Globalization and Top Income Shares

Lin Ma*

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Abstract

This paper presents a new piece of empirical evidence showing that access to the global market, either through exporting or through multinational production, is associated with a higher executive-to-worker pay ratio within the firm in the U.S. It then builds a model with heterogeneous firms, occupational choice, and executive compensation to analytically and quantitatively evaluate the impacts of globalization on within-firm inequality and top income shares. In the model the compensation of an executive grows with the size of the firm, while the wage paid to ordinary workers is determined in a country-wide labor market. As a result, the extra profits earned in the foreign markets benefit the executives more than the average worker. I calibrate the model to the U.S. economy and study the impacts of globalization on top income shares with simulations. Counterfactual exercises suggest that this new channel can potentially explain around half of the observed surge in top income shares in the U.S. between 1988 and 2008.

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1 Introduction

The real income of the top 0.01 percent of the population increased by 118.5 percent between 1993 and 2011 in the United States, and the real income of the bottom 99 percent increased by only 5.8 percent over the same period.[1] Coincidentally, the past several decades also witnessed the fastest pace of globalization ever since the start of the First World War a hundred years ago. What is the link between globalization and the widening income gap between the very rich and the rest of the population? Unfortunately, the literature does not have a good answer. Researchers working on the distributional effects of trade usually focus on wage inequality and especially on the "skill premium," which is the wage difference between the skilled and unskilled workers.[2] However, the income of the top 0.01 percent – which usually consists of executive compensation, business profits, and capital gains – cannot be easily explained using the "skill premium." For example, numerous studies have shown that education level, a widely used measure of skill, has no clear correlation with CEO compensation.[3]

Complementing the literature on the "skill premium," this paper studies how globalization affects the income gaps between the very rich and the rest of the population. This paper first documents a novel empirical pattern that the income gaps between top executives and average workers are higher among exporting firms than among non-exporting firms in the United States. Motivated by the empirical findings, this paper develops a new model that incorporates occupational choice and executive compensation into a heterogeneous-firms trade model. The model is able to yield predictions that are consistent with the new empirical patterns at the firm level. At the aggregate level, the model is able to generate overall income and firm size distributions that closely resemble the U.S. data. I exploit this new feature to quantitatively analyze the impacts of globalization on CEO-to-worker pay ratio within a firm, and at the aggregate level, top income shares.

This paper creates a new dataset that matches executive compensation in both publicly-traded and privately-held firms to confidential firm level data on payroll and international

[1] Piketty and Saez [2003], with data updated to 2011.

[2] Among many others, see Goldberg and Pavcnik [2007], Helpman et al. [2010], and Burstein and Vogel [2012].

[3] For example, see Belliveau et al. [1996] and Geletkanycz et al. [2001] for details.

transactions from the U.S. Census Bureau. The resulting dataset covers around half of the public and private firms that are required by law to disclose executive compensations in the U.S, and it provides detailed information on firm-level executive compensations, employment, payroll, and export sales. To my knowledge this is the first dataset assembled that can be used to study the relationship between international trade and the CEO-to-worker pay ratio. Based on this data set, I find that on average the CEO-to-worker pay ratio within the same firm is around 41 to 50 percent higher among exporting and multinational firms than among domestic firms. Similar results can be found for the income gaps between other top executives and the average workers as well. These empirical findings suggest that globalization might be responsible for the widening income gaps between the rich and the poor through within-firm inequality, a channel that has rarely been explored. Moreover, I find that the "exporter premium" in CEO-to-worker pay ratio is mainly driven by the size premium of exporting and multinational firms. Once the size of the firm is controlled for, the between-group differences in within-firm inequality are no longer significantly different from 0. The link between within-firm inequality and size suggests that the empirical findings can be naturally rationalized in a model where the superiority in size is associated with exporting status.

I therefore propose a new framework that bridges the heterogeneous firm trade model based on Melitz [2003] and Helpman et al. [2004] with the literature of occupational choice and executive compensation. The model world consists of two countries. Each country is populated by a fixed measure of individuals who are endowed with different levels of human capital. Individuals can choose between different occupations, as in Lucas [1978]. They can either (1) create a new firm and become the founder and CEO of the firm or (2) work for an existing firm. If they choose to create a new firm, their human capital determines the productivity of the firm, and their income depends positively on the size of the firm they create. If they choose to be workers, their human capital determines the amount of efficiency labor they supply to the market. The wage rate of efficiency labor is determined in a competitive countrywide labor market and equalized across firms within the same country. In equilibrium, only the individuals with human capital above a certain threshold choose to create firms, while the majority of the population choose to be workers. The production and consumption sides of the economy are modeled following Helpman et al. [2004]. Each firm produces one variety of goods in a monopolistically competitive market. Firms have two options to sell to the foreign market: they can either export or set up subsidiaries abroad (horizontal FDI). Individuals cannot move across borders, and they consume a constant elasticity of substitution (CES) aggregate of all the available varieties in their country.

The model is able to replicate the new empirical pattern documented in this paper. In equilibrium, within-firm inequality is higher among the firms that sell to the foreign market. The key mechanism is that the extra profits earned in the foreign market are not distributed evenly within the same firm. The compensation paid to the CEO of a firm is linked to the sales of the firm, while the wage rate of a typical worker is determined in a countrywide labor market. Any extra profits earned in the foreign market directly benefit the CEO, but only benefit the workers through general equilibrium effects. In the end, as the firm sells to the foreign market, its within-firm inequality will be higher. On the aggregate level, trade creates a gap in within-firm inequality between the exporting and domestic firms. Consistent with the empirical patterns described above, in the model, the size of the firm solely determines the level of within-firm inequality; Once the size is controlled for, the exporting status of a firm has no impact on its CEO-to-worker pay ratio.

At the aggregate level, the contribution of the model is that it offers a parsimonious way to capture the U.S. income distribution and firm size distribution at the same time. Empirically, the U.S. income distribution is well approximated by an exponential distribution for the majority at the left end and a Pareto distribution for the right tail.[4] At the same time, the U.S. firm size distribution can also be well described by a fat-tailed Pareto distribution (Axtell [2001]). These two distributions are captured simultaneously within the model by two assumptions: (1) human capital is distributed exponentially, and (2) firm productivity is an exponential function of the founder's human capital. The model then features a Pareto firm size distribution and a two-class-structured income distribution. The workers' wage depends on their human capital, which implies an exponentially distributed income outside of the very rich. The individuals at the right tail of the income distribution are the CEOs, whose income is linked to the size of the firm they manage. This implies that the right tail

[4]See Drăgulescu and Yakovenko [2001a], Drăgulescu and Yakovenko [2001b], Clementi and Gallegati [2005], and Yakovenko and Silva [2005] for details.

of the income distribution will follow the firm size distribution and thus be Pareto. Once the model is calibrated, it reproduces both the firm size and the income distribution observed in the data with reasonable precision.

I quantitatively evaluate the impacts of globalization on top income inequality with this model. I first calibrate the model to match the U.S. economy in the late 2000s. I then study how income inequality responds to changes in trade barriers with counterfactual analysis. Going from autarky to the observed level of trade openness in 2008 roughly doubles the CEO-to-worker pay ratio at the largest firms in the U.S. At the aggregate level, the income distribution is more skewed to the right: the top 0.01 percent income share increases from 4.26 percent to 5.47 percent between autarky and trade. In another set of counterfactual analysis I vary the barriers-to-trade so that the exports-to-GDP ratio and multinational-firms-sales-to-GDP ratio in the model match their counter-parts in the U.S. data in each year between 1988 and 2008. All the other parameters are held constant, creating a counterfactual world where the only source of change is the access to the foreign market. The model-generated top income shares closely resemble the data. The correlation between the model-generated income share and the data is 0.90 for the top 0.01 percent. The adjusted R-squared of regressing the data sequence against the model-generated sequence is 0.79. In terms of magnitude, the surge in the top 0.01 percent income shares in the model is about 56 percent of the surge in the data. These analysis suggest that a sizable proportion of the observed surge in top income shares in the U.S. might be attributable to globalization.

This paper is related to several strands of literature. First, it contributes to the literature on the distributional effects of globalization, and the discussion on rising income inequality in the U.S. The majority of the existing research in the international trade literature focuses on how globalization affects wage inequality, and particularly the wage and income gap between skilled and unskilled workers.[5] Top income inequality, such as the income gap between top managers and workers and overall top income shares, is often overlooked in the trade literature. At the same time, researchers working on income inequality documented

[5] For example, see Feenstra and Hanson [1996], Manasse and Turrini [2001], Yeaple [2005], Helpman et al. [2010], and Egger and Kreickemeier [2012]. Bernard and Jensen [1997] documented that exporting is associated with higher within-firm inequality in terms of the wage gap between skilled and unskilled workers. This paper focuses on another dimension of within-firm inequality: the wage gap between top managers and workers.

that the rising income inequality in the U.S. is mainly driven by the widening gaps between the top 1 percent and the bottom 99 percent, not by the income inequality within the bottom 99 percent themselves. Moreover, papers in this literature showed that a substantial part of the rise in U.S. top income inequality is due to the rise in labor income inequality, especially when business income is included in the category of labor income.[6] This current paper bridges the gap between the two literature by focusing on the impact of globalization on top income inequality. It is the first paper to empirically show that the access to the world markets is indeed correlated with higher CEO-to-worker pay ratio within the same firm, and thus trade can potentially increase within-firm inequality, and subsequently, top income shares. This paper also quantitatively shows that a large part of the surge in top income shares in the U.S. can potentially be attributed to globalization.

Monte [2011] and Meckl and Weigert [2011] developed models that focus on the effects of trade on income inequality among the managers. The focus of this paper is different. Instead of the income inequality within managers, this paper focuses on the income gaps between the managers and the workers. As a result, the model here is designed to generate an empirically relevant income distribution that spans the entire population in general equilibrium, which has never been done before in the trade literature. This enables quantitative analysis of the aggregate impacts of globalization on income inequality, both within the right tail, and over the entire population.

This paper is also linked to the corporate governance literature that studies executive compensations, such as Roberts [1956], Baker and Hall [2004], Gabaix and Landier [2008], and Frydman and Saks [2010]. My paper contributes to this literature in a number of ways. This paper is the first to introduce census data to the study of executive compensation. Comparing to the existing literature which mostly focus on the level of executive compensation, the census data allow us to measure the magnitude of executive compensation by wages of ordinary workers within the same firm on a large and comprehensive sample, and thus provide a new perspective to understand the implications of surging executive pay on inequality.[7] This paper is also the first to study executive-to-worker pay ratio among privately-held

[6]Among many others, see Piketty and Saez [2003], Atkinson et al. [2011].

[7]It is possible to measure CEO-to-worker pay ratio without using the Census data as well. However, this usually leads to a biased and small sample of firms. This is discussed in detail in Section 2.

firms. A small strand of this literature, such as Sanders and Carpenter [1998], Oxelheim and Randøy [2005], Cuat and Guadalupe [2009], and Gerakos et al. [2009] documented that executive compensation in public firms increases as the firms start to participate in the global markets. This paper further documents that the positive link between executive compensation and globalization can also be observed at privately-held firms, though the magnitude is smaller. Lastly, this paper documents that globalization in itself might not directly lead to higher executive pay relative to the workers. Once the size of the firm is controlled for, the effect of exporting on CEO-to-worker pay ratio can hardly be observed.

The rest of this paper is organized as follows. Section 2 presents the empirical results. Section 3 presents the model and Section 4 focuses on the analytical results. Section 5 provides details of the calibration and quantitative results. Section 6 concludes.

2 Empirical Results

In this section, I document two novel empirical patterns: 1) the CEO-to-worker pay ratio is higher among exporting firms than non-exporting firms, and 2) this differences between exporting and non-exporting firms disappear once the size of the firm is controlled for. These two empirical patterns are robust to different measures of CEO pay and the size of the firm, and they can be consistently observed for both publicly-traded and privately-held firms in the U.S. These new empirical patterns motivate the choice of modelling devices in the next section.

2.1 Main Results: Public Firms

The empirical evidence for public firms is based on a linked data set that has three components: ExecuCompustat from Standard & Poor, the Longitudinal Business Database (LBD) from the Census Bureau, and the Longitudinal Firm Trade Transactions Database (LFTTD) from the U.S. Customs and the Census Bureau. Appendix A provides the details on constructing the data set.

This paper is the first to use census data in the study of executive compensation. The linked data set has several advantages relative to the data used in the existing literature. The first is the coverage of employment and payroll data. U.S. public firms are not required to disclose non-executive compensations. As a result, the majority of firms do not report total payroll expenditure in SEC filings, making it almost impossible to compute wages at the firm level and within-firm inequality. For example, as reported by Faleye et al. [2013], around 87 percent of firms have to be dropped from ExecuCompustat due to this missing value problem in their study of the CEO-to-worker pay ratio. The under-reporting also leads to distortions of sectoral representation in the sample. For example, around 43 percent of the sample in ExecuCompustat are manufacturing firms, but they only constitute 16 percent of the sample in Faleye et al. [2013]. In comparison, the LBD provides universal coverage of employment and payroll and thus minimizes the loss of observations. Overall, around 50 percent of the ExecuCompustat observations can be matched with the linked LBD-LFTTD, which is on par with most studies that use the Compustat-SSEL bridge provided by the census. The sectoral representation in ExecuCompustat is also preserved in the data set used in this paper (See Table A.1 for details). For example, in the linked data set, manufacturing firms constitute 47 percent of the sample, a significant improvement over the sample used in the existing literature. The second advantage of the linked data set is the identification of exporting firms. Again, as firms are not required to report export sales separately, the missing value problem is prevalent, forcing the researcher to discard a large proportion of the data set in studies that involve exporting behavior. This issue is solved by using the LFTTD, which provides universal coverage of U.S. international transactions and thus minimizes the loss of sample.

The final linked data set contains a sample of 17,233 firm-year observations between 1992 and 2007 with 2,561 unique firms. A total of 13,169 firm-year observations are classified as exporters and the remaining 4,054 as non-exporters. Overall the combined dataset contains around half of the US public firms over the period. Due to the nature of publicly-traded firms, large firms are over-represented in the dataset, as compared to the universe of U.S. firms. As a result of this, this dataset is also heavily skewed toward exporting firms: around 76 percent of the observations are exporting firms, and this is higher than the overall percentage of firms that export in the U.S.[8] Over-representation of large firms naturally leads to problems if one

[8] For example, Bernard et al. [2009] reports that 18 percent of U.S. manufacturing firms exported in 2002.

wish to make inferences for the overall economy. This problem is mitigated here, since it is reasonable to believe that the CEO-to-worker pay ratios are much smaller and less variable in small firms, and thus the results for the overall economy will be mainly driven by large firms.

The key variable of interest is the CEO-to-worker pay ratio. I construct this ratio as the total realized compensation (TDC2) divided by the average non-executive wage. I use realized compensation as the benchmark measure of CEO income instead of estimated compensation. This is because the former can be directly observed, while the latter has to be inferred from a pricing formula. I report the robustness checks using total estimated compensation (TDC1) in Table 4, and the results are essentially the same. The average non-executive wage is the total payroll of a firm in a given year minus the salary and bonus of the CEO, then divided by total employment less the CEO. The reason for this definition is as follows: "Total payroll," as reported in the LBD, comes from the Business Register, which is in turn based on IRS tax records. The salary and bonus of the CEO are reported as part of the total payroll for tax purposes, while the income earned from stock options is not.[9] Therefore, I only need to subtract the salary and bonus of the CEO when computing the non-executive wage. The denominator is one less the total employment to account for the fact that the CEO is also counted as an employee in tax filings.

As reported in Table A.2, on average, the CEO earns 89 times more than an average worker in his/her own firm across the entire sample. The CEO-to-worker pay ratio varies by exporting status: it is 92 for exporting firms and 81 for non-exporting firms. To test the difference in the CEO-to-worker pay ratio between the two groups, I estimate the following equation with the pooled panel data:

$$\log(\mathrm{CEO_{it}}/\mathrm{WAGE_{it}}) = \beta_0 + \beta_1 \mathrm{EXP}_{it} + \mathbf{b'}_2 \cdot \mathbf{s} + \mathbf{b'}_3 \cdot \mathbf{y} + \epsilon_{it}, \tag{1}$$

where $\mathrm{CEO_{it}}/\mathrm{WAGE_{it}}$ is the CEO-to-worker pay ratio, EXP_{it} is the exporter status indicator for firm i at year t, $\mathbf{s}$ is a vector of sector dummies at a four-digit Standard Industrial Classification (SIC) level, and $\mathbf{y}$ is a vector of year dummies. The standard errors are

[9] The "total payroll" and "employment" items in LBD are compiled from filings of IRS Form-941/943. See IRS Publications 15, 15-A, and 15-B for the details of tax deductions and exemptions.

clustered at the year-sector level. The coefficient of interest is β_1: if the CEO-to-worker pay ratio is significantly higher for exporters, we shall expect this parameter to be positive.

The specification in Equation (1) does not control for firm fixed effects. This is because very few firms in the sample switched their exporting status during this period. Although entry and exit in the export market are not uncommon among the entire universe of U.S. firms, large and established public firms rarely do so. Therefore the identification of β_1 comes from the cross-sectional variations in CEO-to-worker pay ratio between exporting and non-exporting firms within the same year. Ideally, we would like to identify β_1 from within-firm variations along the time dimension. However, such dataset is difficult to assemble as large and established firms rarely enter or exit the export market, and CEO compensations at smaller firms are rarely observed by researchers.

The first column in Table 1 at the end of the paper confirms that the "exporter premium" in within-firm inequality exists after controlling for time and sector fixed effects. The estimated β_1 is statistically significant at the 1 percent level, and the size of the coefficient suggests that the gap between the groups is large. On average, the CEO-to-worker pay ratio is 50.7 percent higher among exporters than among non-exporters, with a standard error of around 3 percent.

Why is within-firm inequality higher among exporters? The other columns of Table 1 try to shed some light on this. The second column controls for the size of the firm by introducing the logarithm of annual sales, as reported in Compustat into the right-hand side of equation (1) and the third column drops the exporting indicator but keeps the logarithm of annual sales in equation (1). These three columns together suggest that the "exporter premium" in within-firm inequality is driven by the size premium of the exporters. Comparing the first and second columns, the coefficient on the exporting indicator drops to 2 percent and is no longer significantly different from 0 once the sales of the firm is controlled for. In contrast, introducing the exporter indicator on top of the size variable does not change the results significantly. The estimated coefficient on annual sales and the adjusted R-squared barely move, if at all, between the second and the third columns. Columns 4 to 9 repeat the same exercise with other controls for the size of the firm, such as total asset, as reported in Compustat, and total U.S. payroll and employment, as reported in the LBD. Under these controls for firm size, the estimated coefficients on the exporting indicator are significantly different from zero, though the magnitude drops to between 5 and 7 percent.

These exercises convey a consistent message. The difference in the CEO-to-worker pay ratio is mainly driven by the size difference between firms. Larger firms have higher within-firm inequality, and the reason we observe higher within-firm inequality among exporters is precisely because those firms are larger – a stylized fact confirmed by the empirical trade literature that motivated the new generation of heterogeneous firms trade models.[10] This suggests that within-firm inequality can be naturally incorporated into a Melitz trade model, where exporting behavior and size are linked.

