countries is beyond the scope of this study.

3.5 Conclusion

In this chapter, I test the key predictions of the model using country-level data. Using fixed-effects regressions in a large panel of countries, I find a significant and positive correlation between trade openness and the aggregate saving rate. I find a much weaker relationship between trade openness and the investment rate. Furthermore, I show that greater trade openness has a stronger effect on the aggregate saving rate in a country where the initial top 10% share (before any changes in trade openness) of total income is higher. This is in line with my model, where the increase in the aggregate saving is driven by top income earners. Additionally, I build on the gravity-based IV approach pioneered by Frankel and Romer (1999) and extend it to a panel setting. I find a larger effect of trade openness on the aggregate saving rate in the fixed-effects panel regressions with IV than without IV. The results provide strong evidence that a supply-side channel of increased capital accumulation is operative following an increase in trade openness.

²²In the extreme case of small economies with perfect capital account openness, the trade-induced increase in the aggregate saving rate would have no impact on the investment rate, or additional welfare gains for workers, in the domestic economy.

Chapter 4: Openness, Inequality and the Chinese Saving Rate Puzzle

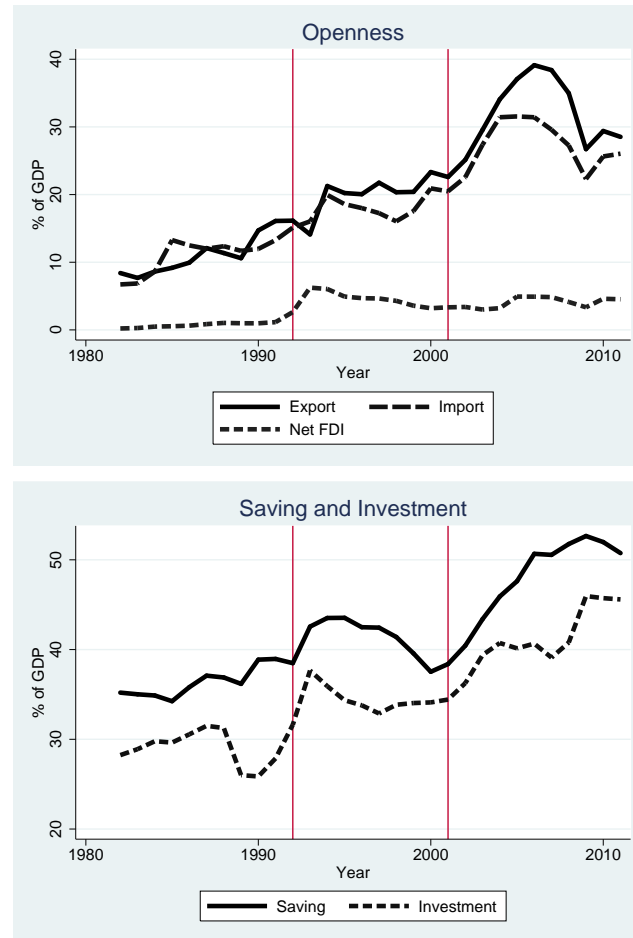
4.1 Introduction

Since the start of reforms in the late 1970s, China has played an increasingly important role in the global economy. Panel A of Figure 4.1 plots exports, imports and net foreign direct investment (FDI) as a percentage of GDP in China from 1982 to 2011. As shown in the figure, China's exports as a share of GDP increased from 8.4% in 1982 to a peak of 39.1% in 2006.¹ The evolution of imports and net FDI in China follow a similar pattern.

The integration of China into the global economy has been accompanied by a large increase in the national saving rate. As shown in Panel B of Figure 4.1, the gross domestic saving rate has increased from around 35%, which was already high compared to other countries, to a peak of 52.7% in 2009. Household saving, defined as the difference between disposable income and consumption expenditures, has been the largest component of aggregate saving for most of the period. According to Yang, Zhang, and Zhou (2012), the household saving rate increased by 11.3

¹The subsequent drop in Export/GDP ratio is related to the 2008 global financial crisis. The drastic fall in global trade during the 2008 financial crisis is termed "Great Trade Collapse."

Figure 4.1: Openness, Saving and Investment in China (1982-2011)



Source: WDI Database

percentage points, from 15.3% in 1990 to 26.9% in 2007, in the data from the China Urban Household Survey (CHUS).² Panel B also plots the gross investment rate in China from 1982 to 2011. While the gross investment rate has also risen dramatically over the period, it has been persistently lower than the gross domestic saving rate.

In light of the theoretical model in Chapter 2, it is interesting to examine the relationship between openness and aggregate saving behavior in China. The hypoth-

²Throughout this chapter, the (average) household saving rate of a group is defined as the difference between average disposable income and average consumption expenditures, as a fraction of average disposable income; I do not take the arithmetic average of individual household saving rates in any instance.

esis in this chapter is that greater openness in China has increased the household saving rate by increasing the income shares received by the high-income households who have the highest saving rate.

To focus on the growth experience of China, this chapter deviates from the framework in Chapter 2 in two ways. First, while the model in Chapter 2 considers only openness to international trade, this chapter considers the effects of openness more generally, or “globalization,” of which openness to international trade and openness to foreign direct investment (FDI) are two important components.³ Second, I consider inequality among workers as well as inequality among entrepreneurs in this chapter. A large literature has found that greater trade openness typically increases wage inequality (Goldberg and Pavcnik, 2007; Harrison, McLaren, and McMillan, 2011). To the extent that workers with higher wages have higher saving rates, an increase in wage inequality can also contribute to the higher saving rate in China.

The hypothesized relationship between openness and the household saving rate in China has two crucial components: a link between openness and income inequality and a link between income inequality and the household saving rate. A comprehensive examination of the hypothesis should cover both the component links and the overall relationship. Han, Liu, and Zhang (2012) find that globalization has a large effect on wage inequality in China.⁴ In Section 4.2, I show that there has

³Openness to FDI can increase top income inequality through two channels. First, foreign firms need to hire local managers. Second, the profits of domestic firms who receive investment and foreign technology from foreign partners can increase significantly relative to those non-joint-venture firms. Harrison and Rodriguez-Clare (2010) note the difficulty of separately identifying the effects of trade openness and FDI openness.

⁴In principle, I could use micro-data to examine the relationship between openness and income

been a large increase in top income shares in China since the late 1970s, and that the household saving rate of the high-income households is extremely high compared to the low-income households. In Section 4.3, I use data from the China Household Income Project (CHIP) to show that there is a strong correlation between income inequality and the household saving rate across Chinese counties. Additionally, using a simple counter-factual exercise, I show that the observed increase in income inequality can play a quantitatively important role for the rise of the household saving rate in China. Finally, in Section 4.4, using provincial-level panel data and exploiting the 1992 liberalization episode, I show that greater openness has a large positive effect on the household saving rate of a province in China.

The high saving rate of China is the subject of numerous papers, perhaps because it is seen as an issue at the heart of global imbalances (Bernanke, 2005). Yang, Zhang, and Zhou (2012) provide a comprehensive review of the relevant literature. While aggregate saving consists of savings by government, by the corporate sector and by the household sector, most of the literature has focused on the household sector.⁵ Earlier research on the Chinese household saving rate, such as Kraay (2000) and Modigliani and Cao (2004), has focused on demographic changes related to the life-cycle hypothesis. Chamon and Prasad (2010) and Chamon, Liu, and Prasad (2013) emphasize the role of precautionary motives and income uncertainty among entrepreneurs in China. However, this is a difficult task given the lack of data on high-income households from different years. As will be discussed later, the China Household Finance Survey has good coverage of high-income households. However, the survey was started only in 2011.

⁵While I focus on the household saving rate in this chapter, I note that accounting for corporate saving would likely strengthen the empirical results in this chapter, since the high-income households are more likely to own shares of firms.

tainty.⁶ Choukhmane, Coeurdacier, and Jin (2013) focus on the role of the one-child policy. Wei and Zhang (2011) argue that the higher male-female sex ratio in China contributes to the high household saving rate, as the young males and their parents save aggressively (for example, towards the purchase of an apartment) to improve the prospects in the marriage market. Wang and Wen (2011) study the role of housing prices and conclude that the rising housing price in China cannot account for the rise in the household saving rate.

It is important to note that while a given channel may be successful in explaining the rise in saving rate by a certain set of households, the channel may contribute little to the increase in the overall household saving rate, if the households affected by the proposed channel account for only a small share of total income. Citing the well-known positive relationship between the household saving rate and income at the micro-level, both Gan (2013) and Lin (2012) argue that the rising household saving rate in China is driven by top income shares. This chapter goes a step further than Gan (2013) and Lin (2012) by proposing globalization as a driver behind rising top income shares in China.

4.2 Inequality in China

In this chapter, I make use of multiple data sources. It is useful to give an overview of the main advantages of the various sources. The China Urban Household Surveys (CUHS) would be best suited to answer many of the questions raised

⁶Song and Yang (2010) document a flattening of the age-earning profiles and use this empirical fact to explain both the rising household saving rate and the unusual U-shaped increase in saving rates over the life cycle.

