Why have payouts by US corporations increased so much?

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Abstract

US corporations have increased the fraction of value added that is paid out directly or indirectly to owners from 1.7% in the early 1970s to 9.4% in the early 2000s. We argue that this change reflects an increase in the fraction of rents from organizational capital flowing to the owners as a result of the IT revolution. The arrival of this general-purpose technology initiates a change in the nature of innovation, away from vintage-specific to general-purpose innovation. When a larger fraction of innovation arises from general purpose technologies, establishments live longer on average and accumulate more organizational capital. The resulting increase in *selection* among establishments increases the aggregate payouts from organizational capital to the owners. Selection benefits the managers of successful establishments and creates an increase in within-industry wage dispersion consistent with the data. The increase in payout rates is associated with an increase in the market value-to-output ratio in both model and data. Finally, the same relationships between payout rates, valuation ratios, and reallocation rates hold in the cross-section of firms.

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1 Introduction

Payouts by all US non-financial corporations to stock- and bondholders have increased from 1.7% of value-added in the early 1970s to 9.4% of value added in the early 200s. This 7.7% increase is illustrates in Figure 1. These payouts are the sum of dividend payments, interest payments, net equity repurchases and net debt repurchases (reductions in financial liabilities minus financial assets). Likewise, the value of these corporations is the value of all equity and debt minus financial assets. We interpret these changes in payouts as an increase in the rents from a third factor of production, which we call *organizational capital*, that flow to the owners of these corporations. We identify the IT revolution, which started in the early 1970s, as the impetus for an increased accumulation of organizational capital.

[Figure 1 about here.]

Organizations store and accumulate knowledge. Organizational capital is distinct from physical capital mainly because it is specific to the unit of production. We refer to these units as establishments. Part of this knowledge is embodied in the establishment's skilled or managerial workers, *managers* for short. In our model, an establishment is started by incurring a sunk cost and hiring a manager. Matches between the manager and owner of an establishment accumulate organizational capital. For the owners, this organizational capital is lost when the match with the manager is broken up. Managerial workers, however, can transfer part of the organizational capital to a new match.

Managers are offered a long-term contract by the owners that smooths their compensation over time. The contract induces them to stay in the match by matching her outside option whenever that is feasible. We solve an optimal dynamic contracting problem with symmetric information, but limited commitment. As a successful establishment accumulates more organizational capital and grows in size, the managers's *outside option* improves because of the partial portability of organizational capital. Her compensation increases in response to such good news about the establishment's productivity. Not so in small establishments, where low-powered incentives contracts prevail. Because of the sunk cost involved in setting up a new establishment, the manager's outside option is only a binding constraint in large establishments.

Production takes place using physical capital, unskilled labor, and organization capital as inputs. There are two sources of productivity growth. General productivity growth affects establishments from different vintages alike, while vintage-specific productivity growth only increased the productivity of the latest-vintage establishments. Because existing establishments have a free exit option, they will shut down when there is no more joint surplus for owner and manager. This occurs more frequently when vintage-specific growth is high. By its very nature, vintage-specific productivity growth depreciates the organizational capital of existing vintages. We model the IT revolution as a change in the nature of innovation. After 1971, productivity growth is increasingly driven by general productivity growth and decreasingly driven by vintagespecific growth. Along the transition path from a high towards a low vintage-specific growth steady state, the successful establishments accumulate more organizational capital, because their organizational capital depreciates at a slower rate. The owners collectively end up with a large share of the resulting organizational rents for two reasons. First, the typical cash-flow profile of an establishment is back-loaded: the sunk cost is paid up front and profits rise as the establishment grows. The owners are compensated for waiting; the more back-loading the higher the average payments. Second, there is selection. Only the productive establishments are continued. The IT revolution increases both the back-loading and the selection effect, thereby causing a large increase in the payouts to the owners.

During the transition to a new steady state, the model predicts a gradual shift from low-powered to *high-powered incentives* contracts. As the dispersion in the size and productivity distribution of establishments widens, there is increasing heterogeneity among establishments. Managers of successful (large) establishments face more tightly binding outside options. Owners resort to increasing managerial compensation as a retention tool. But selection only benefits the managers in successful establishments, not the others. So, the same economic mechanism that generates the increase in payouts, the IT revolution, also leads to a large increase in income inequality. High-powered incentive compensation contracts translate a modest increase in skewness and kurtosis in the size distribution into a large increase in the skewness and kurtosis of the managerial compensation.

The model's predictions are consistent with the data along several dimensions. First, we generate the 7.7% increase in the payout share to the owners of the corporate sector. Second, the model generates a shift to market-based incentive compensation packages, which have become much more prevalent over the last 30 years. The resulting increase in income inequality matches the observed increase in the standard deviation of log wages for non-production workers across establishments within an industry. Third, the cross-sectional relationship between the log compensation and the log size matches the empirical evidence. Fourth, the model generates a decrease in excess job reallocation consistent with the data. Fifth, it generates the observed decline in exit/entry rates of establishments. Sixth, the model generates an increase in the dispersion of the firm size distribution, also a feature of the data. Finally, the increase in selection among establishments gradually raises the market value all surviving establishments. In the data, the ratio of the market value of US non-financial corporations to the aggregate physical capital stock, Tobin's q, doubled over the last 35 years. The benchmark calibration of our model attributes about half of this increase to the selection effect. However, the model also suggests a potential upward bias in the Flow of Funds' measurement of Tobin's q. Finally, we provide some direct evidence for the effect of vintage-specific growth on payouts and valuation from a panel consisting of 55 industries. We find that a one-standard deviation decrease in the reallocation rate in an industry increases the payout ratio by 1.8 percentage points. This effect is larger in industries with more intangibles, suggestive of the importance of organizational capital. A decrease in reallocation also increases Tobin's q in the cross-section of industries. If the reallocation rate were just a measure of business volatility, Tobin's q would fall in response to a decrease in reallocation. This evidence is consistent with the view that there is less vintage-specific growth and more selection in low-reallocation industries. This rises payouts and valuations, as predicted by the model. These effects are stronger in industries with lots of intangible assets.

Related Literature In the absence of permanent monopoly profits, the value of the firm's securities measures the value of its capital. Hall (2001) measures the intangible capital stock as the difference between the total value of US corporations and the value of the physical capital stock. By this measure, US corporations have accumulated large amounts of intangible capital over the last decades. Our model predicts that establishments accumulate a lot more organizational capital during this period as a result of the IT revolution. The model can account for 40% of the run-up in firm valuations over the last 2 decades. Thus our model provides an underpinning for the reemerging view that cash flows play a larger role in explaining variations in the value of firms than previously thought. Recently, Larrain and Yogo (2007) and Bansal and Yaron (2006) found more evidence of cash flow predictability in similarly broad payout measures. The cash flow process in our paper is determined endogenously by technological change and market forces.

In related work on technological change and stock market valuation, Greenwood and Jovanovic (1999) and Hobijn and Jovanovic (2001) argue that the IT revolution can account for the drop in the value of the capital stock in 1973, and the rise of the stock market in the 1980s. Pastor and Veronesi (2005) develop a general equilibrium model in which agents learn about the profitability of new technologies that come online. Stock prices of new technologies that are characterized by high uncertainty about their profitability, display bubble-like behavior.

In a vintage model like ours, there are two sources of technological progress: general-purpose productivity growth that affects all vintages and vintage-specific productivity growth that only increases the productivity of the newest vintage. Since it is not possible to break down total productivity growth along a steady-state growth path (Atkeson and Kehoe (2005)), our focus is on transitions between steady-states. Hobijn and Jovanovic (2001), and Jovanovic and Rousseau (2003) identify the invention of the Intel 4004 micro-processor in 1971 as the start of the IT revolution. This invention coincides with the start of a gradual increase in spending on IT and a drop in the relative price of IT spending. Information technology is a General Purpose Technology (GPT, Bresnahan and Trachtenberg (1996)). We think of IT as a GPT that increase the productivity of all establishments, regardless of their vintage. Correspondingly, we interpret the IT revolution as a shift in the composition of productivity growth towards general productivity growth.¹ The exact shift is calibrated in order to replicate the secular decline in the volatility of firm growth rates and job reallocation rates in all sectors of the US economy since the early 1970s, as documented by Davis, Haltiwanger, Jarmin and Miranda (2006) and Faberman (2006). As the depreciation rate of organizational capital declines, the rate at which labor is reallocated from old to new vintages declines. An additional implication of modeling IT this way is that an increasing fraction of output is produced in older establishments. This is consistent with the evidence in Davis et al. (2006).

A large literature documents the increase of wage inequality in the US in the last three decades and its relation to technological change (e.g., Violante (2002), Guvenen and Kuruscu (2007), and Acemoglu (2002) for a survey). Our paper contributes to this literature by (i) generating an endogenous switch to high-powered incentives contracts and by (ii) connecting the changing distribution of payouts to workers to the payouts to the owners of the capital stock, and ultimately to firm value. This link is usually ignored in the literature. One exception is the work by Merz and Yahsiv (2003).

In our model, managerial compensation is governed by a long-term contract that insures the manager against firm-specific shocks. There is scope for insurance when at least some of the organizational capital is match-specific. See Neal (1995) for some empirical evidence on the importance of match-specific capital. The optimal dynamic compensation contract induces these managers to remain at the firm as long as continuation of the match is beneficial, as described in Thomas and Worall (1988). However, in our model, the manager's outside option is determined endogenously, as in recent work Krueger and Uhlig (2005) and Lustig (2007). The manager can transfer to a new establishment, at the cost of losing part of the knowledge he accumulated in the old match.

Many of the features of these optimal contracts have been analyzed elsewhere, but we are the first to argue these contracts play a key role in understanding the value of the firm, its crosssectional distribution, and how that distribution evolved over time. The wage dynamics are similar to those in Harris and Holmstrom (1982)'s seminal paper, which focusses on a dynamic moral hard problem instead. In our optimal contract, the manager's compensation never goes down. When the manager and the owner have the same time discount rate, wages stays constant, except when the manager's outside option increases. The manager's compensation increases in response to an increase the firm's productivity, because this increases the manager's outside option. This effect is only present in large establishments. In small establishments, the manager's compensation does not respond to increased productivity because of the sunk costs. The change in the size distribution generates a regime shift from *low-powered* to *high-powered* incentives in compensation contracts. In the US, the adoption of high-powered incentives contracts started in the 80's. Holmstrom and Kaplan (2001) link this rise in stock-based compensation to the wave of LBO's. Berk, Stanton and

 $^{^{1}}$ Atkeson and Kehoe (2007) model electrification as a sudden and permanent increase in vintage-specific growth, holding constant general productivity growth.

Zechner (2005) use the Harris and Holmstrom (1982) model to study the optimal capital structure of firms and explain the prevalence of debt.

Our model predicts a sizeable increase in within-industry between-establishment wage dispersion for skilled workers. This is consistent with the data (Dunne, Foster, Haltiwanger and Troske (2004)). At the top end of the compensation scale, the dispersion of executive compensation has increased even more in the last decades (Frydman and Saks (2006)). Gabaix and Landier (2007) relate this increase in to the changing size distribution of firms. In their model, more talented executives are matched to larger firms. The observed change in the firm size distribution can generate the observed change in the distribution of CEO compensation. The optimal compensation contracts which are embedded in our equilibrium model of organizational capital accumulation sheds further light on that relationship between log size and log compensation.

Our paper is organized as follows. In section 2, we establish that corporate payout rates have increased dramatically starting in the late seventies. We compute corporate payouts (i) directly using Flow of Funds data and indirectly by (ii) using national income accounts data and by (iii) aggregating from the firm-level using Compustat data. All three payout measures indicate that the share of value added paid out to owners has increases by about 8 percentage points over the last three decades. We also document the rise in the valuation of these firms relative to their replacement costs. In section (3), we set up the model and describe the transition experiment. Section (4) lists the target moments in the data we used to calibrate the model, and section (5) shows the results of the transition experiment. Finally the last section provides cross-sectional evidence for the effect of vintage-specific growth on payouts and valuations.

2 Aggregate Corporate Payouts and Valuation

Our paper studies the aggregate corporate (non-farm, non-financial) sector in the US. Corporations own the aggregate physical capital stock K_t . In our model, these corporations issue shares, which are claims to the physical capital stock. The model abstracts from bond issuance because the decomposition of total corporate liabilities in equity and debt is irrelevant. In the data, corporations issue both equity and debt, and they may purchase financial assets. The value of corporations is the sum of the value of all securities issued by these corporations **less** the value of financial assets. We use $V_t^a = p_t s_t$ to denote the value of a claim to the aggregate US capital stock at time t; p_t equals the price (per share) of a claim to the US capital stock and s_t the number of shares.

The payouts D_t to the owners come in two forms: cash (denoted D_t^c) and non-cash (D_t^{nc}) .

$$D_t = D_t^c + D_t^{nc} = \underbrace{Div_t + Int_t}_{cash} + \underbrace{p_t(s_{t-1} - s_t)}_{non-cash}$$

Cash payments include dividend payments to equity holders (Div_t) and interest payments to bond holders and other lenders (Int_t) . The non-cash payments measure *net* repurchases of shares s_t at a price p_t . This includes net equity repurchases and net debt repurchases. Net equity repurchases are defined as total equity repurchases less issuance of new equity. Net debt repurchases are defined as the change in financial assets less the change in financial liabilities.

