The Journal of FINANCE
The Journal of THE AMERICAN FINANCE ASSOCIATION

THE JOURNAL OF FINANCE • VOL. LXVIII, NO. 4 • AUGUST 2013

Organization Capital and the Cross-Section of Expected Returns

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ABSTRACT

Organization capital is a production factor that is embodied in the firm's key talent and has an efficiency that is firm specific. Hence, both shareholders and key talent have a claim to its cash flows. We develop a model in which the outside option of the key talent determines the share of firm cash flows that accrue to shareholders. This outside option varies systematically and renders firms with high organization capital riskier from shareholders' perspective. We find that firms with more organization capital have average returns that are 4.6% higher than firms with less organization capital.

IN RECENT DECADES, INTANGIBLE capital has become an increasingly important factor of production. In many instances, such intangible capital is embodied in the firm's key employees. We refer to this type of intangible capital as organization capital and develop a structural model to analyze its effect on asset prices. We argue that shareholders consider firms with high levels of organization capital to be riskier than firms with more physical capital, and provide empirical evidence supporting this claim.

Organization capital is a durable input in production that is distinct from physical capital. In our model, the distinguishing features of organization capital are that its efficiency is partly firm specific and that it is embodied in the firm's key talent. Together, these two characteristics imply that both shareholders and key talent have a claim on the cash flows accruing from organization capital. Since shareholders can appropriate only a fraction of the cash flows from organization capital, investing in firms with high organization capital exposes them to additional risks.

*Eisfeldt is with Anderson School of Management, UCLA. Papanikolaou is with Kellogg School of Management, Northwestern University and NBER. We thank the editor (Cam Harvey), the Associate Editor, two anonymous referees, and Frederico Belo, Nicholas Bloom, John Cochrane, Leonid Kogan, Hanno Lustig, Joshua Pollet, Jayanthi Sunder, Lu Zhang, and seminar participants at the American Economic Association, Booth School of Business, Instituto de Estudios Superiores de la Empresa (IESE), Escuela Superior de Administracion y Direccion de Empresas (ESADE), Norwegian School of Economics, Northwestern University, Ohio State University, Society of Economic Dynamics, Stanford Institute of Theoretical Economics, Toulouse School of Economics, University of California, Los Angeles, University of Illinois at Urbana-Champaign, University of Washington, and the Western Finance Association for helpful comments and discussions. We thank Carola Frydman and Erik Loualiche for sharing their data, and Tyler Muir and Omair Syed for expert research assistance. Dimitris Papanikolaou thanks the Zell Center for financial support.

DOI: 10.1111/jofi.12034

The cash flows that accrue to shareholders are determined in part by the division of surplus between shareholders and key talent. In our model, this sharing rule depends on the shock to the level of productivity of organization capital deployed in new firms, which we refer to as the level of frontier organization capital technology. This shock determines the outside option of key talent and hence the share of cash flows from organization capital that shareholders can appropriate.

As a result, shareholders' cash flows from physical and organization capital have different risk exposures to the frontier technology shock. If the frontier technology shock is correlated with shareholders' marginal utility, heterogeneity in firms' asset composition between physical and organization capital leads to differences in risk premia, as shareholders demand compensation for the additional risk they are exposed to.

To study the empirical relation between organization capital and risk premia, we construct a measure of organization capital using widely available accounting data. Following the accounting literature on measuring organization capital (see, e.g., Lev and Radhakrishnan (2005)), we measure the stock of organization capital by cumulating firms' selling, general, and administrative (SG&A) expenses using the perpetual inventory method. We rank firms based on their ratio of organization capital to book assets relative to their industry peers (O/K), since the accounting treatment of SG&A expenses varies across industries.

Our measure of organization capital is correlated with a number of firm characteristics in a manner that is consistent with our model. We find that high-O/K firms are more productive, smaller, have higher Tobin's Q, and display higher levels of executive compensation. In addition, high-O/K firms have higher managerial quality scores according to the measure of Bloom and Van Reenen (2007), spend more on information technology (IT), and are more likely to list "loss of key personnel" as a risk factor in their 10-K filings. Furthermore, our model implies that the sensitivity of firm profits to firm output increases with the ratio of organization to physical capital, whereas the sensitivity of firm profits to aggregate output is the same across firms. We find support for these implications in the data.

The evidence suggests that shareholders demand higher risk premia to invest in firms with high levels of organization capital relative to firms with more physical capital. We document this difference in risk premia by constructing a portfolio that is long firms with more organization capital relative to their peers (high-O/K) and short firms with more physical capital relative to their peers (low-O/K). The portfolio of firms with high-O/K minus low-O/K (the OMK portfolio) has average returns of 4.7% per year and a Sharpe ratio close to the market portfolio. Moreover, the OMK portfolio is uncorrelated with other risk factors such as the market portfolio, size, value, or momentum. Thus, the dispersion in expected returns arising from heterogeneity in the ratio of organization capital to assets is not explained by the capital asset pricing model (CAPM), Fama and French (1993), or Carhart (1997) models.

Our model implies that this spread in average returns arises because the OMK portfolio is negatively correlated with the systematic frontier technology shock. Empirically, we find that a two-factor model that includes the market and the OMK portfolio prices the cross-section of firms sorted on O/K or on their beta with the OMK portfolio. In addition, and consistent with our model, the realized return of the OMK portfolio is negatively correlated with the aggregate level of compensation to key talent, the level of reallocation, and the level of investment in organization capital.

We calibrate our structural model and show that it can quantitatively replicate our empirical findings. Our model matches the dispersion in firm characteristics and risk premia associated with organization capital. In our calibration, we assume that the frontier technology shock carries a negative risk premium. An improvement in the frontier technology leads to more restructuring and reallocation of organization capital from old firms to new firms. Since restructuring entails substantial costs in the short run, this assumption is consistent with general equilibrium. We also provide generalized method of moments (GMM) estimates of the market price of risk associated with the frontier technology shock, and find that it is negative for all three of our proxies for the frontier shock.

In summary, our work identifies a new source of risk for shareholders: systematic fluctuations in the division of surplus between key talent and shareholders. From the perspective of shareholders, investing in key talent and organization capital is risky, since, unlike physical capital, shareholders do not own all of the cash flow rights. Key talent may leave the firm when their outside option exceeds their inside value. Consequently, organization capital has risk characteristics distinct from those of physical capital, and the risk inherent in this type of specific and intangible form of capital requires significant risk premia.

Our paper belongs to a growing body of work that explores the role of organization capital in the production process and analyzes its properties (Prescott and Visscher (1980), Hall (2000b), Atkeson and Kehoe (2005), Carlin, Chowdhry, and Garmaise (2011), Lustig, Syverson, and Van Nieuwerburgh (2011)). The closest paper to ours is Lustig, Syverson, and Van Nieuwerburgh (2011), who argue that the growing importance of organization capital in the production process is one of the leading causes of the observed increase in compensation inequality and pay-for-performance sensitivity, and the accompanying decrease in labor market reallocation. Our work builds upon Atkeson and Kehoe (2005) and Lustig, Syverson, and Van Nieuwerburgh (2011), to introduce a common stochastic component in the productivity of organization capital in new firms, or frontier technology using the language of Atkeson and Kehoe (2005).

Moreover, our paper is related to the production-based asset pricing literature (Cochrane (1991, 1996)) and in particular to models with endogenous production (Berk, Green, and Naik (1999), Gomes, Kogan, and Zhang (2003), Zhang (2005), Bazdrech, Belo, and Lin (2009)). Most of these models feature a single aggregate shock and generate heterogeneity in asset risk premia through endogenous movements in conditional betas with the market portfolio. In contrast, our model generates heterogeneity in asset risk premia through exposure to a second systematic source of risk, the frontier level of technology, which affects the division of surplus between shareholders and key talent. This systematic shock is an example of technical change embodied in human capital. The macroeconomic literature argues that human-capital-embodied technological change is important for understanding the dynamic behavior of income inequality in the data (Chari and Hopenhayn (1991), Greenwood (1999), Krusell Ohanian, Rios-Rull, and Volante. (2000)).

Our model captures the idea that key talent and shareholders have a joint claim on the cash flows produced by the firm. Mounting evidence suggests that executives significantly affect corporate outcomes (Bertrand and Schoar (2003), Adams, Almeida, and Ferreira (2009), Graham, Harvey, and Puri (2009), Bennedsen, Pérez-González, and Wolfenzon (2011)). In addition, pay of corporate executives accounts for a significant fraction of corporate earnings. Bebchuk (2005) documents that the ratio of executive pay to corporate earnings has risen dramatically in recent years. New evidence suggests that broader classifications of key talent are also important for firm performance. Bernstein (2012) documents the departure of skilled inventors in firms post-IPO, which is associated with a subsequent decline in innovation activity. On the valuation side, Tate and Yang (2011) provide evidence using matched worker/plant data that high-skill workers in diversified firms have better ex-post outcomes following plant closures. Using our model, they argue that the diversification discount may be due to the higher outside option of skilled labor in diversified firms.