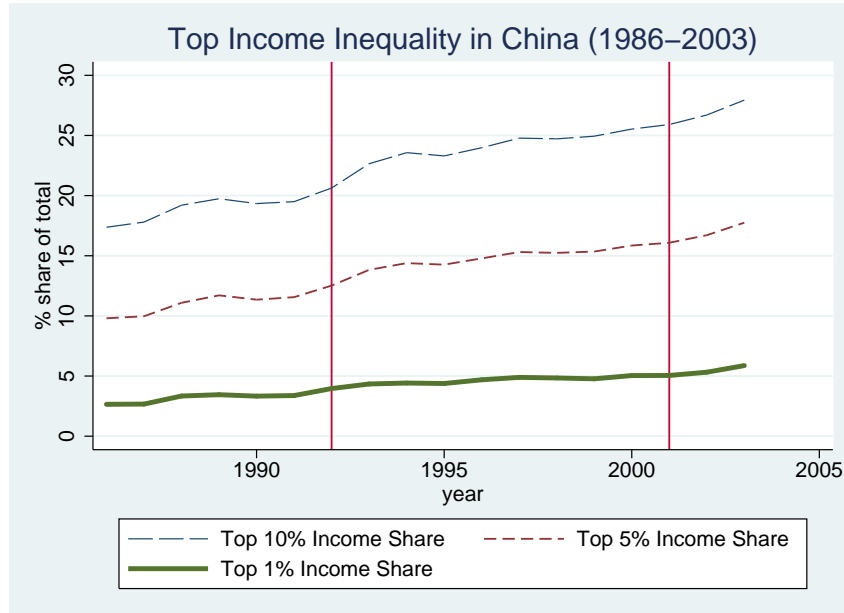
in this chapter. Unfortunately, the data are not publicly available. In the exposition, I rely on evidence on studies published using the CUHS data. To describe the evolution of income inequality in China, I rely on data from China Health and Nutritional Surveys (CHNS), which are conducted by the University of North Carolina at Chapel Hill and the Chinese Center for Disease Control and Prevention. A major advantage of CHNS surveys is that they cover multiple years (1989, 1991, 1993, 1997, 2000, 2004, 2006 and 2009). However, the CHNS data do not contain comprehensive consumption data. To examine the household saving rate at the county and household level, I use data from the China Household Income Projects (CHIP). I also examine data from China Household Finance Survey (CHFS) for a better coverage of high-income households in China. Finally, I supplement the province-level dataset constructed by Wei and Zhang (2011) with additional data series from various statistical yearbooks to study the relationship between openness and the household saving rate in Chinese provinces. More details on the various datasets are provided later.

Figure 4.2 plots the top income shares in China from 1986 to 2003. The series are constructed by Piketty and Qian (2009) from the CUHS survey data.⁷ The share of total income received by the top 10% households increased from 17.4% in 1985 to 27.9% in 2003, while the income share received by the top 1% households increased from 2.7% to 5.9%.⁸

⁷The data series are available through the World Top Income Database. In the World Top Income Database, data series for China are the only series constructed from household surveys while data series for other countries are typically constructed using tax return data. This is a relevant point as household surveys are more likely to underestimate top income shares.

⁸The figures above do not include capital gains in total income.

Figure 4.2: Top Income Shares in China (1986-2003)



Source: World Top Income Database

It is informative to examine the evolution of income inequality among entrepreneur households and workers households separately. Since the CUHS data are not publicly available, I turn to data from China Health and Nutrition Survey (CHNS) which has been used extensively to study income dynamics in China. The survey covers several provinces including Liaoning, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou. I use data from the survey conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006 and 2009.⁹ The number of households in the survey ranges from 3439 in year 1993 to 3654 in year 2009. In line with the model in Chapter 2, I classify a household as an entrepreneur household if at least one household member is either (1) listed as having a primary occupation of “administrator/executive/ manager;” or (2) listed as self-employed with at least one

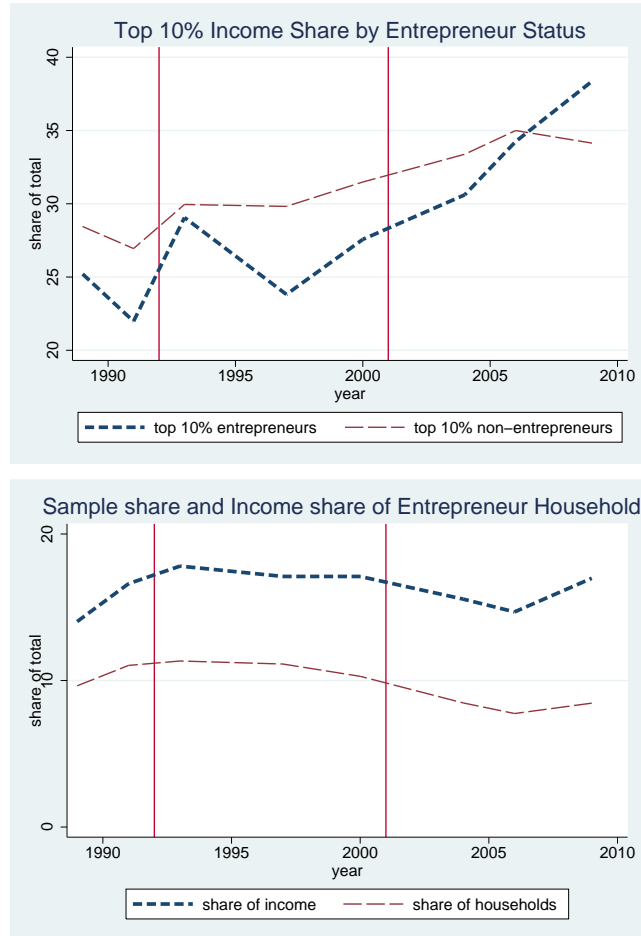
⁹Another round of survey was conducted in 2011. However, the sample from this year is systematically different from those in other years in terms of region coverage and sample size.

unrelated employee. I classify all other households as “worker households.” This classification is consistent with the model in Chapter 2, in the sense that the income of an “entrepreneur” is tied to the performance of the firm and their income risk is uninsurable. With the above definitions, I classify about 350 households as “entrepreneur households” in each year. Panel B of Figure 4.3 plots the number of entrepreneur households as a share of total sample size, as well as the share of total income received by the entrepreneur households. The share of entrepreneur households declined slightly from about 11% in the early 1990s to 8.5% in 2009, while the income share received by entrepreneur households follows a similar but milder trend over the period. Not surprisingly, the average income of entrepreneur households is substantially higher than non-entrepreneur households, as indicated by the gap between the two lines in Panel B of Figure 4.3.

For each year, I then calculate the share of total entrepreneur income received by the top 10% (in terms of income) entrepreneur households. The average number of entrepreneur household is about 350, and I am calculating the income share of the top 10% of these 350 entrepreneurs.¹⁰ I also calculate the share of total worker income received by the top 10% (in terms of income) worker households. Figure 4.3 plots these top 10% income shares. While Figure 4.3 is consistent with Figure 4.2, it also suggests that the increase in top income shares is more substantial for entrepreneur households than for worker households. According to the data, for entrepreneur households, the top 10% income share increased from 25.2% in 1989

¹⁰I drop households at random to ensure that the group sizes are multiples of 10 to minimize rounding errors.

Figure 4.3: Top Income Shares by Entrepreneur Status in China (1988-2009)



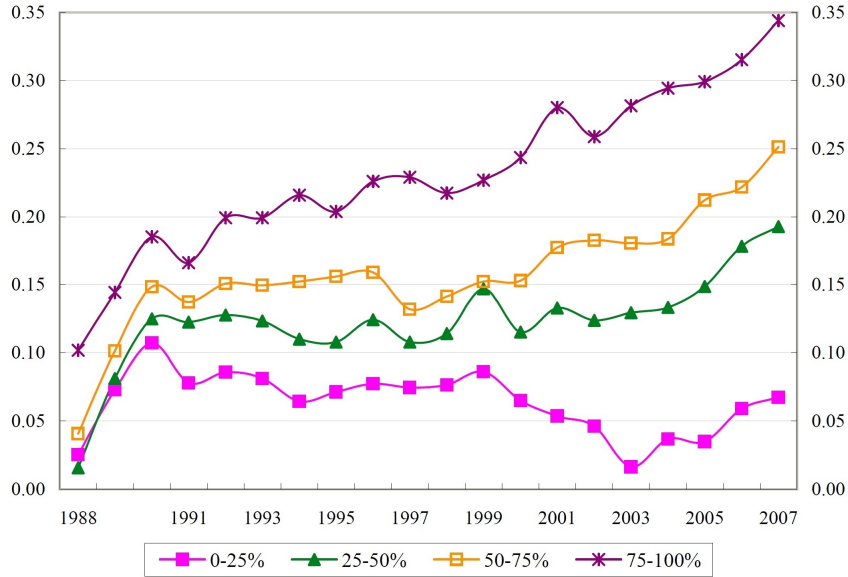
Source: CHNS

to 38.4% in 2009. For worker households, the top 10% income share increased from 28.5% to 33.3%.

Saving Rate and Income

It is well known that higher-income households tend to have higher saving rates. Figure 4.4, taken from Yang et al. (2012), plots the history of the average saving rate by household income quartile. Two main lessons can be drawn from Figure 4.4. First, in line with evidence from other countries, the average household

Figure 4.4: Saving Rate by Household Income Quartile (1988-2007)



Source: Yang et al. (2012) using Data from CUHS

saving rate is strongly correlated with household income in the cross section in any year. In 2007, the average saving rate of households in the highest income quartile is about 28 percentage points higher than in the lowest income quartile. Second, while there was a large increase in the average saving rate of households in the highest income quartile, the increase in the average saving rate for households in the middle income quartiles is more modest. The average saving rate for the households in the lowest income quartile does not have a clear trend over the period. It is also important to note that the increase in the average saving rate in the upper income quartiles can be driven by an increase in inequality within the quartiles, due to the composition channel highlighted in this dissertation.¹¹ Overall, Figure 4.4 points to the importance of income distribution and the saving behaviors of high-income

¹¹This hypothesis can be checked with the CUHS. Unfortunately, the CUHS data are not publicly available.

households in understanding the changes in the overall household saving rate in China.

