

National Income Accounting When Firms Insure Workers: Understanding Firm Size and Compensation Inequality.

Barney Hartman-Glaser
UCLA Anderson

Hanno Lustig
Stanford GSB and NBER

Mindy X. Zhang
UT Austin McCombs

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Abstract

We develop a model in which firm-specific shocks have a first-order effect on the distribution of rents between shareholders and managers. In our model, firms optimally provide managers with contracts that do not expose them to risk. Consequently, larger and more productive firms return a larger share of rents to shareholders while less productive firms endogenously exit. An increase in firm-level risk lowers the threshold at which firms exit and increases the measure of firms in the right tail of the size distribution. As a result, such an increase always increases the aggregate capital share in the economy, but may lower the average firm's capital share. Moreover, the aggregate capital share reported in national income accounts produces a biased estimate of the ex-ante distribution of rents because the data only contain surviving firms. We confirm that the average firm's capital share has declined amongst publicly traded U.S. firms, even though the aggregate capital share has increased. We attribute the secular increase in the aggregate capital share amongst these firms to an increase in firm size inequality that results from an increase in firm-level risk. This effect is only partially mitigated by an increase in inter-firm labor compensation inequality.

Keywords: Idiosyncratic Risk, Selection, Capital Share, Labor Share, National Income Accounting, Selection.

*Hartman-Glaser: UCLA Anderson School of Management, 110 Westwood Plaza, Los Angeles, CA 90034 (bh-glaser@anderson.ucla.edu). Lustig: Stanford Graduate School of Business, 355 Knight Way, Stanford, Ca 94305 (hlustig@stanford.edu). Zhang: UT McCombs School of Business, 2110 Speedway B6600, Austin, TX 78712 (xiaolan.zhang@mcombs.utexas.edu). We received detailed feedback from Hengjie Ai, Alti Aydogan, Frederico Belo, Bob Hall, Ben Hebert, Chad Jones, Pat Kehoe, Arvind Krishnamurthy, Pablo Kurlat, Ed Lazear, Chris Tonetti, Sebastian DiTella, Andres Donangelo and Andy Skrypacz. The authors acknowledge comments received from seminar participants at the Stanford GSB, UT Austin, Universite de Lausanne and EPFL, the Carlson School at the University of Minnesota and the 2016 labor and finance group meeting.

1 Introduction

Over the last decades, publicly traded U.S. firms have experienced a large increase in firm-specific volatility of both firm-level cash flow as well as returns (see, e.g., Campbell, Lettau, Malkiel, and Xu, 2001; Comin and Philippon, 2005; Zhang, 2014; Bloom, 2014; Herskovic, Kelly, Lustig, and Van Nieuwerburgh, 2015). At the same time, the aggregate capital share of these firms as also increased. We present an equilibrium model which links these two facts and provides novel implications for national income accounting. We find that the increase in firm size inequality induced by the increase in risk is the main driver of the increase in the aggregate capital share for publicly traded firms. The capital share at the average firm, however, has decreased. Inter-firm compensation inequality has increased (see Song, Price, Guvenen, Bloom, and von Wachter (2015)), but not enough to offset the effect of the increase the firm size inequality on the capital share.

Since shareholders of publicly traded firms can diversify idiosyncratic firm-specific risk away, while risk-averse workers cannot, it is efficient for firms to provide managers with insurance against firm-specific risk. We analyze a simple compensation contract in an equilibrium model of industry dynamics (see, e.g., Hopenhayn, 1992) that pays managers a fixed wage while allocating the remainder of profits to shareholders. The level of managerial compensation is set in equilibrium by the value of ex-ante identical firms. Ex-post these firms are subject to permanent idiosyncratic shocks that lead some firms to increase in size and productivity while others decrease and potentially exit. We use this model as a laboratory to analyze the impact of changes in firm-level risk on the distribution of rents.

Standard national income accounting applied inside this model yields a new perspective on capital share dynamics. The manager's compensation is set such that the net present value of starting a new firm, computed by integrating over all paths using the density for a new firm, is zero, but the national income accounts only integrate over all firms that are currently active using the stationary size distribution, without discounting. As a result, the aggregate capital share calculation puts more probability mass on the right tail than the NPV calculation. As firm-level risk increases and the right tail of the firm size distribution grows, managers capture a smaller

fraction of aggregate rents ex post, even though they capture all of the ex ante rents. This effect is partly offset by a larger mass of unprofitable firms in the left tail of the stationary size distribution, but, in our model, an increase in firm-level risk invariably increases the capital share. Only when managers receive equity-only compensation is the capital share invariant to changes in firm-level volatility.

At the heart of this mechanism is the selection effect that arises by measuring the distribution of rents excluding firms that have endogenously exited.¹ This effect is closely related to Hopenhayn (2002)'s observation that selection biases average Tobin's Q estimates for industries above one. In a similar manner, the capital share computed in national income accounts also produces a biased estimate of the ex ante profitability of new firms. Moreover, an increase in selection increases the size of the bias. This effect explains the measured divergence between aggregate compensation and profits: Compensation is tied to ex ante profitability, not the ex post realized one. This result also has a natural insurance interpretation. When idiosyncratic risk increases, managers effectively pay a larger idiosyncratic insurance premium to shareholders ex post. The increase in the ex post premium leads to an increase in the aggregate capital share, even though the shareholders are risk-neutral and receive zero rents ex ante. This mechanism has interesting cross-sectional implications. Only the capital share of the largest firms in the right tail increases as risk increases, but they determine aggregate capital share dynamics, echoing Gabaix (2011)'s observation that we need to study the behavior of large firms to understand macroeconomic aggregates. The capital share of the smallest firms will actually decrease. As a result, the average capital share across all firms will tend to decrease.

Between 1960 and 2010, the U.S. labor share of total output in the non-farm business sector of the U.S. economy has shrunk by 15 percent (see Figure 1). This phenomenon does not seem limited to the U.S. (see, e.g., Piketty and Zucman (2014)). In the universe of U.S. publicly traded firms, we find that the shrinkage in the labor (capital) share is concentrated among the largest (smallest) firms in the U.S. In fact, the equal-weighted average labor (capital) share of publicly

¹Jovanovic (1982) is the first study of selection in an equilibrium model of industry dynamics. Selection has also been found to be quantitatively important. Luttmer (2007) attributes about 50 percent of output growth to selection in a model with firm-specific productivity improvements, selection of successful firms and imitation by entrants.

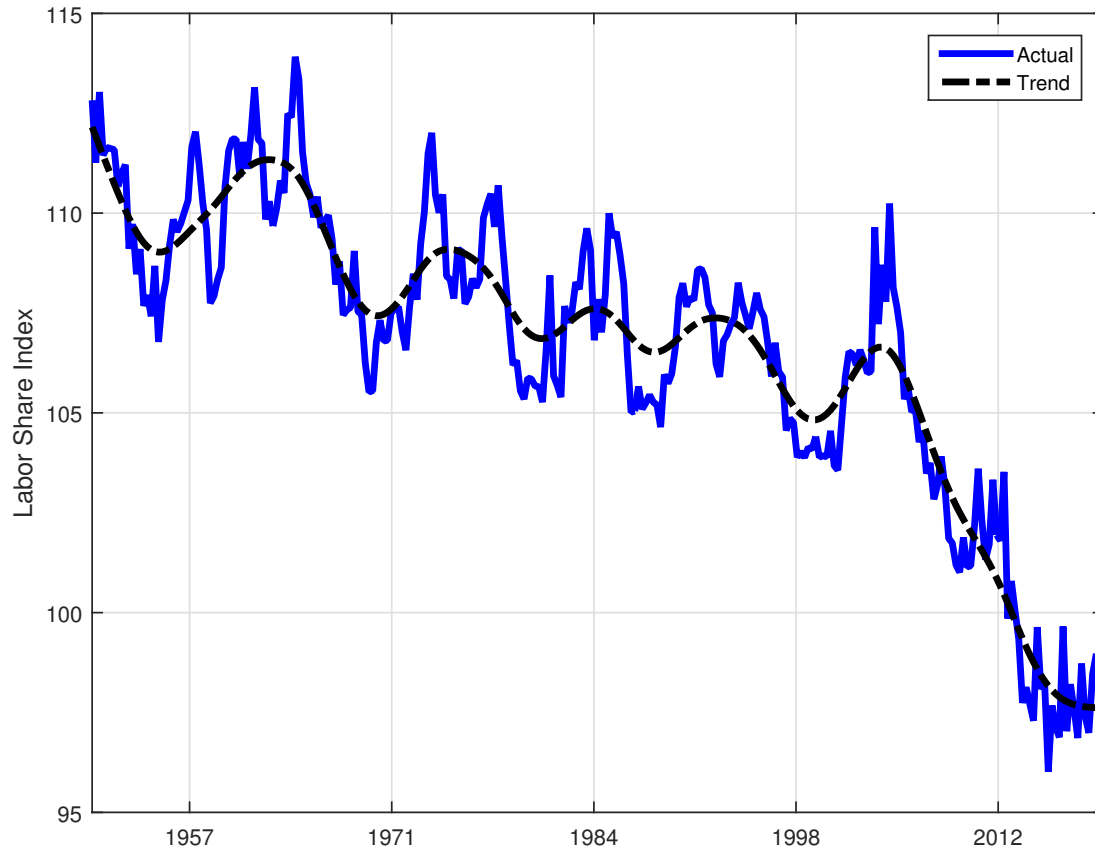
traded companies has increased (decreased), starting in the 80s. This new cross-sectional evidence is consistent with the selection mechanism: The divergence between the average and the aggregate labor share is a key prediction of selection. The main competing hypothesis is that firms are increasingly substituting capital for labor (see, e.g., Karabarbounis and Neiman, 2013) in response to declines. As far as we know, this mechanism does not predict a divergence between the average and aggregate labor share that we document in the data.

Firm-level risk and the firm size inequality that results plays a key role in U.S. factor share dynamics. Consistent with the selection mechanism, we find that the decline in the aggregate U.S. labor share for publicly traded firms cannot be attributed to the averages of log firm-level output and log compensation, but is entirely due to differential changes in the higher-order moments of the cross-sectional firm size and firm compensation distribution, as predicted by our model. In particular, starting in the late seventies, the increases in the variance and kurtosis of the log output distribution are not matched by similar risk increases for log compensation. An increase in firm size inequality that is unmatched by a commensurate increase in inter-firm compensation inequality mechanically lowers the aggregate labor income share. Even though inter-firm wage inequality has increased, as was recently pointed out by Song et al. (2015), the increase was too small to offset the increase in firm size inequality.

In a series of papers, Luttmer (2007, 2012) characterizes the stationary size distribution of firms when firm-specific productivity is subject to permanent shocks. Firms incur a fixed cost of operating a firm. The selection effect of exit at the bottom of the distribution informs the shape of the stationary size distribution, which is Pareto with an endogenous tail index. Our work explores the impact of changes in the stationary size distribution on the distribution of rents in our laboratory economy. In recent work, Perla, Tonetti, Benhabib, et al. (2014) examine the endogenous productivity distribution in an environment where firms choose to innovate, adopt new technology or keep producing with the old technology.

There is a large literature on optimal risk sharing contracts between workers and firms (see Thomas and Worall, 1988; Holmstrom and Milgrom, 1991; Kocherlakota, 1996; Lustig, Syverson, and Nieuwerburgh, 2011; Berk and Walden, 2013; Zhang, 2014). This literature has analyzed the

Figure 1. U.S. Labor Share of Non-farm Business Sector.



Source: U.S. Bureau of Labor Statistics and FRED. The dashed line is the HP-filtered trend. Labor's share in current dollar output is the ratio of labor compensation paid in that sector to current dollar output. Indexes are computed from basic data or analytic ratios by dividing the series by its own base year annual value (2009) and multiplying by 100.

trade-off between insurance and incentives. We analyze the case of two-sided limited commitment on the part of the firm and the manager, similar to Ai and Li (2015); Ai, Kiku, and Li (2013). When we introduce moral hazard and other frictions, our mechanism will be mitigated. However, we show that when we allow workers to have some exposure to firm performance, our primary results remain unchanged. The intuition is that so long as a firm’s owners are providing some insurance to its workers, and can exit when productivity declines, the selection problem still applies. Gabaix and Landier (2008); Edmans, Gabaix, and Landier (2009) examine equilibrium CEO compensation in a competitive market for CEO talent. The equilibrium compensation will be comprised of a cash component and an equity component. We analyze the implications of this class of contracts for our key results.

The rest of this paper is organized as follows. Section 2 present empirical evidence on U.S. capital share dynamics. Section 3 describes the benchmark model that we use as a laboratory. Section 4 derives the stationary firm size distribution in the benchmark model, and it describes the implications for the aggregate capital share. Section 5 considers a large class of compensation contracts that allow for performance sensitivity. Finally, section 6 considers a version of our economy with production and unskilled labor.

2 Understanding U.S. Capital Share Dynamics

In this section, we present empirical evidence on the joint dynamics of compensation, firm size and the implied capital share dynamics. We show the findings are consistent with the selection mechanism.

2.1 Data

Our baseline results are from analyzing two sources of data. To obtain cross-sectional evidence, we use widely available accounting data from Compustat Fundamentals Annual, which includes all publicly-traded firms. The sample is from 1960 to 2014. We exclude financial firms with SIC codes in the interval 6000-6799, and also exclude firms whose sales, employee numbers and total asset

values are negative. We examine the distribution of factor share of output in the publicly traded firm sample.