The insignificance of exporting status conditional on size does not imply that trade is irrelevant for within-firm inequality. Without trade, many of the large firms in the sample will not be able to grow to the size that we observe in the data in the first place. In a counterfactual world where all the firms can only sell to the domestic market, many of the large firms would be smaller, and thus, their within-firm inequality lower. The insignificance of the exporter dummy only implies that whatever effect trade might have on within-firm inequality, the main channel goes through the size of the firm. In some cases, the coefficient on exporter dummy is significantly positive after controlling for size, indicating that there are other factors that predict higher within-firm inequality among exporters. For example, exporting firms might need different managerial skills than domestic firms and thus are recruiting their CEOs in a different market. However, as the size of the coefficients suggests, no matter what these factors are, their explanatory power is small relative to firm size. Therefore, the model presented in Section 3 focuses solely on the size of the firm and leaves the other factors to future research.

2.2 Extensions

Executive compensation often consists of salary, bonus, stock options, and LTIP.[11] While some of the items such as stock options and bonuses are volatile and linked to the performance of the firm, other items such as salary are much less so. Is the "exporter premium" in

[10] For example, see Bernard and Jensen [1999].

[11] See Murphy [1999] for details.

executive-to-worker pay ratio driven by certain components? To answer this question, I decompose executive compensations into three parts: "salary," "bonus," and "stock options and others"[12] and estimate equation (1) for each part separately.

The results are presented in Table 3. The same pattern can be observed in all three components of the CEO compensation: the CEO-to-worker pay ratio is higher among exporters, whether we measure the CEO compensation using salary, bonus, or stock options. On average, the stock-options-to-wage ratio is around 85 percent higher among exporters than among non-exporters. The bonus-to-wage ratio is 51 percent higher, while the salary-to-wage ratio is about 21 percent higher. The "exporter premium" in stock and option rewards is the highest. It could be that exporting firms usually face additional risks related to international trade such as exchange rate uncertainty and disruptions to trade routes. Part of the higher premium in stock and option rewards is probably the compensation for the higher risk. This also applies to the premiums observed in bonus, though to a lesser extent. The coefficient on salary, the riskless component of compensation, is also significantly different from 0. This implies that risk premium cannot fully explain the "exporter premium" in CEO-to-worker pay ratio. The coefficient on salary is the smallest also because the correlation between firm size and salary is relatively weak: many large firms optimally choose to use other rewards to substitute for salary for accounting and tax purposes.[13]

In the second extension I check if the results hold true for top executives other than the CEO. Instead of the CEO-to-worker pay ratio, I measure within-firm inequality using the ratio between average compensation of the top 5 executives and the non-executive wage.[14] The results are reported in Table 4. The main results are robust in this case. On average, the top-5-to-worker pay ratio is 47 percent higher among exporters than among non-exporters. Once again, the "exporter premium" of inequality is driven by the size premium: once the

[12]The items in the "other" category include LTIPs such as restricted stock plans and multi-year accounting-based performance plans.

[13]For example, the provisions to the 1993 legislation "Omnibus Budget Reconciliation Act of 1993" put a $1 million cap on the deductibility of "non-performance based" executive compensations (the so-called Section-162 $1 million rule). This rule primarily reduces the incentives for large firms to pay high salaries but has a limited effect on bonus, stock options and, total compensations in general. See Rose and Wolfram [2002] for details.

[14]ExecuCompustat provides the compensation of the top five highest paid executives for each firm-year. The CEO of each firm is always included in the sample, and the CFO is included in most cases.

size of the firm is controlled for, either by sales, asset, employment, or payroll, the estimated coefficient on exporter indicator drops to around 0 to 7 percent.

The last extension introduces multinational firm indicators. The multinational firm indicators are constructed from the geographic segment data in Compustat. I classify a firm-year observation as multinational if a U.S. firm reports the existence of a non-domestic geographic segment, such as a foreign division. The multinational indicators from segment data are then linked with the ExecuCompustat-LBD. The resulting data set contains 12,943 firm-year observations and 1,606 unique firms. Out of these firm-year observations, 5,885 records are classified as non-MNE and the rest 7,058 as MNE. On average, the CEO-to-worker pay ratio is 87.4 among the non-MNE group and 100.0 among the MNE group.

I re-estimate equation (1) and the results are reported in Table 4. On average, the CEO-to-worker pay ratio is 28.4 percent higher among the MNE group than among the non-MNE group. After controlling for annual sales and assets, the between-group difference is no longer significantly different from 0. After controlling for the total payroll of their U.S. operations, the MNE group sees around 14.0 percent higher in the CEO-to-worker pay ratio. The difference between controlling for sales/total asset and payroll is that sales and asset are based on the aggregate of global operations, while payroll is based on U.S. operations only. Nevertheless, under all three controls, the size of the "MNE premium" in within-firm inequality drops significantly, indicating that the size premium of multinational firms can explain the majority of the difference in within-firm inequality across the groups.

2.3 Private Firms

Similar empirical patterns can be observed for the sample of private firms as well. The majority of U.S. firms are private, and they are responsible for more than 60 percent of firm sales in 2007.[15] The executive compensation is believed to be less affected by corporate governance problems in private firms because they tend to be held more closely.[16] These considerations make the private firms particularly interesting subjects to examine in this

[15] Total sales of U.S. firms come from the Census Bureau's *Statistics of U.S. Businesses, 2007.* Total sales of public firms come from Compustat.

[16] See Jensen [1997] and Hartzell and Starks [2003] for details.

paper. However, unlike public firms, most private firms are not subject to SEC's executive compensation disclosure rules. As a result, the majority of datasets on private firm compensations collect data through surveys, which does not disclose firm identifiers such as names and addresses. This makes it hard to the link these data to the census data.

The data set used in this paper comes from the Standard & Poor's Capital IQ (CIQ). Unlike the survey-based data set, CIQ collects data through regulatory filings,[17] news aggregators, and company websites. The advantage of CIQ data set is that they provide the names, addresses, and telephone numbers for all the firms covered, making the linkage to the census data possible. Appendix A provides the details of constructing the combined dataset. The linked data set contains 6,002 firm-year observations and 2202 unique firms between 2003 and 2007. A total of 3,366 firm-year observations and 1,207 unique firms are exporting firms, while the remaining 2,636 observations with 995 unique firms are non-exporters. This data set is, to my knowledge, the first one that contains private firm executive compensation and reliable measures of exporting status, employment, and payroll at the firm level.

The results of estimating equation (1) using the linked CIQ data are reported in Table 2. Overall, the results are similar to those based on the public firm sample. On average, the Highest-paid-executive-to-worker pay ratio is 41 percent higher among exporters than among non-exporters, with a standard error of 5.4 percent. Again, the gap between exporters and non-exporters is mainly driven by the size difference. Once I control for total sales, total asset, or total payroll, the estimated coefficient on exporting status is no longer significantly positive. In the case of controlling for total payroll, the estimated "exporter premium" is even slightly negative.

I repeat the first two extensions in the previous section.[18] I first extend the analysis to include all top 5 highly paid executives. The results are presented in Table 6 and are again similar to those obtained in the public firm sample. On average, the top-5-to-worker pay ratio is 39 percent higher among exporters than among non-exporters, and the gap is mainly driven by size differences in the firms: once the size of the firm is controlled for, the

[17]Large private firms are subject to executive disclosure rules similar to public firms by the SEC. They usually have more than 500 shareholders and more than $10 million in total assets. See Gao et al. [2012] for more details.

[18]The private data set does not contain enough information to identify multinational firms; therefore, the last extension can not be repeated here.

estimated coefficient drops to between -1.4 and -7.7 percent.

I also decompose the total realized compensation into three parts (i.e., salary, bonus and all others) and re-estimate equation (1).[19] The results are presented in Table 6. The "exporter premium" in within-firm inequality exists in all three components, with the same ranking of magnitude as in the public firm sample. The "all-others"-to-wage ratio is 54 percent higher among exporters than non-exporters, followed by the bonus-to-wage ratio (31 percent) and the salary-to-wage ratio (16 percent). The size of the "exporter premium" drops significantly for all three components once I control for the size of the firm.

3 The Model

3.1 Model Setup

The model setup is based on Helpman et al. [2004]. I introduce occupational choice and executive compensation into the framework. The contribution of my model is two-fold. First, it offers a tractable framework to analyze the effects of trade on the CEO-to-worker pay ratio within each firm and overall income inequality. Second, the simple framework is also empirically relevant: it is able to generate income distribution and firm-size distribution with full support that closely resemble the data. This allows me to carry out quantitative analysis to evaluate the impacts of globalization on income inequality, both within the right-tail of the income distribution, and between the right-tail and the general population.

The model world consists of two countries indexed by i. Each country i is populated by individuals with measure n_i. People in each country are endowed with human capital x. As x uniquely identifies each individual, with a slight abuse of notations, I also use x as index for individuals within a country. The distribution of human capital in each country follows an exponential distribution with shape parameter λ. The cumulative distribution function

[19] "All others" are mainly stock and option rewards. Although these companies are not publicly traded, stock and option rewards are still popular among executives. These stocks and options are usually exercised at the time of buyout or initial public offering (IPO).

(CDF) of human capital is as follows:

$$F(x) = 1 - e^{-\lambda x}.$$

The exponential distribution is used here, together with other assumptions explained later in this section, to capture the structure and shape of the income distribution and firm size distribution at the same time. The details will be provided in the next section.

People can choose between two careers. They can either work for an existing firm or create a new firm. If they choose to be a worker, their human capital directly translates into the amount of efficiency labor that will be inelastically supplied to the market. In this case, their income will be $w_i x$, where w_i is the prevailing wage rate per efficiency unit of labor in country i. Individuals cannot move between countries and the wage rate w_i is determined in a country-wide competitive labor market.

The individual can also create a new firm to start producing a new variety of good. In doing so he/she becomes the founder and CEO of the firm. The productivity of the firm, denoted by $A_i(x)$, depends on the human capital of the founder. Specifically, $A_i(x)$ takes the following form:

$$A_i(x) = b_i e^x, \tag{2}$$

where b_i is the total factor productivity (TFP) in country i. With the assumption on the distribution of x, the above function form implies that firm productivity, A_i, follows a Type-I Pareto distribution with location parameter b_i and shape parameter λ (See appendix for the proof). Subsequently this also implies that firm sales, employment, and profit distributions will also be Paretian.

The payoff to the founder and CEO of the firm is a function of the profit of the firm, denoted as $k(\pi) \leq \pi$, where π is the profit. For simplicity I assume that the residual profit after the CEO compensation is distributed back to the entire population in country i evenly (i.e. all the people in the country own the firms through a market mutual fund).[20] For

[20] Note that this assumption does not affect the analysis of income inequality, and the main results of the paper will not be changed significantly if we release this assumption.

simplicity I directly assume that $k(\pi)$ is exogenously determined, and be 1) monotonically increasing and, 2) regularly-varying in π.

The benchmark model abstracts away from a full-fledged labor market and compensation model for the CEOs. In addition, it assumes that the founders of the firm always remain as CEOs forever, and that the compensation of a CEO is based on the size of the firm, not her managerial talent. These assumptions are certainly not true in reality. However, releasing these assumptions will not change the main results of the model. Appendix B.6 presents an extended version of the model with a labor market for CEOs similar to Gabaix and Landier [2008]. In the extended model CEOs and firms match in the market, and endogenously determine a compensation function for managerial talents, $k(x)$. In equilibrium CEOs with higher talents will be matched with firms with higher productivity, and thus the compensation function will be monotonically increasing in both the managerial talent and the size of the firm — in fact these two variables are proportional to each other up to certain power, and thus there is no need to distinguish if CEO compensation is based on talents or size. Positive assortive matching also implies that the matching pattern between CEOs and firms in a market equilibrium will be the same as if the best managers founded the best firms and remained as CEOs thereafter. Lastly, when x follows an exponential distribution, the resulting endogenous compensation function will be regularly-varying in both x and π as well. In the end an endogenous labor market for CEOs delivers an compensation function and matching patterns identical to those exogenously assumed, and thus can be considered orthogonal to other parts of the model.

The property of regular variation requires a bit more explanation. By definition, a function $k(\pi)$ is regularly-varying with tail index β if and only if for any $z > 0$, the following equation holds:

$$\lim_{\pi \to \infty} \frac{k(z\pi)}{k(\pi)} = z^{\beta}.$$

Intuitively, regularly-varying functions are functions that behave like power functions at the limit.[21] In this context, the assumption on regular variation essentially assumes that the

[21] For more details, see Resnick [1987].

compensation of the CEO in large firms is proportional to the power function of profit of the firm: $k(\pi) \sim \pi^{\beta}$. This is indeed a well-documented empirical pattern in the corporate governance literature, known as Roberts' Law (Roberts [1956]). The assumption of regular variation also implies that the right-tail of the income distribution will exhibit Paretian behavior, though the vast majority of the distribution follows an exponential distribution — again, an empirically relevant result, which will be discussed in detail in the next section.

The production side of the economy is modeled after Helpman et al. [2004]. A firm with productivity $A_i(x)$ produces a single variety of good, indexed by x, with the following production function:

$$q_i(x) = A_i(x) \cdot [L_i(x) - f_{ii}],$$

where $L_i(x)$ is the labor demand and f_{ii} is the fixed cost of production, paid in the units of labor of country i. Each firm operates in a monopolistically-competitive market and earns positive profit in equilibrium.

Firms in country i can serve the foreign market j in two ways: they can either export to country j its good produced in country i, or set up production facilities in country j and supply the market with local production (foreign direct investment, FDI). If a firm in country i wants to export to country j, it first needs to pay a fixed cost f_{ji} denominated in labor to set up the distribution network. Then trade incurs an iceberg cost of $\tau_{ji} > 1$: in order to supply country j with one unit of good from country i, the firm needs to ship τ_{ji} units out. In order to serve country j from country i through FDI, the firm needs to pay the fixed overhead costs g_{ji} in units of labor in country i. The labor costs are interpreted as the overhead costs of starting operation, as well as the costs introduced by policy barriers.

Individuals in country i consume a CES aggregate of all the varieties available in country i. Their utility function is as follows:

$$U_i = \left(\int_{m \in \Theta_i} q_i(m)^{\frac{\epsilon-1}{\epsilon}} dm \right)^{\frac{\epsilon}{\epsilon-1}},$$

where ϵ is the elasticity of substitution, and Θ_i is the set of goods that are available in country i.

3.2 Solution and Equilibrium Conditions

The solution of the occupational choice problem is a single cutoff rule. There exists a human capital level x_i^* in country i such that all the individuals with human capital smaller than x_i^* choose to be workers and all the other individuals choose to create firms. x_i^* is the solution to the following equation:

$$k(\pi(x_i^*)) = w_i x_i^*, \tag{3}$$

which requires that in equilibrium the founder of the marginal firm to be indifferent between creating a new firm or working for an existing firm. The sufficient and necessary condition for the existence of the solution is that $k(\pi_i(0)) < 0$, which means that the individual with the least amount of human capital must find creating a new firm unprofitable.

Figure 1 presents the solution in a simple setting where $k(\pi) = \pi$. The solid line is the income of a worker as a function of his/her human capital. The dashed line is the income of a CEO as a function of his/her human capital. Under the assumption that $k(\pi(0)) < 0$, the two curves cross once and only once at the cutoff human capital level x_i^*.

The solution to the firm's problem is similar to Helpman et al. [2004]. Denote the total spending in country i as H_i and the ideal price index as P_i. The maximum profit a firm in country i can earn in its domestic market is:

$$\pi_{ii}(x) = \frac{H_i}{\epsilon}\left[\frac{\epsilon-1}{\epsilon}\frac{P_i}{w_i}\right]^{\epsilon-1} A_i(x)^{\epsilon-1} - f_{ii}w_i.$$

The *additional* profit a firm in country i can earn from exporting to country j is:

$$\pi_{ji}^e(x) = \frac{H_j}{\epsilon}\left[\frac{\epsilon-1}{\epsilon}\frac{P_j}{\tau_{ji}w_i}\right]^{\epsilon-1} A_i(x)^{\epsilon-1} - f_{ji}w_i, \tag{4}$$

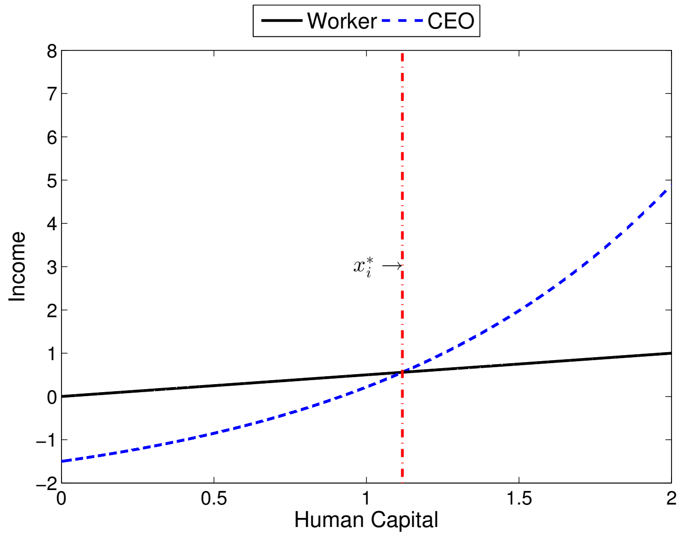


Figure 1: Solution of the Occupational Choice Problem

The graph plots the solution of the occupational choice problem. The black solid line is the income of a worker, and the blue dashed line is the income of a CEO. The vertical line indicates the cutoff human capital that is indifferent between being a worker or a CEO. This graph assumes that $k(\pi) = \pi$.

and the *additional* profit a firm in country i can earn from FDI in country j is:

$$\pi_{ji}^f(x) = \frac{H_j}{\epsilon}\left[\frac{\epsilon - 1}{\epsilon}\frac{P_j}{w_j}\right]^{\epsilon - 1} A_i(x)^{\epsilon-1} - g_{ji}w_i. \tag{5}$$

The details of the solution to the firm's problem can be found in Appendix B.

Similar to Helpman et al. [2004], under some loose parameter restrictions, firms sort into three groups. All the firms founded in country i serve the domestic market first. Moreover, the least productive firms only serve the domestic market. The more productive firms serve the domestic market and the foreign market through export. The most productive firms serve the domestic market and the foreign market through FDI. Denote the human capital of the founder of the least productive exporting firm in country i as x_{ji}^e and the human capital of the least productive MNE in country i as x_{ji}^f. These two cutoffs must be the solution to the following two equations respectively:

$$\pi_{ji}^e(x_{ji}^e) = 0, \tag{6}$$

$$\pi_{ji}^e(x_{ji}^f) = \pi_{ji}^f(x_{ji}^f). \tag{7}$$

The first condition means that the marginal exporter earns zero profit from exporting. The second condition says that the marginal MNE shall find the profit of serving the foreign market by FDI and by exporting to be equal.

The equilibrium of the world economy is a vector of wages, $\{w_i\}$, a vector of the occupational choice cutoffs $\{x_i^*\}$, a vector of exporting cutoffs $\{x_{ji}^e\}$, a vector of FDI cutoffs $\{x_{ji}^f\}$, a vector of ideal price levels $\{P_i\}$, and a vector of total expenditures $\{H_i\}$ such that for $i = 1, 2$ and $j = 1, 2$:

1. Every individual in country i maximizes their income by solving the occupational choice problem (equation (3) holds).

2. Every firm optimally chooses to be a non-exporter, exporter, or multinational firm (equations (6) and (7) hold).

3. Total income equals to total expenditure in each country:

$$H_i = n_i w_i \int_0^{x_i^*} x f_i(x) dx + n_i \int_{x_i^*}^{\infty} \pi_i(x) f_i(x) dx. \tag{8}$$

4. Aggregate price level and the individual prices satisfy the rational expectation condition:

$$P_i = \left(\int_{m \in \Theta_i} p(m)^{1-\epsilon} dm \right)^{\frac{1}{1-\epsilon}}. \tag{9}$$

5. Labor market clears in each country.

Equation (8) is the income-expenditure identity in country i. In equilibrium, the total expenditure in country i must equal the total income in country i, which is the sum of all the wage and profit income[22]. Equation (9) is the definition of the ideal price index, which is the cost of one unit of utility in country i. Appendix B provides the details on these two equilibrium conditions, as well as the details on the labor market clearance condition.