Researchers have noted that the household saving rate calculated from typical household surveys is typically much lower than that from the aggregate data in the flow of funds accounts. While different definitions of income and consumption may also play a role, the discrepancy is mostly attributed to the low survey response rate by high-income households who have higher propensity to save (Chamon et al., 2013). In view of Figure 4.4, it is useful to study the household saving rate in China with data on the saving behaviors of high-income households. I turn to data from the China Household Finance Survey (CHFS), conducted by Southwest University of Finance and Economics. The China Household Finance Survey employs a multi-stage stratified random sample design and is unique in its extensive coverage of high-income households in China.^{12,13} The first wave of the survey was conducted in the summer of 2011 and collected extensive information on the income and consumption of 8438 households in 2010.

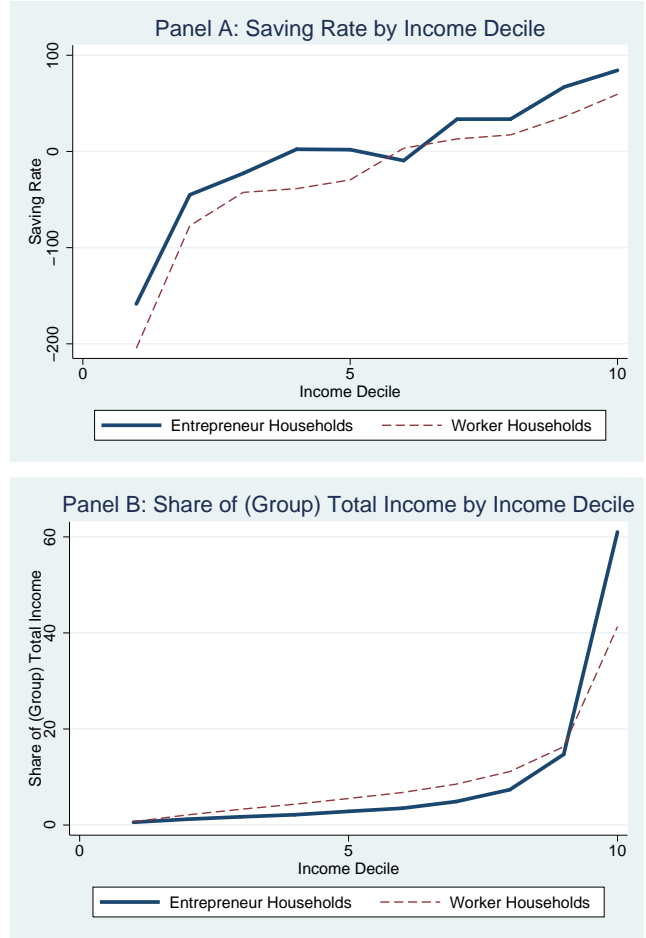
Following the same definitions as before, I group all the households in the CHFS data into entrepreneur households and worker households. For each type of household, I calculate the average saving rate for each income decile.¹⁴ As shown in Panel A of Figure 4.5, the average household saving rate is much higher for the

¹²A comparable survey in the US is the Survey of Consumer Finances.

¹³In the CHFS data released to researchers, household disposable income is top-coded at 3,000,000 yuan (about 440,000 US dollars in 2010), which is much larger than in other households surveys in China.

¹⁴In the following calculations, I exclude households with negative income. I also exclude a household if the total consumption of the household is more than ten times their household disposable income. Inclusion of these households with very negative saving rates in the calculations does not affect the conclusions in this section quantitatively.

Figure 4.5: Saving Rate and Income Share by Income Decile



Source: CHFS

top income deciles than for the lower income deciles. The average household saving rate is in fact negative for many of the lower income deciles, for both entrepreneur households and worker households.¹⁵ This is consistent with the report on the initial findings from the CHFS data by Gan (2013). In contrast, the average household saving rate is 84.3% for the top 10% entrepreneur households and 59.5% for top 10% worker households. Panel B of Figure 4.5 plots the income received by households in each decile as a share of the group total, for entrepreneur households and

¹⁵The average saving rates for the 1st entrepreneur income decile, and for the 1st and 2nd worker income deciles are not plotted in Panel A because they are significantly lower than -100%.

worker households respectively. According to the CHFS data, the share of total entrepreneur income received by the 10% households is 61.0%, while the share of total worker income received by the top 10% households is 41.3% in 2010.¹⁶

4.3 Inequality and the Household Saving Rate

Panel A of Figure 4.3 shows that the income shares received by the top 10% entrepreneur households and top 10% worker households have increased during the integration of China into the world economy, while Panel A of Figure 4.5 shows that top income households have much higher saving rates than the rest of population. Although both Justin Lin Yifu (2012) and Li Gan (2013), two influential scholars on the Chinese economy, have used the saving-rate-income relationship to propose a relationship between the rising Chinese saving rate and increased inequality, it is not clear whether the mechanism is quantitatively important. In the present subsection, I attempt to answer this question.

4.3.1 Evidence from Household Surveys

This section examines whether there is a positive correlation between inequality and the household saving rate in China using household survey data. The literature which examines the correlation between the aggregate saving rate and income inequality at the country level, for example Schmidt-Hebbel and Serven (2000) and

¹⁶The top income shares in the 2010 CHFS data are much higher than those in the 2009 CHNS data. While different survey years and geographic coverage are likely to play a role, a more important explanation is that top income shares in the CHNS data are likely underestimated due to the low survey response rate of high-income households. See Luo (2012) for a critical discussion of the CHFS data.

Table 4.1: Household Saving Rate and Inequality Across Chinese Counties

	(1)	(2)	(3)	(4)
Panel A: County Level Regressions				
Dependent Variable is County-level Household Saving Rate				
Inequality Measure	Top 10% Share		Gini Coefficient	
Inequality within County	0.589*** (0.135)	0.562*** (0.136)	0.371*** (0.104)	0.364*** (0.106)
Log County Average Income	12.44*** (2.067)	13.57*** (2.205)	13.75*** (2.174)	14.76*** (2.272)
Controls	No	Yes	No	Yes
Province-Year FE	Yes	Yes	Yes	Yes
N Counties	203	203	203	203
Panel B: Household Level Regressions				
Dependent Variable is Individual Household Saving Rate				
Inequality Measure	Top 10% Share		Gini Coefficient	
Inequality within County	-0.0167 (0.239)	0.0259 (0.229)	0.0529 (0.202)	0.106 (0.202)
Log Household Income	51.58*** (16.67)	52.31*** (16.87)	51.57*** (16.65)	52.31*** (16.86)
Controls	No	Yes	No	Yes
Province-Year FE	Yes	Yes	Yes	Yes
N Counties	203	203	203	203
N households	16445	16445	16445	16445

Robust standard errors are reported in parentheses. The standard errors in Panel B are clustered at county level. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. The set of control variables in Columns (2) and (4) include shares of population younger than 20, primary age population, sex ratio and share of SOE employment in total employment at the county level.

Cook (1995), is inconclusive. A difficulty in the literature is that the measures of inequality used are constructed from household-level surveys in different countries with potentially incompatible survey designs. In this section, I construct the household saving rate and inequality measures at the county level from a single household data set. I turn to data from China Household Income Project (CHIP), conducted by a group of Chinese and international researchers with assistance from National Bureau of Statistics.¹⁷ I use data from three years, 1995, 2002 and 2007.¹⁸ I construct the household saving rate, share of total income received by the top 10% households and the Gini coefficient using the CHIP data.¹⁹ This approach ensures that these key variables are constructed consistently across all Chinese counties. The disadvantage is that each county-level value is calculated from a relatively small number of households. I drop counties with fewer than 30 households. In constructing the top 10% income share, I drop some households at random to ensure that the number of households in each county are multiples of 10.²⁰ Lastly, I construct a set of control variables from the same data, including the share of population younger than 20, the share of population of primary age population, sex ratio and share of SOE employment in total employment at the county level.

In Panel A of Table 4.1, I analyze the relationship between the household saving rate and measures of inequality at the county level. In addition to a measure

¹⁷<http://www.ciidbnu.org/chip/index.asp>

¹⁸I did not use data from 1988 as the 1988 survey questionnaire omitted important consumption items compared to the later surveys.

¹⁹Recall that the household saving rate at the county level is defined as one minus the ratio between average household consumption and average household income.

²⁰For a county with 50 households, I then calculate the share of total income received by the five households with the highest income.

of inequality, I include the log of average household income as a key right-hand-side variable. Since different counties are covered in each year, I cannot use county fixed effects. Instead, I use province-year fixed effects in the regressions. As shown in Column (1), the positive correlation between the county-level household saving rate and the share of income received by the top 10% households is statistically different from zero at 1%. A 10-percentage-points increase in the top 10% income share is associated with an increase of 5.89 percentage points in the household saving rate. This is a very large effect. In Column (2), I add additional controls and find that the coefficient on inequality is not affected. In Column (3) and Column (4), I find that the results are unchanged when I use the Gini coefficient as the measure of inequality.

The positive correlation between the household saving rate and income inequality in Panel A is suggestive of the theoretical mechanism advanced in this dissertation, but an alternative mechanism is capable of generating this positive correlation. Jin, Li, and Wu (2011) find in household-level regressions that household consumption is negatively correlated with income inequality after controlling for household income. They rationalize their results using status-seeking motives. Therefore, one important question is whether inequality is correlated with the household saving rate at the household level in my data.²¹ I address this question in Panel B. I conduct regressions similar to those in Panel A but at the household level. More precisely, I use the saving rate and log of income of individual households, but keep

²¹This is the same as asking if the inequality is correlated with the unweighted average of individual household saving rate at the county level.

the rest of the county-level variables unchanged. The coefficient on the inequality measure is not statistically different from zero in any specification. This shows that the income inequality at the county level is not correlated with the across-the-board household saving rates (the unweighted average).