The capital income of the firm is measured by operating income before depreciation (OIBDP). OIBDP represents sales/turnover (SALE) minus operating expenses including the cost of goods sold, labor cost and other administrative expenses. Capital share of output is the ratio of OIBDP to sales². We use the ratio of the cost of labor to sales as the measure of labor share of output. The cost of labor is the staff expenses – total (XLR) in Compustat. However, the limitation of XLR is that XLR in Compustat is sparse with roughly 13% firm-year observations in the sample. We then follow Donangelo, Gourio, and Palacios (2015) to construct the extended labor cost. We first estimate the average labor cost per employee (XLR/EMP) within industry for each year using the available XLR observations, and then labor cost of a firm with missing XLR equals the number of employees times the average labor cost per employee of the same industry³ during that year.

We also obtain measures of labor share from U.S. Bureau of Labor Statistics. See Data Appendix for detailed description. Labor’s share in current dollar output is the ratio of labor compensation paid in that sector to current dollar output. Labor compensation is measured as all direct payments to labor: wage and salary accruals (including executive compensation), commissions, tips, bonuses, and payments in kind representing income to the recipients, and supplements to these direct payments. Supplements consist of employer contributions to funds for social insurance, private pension and health and welfare plans, compensation for injuries, etc.

2.2 Capital Share Dynamics

In this section, we examine the capital share dynamics over time. Firm level volatility has increased over the past five decades (Comin and Philippon (2005), Zhang (2014), Herskovic et al. (2015)). Figure 2 confirms the time series results of firm-level volatility. The measure of cash flow volatility and stock return volatility has almost doubled over the period 1960-2010. The rising

²Ideally, capital share should be computed using value added as denominator. However, the cost of material and the cost of labor are not reported separately in the sample. Instead of using different ways to estimate the cost of labor or the cost of material which leads to many negative value added at the tail, we will stick to sales as the measure of output.

³We follow Donangelo et al. (2015) and use Fama-French 17 industry classifications. The result is robust using 2-digit SIC code.

firm-level volatility is a very robust fact using other firm-level variables (Comin and Philippon (2005)).

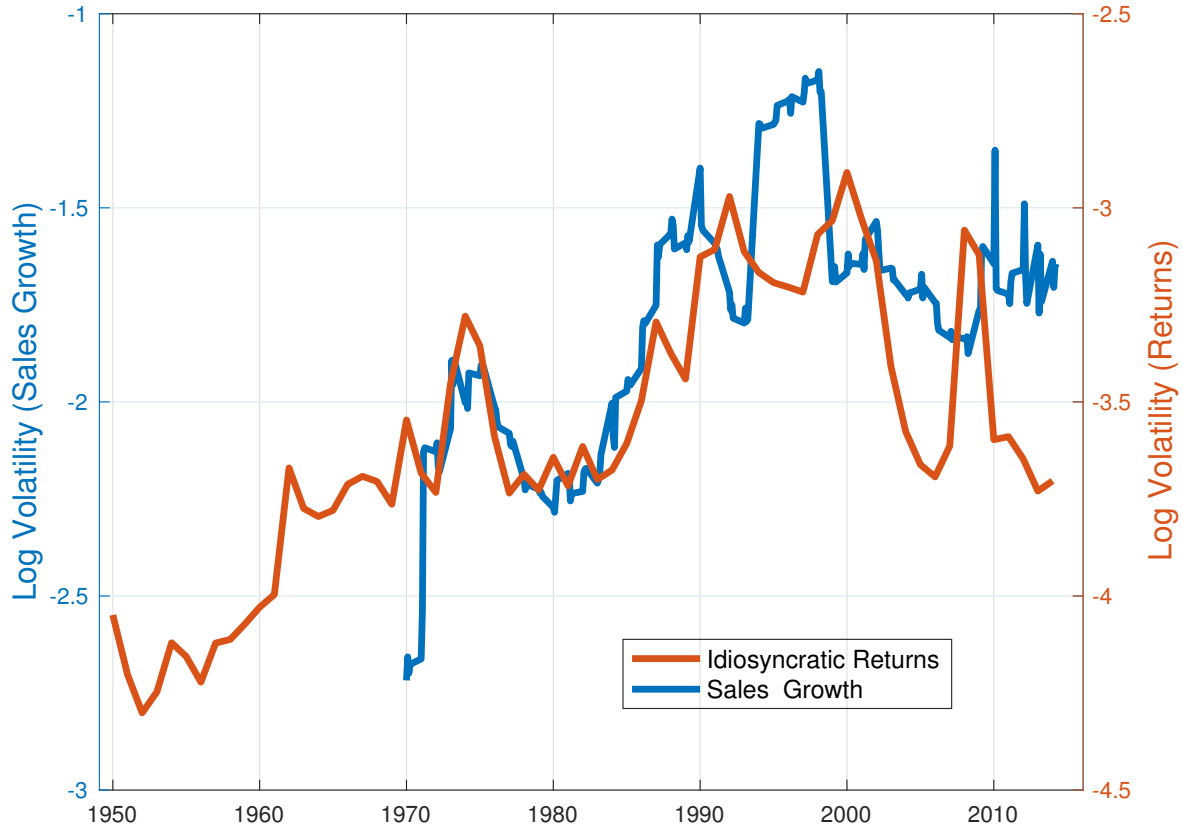
For most of our analysis, we focus on the capital share of output. Figure 3 plots the average and aggregate capital share in the publicly traded firm sample. The average capital share is the sample mean of capital share for a given year. As the firm-level volatility increases, the aggregate capital share and the average capital share diverge. The aggregate capital share equals the sum of capital income (OIBDP) across all the firms divided by aggregate sales. The average capital share drops from 0.13 in 1960 to -0.40 in 2014, while the aggregate capital share increases with a less dramatic scale, from 0.14 in 1960 to 0.17 in 2014. The presence of the contrasting trends in capital share is consistent with the mechanism we highlight in our model. Specifically, the trends we observe in the data are consistent with changes in firm-level volatility causing a shift in the distribution of firm size that favors the owners of capital

We find similar patterns in the labor share dynamics. The aggregate labor share of output in the non-farm business sector has declined by 15%. However, the trend of the average labor share of output in the publicly traded firm sample did not decline. Figure 4 shows the time series of both the average and the aggregate labor share in our sample using the estimated labor cost. The average labor share rises from 0.32 in 1960 to 0.4 in 2014, while the aggregate labor share drops from 0.25 to 0.19 during the same period of time.

2.3 Firm Size and Firm Compensation Inequality

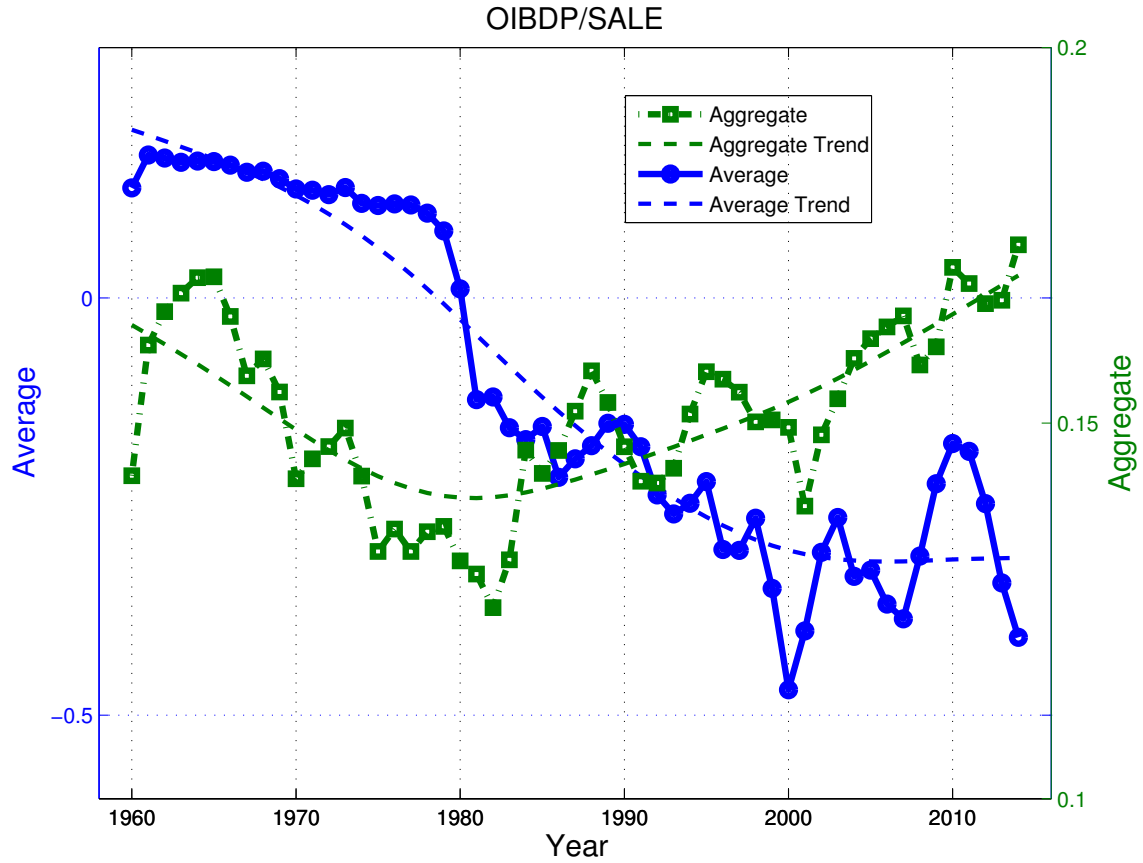
Firm-level risk and firm size inequality are the key drivers of U.S. labor share and capital share dynamics. We can use the cumulant generating function to decompose capital share dynamics. The aggregate labor share is the ratio of two cross-sectional moments: $1 - \Pi = \frac{\mathbb{E}(lab)}{\mathbb{E}(sales)}$ where Π denotes the aggregate capital share. We can decompose these cross-sectional moments using higher-order moments of the log sales and log labor income distribution. In particular, we can expand the log of the aggregate labor share as the difference in the cumulant-generating functions of log output

Figure 2. Firm Level Volatility of U.S. Public Firms



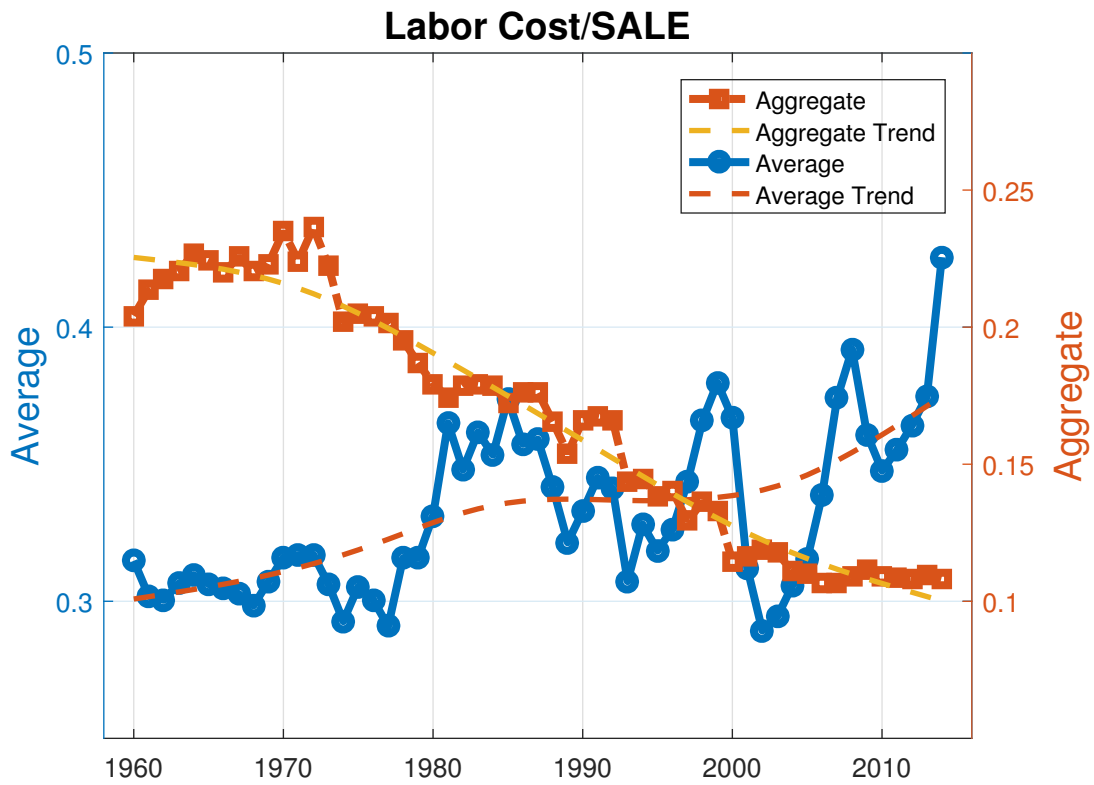
The dashed line is annualized idiosyncratic firm-level stock return volatility. Idiosyncratic returns are constructed within each calendar year by estimating a Fama French 3-factor model using all observations within the year. Idiosyncratic volatility is then calculated as the standard deviation of residuals of the factor model within the calendar year. We obtain the time series of idiosyncratic volatility by average across firms at each year. The solid line is the firm-level cash flow volatility, estimated for all CRSP/Compustat firms using the 20 quarterly year-on-year sales growth observations for calendar years. The idiosyncratic sales growth is the standard deviation of residuals of a factor specification. The factors for sales growth are the first 3 major principal components. Source: CRSP 1960-2014 and Compustat Fundamentals Annual 1950-2014.

Figure 3. Average and Aggregate Capital Share



Capital share of output equals the ratio of operating income to sales. Aggregate capital share = $\frac{\sum_i \text{Operating Income}_i}{\sum_i \text{Sales}_i}$ for each year. Average capital share = $\text{mean}\left(\frac{\text{Operating Income}}{\text{Sales}}\right)$ for each year. The dash lines are the HP-filtered trends. Source: Compustat Fundamentals Annual (1960–2014).