There are inherent difficulties involved in the measurement of organization capital (Blair and Wallman (2001), Black and Lynch (2005)). Black and Lynch (2005, p. 206) argue that one of the main difficulties is that organization capital "cannot be wholly controlled by the firm." Our measure of organization capital is motivated by Lev and Radhakrishnan (2005), who argue that firm SG&A expenditures create corporate value through the formation of organization capital. A number of papers in the organization literature measure the quality of the firm's organizational structure and management practices using surveys (Caroli and Van Reenen (2001), Bresnahan, Brynjolfsson, and Hitt (2002), Bloom and Van Reenen (2007)). Our measure has the advantage that it is readily available for a long time period and a large number of firms. The second alternative method of measuring organization capital is as a residual from a structural model. While this methodology avoids some of the difficulties inherent in measuring intangibles, the resulting estimates are sensitive to the model specification. McGrattan and Prescott (2001) and Hall (2000a, 2001) argue that intangible capital played an important role in the valuation of the U.S. corporate sector in the 1990s. Using a structural model with technology adoption, Atkeson and Kehoe (2005) estimate that the payment flows to the owners of organization capital constitute 8% of output for manufacturing firms. Hansen, Heaton, and Li (2005) measure intangible capital by requiring that the risk adjusted investment returns to total capital be equal across firms.

The rest of the paper is organized as follows Section I develops our modeling framework, Section II details our procedure for measuring organization capital, Section III explores the model's predictions, and Section IV concludes. Details on data construction are delegated to the Appendix.

I. Model

We develop a model illustrating how, from shareholders' perspective, investment in organization capital entails different risks from investment in physical capital. In our view, there are two defining characteristics of organization capital. First, organization capital is embodied in highly specialized labor inputs, and thus is distinct from physical capital. We refer to these specialized labor inputs as key talent throughout the paper, examples of which are management and technical personnel that are essential to the firm. Second, the efficiency of organization capital is specific to the firm, which distinguishes it from general human capital. Hence, an alternative to organization capital could be firm-specific human capital, consistent with the views in Prescott and Visscher (1980). Under this more narrow definition, one could view investment in organization capital as expenditures on hiring and training key talent. Hired and trained key talent would increase overall firm cash flow, but would require higher compensation when their outside option improved.

The unique nature of organization capital implies that both shareholders and key talent have a claim to its cash flows. In particular, organization capital is embodied in key talent, and is therefore potentially movable across firms. As a result, key talent can extract a payment from shareholders equal to their outside option. The value of this claim depends on the efficiency of organization capital in new firms. Shareholders have a claim to the residual cash flows, and the value of this claim depends on the difference between the inside and outside value of organization capital. Furthermore, systematic movements in the efficiency of organization capital in new firms lead to systematic movements in the division of organization capital rents between shareholders and key talent. Therefore, shareholders investing in firms with organization capital are exposed to additional risks.

We first present a simple model in Section I.A that illustrates these ideas and yields closed-form solutions. We extend the basic model along a number of dimensions in Section I.B. The extended model yields additional predictions and helps us assess the quantitative importance of organization capital in explaining the cross section of expected returns.

A. Basic Model

There exists a continuum of firms that produce a common output good using physical capital K and organization capital O. Given an endowment of physical and organization capital, firm i produces a flow of output given by

$$y_{i,t} = \theta_t K_i + \theta_t e^{\varepsilon_i} O_i. \tag{1}$$

Both capital stocks are subject to an aggregate, disembodied technology shock θ. In addition, the productivity of the firm's stock of organization capital O_i depends on the efficiency of that firm's organization ε_i. The level of efficiency ε_i can be viewed as the quality of the match between the firm and key talent. The firm-specificity of ε captures the idea that part of the knowledge embodied in organization capital is specific to the firm. For now we assume that the endowment of physical capital K_i and organization capital O_i, as well as the efficiency of the firm's organization ε_i, are constant over time.[1]

The total factor productivity (TFP) shock θ evolves according to a geometric random walk,

$$d\theta_t = \sigma_\theta \, \theta_t \, dZ_t^\theta, \tag{2}$$

where dZ_t^θ is a Wiener process and σ_θ corresponds to the volatility of the common TFP shock θ. The productivity shock θ affects physical and organization capital symmetrically, thus all firms have the same sensitivity of revenue to θ.

In the spirit of Atkeson and Kehoe (2005), new technologies that improve the frontier efficiency of organization capital emerge over time. Key talent can either upgrade the organizational efficiency in the existing firm (restructure) or leave the existing firm along with part of the accumulated knowledge and existing organization structure O to a newly created firm (reallocation).[2] Given the existence of this outside option, key talent can always extract all of the surplus from restructuring. Creating a new firm requires a positive amount of physical capital K_i. Key talent can buy this physical capital at its competitive market price, and finance this purchase by issuing shares in the new firm. Existing shareholders are thus indifferent between selling their claim to physical capital K_i to key talent or restructuring the existing firm. As a result, the model is silent as to the form of the technology adoption process. For parsimony, in our discussion of the model we assume the former.

Our model implies that new technologies are adopted through a process of creation and destruction, whereby inefficient organization technologies are replaced with the frontier level of organizational efficiency. This process of creation and destruction can be interpreted in several ways. For instance, if the shareholders in the new firm are different from the shareholders in the existing firm, then this process resembles a management buy-out, a start-up, or other form of venture financing, depending on how the purchase of physical capital is financed. Alternatively, if the shareholders in the old firm also own shares in the new firm, then we can interpret this process as a restructuring event. In this case, when the firm decides to upgrade its organization capital, the firm undergoes a period of extensive reorganization that leads to a higher level of organization efficiency.

[1] Our production function is similar to that in van Rens (2004) and assumes that there are no complementarities between organization and physical capital. This assumption allows us to preserve tractability and illustrate our economic mechanism. Exploring the complementarities between organization and physical capital could be important, but we leave such investigation to future work.

[2] For simplicity, we assume that the old firm loses the organization capital as a result of key talent leaving. This assumption captures not just the direct loss in firm value due to key talent leaving the firm, but also indirect losses due to increased competition in the product market by firms that now have inside knowledge of the firm's corporate practices. Several papers provide empirical evidence that changes in management affect value (Bertrand and Schoar (2003), Adams, Almeida, and Ferreira (2009), Graham, Harvey, and Puri (2009), Bennedsen, Pérez-González, and Wolfenzon (2011)), and that loss of key employees reduces innovation (Bernstein (2012)). In Section II.B we provide evidence from 10-K's that loss of key personnel destroys value in high organization capital firms.

Key talent thus optimally chooses the time τ at which to exercise their option to upgrade to the frontier technology. After this option is exercised, the new firm operates at a level of organizational efficiency $\varepsilon_i = x_\tau$ forever. The level of frontier efficiency x evolves according to a random walk,

$$dx_t = \sigma_x \, dZ_t^x, \tag{3}$$

where σ_x is the volatility of x and dZ_t^x is a Wiener process independent from dZ_t^θ. Equation (3) implies that the frontier level of organizational efficiency x varies systematically, capturing the idea that the benefit of upgrading to new technologies varies with the state of the economy. For now, we assume that the option to upgrade to the frontier technology can be exercised only once.

The stochastic discount factor (SDF) in this economy is given by

$$d\pi_t = -r_f \, \pi_t \, dt - \gamma_\theta \, \pi_t \, dZ_t^\theta - \gamma_x \, \pi_t \, dZ_t^x, \tag{4}$$

where the parameters r_f, γ_θ, and γ_x correspond to the interest rate, the price of risk for the aggregate technological shock θ, and the price of risk for the frontier shock x, respectively.

The value of an existing firm equals the sum of the value of physical capital plus the value of organization capital:

$$V_{it} = V_{it}^K + V_{it}^O. \tag{5}$$

Given the specification of output (1), the SDF (4), and the value of the option to upgrade to a new level of organization efficiency, we value each component of firm value in equation (5) separately. We then determine the division of the value of organization capital V^O between shareholders and key talent.

The value of physical capital V^K equals the present value of the cash flows accruing from physical capital discounted at the risk-adjusted rate $\bar{r} = r_f + \sigma_\theta \, \gamma_\theta$:

$$V^K(\theta_t, K_i) = E_t \int_t^\infty \frac{\pi_s}{\pi_t} \theta_s \, K_i \, ds = \frac{\theta_t}{\bar{r}} \, K_i. \tag{6}$$

Shareholders own the claim to the firm's physical capital K_i, and thus they can fully appropriate V^K.

The value of organization capital V^O equals the present value of the discounted future cash flows during the time that organization capital remains with the firm ($t < \tau$), plus its outside value $\overline{V}^O$ in the event of reallocation at the optimal stopping time τ:

$$V^O(\theta_t, O_i, \varepsilon_i, x_t) = E_t \int_t^\tau \frac{\pi_s}{\pi_t} \theta_s \, e^{\varepsilon_i} \, O_i \, ds + E_t \left[\frac{\pi_\tau}{\pi_t} \, \overline{V}^O(\theta_\tau, O_i, x_\tau) \right]. \tag{7}$$

If key talent exercises their outside option at time τ, then organization capital will forever operate at the efficiency level $\varepsilon_i = x_\tau$. Thus, the value of organization capital once the outside option is exercised equals

$$\overline{V}^O(\theta_t, O_i, x_t) = E_t \int_t^\infty \frac{\pi_s}{\pi_t} \theta_s \, e^{x_t} \, O_i \, ds = \frac{\theta_t}{\bar{r}} \, e^{x_t} \, O_i. \tag{8}$$

Key talent will optimally choose the stopping time τ, balancing the gains from reallocation versus the value of the option to wait. When the efficiency of organization capital ε_i lags behind the frontier x_t, the owners of the organization capital have an incentive to leave for a newly created firm. The gain from reallocation depends on the value of the inside option minus the outside option, that is, on ε_i relative to x_t. As a result, key talent will reallocate organization capital to a new firm once the value of the frontier efficiency x exceeds the level of productivity in the existing firm ε_i by a sufficient amount. This threshold $\varepsilon^*(x)$ below which reallocation occurs is determined by the indifference condition

$$V^O(\theta_t, O_i, \varepsilon^*(x_t), x_t) = \overline{V}^O(\theta_t, O_i, x_t). \tag{9}$$