[22]The CEO compensation function does not enter the total income function, because the difference between profit and CEO compensation at a given firm will be distributed back to the individuals in country i, which implies that we only need to consider total profit when accounting for total income in a given country.

4 Analytical Results

4.1 Firm Size Distribution and Income Distribution

The firm productivity distribution in country i follows a Type-I Pareto distribution with shape parameter λ and location parameter b_i. Firm sales is a linear function of $A^{\epsilon-1}$ and therefore follows Type-I Pareto distribution with shape parameter $\lambda/(\epsilon-1)$. As noted in di Giovanni et al. [2011], international trade systematically changes the size distribution of firms. In my framework, this is reflected in the location parameters of the sales distributions. The sales distribution for domestic firms has the smallest location parameter, followed by the exporting firms, and then the multinational firms. Firm employment and profit are affine functions of $A^{\epsilon-1}$ due to the fixed costs of operation, export, and FDI. They follow Type-II Pareto distributions with shape parameter $\lambda/(\epsilon-1)$. Similar to the sales distribution, location parameters vary by the market size accessible to the firm. Appendix B provides details on the distribution of productivity, sales, employment, and profit for different groups of firms.

Individual income is ranked by occupations: the workers earn the lowest income, followed by the CEOs at domestic firm CEOs and the CEOs at exporting firms. The CEOs at multinational firms occupy the pinnacle of the income distribution. The entire income distribution follows a two-class structure. All the workers earn the same wage rate per efficiency labor unit; therefore, their income distribution is exponential with a shape parameter λ/w_i. The income of the CEOs depends on the CEO compensation function. By assumption, the compensation function $k(\pi)$ is monotonically increasing in π and regularly varying. Under these two assumptions, the income distributions of the CEOs adopt the following CDF:

$$U(y) = 1 - y^{-\frac{\lambda}{\beta(\epsilon-1)}} R(y), y > 0,$$

where y is the income, β is the tail index of $k(\pi)$, $\frac{\lambda}{\beta(\epsilon-1)}$ is the shape parameter of the distribution, and $R(y)$ is a slowly-varying function.[23] Distributions with this form of CDF are Pareto-Type distributions and exhibit fat-tail behavior at the right end similar to Type-I

[23] Slowly-varying functions are regularly-varying functions with tail index of 1. Intuitively, slowly-varying functions are functions that behave like linear functions at the limit.

Pareto distributions. Appendix B provides details on the derivation of the income distributions of different groups of individuals.

4.2 Partial Equilibrium

The main mechanism of the model is most clearly demonstrated in partial equilibrium. Suppose that wage rate, product prices, and total expenditure are fixed at their autarky equilibrium values. What happens if two countries open up to trade?

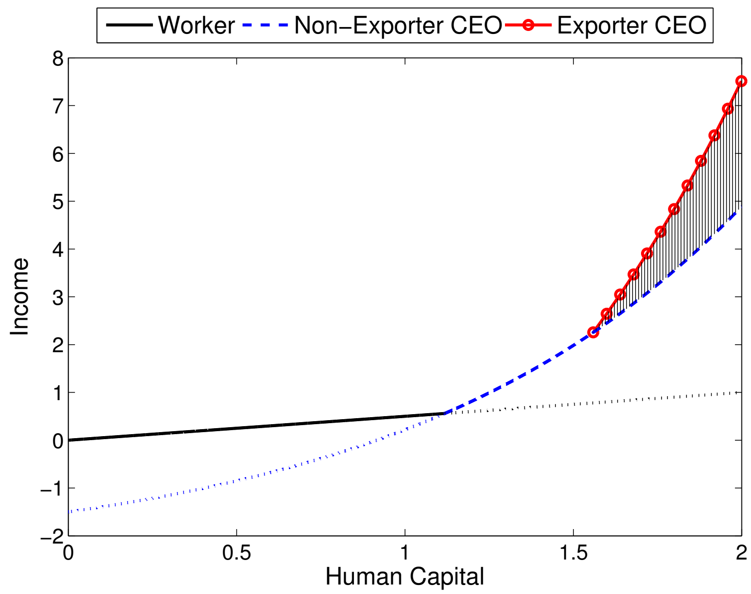


Figure 2: Trade and Top Income Shares in Partial Equilibrium

This graph plots the income of different individuals against their human capital for different occupations under autarky and under trade. The black solid line is the income of a worker. The blue dashed line is the income of CEOs at non-exporting firms. The red circled line is the income of CEOs at exporting firms. The shaded area is the extra profit earned from exporting. This partial equilibrium assumes that $k(\pi) = \pi$ and that wage, total expenditure, and prices are all fixed. It also abstracts away from FDI.

Figure 2 presents the partial equilibrium results in a simplified model where FDI is shut down and $k(\pi) = \pi$. The black solid line and the blue dashed line are the same as in Figure 1: they are the income of workers and CEOs in autarky in the home country. When the world opens up to trade, only the most productive firms export. In the graph, the right end of the CEO income function tilts up into the red circled line, which is the income of CEOs at the exporting firms. The shaded area between the red circled line and the blue dashed line is the extra profit (and extra compensation to the CEO) earned in the foreign country. In this simple case, all the benefits of globalization are claimed by the CEOs at the exporting firms, and none of the benefits trickle down to the workers in those firms. At the aggregate level, top income shares will be higher because the CEOs at the exporting firms are originally the richest people in autarky.

4.3 General Equilibrium

Wage, total expenditure, and the ideal price level respond to the changes in τ_{ij} and g_{ij} in general equilibrium, making the results not as clear-cut as in the partial equilibrium. Nevertheless, the main mechanism of the model works the same way: the access to foreign markets benefits CEOs more than average workers, widening income inequality both within the firm and at aggregate levels. I first present a simple result characterizing the cross-sectional intra-firm inequality of the model in general equilibrium:

Proposition 1 *If the sets of exporting firms and multinational firms in country i are non-empty, then the average CEO-to-worker pay ratio among domestic firms is strictly smaller than the average CEO-to-worker pay ratio among exporting firms, which in turn is strictly smaller than the average CEO-to-worker pay ratio among multinational firms.*

Proof See Appendix B.

Proposition 3 implies that the empirical findings in Section 2 can be replicated in general equilibrium. If an econometrician observes the model world and estimates equation (1) without any size control, he/she will find that the CEO-to-worker pay ratio is significantly higher among firms that sell to the foreign market than those who do not. In addition, in general equilibrium, the CEO-to-worker pay ratio is proportional to the size of the firm. Therefore, if the econometrician can also observe the size of the firm and controls for it when estimating equation (1), the observed between-group difference will disappear, just the same as we observed in the U.S. data.

The next lemma characterizes how within-firm inequality responds to the changes in trade in general equilibrium. I first show that the cutoff points of human capital between different groups of firms are sufficient statistics for within-firm inequalities, as measured by profit-to-wage ratios in general equilibrium. These results are summarized in the following lemma:

Lemma 2 *In general equilibrium, the domestic-profit-to-wage ratio, defined as*

$$\frac{\pi_{ii}(x)}{w_i} = \frac{H_i}{w_i \epsilon} \left(\frac{P_i}{w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x)^{\epsilon - 1} - f_{ii},$$

will be lower when x_i^* is higher; The exporting-profit-to-wage ratio, defined as

$$\frac{\pi_{ji}^e(x)}{w_i} = \frac{H_j}{w_i \epsilon} \left(\frac{P_j}{\tau_{ji} w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x)^{\epsilon - 1} - f_{ji},$$

will be lower when x_{ji}^e is higher; The FDI-profit-to-wage ratio, defined as:

$$\frac{\pi_{ji}^f(x)}{w_i} = \frac{H_j}{w_i \epsilon} \left(\frac{P_j}{w_j} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x)^{\epsilon - 1} - g_{ji},$$

will be lower when x_{ji}^f is higher.

Proof See Appendix B.

Lemma 2 summarizes the key mechanism of the model. As the trade costs, τ_{ji} and g_{ji} decrease, the bilateral trade and multinational sales increase between i and j. It is straightforward to show that x_i^* will be higher, x_{ji}^e be lower, and x_{ji}^f be lower after the change in trade costs. Lemma 2 then links the changes in the cutoffs to the changes in within-firm inequality. Specifically, it establishes that the exporting-profit-to-wage ratio and the FDI-profit-to-wage ratio will be higher if trade costs are lower. This means that the access to foreign markets widens the gap between profit and wage rate. As a result, those whose income is linked to the profit of the firm, the top executives, will see their income increasing faster than the income of the workers. At the firm level, this implies higher within-firm inequality; At the aggregate level, together with Proposition 3, this implies that the top income shares shall be positively linked to the volume of trade and FDI sales.

5 Quantitative Analysis

In this section I quantify the impacts of trade liberalizations on top income inequality in general equilibrium. I first calibrate the model to resemble the U.S. economy in the 2000s, and show that the model provides a reasonably good approximation for U.S. income distribution. I then study how different measures of income inequality respond to changes in barriers of trade, and show that globalization might be responsible for a substantial part of the surge in top income shares in recent decades. In the end I show that the main results of the model are robust to changes in certain parameter values.

5.1 Calibration

I interpret the two countries in the model world as the U.S. and the rest-of-the-world (ROW). I treat 109 economies combined as the ROW. These countries, together with the U.S., are responsible for around 74 percent of the world population and 82 percent of the world GDP in 2008. The selection of countries is strictly due to data availability, and the countries included in ROW are reported in Table 10. [24]

The country TFP, b_i, is calculated as the average Solow residual between 1998 and 2008 using the methods outlined in Caselli [2005] and is normalized so that TFP in the U.S. is 1. The measure of population, n_i, is computed as the by-product in the estimation of the Solow residual. I first compute the "quality-adjusted workforce," as in Caselli [2005], using the Penn World Table 7.0 and the educational attainment data from Barro and Lee [2010]. I then augment this measure of total workforce with the estimated capital stock and arrive at the final measure of the size of "population."[25] This measure of population takes into consideration that worker productivity varies greatly across countries because the human capital embodied in and physical capital associated with each worker varies. For the details of calibrating TFP and population measures, see Appendix B. The relative size of the economies, which is not a targeted moment, is replicated within a reasonable error margin.

[24] A country is included in the sample if and only if its data from 1988 to 2008 are available both in Penn World Table 7.0 and Barro and Lee [2010].

[25] This "population measure" is essentially the ratio between real GDP and the estimated Solow residual in each year.

For example, the ROW is on average 3.56 times larger in output than the U.S. in year 2008 in the data, and the corresponding statistics is 4.16 in the model.

The elasticity of substitution is set to 4 so that the average markup for the firms is 33 percent. This level of mark-up is in the middle of plausible estimates, and I provide robustness checks with ϵ between 2 and 6 later in this section.[26] The shape parameter of the human capital distribution, λ, is set to 3.18. This implies that the Pareto shape parameter of the firm employment distribution is $\lambda/(\epsilon - 1) = 1.06$, the estimation provided by Axtell [2001].

The fixed costs of operation and export are calibrated using the Doing Business database from the World Bank following the methods outlined in di Giovanni and Levchenko [2012] and di Giovanni and Levchenko [2013]. I use the days of starting a business in the U.S. as the raw measure of the fixed costs of operation in the home country. The fixed costs of operation in the ROW are the average across the rest 109 countries, weighted by GDP. I use the Trading across Borders module of the Doing Business Indicators database to measure the fixed costs of international trade. Define ϕ_{ij} as the sum of days required to export a 20-foot dry-cargo container from country i and to import the same kind of container into country j. The fixed cost of exporting from the U.S. to the ROW is computed as the weighted average of $\phi_{\mathrm{i,US}}, i = 1, 2 \cdots, 109$:

$$f_{21} = \frac{\sum_{i=1}^{109} E_{\mathrm{i,US}} \cdot \phi_{i,US}}{\sum_{i=1}^{109} E_{\mathrm{i,US}}},$$

where the weight, $E_{\mathrm{i,US}}$, is the export from the U.S. to country i. Similarly, the fixed cost of export from the ROW to the U.S. is:

$$f_{12} = \frac{\sum_{i=1}^{109} E_{\mathrm{US,i}} \cdot \phi_{US,i}}{\sum_{i=1}^{109} E_{\mathrm{US,i}}},$$

where the weight, $E_{\mathrm{US,i}}$, is the export from country i to the U.S. The f_{ij} matrix at this stage

[26]For example, Domowitz et al. [1988] estimated the average markup for U.S. manufacturing firms to be 0.37. Rotemberg and Woodford [1991] used steady-state markups between 0.2 and 0.6, while Feenstra and Weinstein [2010] estimated the average markup to be 0.3 in 2005 in the U.S. The elasticity of substitution used here is slightly lower than the estimates based on gravity equations, which are usually between 5 and 10, as reported by Anderson and van Wincoop [2004]. Robustness checks show that the main results of the paper hold true with higher levels of ϵ.

is measured in the unit of time. At the end, I normalize the entire f_{ij} matrix so that around 0.83 percent of individuals in the U.S. choose to create firms. This statistics matches the ratio of chief executives to working population in 2000 Public Use Microdata Series (PUMS) 5 percent sample obtained from IPUMS.[27]

I use the following functional form of $k(\pi)$ as CEO compensation:

$$k(\pi) = \begin{cases} \pi & \text{if} \quad \pi \leq \alpha \\ \alpha^{1-\beta}\pi^{\beta} & \text{if} \quad \pi > \alpha \end{cases}, \tag{10}$$

This function is monotonically increasing in π and regularly varying; therefore, all the analytical results in Section 4 carry over. Intuitively, the function means that firms with profit less than or equal to α are "sole proprietorship" firms: the founder and CEO owns the firm and claims all the profit. Firms with profit larger than α are "corporations", and the founder can only claim a proportion of the profit. The power function form for larger firms implies that the right tail of the income distribution follows a Pareto distribution with tail index $\frac{\lambda}{(\epsilon-1)\beta}$.

As noted above in Section 3, the function in equation (10) is based on the empirical findings in the literature that CEO compensation is proportional to the power function of the firm size, $k \sim \pi^{\beta}$, which is otherwise known as "Roberts law"(Roberts [1956]). This functional also arises naturally as an equilibrium compensation function from a matching model analyzed in Gabaix and Landier [2008], where the managers with higher ability are matched with larger and more productive firms in equilibrium. Specifically, this function is a special case of the duo-scaling equation in Gabaix and Landier [2008], where α is the size of the reference firm. Within the context of this paper, the reference firm is the smallest corporation in each country. The calibration strategy described below ensures that the smallest firm in the model is always smaller than α in the benchmark model. This further implies that both types of firms exist in equilibrium.

I calibrate α to match the ratio of sales of all the corporations to the sales of all the firms, which is 62 percent in the U.S. in 2007.[28] I calibrate β to match the right tail index

[27]Note that this statistics measures chief executives, not self-employed to working population ratio, which around 10.9 percent as reported in Hipple [2010]. See Ruggles et al. [2010] for details.

[28]The sales of U.S. firms by legal form come from the *Statistics of U.S. Businesses, 2007* from the Census

of the U.S. income distribution. Drăgulescu and Yakovenko [2001b] documents that the Pareto index of the U.S. income distribution is around 1.7. This implies that in this model, conditional on the tail index of the firm size distribution, β is $\frac{1.06}{1.7} \approx 0.747$.

I impose an upper bound, s, on the human capital distribution to eliminate unrealistically large corporations. I calibrate s to match the highest CEO-to-worker pay ratios in the data. I first compute the ratio between the highest CEO compensation in ExecuCompustat and the average U.S. wage from national income and product accounts (NIPA) in each year between 1992 and 2007[29]. I then set $s = 3.495$ so that the same ratio in the model is matched to the median of the data sequence, which is around 2,903.

I assume that both the iceberg trade costs and the fixed costs of starting foreign subsidiaries are symmetric: $\tau_{12} = \tau_{21}$ and $g_{12} = g_{21}$. I then jointly calibrate the two cost parameters, $\{\tau_{21}, g_{21}\}$, to match the exports-to-GDP ratio and the multinational-firm-sales-to-GDP ratio in the U.S. in year 2008. The first moment condition can be directly estimated using GDP data from NIPA. The second moment condition come from the Bureau of Economic Analysis's *Direct Investment and Multinational Corporations* data set.[30] These two parameters have to be jointly calibrated because iceberg trade costs affect not only the volume of trade but also the multinational sales through the extensive margin. Similarly, the fixed costs of FDI affect the volume of trade as well through the extensive margin. At the end we have $\tau_{21} = 1.95$ and $g_{21} = 1190$. All the above parameters are reported in Table 7.

5.2 Model Fit

The model is calibrated to the *tail* index of U.S. income distribution, and nevertheless, it is able to generate a good fit for the *overall* U.S. income distribution in general equilibrium.

Bureau. The definition of "corporation" in this paper follows the legal form of "corporation" used by the Census. The other legal forms in the Census definition are classified as "proprietorship", which includes "S-corporations", "tax-exempt corporations", "partnership", "sole proprietorship", "other" and "tax-exempt other". The receipts of "government" are subtracted from the total firm sales.

[29] The wage data comes from NIPA Table 6.6A-D. The census does not allow disclosure of extreme values (maximum and minimum) that involve confidential data. Therefore I use the ratio between CEO compensation and the average U.S. wage instead of the CEO-to-worker pay ratio at the firm level in the empirical part.

[30] I use "All non-bank foreign affiliates" sales data up to 2008 as the estimate for the sales of multinational firms.

Figure 3 compares the model-generated income shares with the data in 2008.[31] The model provides a good approximation of the U.S. income distribution for the right tail. For example, the top 0.01 percent income share is 3.37 percent in the data and 5.47 percent in the model in 2008. The top 5 percent income share is 33.78 percent in the data and 33.46 percent in the model. Overall, the difference between the model and the data for the six top income shares reported in Figure 3 is around 14 percent when measured in Euclidean 2-norm.

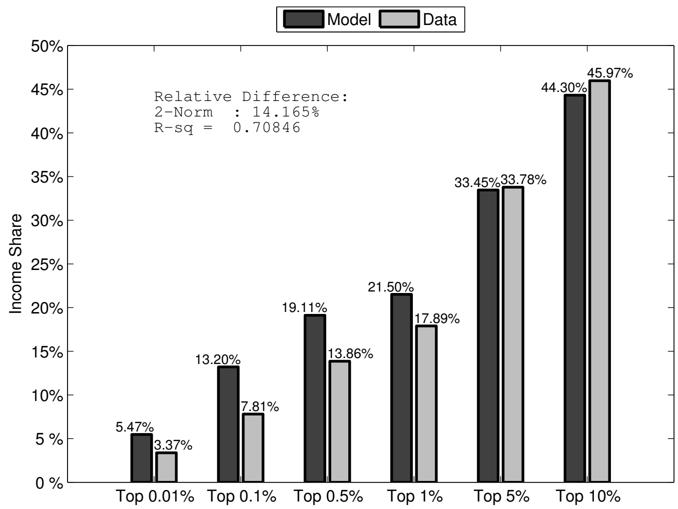


Figure 3: Top Income Shares: Model vs. Data (2008)

Note: This graph compares the top income shares between the model and the data in 2008. The top income shares in the model are described by the dark grey bars and those in the data described by light cray bars. The parameters behind the model simulation can be found in Section 5.1. The source of data is the updated Table A.1 from Piketty and Saez [2003]. The average difference between the model and the data across the six top income shares is measured in Euclidean 2-norm. The differences are reported in percentage terms.