Figure 4. Aggregate and Average Labor Share of U.S. Public Firms



The figure presents the average and aggregate labor share in Compustat public firms database. Labor share is measured by the ratio of estimated staff expenses (XLR) to sales. The dashed lines are the HP-filtered trends of the average and the aggregate labor share. Source: Compustat Fundamentals Annual (1960-2014).

and log capital at the firm level:

$$\log(1 - \Pi) = \log \mathbb{E}(lab) - \log \mathbb{E}(sales) = \sum_{j=1}^{\infty} \frac{\kappa_j(\log lab)}{j!} - \sum_{j=1}^{\infty} \frac{\kappa_j(\log sales)}{j!}, \quad (1)$$

where the cumulants are defined by:

$$\begin{aligned} \text{mean} & : \kappa_1, \\ \text{variance} & : \kappa_2, \\ \text{skewness} & : \kappa_3 / \kappa_2^{3/2}, \\ \text{kurtosis} & : \kappa_4 / \kappa_2^2. \end{aligned}$$

We decompose the aggregate labor share instead of the capital share because labor income is non-negative. Figure 5 plots the difference in the cross-sectional cumulants of log sales and log labor income. The log of labor income is approximated by log of sales minus operating income before depreciation $\log(Sales - OIBDP)$, because the labor data is sparse. The sum of all these weighted differences in cumulants adds up the log labor income share. The means of the log sales and log labor income distribution do not contribute much to the decline in the labor income share.

All of the time series variation in the aggregate labor share is induced by higher order moments. Note that a common measure of risk is the entropy of a random variable $\mathbb{L}(x) = \log(\mathbb{E}(x)) - \mathbb{E} \log(x)$. Hence, much of the change in the aggregate labor share is attributable to difference in entropy between firm size (sales) and firm labor income.

$$\Delta \log(1 - \Pi) \approx \mathbb{L}(lab) - \mathbb{L}(sales) = \sum_{j=2}^{\infty} \frac{\kappa_j(\log lab)}{j!} - \sum_{j=2}^{\infty} \frac{\kappa_j(\log sales)}{j!}$$

We can interpret $\mathbb{L}(lab)$ as a measure of inter-firm compensation inequality, and $\mathbb{L}(sales)$ as a measure of firm size inequality. The log of aggregate labor income share in this sample declines because the overall cross-sectional inequality in labor compensation increases far less than the overall inequality in the size distribution. Table 1 provides a decade-by-decade overview of all four

cumulants for sales and labor income. The top panel considers all sectors, including financials. The bottom panel considers only non-financials. Across-the-board, both for sales and compensation, we see large increase in variance and kurtosis starting in the seventies, together with large increases in negative skewness. However, these increases are much larger for sales than for labor income. Between 1960 and 2014, we record a 279 log point increase in the cumulant sum for firm sales, but only 208 log points for compensation, which implies a 71 log point increase in the difference between the size and compensation weighted sum of cumulants. Table 2 reports the differences between the moments of the compensation and size distribution. The last column shows that 69 log points are due to the difference in firm size and firm compensation inequality ($\approx \mathbb{L}(lab) - \mathbb{L}(sales)$). In this sample, the changes in the means have no bearing on the aggregate labor share. When we exclude financials, reported in the bottom panel, the results are even stronger. Changes in the means do not account for any of the labor share decline.

Basically, the increase in the cross-sectional variance and kurtosis of the log size distribution that started in the late 70s in our universe of firms is not matched by similar changes in the log labor compensation distribution. These forces are only partly mitigated by an increase in negative skewness of the log size distribution, because of a growing mass of small, unprofitable firms in the left tail of the size distribution, that is not offset a similar increase in the log labor compensation distribution. As documented by Fama and French (2004), the wave of new listings that started in 1980 gave rise to a large mass of unprofitable firms in the tail of the size distribution. The increasing left skewness of profitability and right skewness of growth after 1979 are not due to younger firms seeking a public listing: Loughran and Ritter (1995) conclude that during 1980-1998 there is no downtrend in the average age of firms going public. Starting in 1996, this trend in new listings reversed itself, and there was a sharp decline in the number of listed firms (Doidge, Karolyi, and Stulz (2015)). The decline is concentrated mostly in smaller firms.

Figure 6 plots the weighted fourth cumulants by industry. This plot shows that the increase in kurtosis of firm size unmatched by firm compensation is broad-based across industries, but seems most pronounced in high-tech and manufacturing, and smaller in health and consumer goods.

Table 1. Firm Size and Compensation Inequality

Periods	Panel A: Including Financials					
	κ_1	κ_2	κ_3	κ_4	$\sum_{j=1}^4 \frac{\kappa_j}{j!}$	$\sum_{j=2}^4 \frac{\kappa_j}{j!}$
	Sales					
1960 - 1969	4.560	2.416	0.163	0.464	5.814	1.255
1970 - 1979	4.367	3.219	-0.083	5.831	6.205	1.839
1980 - 1989	4.068	6.276	-5.046	13.186	6.915	2.847
1990 - 1999	4.541	5.408	-2.003	13.698	7.482	2.941
2000 - 2009	5.445	5.330	-2.819	13.580	8.206	2.761
2010 - present	5.968	5.386	-5.592	21.023	8.605	2.637
2010's-1960's	1.408	2.970	-5.754	20.558	2.791	1.382
	Labor Compensation					
1960 - 1969	4.384	2.484	0.049	0.771	5.666	1.282
1970 - 1979	4.192	3.294	0.034	2.646	5.954	1.763
1980 - 1989	3.954	5.585	-0.245	-9.251	6.320	2.366
1990 - 1999	4.421	4.677	1.995	-2.940	6.969	2.548
2000 - 2009	5.332	4.531	1.724	-5.040	7.674	2.343
2010 - present	5.774	4.716	0.513	-11.318	7.746	1.972
2010's-1960's	1.390	2.231	0.465	-12.089	2.080	0.689
Periods	Panel B: Excluding Financials					
	Sales					
1960 - 1969	4.585	2.365	0.306	0.329	5.833	1.247
1970 - 1979	4.387	3.168	0.102	6.368	6.254	1.866
1980 - 1989	4.055	6.188	-4.794	14.545	6.956	2.901
1990 - 1999	4.586	5.565	-2.940	14.739	7.493	2.907
2000 - 2009	5.549	5.588	-5.005	17.178	8.224	2.676
2010 - present	6.134	5.570	-8.328	29.108	8.743	2.610
2010's-1960's	1.548	3.205	-8.635	28.778	2.911	1.362
	Labor Compensation					
1960 - 1969	4.413	2.415	0.278	0.230	5.676	1.263
1970 - 1979	4.234	3.151	0.549	2.110	5.988	1.755
1980 - 1989	3.977	5.338	0.348	-6.954	6.415	2.437
1990 - 1999	4.528	4.534	2.069	-4.150	6.967	2.439
2000 - 2009	5.506	4.320	1.335	-6.415	7.621	2.115
2010 - present	5.999	4.378	-0.041	-9.909	7.768	1.769
2010's-1960's	1.586	1.963	-0.319	-10.139	2.092	0.506

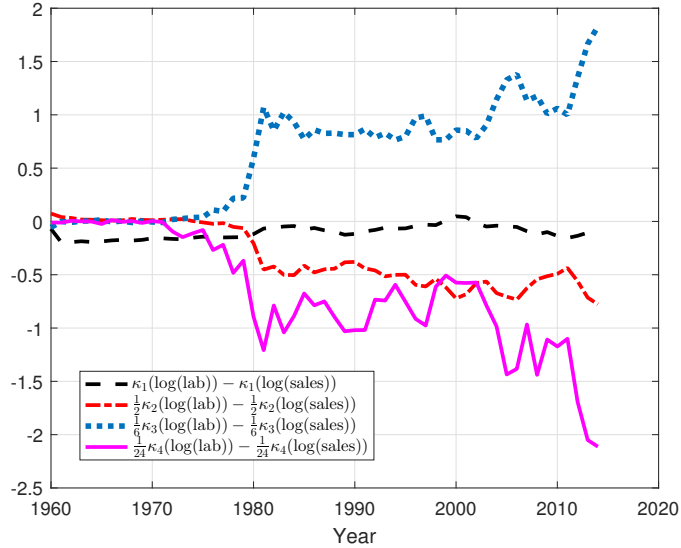
The table shows the first four cumulants of the log labor compensation minus the same cumulants for the log sales distribution. Labor compensation is approximated at the firm level as Sales minus operating income before depreciation (OIBDP). The sample includes all Compustat firms (both **active and inactive**), 1960-2014. The sample is winsorized at 1%.

Table 2. Time Series of Cumulants (Full Sample): $\log \frac{lab}{sales}$ and $\log \frac{oibdp}{sales}$

		Panel A: Including Financials										
Periods	$\kappa_1(\log lab)$	$\kappa_2(\log lab)$	$\kappa_3(\log lab)$	$\kappa_4(\log lab)$	$\sum_{j=1}^4 \frac{\kappa_j(\log lab)}{j!}$	$\sum_{j=2}^4 \frac{\kappa_j(\log lab)}{j!}$	$-\kappa_1(\log sales)$	$-\kappa_2(\log sales)$	$-\kappa_3(\log sales)$	$-\kappa_4(\log sales)$	$\sum_{j=1}^4 \frac{\kappa_j(\log sales)}{j!}$	$\sum_{j=2}^4 \frac{\kappa_j(\log sales)}{j!}$
	1960 - 1969	-0.176	0.068	-0.114	0.307	-0.148	0.028					
1970 - 1979	-0.175	0.074	0.117	-3.185	-0.251	-0.076						
1980 - 1989	-0.114	-0.691	4.801	-22.438	-0.594	-0.480						
1990 - 1999	-0.120	-0.731	3.997	-16.638	-0.513	-0.393						
2000 - 2009	-0.114	-0.799	4.544	-18.620	-0.532	-0.418						
2010 - present	-0.194	-0.670	6.105	-32.340	-0.859	-0.665						
2010's - 1960's	-0.018	-0.739	6.219	-32.647	-0.711	-0.693						
		Panel B: Excluding Financials										
Periods	$\kappa_1(\log lab)$	$\kappa_2(\log lab)$	$\kappa_3(\log lab)$	$\kappa_4(\log lab)$	$\sum_{j=1}^4 \frac{\kappa_j(\log lab)}{j!}$	$\sum_{j=2}^4 \frac{\kappa_j(\log lab)}{j!}$	$-\kappa_1(\log sales)$	$-\kappa_2(\log sales)$	$-\kappa_3(\log sales)$	$-\kappa_4(\log sales)$	$\sum_{j=1}^4 \frac{\kappa_j(\log sales)}{j!}$	$\sum_{j=2}^4 \frac{\kappa_j(\log sales)}{j!}$
	1960 - 1969	-0.173	0.050	-0.028	-0.100	-0.157	0.016					
1970 - 1979	-0.154	-0.018	0.448	-4.258	-0.265	-0.112						
1980 - 1989	-0.078	-0.850	5.141	-21.498	-0.542	-0.464						
1990 - 1999	-0.058	-1.031	5.010	-18.889	-0.526	-0.468						
2000 - 2009	-0.043	-1.268	6.340	-23.592	-0.603	-0.560						
2010 - present	-0.135	-1.192	8.287	-39.017	-0.975	-0.841						
2010's-1960's	0.038	-1.242	8.315	-38.917	-0.819	-0.857						

The table shows the differences in the first four cumulants of the log labor compensation minus the same cumulants for the log sales distribution. Labor compensation is approximated at the firm level as Sales minus operating income before depreciation (OIBDP). The sample includes all Compustat firms (both **active and inactive**), 1960-2014. The sample is winsorized at 1%.

Figure 5. Cross-sectional Cumulants of Firm-level Compensation and Size



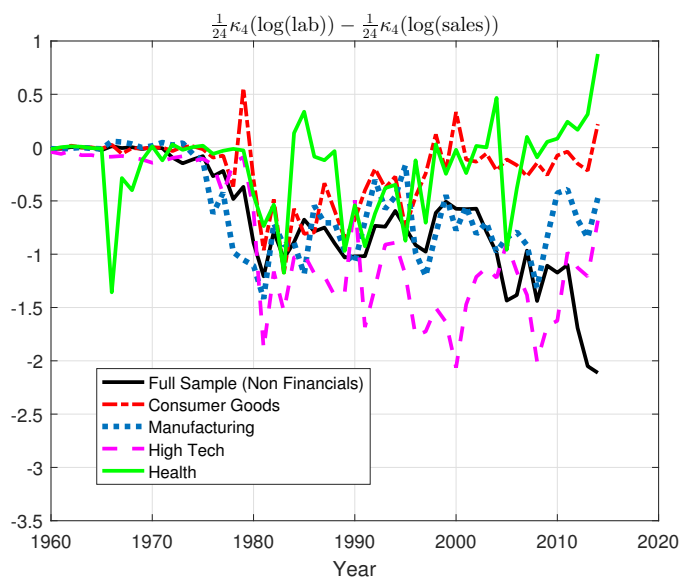
The plot shows the first four cumulants of the log labor compensation minus the same cumulants for the log sales distribution. Labor compensation is approximated at the firm level as Sales minus operating income before depreciation (OIBDP). The sample includes all Compustat firms (both **active and inactive**), 1960-2014. The sample is winsorized at 1%.

2.4 Cross Sectional Variation in Capital Share Dynamics

Figure 7 presents the average and aggregate capital share for difference size groups. All firms are sorted into five groups based on their total assets. Within each group, we compute the average capital share. The average capital share tends to decline more in the smaller size quintiles. Aggregate capital share increases in total, but the increase in profitability mainly happens in the larger firms. Over the period from 1960 to 2014, firm-level volatility has gone up, and hence small firms with low profitability stay in the industry as they find the abandon options are more valuable. During the same period, we find that the capital share of the large firms (group 5) remains stable. The dispersion of capital share across size groups increases over time as the volatility increases. Changes in the capital share of firms on the right tail of size distribution imply the change in the selection process of the public firms. Consistently, we see that the average capital share of firms that were liquidated is declining over time (Figure 13).