The following proposition solves for the value of organization capital in equation (7) and the optimal exercise boundary $\varepsilon^*(x)$ in closed form:

PROPOSITION 1: *The value of organization capital equals*

$$V^O(\theta_t, O_i, \varepsilon_i, x_t) = \frac{\theta_t}{\bar{r}} O_i \left[e^{\varepsilon_i} + \frac{\sigma_x}{\sqrt{2\bar{r}}} e^{\bar{x}_i + \frac{\sqrt{2\bar{r}}}{\sigma_x}(x_t - \bar{x}_i)} \right], \tag{10}$$

where $\bar{x}_i = \varepsilon_i - \log(1 - \frac{\sigma_x}{\sqrt{2\bar{r}}})$*. The threshold* $\varepsilon^*(x)$ *at which it is optimal to reallocate the organization capital is given by*

$$\varepsilon^*(x_t) = x_t + \log\left(1 - \frac{\sigma_x}{\sqrt{2\bar{r}}}\right). \tag{11}$$

Proof: Key talent faces an optimal stopping time problem. Key talent chooses a threshold $\bar{x}$ such that it adopts the new technology if $x_t \geq \bar{x}$. We conjecture that the value of organization capital equals $\theta_t O_i v(x)$. Equation (7) implies that, for $t < \tau$, the unknown function $v(x)$ satisfies the ordinary differential equation

$$e^{\varepsilon} - \bar{r} v(x) + \frac{1}{2}\sigma_x^2 v_{xx}(x) = 0 \qquad \text{if} \quad x < \bar{x}.$$

The solution to the ordinary differential equation is given by

$$v(x_t) = \frac{e^{\varepsilon_i}}{\bar{r}} + C_1 e^{\frac{\sqrt{2\bar{r}}}{\sigma_x} x_t} + C_2 e^{-\frac{\sqrt{2\bar{r}}}{\sigma_x} x_t}.$$

The three unknown constants $\bar{x}$, C_1, and C_2 are jointly determined by: (i) the boundary condition $\lim_{x \to -\infty} V^O(\theta_t, O_i, \varepsilon_i, x_t) = \frac{\theta_t}{\bar{r}} e^{\varepsilon_i} O_i$, which guarantees that the option to move to the new technology is worthless when x is very low, implying that $C_2 = 0$; (ii) the smooth-pasting condition $v_x(\bar{x}) = e^{\bar{x}}/\bar{r}$; and (iii) the indifference (value-matching) condition $v(\bar{x}) = e^{\bar{x}}/\bar{r}$. Under the regularity condition $\bar{r} > \frac{1}{2}\sigma_x^2$, the exercise threshold $\bar{x}$ is finite, and equals $\bar{x}_i = \varepsilon_i - \log(1 - \frac{\sigma_x}{\sqrt{2\bar{r}}})$. Rearranging this equation yields the threshold $\varepsilon^*(x)$ in (11). Q.E.D

Proposition 1 solves for the total value of organization capital V^O. The value of organization capital is increasing in both the level of organization efficiency in the existing firm ε_i and the level of frontier technology x. This value V^O must be split between shareholders and key talent, since both have a claim on the cash flows accruing from organization capital O. Hence, the final step to determining the shareholder value of the firm consists of computing the value of organization capital that can be captured by shareholders. This value equals the difference between the total value of organization capital (7) and the rents that key talent can extract.

The rents that key talent can extract from organization capital depend on the efficiency of organization capital in new firms, which is determined by x_t. Prior to time τ, key talent has the option to depart for a new firm and receive a payoff $\overline{V}^O$, given by equation (8). Shareholders can prevent this reallocation by promising key talent a continuation value W_{it} that is at least as high as the key talent's outside option $\overline{V}^O$. We assume that shareholders cannot commit to giving key talent a payoff greater than its outside option, hence $W_{it} = \overline{V}^O_{it}$ always. Thus, the present value of rents that shareholders can extract from organization capital equals the difference between the total value of organization capital (10) and the value of key talent's outside option (8):

$$V^{OS}(\theta_t, O_i, \varepsilon_i, x_t) = \frac{\theta_t}{\bar{r}} O_i \left(e^{\varepsilon_i} + \frac{\sigma_x}{\sqrt{2\bar{r}}} e^{\bar{x} + \frac{\sqrt{2\bar{r}}}{\sigma_x}(x_t - \bar{x})} - e^{x_t} \right). \tag{12}$$

The value that shareholders can extract from organization capital (12) consists of two terms. The first term $\frac{\theta_t}{\bar{r}} O_i e^{\varepsilon_i}$ is increasing in the efficiency level of organization capital, since shareholders own a claim to the firm-specific level of organizational efficiency ε_i. Absent the option to upgrade to the new technology, this would be the only source of value. However, the key talent owns the decision right to leave for a new firm and operate at a level of organization efficiency x, and thus it will capture some rents from organization capital. The value of these rents depends on key talent's outside option, which is determined by x relative to the firm-specific level of efficiency ε_i. Hence, shareholders effectively have a short position in an option whose value is increasing in the level of frontier technology x. The value of this option is captured by the last two terms in equation (12).

The total shareholder value of the firm equals the sum of the values of physical capital (6) and organization capital (12):

$$V^S_{it} = \frac{\theta_t}{\bar{r}} \left[K_i + O_i \left(e^{\varepsilon_i} + \frac{\sigma_x}{\sqrt{2\bar{r}}} e^{\bar{x} + \frac{\sqrt{2\bar{r}}}{\sigma_x}(x_t - \bar{x})} - e^{x_t} \right) \right]. \tag{13}$$

The shareholder value of the firm is decreasing in the level of the frontier technology shock x.[3] Prior to the reallocation of organization capital ($x < \bar{x}_i$), an increase in the frontier shock x leads shareholders to concede more rents to key talent in order to induce them to remain within the firm. When shareholders are

[3] The requirement that the threshold $\bar{x}$ is finite yields $\bar{r} > \frac{1}{2}\sigma_x^2$, which together with $x < \bar{x}$ implies that $V^{OS}_x < 0$.

unwilling to give up more rents to key talent, key talent decides to leave. At the point $x = \bar{x}_i$, the value of organization capital to shareholders (12) is zero and shareholder value consists only of claims to physical capital K_i. Shareholders sell their claim on physical capital K_i at the market price V^K to key talent, which finances this purchase by issuing new shares.

From shareholders' perspective, firms with more organization capital are exposed to additional risks. Even though the total cash flows from organization and physical capital have the same exposure to systematic risks, the division of surplus between key talent and shareholders depends on the level of frontier technology x. An application of Ito's lemma on the shareholder value of the firm (13) implies that the firm's stock return equals

$$\frac{d\,V_{it}^S + D_{it}\,dt}{V_{it}^S} - r_f\,dt = E_t\left[\frac{d\,V_{it}^S + D_{it}\,dt}{V_{it}^S} - r_f\,dt\right] + \sigma_\theta\,dZ_t^\theta - \frac{O_i\,e^{x_t}\left[1 - e^{(\bar{x}_i - x_t)\left(1 - \frac{\sqrt{2\bar{r}}}{\sigma_x}\right)}\right]}{K_i + O_i\left[e^{\varepsilon_i} + \frac{\sigma_x}{\sqrt{2\bar{r}}}\,e^{\bar{x}_i + \frac{\sqrt{2\bar{r}}}{\sigma_x}(x_t - \bar{x}_i)} - e^{x_t}\right]}\,\sigma_x\,dZ_t^x. \quad (14)$$

Firms in this economy are exposed to two distinct sources of risk, namely, the productivity shock θ and the frontier shock x. The shock θ affects the productivity of all capital. Hence, all firms have the same exposure to θ, as we see from the second term in equation (14). By contrast, firms' exposure to the technology shock x is increasing in their ratio of organization to physical capital O/K, which is captured by the last term in equation (14).

Given that the shareholder value of organization capital V^{OS} declines with the level of frontier technology x, our model predicts that high-O/K firms drop in value relative to low-O/K firms following a positive shock to x. Thus, the first prediction of our model is that returns to a portfolio that buys high-O/K firms and sells low-O/K firms (OMK) will be negatively correlated with the frontier technology shock x.

In equilibrium, asset risk premia are determined by factor loadings times the price of risk. Combining the equation characterizing stock returns (14) with the SDF (4) yields

$$E_t\left[\frac{d\,V_{it}^S + D_{it}\,dt}{V_{it}^S} - r_f\,dt\right] = -\mathrm{cov}_t\left[\frac{d\pi_t}{\pi_t}, \frac{d\,V_{it}^S}{V_{it}^S}\right] = \gamma_\theta\sigma_\theta - \gamma_x\,\sigma_x \times \frac{O_i\,e^{x_t}\left[1 - e^{(\bar{x}_i - x_t)\left(1 - \frac{\sqrt{2\bar{r}}}{\sigma_x}\right)}\right]}{K_i + O_i\left[e^{\varepsilon_i} + \frac{\sigma_x}{\sqrt{2\bar{r}}}\,e^{\bar{x}_i + \frac{\sqrt{2\bar{r}}}{\sigma_x}(x_t - \bar{x}_i)} - e^{x_t}\right]}. \quad (15)$$

All firms have the same exposure to the TFP shock θ, and therefore cross-sectional differences in risk premia are driven by heterogeneity in the ratio of organization to physical capital O/K. The price of risk of the frontier shock γ_x determines whether organization capital commands a higher or lower risk premium than physical capital. In our calibration in Section III.A, we argue that a negative risk premium for the frontier shock x is consistent with economic intuition and the difference in average returns between firms with high- and low-organization capital. In Section III.E, we find that the GMM estimate for the market price of frontier shock risk is negative using three proxies for the frontier shock x.