Outside of the top income decile, the model also captures the overall shape of the income distribution reasonably well. The first two rows of Table 8 report measures of skewness of the income distribution in the model and the data. The mean-to-median ratio of the U.S. economy in the model is 1.84, and the counterpart in the data as reported in Rodriguez et al. [2002] is 1.61. Similarly, the percentile location of the mean in the model is 72, while the counterpart in the U.S. data is 71. The third row in Table 8 compares the workers' share of income in the model and the data. In the model the corresponding statistics is computed as the total wage payment to workers (CEO not included) divided by total output. In the data the statistics is computed as wage compensation divided by the gross domestic income of the

[31] The source of data is the updated Table A.1 from Piketty and Saez [2003].

private sector.[32] Again, the model closely resembles the data: the workers' share of income is 0.75 in the model, and 0.71 in the data. Lastly, the fourth row compares the CEO-to-worker pay ratio. The model statistics is computed for the sample of "public" firms whose profit is higher than α. The counter-part in the data is based on the dataset described in Section 2. In the model the CEO-to-worker pay ratio is larger than in the data by around 130 percent.

5.3 Openness and Income Inequality

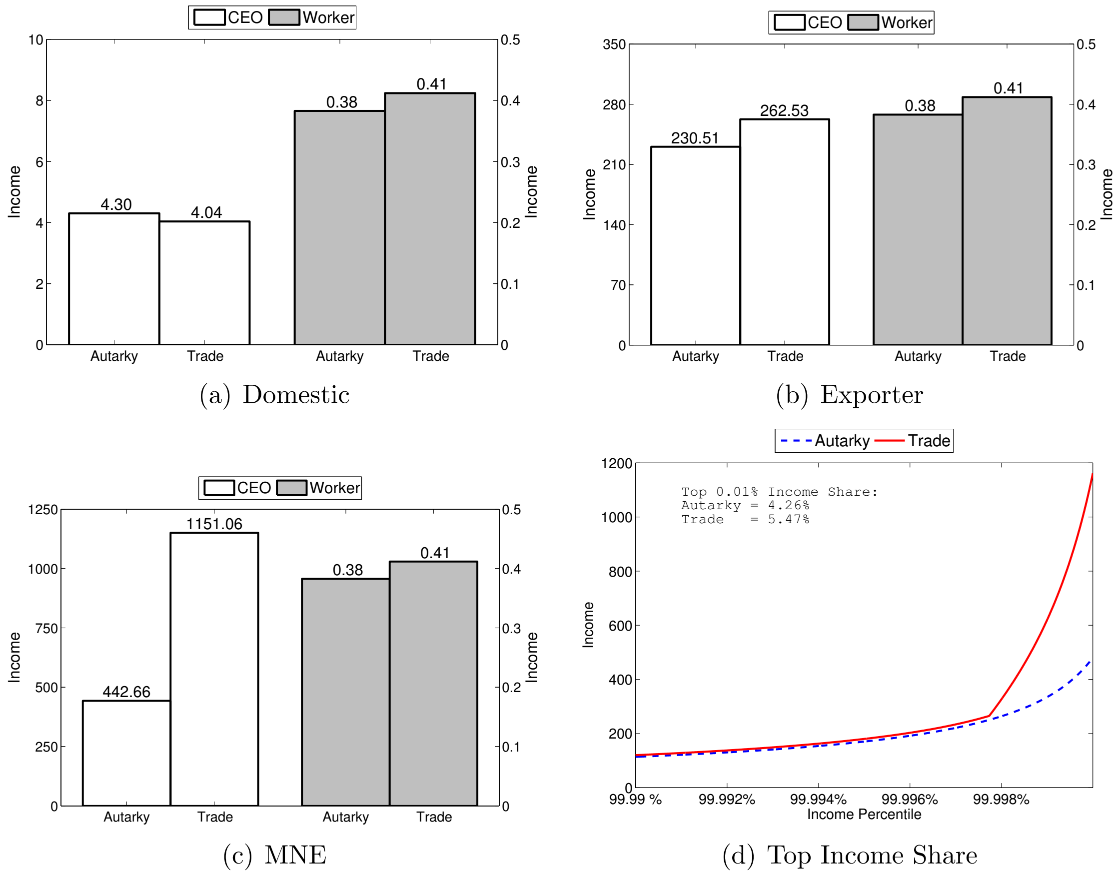
In the benchmark model τ and g are calibrated to match the moments of trade volume and multinational sales in the data. In this section I study how different measures of income inequality vary with the changes in τ and g. The first set of results compare the autarky simulation with the benchmark model, and the second set of results report the sensitivity of income inequality to continuous changes in the openness of trade.

I first compare the income of different individuals between autarky and the benchmark model. In "autarky," I set τ and g matrices high enough such that no trade and foreign investment takes place, while keeping all the other parameters the same as in the benchmark model. The first three panels in Figure 4 compare the income of the CEO and a worker with average human capital across three different firms in autarky and in trade. The firm in panel (a) is a domestic firm in trade equilibrium, the firm in panel (b) an exporter, and the firm in panel (c) a multinational firm.[33] The income of the average worker increases by around 7.9 percent from 0.38 to 0.41 in all three firms between autarky and trade. However, different CEOs see different income paths. The CEO at the domestic firm sees his/her income decrease by around 6.0 percent, the CEO at the exporting firm sees his/her income increase by around 13.9 percent, while the CEO at the multinational firm sees his/her income surge by as much as 160 percent. As a result, trade widens within-firm inequality for the large firms that sell to ROW: the CEO-to-worker pay ratio increases from 606 to 640 in the exporting firm, and from 1,264 to 2,831 in the multinational firm.

Within-firm inequality translates into changes in top income shares. The last panel in

[32] These data come from NIPA table 1.10. The gross domestic income of the private sector is defined as compensation of employees plus net operating surplus of private enterprises.

[33] To keep the results comparable between this section and the robustness check sections, I report the income of the CEO from the largest domestic, exporting, and multinational firm respectively in each graph.



(a) Domestic (b) Exporter (c) MNE (d) Top Income Share

Figure 4: Income Inequality between Autarky and Trade, Benchmark Model

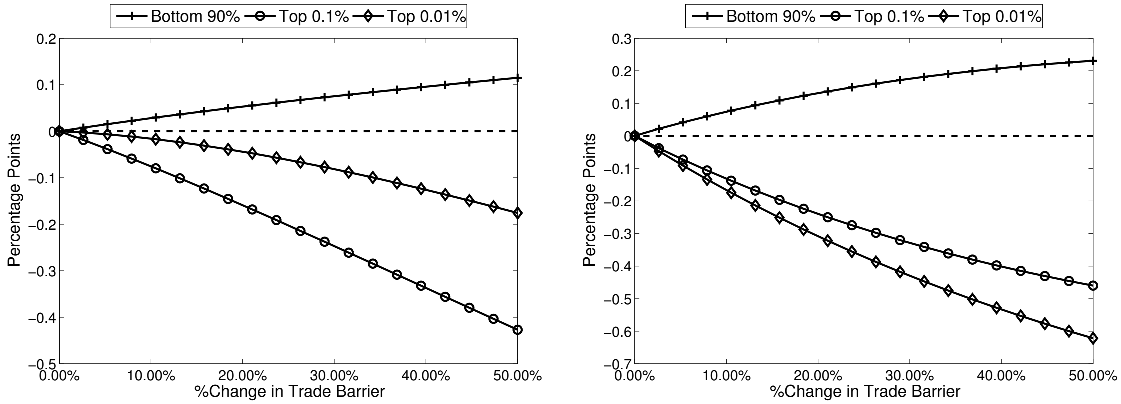
Note: The first three panels of the figure compares the income of the CEO and a worker with average endowment of human capital at three different firms in the economy. The last panel plots the income of top 0.01 percent in autarky v.s. in trade. "Autarky" means both τ and g are set to a large number so trade and FDI fall to 0. "Trade" means the benchmark model when both τ and g are calibrated so the exports-to-GDP ratio and multinational-sales-to-GDP ratio match the U.S. data in 2008.

Figure 4 compares the income of the top 0.01 percent of the population between autarky and the benchmark model. The income distribution is already skewed to the right in autarky, with the top 0.01 percent of the population claiming around 4.26 percent of total income. In trade equilibrium the distribution is even more skewed to the right, as the CEOs at the exporting and multinational firms cut a larger share from the extra profits earned abroad than the average workers. The surge in top income concentration can be observed as the gap between the red solid line (trade) and the blue dashed line (autarky) opens up. In trade equilibrium, the top 0.01 percent income share increases to 5.47 percent. This is a 1.21 percentage point change in absolute income shares, or a 28.4 percent increase in relative terms. In comparison, the top 0.01 percent income share increased by 1.46 percentage points between 1970 and 1988 and another 1.38 percentage points between 1988 and 2008 in the U.S. data. Overall, the model seems to be able to explain a significant proportion of the change in top income share using the change in the volume of trade and FDI sales alone.

In the next set of simulations I study how different income shares respond to gradual changes in τ and g. I first gradually increase τ from the benchmark value, $\tau = 1.95$, by 50 percent to $\tau = 2.43$, while keeping all the other parameters at the benchmark value. As τ increases from the benchmark level to 50 percent higher, the exports-to-GDP ratio drops from 0.129 (2008 value) to 0.043, which is roughly the level in early 1970s. Panel (a) of Figure 5 presents how top 0.01, top 0.1, and bottom 90 percent income shares in the U.S. respond to changes in τ. Higher trade barriers negatively affect the individuals at the top of the income distribution more than the rest of the population. As a result, the top income shares drop. For example, the income share of the top 0.1 income share drops by 0.43 percentage point, the top 0.01 income share drops by 0.18 percentage point, while the bottom 90 percent income share increases by 0.12 percentage point. Similarly, Panel (b) in Figure 5 presents how these income shares respond to changes in g while holding all the other parameters fixed. Again, higher fixed costs to set-up foreign subsidiaries hurt the top income earners much more than the general population: top 0.01 percent income share decreases by 0.62 percentage point, while the bottom 90 percent income share increases by 0.23 percentage point, when g is 50 percent higher than the benchmark model.

How does the changes in top income shares reported above compare to the data? I carry out a third set of counter-factual analysis, in which I calibrate τ and g to match the export-to-GDP ratio and the multinational-sales-to-GDP ratio in each year between 1988 and 2008, while keeping all the other parameters fixed at the benchmark value. This set of τ and g matrices are reported in Table 9. Conditional on the calibrated τ and g in each year, the equilibrium of the model can be solved, and measures of income inequality can be computed. This exercise simulates a counterfactual world where the only things that have changed between 1988 and 2008 are the trade barriers, and seeks to shed light on how top income shares correspond to the openness of the economy.

Panel (a) in Figure 6 compares the change in the top 0.01 percent income shares in the



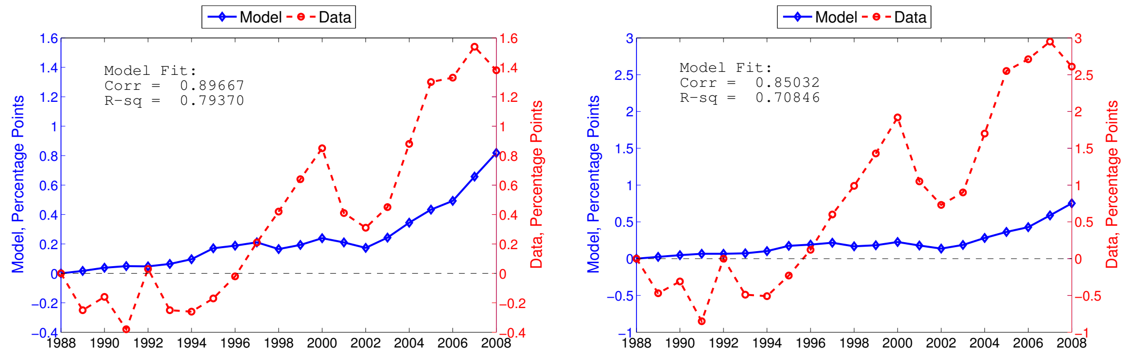
(a) τ (b) g

Figure 5: Income Shares and Barriers to Trade, Model Simulations

Note: This figure plots how income shares respond to changes in trade barriers τ and g. The vertical axis is the change in income shares as compared to the benchmark model. The horizontal axis is the percentage changes in τ and g as compared to the benchmark model.

model and the data between 1988 and 2008. The red dashed line is the change of income shares between a given year in the x-axis and 1988 in the unit of percentage points in the data from the updated Table A.1 in Piketty and Saez [2003]. For example, the last point on this curve indicates that comparing to 1988, the top 0.01 percent income share in 2008 is 1.38 percentage points higher. The blue solid line is the same measure in the model. Each point on the blue solid line is based on the top income share computed based on the calibrated τ and g in that year. Note that the last point on the graph with τ and g calibrated to the trade moments in 2008 is the benchmark model.

The model is able to broadly capture the changes in top income shares over these 20 years. The correlation between the two curves in Panel (a) of Figure 6 is 0.90, and the adjusted R-squared of regressing the data curve on the model curve is 0.79. In terms of magnitude, the changes in income shares in the model are on average half of the data. For example, between 2008 and 1988 the top 0.01 percent income share increased by 1.38 percentage points in the data and 0.82 percentage point in the model, indicating that $0.82/1.38 \approx 59$ percent of the change in top income shares can be explained using the changes in trade volumes. The share of the data that can be explained by the model averages around 56 percent between 1998 and 2008. This result suggests that a large proportion of the observed change in aggregate income inequality can be explained through the channel of within-firm inequality: better access to



(a) Top 0.01 Percent (b) Top 0.1 Percent

Figure 6: Income Share of the Top 0.01 Percent

Note: This graph shows the change in top 0.01 percent and top 0.1 percent income shares in percentage points between 1988 and 2008. In the model simulation τ and g are calibrated to match the imports-to-GDP ratio and multinational-sales-to-GDP ratio in each year. For other model parameters behind this simulation, see Section 5.1. The source of the data is Table A.1 in the updated tables of Piketty and Saez [2003]. Two measures of model fit are computed: the Pearson correlation between the two curves and the adjusted R-squared of estimating a linear relationship with data sequence on the left-hand-side and model sequence on the right (with constant term).

foreign markets benefits the top executives more than the average workers, widening the income gap between the rich and the poor.

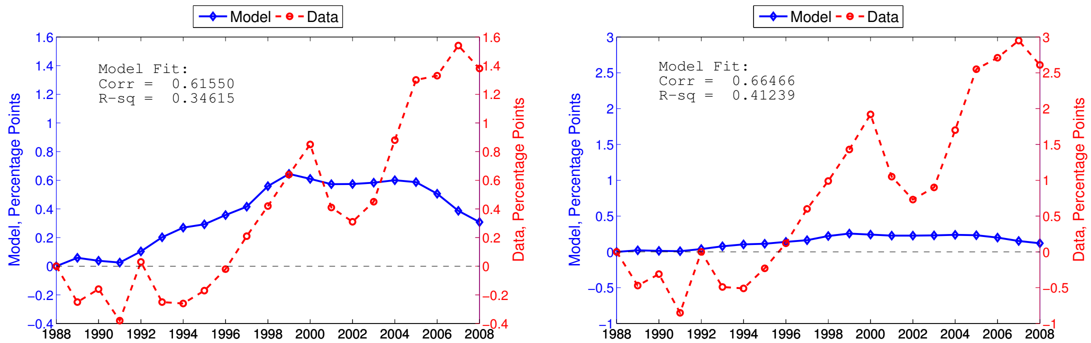
The explanatory power of the model varies from period to period. The first period, from the beginning of the sample to around 1994, is a period during which the top income shares vary greatly from year to year in the data. This is mainly due to the short and long term effects of the 1986 Tax Reform Act.[34] This tax reform drastically changed the marginal tax rates and tax brackets for the top income earners, thus changing the tax reporting incentives significantly. The short-term consequences of the 1986 TRA are reflected in the sharp increase in top income shares measured in the tax return data between 1986 and 1988 (not shown in the graph). The long-term consequences of the tax reform are less clear, but they can still be observed in the volatility of the data curve in Figure 6 before 1994. The model economy, in contrast, exhibits a steady increase in income shares, driven by steady increase in trade and multinational sales. The discrepancy between the model and the data is expected, because the model does not consider various effects of income tax. In the second phase, starting from 1994 until the 2001-2002 stock market crash, we start to observe a rapid increase in the top income share in the data, but only a modest increase in the model. The

[34] See Slemrod [1996] and Poterba and Feenberg [2000] for details.

surge in top income shares in the data can probably be attributed to the rapid economic growth and the stock market boom. In the model world where no equity market exists, top income shares only respond to the changes in the volumes of trade and multinational sales, which grow slowly during this period. For example, the trade-to-GDP ratio in the U.S. only increased by around 0.15 percent point each year between 1994 and 2002. The low explanatory power of the model is again, expected, because the model is not designed to capture capital gains in the stock market. In the last phase, from 2002 to the end of the sample, the explanatory power of the model is high. This is a period during which trade-to-GDP ratio increases at the fastest pace (1.32 percentage points per year) after World War II. As a result, the trade-induced inequality increases rapidly in the model, matching the concurrent surge in top income shares in the data to a large extent.

The results of the same exercise for the top 0.1 percent of the income distribution are presented in Panel (b) of Figure 6. Overall, the model captures the upward trend of the top 0.1 percent income share. However, the share of the data that can be explained by the model is lower. Between 1988 and 2008, income share of the top 0.1 percent increased by 2.61 percentage points in the data, while it increased by 0.75 percentage points in the model. In other words, $0.18/2.61 \approx 29$ percent of the change in the data can be explained, compared to 59 percent for the top 0.01 percent over the same period.

In general, the explanatory power of the model declines when we move down the income ladder. This is because the model is only designed to explain the income of top executives in large corporations, who happen to occupy the pinnacle of the income pyramid. Outside of this group, the key mechanism in the model does not apply. For example, many other occupations such as working professionals are among the top 0.1 or 1 percent of the income ladder in the real world, and they are missing in the model. The more we move down the income ladder, the more frequent are these cases, and the lower the explanatory power of the model will be. It is important to understand how globalization affects different occupations differently, however, this is well beyond the scope of this paper. The model is not trying to provide a comprehensive theory to explain the surge of top income shares in developed countries; Instead, it highlights a particular channel through which globalization can affect the top income earners differently than the general population.



(a) Top 0.01 %

(b) Top 0.1 %

Figure 7: Top Income Shares, TFP Change

Note: This graph shows the change in top 0.01 percent and top 0.1 percent income shares in percentage points between 1988 and 2008. The change in the model is shown on the left axis, and the change in the data is shown on the right axis. In the model simulation, τ and g matrices are fixed at 1988 level, while TFP varies from year to year. For other model parameters behind this simulation, see Section 5.1. The source of the data is Table A.1 in the updated tables of Piketty and Saez [2003]. Two measures of model fit is computed: the Pearson correlation between the two curves and the adjusted R-squared of estimating a linear relationship with data sequence on the left-hand-side and model sequence on the right (with constant term).