4.3.2 Changes in Income Distribution and the Household Saving Rate: A Simple Exercise

Table 4.2: Income Distribution and Household Saving Rate

Panel A: Quantities Assumed to be Time-variant			
Entrepreneur Households' Saving Rate: Top 10%			84.3%
Entrepreneur Households' Saving Rate: Bottom 90%			31.1%
Worker Households' Saving Rate: Top 10%			59.5%
Worker Households' Saving Rate: Bottom 90%			2.5%
Entrepreneurs' Share of Total Income			32.1%
Panel B: Experiments and Results			
Experiment:	(1)	(2)	(3)
Increase in Top 10% Entrepreneurs' Share	10.0%	15.0%	20.0%
Increase in Top 10% Workers' Share	5.0%	7.5%	10.0%
Change in Saving Rate of Entrepreneurs	5.3%	8.0%	10.6%
Change in Saving Rate of Workers	2.9%	4.3%	5.7%
Change in Household Saving Rate	3.6%	5.5%	7.3%

In this subsection, I conduct a simple exercise to demonstrate the quantitative importance of the mechanism. I divide all the households into four groups, top 10% entrepreneur households, bottom 90% entrepreneur households, top 10% worker households, and bottom 90% worker households. I am interested in the following question: holding the household saving rate of each group fixed, and holding the share of total income received by the entrepreneur households constant, to

what extent can an increase in the top 10% income share (within each respective occupation group) affect the household saving rate?

I consider an experiment in which the income share of the top 10% entrepreneur households increases by 15 percentage points while the income share of the top 10% worker households increases by 7.5 percentage points. These numbers are chosen to be comparable to the actual increases observed in Panel A of Figure 4.3. I also consider two additional experiments with different changes in the distribution of income.

Table 4.2 summarizes the experiments and the results. Depending on the experiments considered, the household saving rate in China increases by 3.6, 5.5 and 7.3 percentage points respectively. Therefore, the simple exercise in Table 4.2 suggests that the rise in top income shares can have a quantitatively important effect on the household saving rate in China. For comparison, Chamon et al. (2013) find that the increase in income uncertainty and the reform of the pension system from 1997 to 2007 can account for a 5.3 percentage-points increase in the household saving rate in China. I now turn to the relationship between openness and the household saving rate.

4.4 Openness and the Household Saving Rate in China

In 1992, Deng Xiaoping, the secretary-general of the Communist Party, unveiled a number of policy initiatives to accelerate the outward-oriented liberalization of the Chinese economy. Over the course of the 1992 liberalization, provinces on

the coast experienced much greater increase in international trade and net FDI. I exploit a province's differential increase in openness according to its distance to the coast and analyze the relationship between the household saving rate and openness in a panel of provinces over 1981-2000. I exclude the years after 2000, as China undertook a massive infrastructure project to develop its western provinces in 2000 (Tian, 2004).²²

4.4.1 Empirical Strategy

I test the hypothesis that greater openness increases the household saving rate using provincial-level panel data. I propose an empirical strategy using the 1992 trade liberalization episode in China. This empirical strategy is similar to Han, Liu, and Zhang (2012), who study wage inequality by contrasting wages between high-exposure provinces and low-exposure provinces. My main specification is

$$S_{it} = \beta_0 + \beta_1 \log(\text{DCoast})_i \times \text{Post92}_{it} + \beta_2 X_{it} + c_i + \mu_t + v_{it}, \quad (4.1)$$

where S_{it} is the household saving rate, $\log(\text{DCoast})_i$ is the log of a province's distance to the coast and used as a proxy for access to foreign markets, Post92_{it} is a dummy variable that takes a value of one for years after 1992, X_{it} is a vector of control variables, and c_i and μ_t are province and time fixed effects, respectively. Following Wei and Zhang (2011), the independent variables in X_{it} include the sex ratio of the population aged 7-21, the share of population younger than 20, the share of

²²Moreover, China's accession into the World Trade Organization in 2001 is another watershed event in China's embrace of globalization (Branstetter and Lardy, 2006).

population of primary age, the share of population enrolled under social security, and the share of state-owned-enterprises (SOE) employment in total employment. Since current income is endogenous to the household saving rate, I lag the log of income by four years in the baseline regression, but use the log of contemporaneous income as a robustness check. According to the theory outlined in Chapter 2, $\beta_1 < 0$.

The results from Equation 4.1 would indicate whether greater openness has a statistically significant effect on the household saving rate. However, it is harder to interpret the magnitude of the results from Equation 4.1. To facilitate the interpretation, I study the following specification:

$$S_{it} = \alpha_0 + \alpha_1 \text{Open}_{it} + \alpha_2 X_{it} + c_i + \mu_t + v_{ijt}, \quad (4.2)$$

where Open_{it} is a measure of openness. I instrument for openness with the interaction term $\log(\text{DCoast})_i \times \text{Post92}_{it}$. The exclusion restriction of the IV strategy is that distance to the coast affects the household saving rate only through openness. This is similar to the empirical approach in Wei and Wu (2001), who study the effects of globalization on urban-rural income inequality in Chinese municipalities.²³

In implementing Equation 4.2, I use two different measures of openness, the Trade/GDP ratio and the FDI/GDP ratio. The goal is not to separately identify the effects of trade openness vis-a-vis FDI openness. Instead, the Trade/GDP ratio and the FDI/GDP ratio are intended as two different measures of a broad concept of openness. This point is crucial in establishing the validity of the IV approach, since

²³More precisely, Wei and Wu (2001) use the minimum of the distance to Hong Kong or Shanghai as an instrument for changes in municipality openness over 1988-1993. I find that my measure of distance to the coast results in a stronger instrument for the period 1981-2000.

Chinese provinces closer to the coast not only had larger increases in international trade, but also had larger increases in foreign investment in the period under study.

Data Description

I use the dataset constructed by Wei and Zhang (2011) as my primary data source, and supplement the dataset with the Trade/GDP ratio, the FDI/GDP ratio and the gross investment rate from both national and provincial statistical books, and the distance to the coast of each province.²⁴ I exclude Chongqing from the analysis because it was administered as part of Sichuan Province until 1997. The Trade/GDP ratio of Beijing is abnormally large while data for the FDI/GDP ratio for Tibet are unavailable, and I drop these two provinces when appropriate.

4.4.2 Results

The regression results based on Equation 4.1 are presented in Table 4.3. According to Column (1), comparing the household saving rate before and after 1992, a province has a larger increase in the household saving rate, by 0.922 percentage point ($1.330 \times \ln(2) = 0.922$), than a province with twice the distance to the coast. The coefficient is statistically significant with a t-statistic of 4.45.

Column (2) of Table 4.3 controls for contemporaneous income instead of lagged income. Consistent with the findings in the literature (c.f. Wei and Zhang (2011)),

²⁴To measure a province's distance to the coast, I calculate the distance in kilometers of each city in the province to the nearest port city (which may be from a different province), and then take the average across the cities. I group the years from 1981-2000 into five 4-year intervals.²⁵ Since I use the log of coastal distance in the regressions, a city on the coast is assigned a coastal distance of 1 kilometer.

the household saving rate is strongly correlated with current income. The coefficient on $\log(\text{DCoast})_i \times \text{Post92}_{it}$ is reduced by half but remains statistically significant at 5.0%. This suggests that openness has a significant effect on the household saving rate beyond its effect on current income.

The results in Column (1) may be driven by the increased return to investment in the coastal provinces, as households save more aggressively to take advantage of the investment opportunity. Column (3) shows that the coefficient on $\log(\text{DCoast})_i \times \text{Post92}_{it}$ remains statistically significant at 1.0% when I control for the investment rate of a province.²⁶

A threat to the empirical strategy is the reform of SOEs in Chinese provinces. Column (4) drops the observations from 1997 to 2000 when the privatization of state-owned enterprises began (Bai, Lu, and Tao, 2009). The coefficient on the $\log(\text{DCoast})_i \times \text{Post}_{it}$ increases and is statistically significant at 1.0%.

Another alternative explanation is that households in the coastal provinces anticipated the faster increase in openness, and increased their saving rate to take advantage of future economic opportunities. The results in Column (1) of Table 4.3 may be a reflection of this hypothesis if the household saving rate is very persistent. In Column (5), I use the same independent variables as the baseline specification but use the lagged household saving rate as the dependent variable. The coefficient on interaction term is positive and statistically insignificant. This is at odds with the alternative explanation described above.

²⁶Defined as gross fixed capital formation as a share of GDP of the province.

Table 4.3: Household Saving Rate in China (1981-2000)

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	Cur-Y	Invest	Pre-1997	Lag	Lead
Log (Distance to Coast)	-1.330***	-0.603**	-1.184***	-1.543***	0.0973	-0.234
X Post 1992	(0.299)	(0.265)	(0.299)	(0.360)	(0.309)	(0.421)
Log Income (Lag)	5.379		4.862	5.477	23.66***	4.800
	(3.754)		(3.638)	(6.250)	(4.071)	(4.627)
Log Income (Current)		20.61***				
		(2.983)				
Investment Rate			0.153**			
			(0.0658)			
N Provinces	30	30	30	30	30	30
N Observations	146	149	146	116	146	146

Robust standard errors, clustered at provincial level, are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. We group the years from 1981-2000 into five non-overlapping 4-year intervals. All regressions control for the sex ratio of the population aged 7-21, the share of population younger than 20, the share of population of primary age, the share of population enrolled under social security, and the share of SOE employment in total employment. Column (1) presents the baseline results; Column (2) controls for (log of) current income; Column (3) controls for the investment rate; Column (4) excludes data between 1997 and 2000; Column (5) uses the lagged household saving rate as the dependent variable; Column (6) uses the future household saving rate as the dependent variable.

In Column (6), I use the future household saving rate as the dependent variable. The coefficient on the interaction term is positive but statistically insignificant. Taken together, Column (5) and Column (6) provide additional support that the differential increase in the household saving rate across Chinese provinces coincided with the 1992 liberalization.