The value of the US corporate sector is the present discounted value of total payouts D_{t+j} :

$$V_t^a = E_t \sum_{j=0}^{\infty} e^{-\sum_{s=t}^j r_s} D_{t+j},$$

where r_t is the discount rate. The composition of payouts into cash or non-cash components is irrelevant for the value of the firm.

The stand-in corporation's flow budget constraint links the corporate cash flows to its payouts. Let Y_t denote value-added in the corporate sector. The stand-in US corporation at time 0 maximizes its value V_0^a by choosing gross investment in physical capital $I_t = K_{t+1} - (1 - \delta)K_t$ and it decides how much labor to hire subject to the flow budget constraint for all $t \ge 0$:

$$D_t = Y_t - Comp_t - I_t - T_t, \tag{1}$$

where Y_t is gross value added, $Comp_t$ denotes the total compensation of unskilled and managerial (or skilled) labor, and T_t denotes corporate taxes.

To give an example of how this flow budget constraint works, suppose that the US corporate sector has more internal funds than it invests in a given year t: $Y_t - Comp_t - T_t - D_t^c > I_t$. Suppose also that it invests this surplus in the money market. Then its financial assets on the balance sheet increase, this shows up as a net repurchase (net reduction in net financial liabilities), and hence a non-cash payout to securities holders: $p_t(s_{t-1} - s_t) = D_t^{nc} = Y_t - Comp_t - T_t - D_t^c - I_t > 0$.

We use three different approaches to measure the corporate payout rate. The first one is to measure the payouts directly in the Federal Flow of Funds (Section 2.1). The second approach uses the corporate flow budget constraint to back out the corporate payouts from national income accounts (Section 2.2). The last measure is based on firm-level data from Compustat (Section 2.3).

2.1 Measuring Corporate Payouts in the Flow of Funds

The data to construct our measure of firm value were obtained from the Federal Flow of Funds' flow tables for the non-farm, non-financial corporate sector.² The aggregate value of the corporate sector V_t^a is measured as the market value of equity plus the market value of all financial liabilities minus the market value of financial assets. We correct for changes in the market value of outstanding

²at http://www.federalreserve.gov/ RELEASES/z1/current/data.htm

bonds by applying the Dow Jones Corporate Bond Index to the level of outstanding corporate bonds (which are valued at book values) at the end of the previous year.

The payouts D_t are measured as the sum of dividend payments and interest payments, plus net equity repurchases plus the increase in financial assets less the increase in financial liabilities. We use the Flow of Funds (Table F102) for dividends, equity repurchases and the increase in net financial liabilities. The series for the interest paid on the debt is obtained from the NIPA Table on Gross Value Added of Domestic Non-financial Corporate Business (Table 1.14, line 25). The same NIPA table is used to obtain gross value-added (line 17). The net payout share (NPS) is the sum of net payouts to securities holders divided by gross value-added:

$$NPS_t = \frac{D_t}{Y_t}$$

Appendix A.1 contains a detailed description of the data construction. Larrain and Yogo (2007) use a similar measure of payouts for the non-financial corporate sector.

Column (1) of Table 1 shows five-year averages for the NPS from these Flow of Funds data. After an initial decline from the second half of the 1960s to the first half of the 1970s, the NPS increases virtually without interruption from 1.7% to 9.4% of value-added over the next three decades, an increase of 7.7 percentage points. Figure 1 plots the quarterly time series for the NPS (dashed line). This series is volatile and has a seasonal component. The full line shows the 8-quarter moving averages. At the start of the 80's, the net payout share starts a steep and virtually uninterrupted increase.

[Table 1 about here.]

Decomposing the Payout Share Table 2 decomposes the payout share into a dividend yield component (Column 1), an interest component (Column 2), a net debt repurchase component (Column 3), and a net equity repurchase component (Column 4). Over the 1965-2004 period, cash payments increased from 5.5% to 8% of value-added, while the non-cash net payout share increased from -3.3% to 1.2%. The cash component accounts for most of the increase in the first half of the sample, while the non-cash component accounts for the bulk of the change in the last twenty years. Until the 1985-89 period, US corporations were issuing debt, and to a lesser extent equity, at a high rate. Afterwards, they started to buy back equity, and to a lesser extent debt, instead. At the end of the sample the composition of the non-cash component changes. Between 2005.I and 2007.I, US corporations issued debt to the tune of 5.8% of value-added, and used this debt to buy back 7.3% of value-added in equity, presumably because of the low cost of debt. Indeed, Fama and French (2001), Grullon and Michaely (2002), Brav, Graham, Harvey and Michaely (2005), and others have argued that equity repurchases have substituted for dividend payments over the

last 20 years.³ There are many reasons, including taxes and flexibility, why firms may prefer to substitute dividends for interests or cash for non-cash payments. Berk et al. (2005) investigates the optimal capital structure problem in an optimal contracting model similar to ours. Our goal is to account for the increase in overall payouts, rather than for its components.

[Table 2 about here.]

2.2 Measuring Corporate Payouts in the National Income Accounts

Instead of using the Flow of Funds data to get a direct measure of payouts, we can also infer corporate payouts indirectly from the National Income and Product Accounts (NIPA) data. Using the corporate flow budget constraint, total corporate payouts can be measured as gross value-added for non-financial corporate business minus compensation of employees minus corporate taxes minus investment:

$$D_t = Y_t - Comp_t - T_t - I_t.$$

Appendix A.2 contains the details. To make the NIPA payouts comparable to the Flow of Funds payouts, we add foreign earnings retained abroad and net capital transfers (both from the Flow of Funds) to the NIPA payouts. The reason is that the FoF series contains these foreign payouts, whereas the NIPA measure does not. Whether earnings are retained abroad or at home does not matter for investors in US corporations. By dividing the adjusted payouts by value-added, we create the net payout share from NIPA data. The same appendix also shows how to decompose payouts into a cash and a non-cash component based on NIPA data.

Column 2 in table 1 lists the five-year average NPS using the NIPA measure. We obtain a similar pattern as in Column 1: After an initial decrease from 3.7% in the last part of the 60's to 2% in the first part of the seventies, the NPS climbs to 7.6% in 2000-2004. The total increase between 1970-74 and 2000-2004 is about 5.6 percentage points. Figure 2 offers a direct comparison of the (8-quarter moving averages of the) NPS series obtained from NIPA data (dashed line) and from the FoF (solid line). The figure shows that both measures display the same pattern in corporate payouts over the last 40 years.

[Figure 2 about here.]

Gross Payout Share We also compute the gross payout share share (GPS) of the non-financial corporate sector. The numerator adds the consumption of fixed capital δK_t to the payouts D_t :

$$GPS_t = \frac{(D_t + \delta K_t)}{Y_t} = \frac{Y_t - Comp_t - T_t - (I_t - \delta K_t)}{Y_t}.$$

 $^{^{3}}$ Boudoukh, Michaely, Richardson and Roberts (2004) investigate the importance of total equity payout yields for stock return predictability.

Columns 3 and 4 of Table 1 show that, after an initial decrease, the GPS increases from 11.5% in 1970-74 to 22.3% in 2000-04 with FoF data. With NIPA data, the increase is from 11.8% to 20.5%. The reason for computing the gross payout share is that it relates closely to the capital share.

Capital Share In modern macroeconomics, the capital share is commonly assumed to be constant. This is not inconsistent with a large increase in the payout share. We define the capital share

$$CS = \frac{Y_t - Comp_t}{Y_t} = \frac{T_t}{Y_t} + \frac{I_t - \delta K_t}{Y_t} + GPS.$$

The second equality shows that the capital share can be decomposed as the share of taxes plus the share of net investment plus the gross payout share. The first column of Table 3 confirms that the capital share is pretty much constant at 33% between 1970-74 and 2000-04. However, the composition of the capital share shifts dramatically. The 3.2% decline in the share of taxes (Column 2) and the 4.4% decline in the net investment share (Column 3) are offset by a 7.6% increase in the gross payout share (Column 4) so as to keep the capital share constant.

[Table 3 about here.]

2.3 Measuring Corporate Payouts in Compustat

As a third measure, we used Compustat's data and aggregate firm-level payouts to compute aggregate payouts. Since we do not have value-added data for the firms in Compustat, we define a net payout ratio *NPR* as:

$$NPR_t = \frac{D_t}{Comp_t + D_t}$$

Appendix A.3 contains the details on measurement. In Columns (2) and (4) of Table 4 we use Compustat information on labor and retirement expenses to form $Comp_t$. Since this information is missing for many firms, we alternatively compute $Comp_t$ as the product of the number of employees from Compustat (which is available for most firms) and the average wage per job from the Bureau of Labor Statistics in the industry the firm operates in. The corresponding NPR measures start in 1976 and are reported in Columns (3) and (5). Columns (2) and (3) are NPR measures that include net debt repurchases, while Columns (4) and (5) exclude them. The latter measures are useful because the net debt repurchase series from Compustat are highly volatile.

All four series in Columns (2)-(5) show a 5-7% increase in the NPR between 1975-79 and 2000-04. This is somewhat smaller than the 10.8% increase in the NPR rate in the Flow of Funds data, which is reported in Column (1) for comparison. However, the increase is still substantial. The Compustat NPR measures are much higher than the NPR from the FoF. In the Compustat data, we cannot **net out** payments among firms in the non-financial corporate sector. In addition, Compustat only covers large firms. Finally, we do not have data on IPOs, which should be counted as new issuance of equities in total payouts. The Flow of Funds data does take all these issues into account. However, the secular change we documented in NIPA and FoF data also arises in the Compustat data.

[Table 4 about here.]

2.4 Valuation

The increase in the payouts to securities holders over the last 30 years coincided with a doubling of Tobin's q and the value-output ratio. Tobin's q is measured as the market value of US non-financial corporations, constructed from the Flow of Funds data divided by the replacement cost of physical capital:

$$q_t = \frac{V_t^a}{K_t}.$$

We construct the replacement cost of physical capital using the perpetual inventory method with FoF investment and inventory data (see Appendix A.1). The first column in Table 5 shows that Tobin's q decreased from 2.0 in the 1965-1969 period to 1.0 in the 1975-1979 period. After that, it gradually increases to 2.6 in the 1995-1999 period and then it levels off to 2.3 and 2.0. The value-output ratio for the US corporate sector, reported in Column 2, is computed as the ratio of V_t^a to gross value-added Y_t . It tracks the evolution of Tobin's q almost perfectly. The third column reports the ratio of net payouts to the value of the corporate sector, D/V^a ; its is the net payout yield of the (non-financial) corporate sector.

The table shows that the value of US corporations per unit of physical capital has more than doubled since the late seventies. As a result, the measured increase in payouts to the owners of US corporations over the same period (third column) cannot be explained as merely compensation for physical capital. Rather the increase in valuations seems to be linked to the increase in payouts due to the accumulation of organizational capital rather than physical capital.⁴

[Table 5 about here.]

2.5 Manufacturing

Finally, we checked our findings by recomputing payout shares and valuation ratios for the US manufacturing sector. Much of the literature on the size distribution of establishments focusses on

⁴Likewise, the increase in Tobin's q cannot be explained solely by a decrease in taxes. Indeed, in a model without organizational capital and no adjustment costs, Tobin's q is always one. In a world with reasonable adjustment costs, a decrease in taxes could increase Tobin's q above one, but only temporarily. Finally, the large deviations of Tobin's q from one occur in the second half of the sample when the average tax rate is slightly *increasing* (see Table 3).

manufacturing. The first column of Table 6) shows that the NPR increases from 6.5% in the late seventies to 15.7% in 2000, an increase of 9.2 percentage points. Over the same period, Tobin's q for the manufacturing sector more than doubles from .74 to 1.74 (Column 2). These trends are similar to the entire non-financial corporate sector.

[Table 6 about here.]

3 Model

In this section, we set up a model with a fixed population (mass 1) of skilled or managerial workers.⁵ Each manager is matched to the (representative) owner to form an *establishment*. The formation of a new establishment incurs a one-time fixed cost S_t . Establishments accumulate knowledge as long as the match lasts. We refer to this stock of knowledge as organizational capital A_t . This organizational capital affects the technology of production; it is a third factor of production besides physical capital and unskilled labor, earning organizational rents. What is different from Atkeson and Kehoe (2005) is that part of the establishment's organizational capital is embodied in the manager. Therefore, the division of organizational rents between the owner and the manager is new. This division is governed by an optimal risk-sharing contract, in the spirit of Harris and Holmstrom (1982), Thomas and Worall (1988), and Krueger and Uhlig (2005). The optimal contract maximizes the organizational rents flowing to the owner subject to the manager's promise keeping constraint and a sequence of participation constraints that reflect the manager's inability to commit to stay in the current match. The owner has a free exit option so that separation occurs whenever there is no joint surplus anymore. Upon separation, part of the organizational capital is destroyed while the remainder can be transferred to the manager's next match. The value of all corporations is the value of the physical capital stock plus the value of a claim to the part of organizational rents that accrue to the owners.

In Section 3.7, we trace out the *transition* between two steady-state growth paths: on the "old" steady-state growth path, most of the growth is vintage-specific, while on the "new" steady-state growth path, most of the productivity growth is general instead. A key insight will be that vintage-specific growth effectively depreciates the organizational capital of existing establishments. Thus, the arrival of the GPT reduces the depreciation rate of their organizational capital.

3.1 Technology

On the technology side, our model follow Atkeson and Kehoe (2005). Each establishment operates a vintage-specific technology that uses unskilled labor l_t , physical capital k_t , and organizational

⁵Even though we refer to these managerial workers as "managers", we emphasize that we are not only thinking of the CEO, but rather of skilled workers broadly defined.

capital as its inputs. Gross value-added or output generated with this technology is y:

$$y_t = z_t (A_t)^{1-\nu} F(k_t, l_t)^{\nu}.$$

Following Lucas (1978), ν is the 'span of control' parameter of the manager. This parameter governs the decreasing returns to scale at the establishment level.