The model presented thus far captures the main intuition of the paper. Organization capital is exposed to an additional source of risk relative to physical capital, because shareholders do not necessarily appropriate all the benefits accruing from it. In particular, shareholders receive lower payments from organization capital when the outside option of key talent improves. Shareholders demand compensation for this risk because the outside option of key talent varies with the state of the economy. In particular, this outside option depends on the productivity of organization capital deployed in new firms, which in our model is captured by the frontier technology shock x. An increase in the frontier shock x reduces the share of cash flows that shareholders can extract from organization capital. As a result, heterogeneity in firms' asset composition O_i/K_i leads to differences in risk exposure to the frontier technology x and differences in risk premia.

B. Extended Model

In this section, we extend the model in Section I.A to allow for endogenous accumulation of physical and organization capital. In addition, we allow the option to upgrade to the new technology to remain active regardless of whether the firm has done so in the past. To ensure that this option is infrequently exercised, we allow for costs to reallocating organization capital. These extensions do not qualitatively affect our inferences derived from the model in Section I.A, but instead generate additional testable predictions that help to validate the model.

As before, there exists a continuum of firms that produce a flow of output given by

$$y_{i,t} = \theta_t \, e^{u_{it}} \, K_{it} + \theta_t \, e^{\varepsilon_{it}} \, O_{it}. \tag{16}$$

The output of the firm is affected by an aggregate disembodied productivity shock θ, whose evolution is given by

$$d\theta_t = \mu_\theta \, \theta_t \, dt + \sigma_\theta \, \theta_t \, dZ_t^\theta. \tag{17}$$

The productivity of a firm's physical and organization capital has firm-specific components u_i and ε_i, respectively. These firm-specific shocks evolve according to

$$du_{i,t} = -\kappa_u \, u_{i,t} \, dt + \sigma_u dZ_t^{u_i}, \tag{18}$$

$$d\varepsilon_{i,t} = -\kappa_\varepsilon\, \varepsilon_{i,t}\, dt + \sigma_\varepsilon dZ_t^{\varepsilon_i}. \tag{19}$$

The firm can accumulate physical and organization capital over time through investment

$$dK_{it} = (i_{Kit} - \delta_K)K_{it}\, dt, \tag{20}$$

$$dO_{it} = (i_{Oit} - \delta_O)O_{it}\, dt. \tag{21}$$

Here, i_K and i_O represent the firm's investment in physical and organization capital, respectively. Physical capital depreciates at a rate δ_K as it physically deteriorates or becomes obsolete. Similarly, organization capital depreciates at a rate δ_O either because it becomes obsolete or because key talent retires.

The firm can increase its stock of physical capital by an absolute amount $i_K K$ by purchasing $c_k/\lambda_k\, i_K^{\lambda_k}\, K$ units of the investment good at a relative price $\xi_t = c_q\, \theta_t$.[4] Therefore, the total output cost of increasing the physical capital stock by an absolute amount $i_K K$ equals

$$C_K(i_K, K; \theta) = \theta\, \frac{c_k\, c_q}{\lambda_k}\, i_K^{\lambda_k}\, K. \tag{22}$$

In our investment cost formulation (22), the values of the parameters $c_k > 0$ and $\lambda_k > 1$ capture the degree of steepness and convexity of the adjustment cost function. Moreover, the marginal cost of investing in physical capital increases in the TFP shock θ.

In addition, the firm can expend resources and increase its stock of organization capital O_i. The firm can increase its stock of organization capital by an absolute amount $i_O\, O$ at a total output cost of

$$C_O(i_O, O; \theta) = \theta\, \frac{c_o}{\lambda_o}\, i_O^{\lambda_o}\, O. \tag{23}$$

Just like physical capital, the creation of new organization capital is subject to convex costs, parameterized by $\lambda_o > 1$ and $c_o > 0$. In addition, the marginal cost of investment in organization capital increases with the common productivity shock θ, which can be interpreted as a congestion cost. For instance, if investment in organization capital requires an input whose supply is independent of θ (i.e., worker time), then the marginal cost would be increasing in θ just as in the case of investment goods.

Similar to the model described in Section I.A, new technologies that improve the frontier efficiency of organization capital emerge over time. In contrast to the model in Section I.A, the option to adopt the new technology can be exercised multiple times. In particular, after the new technology is adopted, the efficiency

[4] Our formulation for the adjustment costs to investment follows Jermann (1998). The assumption that the relative price of new investment goods is increasing in the TFP shock θ arises naturally in general equilibrium, if θ does not affect the productivity of the sector producing investment goods (see, e.g., Papanikolaou (2011)).

of organization capital evolves stochastically according to equation (19). Thus, it may be optimal for key talent to adopt a new technology again in the future. To ensure that the equilibrium distribution of firm-specific productivity levels ε_i is stationary, we assume a mean-reverting formulation for x:

$$dx_t = -\kappa_x \, x_t \, dt + \sigma_x \, dZ_t^x. \tag{24}$$

In contrast to the basic model in Section I.A, adopting the new level of organization efficiency x is costly. Specifically, upgrading an amount O of organization capital to the frontier level of technology involves a cost equal to:

$$C_R(O; \theta) = c_R \, \theta \, O. \tag{25}$$

This assumption is consistent with the findings of Foster, Haltiwanger, and Krizan (2001), who show that reallocation is accompanied by a costly period of learning. Without loss of generality, we assume that this cost is paid by the key talent. This cost could arise if part of the accumulated knowledge embedded in O becomes obsolete with the new technology, if there are interruptions of the production process due to the necessary retraining of workers and adjustment of the organization structure to the new technology, or if there are setup or financing costs involved in starting a new firm.

The solution of the extended model closely follows the solution of the basic model in Section I.A. Hence, we omit the proofs but refer to the reader to the Internet Appendix.[5] The shareholder value of the firm is given by the proposition below:

PROPOSITION 2: *The shareholder value of the firm equals*

$$V_{it}^S = \theta_t [q(u_{it}) \, K_{it} + (v(\varepsilon_{it}, x_t) - \bar{v}(x_t)) \, O_{it}]. \tag{26}$$

The function $q(u)$ is the solution to the Hamilton-Jacobi-Bellman equation

$$0 = \max_{i_K} \left\{ e^u - \frac{c_k \, c_q}{\lambda_k} i_K^{\lambda_K} - (\bar{r} + \delta_K - i_K) q(u) - \kappa_u \, u \, q'(u) + \frac{1}{2} \sigma_u^2 \, q''(u) \right\}, \tag{27}$$

where $\bar{r} = r_f - \mu_\theta + \gamma_\theta \sigma_\theta$. The function $v(\varepsilon, x)$ solves the boundary value problem

$$\begin{aligned} 0 = \max_{i_O} \Bigg\{ & e^{\varepsilon} - \frac{c_o}{\lambda_o} \, i_O^{\lambda_o} - (\bar{r} + \delta_O - i_O) \; v(\varepsilon, x) - \kappa_\varepsilon \, \varepsilon \, v_\varepsilon(\varepsilon, x) + \frac{1}{2} \sigma_\varepsilon^2 v_{\varepsilon\varepsilon}(\varepsilon, x) \\ & - \; \kappa_x \, (x - \overline{x}) v_x(\varepsilon, x) + \frac{1}{2} \sigma_x^2 \; v_{xx}(\varepsilon, x) \Bigg\}, \qquad \textit{if} \quad \varepsilon \geq \varepsilon^*(x), \end{aligned} \tag{28}$$

where $\bar{x} \equiv \dfrac{-\sigma_x \lambda_x}{\kappa_x}$. The outside option of key talent equals $\overline{V}_{it}^O = \theta_t O_{it} \bar{v}(x_t)$, where $\bar{v}(x) \equiv \max[v(x, x) - c_R, 0]$. The reallocation threshold $\varepsilon^*(x)$ is the solution to

[5] An Internet Appendix may be found in the online version of this article.

$v(\varepsilon^*(x), x) = \bar{v}(x)$. *Investment in physical and organization capital is given by*

$$i_K(u) = \left(\frac{q(u)}{c_k\, c_q}\right)^{\frac{1}{\lambda_k - 1}}, \tag{29}$$

$$i_O(\varepsilon, x) = \left(\frac{v(\varepsilon, x)}{c_o}\right)^{\frac{1}{\lambda_o - 1}}. \tag{30}$$

Proposition 2 shows that the shareholder value of the firm is equal to the value of physical capital, plus the value of the rents that shareholders can extract from physical capital. This latter component of shareholder value represents a source of risk that shareholders of firms with high-organization capital are exposed to. Hence, the risk premium required by shareholders to invest in firm i equals

$$\begin{aligned} &E_t\left[\frac{d\,V_{it}^S + D_{it}\,dt}{V_{it}^S} - r_f\,dt\right] \\ &\quad = \left(\gamma_\theta\,\sigma_\theta + \gamma_x\,\sigma_x\,\gamma(\varepsilon_{it}, x_t)\frac{(v(\varepsilon_{it}, x_t) - \bar{v}(x_t))O_{it}}{q(u_{it})\,K_{it} + (v(\varepsilon_{it}, x_t) - \bar{v}(x_t))O_{it}}\right) dt, \end{aligned} \tag{31}$$

where $\gamma(\varepsilon, x) \equiv \partial \log(v(\varepsilon, x) - \bar{v}(x))/\partial x < 0$.