Taken together, Table 4.3 demonstrates that the provinces closer to the coast had a larger increase in the household saving rate after 1992 than the interior provinces. This provides support for the hypothesis that greater openness increases the household openness in China. To relate the findings above to conventional measure of openness, I turn to the 2SLS results from estimating Equation 4.2.

Column (1) of Table 4.4 presents the OLS estimates of Equation 4.2 when I use the Trade/GDP ratio as the measure of openness. The coefficient on the Trade/GDP ratio is positive but statistically insignificant. The results from the corresponding 2SLS regression are presented in Column (2). The results from the first-stage regressions are reported in Panel B. In Column (2), the coefficient on the instrument is of the expected sign and statistically significant. The F-statistic for the excluded instrument is 5.1, indicating that the instrument is relatively weak. The 2SLS point estimate on the Trade/GDP ratio is positive and statistically significant at 5%. A one-percentage-point increase in the Trade/GDP ratio increases the saving rate by 0.440 percentage point. In the WDI data (Figure 4.1), the Trade/GDP ratio increases from 15.1% to 44.2% from 1982 to 2000. A naive extrapolation of the results in Column (2) indicates that the increase in openness over the period in China can result in an increase of the household saving rate by 12.8 percentage

Table 4.4: Household Saving Rate and Openness in China (1981-2000)

	(1)	(2)	(3)	(4)
Panel A: OLS and 2SLS Regressions				
	Trade/GDP		FDI/GDP	
Specification	OLS	2SLS	OLS	2SLS
Openness	0.0598	0.440**	0.473***	0.633***
	(0.0385)	(0.198)	(0.0974)	(0.139)
Log Income (Lag)	11.64***	-3.659	6.496	4.189
	(2.814)	(7.903)	(4.148)	(3.880)
Panel B: First Stage Regressions				
Log (Distance to Coast)		-2.995**		-1.943***
X Post 1992		(1.329)		(0.215)
Log Income (Lag)		19.29		1.068
		(12.00)		(2.796)
Excluded IV F-stat		5.076		81.40
N Provinces	29	29	29	29
N Observations	141	141	136	136

Robust standard errors, clustered at provincial level, are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. We group the years from 1981-2000 into five non-overlapping 4-year intervals. All regressions control for the sex ratio of the population aged 7-21, the share of population younger than 20, the share of population of primary age, the share of population enrolled under social security, and the share of SOE employment in total employment. Columns (1)-(2) use the Trade/GDP ratio as the measure of openness while Columns (3)-(4) use the FDI/GDP ratio as the measure of openness.

points.

Columns (3) and (4) present the OLS and 2SLS results respectively when I use the FDI/GDP ratio as the measure of openness. Column (3) shows that the household saving rate is strongly associated with the FDI/GDP ratio in the OLS results. According to Column (4), when the FDI/GDP ratio is used as the measure of openness, the first stage regression is strong, with a F-statistic of 81.4 for the excluded IV test. The coefficient on the FDI/GDP ratio is positive and statistically significant at 1%. The household saving rate increases by 0.529 standard deviation for a one-standard-deviation increase in the FDI/GDP ratio, compared to an increase of 1.444 standard deviations for a one-standard-deviation increase in the Trade/GDP ratio.²⁷

Table 4.5 presents additional 2SLS robustness checks analogous to the specifications in Table 4.3. The 2SLS results are robust to controlling for current income, controlling for the investment rate, and exclusion of data from the period between 1997 and 2000. I do not find a statistically coefficient on the openness measure when I use the past or future household saving rate as the dependent variable. A caveat is that the first stage regression is even weaker when I control for current income or the investment rate in the specification with the Trade/GDP ratio as the measure of openness.

It is interesting to compare the results from using the two different measures of openness. Clearly, there is a stronger spatial pattern in the FDI/GDP ratio than

²⁷In the WDI data (Figure 4.1), the FDI/GDP ratio increases from 0.211% to 6.25% from 1982 to 1993, before declining to 3.2% in 2000.

Table 4.5: Household Saving Rate in China: Robustness of 2SLS Results

	(1)	(2)	(3)	(4)	(5)
	Cur-Y	Invest	Pre-1997	Lag	Lead
Panel A: Trade/GDP as the Measure of Openness					
Openness	0.269 (0.230)	0.390** (0.197)	0.428** (0.168)	-0.0235 (0.0870)	0.0690 (0.113)
Log Income (Lag)		-3.230 (7.309)	1.976 (8.389)	23.61*** (4.662)	3.805 (5.320)
Log Income (Current)	9.084 (14.19)				
Investment Rate		0.175 (0.129)			
Excluded IV F-stat	2.586	3.453	7.561	5.076	5.076
N Provinces	29	29	29	29	29
N Observations	144	141	112	141	141
Panel B: FDI/GDP as the Measure of Openness					
Openness	0.348*** (0.124)	0.571*** (0.141)	0.621*** (0.128)	-0.00946 (0.136)	0.123 (0.197)
Log Income (Lag)		4.170 (3.689)	4.012 (6.406)	21.64*** (3.661)	3.315 (4.216)
Log Income (Current)	18.19*** (3.500)				
Investment Rate		0.116** (0.0567)			
Excluded IV F-stat	100.1	97.87	33.85	81.40	81.40
N Provinces	29	29	29	29	29
N Observations	137	136	107	136	136

Robust standard errors, clustered at provincial level, are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. We group the years from 1981-2000 into five non-overlapping 4-year intervals. All regressions control for the sex ratio of the population aged 7-21, the share of population younger than 20, the share of population of primary age, the share of population enrolled under social security, and the share of SOE employment in total employment. Column (1) controls for (log of) current income; Column (2) controls for the investment rate; Column (3) excludes data between 1997 and 2000; Column (4) uses the lagged household saving rate as the dependent variable; Column (5) uses the future household saving rate as the dependent variable.

in the Trade/GDP ratio. This is consistent with the fact that a central part of the 1992 reform was to attract inflows of foreign capital, and many policies aimed at attracting FDI were first implemented in provinces on the coast. As a result, the first stage of the 2SLS regressions is much stronger when the FDI/GDP ratio is used as the measure of openness. I interpret the results in Table 4.2 and Table 4.5 as reflecting the effects of openness broadly defined, rather than the effects of the Trade/GDP ratio or the FDI/GDP ratio per se, since the different dimensions of openness are highly correlated with each other.²⁸

To further investigate whether the increase in the household saving rate is driven by higher returns to investment, I repeat the analysis in Table 4.3 but use the investment rate as the dependent variable. If the increase in household saving rate is mostly driven by greater returns to investment, we should see a more pronounced spatial pattern in the investment rate than in the household saving rate.

²⁸In this chapter, I consistently find that the FDI/GDP ratio to have a more significant effect on the household saving rate. One explanation is that the differential increase in the FDI/GDP ratio dominates the differential increase in the Trade/GDP ratio in the 1992 reform. Another potential explanation is that the data on the Trade/GDP ratio is less reliable on the FDI/GDP ratio. For example, the total trade of a province is calculated based on the place of firm registration, rather than the actual place of production and import destination.

Table 4.6: Investment Rate in China (1981-2000)

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	Cur-Y	Saving	Pre-1997	Lagged	Lead
Log (Distance to Coast)	-0.960*	-0.451	-0.458	-1.189*	-1.770**	1.166
X Post 1992	(0.556)	(0.473)	(0.572)	(0.645)	(0.716)	(0.877)
Log Income (Lag)	3.382		1.352	8.511	11.94	-3.357
	(5.799)		(5.872)	(6.199)	(7.175)	(8.759)
Log Income (Current)		19.35**				
		(7.985)				
Household Saving Rate			0.377*			
			(0.191)			
N Provinces	30	30	30	30	30	30
N Observations	146	148	146	116	145	146

Robust standard errors, clustered at provincial level, are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. We group the years from 1981-2000 into five non-overlapping 4-year intervals. All regressions control for the sex ratio of the population aged 7-21, the share of population younger than 20, the share of population of primary age, the share of population enrolled under social security, and the share of SOE employment in total employment. Column (1) presents the baseline results; Column (2) controls for (log of) current income; Column (3) controls for the household saving rate; Column (4) excludes data between 1997 and 2000; Column (5) uses the lagged investment rate as the dependent variable; Column (6) uses the future investment rate as the dependent variable.

According to Column (1) of Table 4.6, comparing the investment rate before and after 1992, a province has a larger increase in investment, by 0.665 percentage point ($0.960 \times \ln(2) = 0.665$), than a province with twice the distance to the coast. The coefficient is statistically significant at 10%. As in Table 4.3, the coefficient on $\log(\text{DCoast})_i \times \text{Post92}_{it}$ is approximately halved when I control for current income instead of lagged income in Column (2). In Column (3), when I control for the household saving rate, the coefficient on $\log(\text{DCoast})_i \times \text{Post92}_{it}$ is not statistically significant. This suggests that the relationship between openness and the investment rate in Column (1) of Table 4.6 may be a consequence of, rather than a cause of the relationship between openness and the household saving rate. Column (4) shows that the baseline investment rate results are robust to the exclusion of data from the period between 1997 and 2000. Column (5) indicates that the investment rate has risen in the coastal provinces prior to 1992, while Column (6) does not find a statistically significant effect of the interaction term on the future investment rate.

Table 4.7 presents the OLS and 2SLS results when I use the Trade/GDP ratio and the FDI/GDP ratio as measures of openness to study the relationship between openness and the investment rate. Comparing the 2SLS results from Table 4.7 with those from Table 4.4, I find that the relationship between openness and the household saving rate is stronger than that between openness and the investment rate in terms of statistical significance. In terms of magnitude, a one standard deviation increase in the Trade/GDP ratio increases the household saving rate by 1.444 standard deviations, and the investment rate by 0.684 standard deviation. A one standard deviation increase in the FDI/GDP ratio increases the investment rate

by 0.330 standard deviation, compared to an increase of 0.529 standard deviation in the household saving rate. Therefore, reminiscent of the empirical results in Chapter 3, the relationship between the household saving rate and openness appears to be stronger than the relationship between the investment rate and openness.