The general productivity level z_t grows at a deterministic and constant rate g_z :

$$z_t = (1+g_z)z_{t-1}.$$

As is clear from the production function, general-purpose productivity growth affects all establishments alike. In addition, it affects all three production inputs symmetrically, so it is *skill-neutral*.

Each establishment belongs to a vintage s. An establishment of vintage s at time t was born at t-s. Following Hopenhayn and Rogerson (1993), the match-specific level of organizational capital follows an exogenous process. It is hit by random shocks ε_s , drawn from a vintage s-specific distribution Γ_s :

$$\log A_{t+1} = \log A_t + \log \varepsilon_{t+1,s}, \ge 0, \tag{2}$$

We do not explicitly model the learning process that underlies the accumulation process of organizational knowledge.⁶

A new establishment can always start with a *blueprint* or *frontier* technology level θ_t : $A_{t,t} \ge \theta_t$. The productivity level of the blue print grows at a deterministic and constant rate g_{θ}

$$\theta_t = \theta_{t-1}(1+g_\theta).$$

This vintage-specific growth is often referred to as *embodied* technical change. Likewise, general productivity growth is referred to as *disembodied* technical change.

⁶However, the ε shocks are a reduced-form for productivity gains derived from active or passive learning, from matching, or from adoption of new technologies in existing firms (Atkeson and Kehoe (2005)). Additionally, they can be interpreted as reduced-form for heterogeneity across managers, for the outcomes from good or bad decisions made by the manager. Jovanovic and Nyarko (1982) explicitly model learning-by-doing. Bertrand and Schoar (2003) and Bennedsen, Prez-Gonzlez and Wolfenzon (2007) show that heterogeneity across managers leads to heterogeneity in firm outcomes.

3.2 Contract Between Owner and Manager

Owner There is a representative owner of all establishments, who is perfectly diversified. He maximizes the present discounted value of aggregate payouts D_t :

$$E_0 \sum_{t=0}^{\infty} e^{-\sum_{s=0}^{t} r_s} D_t.$$
 (3)

The owner has a residual claim to the aggregate stream of cash flows that are not claimed by the other factors:

$$\Pi_t = Y_t - W_t L_t - R_t K_t - C_t - N_t S_t, \tag{4}$$

where $W_t L_t$ is the aggregate compensation of unskilled labor, $R_t K_t$ that of physical capital, C_t the aggregate compensation of all the managers of the establishments, and $N_t S_t$ the total sunk costs incurred for starting N_t new establishments. In other words, Π_t is the sum of all rents from organizational capital accruing to the owners. To facilitate comparison with the data, we assume that the owner also owns the physical capital stock. We can think of R_t as a *shadow* rental rate of physical capital. This assumption is without loss of generality. This implies that the aggregate payouts to the owners of the capital stock, D_t , equal:

$$D_t = \Pi_t + R_t K_t - I_t, \ \forall t.$$

Manager The owner offers the manager a non-renegotiable, complete-contingent contract $\{c_t(h^t), \beta_t(h^t)\}$ at the start of the match, where $\{c_t(h^t)\}$ is the compensation of the manager as a function of the history of shocks h^t and $\{\beta_t(h^t)\}$ governs when the match is dissolved. The manager is risk averse with CRRA parameter γ and time discount factor ρ_m .

The optimal contract is the contract that maximizes the total expected payoff of the owner subject to delivering initial utility v_0 to the manager:

$$v_0(h^0) = E_{h^0} \left[\sum_{\tau=0}^{\infty} e^{-\rho_m t} \frac{c_{\tau}(h^{\tau})^{1-\gamma}}{1-\gamma} \right]$$

In general, the history-dependence of the manager's compensation makes this a complicated problem. However, as is commonly done in the literature on recursive contracts, we use the manager's promised utility as a state variable to make the problem recursive. The contract delivers v_t in total expected utility to the manager today by delivering current consumption c_t and state-contingent consumption promises v_{t+1} tomorrow.

We use $V_t(A_t, v_t; s)$ to denote the value of the owner's equity in an establishment of vintage s with current organizational capital A_t , and an outstanding promise to deliver v_t to the manager.

It is the value of the owner's claim to the rents from organizational capital, i.e., net of physical capital. The function $V_t(A_t, \cdot; s)$ is defined on a domain $[\underline{v}, \overline{v}]$.

Finally, we use $\omega_t(A_t)$ to denote the outside option of a manager currently employed in an establishment with organizational capital A_t . When a manager switches to a new match, a fraction ϕ of the organizational capital is transferable to the next match and a fraction $1 - \phi$ is destroyed. Free disposal applies: If the manager brings organizational capital worth less than the current blue print, then the new match simply starts off with the blue print technology for the new vintage: $A_t = \theta_t$. The value of the outside option is determined in equilibrium by a zero-profit condition for new entrants. The outside option of the manager only depends on the amount of organizational capital accumulated in the preceding match as long as not all of it is destroyed upon termination of the match.

Recursive Formulation For given outside options $\{\omega_t\}$ and discount rates $\{r_t\}$, the optimal contract in an establishment of vintage s that has promised v_t to its manager maximizes the owner's value V

$$V_t(A_t, v_t; s) = \max\left[\widehat{V}_t(A_t, v_t; s), 0\right],$$
(5)

and

$$\widehat{V}_{t}(A_{t}, v_{t}; s) = \max_{c_{t}, v_{t+1}(\cdot)} \left[\begin{array}{c} y_{t} - W_{t}l_{t} - R_{t}k_{t} - c_{t} \\ \int e^{-r_{t}} V(A_{t+1}, v_{t+1}; s+1)\Gamma_{s+1}(\varepsilon_{t+1;s+1}) d\varepsilon_{t+1;s+1} \end{array} \right],$$
(6)

by choosing the state-contingent promised utility schedule $v_{t+1}(\cdot)$ and the current compensation c_t , subject to the law of motion for organizational capital (2), a promise keeping constraint

$$v_{t} = u(c_{t}) + e^{-\rho_{m}} \int \beta_{t+1;s+1}(v_{t}, \varepsilon_{t+1;s+1}) v_{t+1}(A_{t+1}) \Gamma_{s+1}(\varepsilon_{t+1;s+1}) d\varepsilon_{t+1;s+1} + e^{-\rho_{m}} \int \omega_{t+1}(A_{t+1}) (1 - \beta_{t+1;s+1}(v_{t}, \varepsilon_{t+1;s+1})) \Gamma_{s+1}(\varepsilon_{t+1}; s+1) d\varepsilon_{t+1;s+1}$$
(7)

and a series of participation constraints

$$v_{t+1}(A_{t+1}) \ge \omega_{t+1}(A_{t+1}). \tag{8}$$

The indicator variable β is one if continuation is optimal and 0 elsewhere:

$$\beta_{t+1;s+1} = 1 \text{ if } v_{t+1}(A_{t+1}) \le v^*(A_{t+1};s+1)$$

$$\beta_{t+1;s+1} = 0 \text{ elsewhere.}$$

The minimum value of zero on V in equation (5) reflects that the match will be terminated if the joint surplus is negative. If the match is dissolved, the manager receives $\omega_{t+1}(A_{t+1})$ in promised utility. In this recursive formulation, we have exploited the fact that $V_t(A_t, \cdot; s)$ is nonincreasing in its second argument. For each A_t , there exists a cutoff value $v^*(A_t; s)$ that satisfies $\widehat{V}_t(A_t, v^*(A_t; s); s) = 0$. The match is dissolved when the promised utility exceeds the cutoff level: $\beta_{t+1;s+1} = 0$ if and only if $v_{t+1}(A_{t+1}) > v^*(A_{t+1}; s+1)$.

3.3 Equilibrium

A competitive equilibrium is a price vector $\{W_t, R_t, r_t\}$, an allocation vector $\{k_t, l_t, c_t, \beta_t\}$, an outside option process $\{\omega_t\}$, and a sequence of distributions $\{\Psi_{t,s}, \lambda_{t,s}, N_t\}$ that satisfy optimality and market clearing conditions spelled out below.

Physical Capital and Unskilled Labor Unskilled labor l and physical capital k can be reallocated freely across different establishments. Hence, the problem of how much l and k to rent at factor prices W and R, is entirely static. We use K_t and L_t to denote the aggregate quantities, and we use \overline{A}_t to denote the average stock of organizational capital across all establishments and vintages:

$$\overline{A}_t = \sum_{s=0}^{\infty} \int_A A\Phi_{t,s} dA,$$

where $\Phi_{t,s}$ denotes the measure over organizational capital at the start of period t for vintage s. Physical capital and unskilled labor are allocated in proportion to the establishment's productivity level A_t :

$$k_t(A_t) = \frac{A_t}{\overline{A}_t} K_t$$
$$l_t(A_t) = \frac{A_t}{\overline{A}_t} L_t.$$

This allocation satisfies the first order conditions, and the market clearing conditions for capital and labor. The equilibrium wage rate W_t for unskilled labor and rental rate for physical capital R_t are determined by the standard first order conditions:

$$W_t = \nu \overline{A}_t^{1-\nu} F_L(K_t, L_t)^{\nu-1}, \quad R_t = \nu \overline{A}_t^{1-\nu} F_K(K_t, L_t)^{\nu-1}$$

The factor payments to unskilled labor and physical capital absorb a fraction $(1 - \nu)$ of aggregate output Y_t , where Y_t is given by:

$$Y_t = z_t \overline{A}_t^{1-\nu} F(K_t, L_t)^{\nu}.$$

Discount Rate The payoffs are priced off the inter-temporal marginal rate of substitution of the representative owner. Just like the manager, the owner has constant relative risk aversion

preferences with CRRA parameter γ . His subjective time discount factor is ρ_o . Let g_t denote the rate of change in log D_t . Then, the equilibrium discount rate or "cost of capital" r_t is given by:⁷

$$r_t = \rho_o + \gamma g_t \tag{9}$$

Managerial Compensation Once we have solved for the value function $\{V_t(\cdot, \cdot; s)\}$ that satisfies the Bellman equation above for given $\{\omega_t(\cdot), r_t\}$, we can construct the optimal contract for a new match starting at $t \{c_{t+j}(h^{t+j}), \beta_{t+j}(h^{t+j})\}$ in sequential form.

A fraction ν_t of aggregate output Y_t goes to organizational capital. These organizational rents are split between the owners Π_t , managers C_t , and sunk costs $N_t S_t$:

$$\sum_{s=0}^{\infty} \int_{v} \int_{A} \pi_{t}(A, v; s) \Psi_{t,s}(A, v) d(A, v) - N_{t}S_{t} = Y_{t} - W_{t}L_{t} - R_{t}K_{t} - C_{t} - N_{t}S_{t} = \Pi_{t},$$

where the second equality follows from (4). This ensures that the goods market clears.

Outside Option Starting up a new establishment incurs a sunk cost S_t . The manager in a new establishment brings a fraction ϕ of organizational capital A to a new match. If this is more than the blueprint level of technology θ_t , the new match starts with ϕA_t . If it is less, it starts with θ_t . Free entry stipulates that the equilibrium value of a new establishment to the owner is equal to the sunk cost S_t :

$$V_t\left(max(A_t\phi,\theta_t),\omega_t(A_t);t\right) = S_t,\tag{10}$$

The total expected utility $\omega_t(A_t)$ offered to the manager at the start of a new match is such that the net value of the new match is zero in expectation. We assume the sunk cost S_t grows at the same rate as output.

Law of Motion for Distributions We use χ to denote the implied probability density function for A_{t+1} given A_t . κ is an indicator function defined by the policy function for promised utilities: $\kappa (A'; A, v, s) = 1$ if v'(A'; A, v, s) = v', 0 elsewhere. Using this indicator function, we can define the transition function:

$$Q((A', v'), (A, v); s) = \chi(A'|A)\kappa'(A'; A, v, s).$$

⁷Because there is no aggregate uncertainty, our setting is equivalent to one with a risk neutral owner who discounts future cash-flows as in equation (3).