We then compare the average and aggregate factor share of output for different volatility sectors.

Figure 6. Fourth Cumulants of Compensation and Size by Industry



The plot shows the fourth cumulant of the log labor compensation minus the fourth cumulant of the log sales distribution computed by industry. Labor compensation is approximated at the firm level as Sales minus operating income before depreciation (OIBDP). The sample includes all Compustat firms (both **active and inactive**), 1960-2014. The sample is winsorized at 1%.

Figure 11 presents the time series of factor shares for low volatility and high volatility sectors. Panel (a) reports the trends of OIBDP to Sales ratio. The divergence of average and aggregate trends only presents in the high volatility sectors. In Figure 12, the decline of capital share in the small firms group (group 1) is much more sizable in the high volatility sector than in the low volatility sector.

To address the concern of changing composition of public firm sample, we examine the distribution of capital share controlling for industries. We examine four main industries in this paper: consumer goods, manufacturing, health products and information, computer and technology (high tech) industry. The definition of consumer goods, manufacturing and health products are taken from Fama-French 5 industry classification. The high tech industry definition is from BEA Industry Economic Accounts⁴. We fix the definitions of industries over time, and sort firms into five different size groups within each industry. We find similar cross-sectional patterns within each industry: the dispersion of capital share across size groups increases over the last five decades, while the more significant decline in capital share happens in the smaller size quintiles. We also see stronger selection effect in the high tech industry and in the health products industry which have relatively high firm-level volatility.

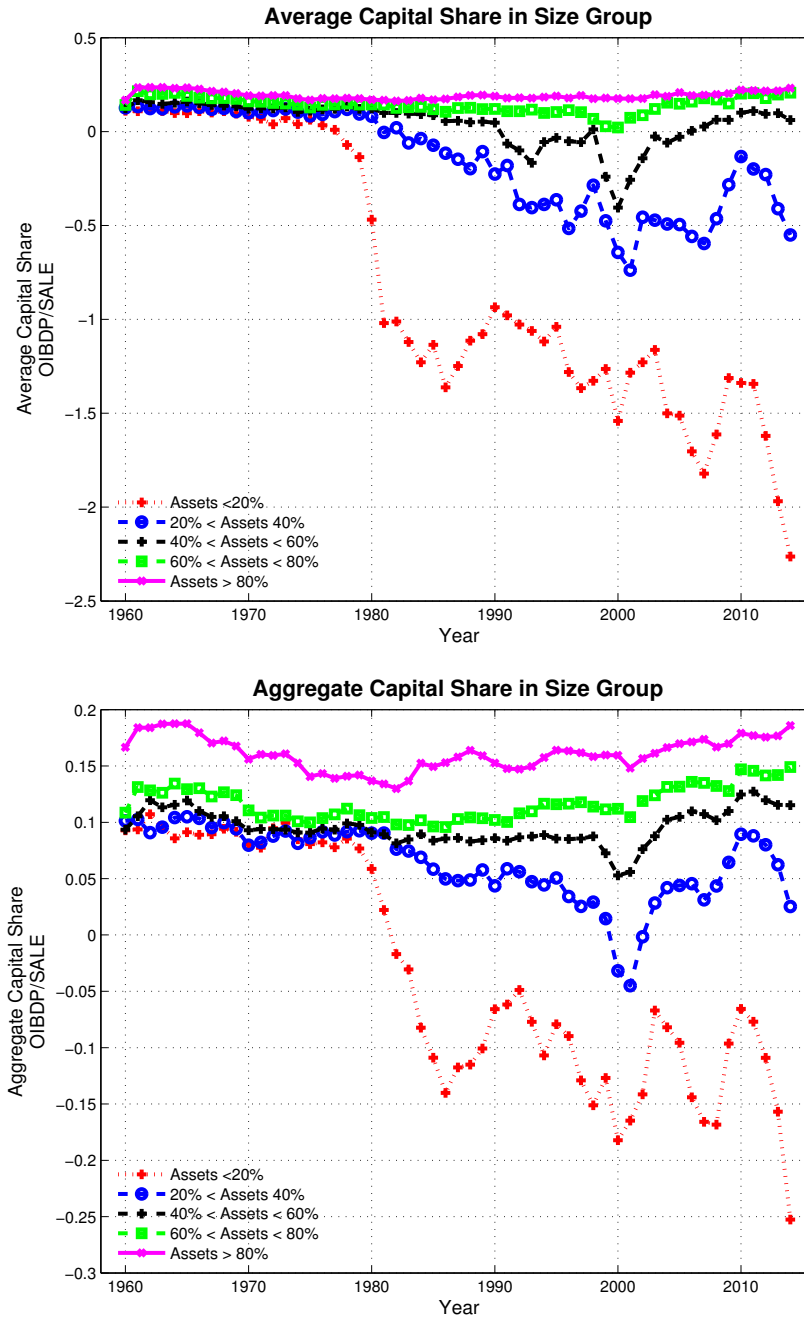
3 Model

In this section we present a model to rationalize the facts we present above. In the model, firms produce cash flows according to a simple production function. We abstract from physical capital and unskilled labor. As we show in Section 6, adding these factors does not change any of the main results, but does substantially complicate the analysis.

Importantly, the shareholders of a given firm hold an option to cease operations when productivity falls. This is the classic abandonment option that has been well studied in the real options literature. As is standard in that literature, increasing the volatility of the firms cash flows increases the value of the option to wait to abandon, and thus decreases the threshold in productivity at which the

⁴The high tech industry is classified using NAICS, consisting of computer and electronic products, publishing and software, information and data processing, and computer system design and related services.

Figure 7. Capital Share of Output by Firm Size



The plot shows the average and aggregate capital share in each size quintile. Size is measured by total assets, and the capital share is measured as operating income (OIBDP) divided by sales (SALE). The sample includes all Compustat firms (both **active and inactive**), 1960-2014. The sample is winsorized at 1%.

firm ceases operations.

Given the solution to the optimal abandonment problem, we characterize the stationary distribution of firms. Increasing (idiosyncratic) cash flow volatility leads more firms to delay abandonment and survive long enough to become very productive. As such, the average across firms of the capital share of profits can be increasing in volatility.

3.1 Environment

The economy is populated by a measure of ex ante identical firms each operating a unit of physical capital with productivity $X^i dt$ given by

$$dX^i = \mu X^i dt + \sigma X^i dZ^i - X^i dN_t^i; \quad \text{for } X^i > X_{\min}$$

where Z^i is a standard Brownian motion independent across firms, N^i is a Poisson process with intensity λ , and $X_{\min} > 0$ is some minimum level of productivity. If $dN_t^i = 1$, or if X^i reaches X_{\min} , X^i jumps to zero, and the firm exits. The process N_t^i gives rise to what is often referred to as an exogenous death rate of firms and is necessary to guarantee the existence of a stationary distribution of firms for all parameterizations of the model. Physical capital is normalized to one for simplicity for the time being. We also abstract from the use of unskilled labor in production. In section 6 we enrich the environment to production functions that include physical capital and unskilled labor. Since all firms produce independent and identically distributed cash flows, we will drop the i superscript for the remainder of the paper.

Each firm is owned by a shareholder and requires a skilled manager to operate. We assume shareholders are risk-neutral and discount cash flows at the risk free rate $r > \mu$ while managers value a stream of payment $\{c_t\}_{t \geq 0}$ according to the following utility function

$$U(\{c_t\}_{t \geq 0}) = E \left[\int_0^\infty e^{-rt} u(c_t) dt \right],$$

where $u'(c) \geq 0$ and $u''(c) < 0$. We normalize the measure of managers in the economy to one.

Firms can exit at the discretion of the shareholder. When a firm exits, its shareholder receives

the liquidation value of the firm, which normalize to zero. There is a competitive fringe of shareholders waiting to create new firms. When an shareholder creates a new firm, she must match with a manager then pay a cost P for a new unit of physical capital and the technology to operate it. After creating a new firm, the firm's initial productivity is drawn from a Pareto distribution with density

$$f(X) = \frac{\rho}{X^{1+\rho}}; \quad X \in [X_{\min}, \infty).$$

This distribution implies that the log-productivity of an entering firm is exponentially distributed with parameter $\rho > 1$ and simplifies the characterization of equilibrium that follows. We denote the rate at which new firms are created by ψ_t . Note that this implies that the entry rate at a given point X is $\psi_t f(X)$.

Upon matching with a manager, a shareholder in a new firm offers a long term contract to the manager prior to the realization of the firm's productivity and payment of the cost P . The manager can reject the contract at which point she is instantaneously matched with a new shareholder. Formally, this contract can be denoted by a process $\{c_t\}_{t \geq 0}$ determining payment to the manager of c_t at time t . We assume that the investor cannot commit to continue operations or to pay the manager once the firm has ceased operations. We also assume that the manager can choose to exit the contract and match with a new firm at any time and that she does not have access to a savings technology. When the firm ceases operations, the manager is matched with a entering firm and signs a new contract. This contracting environment features a two sided limited commitment problem similar to Ai and Li (2015); Ai et al. (2013). Importantly the outside option of the manager will depend on the value of starting a new firm, which is endogenously determined in equilibrium.

We denote the utility the manager receives upon entering this market by U_0 , which is also the manager's reservation utility. At the inception of the contract, the investor and manager takes U_0 as exogenously given, although it will be determined in equilibrium by the market for managers. The investor will continue operations as long as doing so yields a positive present value. This means that the investor operating for the firm is the solution to a standard *abandonment option* common in the real options literature. Specifically, the investor operates the firm until a stopping time denoted

by τ . The investor's problem is thus

$$\max_{\tau, c} E \left[\int_0^\tau e^{-rt} (X_t - c_t) dt \right] \quad (2)$$

such that

$$U_0 \leq E \left[\int_t^\tau e^{-r(s-t)} u(c_s) ds + e^{-r(\tau-t)} U_0 \right] \text{ for all } t > 0. \quad (3)$$

Intuitively, the manager's limited commitment constraint given in equation (3) must bind as delivering more continuation utility to the manager can only ever reduce the investor's value for the firm. As a result, the manager value for the contract is constant over time and it is without loss of generality to restrict attention to contracts that offer the manager a fixed wage c until the firm exits, at which point the manager reenters the market and receives her outside option. Thus, we can simplify the investors problem to

$$V(X; c) = \max_{\tau} E \left[\int_0^\tau e^{-rt} (X_t - c) dt \right], \quad (4)$$

where $V(X; c)$ is the value of operating a firm with current productivity X given a manager contract c . The payment c to the manager then acts as a fixed cost or operating leverage. As such, the investor in a given firm will choose to exit if productivity X is low enough as in the classic problems of optimal abandonment considered in the real options literature or optimal default as in Leland (1994). It is without loss of generality to restrict attention to firm exit times that are given by threshold rules of the form

$$\tau = \inf\{t | X_t \leq \bar{X} \text{ or } dN_t = 1\}$$

for some $\bar{X} \geq 0$.

Before stating the definition of equilibrium, it will be useful define $x_t = \log(X_t)$.

Definition 1. A stationary equilibrium consists of a compensation c^* for the skilled worker, an entry rate of new firms ψ^* , an exit policy for the investors \bar{X} , and a stationary distribution $\phi(x)$

such that

1. The exit policy \bar{X} solves the investors problem given by (4).
2. The stationary distribution $\phi(x)$ is consistent with the entry rate of new firms ψ and the exit policy \bar{X} .
3. Creating a new firm leaves the investor with zero expected NPV

$$\int_{X_{\min}}^{\infty} V(X; c) f(X) dX = P.$$

4. The market for managers clears

$$\int_{X_{\min}}^{\infty} \phi(X) dX = 1.$$

Conditions 3 and 4 of the above definition merit some discussion. Condition 3 derives from the existence of the competitive fringe of investors waiting to create new firms. If an investor in a new firm offers a contract that leaves her with positive ex ante expected NPV, then the manager will reject since she can simply reenter the market and instantaneously match with a new firm. Thus our definition of equilibrium corresponds to allocating all of the ex ante bargaining power to the manager. This condition will pin down the level of compensation to the managers in the economy. Note that an alternative definition would be to allocate some bargaining power to the investor, however, doing so will not drastically change the results.

Condition 4 states that there measure of firms in the economy must match the measure of managers. This condition will pin down the entry rate of new firms.

4 Equilibrium and National Income Accounting

In this section, we characterize the stationary equilibrium of the model and study its implications for national income accounting.

4.1 Ex Ante Firm Value and the Equilibrium Wage

To solve for the firm value function and exit policy of the investor, we use standard techniques from the real options literature. An application of Ito's formula and the dynamic programming principal imply that $V(X; c)$ must satisfy the following ordinary differential equation

$$(r + \lambda)V(X; c) = X - c + \mu X \frac{\partial}{\partial X} V(X; c) + \frac{1}{2} \sigma^2 X^2 \frac{\partial^2}{\partial X^2} V(X; c), \quad (5)$$

with the boundary conditions

$$V(\bar{X}(c); c) = 0, \quad (6)$$

$$\frac{\partial}{\partial X} V(\bar{X}(c); c) = 0, \quad (7)$$

$$\lim_{X \rightarrow \infty} \left| V(X; c) - \left(\frac{X}{r + \lambda - \mu} - \frac{c}{r + \lambda} \right) \right| = 0. \quad (8)$$

Conditions (6) and (7) are the standard value matching and smooth pasting conditions pinning down the optimal exercise boundary for the abandonment option. Condition (8) arises because as X_t tends to infinity, abandonment occurs with zero probability and the value of the firm must tend to the present value of a growing cash flow less a fixed cost.