Table 4.7: Investment Rate and Openness in China (1981-2000)

	(1)	(2)	(3)	(4)
Panel A: OLS and 2SLS Regressions				
Measure of Openness:	Trade/GDP		FDI/GDP	
Specification	OLS	2SLS	OLS	2SLS
Openness	0.0146 (0.0969)	0.287 (0.207)	0.615*** (0.170)	0.543** (0.257)
Log Income (Lag)	8.519 (5.726)	-2.453 (8.344)	-0.861 (7.261)	0.167 (6.046)
Panel B: First Stage Regressions				
Log (Distance to Coast)		-2.995**		-1.943***
X Post 1992		(1.329)		(0.215)
Log Income (Lag)		19.29 (12.00)		1.068 (2.796)
Excluded IV F-stat		5.076		81.40
N Provinces	29	29	29	29
N Observations	141	141	136	136

Robust standard errors, clustered at provincial level, are reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. We group the years from 1981-2000 into five non-overlapping 4-year intervals. All regressions control for the sex ratio of the population aged 7-21, the share of population younger than 20, the share of population of primary age, the share of population enrolled under social security, and the share of SOE employment in total employment. Columns (1)-(2) use the Trade/GDP ratio as the measure of openness while Columns (3)-(4) use the FDI/GDP ratio as the measure of openness.

4.5 Conclusion

In this chapter, I test the hypothesis that the integration of China into the global economy contributed to the rising household saving rate in China through the effect of globalization on income inequality. Using data from various household surveys, I show that top income shares have increased over the past thirty years in China. Furthermore, the saving rate of high-income households is much higher than that of lower-income households. Lastly, using provincial-level panel data and exploiting the 1992 trade liberalization in China to develop an IV strategy, I show that greater openness has a large effect on the household saving rate of a province.

Some important modifications are needed in order to use the model to explain quantitatively the rise in household saving in China. Data from household surveys find that although the saving rates of worker households are lower than those of entrepreneur households, worker households contribute substantially to overall household saving in China. Additionally, wage inequality among worker households is large and appears to be increasing with greater openness. Lastly, besides the inequality channel emphasized in this dissertation, the saving rate of the highest-income households appears to be an important driver of the rise in the overall household saving rate. To explain the saving behavior of these households with very high incomes, it would be interesting to introduce wealth-in-utility preferences into the model. I plan to incorporate these elements in future research.

Chapter 5: Conclusion

I propose a mechanism linking top income inequality and the gains from trade, through the effects of trade on aggregate saving. I calibrate the model to US data and show that the supply-side channel of capital accumulation is quantitatively relevant for the evaluation of the gains from trade.

I test the key predictions from the model using country-level data and find strong support for the proposed mechanism. While the empirical results in the third chapter suggest that the proposed mechanism is relevant for a typical country, the mechanism is particularly interesting when we consider the recent experience of China. China's recent integration into the global economy coincided with a rise in top income shares (Piketty and Qian, 2009) and a rise in the aggregate saving rate (Yang, 2012). Using the 1992 liberalization episode in China, I find that greater openness has positive and statistically significant effects on both the household saving rate and the investment rate of a province.

In the theoretical model, to focus on the interaction between top income inequality and the gains from trade for the average worker, I have abstracted from worker heterogeneity. Introducing worker heterogeneity would allow me to consider a setting where workers differentially benefit from the increase in capital accumulation

according to their skill levels. Lastly, as discussed earlier, allowing for international capital flows would allow me to examine the distribution of the gains from trade between countries. I leave these interesting topics for future research.

Appendix 2A: 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

$$E = \frac{w \cdot L_v}{1 - \alpha} \cdot \frac{\sigma}{\sigma - 1}. \quad (2A.1)$$

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 (2A.1).
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 2B: Proof of Propositions

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

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

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

Proof:

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

The following algebraic properties are useful in the proofs.

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

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

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

Proof of Proposition 1.

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

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

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

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

By Lemma (1),

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

which implies

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

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

$w \cdot f_X \int_{z_x}^{\infty} \mu(dx)$. From Property (1),

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

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

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

From Property (2), I obtain

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

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

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

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

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

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

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

From Property (3),

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

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

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

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

increases.

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

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

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

$$\frac{w_A}{w_A + \left(\frac{w_A \cdot \alpha}{1-\alpha} + \frac{\sigma}{\sigma-1} \frac{w_A}{1-\alpha}\right)} = (1-\alpha) \frac{\sigma-1}{2\sigma-1} \quad (2B.1)$$

Analogously under Trade, the share of total income received by workers is given by

$$\begin{aligned} & \frac{w_T}{(L_v^T \cdot w_T + \text{pctX} w_T f_X) + \left(\frac{L_v^T \cdot w_T \cdot \alpha}{1-\alpha} + \frac{\sigma}{\sigma-1} \frac{L_v^T w_T}{1-\alpha} - \text{pctX} w_T f_X\right)} \quad (2B.2) \\ = & \frac{w_T}{(L_v^T \cdot w_T) + \left(\frac{L_v^T \cdot w_T \cdot \alpha}{1-\alpha} + \frac{\sigma}{\sigma-1} \frac{L_v^T w_T}{1-\alpha}\right)} \quad (2B.3) \\ = & \frac{1}{L_v^T} (1-\alpha) \frac{\sigma-1}{2\sigma-1} \quad (2B.4) \end{aligned}$$

The value in Equation (2B.4) is lower than that in Equation (2B.1) by inspection.

Appendix 2C: Decomposition Exercises

2C.1 Decomposition of Change in the Aggregate Saving Rate

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

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

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

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

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

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

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

In a stationary equilibrium, we have $K = K'$. Therefore, we have $C = \Pi + rK$. The left hand side is consumption while the right hand side is total income, which consists of total profit income and total interest income. The aggregate saving rate

of entrepreneurs is given by $SR_s = \frac{\Pi+rK-C}{\Pi+rK} = 0$, $\{s=A, T\}$. Therefore, when we compare the stationary equilibria under Autarky and under Trade, the aggregate saving rate by entrepreneurs is necessarily the same at 0.¹

Let the average saving rate of entrepreneurs with productivity z be $sr_s(z) = \frac{y_s(z)-c_s(z)}{y_s(z)}$. Then the aggregate saving rate equals $SR = \frac{\int y_s(z)-c_s(z)\mu(dz)}{\int y_s(z)\mu(dz)} = \int sr_s(z) \cdot share_s^y(z)\mu(dz)$ where $y_s(z)$ is the average income of all entrepreneurs with productivity z ,² and $share_s^y(z) = \frac{y_s(z)}{\int y_s(z)\mu(dz)}$. Following Olley and Pakes (1996),

$$\begin{aligned} SR_T - SR_A &= \int sr_A(z)(share_T^y(z) - share_A^y(z))\mu(dz) \\ &+ \int (sr_T(z) - sr_A(z))share_A^y(z)\mu(dz) \\ &+ \int (sr_T(z) - sr_A(z))(share_T^y - share_A^y(z))\mu(dz) \end{aligned} \tag{2C.1}$$

The first term in Equation (2C.1) is the “between” change in the saving rate, which is the change in the saving rate if we hold the average saving rate of all entrepreneurs of a given z fixed at its level under Autarky, but change the income shares to their levels under Trade. The second term is the “within” change in the saving rate, which is the change in the saving rate if we fix the income share of all

¹Moving from Autarky to Trade, the gross saving rate of the economy increases. The aggregate capital stock in the economy is K . In each period, δK amount of capital is depreciated, and the same amount must be saved to maintain the capital stock at K . Therefore, the gross saving rate of the economy in steady state is given by $\frac{\delta K}{Y}$. Since K increases more proportionally than Y from Autarky to Trade in the calibration exercise, the gross saving rate $\frac{\delta K}{Y}$ is higher under Trade than under Autarky. It is helpful to note that the replacement of depreciated capital is carried out by financial intermediaries instead of by entrepreneurs in the model, and entrepreneurs earn the net return of saving r (instead of “ $R = r + \delta$ ”).

²The average is taken over entrepreneurs with different a . I am grouping the entrepreneurs by z instead of by (a, z) because the joint distribution of (a, z) is an endogenous object. It is not possible to match the entrepreneurs by (a, z) between the equilibria under Autarky and under Trade.

entrepreneurs at a given z at its level under Autarky, but change the saving rates to their levels under Trade. In the baseline calibration of the full model, I find the “between” change to be 1.72 percentage points and the “within” change to be -1.83 percentage points. The last term is a co-variance term relating changes in income shares to changes in the individual saving rate. The covariance term is 0.11 percentage point in the current application.

2C.2 Decomposition of Change in the Target-Wealth-to-Profit Ratio

Recall that $a'_s(a, z), s = \{A, T\}$ is the asset policy function of an entrepreneur with asset a and productivity z , where the subscript s is added to emphasize that the policy function is dependent on the trade regime, and A and T denote “Autarky” and “Trade” respectively. Define $a_s^*(z)$ to be such that $a'_s(a_s^*(z), z) = a_s^*(z)$. The target wealth $a_s^*(z)$ of an entrepreneur is the steady state asset holding if the entrepreneur were to receive the same z forever.³ Let the profit of an entrepreneur with productivity z be $\pi_s(z)$, $s = \{A, T\}$. The target-wealth-to-profit ratio $m_s(z) = \frac{a_s^*(z)}{\pi_s(z)}$, $s = \{A, T\}$, is a measure of the incentive to save at each productivity level.^{4,5}

Let $M_s = \frac{\int a_s^*(z)\mu(dz)}{\int \pi_s(z)\mu(dz)}$, $s = \{A, T\}$ be the aggregate target-wealth-profit ratio. In

³CRRA utility guarantees that $a_s^*(z)$ is bounded for all z (Krueger, 2012). Numerically, $a_s^*(z)$ is obtained by starting at $a = 0$ and iterating on the asset policy function $a'_s(a, z)$ until $a'_s(a, z) = a$.