We use $\Psi_{t,s}$ to denote the joint measure over organizational capital A and promised utilities v for matches of vintage s. Its law of motion is implied by the transition function:

$$\Psi_{t+1,s+1}(A',v') = \int_0^\infty \int_{\underline{v}}^{\overline{v}} Q((A',v'),(A,v);s)\lambda_{t,s}(A,v)d(A,v),$$
(11)

where $\lambda_{t,s}(A, v)$ is the measure of active establishments in period t of vintage s:

$$\lambda_{t,s}(A,v) = \int_0^A \int_{\underline{v}}^v \beta(a,u) d\Psi_{t,s}(a,u) \ge 0.$$
(12)

In equilibrium, the mass of new establishments created in each period N_t equals the mass of matches destroyed in that same period:

$$N_t = \sum_{s=0}^{\infty} \int_0^{\infty} \int_{\underline{v}}^{\overline{v}} (1 - \beta_{t,s}(A, v)) \Psi_{t,s}(A, v) d(A, v) \ge 0.$$

3.4 Back-loading and Selection

The net payouts (before sunk costs and physical capital income) generated by an establishment for the owner are given by

$$\pi_t = y_t - W_t l_t - R_t k_t - c_t,$$

The zero-profit condition implies that the value of a start-up is exactly zero:

$$\int_0^\infty \int_{\underline{v}}^{\overline{v}} \sum_{j=0}^\infty e^{-\sum_0^j r_s ds} \pi_{t+j} \Psi_{t+j,s}(A,v) d(A,v) - S_t = 0$$

However, this does not imply that the aggregate value of the net payouts to the owners is zero when discount rates are positive (Atkeson and Kehoe (2005)):

$$\int_0^\infty \int_{\underline{v}}^{\overline{v}} \sum_{j=0}^\infty \pi_{t+j} \Psi_{t+j,s}(A,v) d(A,v) - S_t > 0,$$

for two reasons. The first reason is a **back-loading** effect. The establishments grow over time so that most of the organizational rents are paid in the future. The owners are compensated for waiting in the form of positive payouts, as long as discount rates r are positive. The more back-loaded the payments are the higher the average payments. This back-loading arises naturally in a setting with a large sunk cost to start up a new establishment. Second, and more importantly, there is a **selection** effect operative. Only the establishments that have fast enough organizational capital, or equivalently productivity, growth survive. When we compute aggregate payouts, we are only

sampling from the survivors $(A_t > \underline{A}_t(v_t; s))$, and this is a second important reason why payouts to owners are positive. Since the sunk cost is lost, value added is defined as $Y_t - S_t^A$. The net payout share in the model equals $NPS = \frac{D_t}{Y_t - S_t^A}$. The gross payout share equals $GPS = NPS + \frac{\delta K_t}{Y_t - S_t^A}$. An increase in selection will increase the net and gross payout shares because the survivors generate more organizational capital and more payouts.

As pointed out by Hopenhayn (2002), an increase in selection among establishments gradually raises the market value all surviving establishments. This explains why Tobin's q, $q_t = \frac{V_t^a}{K_t}$, is larger than one on average. The aggregate value of establishments is given by the present discounted value of a claim to $\{D_t\}$; this equals the sum of all equity values across all establishment minus sunk costs plus the value of the physical capital stock holdings, K_t :

$$V_t^a = \sum_{s=0}^{\infty} \int_0^{\infty} \int_{\underline{v}}^{\overline{v}} V(A, v; s) \Psi_{t+j,s}(A, v) d(A, v) - S_t^A + K_t > K_t,$$

Tobin's q is larger than one on average, in spite of the fact that new matches are valued at zero (net of their physical capital). The reason is selection. For example, for establishments of vintage s, we only sample from the ones with $A_t > \underline{A}_t(v_t; s)$. Indeed, when we compute q, we only sample survivors.

For future reference, we also define aggregate managerial wealth in the economy as:

$$M_t^a = \sum_{s=0}^{\infty} \int_A \int_v v_t(A, v; s) \Psi_{t+j,s}(A, v) d(A, v).$$

3.5 Steady-state Growth Path

Following Atkeson and Kehoe (2005), we start by solving for a steady-state growth path in which all aggregate variables grow at a constant rate.

Definition 1. A steady-state growth path is defined as a path for which aggregate establishment productivity $\{\overline{A}_t\}$ and the productivity of the newest vintage $\{\theta_t\}$ grow at a constant rate g_{θ} , the variables $\{r_t, R_t, N_t\}$ are constant, the economy-wide productivity-level grows at a constant rate g_z , and all aggregate variables $\{Y_t, K_t, W_t, S_t, C_t, D_t, V_t^a\}$ grow at a constant rate

$$g = \left((1+g_z)(1+g_\theta)^{1-\nu} \right)^{\frac{1}{1-\alpha\nu}}.$$
 (13)

Along the steady-state growth path, the measure over establishment productivity and promised utilities satisfies:

$$\Psi_{t+1,s+1}(A,v) = \Psi_{t,s}\left(\frac{A}{1+g_{\theta}},v\right),$$

the measure of active establishments satisfies:

$$\lambda_{t+1,s}(A,v) = \lambda_{t,s}\left(\frac{A}{1+g_{\theta}},v\right),$$

and the value of an establishment of vintage s evolves according to:

$$V_{t+1}(A, v; s+1) = (1+g)V_t\left(\frac{A}{1+g_{\theta}}, v(1+g)^{1-\gamma}, s\right).$$

In the remainder, we assume a Cobb-Douglas production function $F(k, l) = k^{\alpha} l^{1-\alpha}$. To construct the steady-state growth path, we normalize variables in efficiency units. This allows us to restate the production technology as follows :

$$\widetilde{y}_t = \widetilde{k}_t^{\alpha\nu},$$

where a variable with a tilde, \tilde{x}_t , denotes the variable, x, expressed in per capita terms and in adjusted efficiency units of the latest vintage (blueprint):

$$\widetilde{x}_t = \frac{x_t}{z_t^{\frac{1}{1-\alpha\nu}} \theta_t^{\frac{1-\nu}{1-\alpha\nu}}}.$$

We have normalized the population L to one. We normalize productivity by the blueprint level of technology, and denote the normalized variables with a hat: $\hat{A}_t = A_t/\theta_t$. By construction, $\hat{A} = 1$ for a new establishment (vintage zero). The organizational capital of existing establishments in the new efficiency units *shrinks* at a rate $(1 + g_{\theta})$:

$$\widehat{A}' = \varepsilon' \frac{\widehat{A}}{1 + g_{\theta}}.$$
(14)

The prime denotes next period's value. This notation allows us to reformulate the optimal contract along the steady-state growth path.

The contract maximizes the (rescaled) owner's value \tilde{V}

$$\widetilde{V}(\widehat{A}, \widetilde{v}; s) = \max\left[\widehat{V}(\widehat{A}, \widetilde{v}; s), 0\right]$$

and

$$\widehat{V}(\widehat{A},\widetilde{v};s) = \max_{\widetilde{c},\widetilde{v}'(\cdot)} \left[\begin{array}{c} \widetilde{y} - \widetilde{W} - R\widetilde{k} - \widetilde{c} \\ +e^{-(\rho_o - (1-\gamma)\widehat{g})} \int \widetilde{V}(\widehat{A}',\widetilde{v}';s')\Gamma_{s'}(\varepsilon_{s'}') d\varepsilon_{s'}', \end{array} \right]$$

subject to the law of motion for organizational capital in (14), the promise keeping constraint

$$\widetilde{v} = u(\widetilde{c}) + e^{-(\rho_m - (1 - \gamma)\widehat{g})} \left[\int \beta_{s'}(\widetilde{v}, \varepsilon_{s'}') \widetilde{v}'(\widehat{A}') \Gamma_{s'}(\varepsilon_{s'}') d\varepsilon_{s'}' + \widetilde{\omega}(\widehat{A}', s') \int (1 - \beta_{s'}(\widetilde{v}, \varepsilon_{s'}')) \Gamma_{s'}(\varepsilon_{s'}') d\varepsilon_{s'}' \right],$$

and subject to participation constraints for all \widehat{A}' :

$$\widetilde{v}'(\widehat{A}') \ge \widetilde{\omega}(\widehat{A}';s').$$

The indicator variable β is one if continuation is optimal and zero elsewhere:

$$\beta_{s'} = 1 \text{ if } \widetilde{v}'\left(\widehat{A}'\right) \leq \widetilde{v}^*(\widehat{A}', s')$$

$$\beta_{s'} = 0 \text{ elsewhere}$$

The outside option process is determined in equilibrium by the zero-profit condition for new entrants:

$$\widehat{V}\left(\max(\widehat{A}\phi,1),\omega(\widehat{A});s\right) = S,\tag{15}$$

Equation (15) implies that the outside option $\omega(\hat{A}_t)$ is constant in the range $A \in [0, \phi^{-1}]$. We refer to this range as the insensitivity region, because the outside option does not depend on the organizational capital accumulated in the current establishment. As the fraction of capital ϕ that is portable goes to zero, the outside option is constant for all A > 0.

3.6 Properties of Wage Contract

Limited portability of organizational capital creates collateral in the matches necessary to sustain risk sharing. Two extreme cases illustrate this point. In a first polar case, there is no capital specific to the match, and there are no other frictions. This case, considered by Krueger and Uhlig (2005), corresponds to 100% portability of organizational capital to the next match ($\phi = 1$) and no sunk costs (S = 0). Because there is no relationship capital, no risk sharing can be sustained. Managers earn all the rents from organizational capital and the value of the owner's equity is zero. This implies that $V_t^a = K_t$ and Tobin's q is one for all t in this case. The other polar case is $\phi = 0$ so that all organizational capital is match-specific. The manager's outside option is constant so that perfect risk sharing can be sustained. In the quantitative section of the paper, we consider an intermediate case in which a fraction $0 < \phi < 1$ is portable.

When a new match is formed, \tilde{v} starts off at $\tilde{v}_0 = \omega(\hat{A}_t)$. We can characterize the dynamics of the optimal wage contract by setting up a Lagrangian. Let μ denote the multiplier on the promised utility constraint and let $\lambda(\hat{A}')$ denote the multiplier on the participation constraint in state \hat{A}' . We assume $\hat{V}(\cdot)$ is strictly concave and twice continuously differentiable. No Discount Rate Wedge Suppose first that manager and owner are equally impatient ($\rho_m = \rho_o$) and that the participation constraint in some state \hat{A}' does not bind ($\lambda(\hat{A}') = 0$). Conditional on continuation of the relationship ($\beta = 1$), the promised utility in efficiency units \tilde{v} is constant over time:

$$\frac{-\partial \widehat{V}(\widehat{A},\widetilde{v};s)}{\partial \widetilde{v}} = \mu = \frac{-\partial \widehat{V}(\widehat{A}',\widetilde{v}';s')}{\partial \widetilde{v}'}$$

The left hand side is the cost to the owner of increasing the manager's compensation today. It equals μ , the shadow price of a dollar today, from the envelope condition. The right-hand side is the cost of increasing the manager's compensation tomorrow, from the first-order condition for \tilde{v}' . Because this cost is constant over time and equal to $\mu = u_c^{-1}(\tilde{c})$, current consumption \tilde{c} must also be constant over time. As a result, managerial compensation c grows at the rate of output growth g on the steady-state growth path.

When the participation constraint does bind, the following inequality obtains:

$$\frac{-\partial \widehat{V}(\widehat{A}, \widetilde{v}; s)}{\partial \widetilde{v}} = \mu < \frac{-\partial \widehat{V}(\widehat{A}', \widetilde{v}'; s')}{\partial \widetilde{v}'}$$

The utility cost of increasing the manager's compensation to the owner increases. From the concavity of \hat{V} , it follows that the manager's promised utility and current compensation (in efficiency units) increase when the participation constraint binds.

Combining the two, the manager's wage relative to the establishment's value-added is a submartingale. It is constant as long as the participation constraint does not bind. The optimal contract prescribes to increase compensation when the participation constraint binds. Intuitively, this is to prevent a break-up when a better outside option tempts the manager. When organizational capital \hat{A} grows and leaves the insensitivity region $[0, \phi^{-1}]$, the constraint starts to bind. In the model, \hat{A} has the interpretation of a measure of the size of the establishment. When the establishment is large enough, the manager's compensation increases relative to value-added when the establishment grows. So the model endogenously generates non-linearities in managerial compensation which are related to the size of the establishment.

Figure 3 plots a time series for the log of the manager's wages, $\log \tilde{c}$, against the log of organizational capital $\log \hat{A}$, a measure of size and productivity, from a simulation of the model. First, as the establishment size leaves the insensitivity region, the wage starts to increase in response to increases in \hat{A} . Second, the manager's compensation does not track the downward movements in size. Third, when the productivity level drops below the lower bound $\underline{A}(v)$, the match is dissolved and the worker switches to a new match. New matches start off at productivity level $\hat{A} = 1$. Endogenous break-ups are indicated by the arrows in the plot.

[Figure 3 about here.]

Discount Rate Wedge In the literature, it is more common to consider the case where the manager discounts cash flows at a higher rate than the owner $(\rho_m > \rho_o)$. Such a scenario would arise when the manager faces binding borrowing constraints, has a lower willingness to substitute consumption over time, or simply a higher rate of time preference. This assumption changes dynamics of the optimal compensation. The discount rate wedge induces a downward drift to the manager's consumption and promised utility in the absence of binding participation constraints $(\lambda(\hat{A}') = 0)$. To see this, we use the envelope condition (left equation) and the first order condition for \tilde{v}' to get:

$$\frac{-\partial \widehat{V}(\widehat{A},\widetilde{v};s)}{\partial \widetilde{v}} = \mu = e^{(\rho_m - \rho_o)} \frac{-\partial \widehat{V}(\widehat{A}',\widetilde{v}';s')}{\partial \widetilde{v}'}$$

Because $e^{\rho_m - \rho_o} > 1$, we have that the owner's utility cost of providing compensation tomorrow is lower than μ , the cost today. As a result, the optimal promised utility is decreasing over time. Because, $\mu = u_c^{-1}(\tilde{c})$, this also implies that current consumption drifts down. In sum, in the absence of binding participation constraints, managerial compensation c grows at a rate smaller than the rate of value-added on the steady-state growth path. This compensation structure back-loads the payoffs from the venture to the owners. This back-loading increases average payouts because of the selection effect.

Composition Effects Our main exercise below is to study how the change in the composition of productivity growth affects the optimal wage contract and the distribution of rents from organizational capital between the owner and the manager. A high vintage-specific growth rate g_{θ} depreciates the organizational capital of existing vintages at a higher rate. This reduces the value of the owner's claim to rents from organizational capital V relative to output. Intuitively, the owners are not hedged against a high vintage-specific growth rate. Managerial workers are hedged because they can always switch to a new match. As a result, they capture most of the rents. If most of the growth is vintage-specific, establishments are short-lived, they do not accumulate much organizational capital, and the selection effect is not as powerful. Because of a lack of back-loading of payments, aggregate rents flowing to owners are small.