The solution to equations (5)-(8) is given by

$$\bar{X}(c) = \frac{\eta}{\eta + 1} \frac{c(r + \lambda - \mu)}{r + \lambda} \quad (9)$$

$$V(X; c) = \frac{X}{r + \lambda - \mu} - \frac{c}{r + \lambda} - \left(\frac{\bar{X}(c)}{r + \lambda - \mu} - \frac{c}{r + \lambda} \right) \left(\frac{X}{\bar{X}(c)} \right)^{-\eta} \quad (10)$$

where

$$\eta = \frac{\mu - \frac{1}{2}\sigma^2 + \sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2(r + \lambda)\sigma^2}}{\sigma^2}.$$

Note that an increase in firm-level volatility σ invariably lowers the abandonment threshold, simply because an increase in volatility raises the option value of keeping the firm alive. This feature of the abandonment option will play key role in our analysis as will become apparent when we discuss

the stationary distribution of firm size. Specifically, an increase in firm-level volatility will lead to a increase mass of firm's that delay exit, increasing the mass of firms that have low productivity as well the mass of firms that survive long enough to achieve high productivity.

Given the solution for firm value conditional on a manager wage c as well as our assumption on the distribution of productivity of new firms, we can solve for the equilibrium compensation in closed form. We have

$$c^* = \left(\frac{P(r + \lambda)(\rho - 1)(\rho - \eta)}{\eta} \left(\frac{\eta(r + \lambda - \mu)}{(\eta + 1)(r + \lambda)} \right)^\rho \right)^{-\frac{1}{\rho - 1}}. \quad (11)$$

The derivation of c^* is given in section of the Appendix.

4.2 The Kolmogorov Forward Equation

We use ϕ to denote the stationary distribution of $x = \log X$. To remain stationary, the expected change via inflow and outflow in the measure of firms at a given level of x must be equal to the measure of firms that exogenously die at the rate λ less the measure of firms that endogenously enter at the rate $\psi g(x)$ (see p. 273 in Dixit and Pindyck, 1994). This leads to the following Kolmogorov forward equation for $\phi(x)$

$$\frac{1}{2}\sigma^2\phi''(x) - \left(\mu - \frac{1}{2}\sigma^2 \right) \phi'(x) - \lambda\phi(x) + \psi g(x) = 0. \quad (12)$$

where

$$g(x) = \rho e^{-\rho x}.$$

is the density of initial log productivity x for entering firms. A similarly argument gives a boundary condition for $\phi(x)$ at the exit barrier $\bar{x} = \log \bar{X}$

$$\phi(\bar{x}) = 0. \quad (13)$$

The final equation that determines the stationary distribution of firm size is given by the market clearing condition for managers

$$\int_{\bar{x}}^{\infty} \phi(x) dx = 1. \quad (14)$$

The solution to equations (12)-(14) is given by

$$\phi(x) = \frac{\rho\gamma}{\rho - \gamma} \left(e^{-\gamma(x-\bar{x})} - e^{-\rho(x-\bar{x})} \right) \quad (15)$$

for $x \in [\bar{x}, \infty)$, where

$$\gamma = \frac{-(\mu + \frac{1}{2}\sigma^2) + \sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2\sigma^2\lambda}}{\sigma^2}. \quad (16)$$

The solution also allows us to characterize the aggregate entry rate of new firms

$$\psi = \frac{\gamma(\rho(\mu + \frac{1}{2}\sigma^2) - \frac{1}{2}\rho^2\sigma^2 - \lambda)}{\rho - \gamma} e^{\rho\bar{x}}. \quad (17)$$

We note that our assumption on the density of productivity of entering firms allows for the simple closed form solutions above. The general solution to the ODE given in equation (12) is exponential. By assuming that $g(x)$ is exponential as well, we are left with a solution to equation (12) for which it is possible to solve the boundary condition given in equation (13).

Figure 8 plots the stationary distribution of firm productivity for different levels of σ . The other parameters are calibrated at $r = 5\%$, $\mu = 2\%$, $\lambda = .05$, $\rho = 3$, $P = 1$. As σ increases, the stationary distribution shifts to the left and becomes more diffuse, with a fatter right tail. The shift to the left is due to the fact that as firm-level volatility increases, the value of the option to wait to exit increases, and the optimal point at which the investor chooses to exit necessarily decreases.

The effect of firm-level volatility on the shape of $\phi(x)$ visible in figure 8 is borne out by examining the higher-ordered moments of $\phi(x)$. Table 3 reports the standard deviation, the skewness and the kurtosis of the log size distribution as we increase σ . As σ increases, the right skewness increases from 0.12 to 2.74 and the excess kurtosis of the log size distribution increases from 0.15 to 7.31. This overall widening of the distribution with a fattening of the left tail comes from two effects.

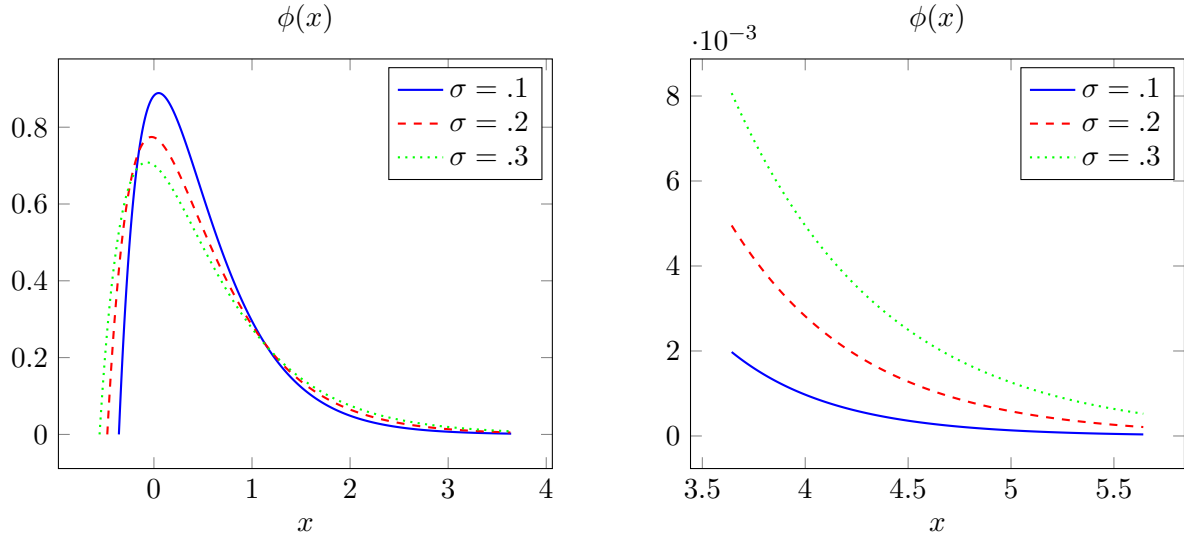


Figure 8. The stationary distribution of log-productivity for $\sigma = .1, .2,$ and $.3$. Parameter values: $r = 5\%, \mu = 2\%, \lambda = .05, \rho = 3, p = 1$.

Table 3. Higher order moments of the log-size distribution implied by the model

σ	Mean	Std. Dev.	Skew.	Kurt.
.1	1.879	0.700	0.120	0.151
.2	1.493	0.696	2.186	5.631
.3	1.181	0.789	2.742	7.310

Moments of the stationary distribution of log-productivity for $\sigma = .1, .2,$ and $.3$. Parameter values: $r = 5\%, \mu = 2\%, \lambda = .05, \rho = 3, p = 1$.

First there is a direct effect of σ on the dispersion of the distribution of firm size. When firm-level productivity is more volatile, the stationary distribution of firms must be more dispersed. This is evident by examining the dependence of γ on σ . The second effect operates through the abandonment option. When the option to wait to exit becomes more valuable, more firms delay exit, and as a result more firms survive long enough to become very productive. As a result the right tail of the distribution becomes fatter. In the next section, we show that this effect has important implications for national income accounting.

4.3 Capital Share and Ex Post Profitability

Armed with this stationary distribution, we can do national income accounting inside our model. We use this stationary distribution to calculate the total and average profit share for a range of σ . Specifically, we use the stationary distribution to calculate the aggregate capital share:

$$\begin{aligned} \text{Capital Share of Profits} = \Pi &= \frac{\int_{\bar{x}}^{\infty} (e^x - c)\phi(x)dx}{\int_{\bar{x}}^{\infty} e^x\phi(x)dx}, \\ &= 1 - \left(\frac{\rho - 1}{\rho}\right) \left(\frac{\gamma - 1}{\gamma}\right) \left(\frac{c}{\bar{X}}\right) \end{aligned}$$

and the average capital share:

$$\begin{aligned} \text{Average Capital Share of Profits} &= \int_{\bar{x}}^{\infty} \left(\frac{e^x - c}{e^x}\right) \phi(x)dx. \\ &= 1 - \left(\frac{\rho}{\rho + 1}\right) \left(\frac{\gamma}{\gamma + 1}\right) \left(\frac{c}{\bar{X}}\right) \end{aligned}$$

We note that our expressions for both aggregate and average capital share are gross of the costs of starting new firms. Including these costs leads to a less transparent expressions and does not change the results of the analysis below.

Given the exponential entry distribution given above, the aggregate capital share is independent of c and available in closed form:

$$\Pi = 1 - \left(\frac{r + \lambda}{r + \lambda - \mu}\right) \left(\frac{\rho - 1}{\rho}\right) \left(\frac{\gamma - 1}{\gamma}\right) \left(\frac{\eta + 1}{\eta}\right). \quad (18)$$

One main goal of our paper is to understand the effect of an increase in idiosyncratic volatility on the aggregate capital share. To do so we consider the comparative static effect of a change in σ on Π . Note that the only the last two terms of Π depend on σ . The second to last term depends on the rate of decay of γ of the stationary distribution while the last term depends on the exponent of the investor's value function η . As σ increases, γ decreases, and the measure of firms in the right tail of the stationary distribution of X increases. Thus, the second to last term measures the effect that very productive firms have on the aggregate capital share and is decreasing in σ .

The last term is proportional to the ratio of the equilibrium wage c^* to the optimal exit threshold \bar{X} . We can think of this term as relating to the effect that the least productive firms have on the aggregate capital share. As σ increases, η decreases, and this ratio increases. When σ is large, the option to wait to abandon the firm is more valuable. This leads to two effects. First, the optimal abandonment threshold decreases. Second, the ex ante surplus created by starting a new firm, and thus the manager's payment, increases. Together, these effects imply that the ratio of the manager's payment to the optimal abandonment threshold is increasing in σ . To summarize, an increase in σ increases the measure of firms in the right tail of the distribution, which serves to increase capital share. At the same time, an increase in σ means that the least productive firms have increasing negative capital share of profits, which serves to decrease the aggregate capital share. The net effect of σ on the aggregate capital share depends on which effect dominates.

To determine which effect dominates, we calculate the derivative of Π with respect to the volatility parameter σ :

$$\frac{\partial \Pi}{\partial \sigma} = - \left(\frac{r + \lambda}{r + \lambda - \mu} \right) \left(\frac{\rho - 1}{\rho} \right) \left[\left(\frac{\eta + 1}{\eta} \right) \frac{1}{\gamma^2} \frac{\partial \gamma}{\partial \sigma} - \left(\frac{\gamma - 1}{\gamma} \right) \frac{1}{\eta^2} \frac{\partial \eta}{\partial \sigma} \right]. \quad (19)$$

So $\partial \Pi / \partial \sigma$ is positive if and only if

$$\eta(\eta + 1) \frac{\partial \gamma}{\partial \sigma} \leq \gamma(\gamma - 1) \frac{\partial \eta}{\partial \sigma}. \quad (20)$$

It is straightforward to show that $\eta(\eta + 1) \frac{\partial \eta}{\partial \sigma} \leq 0$ and $\gamma(\gamma - 1) \frac{\partial \gamma}{\partial \sigma} \leq 0$, so to verify (20), it is equivalent to verify

$$\frac{\eta(\eta + 1) \frac{\partial \gamma}{\partial \sigma}}{\gamma(\gamma - 1) \frac{\partial \eta}{\partial \sigma}} \geq 1. \quad (21)$$

After considerable algebra, one can show that

$$\frac{\eta(\eta + 1) \frac{\partial \gamma}{\partial \sigma}}{\gamma(\gamma - 1) \frac{\partial \eta}{\partial \sigma}} = \frac{\sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2(r + \lambda)\sigma^2}}{\sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2\lambda\sigma^2}} > 1 \quad (22)$$

which verifies that $\partial \Pi / \partial \sigma > 0$. Hence, in our model, the aggregate capital share always increases

as volatility increases.

Using the decomposition of the log labor share inside our model, we obtain:

$$\log(1 - \Pi) = \log \mathbb{E}(c) - \log \mathbb{E}(y) = \log c - \sum_{j=1}^{\infty} \frac{\kappa_j(\log y)}{j!}, \quad (23)$$

$$= \log \left[\left(\frac{r + \lambda}{r + \lambda - \mu} \right) \left(\frac{\rho - 1}{\rho} \right) \left(\frac{\gamma - 1}{\gamma} \right) \left(\frac{\eta + 1}{\eta} \right) \right]. \quad (24)$$

The higher-order moments drop out for compensation, because of perfect insurance. The labor share is then determined by the higher-order moments of the size (output) distribution. An increase in volatility increases the higher-order moments of the size distribution and reduces the labor share.

Figure 9 plots a calibrated example. The figure plots the total and average capital share of profit as a functions of σ . We use the following parameter values: $r = 5\%$, $\mu = 2\%$, $\lambda = .05$, $\rho = 3$, $p = 1$. We can see that the total capital share of profits is increasing in σ while the average capital share of profits is decreasing. The intuition is as follows. As σ increases, the value of the option to delay abandonment increases, and hence the optimal threshold at which firms exit decreases. Holding the total measure of firms fixed, this means that the distribution of profits becomes more dispersed. The increase in mass of firms in the right tail of the firm size distribution increases the total profit share, because the profit share measures the ex post profitability of existing firms. This is effectively a selection bias. The profit share of entering firms is set by setting the NPV of the investor's stake in the firm to zero. This NPV calculation integrates over all possible future paths for firm-level productivity, including those that lead the investor to choose to exit. In contrast, the stationary distribution of existing firms only consider firms that have survived. Surviving firms necessarily have a higher capital share of profits, otherwise the investor would have chosen to exit.