The above counterfactual analysis shows that the expansions of trade volumes and multinational sales widen the income gap between the rich and the poor and drive up top income shares along the way. To highlight the effect of globalization on top income inequality further, I run another set of counterfactual simulations and show that *without* the expansion in trade and multinational sales, top income shares in the model will *not* exhibit the trends that we have observed in the data. In this analysis I fix the τ and g matrices to the benchmark value, and allow the TFP vector b_i to vary from year to year to match the trend in technology progress and economic growth in U.S. and ROW.[35] Table 9 reports the b_i vectors used in this exercise. All the other parameters are fixed at values reported in Table 7. Conditional on year-specific b_i, I solve the model and compute the top income shares for each year, and check how income inequality in the model responds to changes in technology.

The results for top 0.01 percent and top 0.1 percent income shares are presented in the two panels of Figures 7 in similar manners as in Figure 6. Without the expansion of the volume of trade and multinational sales, top income shares in the model do not follow the data closely. For example, the correlation between the data and model sequence is only

[35] I compute b_i year by year using the methods outlined in Section 5.1, instead of fixing b_i to 1988 levels as in the previous case.

0.61 for the top 0.01 income share, compared to 0.90 in the case where trade moments are matched. The adjusted R-squared of regressing the data sequence on the model sequence is only 0.35, compared to 0.79 in the previous case. The magnitude of change is also smaller: between 1988 and 2008, the top 0.01 percent income share increase by only 0.31 percentage point, as compared to 0.82 percentage point when I allow τ and g to move. The results for the top 0.1 percent is similar: top income share barely moves when τ and g are fixed at the benchmark value.

5.4 Robustness Checks

In this section I report robustness checks with different values of ϵ. In the benchmark model I calibrate $\epsilon = 4$ to capture the average markup. In this section I set ϵ to 2 and 6 and check the main results of the model. In each of the robustness checks I re-calibrate every parameter to match the same moments as in the benchmark model, and they are reported in Table 7.

Figure 8 reports the results when $\epsilon = 6$. The main results of the benchmark model carry through in this case: when countries open up to trade, the individuals at the top of the income distribution benefit much more than the general population. In this case, the real income of workers increase by around 4.7 percent between autarky and trade, while the CEO at a multinational firm sees his/her income increasing by $748.49/274.82 - 1 \approx 172$ percent. The impact of trade can also be observed at the aggregate level: top 0.01 percent income share increases from 3.54 to 3.81 percentage points. Overall the impacts of trade are smaller in this case, as compared to the benchmark model. When the elasticity of substitution is higher, the markup and profit margin of the firms decrease. As a result, the income distribution is less concentrated in the hands of the executives, and top income shares are less responsive to changes in trade barriers.

Figure 9 reports the results when $\epsilon = 2$. Again, the main results of the benchmark model are preserved in this case. Moreover, the impacts of trade are higher as compared to the benchmark model, due to the same reason outlined above. Between autarky and trade, the real income of the workers increases by $2.15/1.55 - 1 \approx 39$ percent, while the income of the CEO at the multinational firm increases by $3082/1393 \approx 121$ percent. At the aggregate level, the top 0.01 percent income share increases from 4.85 to 8.04 percentage points between autarky and trade.

6 Conclusion

This paper studies the relationship between globalization and income inequality with a special focus on the gap between the rich and the poor. Empirically, this paper presents a new fact that within-firm inequality is higher among the firms that have access to global markets. On average, the CEO-to-worker pay ratio is about 50 percent higher among the exporting firms than among domestic firms. The differences in within-firm inequality are mainly driven by differences in firm size. Exporting firms are more unequal because they are usually larger than their domestic counterparts.

This paper presents a new framework to study the distributional effect of trade. It merges the heterogeneous firms trade model with a model of occupational choice and executive compensation. The key mechanism to generate higher within-firm inequality among exporters and MNEs is through the size effect. On the one hand, CEO compensation is positively linked to the performance of the firm, and only the large and productive firms find it profitable to sell to the global markets. On the other hand, the wage rate is determined in a countrywide labor market and is not linked to each specific firm. These two forces imply that within-firm inequality is higher among the firms that have access to the global markets.

The paper argues that within-firm inequality can be responsible for a significant proportion of the surge of top income shares between 1988 and 2008. Using counterfactual analysis in which only the trade barriers are allowed to move exogenously, the model is able to broadly replicate the trends of top income shares in the U.S. The correlation between the model-generated changes in top income share and the data is 0.90, and the adjusted R-squared is 0.79. In terms of magnitude, the changes in the model-generated income share are around 56 percent of the changes in the data. Similar but weaker results are found for the top 0.1 percent income share. These results suggest that globalization could have shaped the surge in top income shares in the U.S. through within-firm inequality significantly.

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.507***	0.0238		0.0621**		0.0496*		0.0700***	
	(0.0300)	(0.0246)		(0.0247)		(0.0257)		(0.0270)	
Sales		0.436***	0.437***						
		(0.00719)	(0.00702)						
Asset				0.420***	0.425***				
				(0.00692)	(0.00676)				
Employment						0.388***	0.391***		
						(0.00731)	(0.00706)		
Payroll								0.364***	0.370***
								(0.00864)	(0.00828)
Constant	2.017***	-0.144	-0.132	-0.0576	-0.0248	-0.444**	-0.425**	-1.574***	-1.569***
	(0.210)	(0.196)	(0.196)	(0.202)	(0.201)	(0.203)	(0.203)	(0.216)	(0.216)
Observations	17223	17223	17223	17223	17223	17223	17223	17223	17223
R-squared	0.270	0.439	0.439	0.428	0.428	0.407	0.407	0.385	0.385

Table 1: CEO-to-Worker Pay Ratio of U.S. Public Firms

Note: This table reports the results of estimating equation (1) for U.S. public firms based on the linked ExecuCompustat-LBD-LFTTD data. The left-hand side variable for each of the regressions is the (log of) CEO-to-worker pay ratio. "Exporter" is the exporter indicator computed from LFTTD. "Sales" is the (log of) total annual sales reported in Compustat. "Asset" is the (log of) total asset reported in Compustat. "Employment" is the (log of) total annual employment reported in LBD. "Payroll" is the (log of) total annual payroll reported in LBD. The unit of observation is firm-year and year varies between 1992 and 2007. All specifications include year and four-digit SIC fixed effects. See Table A.1 for sector distribution of the sample.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.411***	-0.0630		-0.0441		-0.0932**	
	(0.0546)	(0.0415)		(0.0419)		(0.0426)	
Sales		0.388***	0.384***				
		(0.0108)	(0.0105)				
Asset				0.391***	0.389***		
				(0.00910)	(0.00916)		
Payroll						0.353***	0.345***
						(0.0112)	(0.0105)
Constant	2.690***	0.844***	0.831***	0.792***	0.782***	-3.248***	-3.169***
	(0.199)	(0.233)	(0.230)	(0.221)	(0.219)	(0.307)	(0.300)
Observations	6002	6002	6002	6002	6002	6002	6002
R-squared	0.402	0.619	0.618	0.627	0.627	0.566	0.565

Table 2: Highest-Paid-Executive-to-Worker Pay Ratio of U.S. Private Firms

Note: This table reports the results of estimating equation (1) for U.S. private firms based on the linked CIQ-LBD-LFTTD data. The left-hand side variable for each of the regressions is the (log of) highest-paid-executive-to-worker pay ratio. "Exporter" is the exporter indicator computed from LFTTD. "Sales" is the (log of) total annual sales reported in CIQ. "Asset" is the (log of) total asset reported in CIQ. "Payroll" is the (log of) total annual payroll reported in LBD. The unit of observation is firm-year and year varies between 2003 and 2007. All specifications include year and four-digit SIC fixed effects. See Table A.3 for sector distribution of the sample. Robust standard errors are clustered at the year-sector level.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(a) Salary

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.213***	-0.0340*		0.00479		-0.0822***		0.0104	
	(0.0227)	(0.0199)		(0.0206)		(0.0201)		(0.0211)	
Sales		0.223***	0.220***						
		(0.00619)	(0.00636)						
Asset				0.197***	0.197***				
				(0.00644)	(0.00660)				
Employment						0.250***	0.244***		
						(0.00623)	(0.00619)		
Payroll								0.169***	0.170***
								(0.00744)	(0.00745)
Constant	1.767***	0.669***	0.652***	0.804***	0.807***	0.188	0.156	0.110	0.111
	(0.135)	(0.131)	(0.130)	(0.136)	(0.134)	(0.133)	(0.132)	(0.151)	(0.151)
Observations	17156	17156	17156	17156	17156	17156	17156	17156	17156
R-squared	0.370	0.438	0.438	0.423	0.423	0.458	0.457	0.408	0.408

(b) Bonus

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.508***	-0.00229		0.0503*		0.0294		0.0759**	
	(0.0352)	(0.0278)		(0.0283)		(0.0301)		(0.0316)	
Sales		0.454***	0.454***						
		(0.00797)	(0.00770)						
Asset				0.429***	0.433***				
				(0.00785)	(0.00760)				
Employment						0.411***	0.414***		
						(0.00838)	(0.00817)		
Payroll								0.370***	0.376***
								(0.00974)	(0.00944)
Constant	1.078***	-0.963***	-0.964***	-0.848***	-0.819***	-1.416***	-1.403***	-2.482***	-2.471***
	(0.198)	(0.179)	(0.178)	(0.184)	(0.183)	(0.179)	(0.178)	(0.202)	(0.202)
Observations	12681	12681	12681	12681	12681	12681	12681	12681	12681
R-squared	0.340	0.502	0.502	0.485	0.485	0.476	0.476	0.444	0.444

(c) Stock Option and Others

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.855***	0.0232		0.0733		0.119*		0.0682	
	(0.0711)	(0.0678)		(0.0676)		(0.0706)		(0.0713)	
Sales		0.751***	0.753***						
		(0.0186)	(0.0179)						
Asset				0.736***	0.741***				
				(0.0177)	(0.0169)				
Employment						0.626***	0.634***		
						(0.0186)	(0.0177)		
Payroll								0.657***	0.663***
								(0.0196)	(0.0184)
Constant	-0.721	-4.474***	-4.462***	-4.359***	-4.319***	-4.718***	-4.670***	-7.229***	-7.222***
	(0.467)	(0.453)	(0.452)	(0.449)	(0.448)	(0.460)	(0.459)	(0.482)	(0.482)
Observations	16963	16963	16963	16963	16963	16963	16963	16963	16963
R-squared	0.182	0.275	0.275	0.272	0.272	0.248	0.248	0.252	0.252

Table 3: Decomposition of CEO Compensation, U.S. Public Firms

Note: This table reports the results of estimating equation (1) based on the ExecuCompustat-LBD-LFTTD data. The upper panel uses the annual salary of the CEO, the middle panel uses annual bonus, and the lower panel uses returns from stock options and others sources of income as measures of CEO compensation. For other details, see the note to Table 1.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(a) Estimated CEO Compensation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.486***	2.22e-05		0.0265		0.0168		0.0478*	
	(0.0292)	(0.0226)		(0.0226)		(0.0245)		(0.0255)	
Sales		0.438***	0.438***						
		(0.00712)	(0.00704)						
Asset				0.434***	0.436***				
				(0.00660)	(0.00654)				
Employment						0.398***	0.399***		
						(0.00706)	(0.00694)		
Payroll								0.365***	0.369***
								(0.00834)	(0.00810)
Constant	2.066***	-0.107	-0.107	-0.0754	-0.0614	-0.458**	-0.452**	-1.533***	-1.529***
	(0.194)	(0.184)	(0.183)	(0.185)	(0.185)	(0.187)	(0.186)	(0.199)	(0.200)
Observations	17223	17223	17223	17223	17223	17223	17223	17223	17223
R-squared	0.266	0.459	0.459	0.457	0.457	0.429	0.429	0.397	0.397

(b) Top-Five-Executives-to-Worker

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exporter	0.477***	0.00622		0.0336*		0.0585***		0.0743***	
	(0.0268)	(0.0202)		(0.0201)		(0.0221)		(0.0232)	
Sales		0.430***	0.430***						
		(0.00624)	(0.00609)						
Asset				0.419***	0.422***				
				(0.00553)	(0.00540)				
Employment						0.358***	0.363***		
						(0.00688)	(0.00679)		
Payroll								0.340***	0.345***
								(0.00841)	(0.00813)
Constant	2.001***	-0.170	-0.167	-0.0800	-0.0614	-0.300**	-0.276**	-1.367***	-1.359***
	(0.144)	(0.129)	(0.128)	(0.130)	(0.130)	(0.135)	(0.134)	(0.155)	(0.155)
Observations	16268	16268	16268	16268	16268	16268	16268	16268	16268
R-squared	0.341	0.575	0.575	0.566	0.566	0.508	0.508	0.484	0.483

(c) MNE v.s. non-MNE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
MNE	0.197***	-0.0669***		-0.0709***		0.0562**		0.0515**	
	(0.0285)	(0.0245)		(0.0254)		(0.0252)		(0.0259)	
Sales		0.444***	0.441***						
		(0.00831)	(0.00816)						
Asset				0.422***	0.418***				
				(0.00821)	(0.00807)				
Employment						0.382***	0.383***		
						(0.00852)	(0.00844)		
Payroll								0.357***	0.359***
								(0.0103)	(0.0102)
Constant	2.338***	-0.400	-0.397	-0.215	-0.211	-0.483*	-0.480*	-1.564***	-1.569***
	(0.288)	(0.252)	(0.251)	(0.261)	(0.261)	(0.262)	(0.262)	(0.279)	(0.279)
Observations	12943	12943	12943	12943	12943	12943	12943	12943	12943
R-squared	0.277	0.443	0.443	0.431	0.430	0.410	0.410	0.387	0.387

Table 4: Robustness Checks, Other Executives and MNE

Note: This table reports three robustness checks. The upper panel uses the "estimated" (TDC1), instead of "realized" compensation (TDC2) of the CEO when computing the CEO-to-worker pay ratio. The middle panel uses the average compensation of the top five highly paid executives divided by the average wage. The lower panel compares multinational enterprises (MNE) v.s. non-MNE. "MNE" is the multinational firm indicator. For other details, see the note to Table 1.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(a) Estimated Compensation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.442***	-0.0683*		-0.0398		-0.0919**	
	(0.0520)	(0.0392)		(0.0401)		(0.0420)	
Sales		0.417***	0.413***				
		(0.0104)	(0.0101)				
Asset				0.414***	0.412***		
				(0.00895)	(0.00879)		
Payroll						0.373***	0.366***
						(0.0112)	(0.0105)
Constant	2.810***	0.824***	0.810***	0.801***	0.792***	-3.477***	-3.399***
	(0.160)	(0.193)	(0.190)	(0.174)	(0.172)	(0.275)	(0.269)
Observations	6002	6002	6002	6002	6002	6002	6002
R-squared	0.363	0.595	0.595	0.596	0.596	0.533	0.532

(b) Top-Five Executives

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.390***	-0.0444		-0.0136		-0.0725*	
	(0.0540)	(0.0392)		(0.0390)		(0.0397)	
Sales		0.385***	0.382***				
		(0.0128)	(0.0120)				
Asset				0.388***	0.387***		
				(0.00995)	(0.00954)		
Payroll						0.353***	0.347***
						(0.0110)	(0.0106)
Constant	1.988***	0.198	0.183	0.164	0.159	-3.857***	-3.804***
	(0.122)	(0.160)	(0.158)	(0.142)	(0.141)	(0.244)	(0.238)
Observations	4827	4827	4827	4827	4827	4827	4827
R-squared	0.429	0.657	0.657	0.665	0.665	0.613	0.612

Table 5: Executive-to-Worker Pay Ratio: U.S. Private Firms

Note: This table reports two robustness checks for the estimation of U.S. private firms based on the linked CIQ-LBD-LFTTD data. The upper panel uses estimated compensation of the highest paid executive when constructing the LHS variable, and the lower panel uses average realized compensation of top 5 highly paid executives. "Exporter" is the exporter indicator computed from LFTTD. "Sales" is the (log of) total annual sales reported in CIQ. "Asset" is the (log of) total asset reported in CIQ. "Payroll" is the (log of) total annual payroll reported in LBD. The unit of observation is firm-year. In all the regressions, year and four-digit SIC fixed effects are controlled for.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(a) Salary

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.168***	-0.0451		-0.0236		-0.0742**	
	(0.0364)	(0.0349)		(0.0349)		(0.0341)	
Sales		0.176***	0.173***				
		(0.00843)	(0.00779)				
Asset				0.164***	0.162***		
				(0.00908)	(0.00872)		
Payroll						0.169***	0.163***
						(0.00841)	(0.00773)
Constant	2.070***	1.237***	1.228***	1.282***	1.276***	-0.778***	-0.716***
	(0.0430)	(0.0672)	(0.0662)	(0.0702)	(0.0696)	(0.155)	(0.148)
Observations	5123	5123	5123	5123	5123	5123	5123
R-squared	0.497	0.573	0.573	0.566	0.566	0.563	0.562

(b) Bonus

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.313***	-0.237***		-0.214***		-0.270***	
	(0.0855)	(0.0648)		(0.0634)		(0.0693)	
Sales		0.490***	0.474***				
		(0.0227)	(0.0216)				
Asset				0.482***	0.469***		
				(0.0210)	(0.0206)		
Payroll						0.430***	0.408***
						(0.0245)	(0.0233)
Constant	1.587***	-0.766***	-0.809***	-0.768***	-0.813***	-5.660***	-5.428***
	(0.0702)	(0.137)	(0.134)	(0.141)	(0.137)	(0.429)	(0.415)
Observations	3927	3927	3927	3927	3927	3927	3927
R-squared	0.388	0.546	0.544	0.551	0.549	0.511	0.508

(c) Stock and Option Rewards

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exporter	0.544***	-0.0457		-0.0281		-0.115	
	(0.103)	(0.0836)		(0.0858)		(0.0817)	
Sales		0.498***	0.495***				
		(0.0215)	(0.0215)				
Asset				0.510***	0.509***		
				(0.0201)	(0.0206)		
Payroll						0.454***	0.444***
						(0.0205)	(0.0201)
Constant	0.401	-1.929***	-1.945***	-1.987***	-1.998***	-7.068***	-6.989***
	(0.699)	(0.742)	(0.740)	(0.723)	(0.721)	(0.801)	(0.801)
Observations	4742	4742	4742	4742	4742	4742	4742
R-squared	0.393	0.500	0.500	0.507	0.507	0.477	0.477

Table 6: Decomposition of the Highest Compensation: Salary, Bonus, and Stock and Option Rewards in U.S. Private Firms

Note: This table reports the results of estimating equation (1) based on the CIQ-LBD-LFTTD data. The LHS variable for the upper panel is the (log of) annual salary of the highest-paid executive divided by average wage. The LHS variable for the middle panel is the (log of) annual bonus of the highest-paid executive divided by average wage. The LHS variable for the lower panel is the (log of) annual other compensation of the highest-paid executive divided by average wage. For other details, see the note to Table 5.
Robust standard errors are clustered at the year-sector level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Parameter	Benchmark	High ϵ	Low ϵ	Target/Source
λ	3.81	5.3	1.06	Axtell [2001]
ϵ	4.0	6.0	2.0	Average mark-up
α	56.0	28.8	420	Corporate sales as a percentage of all firms sales
β	0.747	0.747	0.747	Tail index of income dist., Drăgulescu and Yakovenko [2001b]
f_{11}	6.0	6.0	6.0	World Bank Doing Business Index
f_{12}	19.6	19.6	19.6	World Bank Doing Business Index
f_{21}	24.6	24.6	24.6	World Bank Doing Business Index
f_{22}	38.9	38.9	38.9	World Bank Doing Business Index
f-Scale	0.182	0.0476	9.7	Percentage. of chief execu. in work force.
n_{ROW}	6.0	6.0	6.0	Caselli [2005], Barro and Lee [2010]
n_{USA}	1.0	1.0	1.0	Caselli [2005], Barro and Lee [2010]
b_{ROW}	0.57	0.57	0.57	Caselli [2005], Barro and Lee [2010]
b_{USA}	1.0	1.0	1.0	Caselli [2005], Barro and Lee [2010]
s	3.495	2.205	8.63	Highest-CEO-to-average-wage ratio among public firms
τ	1.946	1.565	3.451	Export-GDP ratio in 2008
g	1190	3753.7	551.25	Multinational-sales-GDP ratio in 2008

Table 7: Calibration Targets and Results

Note: λ is the shape parameter of the exponential distribution. ϵ is the elasticity of substitution in the utility functions. α is the size of the smallest public firm. β is the tail index of the compensation function. f_{ij} is the fixed cost of exporting from country j to country i. f-Scale is the normalizing factor of the entire f_{ij} matrix. I divide the f_{ij} matrix by this number. n_i is the measure of capital-adjusted endowment of human capital in country i. b_i is the TFP in country i. s is the upper bound of human capital distribution. See Section 5.1 and the appendix for the details of calibration. See Table 9 for the calibrated values of τ, g and TFP by year.