In another steady state where most of the growth is general, organizational capital depreciates much less. Establishments accumulate substantial organizational capital and are longer-lived. This makes for more back-loading of payments to the owners. In addition, there is more selection as well, raising the expected value of the average match. However, it takes time before managerial compensation responds to changes in organizational capital (size), because of the sunk costs. Finally, if there is a discount rate wedge, then the share of rents captured by the managers is smaller, because their compensation drifts down relative to output, when the constraint does not bind.

3.7 Constant Cost of Capital Transition

We study the transition between a low and a high general-purpose innovation growth path. The arrival of the GPT increases productivity growth for all establishments regardless of vintage. To keep the analysis tractable, we assume that the total productivity growth rate of the economy g_t is constant at its initial *steady-state growth path* value:

$$g = \left((1 + g_{t,z})(1 + g_{t,\theta})^{1-\nu} \right)^{\frac{1}{1-\alpha\nu}}.$$
 (16)

To trace out the effect of a change in the composition of productivity growth, we study the transition between a stationary equilibrium with high $g_{0,\theta}$ to a stationary equilibrium with low $g_{T,\theta}$. We use $\{g_{t,\theta}\}$ to denote the sequence of vintage-specific growth rates. At t = 0, agents know the entire future path for $\{g_{t,\theta}\}_{t=0}^{T}$, although the arrival of the GPT itself at t = 0 is not anticipated at $t = \ldots, -2, -1$. Because we want to focus on the cash flow effects (not the discount rate effects), we consider a transition with a constant discount rate (cost of capital). Appendix B defines the constant discount rate transition. It also explains the reverse shooting algorithm we use to solve for the entire transition path. This is a non-trivial problem because we need to keep track of how the cross-sectional distribution of (A, v) evolves. We then simulate the economy forward for a cross-section of 5,000 establishments, starting in the initial steady state. We assume the change in the relative importance of growth rates is accomplished in 20 years. However, the economy continues to adjust substantially afterwards on its way to the final steady state.

4 Model Calibration

In order to assess its quantitative implications, we calibrate the model at annual frequency. Table 7 summarizes the parameters.

4.1 Benchmark Parameter Choices

Production Technology and Preferences The parameter ν governs the decreasing returns to scale at the establishment level. It is set to .75, at the low end of the range considered by Atkeson and Kehoe (2005). The other technology and preferences parameters are chosen to match the depreciation, the average capital-to-output ratio and the average cost of capital for the US non-financial sector over the period 1950-2005. The depreciation rate δ is calibrated to .06 based on NIPA data. Next, we calibrate the Cobb-Douglas productivity exponent on capital, α . Because there is no aggregate risk, the rate of return on physical capital is deterministic in the model. In equilibrium that rate equals the discount rate. Both are fixed along the transition path. From the Euler equation for physical capital, we get:

$$r = (1 - \tau_c) \left(1 - \delta + \alpha \nu \frac{Y}{K} \right)$$

We compute the cost of capital r in the data as the weighted-average realized return on equity and corporate bonds; it is 5.5%. The average corporate tax rate τ_c is 28%. The average capital-tooutput ratio is 1.77. The above equation then implies $\alpha \nu = 0.23$. As a result, $\alpha = 0.30$. Appendix C provides more details.

We chose the rate of time preference of the owner $\rho_o = .02$ such that his subjective time discount factor is $\exp(-\rho_o) = .98$. In our benchmark results, we assume that the manager is less patient: $\rho_m = .04$. Finally, we choose a coefficient of relative risk aversion $\gamma = 1.6$. This is the value that solves equation 9 given our choices for r, ρ_o , and given the average growth rate of real aggregate output of g = 0.022.

[Table 7 about here.]

Organizational Capital Accumulation and Transfer Technology To calibrate the organizational capital accumulation, its portability and the sunk costs of forming a new match, we match (i) excess job reallocation rates, (ii) firm entry and exit rates, and (iii) the log productivity dispersion in the old steady state to those observed in the data in 1970-74.

Following Atkeson and Kehoe (2005), we assume the ε shocks are log-normal with mean m_s and standard deviation σ_s . We abstract from the dependence on these parameters on the vintage s. For parsimony, the mean m_s is set zero. However, younger matches (lower s) will grow faster in equilibrium because of selection, even without the age dependence in the drift m_s . The standard deviation $\sigma_s = \sigma$ of these shocks is chosen to generate an excess job reallocation rate of 19% in the initial steady state. This matches the reallocation rate, defined and described below, in the 1970-74 data.

The size of the sunk cost (S) was chosen to match the entry-exit rates in the initial steady state. The sunk cost is equal to 6.5 times the annual cash flow generated by the average firm. This delivers an entry/exit rate of 4.3% in the initial steady-state, again matching the 1970-74 data.

The portability or match-specificity parameter ϕ governs the increase in wage dispersion in the model. We set it equal to 0.5, which means that 50% of organizational capital is transferable to a next match. This value matches the increase in intra-wage inequality described below.

Productivity Growth Composition In the baseline experiment, we assume the change in the composition of growth to $g_{new,z}$ occurs over 20 years, and we assume it starts in 1971. After 20 years, in 1990, productivity growth settles down at $(g_{new,z}, g_{new,\theta})$. The actual transition to

a new steady-state growth path takes much longer. The total trend growth rate (g = 2.19%) is constant throughout. The change in the composition of growth is calibrated to match the *change* in reallocation rates in the data. The vintage-specific productivity growth rate $g_{old,\theta}$ is 5.5% in the initial steady state. This implies a general productivity growth rate of only 0.3% (see equation 16). We chose $g_{new,\theta}$ of 0.8% to match an excess reallocation rate of 11% in the new steady state. This implies a general productivity growth rate $g_{new,z}$ of 1.45%. So, the vintage-specific growth declines from 5.5% to 0.8%, while general productivity growth increases from .3% to 1.45%.

4.2 Supporting Evidence from Data

Intra-Industry Wage Dispersion Wage inequality has increased substantially in the US. According to Dunne et al. (2004), increasing within-industry, between-establishment wage dispersion accounts for a large fraction of the increase. This is true especially for non-production workers, which includes managers.⁸ Table 8 presents evidence of the increasing within-industry wage dispersion from a panel of 55 2-digit SIC-code industries. The data are from the Quarterly Census of Employment and Wages (QCEW) collected by the Bureau of Labor Statistics (BLS). Between 1975-1979 and 2000-2004, there has been a substantial increase in intra-industry wage inequality. The cross-sectional standard deviation of log wages increased by 7.3, the inter-quartile range by 5.4, and the inter-decline range by 14.7 percentage points.

[Table 8 about here.]

Declining Excess Job Reallocation The excess job reallocation rate is a direct measure of the cross-sectional dispersion of establishment growth rates. It is defined as the the sum of the job creation rate plus the job destruction rate less the net employment growth rate. Before 1990, we only have establishment-level data for the US manufacturing sector. Figure 4 shows that the excess reallocation rate in manufacturing declined from 11.7% in 1965-1969 to 9.5% in 2000-2005, and further to 7.5% between 2006-2007.I. After 1990, the BLS provides establishment-level data for all sectors of the economy. Over the 1990-2007 sample, the excess reallocation rate declined from 10.6 to 7.2% in manufacturing, from 15 to 12.4% in services, and from 15.6 to 12.8% in the entire private sector. Half of this decline is due to a decline in entry and exit rates for establishments, from 4% to 2.5%. The other half is due to a decline in expansions and contractions of existing establishments.

Similar trends have been documented in *firm-level* (rather than establishment-level) data. For the US economy as a whole, Davis et al. (2006) document large declines in the dispersion and the

 $^{^{8}}$ They study US manufacturing establishments. Between 1977 and 1988 the between-plant coefficient of variation for non-production worker's wages increased from 44% to 56%, while the within-plant dispersion actually decreased. They also document an increase in the dispersion of productivity between plants.

volatility of firm growth rates, either measured based on employment or sales. The employmentweighted dispersion of firm growth rates declined from .70 in 1978 to .55 in 2001, while the employment-weighted volatility of firm growth rates declined from .22 in 1980 to .12 in 2001. The former measures the cross-sectional standard deviation of firm growth rates, while the latter measures the standard deviation of firm growth rates over time.⁹ Finally, Haltiwanger and Schuh (1999) constructs a proxy for establishment-level reallocation by studying intra-industry *job flows*. The excess reallocation rate for the non-financial sector declines from 19% in 1960 to an average of 11.5% in 2000. This 19-11% change is what we attempt to capture in our benchmark calibration.

[Figure 4 about here.]

5 Transition Experiment

We start by comparing the size and compensation distribution in the two steady states, as well as its evolution during the transition. Then, we trace out the dynamics of key aggregates such as the payout share. Figure 5 summarizes these transitional dynamics. These dynamics are similar to what we have documented in the data.

[Figure 5 about here.]

5.1 Compensation and Size Distribution

Figure 6 illustrates how a relatively modest change in the size distribution of firms, brought about by a change in the composition of productivity growth, translates in a much larger change in the distribution of compensation. The left panel plots the log compensation of managers $(\log \tilde{c})$ against the log of establishment size $(\log \hat{A})$ in the initial steady-state growth path of the model. The right panel shows the new steady state, i.e., after the effects of the introduction of the general purpose technology have settled down. Each dot represents one firm in the cross-section. The key to the amplification is the compensation contract. Because of the sunk cost, the optimal contract features a lower bound on size below which the skilled wage does not respond to changes in size. Above a certain size, the manager's compensation only responds to good news about the establishment's productivity. In the old steady state, few establishments become large enough to exceed the insensitivity range. Managerial compensation hardly responds to changes in size; there is no cross-sectional variation in managerial compensation in the left panel. In the initial steady-state, the kurtosis of log size is 1.92, while the skewness is .02.

⁹Comin and Philippon (2005) show that there is an increase in volatility for the subsample of publicly traded firms. Our analysis is for the entire non-financial sector, publicly-traded and privately-held.

[Figure 6 about here.]

The right panel shows that this is no longer true in the new steady-state. With a higher importance of general instead of vintage-specific productivity, establishments live longer on average and the successful ones grow larger. The log size distribution is much more skewed than in the initial steady-state. The figure shows a strong positive cross-sectional relationship between size and compensation. Thus, our model endogenously generates a shift from low-powered to high-powered compensation contracts. The distribution of managerial compensation has much fatter tails than the size distribution, as shown in Figure 7. Its left panel shows the histogram of log compensation in the new steady state; the right panel is the histogram of log size. Both were demeaned. The distribution of managerial compensation is more skewed and it has fatter tails than the size distribution. The kurtosis of log compensation is 17.7, compared to 3.25 for log size. The skewness is 3.69 for log compensation, compared to .38 for log size.

[Figure 7 about here.]

There is a large finance literature that studies compensation for top managers (e.g., Frydman and Saks (2006) and Kaplan and Rauh (2007)). Gabaix and Landier (2007) and other studies have documented that managerial compensation is well-described by a power function of size, a finding referred to as *Roberts' law*. In our model too, the compensation distribution has much fatter tails than a log-normal. On average, the relation between compensation and size in the new steady state satisfies $\log \tilde{c} = \alpha + \kappa \log \hat{A}$. The slope coefficient κ is .31 in the new steady-state, a value consistent with the empirical literature.

Our model also has implications for the size distribution of firms. Luttmer (2005) and others show that the size distribution for *large* firms follows a Pareto distribution. The same is true for the large firms in our new steady-state. Figure 8 shows that the relation between log rank and log size is linear for large establishments. Quantitatively, the slope of that relationship is too steep compared to the data, implying a Pareto coefficient that is too small (close to 0.5).

[Figure 8 about here.]

Table 9 reports the impact of the change in the composition of growth on the distribution of compensation and productivity. The log of establishment productivity (TFP) is given by $(1 - \nu) \log \hat{A}$. The log of the manager's wage is given by $\log \tilde{c}$. The left panel reports the cross-sectional standard deviation *Std*, the 75-25% range *IQR* and the 90-10% range *IDR* for log wages; the right panel does the same for log TFP. The first (last) line shows the values in the initial (final) steady-state. The numbers in between are five-year averages computed along the transition path. The main message is that small changes in the productivity (or size) distribution cause big changes

in the distribution of compensation. The standard deviation of managerial compensation increases by 8.3 percentage points in the first 35 years of the transition. The IQR increases by 6.8 and the IDR by 16 log points. These are similar to the increases we reported in within-industry wage dispersion.¹⁰ In the next ten years from 2006-2015, the standard deviation of log wage dispersion is predicted to increase by another 3.3 percentage points and the *IDR* by as much as 6 percentage points.¹¹ In sum, the shift towards high-powered incentives leads to a substantial increase in income inequality.

The increase in productivity dispersion that generate this explosion in compensation inequality is rather modest. The standard deviation increases by only 1.8 percentage points in the first 35 years of the transition. The IQR for increases from 18.3 to 18.9% and the IDR from 29.2 to 32.7% over the same period. Overall, productivity dispersion in our model is somewhat smaller than what is found in the data. Using 1977 US manufacturing data at the 4-digit industry level, Syverson (2004) reports a within-industry IQR of log TFP between 29 and 44%. Increasing log TFP dispersion in the model would give rise to too much reallocation, absent other frictions.