Our model also makes a novel prediction about the capital share at the average firm. The increase in mass of firms that delay exist means that there will be more firms with a low capital share. Thus an increase in firm-level volatility can decrease the average profit share. This is in contrast to the effect one would expect to see if the increase in total capital share of profits is due to a greater growth rate in the value of capital relative to wages that may follow the substitution of capital for labor. In that case, one would expect both the total and average capital share to

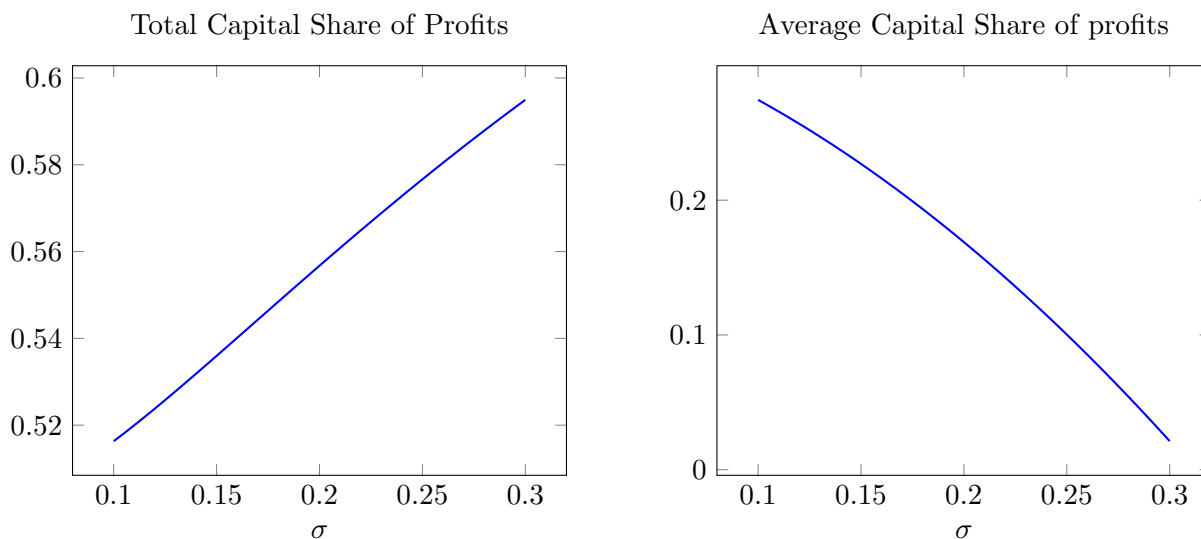


Figure 9. The total and average capital share of profit as a functions of σ . Parameter values: $r = 5\%$, $\mu = 2\%$, $\lambda = .05$, $\rho = 3$, $p = 1$.

increase.

We can also examine the capital share of firm value, with similar results as for profits. Figure 10 plots the total and average capital share of firm value derived from the model.

5 Pay for Performance and the Capital Share

In this section we allow the manager some exposure firm performance. Edmans et al. (2009) derive CEO compensation in a competitive equilibrium with a talent assignment and moral hazard problem. This exposure could arise for a variety of reasons. For example, there could be a firm-level agency conflict between the manager and investors or the investor could be risk averse. In either case, the optimal contract will call for the manger to bear some exposure to firm performance, either for incentive purposes or to improve risk sharing. The precise form of the optimal contract will depend on the nature of the agency problem or the exact preferences of the managers and investors. A concern with our results thus far might be that such a sensitivity could mitigate the insurance nature of the relationship between firms' owners and their managers, thus decreasing or reversing the effect of firm level volatility on the capital share of profits. Rather than solve directly

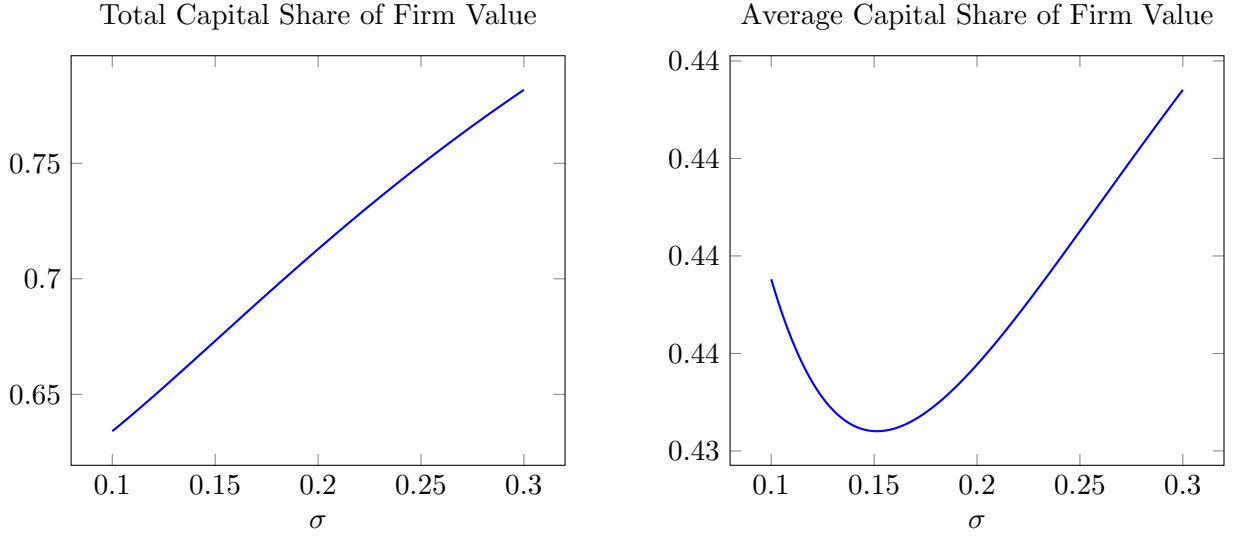


Figure 10. The total and average capital share of firm value as a functions of σ . Parameter values: $r = 5\%$, $\mu = 2\%$, $\lambda = .05$, $\rho = 3$, $p = 1$.

for an optimal contract for a particular problem, we assume that the manager's contract takes the following simple affine form

$$c_t = \beta X_t + w. \quad (25)$$

The sensitivity β of the managers payment c_t to the level of productivity is determined by either the severity of the agency problem or the nature of the risk-sharing problem, and is exogenous from the standpoint of our model. The fixed wage w is set in equilibrium in the same manner as total wages are set above. This contract has the advantage of being particularly tractable to analyze in the context of our model of equilibrium.

For a given fixed wage w , the investors problem is

$$\max_{\tau} \left[\int_0^{\tau} e^{-rt} ((1 - \beta)X_t - w) dt \right]. \quad (26)$$

Again, standard arguments imply that the investor's value function $V(X)$ must satisfy the following

ODE

$$(r + \lambda)V = (1 - \beta)X - w + \mu XV' + \frac{1}{2}\sigma^2 X^2 V'', \quad (27)$$

with the boundary conditions

$$V(\bar{X}) = 0, \quad (28)$$

$$V'(\bar{X}) = 0, \quad (29)$$

$$\lim_{X \rightarrow \infty} \left| V(X) - \left(\frac{(1 - \beta)X}{r + \lambda - \mu} - \frac{w}{r + \lambda} \right) \right| = 0. \quad (30)$$

This problem is essentially the same as one given in equations (5)-(8), up to a scaling of the leading term by a factor of $(1 - \beta)$. Thus, the solution to equation (27)-(30) is

$$\begin{aligned} \bar{X} &= \left(\frac{1}{1 - \beta} \right) \left(\frac{\eta}{\eta + 1} \right) \frac{w(r + \lambda - \mu)}{r + \lambda} \\ V(X) &= \frac{(1 - \beta)X}{r + \lambda - \mu} - \frac{c}{r + \lambda} - \left(\frac{(1 - \beta)\bar{X}}{r + \lambda - \mu} - \frac{c}{r + \lambda} \right) \left(\frac{X}{\bar{X}} \right)^{-\eta} \end{aligned}$$

where η is defined as above.

Given the solution for the investor's value, we can apply the investor's zero ex-ante profit condition to determine the fixed component of the manager's equilibrium contract. Doing this calculation yields

$$w^* = \left(\frac{P(r + \lambda)(\rho - 1)(\rho - \eta)}{\eta} \left(\frac{\eta(r + \lambda - \mu)}{(1 - \beta)(\eta + 1)(r + \lambda)} \right)^\rho \right)^{-\frac{1}{\rho - 1}}. \quad (31)$$

Comparing equations (11) and (31) reveals that the fixed component of the equilibrium affine contract is just the equilibrium wage under full insurance scaled by a function of β . The intuition here is that we can essentially view the investor's problem under the affine contract has identically to the problem under full insurance when the firm's productivity is scaled by a factor of $1 - \beta$.

Now note that the stationary distribution of firm productivity is unaffected by our assumption of affine contracts, up to a shifting of the optimal abandonment threshold, i.e. the left support of

the stationary distribution. Thus we can again calculate the total capital share of profits in the stationary distribution to get

$$\Pi = 1 - (1 - \beta) \left(\frac{r + \lambda}{r + \lambda - \mu} \right) \left(\frac{\rho - 1}{\rho} \right) \left(\frac{\gamma - 1}{\gamma} \right) \left(\frac{\eta + 1}{\eta} \right). \quad (32)$$

Comparing equations (18) and (32) shows that the total capital share profits under the affine contract depends on γ and η , and hence on σ , in the same manner as the total capital share of profits under full insurance. In other words, allowing the manager to share in success of the successful firms does not change our main results.

6 Economy with Physical Capital and Unskilled Labor

To quantify the effects we describe above, we analyze an extended version of our economy with physical capital accumulation and unskilled labor.

Again we study an economy populated by a measure of ex ante identical firms. However, now we will consider firms that require unskilled labor in addition to a manager and that can adjust the amount of capital under production. A given firm with productivity X_t has a single manager, capital k_t and unskilled labor l_t . Total output produced by this firm is given by:

$$Y_t = X_t^\nu F(k_t, l_t)^{1-\nu},$$

where F is homogeneous of degree one and $0 < \nu < 1$. Lucas refers to ν as the span of control parameter of the firm's manager. Unskilled labor is in fixed supply. We normalize $l_t = 1$. This is without loss of generality.

The firm rents physical capital at a rental rate ρ_t and unskilled labor at a spot rate w_t . The firm's gross earnings are given by:

$$d_t(X_t) = Y_t - w_t l_t(X_t) - \rho_t k_t(X_t).$$

The firm chooses physical capital and unskilled labor to maximize gross earnings. This is a static

optimization problem. We can simply characterize the optimal allocation of physical capital and labor as a function of the firm's productivity X_t . To do so, we can define the first moment of X :

$$\underline{X}_t = \int_{\bar{x}}^{\infty} (e^x) \phi_t(x) dx.$$

Given the homogeneity of the production function, it is straightforward to show that physical capital and unskilled labor are allocated across firms according to the following linear allocation rule:

$$\begin{aligned} k_t(X_t) &= \frac{X_t}{\underline{X}_t} k_t, \\ l_t(X_t) &= \frac{X_t}{\underline{X}_t} l_t, \\ y_t(X_t) &= \frac{X_t}{\underline{X}_t} y_t, \end{aligned}$$

where $y_t = \underline{X}_t^{1-\nu} F(k_t, l_t)^\nu$ denotes aggregate output. One can verify that this allocation rule satisfies the firm's static first order conditions. As a result, we know that a firm's gross earnings are proportional to X_t :

$$d_t(X_t) = (1 - \nu) y_t(X_t) = (1 - \nu) \frac{X_t}{\underline{X}_t} y_t.$$

Thus, we can simplify the investors problem to

$$V(X; c) = \max_{\tau} E \left[\int_0^{\tau} e^{-rt} \left((1 - \nu) \frac{X_t}{\underline{X}_t} y_t - c \right) dt \right], \quad (33)$$

where $V(X; c)$ is the value of operating a firm with current productivity X given a manager contract c .

The definition of a stationary equilibrium in this economy is the natural extension of the one given above to a setting in which firms employ unskilled labor and can adjust capital.

Definition 2. A stationary equilibrium consists of a rental rate ρ for physical capital, a wage rate w , a compensation c for the skilled worker, an exit policy for the shareholder $\bar{X}(\cdot)$, a stationary distribution ϕ , such that, for given (\underline{X}, y) , the exit policy solves the shareholder problem, the

wage rate clears the labor market, the rental rate r clears the market for physical capital, and the stationary size distribution is consistent with the exit policy $\bar{X}(\cdot)$.

We focus on a stationary equilibrium in which (\underline{X}_t, y_t) are constant. The solution technique for the investor's problem is essentially the same as in the case with constant physical capital and labor up to a change in the coefficients in the ODE and determination of the optimal abandonment threshold. For a given candidate equilibrium abandonment threshold $\bar{X}(c)$, $V(X; c)$ must satisfy the following ordinary differential equation

$$(r + \lambda)V(X; c) = (1 - \nu)\frac{X}{\underline{X}}y - c + \mu X \frac{\partial}{\partial X}V(X; c) + \frac{1}{2}\sigma^2 X^2 \frac{\partial^2}{\partial X^2}V(X; c), \quad (34)$$

with the boundary conditions

$$V(\bar{X}(c); c) = 0, \quad (35)$$

$$\lim_{X \rightarrow \infty} \left| V(X; c) - \left(\frac{X}{r + \lambda - \mu} - \frac{c}{r + \lambda} \right) \right| = 0. \quad (36)$$

Conditions (35) is the standard value matching, while condition (36) arises because as X_t tends to infinity, abandonment occurs with zero probability as in the simple model we analyzed above.