Equation (31) is the counterpart to equation (15) in the basic model. As before, cross-sectional differences in risk premia across firms arise only due to firms' differential sensitivity to the frontier shock x, which is captured by the last term in equation (31). This heterogeneity in firms' exposure to the frontier shock arises due to differences in their asset composition O/K and the firm-specific productivity u and ε. The price of risk of the frontier technology shock γ_x determines the sign and magnitude of the difference in risk premia between organization and physical capital.

In contrast to the basic model, the accumulation of physical and organization capital is an endogenous decision on the part of the firm. In particular, the accumulation of physical and organization capital depends on the firm-specific shocks u_i and ε_i, as we see from equations (29) and (30). In addition, equation (30) shows that investment in organization capital is increasing in the level of frontier technology x.[6]

As before, the presence of constant returns to scale in production implies that firm boundaries are not defined in our model. To resolve this indeterminacy, we assume that, once key talent decides to move to a new firm, existing shareholders sell their claim on physical capital, along with its current level of

[6] We derive this prediction under the assumption that, irrespective of whether management or shareholders alone own the decision right to investment in organization capital, the two parties agree to choose the optimal level of investment i_O that maximizes the total value of organization capital. However, if the level of investment in organization capital is not observable to both parties, then there could be over- or under-investment in organization capital, since both parties do not equally share the costs and benefits. Analyzing the effect of the conflicts of interest between key talent and shareholders in investment in organization capital is an important question that we leave for future research.

productivity u_i, to key talent at its market value. The shareholders are indifferent to doing so, since at that point they earn zero rents from organization capital. Key talent finances this purchase of physical capital by issuing new shares. Our assumption implies that the number of firms is constant, as new firms replace existing firms that lose key talent.

Proposition 2 shows that it is optimal to reallocate organization capital to a new firm if the value of the outside option is high enough, $\varepsilon_{it} \le \varepsilon^*(x_t)$. This reallocation threshold $\varepsilon^*(x)$ is an increasing function of the frontier shock x, since reallocation becomes more attractive when the frontier efficiency level is high. Thus, the amount of technology adoption, regardless of whether it takes the form of reallocation to a new firm or restructuring of the existing firm, is an increasing function of x. Hence, our model implies that the aggregate amount of reallocation or restructuring should be negatively correlated with a portfolio long high-O/K firms and short low-O/K firms. We explore this prediction in Section III.D.

The final step in characterizing the solution to the model is to compute the dynamics of compensation to key talent. Just as in the basic model, we assume that shareholders have limited commitment, hence key talent can extract a value equal at most to its outside option $\overline{V}^O$ from existing shareholders. For the organization capital to remain with the firm, the continuation value of key talent W_{it} has to equal its outside option in all states of the world:

$$W_{it} = \theta_t\, O_{it}\, \bar{v}(x_t). \tag{32}$$

Shareholders can implement this continuation value by promising key talent a flow payment of $w_{it}\, dt$ as long as organization capital remains in the firm. Hence, the continuation value of key talent equals the present value of compensation while organization capital remains in the existing firm plus the option value of moving to a new firm:

$$W_{it} = E_t \int_t^{\tau} \frac{\pi_s}{\pi_t} w_{is} ds + E_t \left[\frac{\pi_\tau}{\pi_t}\, \theta_\tau\, O_{i\tau}\, \bar{v}(x_\tau) \right]. \tag{33}$$

Given equations (32) and (33), we explicitly solve for the dynamics of compensation to key talent w_{it}. The requirement that the key talent's continuation value equals their outside option in every state of the world pins down W_{it} and W_{it+dt}. Shareholders will then compensate key talent in such a way as to ensure that promises are kept, that is, $W_{it} = w_{it}\, dt + E_t[\frac{\pi_{t+dt}}{\pi_t} W_{it+dt}]$ always holds. The following corollary describes the compensation dynamics to key talent:

COROLLARY 1: *Key talent in firm i receives a flow payment $w_{it}\, dt$ every period:*

$$w_{it} = \left(\bar{r} + \delta_O - i_O(\varepsilon_{it}, x_t) + \kappa_x\, (x_t - \bar{x})\, \frac{\overline{v}_x(x_t)}{\overline{v}(x_t)} - \frac{1}{2}\, \sigma_x^2\, \frac{\bar{v}_{xx}(x_t)}{\overline{v}(x_t)} \right) \theta_t\, O_{it}\, \bar{v}(x_t), \tag{34}$$

where $\overline{v}(x)$ is defined in Proposition (2).

Corollary 1 shows that the compensation to key talent is increasing proportionally to the value of its outside option $\bar{v}(x_t)$. Hence, an increase in the frontier technology shock x leads to an increase in the compensation of key talent. The term $\bar{r} + \delta_O$ inside parentheses compensates key talent for the cost of waiting, exposure to the technology shock θ, and the fact that organization capital depreciates over time. The second term inside parentheses is negative and decreasing in the level of investment in organization capital. Key talent is willing to accept lower compensation today in return for the firm increasing its investment in organization capital, since doing so raises key talent's outside option. Hence, the cost of investment in organization capital is implicitly shared between shareholders and key talent. The third term inside parentheses is increasing in x because the frontier shock x is mean reverting. The temporary increase in the outside option implies that key talent receives an accelerated payment today, and hence the compensation to key talent increases faster than its outside option. The last term inside parentheses in equation (34) illustrates that key talent is willing to accept a lower flow payment today as the volatility of the frontier shock x increases, due to the convexity of the outside option $\bar{v}(x)$.

Three additional predictions follow directly from Corollary 1. First, the compensation to key talent (34) is increasing in the level of organization capital O_i. Hence, we expect that firms with more organization capital should have higher levels of executive compensation. Second, the average level of executive compensation $\bar{w}_t = \int w_{it}\, di$ is increasing in the frontier level of efficiency x. As a result, the aggregate level of executive compensation should be negatively correlated with returns to a portfolio long high-O/K firms and short low-O/K firms. Third, the sensitivity of firm profits to firm output increases with the ratio of organization to physical capital. To see this last prediction, note that compensation to key talent (34) does not increase with the firm-specific shocks u_i and ε_i. Therefore, firm earnings (defined as $y_i - w_i$) will increase by a proportionally greater amount than firm output y_i following a positive shock to either u_i or ε_i. This increased sensitivity depends on the ratio w_i/y_i, which itself is increasing in O/K. By contrast, compensation to key talent w_{it} increases proportionally with θ, implying that the elasticity of firm profits with respect to aggregate output is independent of the level of organization to physical capital. We explore these predictions in Section III.D.

II. Measuring Organization Capital

A. Methodology

Our model suggests that we use a measure that captures investment in capital that is intangible, specific, and closely tied to labor inputs. We construct a direct measure of organization capital using SG&A expenditures. The U.S. GAAP definition of SG&A expenses states that this item represents all commercial expenses of operation (i.e., expenses not directly related to product production) incurred in the regular course of business pertaining to the securing of operating income. A large part of SG&A consists of expenses related to labor and IT (white collar wages, training, consulting, and IT expenses), consistent with the idea that any accrued value will be somewhat firm specific and must be shared with key talent.

Our measure is motivated by Lev and Radhakrishnan (2005), who use SG&A to measure flows to organization capital. SG&A contains the part of labor expenses that cannot be directly attributed to a particular unit of output. Hence, any spending on the part of the firm to increase its organization capital will be included in SG&A expenses. Lev and Radhakrishnan (2005) and Lev (2001) present detailed arguments and examples of how resources allocated to this expense item yield improvements in employee incentives, internal communication systems, distribution systems, and other examples of organization capital. Our methodology is also consistent with advice from popular textbooks on value investing, which advocate capitalizing SG&A expenses to detect off-balance-sheet sources of firm value Greenwald et al. (2004).

We construct the stock of organization capital O using the perpetual inventory method.[7] Specifically, we recursively construct the stock of organization capital by cumulating the deflated value of SG&A expenses,

$$O_{it} = (1 - \delta_O)O_{it-1} + \frac{SGA_{i,t}}{cpi_t}, \tag{35}$$

where cpi_t denotes the consumer price index. To implement the law of motion in equation (35) we must choose an initial stock and a depreciation rate. We choose the initial stock according to

$$O_0 = \frac{SGA_1}{g + \delta_O}. \tag{36}$$

For most of our analysis, we use a depreciation rate of 15%, which is equal to the depreciation rate used by the BEA in its estimation of R&D capital in 2006. We choose g to match the average real growth rate of firm-level SG&A expenditures, which in our sample equals 10%. Finally, we treat missing values in the SG&A as zero. Our results are robust to a choice of depreciation rate δ_O between 10% and 50%, and to dropping the first 5 years of data for every firm, which minimizes the impact of the initialization scheme O_0 (see the Internet Appendix for more details). We scale organization capital O by the firm's book assets K.

To the extent that some SG&A expenditures do not constitute investment in organization capital, we measure this capital with error. If the fraction of SG&A expenses that represents investment in organization capital does not vary across firms, this error will not affect firms' ranking in terms of O/K. However, accounting practices governing the exact composition of SG&A expenditures vary across industries, and hence this error may have an industry component. To address this concern, in our empirical work we rank firms on their ratio of organization capital to assets O/K relative to their industry

[7] The Bureau of Economic Analysis (BEA) uses a similar methodology to construct a stock of research and development (R&D) capital; see Sliker (2007).

peers. Specifically, we first group firms into 17 industries based on the Fama and French (1997) classification. Then, within each industry, we assign firms a rank (1 to 5) based on the firm's quintile of the ratio of organization capital to book assets. Finally, we form five value-weighted portfolios based on each firm's within-industry organization capital rank, and rebalance these portfolios in June every year. Therefore, portfolio 1 (5) contains firms in the lowest (highest) O/K quintile in each industry. This procedure ensures that our results are driven by within—rather than between—industry variation in the contribution of organization capital to firm value.