⁴The actual wealth-to-profit ratio at a given z is not a good measure of incentive to save for entrepreneurs. For example, if an entrepreneur receives a low productivity draw after a long series of high productivity draws, the wealth-to-profit ratio would be very high, even though this entrepreneur would be actively dis-saving at the low z state. The ratio between aggregate target wealth and actual aggregate wealth is 1.09 and 1.08 under Autarky and Trade, respectively.

⁵I conduct a similar decomposition exercise based on the target-wealth-to-income ratio $\frac{a_s^*(z)}{y_s(z)}$, $s = \{A, T\}$, where $y_s(z)$ is the average total income of entrepreneurs with productivity z . This alternative approach produces similar results. I present the results based on $\pi_s(z)$ because some interest income in $y_s(z)$ is derived from wealth accumulated under different values of z .

the calibration exercise, $M_A = 11.9$ and $M_T = 12.3$. Define $share_s^\pi(z) = \frac{\pi_s(z)}{\int \pi_s(z)\mu(dz)}$, $s = \{A, T\}$. I obtain

$$M_s = \frac{\int a_s^*(z)\mu(dz)}{\int \pi_s(z)\mu(dz)} = \int \frac{\pi_s(z)}{\int \pi_s(z)\mu(dz)} \cdot \frac{a_s^*(z)}{\pi_s(z)}\mu(dz) = \int share_s^\pi(z)m_s(z)\mu(dz) \quad (2C.2)$$

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

$$\begin{aligned} M_T - M_A &= \int \left(share_T^\pi(z) - share_A^\pi(z) \right) \cdot m_A(z)\mu(dz) \\ &\quad + \int share_A^\pi(z) \cdot \left(m_T(z) - m_A(z) \right)\mu(dz) \\ &\quad + \int \left(share_T^\pi(z) - share_A^\pi(z) \right) \cdot \left(m_T(z) - m_A(z) \right)\mu(dz) \end{aligned} \quad (2C.3)$$

The first term Equation (2C.3) is the “between” change, which is the change in M if we fix $m_s(z)$ at its level under Autarky but change the profit shares to their levels under Trade. The second term is the “within” change, which is the change in M if we keep the profit shares at their levels under Autarky, but change $m_s(z)$ to its level under Trade. The last term is a co-variance term relating changes in profit shares to changes in the target-wealth-to-profit ratio. In my baseline calibration, the “between” component, the “within” component and the covariance term account for 152%, -46% and 6% of the change in the aggregate target-wealth-to-profit ratio between Autarky and Trade, respectively.

Appendix 3A: Data Sources

Table 3A.1: Data Sources for the Empirical Exercises in Chapter 3

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

Appendix 3B: Robustness of Panel Regressions with IV

Table 3B.1: Robustness of Fixed-Effects Panel Regressions with IV: Alternative Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
	K-Open	Current-Y	Growth	D-graph	Inflation	Balance	Gov-Size	
Panel A:			Gross National Saving Rate					
Trade/GDP	0.278*** (0.0788)	0.222* (0.123)	0.216** (0.0922)	0.224** (0.0939)	0.234** (0.0952)	0.103 (0.110)	0.175** (0.0883)	
Panel B:			Gross Investment Rate					
Trade/GDP	-0.0209 (0.0641)	-0.0923 (0.0915)	-0.0510 (0.0634)	-0.0525 (0.0668)	-0.0434 (0.0658)	0.0607 (0.0716)	-0.0338 (0.0629)	
N Countries	68	83	83	83	83	83	83	
N Observations	372	441	440	441	440	441	439	

Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively. I group the years 1961-2000 into eight five-year intervals and use the averages of yearly data in the regressions. Time and country fixed effects are included in all regressions. The instrument is the predicted trade share from a panel gravity regression (see text). The standard set of control variables include log income and its square (both lagged), the Credit/GDP ratio (lagged) and log population. Column (1) controls for capital account openness; Column (2) replaces the lagged income terms with current income terms; Column (3) controls for the GDP growth rate; Column (4) controls for old and young dependency ratios; Column (5) controls for the inflation rate; Column (6) controls for the trade balance; Column (7) controls for total government expenditure as a share of GDP.

Table 3B.2: Robustness of Fixed-Effects Regressions with IV

Exclusion of Subsamples

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subsample Excluded	None	E. Asia & Pacific	Europe & C. Asia	L. America & Caribbean	M. East & N. Africa	N. America	S. Asia	S.S. Africa
Panel A:				Gross National Saving Rate				
Trade/GDP	0.221** (0.0952)	0.179 (0.296)	0.305** (0.129)	0.151 (0.0966)	0.179** (0.0840)	0.246** (0.0988)	0.207** (0.0953)	0.313*** (0.0846)
Panel B:				Gross Investment Rate				
Trade/GDP	-0.0479 (0.0679)	-0.199 (0.207)	-0.0226 (0.0821)	-0.0847 (0.0707)	-0.0134 (0.0593)	-0.0167 (0.0599)	-0.0566 (0.0692)	-0.0381 (0.0588)
N Countries	83	73	65	67	75	81	78	59
N Observations	441	387	337	355	401	427	414	325

Column (1) reproduces Column (2) of Table 3.9. Robust standard errors are clustered at the country level and reported in parentheses. *, **, and *** denote statistical significance at 10%, 5% and 1%, respectively.

Bibliography

- D. Acemoglu and J. Robinson. The rise and fall of general laws of capitalism. *Working Paper*, 2014.
- F. Alcalá and A. Ciccone. Trade and productivity. *Quarterly Journal of Economics*, 119(2):613–646, 2004.
- G. Alessandria and H. Choi. Establishment heterogeneity, exporter dynamics, and the effects of trade liberalization. *Journal of International Economics*, forthcoming, 2014.
- G. Alessandria, H. Choi, and K. Ruhl. Trade adjustment dynamics and the welfare gains from trade. *Federal Reserve Bank of Philadelphia Working Paper Series*, 14-14, 2014.
- F. Alvaredo, A. Atkinson, T. Piketty, and E. Saez. The world top incomes database. 2011.
- J. Angrist and J.-S. Pischke. *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press, 2008.
- C. Arkolakis, A. Costinot, and A. Rodriguez-Clare. New trade models, same old gains? *American Economic Review*, 102(1):94–130, 2012.
- A. Atkinson, T. Piketty, and E. Saez. Top incomes in the long run of history. *Journal of Economic Literature*, 49(1):3–71, 2011.
- C.-E. Bai, J. Lu, and Z. Tao. How does privatization work in china? *Journal of Comparative Economics*, 37(3):453–470, 2009.
- Y. Bai and J. Zhang. Solving the Feldstein-Horioka puzzle with financial frictions. *Econometrica*, 78(2):603–632, 2010.
- J. Bakija, A. Cole, and B. Heim. Jobs and income growth of top earners and the causes of changing income inequality: Evidence from US tax return data. *Working Paper*, 2012.

- R. Baldwin. Measurable dynamic gains from trade. *Journal of Political Economy*, 100(1):162–74, February 1992.
- B. Bernanke. The global saving glut and the us current account deficit. *Board of Governors of the Federal Reserve System (US) Speech*, (Mar 10), 2005.
- A. Bernard, B. Jensen, S. Redding, and P. Schott. Firms in international trade. *Journal of Economic Perspectives*, 21(3):105–130, 2007.
- G. Bertola, R. Foellmi, and J. Zweimüller. *Income distribution in macroeconomic models*. Princeton University Press, 2006.
- F. Bourguignon. Pareto superiority of unegalitarian equilibria in Stiglitz’ model of wealth distribution with convex saving function. *Econometrica*, 49(6):pp. 1469–1475, 1981.
- L. Branstetter and N. Lardy. China’s embrace of globalization. *NBER Working Paper 12373*, 2006.
- F. Buera and Y. Shin. Financial frictions and the persistence of history: A quantitative exploration. *Journal of Political Economy*, 121(2):221–272, 2013.
- F. Buera, J. Kaboski, and Y. Shin. The macroeconomics of microfinance. *NBER Working Paper Series*, 17905, 2012.
- F. Buera, J. Kaboski, and Y. Shin. Macro-perspective on asset grants programs: Occupational and wealth mobility. *American Economic Review Papers and Proceedings*, 104(5):159–164, 2014.
- M. Cagetti and M. De Nardi. Entrepreneurship, frictions, and wealth. *Journal of Political Economy*, 114(5):835–870, 2006.
- C. Carroll. Why do the rich save so much? In J. B. Slemrod, editor, *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*. Harvard University Press, Cambridge, Mass, 2000.
- M. Chamon and E. Prasad. Why are saving rates of urban households in China rising? *American Economic Journal: Macroeconomics*, 2(1):93–130, 2010.
- M. Chamon, K. Liu, and E. Prasad. Income uncertainty and household savings in china. *Journal of Development Economics*, 105(0):164 – 177, 2013.
- T. Chaney. Distorted gravity: The intensive and extensive margins of international trade. *American Economic Review*, 98(4):1707–21, 2008.
- T. Choukhmane, N. Coeurdacier, and K. Jin. The one-child policy and household savings. *CEPR Discussion Papers*, 2013.
- G. L. Clementi and T. Cooley. Executive compensation: Facts. *Fondazione Eni Enrico Mattei Working Papers*, 478, 2010.