[Table 9 about here.]

5.2 Main Aggregates

Table 10 summarizes our main findings. The first column shows the excess job reallocation rate. We calibrated the model so as to match the initial steady-state value of 19% as well as the subsequent decline to 11% over the ensuing 35 years. We also successfully match the entry/exit rate (on a steady-state growth path those are identical). The exit rate starts from 4.3% and declines to 2.7% by 2001-05. In the data, it declined from 4% to 2.5%. The exit rate is highest in the first ten years of the transition because there is a shake-out of establishments that are no longer profitable under the increased managerial.

Our model is able to account for the 7.7% increase in the net payout share, the main new stylized fact we documented in Section 2. The NPR increases gradually from 4.2% in the initial steady state to 11.9% in the early 2000s, tracking the data. The model generates this increase as a result of the increased selection that takes place in the wake of the advent of the general purpose technology, and because of back-loading. The gross payout share in the fourth column shows a similar increase.

[Table 10 about here.]

¹⁰In the model, unskilled wages are equalized across establishments and do not affect the dispersion.

¹¹In the new steady-state, compensation becomes very skewed: the IDR increases so much that the IQR actually decreases.

The last three columns of Table 10 report valuation ratios. As establishments start to live longer and accumulate more organizational capital, the aggregate value of organizational capital starts to increase. This is the selection effect: We are only sampling the survivors when computing the market value of matches. Correspondingly, Tobin's q shows an initial drop, and subsequently increases from 1.41 in 1971-75 to 1.63 in 2001-05 (Column 5) and the the value of organizational capital as a fraction of value-added $(V_t^a - K_t)/Y$ increases from 0.78 to 1.15, a 39% increase (Column 6). The increase in the data from 1.54 to 2.41 represents a 45% increase.

The increase in valuation ratios in the data suggests that a simpler model, based on a decline in the volatility of shocks to firm productivity σ , cannot account for the facts. Because an establishment's operations are discontinued when the match has no value ($V \ge 0$ in equation 5), it has an option-like structure. A decrease in volatility would reduce the value of the option, and therefore reduce valuation ratios. Our explanation features this increase in valuation ratios.

Managerial workers capture only part of this increase in rents because of the sunk costs and limited portability of organizational capital. The sunk costs create an insensitivity range in which managerial compensation does not respond to productivity shocks. In addition, the discount rate wedge imputes a downward drift to the managerial compensation. As matches live longer, managers end up with a smaller share of the surplus. This is consistent with the findings of Lustig and Van Nieuwerburgh (2007), who document a negative correlation between innovations to future cash flow growth for financial (owners) and human wealth (managers). The managerial wealthto-output ratio (M^a/Y) declines from 6.5 to 5.8% (Column 7). The model thus implies a huge transfer of wealth from the managers to the owners.

Figure 9 shows an enormous amount of heterogeneity in the evolution of managerial wealth to value-added (M/Y). We sorted all managers by their final steady-state M/Y ratio. Managers in the 95th percentile saw a large *increase* from 6.6 in 1975 to 7.3 in the final steady-state. Managers in the 90th percentile, maintain the status quo. All other managers, especially those in the smaller establishments, see a decline in wealth. Managers in the 5th see their wealth declines from 6.42 to 5.02 times per capita aggregate output.

[Figure 9 about here.]

5.3 Stock Market Sampling Bias

The increase in aggregate Tobin's q generated by the model is smaller than in the data. This could partially be due to a reduction in the cost of capital during that period that we deliberately abstract from. However, it is possible that the data overstate the increase in Tobin's q. Our model helps us understand this potential bias.

Table 11 shows the cross-sectional distribution of Tobin's q (market value to physical capital),

where establishments were sorted by market value. In the 95^{th} percentile, market values increased from 1.98 to 2.48, an increase of 23%. In the 10^{th} percentile, the increase is only 5%.

The Flow of Funds (FoF) computes the market value of all equities outstanding as the value of all common and preferred stock for firms listed on the NASDAQ, the NYSE, AMEX, and other US exchanges plus the *FOF estimate* of closely held shares.¹² This FoF estimate effectively imputes the returns on the publicly traded firms to non-traded firms. Because publicly traded firms are much more likely to be drawn from the 95^{th} than the 10^{th} percentile of the entire firm distribution, the imputation procedure may overstate the increase in Tobin's q. Put differently, the stock market over-samples larger establishments because of selection.

[Table 11 about here.]

5.4 Robustness

We evaluate two alternative calibrations to our benchmark.

Lower Portability The model can generate larger increases in aggregate valuation ratios, but only at the expense of understating the increase in wage dispersion. When we lower the portability parameter ϕ from .5 to .3, the increase in the market value of organizational capital between 1971-75 and 2001-05 is 52% instead of 39% in the benchmark case. Tobin's q increases from 1.41 to 1.73 by 2001-05 instead of 1.63 in the benchmark. The match-specificity parameter ϕ also governs the sensitivity of managerial compensation to the size changes that take place at the establishment level. Lowering ϕ reduces the increase in the standard deviation of log compensation between the initial and the new steady state from 40 to 22 log points. The increase in the net payout share is also lower: from 7.5% in 1971-75 to 13.5% in 2001-05.

No Discount Rate Wedge Finally, we solved a calibration where the owner and manager share the same subjective time discount factor $\rho_o = \rho_m$. Making the manager more patient reduces the back-loading effect and therefore reduces the value accumulation to the owner. The increase in the net payout share is mitigated.

6 Evidence from the Cross-Section

Our analysis so far focused on the time-series relationship between the composition of productivity growth and the payout share, reallocation rate, and Tobin's q. In the model, these same

 $^{^{12}}$ It also subtracts the market value of financial companies and the market value of foreign equities held by US residents.

relationships hold in the cross-section. We investigate now in the data whether industries characterized by high vintage-specific growth have lower payout and valuation ratios. We identify high vintage-specific growth industries as those with high reallocation rates.

We build a panel of 55 industries at the 2-digit SIC level covering the 1976-2005 sample. The payout data are from Compustat. The employment data are from the QCEW program (see Appendix A.3 for details). As before, we exclude the financial sector. To gauge the effects of reallocation on payout ratios in the cross-section of industries, we estimate fixed-effects regression of the payout ratios on the reallocation rates, excess reallocation rates and the reallocation rates interacted with the ratio of intangibles to physical capital (property, plants and equipment). Table 12 lists the results from four different specifications. In Column (1) we use the excess reallocation rate (*EREALL*), in Column (2) we use the reallocation rate (*REALL*), which is measured as the sum of job creation and job destruction rates. We find that payout ratios tend to be lower when the reallocation rates are higher, and they tend to decline, when the reallocation rates increase, consistent with the theory. These results are statistically significant and quite robust across different specifications and samples. On average, a one standard deviation increase in the reallocation rate in an industry decreases the payout ratio by about 1.8 percentage points. In Columns (3) and (4) we interact the reallocation effect with the ratio of intangibles to plants, property and equipment (INTAN). Intangibles are a proxy for the organization-capital intensity of an industry. The effect of reallocation on payout ratios is much *larger* in industries with more intangible assets.

[Table 12 about here.]

We also examined the cross-sectional relationship between reallocation and the average Tobin's q in the same panel of 55 industries. Table 13 reports the results. We use two different measures for the average Tobin's q in each industry. The first measure (Columns 1 and 2) uses total assets less financial assets at book value in the denominator. The second measure (Columns 3 and 4) uses the book value of total assets in the denominator. The numerator in both ratios is the market value of the firm. Appendix A.3 provides more details. We find that an increase in the reallocation rate tends to lower Tobin's q. The results are statistically significant at the 1% level across all four specifications. A one percentage point drop in the reallocation rate increases Tobin's q by 0.12.

[Table 13 about here.]

7 Conclusion

The payouts that owners of the US on-financial corporate sector receive as a fraction of gross valueadded has increased from 1.7 in the first half of the 1970s to 9.4% in the first half of the 2000s. These payouts include not only cash payouts such as dividends and interests, but also net equity and net debt repurchases. This paper links the increase in payouts to the evolution of managerial compensation contracts caused by a shift in the composition of technological progress.

In our model, the higher payouts to owners arise from higher rents accruing to organizational capital. Managerial workers, or skilled workers more generally, embody this organizational capital. They accumulate it inside an establishment, a collaboration between an owner, a manager, physical capital, and unskilled labor. How the rents from the accumulation of organizational capital are divided between the owner and the manager is governed by a long-term incentive compensation contract. When the manager has the freedom to move to a new establishment, the optimal compensation scheme is to increase current and future compensation whenever the outside option constraint binds. The reason for the increased accumulation of organizational capital, and ultimately for the higher payout rates to owners comes from a change in the mature of technological progress. The early 1970s marked the beginning of the information technology age. The advent and gradual adoption of this general purpose technology has shifted the composition of productivity growth towards general productivity growth. The latter improves the productivity of all existing establishments, rather than only the productivity of the latest vintage of establishments. Information technology has allowed establishments to leverage their technology and operate it on a larger scale. Put differently, establishments face a lower depreciation rate on organizational capital after the IT revolution.

As a result of this change, establishments grow larger on average. The size and productivity distribution become more skewed. The entry and exit rate of establishments decreases, as does the labor reallocation rate. Because the manager can transfer some of his organizational capital to a future employer, the increase in organizational capital improves his outside option. This leads to a gradual shift from low-powered to high-powered incentive compensation contracts. The resulting between-establishment wage inequality increases substantially. Managers in the most successful (and large) establishments are compensated extremely well compared to those in smaller establishments. While each new startup has a zero expected present discounted value because of free entry, the average payouts to the owner are strictly positive because only the best establishments survive. This selection or back-loading effect is responsible for the large increase in valuation ratios, such as the value of the corporate sector relative to the physical capital stock (Tobin's q) or relative to output.

The model's calibration matches the data along all these dimensions: the level and 35-year change in the net and gross payout shares, the aggregate job reallocation rate, the entry and exit rates, the wage inequality, the skewness of managerial compensation and its relationship to the size of the employer. It also generates an increase in valuation ratios, such as Tobin's q, albeit smaller than in the data. Our model suggests that selection may cause an upward bias in the Flow of Fund's construction of Tobin's q. Finally, evidence from the cross-section of firms provides additional evidence for the link between payout rates, valuation ratios, and the composition of productivity growth.

More broadly, we see this paper as an attempt to study the macro-economic implications from micro-level frictions. We have shown that the interaction of frictions in managerial compensation contracts and a shift in the composition of productivity growth prompted by the IT revolution can go a long way towards accounting for several macro trends in the data. Simultaneously, the model has realistic implications for the cross-sectional distribution of size, productivity, and wages at the establishment-level.

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A Data Appendix

A.1 Using Flow of Funds Data

The computation of firm value returns is based on Hall (2001). The data to construct our measure of returns on firm value were obtained from the Federal Flow of Funds, henceforth FoF.¹³ We use the (seasonally-unadjusted) flow tables for the non-farm, non-financial corporate sector, in file UTABS 102D. We calculate the market value of the corporate sector V^a as financial liabilities (item 144190005) plus the market value of equity (item 1031640030) minus financial assets (item 144090005). Because outstanding bonds are valued at book value, we transform them into a market value using the Dow Jones Corporate Bond Index.

The flow of aggregate corporate pay-outs is measured as dividends (item 10612005) plus the interest paid on debt (from the NIPA Table 1.14 on the Gross Product of Non-financial, Corporate Business, line 25) less the increase in net financial liabilities (item 10419005). The latter includes issues of equity (item 103164003).

Finally, capital expenditures (item 105050005) and foreign retained earnings ('US Internal Funds, book value', item 106000305) are also obtained from the Flow of Funds.

Tobin's q for the non-financial sector is constructed as the ratio of the market value of the corporate sector V^a and the replacement cost of physical capital (K). We construct the replacement cost of physical capital using the perpetual inventory method with FoF investment data (item 105013003) and inventory data (item 10502005). To deflate the series, we use the implicit deflator for fixed non-residential investment from NIPA, Table 7.1. The depreciation rate is set to 2.6% per quarter.

A.2 Using NIPA Data

To compute the payouts using National Income and Product Accounts, henceforth NIPA, data for the US non-financial corporate sector, we use Table 1.14. on Gross Value Added of Nonfinancial Domestic Corporate Business in Current and Chained Dollars.¹⁴.

Payouts are the sum of cash and non-cash payouts. The cash payouts are defined as the sum of net dividend payments (line 30) plus interest payments (line 25). The non-cash payouts are the difference between *internal funds* and capital expenditures. Internal funds are defined as profits after tax without inventory valuation and capital consumption adjustment (line 37) minus dividend payments (line 25) plus capital consumption adjustment (line 39) plus inventory valuation adjustment (line 38) plus consumption of fixed capital (line 18). Equivalently, internal funds can be defined as gross value added (line 17) minus compensation of employees (line 20) minus taxes on production and imports less subsidies (line 23) minus business current transfer payments (line 26) minus taxes on corporate income (line 28) minus cash payouts (line 25+30). In other words, internal funds IF are given by: $IF = Y_t - Comp_t - T_t - D_t^c$. Capital expenditures are from the Flow of Funds, as defined above.

¹³Data are available at http://www.federalreserve.gov/ RELEASES/z1/current/data.htm

¹⁴Data are available at http://bea.gov/bea/dn/nipaweb/SelectTable.asp

A.3 Using Compustat Data

We use annual and quarterly data from Compustat¹⁵ and the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) program.¹⁶ If an item from Compustat is not available quarterly, we use its annual figure for each quarter, dividing by four if it is a flow variable. For each industry, the **net payout ratio** is defined as the ratio of payouts to security holders over payouts to workers plus security holders.