Our sample includes all nonfinancial firms in Compustat with fiscal year ending in December with common shares that are traded on NYSE, AMEX, or NASDAQ, that have nonmissing SIC codes and nonzero values of organization capital. Our sample includes a total of 5,917 firms, which collectively represent about 60% of the total market capitalization of firms in CRSP. Our sample period is 1970 to 2008.

B. Validation

Our measure of organization capital is constructed using the firm's SG&A expenditures, which can include other items that are unrelated to improving the organizational efficiency of the firm. In this section, we consider several ways of validating our measure.

B.1. Evidence from 10-K Filings

Our model implies that shareholders investing in firms with high organization capital are exposed to the risk of key talent leaving the firm. Firms are obliged to disclose potential risk factors that might adversely affect future performance in the managerial discussion section of their 10-K filings. We explore whether firms with more organization capital are more likely to list loss of key personnel as a risk factor. We focus on a random sample of 100 firms, constructed by randomly selecting five firms every year from the top and bottom quintile of firms in terms of organization capital to assets (relative to their industry peers). We restrict attention to the years for which the SEC filings are electronically available (1996 to 2005).

We find that firms with more organization capital are more likely to list as a risk factor that they are dependent upon a number of key personnel, the loss of which might adversely affect future performance. Out of the 50 firms in the high organization capital to assets quintile, 48% list the loss of key personnel as a risk factor. In contrast, only 20% of the 50 firms in the bottom organization capital to assets quintile list the loss of key personnel as a risk factor for future performance. Assuming independent observations, a difference in means test rejects the null that the two fractions are equal with a t-statistic of 3.06.

B.2. Evidence from Managerial Quality Surveys

Bloom and Van Reenen (2007) develop an interview-based survey tool designed to quantify management practices across firms.[8] Firms are scored on a scale of 1 to 5 based on their responses to a managerial survey relative to a benchmark of global best practices. The survey defines and assigns scores from 1 (worst practice) to 5 (best practice) to 18 management practices used by industrial firms. These practices are grouped into four areas: operations (three practices), monitoring (five practices), targets (five practices), and incentives (five practices). Bloom and Van Reenen (2007) find that the average management practice score is strongly correlated with firm performance and Tobin's Q. Other research using the same data shows that better management practices are associated with greater productivity of IT (see, e.g. Bloom, Sadun, and Reenen (2012)) and more efficient production (see Bloom, Sadun, and Van Reenen (2010) for a survey).

Our measure of organization capital is correlated with the managerial quality score constructed by Bloom and Van Reenen (2007). The 2004 survey data contain a cross-section of 250 U.S. firms that overlap with our sample.[9] Focusing on the period 2000 to 2005, we estimate a regression of the organization capital measure on the managerial score measure,

$$\frac{O_{it}}{A_{it}} = a + b\,M_i + u_{it}, \tag{37}$$

and cluster the standard errors by firm. The estimated coefficient b is positive, and equal to 0.13, while the t-statistic is equal to 1.94. Thus, the evidence suggests that our measure of organization capital, which is constructed using accounting data, is informative about the quality of management practices across firms.

B.3. Evidence from Investment in Information Technology

Bresnahan, Brynjolfsson, and Hitt (2002) and Bloom, Sadun, and Reenen (2012) find evidence suggesting the presence of strong complementarities between organization capital and IT. We explore whether firms with more organization capital according to our measure also have greater demand for IT. We obtain information on the IT spending budget for a sample of 500 firms from *Information Week* for the years 1995 and 1996. The firms participating in the *Information Week* survey are selected based on the amount of IT spending and a subjective assessment of their IT activities.

[8] In 2003, Bloom and Van Reenen founded the World Management Survey in order to systematically collect quantitative data on management practices and organization structures for domestic and international firms. The data from Bloom and Van Reenen (2007) covers 732 medium-sized manufacturing firms in the United States, France, Germany, and the United Kingdom and comprise the largest and most comprehensive output from the World Management Survey thus far.

[9] We are grateful to Nicholas Bloom for performing this analysis, since the data are publicly available.

We find that firms with more organization capital to assets relative to their industry peers have a greater demand for IT. As we see in Table III below, firms in the high-O/K portfolio spend almost twice as much on IT relative to book assets than low-O/K firms (2.10% vs. 1.17%). Hence, the evidence supports the view that our measure of organization capital is correlated with firms' demand for IT.

B.4. Evidence from Firm Profitability

Organization capital is a factor of production that is usually omitted from productivity calculations. Hence, we expect that firms with high organization capital have higher productivity, accounting for physical capital and labor. We focus on two measures of productivity. The first measure is the ratio of sales to book assets. The second measure of productivity is the regression residual of log sales on log capital and labor, where the intercept and slopes are allowed to vary by industry-year (see the Appendix for details).

We find that firms with higher ratios of organization capital to assets are more productive using both measures. This evidence is supportive of the view that our measure of organization capital is a factor of production that enhances output, holding other inputs constant. Our evidence is consistent with the findings of De and Dutta (2007) and Tronconi and Vittucci Marzetti (2011). Both papers construct a similar measure of organization capital by capitalizing SG&A expenditures and report similar results for a sample of Indian IT firms and a large sample of European firms, respectively.

III. Model Predictions

Here, we explore the predictions of our model in the data. In addition, we explore whether our model can quantitatively replicate the main features of the data by replicating our estimation results on simulated data from the model.

A. Calibration

Table I shows the parameters used in our calibration. We select parameters to match key moments of the data, and document the properties of the solution. In Table II we compare the moments in the data that we target with their model-implied counterparts. We report the median moment, along with the 5% and 95% percentiles across simulations. We simulate the model at a monthly frequency and aggregate the data to form annual observations. Each simulation contains 1,500 firms and has a length of 80 years. We drop the first half of each simulation sample to avoid dependence on initial values, and repeat the process 5,000 times.

A.1. Parameters of the Firm Economic Environment

We set the depreciation rate of physical capital to $\delta_K = 6\%$, consistent with values commonly used in the macroeconomic literature. We set the depreciation

Table I
Parameters

This table presents the parameters used in the calibration of our model.

Parameter	Symbol	Value
Technology		
Growth rate of TFP-shock	μ_θ	0.00
Volatility of TFP-shock	σ_θ	0.11
Mean-reversion parameter of frontier shock	κ_x	0.10
Volatility of frontier shock	σ_x	0.20
Mean-reversion parameter of firm O-specific shock	κ_ε	0.35
Volatility of firm O-specific shock	σ_ε	0.45
Mean-reversion parameter of firm K-specific shock	κ_u	0.12
Volatility of firm K-specific shock	σ_u	0.25
Investment and Reallocation		
Convexity of adjustment costs for investment in O-capital	λ_O	3.20
Proportional adjustment cost for investment in O-capital	c_O	625
Depreciation rate of O-capital	δ_O	0.15
Proportional reallocation cost of O-capital	c_R	1.75
Convexity of adjustment costs for investment in K-capital	λ_K	1.80
Proportional adjustment cost for investment in K-capital	c_k	435
Cost of investment goods	c_q	0.13
Depreciation rate of K-capital	δ_K	0.06
Stochastic Discount Factor		
Risk-free rate	r	0.04
Price of risk of TFP-shock	γ_θ	0.40
Price of risk of reallocation shock	γ_x	−0.53

rate of organization capital to $\delta_O = 15\%$ to be consistent with our empirical implementation. These values are also consistent with empirical estimates of the depreciation rate of physical and intangible capital (Pakes and Schankerman (1979), Nadiri and Prucha (1996)). We choose values for the parameter governing the cost of investment goods $c_q = 0.13$ and the parameter $\lambda_K = 1.8$ governing the convexity of adjustment costs to physical capital to match the level and cross-sectional dispersion of Tobin's Q. Moreover, we choose the parameters governing the cost of investing in physical and organization capital, $c_k = 435$ and $c_o = 625$, respectively, to match the level of investment in physical and organization capital. In terms of magnitudes, the average ratio of adjustment costs in organization (physical) capital to output is equal to 1.2% (0.8%).

We set values $\mu_\theta = 0.25\%$ for the mean growth rate and $\sigma_\theta = 0.11$ for the volatility of the common technology shock to match the mean growth rate and the volatility of dividends, as well as the volatility of the returns to the market portfolio. We choose the parameters governing the rate of mean-reversion and volatility of the firm-specific shocks to match the cross-sectional dispersion in profitability, organization to physical capital, and firm size in the data ($\kappa_u = 0.12$, $\kappa_\varepsilon = 0.35$, $\sigma_u = 25\%$, $\sigma_\varepsilon = 45\%$).

The literature offers little guidance in selecting the parameters governing the dynamics of the frontier technology shock x or the costs associated with

Table II

Aggregate and Firm-Specific Moments

This table presents the target moments used for calibration. We compare the moments in the data versus moments of simulated data. We report median values across simulations, along with the 5% and 95% percentiles. Moments of dividend growth are from the long sample in Campbell and Cochrane (1999). The rate of capital reallocation is from Eisfeldt and Rampini (2006), defined as the sum of sales of PPE plus the sum of mergers and acquisitions to the sum of PPE. The remaining moments are computed using Compustat data over the 1970 to 2008 period (see the Appendix for variable definitions). The firm-specific moments are time-series averages of the median and interquintile range (IQR).