- C. Cook. Savings rates and income distribution: further evidence from LDCs. *Applied Economics*, 27(1):71–82, 1995.
- A. Costinot and A. Rodriguez-Clare. Trade theory with numbers: Quantifying the consequences of globalization. *NBER Working Paper Series*, 18896, 2013.
- J. De Loecker and F. Warzynski. Markups and firm-level export status. *American Economic Review*, 102(6):2437–2471, 2012.
- J. di Giovanni and A. Levchenko. Firm entry, trade, and welfare in Zipf’s world. *Journal of International Economics*, 89(2):283–296, 2013.
- E. Dinopoulos and B. Unel. Firm productivity, occupational choice, and inequality in a global economy. *Working Paper*, 2014.
- D. Dollar, T. Kleineberg, and A. Kraay. Growth, inequality, and social welfare: cross-country evidence. *World Bank Policy Research Working Paper*, (6842), 2014.
- K. Dynan, J. Skinner, and S. Zeldes. Do the rich save more? *Journal of Political Economy*, 112(2):397–444, 2004.
- J. Eaton and S. Kortum. Trade in capital goods. *European Economic Review*, 45(7):1195–1235, 2001.
- R. Feenstra, R. Lipsey, H. Deng, A. Ma, and H. Mo. World trade flows: 1962-2000. *NBER Working Paper Series*, 11040, 2005.
- R. Feenstra, R. Inklaar, and M. Timmer. PWT 8.0—a user guide. 2013.
- G. Felbermayr and J. Gröschl. Natural disasters and the effect of trade on income: A new panel IV approach. *European Economic Review*, 58:18–30, 2013.
- M. Feldstein and C. Horioka. Domestic saving and international capital flows. *Economic Journal*, 90(358):314–329, 1980.
- J. Feyrer. Trade and income-exploiting time series in geography. *NBER Working Paper Series*, 14910, 2009.
- R. Foellmi and M. Oechslin. Market imperfections, wealth inequality, and the distribution of trade gains. *Journal of International Economics*, 81(1):15–25, 2010.
- L. Foster, J. Haltiwanger, and C. Syverson. Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *American Economic Review*, 98(1):394–425, 2008.
- J. Frankel and D. Romer. Does trade cause growth? *American Economic Review*, 89(3):379–399, 1999.

- O. Galor and O. Moav. From physical to human capital accumulation: Inequality and the process of development. *Review of Economic Studies*, 71(4):pp. 1001–1026, 2004.
- L. Gan. Income inequality and an economy in transition. *Report on Findings from the China Household Finance Survey*, 2013.
- W. Gentry and G. Hubbard. Entrepreneurship and household saving. *The B.E. Journal of Economic Analysis and Policy*, 4(1):1–57, 2004.
- P. Goldberg and N. Pavcnik. Distributional effects of globalization in developing countries. *Journal of Economic Literature*, 45(1):39–82, 2007.
- F. Guvenen. Do stockholders share risk more effectively than nonstockholders? *Review of Economics and Statistics*, 89(2):275–288, 2007.
- R. Hall and C. Jones. Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics*, 114(1):83–116, 1999.
- J. Han, R. Liu, and J. Zhang. Globalization and wage inequality: Evidence from urban China. *Journal of International Economics*, 87(2):288–297, 2012.
- A. Harrison. Has globalization eroded labors share? some cross-country evidence. *Working Paper*, 39649, 2005.
- A. Harrison and A. Rodriguez-Clare. Trade, foreign investment, and industrial policy for developing countries. *Handbook of Development Economics*, 5:4039–4214, 2010.
- A. Harrison, J. McLaren, and M. McMillan. Recent perspectives on trade and inequality. *Annual Reviews of Economics*, 3(1):261–289, 2011.
- J. Haskel, R. Lawrence, E. Leamer, and M. Slaughter. Globalization and U.S. wages: Modifying classic theory to explain recent facts. *Journal of Economic Perspectives*, 26(2):119–40, 2012.
- D. Hummels. Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives*, 21(3):131–154, 2007.
- O. Itskhoki. Optimal redistribution in an open economy. *Society for Economic Dynamics Meeting Papers*, 967, 2009.
- Y. Jin, H. Li, and B. Wu. Income inequality, consumption, and social-status seeking. *Journal of Comparative Economics*, 39(2):191–204, June 2011.
- N. Kaldor. *Strategic factors in economic development*. New York State School of Industrial and Labor Relations, Cornell University, 1967.
- L. Karabarbounis and B. Neiman. The global decline of the labor share. *Quarterly Journal of Economics*, 61:103, 2014.

- D. Kaufmann, A. Kraay, and P. Zoido-Lobaton. Aggregating governance indicators. *World Bank Publications*, 2195, 1999.
- A. Kraay. Household saving in china. *World Bank Economic Review*, 14(3):545–570, 2000.
- D. Krueger. Macroeconomic theory. *Lecture Notes*, 2012.
- M. Kumhof, R. Rancière, and P. Winant. Inequality, leverage and crises. *American Economic Review*, forthcoming, 2014.
- S. Kuznets. Economic growth and income inequality. *American Economic Review*, 45(1), 1955.
- R. Levine and D. Renelt. A sensitivity analysis of cross-country growth regressions. *American Economic Review*, 82(4):942–63, 1992.
- J. Lin. *Demystifying the Chinese economy*. Cambridge University Press, 2012.
- N. Loayza, K. Schmidt-Hebbel, and L. Serven. What drives private saving across the world? *Review of Economics and Statistics*, 82(2):165–181, 2000.
- C. Luo. Dui “zhong guo jia ting bu ping deng bao gao” de ping lun [comments on “reports on China household income inequality”]. *Working Paper*, 2012.
- L. Ma. Globalization and top income shares. *Working Paper*, 2013.
- G. Mankiw, D. Romer, and D. Weil. A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107(2):407–437, 1992.
- K. Manova. Credit constraints, heterogeneous firms, and international trade. *Review of Economic Studies*, 80(2):711–744, 2013.
- M. Melitz. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725, 2003.
- M. Melitz and S. Redding. Firm heterogeneity and aggregate welfare. *NBER Working Paper Series*, 18919, 2013.
- F. Modigliani and S. Cao. The Chinese saving puzzle and the life-cycle hypothesis. *Journal of Economic Literature*, 42(1):145–170, 2004.
- S. Olley and A. Pakes. The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, 64(6):1263–1297, 1996.
- N. Pavcnik. Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants. *Review of Economic Studies*, 69(1):245–276, 2002.
- T. Piketty. *Capital in the Twenty-First Century*. Harvard University Press, 2014.

- T. Piketty and N. Qian. Income inequality and progressive income taxation in China and India, 1986–2015. *American Economic Journal: Applied Economics*, 1(2):53–63, 2009.
- T. Piketty and E. Saez. Income inequality in the United States, 1913–1998. *Quarterly Journal of Economics*, 118(1):1–39, February 2003.
- V. Quadrini. Entrepreneurship, saving, and social mobility. *Review of Economic Dynamics*, 3(1):1–40, 2000.
- D. Quinn and M. Toyoda. Does capital account liberalization lead to growth? *Review of Financial Studies*, 21(3):1403–1449, 2008.
- J. Roine, J. Vlachos, and D. Waldenstrom. The long-run determinants of inequality: What can we learn from top income data? *Journal of Public Economics*, 93(7):974–988, 2009.
- S. Rosen. The economics of superstars. *American Economic Review*, 71(5):pp. 845–858, 1981.
- E. Saez and G. Zucman. Wealth inequality in the United States since 1913: Evidence from capitalized income tax data. *NBER Working Paper Series*, 20625, Oct 2014.
- J. Santos Silva and S. Tenreyro. The log of gravity. *Review of Economics and statistics*, 88(4):641–658, 2006.
- K. Schmidt-Hebbel and L. Serven. Does income inequality raise aggregate saving? *Journal of Development Economics*, 61(2):417–446, 2000.
- I. Simonovska and M. Waugh. Trade models, trade elasticities, and the gains from trade. *NBER Working Paper Series*, 20495, Sept. 2014.
- R. Solow. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1):65–94, 1956.
- M. Song and D. Yang. Life cycle earnings and the household saving puzzle in a fast-growing economy. *Working paper*, 2010.
- Q. Tian. China develops its west: motivation, strategy and prospect. *Journal of Contemporary China*, 13(41):611–636, 2004.
- D. Trefler. The long and short of the Canada-U.S. free trade agreement. *American Economic Review*, 94(4):870–895, September 2004.
- UNU-WIDER. World income inequality database (WIID3.0b). 2014.
- S. Voitchovsky. Does the profile of income inequality matter for economic growth? *Journal of Economic Growth*, 10(3):273–296, 09 2005.

- R. Wacziarg. Measuring the dynamic gains from trade. *World Bank Economic Review*, 15(3):393–429, 2001.
- R. Wacziarg and K. Welch. Trade liberalization and growth: New evidence. *World Bank Economic Review*, 22(2):187–231, June 2008.
- X. Wang and Y. Wen. Can rising housing prices explain China’s high household saving rate? *Federal Reserve Bank of St. Louis Review*, (Mar):67–88, 2011.
- S.-J. Wei and Y. Wu. Globalization and inequality: Evidence from within China. 2001.
- S.-J. Wei and X. Zhang. The competitive saving motive: Evidence from rising sex ratios and savings rates in China. *Journal of Political Economy*, 119(3), 2011.
- World Bank. *World Development Indicators 2012*. The World Bank, 2012.
- D. Yang. Aggregate savings and external imbalances in China. *Journal of Economic Perspectives*, 26(4):125–146, 2012.
- D. Yang, J. Zhang, and S. Zhou. *Why Are Saving Rates So High in China?*, pages 249–278. University of Chicago Press, November 2012.