Moments	Model	Data
Mean-to-median ratio, income	1.84	1.61
Percentile location of mean, income	72	71
Workers' share of income	0.750	0.711
CEO-worker pay ratio	205	89

Table 8: Model Fit, Untargeted Moments

Note: The Mean-to-median ratio and the percentile location of the mean come from Rodriguez et al. [2002]. The workers' share of income is computed from NIPA. Table 1.10. The CEO-worker pay ratio is computed in Section 2.

	τ	g	TFP, USA	TFP, ROW
1988	2.287	2051.500	1.000	0.573
1989	2.256	2028.600	1.009	0.570
1990	2.231	1993.700	1.004	0.571
1991	2.206	1981.000	0.986	0.562
1992	2.204	1985.200	1.000	0.559
1993	2.207	1951.500	1.012	0.553
1994	2.182	1900.900	1.031	0.555
1995	2.128	1795.500	1.035	0.554
1996	2.119	1771.100	1.051	0.555
1997	2.097	1743.600	1.069	0.557
1998	2.134	1802.100	1.090	0.551
1999	2.139	1758.900	1.113	0.552
2000	2.111	1701.700	1.119	0.559
2001	2.161	1727.700	1.103	0.555
2002	2.197	1770.900	1.098	0.553
2003	2.184	1677.200	1.101	0.553
2004	2.134	1567.100	1.120	0.560
2005	2.101	1480.700	1.127	0.566
2006	2.063	1430.900	1.131	0.578
2007	2.005	1299.500	1.127	0.591
2008	1.946	1190.000	1.102	0.588

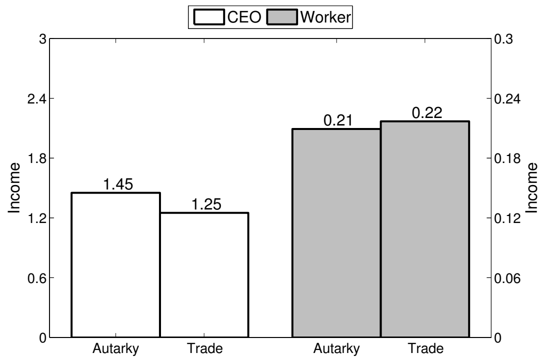
Table 9: τ, g, and TFP

Note: This table reports the calibrated trade cost τ, g, and the estimated TFP. The τ and g matrices are assumed to be symmetric. The calibrated τ and g assume that the TFP for both countries is fixed at the 1988 level. The TFP reported is calculated using the method outlined in Caselli [2005] and normalized so that the TFP in the U.S. in 1988 is 1. See appendix for details.

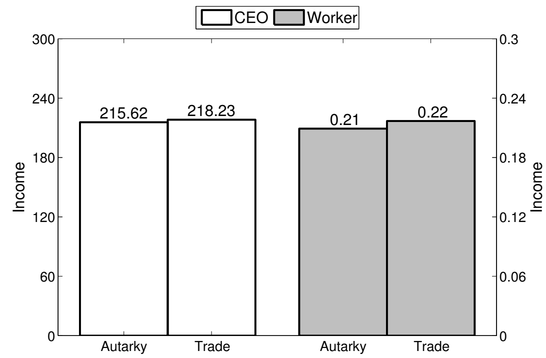
Afghanistan	Cote d'Ivoire	Iraq	Nepal	Spain
Albania	Denmark	Ireland	Netherlands	Sri Lanka
Algeria	Dominican	Israel	New Zealand	Sudan
Argentina	Ecuador	Italy	Nicaragua	Sweden
Australia	Egypt	Jamaica	Niger	Switzerland
Austria	El Salvador	Japan	Norway	Syria
Bangladesh	Fiji	Jordan	Pakistan	Tanzania
Belgium	Finland	Kenya	Panama	Thailand
Benin	France	Korea	Papua New Guinea	Togo
Bolivia	Germany	Laos	Paraguay	Tonga
Botswana	Ghana	Lesotho	Peru	Trinidad &Tobago
Brazil	Greece	Malawi	Philippines	Tunisia
Bulgaria	Guatemala	Malaysia	Poland	Turkey
Burundi	Guyana	Maldives	Portugal	Uganda
Cameroon	Haiti	Mali	Romania	United Arab Emirates
Canada	Honduras	Mauritania	Rwanda	United Kingdom
Central African	Hong Kong	Mauritius	Saudi Arabia	United States
Chile	Hungary	Mexico	Senegal	Uruguay
China	Iceland	Mongolia	Sierra Leone	Venezuela
Colombia	India	Morocco	Singapore	Vietnam
Congo	Indonesia	Mozambique	Slovak	Zambia
Costa Rica	Iran	Namibia	South Africa	Zimbabwe

Table 10: Countries Included in Calibration

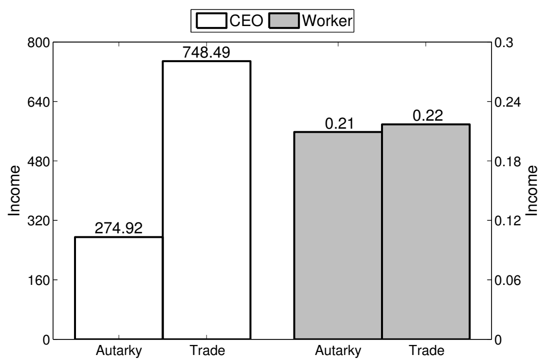
Note: This table reports the list of countries (110 in total) included in the calibration. All the countries except the U.S. are included in ROW. The GDP and population data are based on Penn World Table 7.0 in the year 2008. GDP is in the unit of constant 2005 international dollar and calculated as the product of *RGDPL* and *POP*.



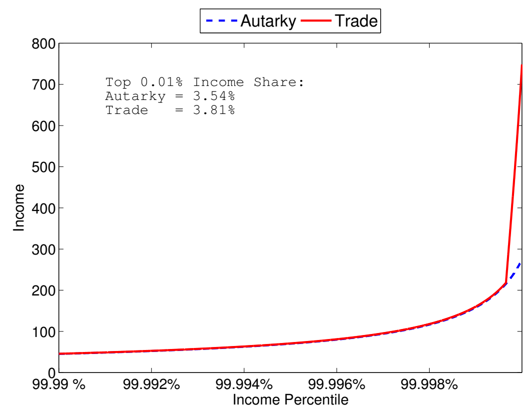
(a) Domestic Firms



(b) Exporting Firms



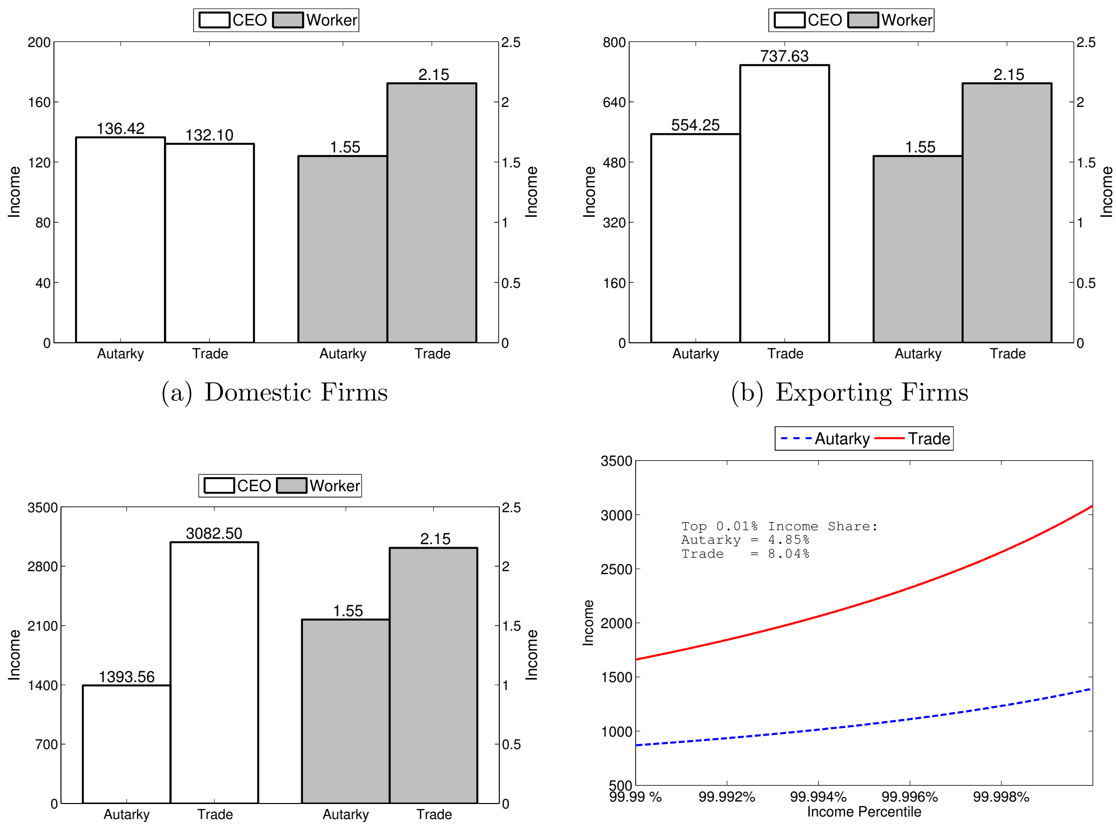
(c) MNE



(d) Top Income Share

Figure 8: Income Inequality Between Autarky and Trade, $\epsilon = 6$

Note: This figure plots how income inequality changes between autarky and trade for the case when $\epsilon = 6$. For more details, see the notes to Figure 4.



(a) Domestic Firms

(b) Exporting Firms

(c) MNE

(d) Top Income Share

Figure 9: Income Inequality Between Autarky and Trade, $\epsilon = 2$

Note: This figure plots how income inequality changes between autarky and trade for the case when $\epsilon = 2$. For more details, see the notes to Figure 4.

A Data Descriptions

A.1 Publicly-Traded Firms

The empirical evidence on public firms is based on a linked data set that has three components. In this appendix I describe the details of the dataset.

The ExecuCompustat provides data on executive compensation. It reports the total realized and estimated compensation of the CEO, CFO, and three other highly paid executives of U.S. public firms in the S&P Composite 1500 Index from 1992 onward.[36] The executive compensation consists of salary, bonus, stock options, long term incentive plans (LTIPs), restricted stock awards, and all others. "Realized" compensation (variable name: TDC2) measures the value of stock option awards at the time of execution, while "estimated" compensation (variable name: TDC1) measures the value of stock options at the time of granting using the Black-Scholes formula.[37]

The confidential Census Bureau databases provide the other key variables needed to measure within-firm inequality and exporting status. The LBD is compiled from the Census Bureau's Business Register, which covers the universe of U.S. firms at the establishment level. I aggregate it up to the firm level and extract annual employment and payroll variables, which are used to compute the average non-executive wage for each firm in a given year. The LBD is linked to the last component of the data set, the LFTTD, using the methods described in McCallum [2013]. The LFTTD records the universe of individual international trade transactions made by U.S. firms based on the data collected by U.S. Customs from 1992 onward. It links each export transaction to the U.S. exporting firm and thus provides the base to identify exporting firms in each year. The final linkage between ExecuCompustat and the linked LBD-LFTTD is done through the Compustat-SSEL Bridge provided by the Census Bureau. Table A.1 and A.2 provide summary statistics of the combined data set.

A.2 Privately-Held Firms

The evidence on privately-held firms in the US is based on the linked CIQ-LBD-LFTTD dataset. In this appendix I describe the details of the datasets.

To construct the dataset, I start with executives working in private U.S. firms between 2003 and 2007 from the CIQ data. This yields a data set that contains around 33,000 individuals working in 3,849 privately held firms and 11,706 firm-year level observations. I then link this data set to the Standard Statistical Establishment List (SSEL) in the Census Bureau. Unlike the ExecuCompustat, where the bridge files exist and firms can be matched using standardized identifiers, the CIQ data have not been linked to the census data sets before. Therefore, I carry out a fuzzy match based on name, street address, and zip code.

[36] The Securities and Exchange Commission (SEC) requires public firms to disclose the total compensation of at least five said executives starting from 1992. Any firm that was once included in the S&P 1500 Index is included in the sample, even if the firm is later dropped from the index. The S&P 1500 Index is the union of three commonly used indices: S&P 500 (LargeCap), S&P MidCap 400 Index, and S&P SmallCap 600 Index. This index covers approximately 90 percent of the total U.S. public firm capitalization.

[37] In 2006, the SEC changed the disclosure rule on executive compensation, which makes the raw data before and after 2006 not directly comparable. The ExecuCompustat data set takes this into account when constructing TDC1 and TDC2 so these two variables can be used for the entire sample.

Sector	Matched Data Percent	N.Obs.	ExecuCompustat Percent	N.Obs.
Mineral & Construction	4.39%	751	5.44%	1876
Manufacturing	46.15%	7892	42.51%	14649
Transportation, Communications and Utilities	10.79%	1845	11.24%	3873
Wholesale and Retail Trade	12.36%	2113	11.49%	3960
Finance, Insurance and Real Estate	13.91%	2379	15.28%	5265
Services	12.40%	2121	14.03%	4835
Other	0.71%	122	0.69%	239
Total	100.00%	17223	100.00%	34697

Table A.1: Sector Composition: Public Firm Sample

Note: This table reports the sectoral composition of the firm-year observations in the linked ExecuCompustat-LBD-LFTTD data set and compares the distribution with the original ExecuCompustat data set. The sector definition is based on a one-digit SIC code.

Mean	Exporters	Non-Exporters	Overall
CEO Compensation, Estimated	4487.7	3254.3	4197.1
CEO Compensation, Realized	4662.4	3340.4	4350.8
CEO-to-worker Pay Ratio, Estimated	91.9	80.8	89.3
CEO-to-worker Pay Ratio, Realized	91.8	79.6	88.9
N. Observations	13169	4054	17223

Table A.2: Summary Statistics: Public Firm Sample

Note: This table reports the mean of key variables of the linked ExecuCompustat-LBD-LFTTD data set. The unit of observation is firm-year. Executive compensations are measured in thousands of U.S. dollars. For the difference between estimated and realized compensation, see Section 2.

I require that the weighted similarity has to be at least 95 percent for two entries to be considered a match and then hand-screen all the matched records to eliminate obvious errors. The matched CIQ records are then linked with LBD-LFTTD constructed by McCallum [2013].

Table A.3 summarizes the results of the fuzzy merge and compares the distribution of firms across sectors in the linked data set and the original CIQ data. The linked data set contains 6,002 firm-year observations and 2202 unique firms. A total of 3,366 firm-year observations and 1,207 unique firms are exporting firms, while the remaining 2,636 observations with 9,95 unique firms are non-exporters. Overall, 51 percent of the CIQ records are matched with the census data. The sectoral distribution of the CIQ is preserved in the linked data set. For example, manufacturing firms constitute 33.8 percent in the linked data and 34.4 percent in the original data; financial firms are responsible for 22.0 percent in the linked data and 18.9 percent in CIQ.

Instead of the CEO-to-worker pay ratio, I construct the ratio between the highest-paid executive and the non-executive wage as the benchmark measure of intra-firm inequality.

The CIQ data does not report standardized job titles, and therefore, constructing the CEO title from the raw data would introduce unnecessary noise. Nevertheless, most of the highest-paid executives are indeed CEOs: in ExecuCompustat, more than 98 percent of the highest-paid executives are the CEOs. There is no strong reason to believe that this ratio will be significantly different in the CIQ sample.

The summary statistics of the top-1-to-worker pay ratio are reported in Table A.4. Overall, within-firm inequality is lower among private firms than among public firms. The top-1-to-worker pay ratio is 37.6 in the private firm sample compared with 89 in the public firm sample. Again, the top-1-to-worker pay ratio varies with exporting status. The ratio is 41.3 among exporters and only 32.8 among non-exporters.

	Matched Data		Capital IQ	
Sector	Percent	N.Obs.	Percent	N.obs.
Mineral & Construction	3.32%	199	4.13%	483
Manufacturing	33.86%	2032	34.44%	4032
Transportation, Communications and Utilities	10.71%	643	10.23%	1197
Wholesale and Retail Trade	9.30%	558	9.18%	1075
Finance, Insurance and Real Estate	21.98%	1319	18.85%	2206
Services	19.99%	1200	21.80%	2552
Other	0.85%	51	1.38%	161
Total	100.00%	6002	100.00%	11706

Table A.3: Sector Composition: Private Firm Sample

Note: This table reports the sectoral composition of the firm-year observations in the linked CIQ-LBD-LFTTD data set and compares the distribution with the original Capital-IQ data set. The sector definition is based on one-digit SIC code.

Mean	Exporters	Non-Exporters	Overall
Top 1 Compensation, Estimated	2626.9	1731.2	2233.5
Top 1 Compensation, Realized	2157	1522.1	1878.2
Top-1-to-worker Pay Ratio, Estimated	49.8	36.7	44
Top-1-to-worker Pay Ratio, Realized	41.3	32.8	37.6
N. Observations	3366	2636	6002

Table A.4: Summary Statistics: Private Firm Sample

Note: This table reports the mean of key variables of the linked CIQ-LBD-LFTTD data set. The unit of observation is firm-year. Executive compensations are measured in thousands of U.S. dollars. For the difference between estimated and realized compensation, see Section 2.