Payouts to security holders are computed as the sum of interest expense (item 22), dividends from preferred stock (item 24), dividends from common stock (item 20) and equity repurchases, computed as the difference between the purchase (annual item 115) and the sale (annual item 108) of common and preferred stock. If there is no information available on the purchase and sale of stock, we assume that it is zero.

Payouts to workers are computed as the product of number of employees (Compustat, annual item 29) and wages per employee (BLS, QCEW). We only include those firms for which the payouts to security holders is less than the firm assets (annual item 6).

The intangibles ratio is defined as the ratio of intangibles (annual item 33) to net property, plant and equipment (PPE, annual item 8). We filter out those firms whose intangibles ratio is greater than 1000. The intangibles ratio for each industry is then computed as the total intangibles over the total PPE for each industry.

Job Reallocation Job Reallocation is computed from the BLS QCEW program. This program reports monthly employment and quarterly wages data at the SIC code level from 1975 to 2000, and at the NAICS code level from 1990 to 2005. Since there is no one-to-one correspondence between SIC and NAICS codes, we form industries at the 2-digit SIC code level that match industries at the 3-digit NAICS code level. We finally end up with 55 different industries, that match to only 47 different Compustat industries. We exclude the financial sector from our calculations. The employment data from the QCEW program is spliced in 1992.

We first compute the change in employment from month to month at the SIC and NAICS code level. If it is positive it is recorded as Job Creation, otherwise it corresponds to Job Destruction. We then aggregate Job Creation, Job Destruction and Employment by quarter, and de-seasonalize each of these series separately using the X12-arima from the Census. Job Reallocation is then computed as the sum of Job Creation and Job Destruction, divided by Employment. Excess Job Reallocation is computed as the sum of Job Creation and Job Destruction minus the absolute change in Employment, divided by Employment.

Tobin's q The variable q_1 is computed first for all firms having the following items available from COM-PUSTAT: *DATA1* (Cash and Short-Term Investments), *DATA2* (Receivables - Total), *DATA6* (Assets -Total), *DATA9* (Long-Term Debt - Total), *DATA34* (Debt in Current Liabilities), *DATA56* (Preferred Stock - Redemption Value), *DATA68* (Current Assets - Other), and the following items available from

¹⁵Data are available at http://wrds.wharton.upenn.edu/

¹⁶Data are available at http://www.bls.gov/

CRSP: *PRC* (Closing Price of Bid/Ask average), *SHROUT* (Number of shares outstanding). For each firm, Tobin's q is defined as follows

$$q_1 = \frac{\text{totalvaluefirm}}{\text{DATA6 - fin_assets}},$$

where:

$$totalvalue firm = mcap + totaldebt - fin_assets$$

 $totaldebt = DATA9 + DATA34 + DATA56$
 $fin_assets = DATA1 + DATA2 + DATA68$
 $mcap = PRC * SHROUT/1000.$

We select only those firms for which $0 < q_1 < 100$. For the selected firms, we compute industry I's Tobin's q as :

$$q_{1,agg} = \frac{\sum_{i \in I} \text{totalvaluefirm}_i}{\sum_{i \in I} \text{DATA6}_i - \text{fin_assets}_i}.$$

Tobin's q_2 The variable q_2 is computed first for all firms having the following items available from COMPUSTAT. For each firm, q_2 is defined as :

$$q_2 = \frac{\text{firm_value}}{\text{DATA6}},$$

where

$$firm_value = mcap + DATA6 - DATA60 - DATA74$$

 $mcap = PRC * SHROUT/1000$

We select only those firms for which $0 < q_2 < 100$. For the selected firms, we compute the tobinQ2 for each industry I as:

$$q_{2,agg} = \frac{\sum_{i \in I} \text{firm_value}_i}{\sum_{i \in I} \text{DATA6}_i}$$

B Transition Experiment

Definition 2. A constant-discount rate transition between two steady state growth paths is defined as a path for which the productivity of the newest vintage grows at rate $g_{t,\theta}$, the economy-wide productivity-level grows at a rate $g_{z,t}$, and all aggregate variables $\{Y_t, K_t, w_t, C_t\}_{t=0,T}$ have a constant trend growth rate

$$g = \left((1+g_z)(1+g_\theta)^{1-\nu}\right)^{\frac{1}{1-\alpha\nu}}.$$

The rental rate on capital R_t and the discount rate r_t are constant. The measure over promised utilities and establishment productivity satisfies (11) and (12) during the transition. At t = T, this economy reaches its new steady-state growth path. So for i > 1:

$$\Psi_{T+i,s}(A,v) = \Psi_{T+i-1,s}\left(\frac{A}{1+g_{\theta}},v\right)$$
(17)

$$\lambda_{T+i,s}(A,v) = \lambda_{T+i-1,s}\left(\frac{A}{1+g_{\theta}},v\right).$$
(18)

Output deviates from its trend growth path during the transition because the average establishment productivity level deviates from its initial steady-state growth path $\{\overline{A}_{old,t}\}$. The average productivity levels changes, because the joint measure over establishment-specific productivity and promised utility is changing. Along the transition path, we check that the rental rate for physical capital is constant:

$$R_t = \alpha v \widetilde{K}_{new,t}^{\alpha \nu - 1} = \alpha v \left(\widetilde{K}_{old,t} \right)^{\alpha \nu - 1}$$

where $\widetilde{K}_t = \frac{K_t}{\overline{A}_t^{1-\nu} z_t^{1-\alpha\nu}}$ denotes the capital stock in *adjusted* efficiency units. The aggregate capital stock is adjusted such that

$$\varphi_t = \frac{\widehat{K}_{new,t}}{\widehat{K}_{old,t}} = \left(\frac{\overline{A}_{new,t}}{\overline{A}_{old,t}}\right)^{\frac{1-\nu}{1-\alpha\nu}}$$

Capital is supplied perfectly elastically at a constant interest rate. Along the transition path, all aggregate variables $\{Y_{new,t}, K_{new,t}, W_{new,t}, C_{new,t}\}_{t=0,T}$ are scaled up by φ_t . This is the productivity adjustment relative to the old steady-state growth path. Once we have computed $\{\varphi_t\}$, we can back out the transition path for all the other variables.

Reverse Shooting Algorithm The objective is to compute the transition for the value function, aggregate productivity, the outside option function and the joint measure over promised consumption and productivity $\{V_t, \overline{A}_t, \omega_t, \Psi_{t,s}, \lambda_{t,s}\}$. We start in the new steady state with the new vintage-specific growth rate $g_{\theta,T}$ at T, and the "stationary" joint measure $\Psi_{T,s}$ over organizational capital and promised consumption, which satisfy the conditions in equation (18). We conjecture a $\{\varphi_t\}_{t=0}^T$ sequence. Because we know \widehat{V}_T , the owner's value of an establishment at the beginning of period t can be constructed recursively, starting in i = 1:

$$\widehat{V}_{T-i}(\widehat{A},\widetilde{v};s) = \max_{\widetilde{c},\widetilde{v}'_{t}(\cdot)} \left[\begin{array}{c} \widetilde{y}_{T-i+1} - W - R\widetilde{k}_{T-i+1} - \widetilde{c}_{T-i+1} \\ + R^{-1}(1+g) \int \widetilde{V}_{T-i+1}(\widehat{A}',\widetilde{v}';s+1) \ Q_{s'}(\varepsilon')d\varepsilon' \end{array} \right],$$

subject to the law of motion for capital in (14), the promised consumption constraint in (15), and a series of participation constraints:

$$\widetilde{v}' \ge \widetilde{\omega}_{T-i+1}(A')$$

and, finally, the value of the firm is defined as:

$$\widetilde{V}_{T-i}(\widehat{A},\widetilde{v}) = \max\left[\widehat{V}_{T-i}(\widehat{A},\widetilde{v}),0\right].$$

We solve for $\{V_t, \overline{A}_t, \omega_t, \Psi_{t,s}, \lambda_{t,s}\}_{t=1}^T$ starting in the last period T.

Simulating Forward Next, we simulate this economy forward, starting at the initial values for $(V_0, \overline{A}_0, \omega_0, \Psi_{0,s}, \lambda_{0,s})$ in the old steady-state growth path, using our solution for the transition path $\{V_t, \overline{A}_t, \omega_t, \Psi_{t,s}, \lambda_{t,s}\}_{t=1}^T$. We use a sample of N = 5000 establishments. This gives us a new guess for the aggregate establishment productivity series and hence for $\{\varphi'_t\}_{t=0}^T$. We continue iterating until we achieve convergence.

C Calibration Details

To calibrate the depreciation rate, the tax rate and the capital share $\alpha\nu$, we used mostly NIPA data. Let *CFC* denote the consumption of fixed capital. Let K_{INV} denote the stock of inventories, obtained from NIPA Table 5.7.5B. (Private Inventories and Domestic Final Sales by Industry). Let K_{ES} denote fixed assets, obtained from NIPA Table 6.1. (Current-Cost Net Stock of Private Fixed Assets by Industry Group and Legal Form of Organization). The depreciation rate is computed as

$$\delta = CFC/(K_{ES} + K_{INV}).$$

The average tax rate τ_c is computed as follows. Let CT denote corporate taxes, let NP denote net product, let ST denote Sales Taxes, and let SLPTR denote state and local taxes. The tax rate is computed as

$$\tau_c = CT/(NP - CE - ST),$$

where we compute ST as $CT - RATIO \times SLPTR$ and RATIO is the average ratio of fixed assets held by non-farm, non-financial corporations to total fixed assets.

To compute the average cost of capital r, we computed the weighted-average of the average return on equity and the average return on corporate bonds over the period 1950-2005. The average return on corporate bonds was computed using the Dow Jones corporate bond index.¹⁷. The average return on equity is computed from the log price/dividend ratio and a constant real growth rate for dividends of 1.8%, the average growth rate over the sample.¹⁸ The dividend series and the price/dividend ratio from CRSP are adjusted for repurchases. The weights in the average are based on the aggregate market value of equity and corporate bonds. The resulting average cost of capital is 5.5%.

¹⁷Data are available at http://www.globalfinancialdata.com

¹⁸Data are available at http://wrds.wharton.upenn.edu

	(1)	(2)	(3)	(4)
	NPS FoF	NPS NIPA	GPS FoF	GPS NIPA
1965-1969	2.36	3.66	11.82	13.11
1970-1974	1.74	1.99	11.53	11.78
1975-1979	1.06	2.70	10.68	12.32
1980-1984	3.51	4.42	15.58	16.50
1985-1989	3.08	7.26	16.08	20.26
1990-1995	8.26	7.61	20.20	19.55
1995-1999	7.86	6.21	19.86	18.21
2000-2004	9.41	7.64	22.26	20.49
2005-2007	6.73	7.61	15.97	16.85

Table 1: Payout Share for US Corporate Sector: FoF and NIPA Data

Notes: NPS FoF is the net payout share, the ratio of net payouts to securities holders (Flow of Funds) to gross value-added (NIPA) in the US non-farm, non-financial, corporate sector. GPS FoF is the gross payout share, the ratio of gross payouts to securities holders (including consumption of fixed capital) to gross value-added in the US non-farm, non-financial, corporate sector. We also report the same payout measures based on NIPA data in NPS NIPA and GPS NIPA for the non-financial corporate sector.

	(1)	(2)	(1)+(2)	(3)	(4)	(3)+(4)
	Div	Int	Cash	Debt Rep.	Equity Rep.	Non- $Cash$
1965-1969	3.78	1.71	5.49	-2.98	-0.29	-3.27
1970-1974	2.91	2.88	5.79	-2.95	-1.22	-4.17
1975-1979	2.67	2.74	5.41	-4.12	-0.37	-4.49
1980-1984	2.96	3.80	6.76	-3.97	0.52	-3.46
1985-1989	3.06	4.01	7.08	-7.97	3.82	-4.16
1990-1994	4.02	3.74	7.76	0.21	0.24	0.46
1995-1999	4.70	2.90	7.60	-2.12	2.24	0.12
2000-2004	4.85	3.16	8.02	-0.16	1.36	1.20
2005-2007	3.73	2.05	5.78	-5.77	7.37	1.61

Table 2: Decomposition of the Net Payout Share

Notes: This table lists the components of the payouts to securities holders for the US non-financial corporate sector as a fraction of value-added: dividend payments (Column 1), interest payments (Column 2), net debt repurchases (Column 3) and net equity repurchases (Column 4). Cash payments are the sum of dividends and interest payments. Non-cash payments are the sum of net debt and net equity debt repurchases. All series are scaled by aggregate gross value-added, so that the table gives a decomposition of the Net Payout Share. This table uses data from the Flow of Funds.

	(1)	(2)	(3)	(4)
	CS	Taxes	Net Inv	GPS
1965-1969	35.85	16.28	8.81	10.76
1970-1974	32.99	15.23	7.99	9.78
1975-1979	33.73	14.30	7.59	11.84
1980-1984	33.62	12.50	6.58	14.53
1985-1989	34.24	12.90	4.58	16.75
1990-1994	34.04	13.22	3.75	17.07
1995-1999	35.19	13.22	6.43	15.55
2000-2004	33.14	12.14	3.60	17.40
2005-2007	35.37	13.99	3.08	18.30

Table 3: Link With Capital Share

Notes: This table lists the following ratios for the US non-financial corporate sector as a fraction of value-added: capital share (column 1), taxes (column 2), net investment $(I - \delta K)$ (column 3) and the gross payouts (column 4). The last column is the difference between the first and the second and third. It does not exactly correspond to the GPS measure in Table 1 because Apart of the adjustment for foreign-earned payouts in Table 1.