		Model		
Moment	Data	Median	5%	95%
Aggregate Moments				
Mean of dividend growth	0.025	0.028	−0.012	0.056
Volatility of dividend growth	0.118	0.116	0.084	0.278
Mean of investment rate in O-capital	0.211	0.199	0.189	0.217
Volatility of investment rate in O-capital	0.015	0.009	0.004	0.020
Autocorrelation of investment rate in O-capital	0.817	0.861	0.693	0.943
Mean of capital reallocation rate	0.042	0.051	0.001	0.277
Volatility of capital reallocation rate	0.026	0.088	0.003	0.283
Asset Returns				
Mean excess return of market portfolio	0.064	0.049	0.012	0.083
Volatility of market portfolio return	0.171	0.128	0.105	0.159
Firm Moments				
Tobin's Q (median)	1.101	1.107	1.018	1.321
Tobin's Q (IQR)	0.848	0.614	0.452	0.835
Organization-to-physical capital (median)	1.079	0.678	0.394	1.678
Organization-to-physical capital (IQR)	1.320	0.770	0.444	1.910
Investment rate in O-capital (median)	0.222	0.172	0.158	0.197
Investment rate in K-capital (median)	0.111	0.099	0.097	0.108
Cash flows-to-capital (IQR)	0.234	0.145	0.119	0.242
Firm size (log) (IQR)	2.207	1.377	1.236	1.487

organization capital. We calibrate these parameters to match the dynamics of capital reallocation and investment in organization capital in the model ($c_R = 1.75$, $\lambda_o = 3.2$, $\kappa_x = 0.10$, $\sigma_x = 14\%$). These choices ensure that our model approximately matches the volatility and serial correlation of the average rate of investment in organization capital, and the mean and volatility of the average rate of capital reallocation from Eisfeldt and Rampini (2006).

A.2. Parameters of the Stochastic Discount Factor

We set the risk-free rate to equal $r = 4\%$, which is slightly higher than the historical average (3%), but ensures that the value function does not explode at the edges of our computational grid. We choose the price of risk of the TFP $\gamma_\theta = 0.4$ to match the average excess return of the market portfolio. The effect of organization capital on risk premia depends on the price of risk of the frontier technology shock γ_x. In the data, firms with more organization capital to assets (O/K) have higher average returns than low-O/K firms, suggesting a negative risk price for γ_x. Hence, we choose a risk price $\gamma_x = -0.53$ to match the difference in average returns between high- and low-O/K firms.

Our choice for the price of risk γ_x implies that the frontier technology shock x leads to high marginal utility states. This assumption is consistent with general equilibrium under certain assumptions on preferences. In our model, high realizations of x imply that reallocation becomes more attractive (the threshold $\varepsilon^*(x)$ increases). In addition, upgrading to the new technology involves an immediate loss in resources given by (25), but no immediate increase in output. Thus, in the short run, resources available for consumption are lower. In the long run, consumption increases as more firms operate at a higher level of efficiency. Whether marginal utility is positively or negatively correlated with x depends on the relative magnitudes of the elasticity of intertemporal substitution and risk aversion.[10]

A.3. Numerical Solution and Simulation

Figure 1 illustrates several features of the numerical solution of the model. Panel A plots the market value of physical capital $q(u_i)$, and Panel B plots the total value of organization capital $v(\varepsilon_i, x)$. Both values are increasing in the firm-specific levels of productivity of physical capital u and organization capital ε, respectively. In addition, the total value of organization capital increases with the level of frontier efficiency, as the option to upgrade becomes more valuable.

Panel C graphs the outside option of key talent $\bar{v}(x)$. This value increases in the level of the frontier technology shock x, since the latter determines the efficiency of organization capital in new firms. Panel D graphs the shareholder share of the value of organization capital $v(\varepsilon_i, x) - \bar{v}(x)$. Importantly, the shareholder value of organization capital is decreasing in the level of the frontier technology shock x. This decrease in value represents the differential source of risk that investors in firms with high levels of organization capital are exposed to.

Panel E plots the restructuring threshold $\varepsilon^*(x)$, which is increasing in x, because the latter improves the gains from reallocation. Panel F plots the invariant joint distribution of ε_i and x, illustrating the process of creative destruction in our model. Firms with low levels of firm-specific efficiency $\varepsilon_i < \varepsilon^*(x)$ are replaced by firms with the frontier level of technology x. Hence, in equilibrium, the mean level of productivity ε_i among active firms is increasing in the level of the frontier technology shock.

[10] This intuition follows Papanikolaou (2011), who explores the risk premium associated with capital-embodied shocks in general equilibrium. Investment shocks are shocks to real investment opportunities, and generate similar consumption dynamics to our frontier shock x. Our calibrated value for γ_x falls in the range of empirical estimates reported in Papanikolaou (2011), who estimates a negative price of risk for investment shocks.

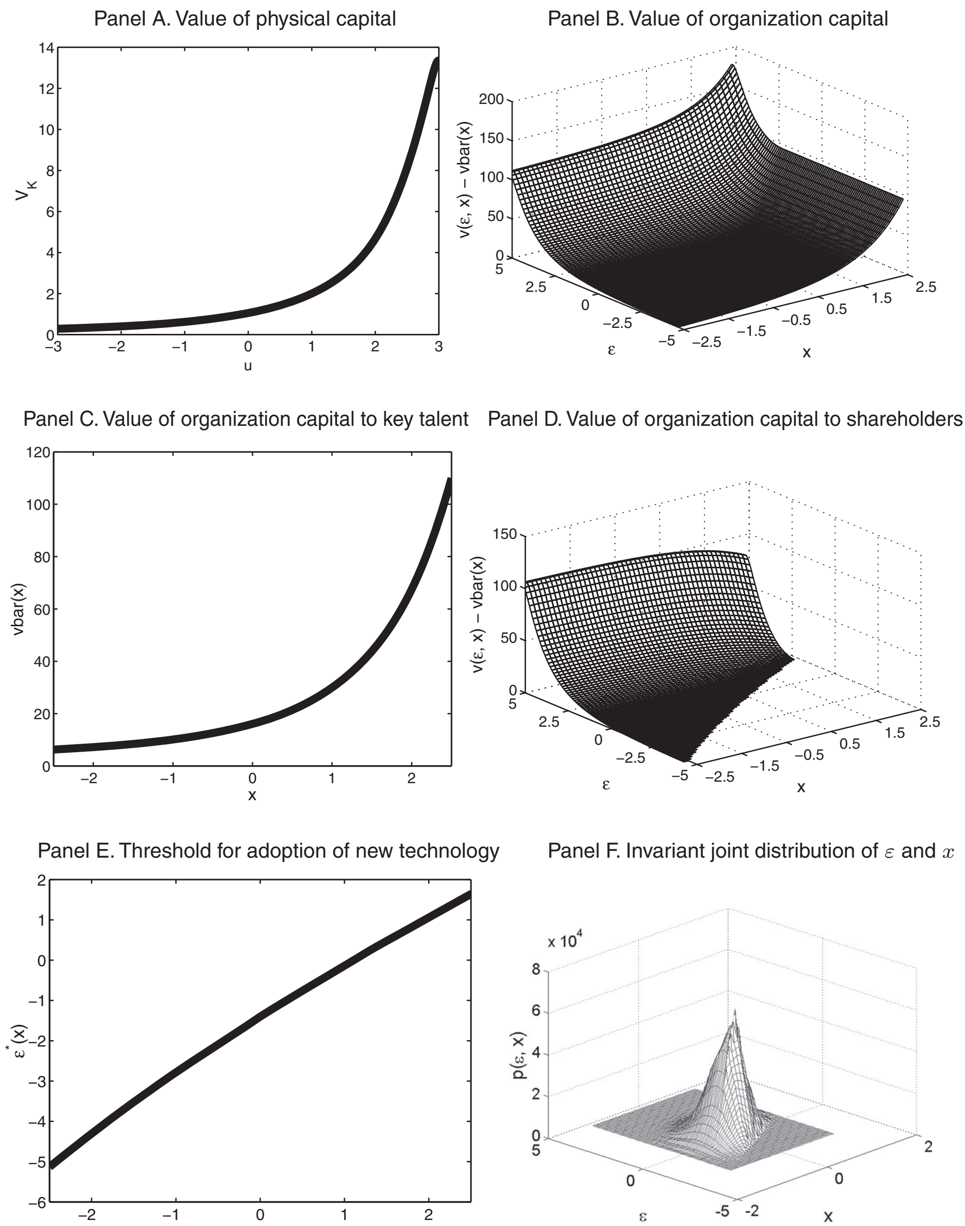

Figure 1. Model solution. This figure plots the solution of the model as a function of the firm-specific level of productivity shocks u and ε and the level of frontier technology x. Panel A plots the market value of physical capital $q(u)$, Panel B plots the total value of organization capital $v(\varepsilon, x)$, Panel C plots the value of the outside option of key talent $\bar{v}(x)$, Panel D plots the value of rents that shareholders can extract from organization capital $v(\varepsilon, x) - \bar{v}(x)$, Panel E plots the threshold for the adoption of new technologies $\varepsilon^*(x)$, and Panel F plots the stationary joint distribution of ε and x.