B Details of the Model

B.1 The Firm's Problem

Denote the total expenditure in country i as H_i, the ideal price level as P_i. If a firm in country j wants to sell to the market i, denote the price of the good as $p_{ij}(x)$ and the marginal cost (iceberg cost included) of selling to market i as $M_{ij}(x)$. The firm solves the following problem:

$$\max_{q_{ij}(x)} \quad p_{ij}(x)q_{ij}(x) - M_{ij}(x)q_{ij}(x),$$
$$\text{s.t.} \quad p_{ij}(x) = H_i^{\frac{1}{\epsilon}} P_i^{\frac{\epsilon-1}{\epsilon}} q_{ij}(x)^{-\frac{1}{\epsilon}},$$

where the constraint of the maximization problem is the inverse of the derived demand function from solving the consumer's problem in market i.

The solution of the above maximization problem is

$$q_{ij}(x) = H_i P_i^{\epsilon-1} \left(\frac{\epsilon}{\epsilon-1} M_{ij}(x) \right)^{-\epsilon}, \tag{11}$$
$$p_{ij}(x) = \frac{\epsilon}{\epsilon-1} M_{ij}(x). \tag{12}$$

Equation (12) is the result of plugging equation (11) into the inverse derived demand function.

The marginal cost of supplying to market i depends on the productivity of the firm, as well as the method through which the firm chooses to serve market i. If market i is served by a domestic firm or by an exporter in country j, then:

$$M_{ij}(x) = \frac{\tau_{ij} w_j}{A_j(x)}.$$

In the special case of $i = j$, market i is served by the domestic firm in country i:

$$M_{ii}(x) = \frac{w_i}{A_i(x)}.$$

If market i is served by an MNE founded in country j, then

$$M_{ij}(x) = \frac{w_i}{A_j(x)}.$$

The sales to market i, $\sigma_{ij}(x)$ is therefore

$$\sigma_{ij}(x) = p_{ij}(x)q_{ij}(x) = H_i P_i^{\epsilon-1} \left(\frac{\epsilon}{\epsilon-1} M_{ij}(x) \right)^{1-\epsilon}.$$

To supply $q_{ij}(x)$ to market i, the labor used in production is

$$L_{ij}(x) = H_i P_i^{\epsilon-1} \left(\frac{\epsilon}{\epsilon-1} M_{ij}(x) \right)^{\epsilon} \frac{\tau_{ij}}{A_j(x)},$$

with the understanding that when $i = j$, $\tau_{ij} = 1$.

The profit earned in market i before the fixed cost is

$$[p_{ij}(x) - M_{ij}(x)]q_{ij}(x) = \frac{H_i}{\epsilon} P_i^{\epsilon-1} \left(\frac{\epsilon}{\epsilon - 1} M_{ij}(x) \right)^{1-\epsilon}$$

To ensure that firms sort into non-exporters, exporters, and multinational firms by productivity, I impose the following assumption similar to the one used in Helpman et al. [2004]:

$$\frac{g_{ji}}{f_{ji}} \leq \left(\frac{\tau_{ji} w_i}{w_j} \right)^{\epsilon-1}$$

This equation implies that only the most productive firms will engage in FDI, while the other productive firms choose export over FDI.

A similar restriction needs to be imposed to ensure the separation of the domestic firms: we need to make sure that in equilibrium, not all the firms choose to sell to the foreign market. In a Melitz model, this condition can be written down explicitly. Unfortunately, it is not possible to do so for this paper. The reason is that x_i^* does not admit a closed-form solution. Nevertheless, characterization of the restriction is still possible. Generally, we need the market size of the home country to be above a certain level relative to the foreign country, or the variable trade cost to be above a certain level, so the firms in the home country will not find exporting to the foreign country too easy. In all the results presented in this paper, the separation of firms into domestic and exporting/multinational firms is checked and ensured.

B.2 The Equilibrium Conditions

The first three equilibrium conditions on cutoff human capital levels are self-evident. Here I explain the other two equilibrium conditions in detail. In this section, I derive the equilibrium conditions under truncation.

Income-Expenditure Identity The third equilibrium condition, equation (8), requires that the total expenditure and total income in country i must be the same:

$$H_i = n_i w_i \int_0^{x_i^*} x f_i(x) dx + n_i \int_{x_i^*}^{\infty} \pi_i(x) f_i(x) dx. \tag{13}$$

Total expenditure is denoted as H_i. Total income consists of two parts: the total labor income and the total profits. The CEO compensation function, $k(\pi)$, does not enter the accounting equation. The difference between the profit and the CEO compensation at each firm is distributed to all the individuals in the same country, and therefore $k(\pi)$ does not matter for total income.

The total labor income is easy to compute. It is the wage rate $w(i)$ times the total labor supply:

$$w_i \cdot \left(n_i \int_0^{x_i^*} x f_i(x) dx \right) = w_i n_i \frac{\lambda}{1 - e^{s_i \lambda}} \int_0^{x_i^*} x e^{-\lambda x} dx, \tag{14}$$

$$= \frac{w_i n_i}{(1 - e^{-\lambda s_i} \lambda)} \left[e^{-\lambda x_i^*} (-\lambda x_i^* - 1) + 1 \right], \tag{15}$$

$$= w_i n_i \frac{F(x_i^*)}{\lambda} - \frac{n_i x_i^* e^{-\lambda x_i^*}}{1 - e^{-\lambda s_i}}, \tag{16}$$

$$= w_i \cdot \underbrace{\left\{ \frac{n_i}{\lambda} [F(x_i^*) - x_i^* f(x_i^*)] \right\}}_{\text{Labor Supply}}, \tag{17}$$

where $f(.)$ is the PDF of the truncated exponential distribution. The part in the curly brackets is the total labor supply in country i.

The total profit in country i is composed of three parts: the profit earned in the home country i, the profit earned in the other country j through export, and the profit earned in country j through FDI. This three-part separation is not the same as separating the profits into firms in the three corresponding groups. The difference is that, the profits earned in the home country i includes the profits from all the firms, as the exporters and MNEs also sell to the home market.

The total profit earned in the home market i is

$$n_i \int_{x_i^*}^{s} \frac{H_i}{\epsilon} P_i^{\epsilon - 1} \left(\frac{\epsilon}{\epsilon - 1} w_i \right)^{1-\epsilon} (b_i e^x)^{\epsilon - 1} f_i(x) dx - n_i f_{ii} w_i [1 - F(x_i^*)].$$

The total profit earned in the foreign market though exporting is

$$n_i \int_{x_{ji}^e}^{x_{ji}^f} \frac{H_j}{\epsilon} P_j^{\epsilon - 1} \left(\frac{\epsilon}{\epsilon - 1} \tau_{ji} w_i \right)^{1-\epsilon} (b_i e^x)^{\epsilon - 1} f_i(x) dx - n_i f_{ji} w_i [F(x_{ji}^f) - F(x_{ji}^e)],$$

and the total profit earned in the foreign market through FDI is

$$n_i \int_{x_{ji}^f}^{s} \frac{H_j}{\epsilon} P_j^{\epsilon - 1} \left(\frac{\epsilon}{\epsilon - 1} w_j \right)^{1-\epsilon} (b_i e^x)^{\epsilon - 1} f_i(x) dx - n_i g_{ji} w_i [1 - F(x_{ji}^f)].$$

The total profit in country i is the summation over these three parts. The income-expenditure identity here does not imply trade balance, as it usually does in a Melitz model. What it does imply is trade and financial balance. Trade in equilibrium is almost surely unbalanced, and the gap will be offset by the differences in capital flow: the differences between the profits the domestic MNEs collected from abroad and the foreign MNEs collected from the home market.

Ideal Price Level Equation (9) is the definition of the ideal price level in country i:

$$P_i = \left(\int_{m \in \Theta_i} p(m)^{1-\epsilon} dm \right)^{\frac{1}{1-\epsilon}}. \tag{18}$$

What needs further explanation is the set of goods available in country i: Θ_i. This set is the union of three mutually exclusive subsets: (1) the goods provided by all the firms created in country i, (2) the goods provided by all the exporting firms in country j, and (3) the goods provided by all the MNEs in country j. The price for every single variety in each of the subsets is a constant mark-up over the marginal cost in that subset. The marginal cost for goods in different subsets can be found in Appendix B.1. The ideal price level is a CES integration of all the individual prices over the set Θ_i.

After decomposing the set Θ_i into the three subsets mentioned above, the ideal price level can be expressed based on the firm productivity distribution directly:

$$P_i^{1-\epsilon} = \left\{ \sum_{j=1}^{2} \left[n_j \left(\frac{\epsilon}{\epsilon - 1} \tau_{ij} w_j \right)^{1-\epsilon} \int_{x_{ij}^e}^{x_{ij}^f} b_i e^x f(x) dx + n_j \left(\frac{\epsilon}{\epsilon - 1} w_i \right)^{1-\epsilon} \int_{x_{ij}^f}^{s} b_i e^x f(x) dx \right] \right\}.$$

Note that when $i = j$, $x_{ij}^e = x_i^*$. The first part in the square bracket includes all the goods provided by domestic firms, domestic exporters, and foreign exporters. The second part in the square bracket includes all the goods provided by the domestic and foreign MNEs.

Labor Market Clearing Condition The labor market clearing condition in country i requires that total supply of efficiency labor equals to total demand. Total supply equals the integral of x from 0 to x_i^* over the density function $f(x)$. Total labor demand is more complicated. It has four parts:

1. The labor used in the production of all the goods supplied to the home market i and exported to the foreign market j by the firms founded in country i:

$$L_i^{(1)} = n_i \sum_{j=1}^{2} \int_{x_{ji}}^{x_{ji}^f} \frac{H_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{\tau_{ji} w_i}{A_i(x)} \right)^{-\epsilon} \frac{\tau_{ji}}{A_i(x)} f(x) dx.$$

2. The labor used in fixed costs of operation and export incurred for the production in part 1:

$$L_i^{(2)} = n_i \sum_{j=1}^{n} f_{ji} \int_{x_{ji}}^{x_{ji}^f} f(x) dx.$$

3. The labor used in fixed costs for the goods supplied to country j through FDI by the firms created in country i:

$$L_i^{(3)} = n_i \sum_{j=1}^{2} g_{ji} \int_{x_{ji}^f}^{\infty} f(x) dx.$$

4. The labor used in the production of the goods supplied to country i by the foreign subsidiaries in country i from the firms founded in country j:

$$L_i^{(4)} = \sum_{j=1}^{2} n_j \int_{x_{ij}^f}^{\infty} \frac{H_i}{P_i^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{w_i}{A_i(x)} \right)^{-\epsilon} \frac{1}{A_i(x)} f(x) dx.$$

B.3 Firm Size Distributions

In this appendix, I derive the CDF of firm productivity, sales, profit, and employment distributions for different groups of firms.

B.3.1 Productivity Distribution

The human capital, x, in country i is distributed exponentially with the following CDF:

$$F(x) = 1 - e^{-\lambda x},$$

and the firm founded by the individual with human capital x has the following productivity:

$$A_i(x) = b_i e^x.$$

The CDF of the firm productivity distribution, denoted as $F_A(y)$, can be derived as follows:

$$\begin{aligned}
F_A(y) &= \Pr(A_i(x) \leq y) = \Pr(b_i e^x \leq y) = \Pr(e^x \leq \frac{y}{b_i}), \\
&= \Pr(x \leq \log(y/b_i)) = F(\log(y/b_i)), \\
&= 1 - e^{-\lambda \log(y/b_i)}, \\
&= 1 - b_i^{\lambda} y^{-\lambda},
\end{aligned}$$

which is the CDF of a Type-I Pareto distribution with location parameter b_i and shape parameter λ. This CDF is shared by all the firms in country i whether they are non-exporting firms, exporting firms, or multinational firms.

Truncation If the exponential distribution is truncated from above at s, then the CDF of the human capital distribution will be

$$F(x) = \frac{1 - e^{-\lambda x}}{1 - e^{-\lambda s}}, x \in [0, s].$$

Given the same functional form of firm productivity, the CDF of the productivity distribution can be derived using similar methods outlined above. The distribution can be verified to be a truncated Pareto distribution,

$$F_A(y) = \frac{1 - b_i^{\lambda} y^{-\lambda}}{1 - b_i^{\lambda} u_i^{-\lambda}}, y \in [b_i, u_i],$$

where u_i is the country-specific upper bound of firm productivity:

$$u_i = b_i e^s.$$

In the rest of the this appendix, I use the original distribution without truncation.

B.3.2 Sales Distribution

The sales from country j to country i is derived in Appendix B.1 and repeated here:

$$p_{ij}(x)q_{ij}(x) = H_i P_i^{\epsilon-1}\left(\frac{\epsilon}{\epsilon-1}M_{ij}(x)\right)^{1-\epsilon}, \tag{19}$$

where $M_{ij}(x)$ is the marginal cost of production conditional on the mode of access (export or multinational production). Based on the market-specific sales, I derive the firm sales. I denote sales for a firm with CEO human capital x in country i as $\sigma_i(x)$ and rewrite it as a linear function of $A_i(x)^{\epsilon-1}$:

$$\sigma_i(x) = \Sigma_i(x)A_i(x)^{\epsilon-1}.$$

$\Sigma_i(x)$ summarizes the market size accessible to the firm. It is a step function depending on x:

$$\Sigma_i(x) = \begin{cases} H_i\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_i^*, x_{ji}^e), \\ H_i\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} + H_j\left(\frac{P_j}{\tau_{ji}w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_{ji}^e, x_{ji}^f), \\ H_i\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} + H_j\left(\frac{P_j}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_{ji}^f, \infty). \end{cases}$$

The first line is the market accessible to the non-exporters, the second line the exporters, and the last line the multinational producers. The general formula for the CDF of the sales distribution is

$$\begin{aligned} F_\sigma(y) &= \Pr(\sigma < y), \\ &= \Pr(\Sigma_i(x)A_i(x)^{\epsilon-1} < y) = \Pr\left(A_i(x) < \left(\frac{y}{\Sigma_i(x)}\right)^{\frac{1}{\epsilon-1}}\right), \\ &= F_A\left(\left(\frac{y}{\Sigma_i(x)}\right)^{\frac{1}{\epsilon-1}}\right) = 1 - b_i^\lambda\left(\frac{y}{\Sigma_i(x)}\right)^{\frac{-\lambda}{\epsilon-1}}, \\ &= 1 - \left(\frac{\Sigma_i(x)}{b_i^{1-\epsilon}}\right)^\theta y^{-\theta}, \end{aligned}$$

where

$$\theta = \frac{\lambda}{\epsilon-1}.$$

The above equation defines Type-I Pareto distribution with shape parameter $\frac{\lambda}{\epsilon-1}$ and location parameter $\Sigma_i(x)b_i^{\epsilon-1}$. The location parameter differs by $\Sigma_i(x)$. The non-exporting firms have the smallest $\Sigma_i(x)$ and therefore the lowest location parameter. The exporting firms have higher $\Sigma_i(x)$ and the multinational firms have the highest $\Sigma_i(x)$. Note that within the same group (non-exporters, exporters, and multinationals), $\Sigma_i(x)$ is the same for all the firms.

B.3.3 Profit Distribution

The profit earned in each market is provided in Appendix B.1. Based on the market-specific profit, the firm profit can be written as an affine function of $A_i(x)^{\epsilon-1}$:

$$\pi_i(x) = \Pi_i(x)A_i(x)^{\epsilon-1} - C_i(x).$$

Similar to the sales distribution, $\Pi_i(x)$ takes three values depending on x:

$$\Pi_i(x) = \begin{cases} \frac{H_i}{\epsilon}\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_i^*, x_{ji}^e), \\ \frac{H_i}{\epsilon}\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} + \frac{H_j}{\epsilon}\left(\frac{P_j}{\tau_{ji}w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_{ji}^e, x_{ji}^f), \\ \frac{H_i}{\epsilon}\left(\frac{P_i}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} + \frac{H_j}{\epsilon}\left(\frac{P_j}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} & , x \in [x_{ji}^f, \infty). \end{cases}$$

The first line is the market size accessible to a domestic firm. The second line is the market size for exporting firms, and the third line is the market size for multinational firms. Similarly, the fixed cost term $C_i(x)$ depends on the type of the firm

$$C_i(x) = \begin{cases} w_i f_{ii} & , x \in [x_i^*, x_{ji}^s), \\ w_i(f_{ii} + f_{ji}) & , x \in [x_{ji}^e, x_{ji}^f), \\ w_i(f_{ii} + g_{ji}) & , x \in [x_{ji}^f, \infty). \end{cases}$$

The distribution function of π takes the following general formula

$$\begin{aligned} F_\pi(y) = \Pr(\pi \le y) &= \Pr(\Pi_i(x) \cdot A_i(x)^{\epsilon-1} - C_i(x) \le y), \\ &= \Pr\left(A_i(x) \le \left(\frac{y + C_i(x)}{T_i(x)})\right)^{\frac{1}{\epsilon-1}}\right), \\ &= 1 - b_i^\lambda \left(\frac{y + C_i(x)}{T_i(x)})\right)^{\frac{-\lambda}{\epsilon-1}} = 1 - \left(\frac{y + C_i(x)}{T_i(x) b_i^{\epsilon-1}}\right)^{-\frac{\lambda}{\epsilon-1}}, \\ &= 1 - \left(1 + \frac{y + \mu_i(x)}{\chi_i(x)}\right)^{-\theta}, \end{aligned}$$

where

$$\begin{aligned} \mu_i(x) &= \chi_i(x) - C_i(x), \\ \chi_i(x) &= T_i(x) \cdot b_i^{\epsilon-1}, \\ \theta &= \frac{\lambda}{\epsilon - 1}. \end{aligned}$$

This equation is the CDF of a Type-II Pareto distribution as defined in Arnold [1985]. The shape index of the firm profit distribution is $\theta = \frac{\lambda}{\epsilon-1}$. The two location parameters $\mu_i(x)$ and $\chi_i(x)$ depend on the market that the firm can access to.

B.3.4 Employment Distribution

Employment distribution is similar to the profit distribution. Market-specific employment is provided in Appendix B.1 and here I aggregate it up to firm-level employment. For each firm the employment, $L_i(x)$, can be written as an affine function of $A_i(x)^{\epsilon-1}$:

$$L_i(x) = \Lambda_i(x) A_i(x)^{\epsilon-1} + T_i(x).$$

$\Lambda_i(x)$, again, summarizes the market size accessible to a firm x and is a step function that takes three values:

$$\Lambda_i(x) = \begin{cases} \frac{H_i}{P_i^{1-\epsilon}} \left(\frac{1}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon} & , x \in [x_i^*, x_{ji}^e), \\ \frac{H_i}{P_i^{1-\epsilon}} \left(\frac{1}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon} + \frac{H_j}{P_j^{1-\epsilon}} \left(\frac{1}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon} \tau_{ji}^{1-\epsilon} & , x \in [x_{ji}^e, x_{ji}^f), \\ \frac{H_i}{P_i^{1-\epsilon}} \left(\frac{1}{w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon} + \frac{H_j}{P_j^{1-\epsilon}} \left(\frac{1}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon} & , x \in [x_{ji}^f, \infty). \end{cases}$$

$T_i(x)$ is the labor used as fixed cost of operation, export, and multinational production:

$$T_i(x) = \begin{cases} f_{ii} & , x \in [x_i^*, x_{ji}^s), \\ f_{ii} + f_{ji} & , x \in [x_{ji}^e, x_{ji}^f), \\ f_{ii} + g_{ji} & , x \in [x_{ji}^f, \infty). \end{cases}$$

Because both the employment and the profit are affine transformations of $A_i(x)^{\epsilon-1}$, the steps to derive the general formula of CDF are exactly the same. In the end, employment distributions are also Type-II Pareto distributions with shape parameter θ. The two location parameters depend on the market size accessible to the firm as well.