An important difference between the model with physical capital and unskilled labor and the simple model given above, is that the abandonment threshold must be consistent with the equilibrium distribution of capital and labor. Consider a candidate equilibrium threshold $\bar{X}(c)$. If all firms choose to delay abandonment beyond this threshold, average productivity decreases, increasing the allocation of capital and labor to existing firms with higher productivity. This in turn increases the benefit to delaying abandonment. Whether it is for some abandonment threshold above the minimum level of productivity to obtain in equilibrium depends on how sensitive average productivity is to the left support of the stationary distribution. For the Pareto distribution we have considered above, average productivity is very sensitive to the left support of the stationary distribution and

$\bar{X}(c) > X_{\min}$ cannot obtain in equilibrium. Thus, the optimal abandonment threshold is given by

$$\bar{X}(c) = X_{\min} \quad (37)$$

and the solution to equations (34)-(36) is given by

$$V(X; c) = \frac{\underline{X}}{(1-\nu)y} \frac{X}{r+\lambda-\mu} - \frac{c}{r+\lambda} - \left(\frac{\underline{X}}{(1-\nu)y} \frac{X_{\min}}{r+\lambda-\mu} - \frac{c}{r+\lambda} \right) \left(\frac{X}{X_{\min}} \right)^{-\eta}. \quad (38)$$

where the exponent η is the same as given in the simple model.

Now note that since X_t still has the same dynamics as in the simple model, the form of the stationary distribution for productivity is unchanged. The only difference is the left support is now X_{\min} . It is then possible to calculate the equilibrium average productivity

$$\underline{X} = \frac{X_{\min} \gamma \rho}{(\gamma - 1)(\rho - 1)}.$$

Finally, we have assumed that entering firms still draw initial productivity from a Pareto distribution as in the simple model. Thus, given the solution to the investors value function, it is straightforward to solve the investors ex ante zero profit condition for the equilibrium c . The closed form solution for c is somewhat messy and uninformative, so we omit it for brevity.

Once we have solved for the \hat{c} that sets the NPV to zero, we can back out the actual c , using (y, \underline{X}) .

6.1 National Income Accounting

Armed with this stationary distribution, we can do national income accounting inside our model. We use this stationary distribution to calculate the total and average profit share for a range of σ .

Specifically, we use the stationary distribution to calculate the aggregate capital share:

$$\begin{aligned}
\text{Total Capital Share of Rents} &= \frac{\int_{\bar{x}}^{\infty} ((1 - \nu) \frac{y}{X} e^x - c) \phi(x) dx}{\int_{\bar{x}}^{\infty} (1 - \nu) \frac{y}{X} e^x \phi(x) dx} \\
&= 1 - \frac{c}{(1 - \nu)y} \\
\text{Total Capital Share of Output} &= \frac{\int_{\bar{x}}^{\infty} (\alpha \nu y + (1 - \nu) \frac{y}{X} e^x - c) \phi(x) dx}{\int_{\bar{x}}^{\infty} (1 - \nu) \frac{y}{X} e^x \phi(x) dx} \\
&= 1 + \frac{\alpha \nu}{1 - \nu} - \frac{c}{(1 - \nu)y}.
\end{aligned}$$

$$\begin{aligned}
\text{Average Capital Share of Rents} &= E \left[\frac{X - c}{X} \right] \\
&= \int_{\bar{x}}^{\infty} \left(\frac{(1 - \nu) \frac{y}{X} e^x - c}{(1 - \nu) \frac{y}{X} e^x} \right) \phi(x) dx.
\end{aligned}$$

Note, total capital share of out put is equal to total capital share of rents plus a constant that doesn't depend on σ , hence the two will have the same comparative static.

In order to make our predictions sharpe, we make some simple assumptions on functional forms. Specifically we use $F(k, l) = k^\alpha l^{1-\alpha}$. The stand-in agent's Euler equation for consumption implies that:

$$1 + r = (1 - \tau_c) \left(\nu \alpha \frac{y}{k} - \delta \right) + 1.$$

Atkeson and Kehoe set the capital share $\frac{k}{y}$ to 1.46, the corporate tax rate τ to 48.1 percent, δ to 5.5 percent. Hence, the implied $\nu \alpha$ is 19.9 percent. Without loss of generality, we can normalize the unskilled labor force to one. We also know that we can state total output as:

$$y = \underline{X}^{\frac{1-\nu}{1-\alpha\nu}} \left(\frac{k}{y} \right)^{\frac{\alpha\nu}{1-\alpha\nu}}$$

As a result we can restate the expressions for the factor shares as follows:

$$\begin{aligned} \text{Total Capital Share of Rents} &= 1 - \frac{c}{(1-\nu)\underline{X}^{\frac{1-\nu}{1-\alpha\nu}}\left(\frac{k}{y}\right)^{\frac{\alpha\nu}{1-\alpha\nu}}} \\ \text{Total Capital Share of Output} &= 1 + \frac{\alpha\nu}{1-\nu} - \frac{c}{(1-\nu)\underline{X}^{\frac{1-\nu}{1-\alpha\nu}}\left(\frac{k}{y}\right)^{\frac{\alpha\nu}{1-\alpha\nu}}}. \end{aligned}$$

where k/y is a constant pinned down by the intertemporal Euler equation. We have

$$\text{Total Capital Share of Output} = 1 + \frac{\alpha\nu}{1-\nu} - \left(\frac{1}{1-\nu}\right) \left(\frac{k}{y}\right)^{-\frac{\alpha\nu}{1-\alpha\nu}} \left(\left(\frac{\rho-1}{\rho}\right) \left(\frac{\gamma-1}{\gamma}\right) \left(\frac{1}{X_{\min}}\right)\right)^\beta c$$

where

$$\beta = \frac{1-\nu}{1-\alpha\nu}.$$

After some algebra, we can show that

$$\text{Total Capital Share of Output} = \alpha_1 - \alpha_2 \left(\frac{\gamma-1}{\gamma}\right) \left(\frac{\eta+1}{\eta}\right) + \alpha_3 \left(\frac{\gamma-1}{\gamma}\right) \frac{\eta+\rho}{\eta} \quad (39)$$

where α_1, α_2 and α_3 are positive constants that don't depend on σ . The sign of the comparative static of total capital share of output thus depends on the relative magnitude of κ_2 and κ_3 . When X_{\min} is small, $\kappa_3 \ll \kappa_2$ and the total capital share of output is increasing in σ

7 Conclusion

We propose a mechanism whereby an increase in firm-level volatility can have important effects on national income accounting. A firm's owner insures its manager against firm-level productivity shocks. As a result, that owner may choose to exit if productivity becomes too low. The level of the manager's compensation is set based on expected firm value—which necessarily integrates

over paths that end in exit. In contrast, when accounting for income, one typically integrates over surviving firms which necessarily feature lower capital shares of profit. This leads to a difference between the aggregate capital share of income, which is calculated ex post, and the capital share of value at the origination of firm, which is calculated ex ante. When firm-level volatility increases, the difference can increase, increasing the aggregate capital share and decreasing the average capital share. We also present time series and cross sectional evidence for Compustat firms consistent with our proposed mechanism.

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A Proofs

A.1 Derivation of equilibrium compensation

The equilibrium wage is given by the solution to the following equation

$$\int_{\bar{X}(c)}^{\infty} V(X; c) f(X) dX = P$$

where $\bar{X}(c)$ is given by equation (9) and $V(X; c)$ is given by equation (10). Note that this equation is equivalent to condition 3 of Definition 1. First evaluate the integral on the left hand side we have

$$\begin{aligned} & \int_{\bar{X}(c)}^{\infty} \left(\frac{X}{r + \lambda - \mu} - \frac{c}{r + \lambda} - \left(\frac{\bar{X}(c)}{r + \lambda - \mu} - \frac{c}{r + \lambda} \right) \left(\frac{X}{\bar{X}(c)} \right)^{-\eta} \right) \frac{\rho}{X^{1+\rho}} dX \\ &= (\rho \bar{X}(c))^\rho \left(\frac{\bar{X}(c)}{(r + \lambda - \mu)(\rho - 1)} + \frac{c}{(r + \lambda)\rho} + \frac{\bar{X}(c)(r + \lambda) - c(r + \lambda - \mu)}{(r + \lambda - \mu)(r + \lambda)(\eta + \rho)} \right) \\ &= \left(\frac{\eta(r + \lambda - \mu)}{(1 + \eta)(r + \lambda)} \right)^{-\rho} \left(\frac{\eta}{(r + \lambda)(\rho - 1)(\eta + \rho)} \right) c^{-(\rho-1)}. \end{aligned}$$

Note that our assumption on the Pareto form $f(X)$ facilitates that computation of the integral above because both $V(X; c)$ and $f(X)$ are power functions. This integral represent the expected value of the firm to the shareholder after paying the fixed cost but before realizing the initial productivity of the firm. Since $\rho > 1$, it is monotonically increasing in c , and we can solve to get the expression for equilibrium compensation given in (11).

A.2 Derivation of stationary distribution

The ODE for $\phi(x)$ has the following general solution

$$\phi(x) = A_1 e^{\gamma_1 x} + A_2 e^{-\gamma_2 x} + A_3 e^{-\rho x} \tag{40}$$

where γ_1 and γ_2 are given by:

$$\gamma_1 = \frac{\mu - \frac{1}{2}\sigma^2 + \sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2\sigma^2\lambda}}{\sigma^2} \quad (41)$$

$$\gamma_2 = \frac{-(\mu - \frac{1}{2}\sigma^2) + \sqrt{(\mu - \frac{1}{2}\sigma^2)^2 + 2\sigma^2\lambda}}{\sigma^2} \quad (42)$$

First note that $\gamma_1 > 0$ implies $A_1 = 0$. To ease notation we drop the subscript on γ_2 . Next note that an application of the ODE gives

$$A_3 = -\frac{\rho\psi}{\frac{1}{2}\rho^2\sigma^2 + \rho(\mu - \frac{1}{2}\sigma^2) - \lambda}. \quad (43)$$

Finally, the boundary condition implies that

$$A_2e^{-\gamma\bar{x}} + A_3e^{-\rho\bar{x}} = 0$$

so

$$A_2 = -A_3e^{(\gamma-\rho)\bar{x}}. \quad (44)$$

The result in equation (15) directly follows from the above and an application of the market clearing condition for managers.

A.3 Derivation of Total and Average Capital Share of Profits.

We have

$$\begin{aligned} \Pi &= \frac{\int_{\bar{x}}^{\infty} (e^x - c)\phi(x)dx}{\int_{\bar{x}}^{\infty} e^x\phi(x)dx} = 1 - \frac{c \int_{\bar{x}}^{\infty} \phi(x)dx}{\int_{\bar{x}}^{\infty} e^x\phi(x)dx} \\ &= 1 - \frac{c}{\int_{\bar{x}}^{\infty} e^x\phi(x)dx} \end{aligned}$$

where the second step follows from the market clearing condition given in equation (14). To continue the calculation we have

$$\begin{aligned} \int_{\bar{x}}^{\infty} e^x \phi(x) dx &= \int_{\bar{x}}^{\infty} \frac{\rho\gamma}{\rho-\gamma} \left(e^{-(\gamma-1)x+\gamma\bar{x}} - e^{-(\rho-1)x+\rho\bar{x}} \right) dx \\ &= \bar{X} \left(\frac{\rho}{\rho-1} \right) \left(\frac{\gamma}{\gamma-1} \right) \\ &= \left(\frac{\rho}{\rho-1} \right) \left(\frac{\gamma}{\gamma-1} \right) \left(\frac{\eta}{\eta+1} \right) \left(\frac{r+\lambda-\mu}{r+\lambda} \right) c \end{aligned}$$

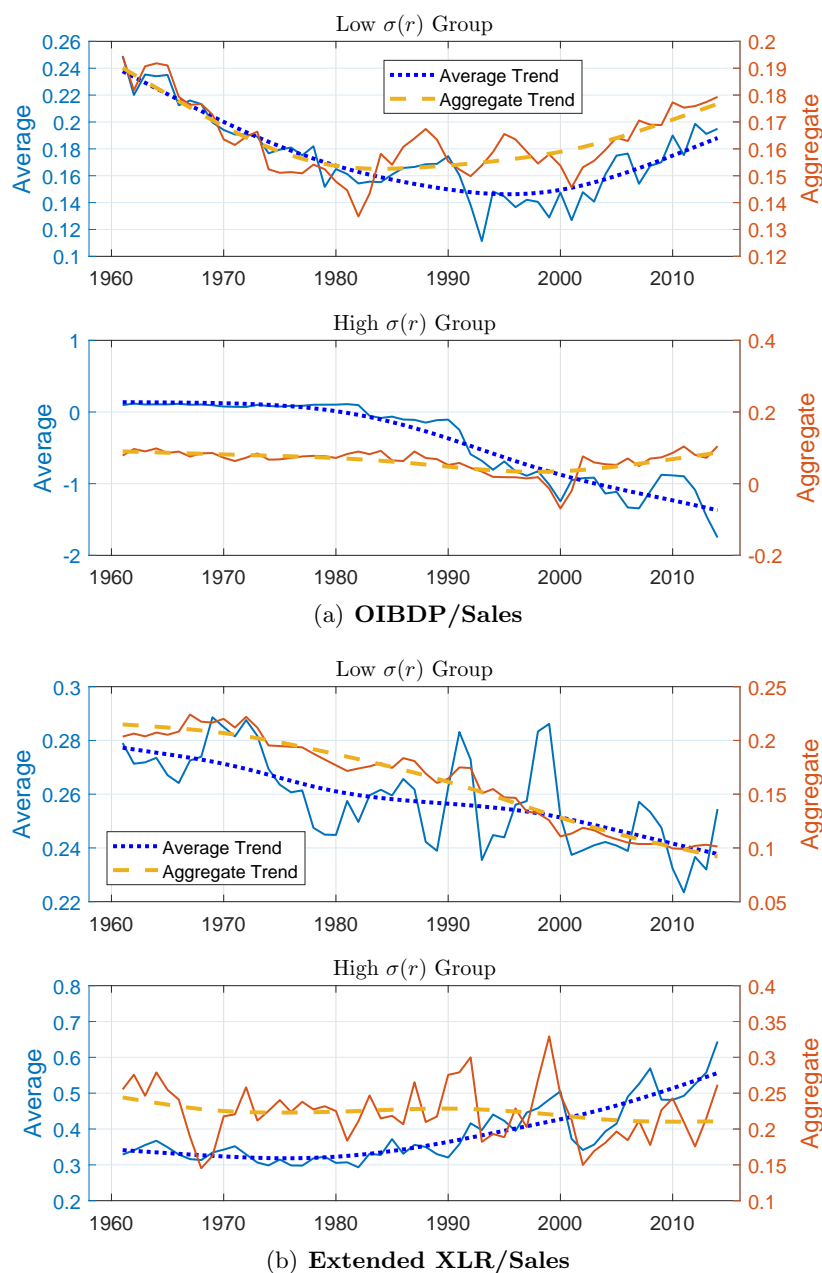
Substituting this expression into the expression for Π given above yields the desired result. The derivation of the average capital share is similar.