	(1)	(2)	(3)	(4)	(5)
	FoF	Compustat	: Includes Debt	Compust	at: Excludes Debt
1965-1969	3.45	7.69		14.57	
1970-1974	2.38	11.91		14.36	
1975-1979	1.48	13.97	18.01	14.00	17.04
1980-1984	4.91	14.57	17.93	17.36	20.56
1985-1989	4.31	19.37	22.58	22.97	25.70
1990-1994	11.07	20.16	24.37	23.59	24.29
1995-1999	10.77	21.85	20.74	22.98	23.63
2000-2004	12.26	18.90	24.93	19.85	23.13

Table 4: Net Payout Ratio for US Non-financial Corporate Sector

Notes: Net Payout Ratio for the non-financial corporate sector, based on Compustat data. The net payout ratio is the ratio of net payouts to securities holders to the sum of payouts to securities holders and payouts to employees $Comp_t$. Columns (2) and (4) use labor expenses plus retirement expenses reported in Compustat to measure $Comp_t$. Columns (3) and (5) use BLS data on wages per sector to form $Comp_t$. The BLS data start only in 1976.

	(1)	(2)	(3)
	Tobin's q	V/Y	D/V
1965-1969	1.96	1.80	1.29
1970-1974	1.49	1.54	0.98
1975-1979	0.97	1.13	0.86
1980-1984	0.94	1.16	2.95
1985-1989	1.33	1.49	2.00
1990-1994	1.70	1.82	4.52
1995-1999	2.58	2.53	3.21
2000-2004	2.33	2.41	4.08
2005-2007	2.02	2.15	3.13

Table 5: Valuation Ratios for US Corporate Sector

Notes: Tobin's q is the ratio of the market value of US corporations V^a divided by the replacement cost of the physical capital stock K. The value-output ratio (V/Y) is V^a divided by value-added Y of the non-financial corporate sector. The net payout yield is the ratio of net payouts D to the market value V^a .

	NPR	Tobin's q
1976-1979	6.51	0.75
1980-1984	9.10	0.74
1985-1989	15.32	1.02
1990-1994	14.15	1.16
1995-1999	17.00	1.80
2000-2005	15.68	1.74

Table 6: US Manufacturing Sector

Notes: The payout ratio is the ratio of payouts to securities holders to total payouts (to securities holders and employees), based on Compustat data for publicly traded companies in the manufacturing sector. Tobin's q is computed as the value of all securities divided by the value of PPE (Property, Plants and Equipment).

Parameter	Value	Source
ν	.75	Atkeson and Kehoe (2005)
δ	.06	NIPA
lpha	.30	K/Y = 1.77
r	.055	FoF, CRSP, DJCBI
$ ho_o$.02	
$ ho_o$.04	
γ	1.6	equation 9
g	.022	NIPA
m_s	0	
σ_s	19% exc. reall. rate	job reallocation - QCEW BLS
S	5% exit rate	entry and exit
ϕ	0.5	wage inequality - QCEW BLS

Table 7: Benchmark Calibration

Notes: This Table lists our benchmark parameter choices. Section 4 justifies these choices and Appendix C provides more details on the data we used. NIPA stands for National Income and Products Accounts, CRSP for Center for Research in Securities Prices, DJCBI for Dow Jones Corporate Bond Index, QCEW stands for Quarterly Census of Employment and Wages, and BLS for Bureau of Labor Statistics. The abbreviation "exc. reall. rate" stands for excess reallocation rate in the initial steady state.

	Std Wages	75%-25% Wages	90%-10% Wages
1975-1979	0.214	0.291	0.532
1980-1984	0.229	0.293	0.572
1985-1989	0.242	0.308	0.585
1990-1994	0.251	0.316	0.611
1995-1999	0.269	0.328	0.657
2000-2004	0.287	0.345	0.679

Table 8: Increasing Intra-Industry, Between-Establishment Wage Dispersion

Notes: std wages is the time-averaged cross-sectional standard deviation for the log of wages per employee within a 2-digit industry. 75%-25% wages is the average inter-quartile range for log wages and 90%-10% wages is the average inter-decile range for log wages. Each number represents an equally-weighted average across 55 industries. Data are from the Quarterly Census of Employment and Wages program run by the Bureau of Labor Statistics.

	Log Compensation			Log Productivity			
	Std	IQR	IDR	Std	IQR	IDR	
before	0.95	0.01	0.08	10.78	18.47	29.13	
1971-1975	3.57	0.02	3.26	10.81	18.28	29.23	
1976-1980	1.32	0.01	0.09	10.99	18.53	29.05	
1981-1985	1.59	0.01	0.10	11.22	18.64	29.20	
1986-1990	2.25	0.01	0.11	11.37	18.44	29.85	
1991-1995	4.36	0.03	0.13	11.63	18.27	30.65	
1996-2000	5.70	0.08	9.37	12.14	18.99	31.89	
2001-2005	8.66	0.12	8.60	12.46	18.89	32.72	
2006-2010	10.51	6.87	16.23	12.86	19.52	33.53	
2011-2015	11.90	8.53	14.55	13.18	20.10	34.27	
after	37.83	0.06	47.52	16.75	23.37	42.15	

 Table 9: Compensation and Productivity Along the Transition Path

Notes: The economy transitions from high vintage-specific growth $g_{\theta,0}$ before 1971 to low vintage-specific growth $g_{\theta,T}$ after 1971. The transition takes place over T = 20 years. The table reports the cross-sectional standard deviation (Std), inter-quartile range (IQR) and the inter-decile range (IDR) for log compensation $\log \tilde{c}$ and \log productivity $(1 - \nu) \log \hat{A}$ in percentage points. The results are for the benchmark parameters.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	EREALL	EXIT	NPS	GPS	$Tobin's \ q$	V/Y	M/Y
before	18.92	4.32	4.23	15.75	1.43	0.83	6.77
1971-1975	18.23	7.78	4.70	16.20	1.41	0.78	6.50
1976-1980	16.59	6.63	5.53	17.17	1.45	0.84	6.39
1981-1985	15.24	5.51	6.61	18.33	1.48	0.90	6.24
1986-1990	13.48	3.94	7.85	19.41	1.52	0.96	6.05
1991-1995	12.83	3.52	8.78	20.33	1.56	1.03	5.94
1996-2000	12.57	3.33	10.15	21.61	1.60	1.10	5.85
2001-2005	11.97	2.71	11.94	23.10	1.63	1.15	5.80
2006-2010	11.93	2.75	12.80	24.01	1.65	1.20	5.78
2011-2015	11.87	2.63	13.68	24.76	1.67	1.23	5.75
after	11.19	1.06	21.11	32.02	1.66	1.20	4.37

 Table 10:
 Main Aggregates Along Transition Path

Notes: The economy transitions from high vintage-specific growth $g_{\theta,0}$ before 1971 to low vintage-specific growth $g_{\theta,T}$ after 1971. The transition takes place over T = 20 years. The table reports the excess job reallocation rate (EREALL), the entry/exit rate (EXIT), the net payout share (NPS), the gross payout share *GPS*, Tobin's q, the ratio of aggregate firm value to output (V/Y), and the ratio of managerial wealth to output (M/Y). The results are for the benchmark parameters.

percentile	95	90	80	70	60	50	40	30	20	10
1971-1975	1.98	1.87	1.71	1.58	1.46	1.35	1.26	1.18	1.11	1.05
1976-1980	2.05	1.93	1.75	1.62	1.50	1.39	1.29	1.21	1.13	1.06
1981-1985	2.14	1.99	1.80	1.65	1.53	1.41	1.31	1.22	1.14	1.07
1986-1989	2.24	2.06	1.86	1.71	1.57	1.45	1.35	1.25	1.16	1.09
1991-1995	2.36	2.14	1.92	1.75	1.62	1.49	1.38	1.28	1.19	1.10
1996-2000	2.44	2.20	1.95	1.79	1.65	1.52	1.41	1.30	1.20	1.11
2001-2005	2.48	2.23	1.98	1.81	1.66	1.53	1.41	1.30	1.20	1.11
after	2.77	2.42	2.09	1.90	1.74	1.59	1.46	1.34	1.23	1.12

Table 11: Cross-section of Tobin's Q

Notes: The economy transitions from high vintage-specific growth $g_{\theta,0}$ before 1971 to low vintage-specific growth $g_{\theta,T}$ after 1971. The transition takes place over T = 20 years. The table reports the ratio of market value of the establishment to the aggregate capital stock, at different percentiles of the cross-sectional market value distribution. The results are for the benchmark parameters.

	(1)	(2)	(3)	(4)
Constant	0.167 (0.004)***	0.170 (0.004)***	0.140 (0.004)***	0.140 $(0.005)^{***}$
INTAN			0.075 $(0.005)^{***}$	0.084 $(0.005)^{***}$
EREALL	-0.300 $(0.067)^{***}$		-0.071 (0.068)	
REALL		-0.306 $(0.067)^{***}$		-0.061 (0.067)
EREALL*INTAN			-0.612 $(0.063)^{***}$	
REALL*INTAN				-0.640 $(0.064)^{***}$
Δ Payout Ratio / Δ EREALL			-0.273 (0.067)***	
Δ Payout Ratio / Δ REALL				-0.272 $(0.066)^{***}$
Number of Industries		4	7	
Observations		54	52	

 Table 12:
 Cross-sectional Results: Payout Ratios

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. This table reports fixed effects estimates of the Payout Ratio (Payout Ratio) on Excess Job Reallocation (*EREALL*), Job Reallocation (*REALL*), Intangibles Ratio (*INTAN*), the interaction of Excess Job Reallocation Intangibles Ratio (*EREALLINTAN*) and the interaction of Job Reallocation and Intangibles Ratio (*REALL*INTAN*) for the periods 1976-2005. The definition of these variables is detailed in Appendix A.3. Partial effects of changes in Excess Job Reallocation and Job Reallocation on the Payout Ratio are also reported. Robust standard errors are shown in parentheses.

	(1)	(2)	(3)	(4)
Constant	1.349 (0.021)***	1.303 (0.018)***	1.462 (0.014)***	1.427 (0.012)***
EREALL	-2.004 (0.317)***		-1.507 (0.229)***	
REALL		-1.462 (0.320)***		-1.108 (0.228)***
Number of Industries Observations	47 5452			

Table 13: Cross-sectional Results: Tobin's q

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. This table reports fixed effects estimates of *Tobin q1* and *Tobin q2* on Excess Job Reallocation (*EREALL*), Job Reallocation (*REALL*), for the periods 1976-2005. The definition of these variables is detailed in Appendix A.3. Robust standard errors are shown in parentheses.

Figure 1: Payout Share

The dashed line is the quarterly net payout share (NPS), defined as net pay-outs to securities holders for the non-financial, non-farm corporate sector (Flow of Funds), divided by value-added (NIPA). The solid line is the 8-quarter moving average of the dashed line.



Figure 2: Payout Share: FoF vs. NIPA

The dashed line is the 8-quarter moving average of the net payout share (NPS), defined as the sum of net payouts to securities holders, divided by value-added, computed using NIPA data for the non-financial corporate sector. The full line is the 8-quarter moving average of the net payout share (NPS) computed using FoF data for the non-financial, non-farm corporate sector.



Figure 3: Optimal Compensation Contract

This figure plots the evolution of the optimal current consumption of the manager $\log \tilde{c}$ (dashed line) alongside the evolution of the establishment's organizational capital $\log \hat{A}$ (full line). The latter is a measure of size and productivity of the establishment. The two time-series are produced by simulating model for 300 periods (horizontal axis) under the benchmark calibration described below ($\phi = .5$).



Figure 4: Excess Reallocation Rate

The dashed line is the excess reallocation rate for the manufacturing sector, constructed by Faberman (2006). The excess job reallocation rate is a direct measure of the cross-sectional dispersion of establishment growth rates. It is defined as the the sum of the job creation rate plus the job destruction rate less the net employment growth rate. The Faberman data are extended to 2007. I using BLS data. The solid line is the 8-quarter moving average.



Figure 5: Summary Transitional Dynamics of Ky Aggregates

The economy transitions from high vintage-specific growth $g_{\theta,0}$ before 1971 to low vintage-specific growth $g_{\theta,T}$ after 1971. The transition takes place over T = 20 years. The results are for the benchmark parameters.



Figure 6: From Low-Powered to High-Powered Incentives

Plot of log compensation against log size of establishment. The left panel shows the initial steady-state growth path (high vintage-specific growth). The right panel shows the new steady-state growth path (high general productivity growth). The data are generated form the model under its benchmark calibration.



Figure 7: Compensation and Size Distribution in the New Steady State

Histogram of log compensation and log size of establishments. The data are generated form the model's new steady state (high general productivity growth) under its benchmark calibration.



Figure 8: Size Distribution in the New Steady State

The figure plots the relationship between the log size of establishments on the horizontal axis and the rank in the distribution log(Rank - .5) on the vertical axis. The figure is for the new steady state growth path under our benchmark calibration.



Figure 9: Cross-section of Managerial Wealth-to-Output

This figure shows the ratio of managerial wealth to aggregate output at different percentiles. We ranked establishments according to managerial compensation. The economy transitions from high vintage-specific growth $g_{\theta,T}$ after 1971. The transition takes place over T = 20 years. The results are for the benchmark parameters.