B.4 Income Distribution

The equilibrium income distribution in the model follows a two-class structure: the worker's income distribution follows an exponential distribution, and the CEO's income follows various Pareto-Type distributions. In this appendix, I present the details of the income distributions of the model.

Workers Workers in country i receive w_i for each unit of efficiency labor supplied to the market. The income for a worker with human capital x is $w_i x$, which follows an exponential distribution, same as x. The shape parameter of the income distribution is $\frac{\lambda}{w_i}$. The CDF of the distribution is

$$\begin{aligned} V(y) = \Pr(w_i x \leq y) &= \Pr(x \leq \frac{y}{w_i}), \\ &= 1 - e^{-\frac{\lambda}{w_i} y}. \end{aligned}$$

CEOs If $k(\pi)$ is monotonic and regularly varying with tail index β, then the CEO income follows a Pareto-Type distribution with shape parameter θ/β. Given a compensation function $k(\pi)$, the CDF of the CEO income is

$$U(y) = \Pr(k(\pi) \leq y) = \Pr(\pi \leq k^{-1}(y)) = F_\pi(k^{-1}(y)),$$

where $k^{-1}(y)$ is the inverse of $k(\pi)$ and $F_\pi(\cdot)$ is the CDF of firm profit distribution derived in Appendix B.3. The inverse function exists because $k(\pi)$ is monotonic. Because $k(\pi)$ is a regularly varying function with tail index β, the inverse function $k^{-1}(\cdot)$ is also a regularly varying function with tail index $1/\beta$ (Proposition 0.8.5, Resnick [1987]).

The survival function of π is a regularly varying function, with tail index $-\theta$ as well. To see this:

$$\lim_{\pi\to\infty} \frac{1 - F_\pi(\eta\pi)}{1 - F_\pi(\pi)} = \frac{\left(1 + \frac{\eta\pi+\mu}{\chi}\right)^{-\theta}}{\left(1 + \frac{\pi+\mu}{\chi}\right)^{-\theta}} = \eta^{-\theta}.$$

The composition of two regularly varying functions is a regularly varying function, and the tail index of the composition function is the product of the two indices (Proposition 0.8.4, Resnick [1987]). Therefore $1-U(y)$, as the composition of $k^{-1}(y)$ and $1-F_\pi(\pi)$, is a regularly varying function with tail index $-\frac{\theta}{\beta}$. This defines $y = k(\pi)$ as a Pareto-Type distribution with shape parameter $\frac{\theta}{\beta}$ (Definition 7.25, Gulisashvili [2012]). Moreover, the CDF of $k(\pi)$ can be re-written as:

$$U(y) = 1 - y^{-\theta/\beta} R(y),$$

where $R(y)$ is a slowly varying function:

$$\lim_{y\to\infty} \frac{R(\eta y)}{R(y)} = 1.$$

Example The CEO compensation function is

$$k(\pi) = \alpha^{1-\beta}\pi^\beta = \alpha^{1-\beta}\left(\Pi \cdot A^{\epsilon-1} - C\right)^\beta.$$

The CDF of $k(\pi)$ is

$$\begin{aligned}
U(y) &= \Pr(k \leq y) = \Pr(\alpha^{1-\beta}\left(\Pi \cdot A^{\epsilon-1} - C\right)^\beta \leq y), \\
&= \Pr\left(A^{\epsilon-1} \leq \frac{y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}} + C}{\Pi}\right), \\
&= 1 - b^\lambda \left(\frac{y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}} + C}{\Pi}\right)^{-\frac{\lambda}{\epsilon-1}}.
\end{aligned}$$

Using the general result proved above, it is trivial to show that $k(\pi)$ follows a Pareto-Type distribution. Here I follow a different route and prove directly that the survival function

$1-U(y)$ is a regularly varying function. To see this:

$$\lim_{y\to\infty}\frac{1-U(\eta y)}{1-U(y)} = \lim_{y\to\infty}\left(\frac{\eta^{\frac{1}{\beta}}y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}}+C}{y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}}+C}\right)^{-\frac{\lambda}{\epsilon-1}},$$

$$= \lim_{y\to\infty}\left(\frac{\eta^{\frac{1}{\beta}}+\frac{C}{y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}}}}{1+\frac{C}{y^{\frac{1}{\beta}}\alpha^{\frac{\beta-1}{\beta}}}}\right)^{-\frac{\lambda}{\epsilon-1}}.$$

As $y\to\infty$, $y^{\frac{1}{\beta}}\to\infty$, therefore

$$\lim_{y\to\infty}\frac{1-U(\eta y)}{1-U(y)} = \eta^{-\frac{\lambda}{\beta(\epsilon-1)}},$$

which defines $1-U(y)$ as a regularly varying function with index $-\frac{\lambda}{\beta(\epsilon-1)}$. This further implies that the income distribution function of CEOs in corporations can be expressed as

$$U(y) = 1-y^{-\frac{\lambda}{\beta(\epsilon-1)}}R(y).$$

The income distribution of the CEOs at sole proprietorship firms is the same as the profit distribution and therefore is Type-II Pareto.

See Feller [1966], Resnick [1987], and Gulisashvili [2012] for more details on regularly varying functions and Pareto-Type distributions.

B.5 Profit-to-Wage Ratios

Proposition 3 *If the sets of exporting firms and multinational firms in country i are non-empty, then the average CEO-to-worker pay ratio among domestic firms is strictly smaller than the average CEO-to-worker pay ratio among exporting firms, which in turn is strictly smaller than the average CEO-to-worker pay ratio among multinational firms.*

Proof The least productive CEOs manage the domestic firms, which implies that, on average, they receive the lowest compensation among all the CEOs. The more productive CEOs manage the exporting firms, and the most productive CEOs manage the multinational firms. Since wage is equalized across the firms, the ranking of the CEO-to-worker pay ratio is the same as the ranking of the CEO income.

Profit-to-wage ratios in this model only depends on the cutoff human capitals in general equilibrium. This property can be exploited to gain some insight into the basic mechanism of the model without quantification.

Domestic Profit The profit-to-wage ratio in the domestic market is the profit earned from the domestic market divided by domestic wage. This part of profit is earned by the domestic firms, the exporters, and the MNEs created in the home country.

The profit-to-wage ratio is

$$\frac{\pi_{ii}(x)}{w_i} = \frac{H_i}{w_i \epsilon} \left(\frac{P_i}{w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x)^{\epsilon - 1} - f_{ii}.$$

From the cutoff condition of the marginal firm, we know:

$$\frac{H_i}{w_i \epsilon} \left(\frac{P_i}{w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} b_i^{\epsilon - 1} e^{(\epsilon - 1) x_i^*} - f_{ii} = x_i^*,$$

and therefore

$$\frac{H_i}{w_i \epsilon} \left(\frac{P_i}{w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} = \frac{x_i^* + f_{ii}}{b_i e^{(\epsilon - 1) x_i^*}}. \tag{20}$$

Plug this into the first equation, we have

$$\frac{\pi_{ii}(x)}{w_i} = (x_i^* + f_{ii}) e^{(\epsilon - 1)(x - x_i^*)} - f_{ii}.$$

The partial derivative of this ratio with respect to x is positive, so in general, the profit-to-wage ratio is higher when the firm is more productive and larger. All the general equilibrium movements affect this ratio through the only endogenous variable in this equation: the cutoff value x_i^*. The cutoff human capital is a measure of the competitiveness of the home market in general equilibrium: it will be higher when the market is more competitive due to highly productive foreign firms entering. The partial derivative of this ratio with respect to x_i^* is

$$\frac{\partial}{\partial x_i^*} \left(\frac{\pi_{ii}(x)}{w_i} \right) = e^{(\epsilon - 1)(x - x_i^*)} [1 - (\epsilon - 1)(x_i^* + f_{ii})]. \tag{21}$$

The sign of this derivative is the same as $[1 - (\epsilon - 1)(x_i^* + f_{ii})]$. I claim that this sign is always negative under the assumption that the least productive individual in country i must not find creating a new firm profitable. This restriction is imposed to guarantee the existence and uniqueness of the occupational choice cutoff in the paper. This assumption means:

$$\begin{aligned} \frac{H_i}{\epsilon} P_i^{\epsilon - 1} w_i^{1 - \epsilon} \left(\frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(0)^{\epsilon - 1} - f_{ii} w_i < 0, \\ f_{ii} > \frac{H_i}{\epsilon w_i}^{\epsilon - 1} \left(\frac{\epsilon - 1}{\epsilon} \frac{P_i}{w_i} \right)^{\epsilon - 1} A_i(0)^{\epsilon - 1}. \end{aligned}$$

Plug equation (20) into the above inequality, we have

$$\begin{aligned} f_{ii} &> \frac{x_i^* + f_{ii}}{A_i(x_i^*)^{\epsilon - 1}} A_i(0)^{\epsilon - 1} \\ f_{ii} &> \frac{x_i^*}{e^{(\epsilon - 1) x_i^*} - 1}. \end{aligned}$$

Now I need to prove

$$x_i^* + f_{ii} > \frac{1}{\epsilon - 1}. \tag{22}$$

To do this, I define

$$m(x_i^*) = x_i^* + \frac{x_i^*}{e^{(\epsilon-1)x_i^*} - 1} - \frac{1}{\epsilon - 1}.$$

It is easy to show that $m(x_i^*)$ is monotonically increasing,

$$\frac{\partial m(x_i^*)}{\partial x_i^*} = 1 + \frac{e^{(\epsilon-1)x_i^*}(1 + (\epsilon - 1)x_i^*) - 1}{(e^{(\epsilon-1)x_i^*} - 1)^2} > 0,$$

because

$$((\epsilon - 1)x_i^* > 0) \wedge (e^{(\epsilon-1)x_i^*} > 1).$$

Therefore, the minimum of $m(x^*)$ is obtained at $x_i^* = 0$, which is precisely 0. To see this, we need to apply L'Hôpital's rule to the second term at $x_i^* = 0$:

$$\begin{aligned}\lim_{x_i^* \to 0} m(x^*) &= x_i^* + \frac{1}{e^{(\epsilon-1)x_i^*}(\epsilon - 1)} - \frac{1}{\epsilon - 1}, \\ &= \frac{1}{\epsilon - 1} - \frac{1}{\epsilon - 1} = 0.\end{aligned}$$

This implies that for all possible values of $x_i^* \in [0, \infty)$, equation (22) is true and therefore the profit-to-wage ratio decreases with x_i^*.

Exporting Profits The profits earned from exporting to the foreign country, divided by local wage, is

$$\frac{\pi_{ji}^e(x)}{w_i} = \frac{H_j}{w_i \epsilon} \left(\frac{P_j}{\tau_{ji} w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x)^{\epsilon - 1} - f_{ji}.$$

Similar to the domestic profit, the cutoff human capital of the marginal exporter is a sufficient statistics for the size of the foreign market and the marginal cost of accessing to that market. To see this, we start with the cutoff condition:

$$\begin{aligned}\frac{H_j}{\epsilon} \left(\frac{P_j}{\tau_{ji} w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} A_i(x_{ji}^e)^{\epsilon - 1} - f_{ji} w_i = 0, \\ \frac{H_j}{w_i \epsilon} \left(\frac{P_j}{\tau_{ji} w_i} \frac{\epsilon - 1}{\epsilon} \right)^{\epsilon - 1} = \frac{f_{ji}}{b_i e^{(\epsilon-1)(x - x_{ji}^e)}}.\end{aligned}$$

Plugging the above equation into the original profit-to-wage ratio, we have:

$$\frac{\pi_{ji}^e(x)}{w_i} = f_{ji}[e^{(\epsilon-1)(x - x_{ji}^e)} - 1].$$

This ratio depends positively on x and negatively on x_{ji}^e. x_{ji}^e is a measure of the access to the foreign market: it will be lower (easier to access) when τ_{ji} is lower, or the foreign market is larger (H_j or P_j higher). When τ_{ji} is lower, the profit-to-wage ratio from the exporting market will be higher.

FDI Profits The profits earned from FDI to the foreign country, divided by local wage, is:

$$\frac{\pi_{ji}^{f}(x)}{w_i} = \frac{H_j}{w_i \epsilon}\left(\frac{P_j}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} A_i(x)^{\epsilon-1} - g_{ji}.$$

From the FDI cutoff condition, we know

$$\frac{H_j}{w_i \epsilon}\left(\frac{P_j}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} A_i(x_{ji}^{f})^{\epsilon-1} = \frac{H_j}{w_i \epsilon}\left(\frac{P_j}{\tau_{ji} w_i}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} A_i(x_{ji}^{f})^{\epsilon-1} + (g_{ji} - f_{ji}),$$

$$\frac{H_j}{w_i \epsilon}\left(\frac{P_j}{w_j}\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} = \left[f_{ji}\frac{A_i(x_{ji}^{f})^{\epsilon-1}}{A_i(x_{ji}^{e})^{\epsilon-1}} + g_{ji} - f_{ji}\right]\frac{1}{A_i(x_{ji}^{f})^{\epsilon-1}}.$$

Therefore

$$\frac{\pi_{ji}^{f}(x)}{w_i} = f_{ji} e^{(\epsilon-1)(x-x_{ji}^{e})} + (g_{ji} - f_{ji}) e^{(\epsilon-1)(x-x_{ji}^{f})} - g_{ji}.$$

This profit-to-wage ratio decreases with x_{ji}^{f}:

$$\frac{\partial \frac{\pi_{ji}^{f}(x)}{w_i}}{\partial x_{ji}^{f}} = e^{(\epsilon-1)(x-x_{ji}^{f})}(g_{ji} - f_{ji})(1-\epsilon) < 0.$$

B.6 A Model for the CEO Market

In this section I extend the benchmark model to allow for a labor market for CEOs, and an endogenously-determined CEO compensation function. The model here closely follows the work of Gabaix and Landier [2008]. The key message of the extended model is, as long as the CEO contributes to the productivity of the firm, the equilibrium compensation function will satisfy the key assumptions that were used to exogenously define the compensation functions in the benchmark model.

Instead of allowing the individuals to create firms, we start by assuming that there exists a continuum of potential firms with different innate productivity, denoted and indexed by $\phi \in \Phi$, where Φ is a subset of real numbers. A firm needs to hire a CEO in order to operate. A potential CEO comes from the pool of candidates who are differentiated by their human capital x. The distribution of x follows the same exponential distribution as in the benchmark model. The final productivity of the firm depends on both the innate productivity of the firm, and the ability of the CEO. Following the notation of the benchmark model, the final productivity of the firm is:

$$A(\phi, x) = \phi \cdot b \cdot e^{x},$$

where b denotes the TFP of the country. CEO receives compensation k from the firm. The compensation as a function of talent, $k(x)$, will be determined in equilibrium. Following the notation of the benchmark model, the profit of the firm in this extension can be written as:

$$\pi(\phi, x) = \tilde{H} A(\phi, x)^{\epsilon-1} - fw - k(x),$$

where $\tilde{H}$ describes the size of the markets to which the firm has access:

$$\tilde{H} = \frac{H}{\epsilon} P^{\epsilon-1} w^{-\epsilon} \left(\frac{\epsilon}{\epsilon-1}\right)^{1-\epsilon}.$$

When the firm determines which CEO to hire, it takes the market price of talent, $k(x)$ as given. The first order condition of the firm is:

$$\tilde{H}(\epsilon-1)A(\phi,x)^{\epsilon}A(\phi,x)' = k'(x)$$

which is essentially balancing the benefit of hiring a slightly better CEO with the extra cost of doing so. The solution to the differential equation of $k'(x)$ is:

$$k(x) = \tilde{H}b(\epsilon-1)\int_{\underline{x}}^{\infty} \phi(x)e^{x(\epsilon-1)}dx + C, \tag{23}$$

where $\phi(x) : \mathcal{R} \to \Phi$ is the equilibrium mapping between CEO with talent x and the firm with productivity ϕ. C is the integration constant, which can be pinned down by the outside option of the least talented CEO, $\underline{x}$:

$$C = \underline{x}w.$$

It is impossible to exactly solve equation (23) without specifying the functional form of $\phi(x)$. However, without a closed-form solution we can still establish a couple of properties of $k(x)$. Gabaix and Landier [2008] characterized $k(x)$ by re-mapping x and ϕ into sequential indices, and utilizing an approximate spacing function of x. Specifically, they showed that equation (23) can approximately obtain a closed form solution if x follows an exponential distribution, up to a slowly varying function. Their key insights are two-folds. First, efficient market implies that in equilibrium there must be assortive matching between firms and CEOs, and thus $\phi(x)$ must be monotonically increasing in x. This implies that $k(x)$ must be monotonically increasing in x as well. Further more, when x follows an exponential distribution, the spacing function of x is regularly varying. This implies that in equilibrium, $k(x)$ must be regularly varying as well.

The arguments above establish that in equilibrium, the endogenously-determined $k(x)$ must be 1) monotonically increasing in x, and 2) regularly varying in x. These two results are precisely the assumptions that I made in the benchmark model, where $k(x)$ is exogenously imposed on the market. Moreover, it shows that even if we separate CEOs and founders, and model the market between CEO talents and firms, the end result in terms of the compensation scheme and matching pattern, will not change.

B.7 Calibration

The TFP b_i and measure of population are computed following the method in Caselli [2005]. The computation is based on Penn World Table 7.0, and all undefined variable names in italics are the standard variable names in PWT. I first compute real GDP in year t, Y_t, as

$$Y_t = pop_t \cdot rgdpl_t.$$

The number of workers, L_t, is backed out by

$$L_t = Y_t / rgdpwok_t.$$

This raw measure of the stock of work-force is first adjusted by human capital. Using years of school attainment for both males and females 25 years old and above from Barro and Lee [2010], I construct human capital h_t as

$$h_t = e^{\phi(c_t)},$$

where c_t is the years of schooling and $\phi(c_t)$ is piece-wise linear:

$$\phi(c_t) = \begin{cases} 0.134 * c & \text{if} \quad c_t \leq 4 \\ 0.134 * 4 + 0.101 * (c_t - 4) & \text{if} \quad 4 < c_t \leq 8 \\ 0.134 * 4 + 0.101 * 4 + 0.068 * (c_t - 8) & \text{if} \quad 8 < c_t \end{cases}.$$

Because the year of schooling data are only available at five-year intervals, linear interpolation is used to fill in the gap years. c_t is a slow-moving variable; therefore, linear interpolation can provide reasonably smooth estimations.

To construct the stock of physical capital in each year, I first compute investment in each year as

$$I_t = Y_t * \mathrm{ki_t}/100,$$

and then back out the initial capital stock using perpetual inventory method. I assume that capital and output grow at the same rate, and the depreciation rate is 6 percent per year. The initial capital stock when $t = 0$ is

$$K_0 = I_0 / (g_k + 0.06),$$

where g_k is the average growth rate of GDP in the first 10 years of data. Given the initial capital stock, the sequence of capital stock in year t is computed as

$$K_t = (1 - 0.06) K_{t-1} + I_t.$$

With a computed sequence of physical capital, the final measure of population year t, n_t, is computed as

$$n_t = K_t^a (h_t L_t)^{1-a},$$

where $a = 1/3$ and the TFP, b_t, is calculated as

$$b_t = Y_t / n_t.$$

At the end, b_t is normalized so that the TFP for the U.S. in 1988 is 1. For the sequence of estimated TFP, see Table in the paper. Given a sequence of n_t for each country, I first average across the years to get a single measure for each country. I then normalize across the countries so n_{USA} is 1.