B Data Appendix

BLS Data: BEA develops employee compensation data as part of the national income accounts. These quarterly data include direct payments to labor, wage and salary accruals (including executive compensation), commissions, tips, bonuses, and payments in kind representing income to the recipients and supplements to these direct payments. Supplements consist of employer contributions to funds for social insurance, private pension and health and welfare plans, compensation for injuries, etc.

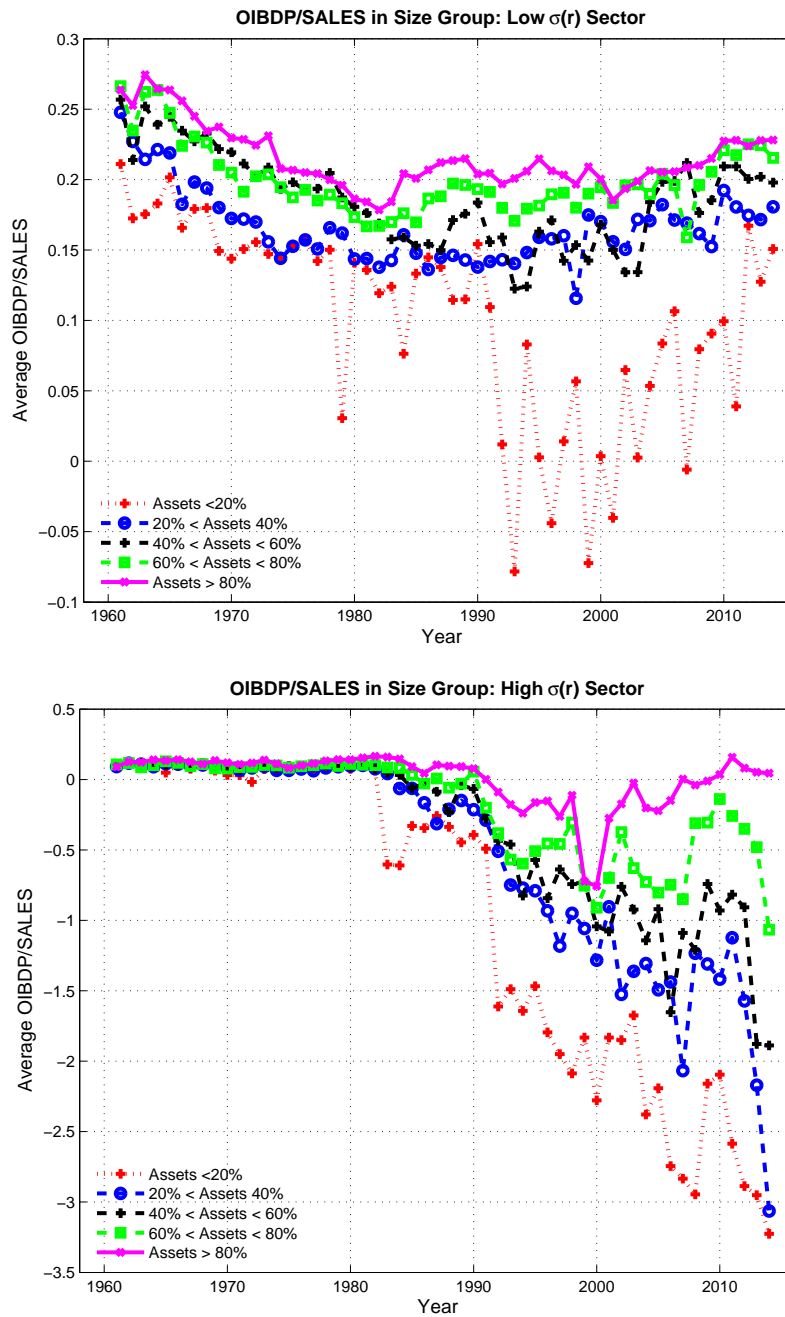
The compensation measures taken from establishment payrolls refer exclusively to wage and salary workers. Labor cost would be seriously understated by this measure of employee compensation alone in sectors such as farm and retail trade, where hours at work by proprietors represent a substantial portion of total labor input. BLS, therefore, imputes a compensation cost for labor services of proprietors and includes the hours of unpaid family workers in the hours of all employees engaged in a sector. Labor compensation per hour for proprietors is assumed to be the same as that of the average employee in that sector for measures found in the BLS news release, “Productivity and Costs”.

Figure 11. Average and Aggregate Factor Share of Output – Volatility Sectors



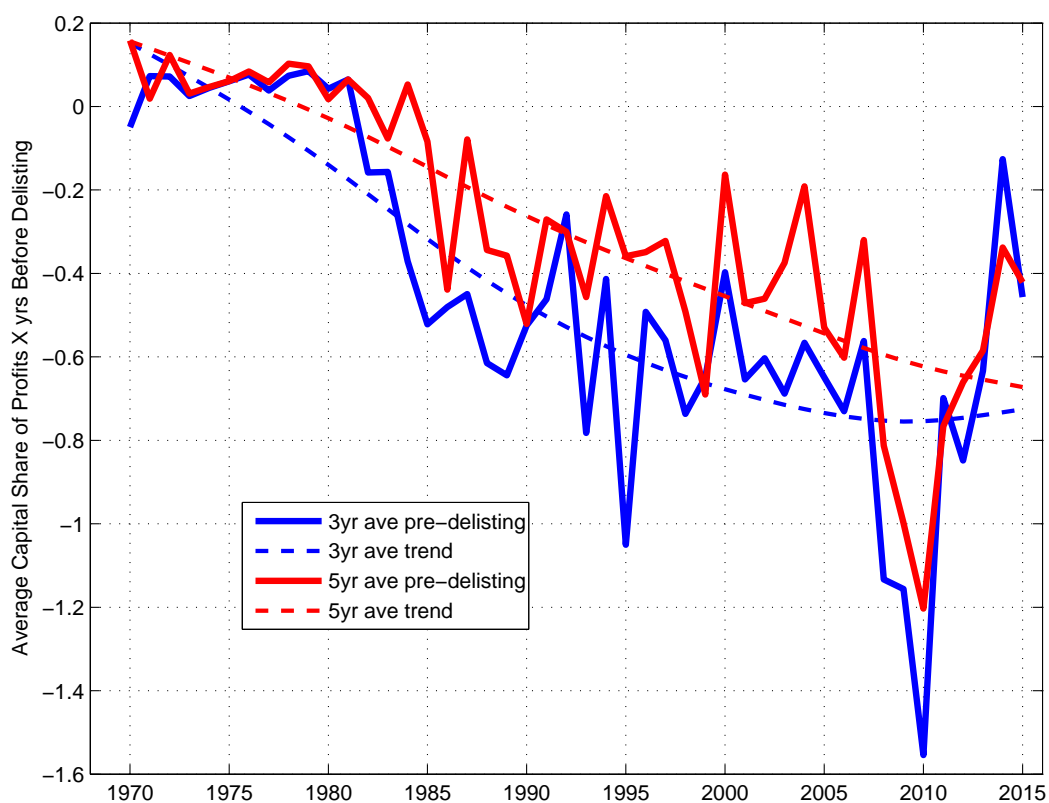
The plots present the time series of factor share of output for low and high volatility groups. Panel (a) shows the average and aggregate time series of operating income (OIBDP) to sales ratio. Panel (b) shows the average and aggregate time series of extended labor cost (XLR) to sales ratio. For both (a) and (b), we classify firms into three groups (low, median, high) based on the idiosyncratic return volatility. The plots show data moments of the lowest and highest volatility groups. Source: Compustat Fundamentals Annual (1960-2014).

Figure 12. Average Capital Share of Output – Volatility Sectors



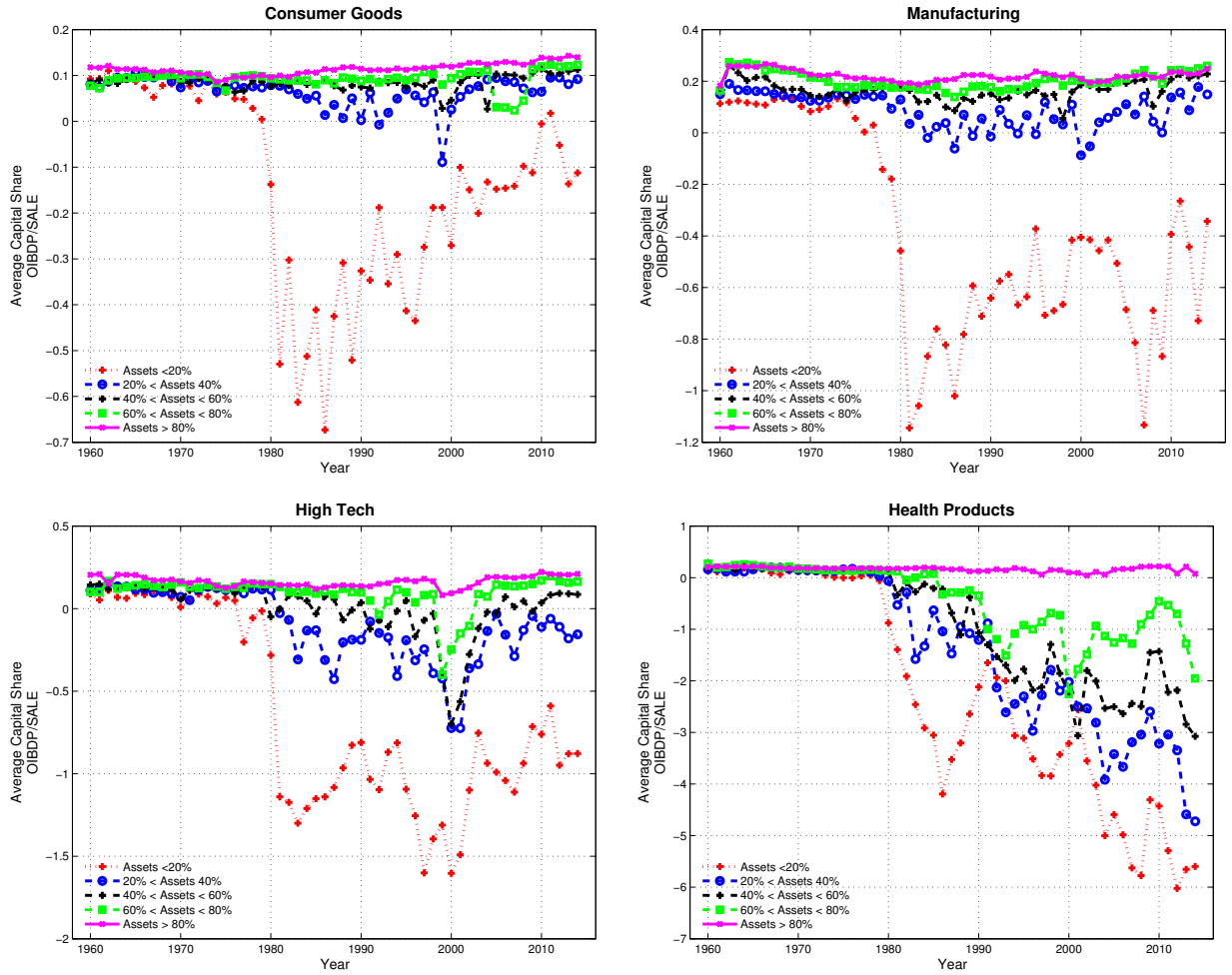
The plots present the average capital share of output within each size quintile for both high and low volatility sectors. Size is measured by total assets, and the capital share is measured as operating income (OIBDP) divided by sales (SALE). Source: Compustat Fundamentals Annual (1960-2014).

Figure 13. Exit Threshold: Average Capital Share x-years before Delisting



The plots present the average capital share of output 3-yr or 5-yr before delisting. We define firms' exiting the public firm domain by delisting code from 400 to 490 and from 550 to 591. The dashed line is the HP filtered trend. Source: Compustat Fundamentals Annual (1960-2014) and CRSP delisting code.

Figure 14. Average Capital Share of Output – Industries



We use revised Fama-French 5 industry classification. Within each industry, we sort firms into five groups based on their total assets. The plot shows the average capital share within each size group for four different industries. Source: Compustat Fundamentals Annual (1960-2014).