Table III

Firm Characteristics and Organization Capital

This table compares characteristics of the five portfolios sorted on organization to physical capital between the data (Panel A) and the model (Panel B). We report the time-series average of the median portfolio characteristic. In the data, we sort firms in five portfolios based on the ratio of organization capital to book assets (Compustat item at), using industry-specific breakpoints. We use the 17 industry classification of Fama and French (1997), and rebalance portfolios every June. In simulated data, we sort firms into five portfolios based on the ratio of organization O_{it} to physical capital K_{it}, and rebalance every year. We report median values across simulations, along with the 5% and 95% percentiles. See the Appendix for variable definitions. The sample period is January 1970 to December 2008.

Portfolio	Low	2	3	4	High
Panel A: Data					
Organization capital to book assets	0.27	0.66	1.09	1.60	2.71
Market capitalization (log, real)	4.89	4.67	4.41	4.10	3.26
Tobin's Q	1.05	1.11	1.18	1.19	1.25
Productivity - sales to book assets (%)	72.38	97.77	111.01	122.99	145.46
Productivity - Solow residual (%)	−11.38	−1.21	2.18	4.02	4.18
Investment to capital (organization, %)	27.11	25.40	22.31	21.35	17.80
Investment to capital (physical, %)	12.63	12.34	12.05	11.60	10.18
Executive compensation to book assets (%)	0.57	0.84	0.89	0.91	1.29
IT expenditures to book assets (%)	1.17	1.69	1.67	1.91	2.10
Labor expense per employee (1,000, real)	54.10	54.60	55.30	56.70	60.10
Capital to labor (log)	3.66	3.28	3.01	2.83	2.56
Physical capital to book assets	38.11	30.72	26.55	24.46	21.30
R&D expenditures to book assets	1.36	2.14	3.17	4.02	6.03
Advertising expenditures to book assets	1.10	1.54	1.88	2.50	3.64
Debt to book assets	29.91	24.69	20.01	17.62	15.07
Panel B: Model					
Organization capital to book assets	0.19	0.42	0.66	1.00	1.65
Market capitalization (log)	4.10	3.24	2.82	2.49	2.18
Tobin's Q	1.03	1.02	1.05	1.11	1.28
Productivity - sales to book assets (%)	20.18	21.94	24.59	28.59	38.77
Productivity - Solow residual (%)	1.10	−10.86	−9.38	−2.59	17.58
Investment to capital (organization, %)	19.24	19.26	19.28	19.31	19.39
Investment to capital (physical, %)	10.74	10.01	9.58	9.18	8.62
Executive compensation to book assets (%)	0.14	0.58	1.13	1.78	2.98
Value of organization capital to firm value (%)	4.03	10.37	16.39	23.84	37.30

B. Organization Capital and Firm Characteristics

In Table III, we document how firm differences in their ratio of organization to physical capital O/K are related to firm characteristics, both in the data (Panel A) and in the model (Panel B). We report the time-series average of the median firm characteristic in each O/K portfolio.

High-O/K firms have somewhat higher Tobin's Q than low-O/K firms (1.25 vs. 1.05). Despite this increasing pattern in Tobin's Q, high-O/K firms have lower investment rates in physical capital (10.1% vs. 12.6%). In addition, firms with higher ratios of organization capital to physical capital tend to have smaller market capitalization and have higher productivity. In addition, we find that high-O/K firms have a higher ratio of total executive compensation to assets (1.29% to 0.57%). As we see in Panel B, the model performs well in quantitatively replicating these patterns. The fraction of shareholder value that is due to organization capital ranges from 37% for the firms in the high-O/K portfolio to 4% for the firms in the low-O/K portfolio.

Furthermore, we document a number of other firm characteristics that are outside the model. High-O/K firms are more labor intensive, and also have higher labor expenses per worker. This last fact suggests that high-O/K firms employ more skilled workers, consistent with the findings of Caroli and Van Reenen (2001) and Bresnahan, Brynjolfsson, and Hitt (2002). In addition, high-O/K firms have higher rates of investment in other forms of intangible capital, such as advertising or R&D. Finally, firms with more organization capital also have lower financial leverage.

C. Asset Prices

In this section, we explore the main prediction of our paper, namely that cross-sectional differences in the ratio of organization to physical capital are associated with differences in risk premia. Table IV compares the empirical results in the data (Panel A) and in the model (Panel B).

The left panel (A) shows the results in the data. Firms with a higher ratio of organization capital to book assets have 4.7% higher average returns per year than firms with low organization capital to assets. This difference in average returns is not explained by the CAPM. The CAPM alpha of the long-short portfolio is 5.6%, and statistically significant. As we see in the right panel (B) of Table IV, our model quantitatively replicates the dispersion in risk premia across O/K portfolios, including the failure of the CAPM.

The dispersion in returns across O/K portfolios is distinct from the size, value, and momentum effects. Computing alphas using the Fama and French (1993) or Carhart (1997) empirical factor models leads to similar results, as we see in Table IV. The high-O/K minus low-O/K portfolio has an alpha of 5.9% and 4.2% when we use the Fama and French (1993) and Carhart (1997) models, respectively (Table V).

Our model implies that this difference in average returns arises because high- and low-O/K firms have differential sensitivities to the frontier organizational efficiency shock x. Consistent with this view, there is substantial comovement among these portfolios, and this comovement can account for these differences in risk premia. Specifically, the two-factor model that includes the market portfolio and the OMK portfolio produces alphas that are not statistically different from zero. In addition, the betas with respect to the OMK portfolio are monotonically increasing from −0.37 to 0.63. This comovement among firms suggests that high- and low-O/K firms are exposed to different sources of risk, and this differential risk factor exposure is sufficient to explain the differences in their average returns. Furthermore, sorting firms into

Table IV

Asset Pricing: Five Portfolios Sorted on O/K

This table shows asset pricing tests for five portfolios sorted on organization capital over assets relative to their industry peers (see notes to Table III), where we rebalance portfolios in June every year. Panel A reports results using monthly data, where the sample period is June 1970 to December 2008. Panel B shows results using simulated monthly data from the model, where we report the median coefficient across simulations. In panels 1 we report average excess returns over the risk-free rate $E[R] - r_f$, standard deviations σ, and Sharpe ratios SR across portfolios. In panels 2 we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio. In panels 3 we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio and the OMK portfolio (OMK portfolio corresponds to the 5 − 1 portfolio). We include t-statistics in parentheses computed using the Newey-West estimator allowing for one lag of serial correlation in returns. We annualize numbers by multiplying by 12. All portfolio returns correspond to value-weighted returns by firm market capitalization.

	Panel A: Data						Panel B: Model					
Portfolio	1	2	3	4	5	5 − 1	1	2	3	4	5	5 − 1
	1. Portfolio moments						1. Portfolio moments					
$E[R] - r_f$ (%)	4.18	4.54	5.54	5.95	8.81	4.63	4.45	5.47	6.26	7.19	8.69	4.14
	(1.48)	(1.59)	(2.12)	(2.43)	(3.52)	(2.85)	(2.17)	(2.73)	(2.97)	(3.21)	(3.45)	(2.76)
σ (%)	17.50	17.71	16.26	15.17	15.55	10.10	12.74	12.64	13.19	14.00	15.72	9.67
SR (%)	23.89	25.64	34.07	39.22	56.66	45.84	34.93	43.28	47.46	51.36	55.28	42.81
	2. CAPM						2. CAPM					
α(%)	−1.19	−0.92	0.57	1.46	4.38	5.57	−0.68	0.42	1.06	1.80	3.02	3.71
	(−1.29)	(−1.07)	(0.67)	(1.54)	(3.69)	(3.47)	(−2.23)	(1.12)	(2.05)	(2.44)	(2.59)	(2.57)
β_{MKT}	1.05	1.07	0.97	0.88	0.86	−0.18	0.99	0.98	1.00	1.03	1.08	0.09
	(49.93)	(51.81)	(48.11)	(31.08)	(26.72)	(−4.30)	(40.82)	(34.08)	(25.20)	(17.83)	(11.71)	(0.79)
R^2(%)	90.07	90.90	89.44	83.78	77.62	8.29	97.65	96.63	93.93	88.48	76.74	3.27
	3. Two-factor model						3. Two-factor model					
α(%)	0.89	−0.03	−0.32	−0.17	0.89		0.04	-0.10	−0.02	0.05	0.04	
	(1.32)	(−0.04)	(−0.41)	(−0.20)	(1.32)		(0.29)	(−0.29)	(−0.06)	(0.15)	(0.29)	
β_{MKT}	0.98	1.04	1.00	0.93	0.98		1.01	0.97	0.98	0.99	1.01	
	(65.09)	(55.79)	(59.22)	(43.02)	(65.09)		(103.29)	(38.63)	(43.06)	(44.83)	(103.29)	
β_{OMK}	−0.37	−0.16	0.16	0.29	0.63		−0.19	0.13	0.28	0.47	0.81	
	(−14.83)	(−5.18)	(5.93)	(8.28)	(24.89)		(−11.92)	(3.80)	(9.10)	(15.17)	(50.26)	
R^2(%)	94.33	91.65	90.33	87.23	92.82		99.62	97.58	98.16	98.40	99.76	

Table V

Asset Pricing: Five Portfolios Sorted on O/K, Controlling for Size, Value, and Momentum

This table shows asset pricing tests for five portfolios sorted on organization capital over assets relative to their industry peers (see notes to Table IV for details). In Panel A we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio and the Fama and French (1993) SMB and HML factors. In Panel B we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio, the Fama and French (1993) SMB and HML factors, and the Carhart (1997) MOM factor. Data on SMB, HML, and MOM are from Kenneth French's website. The sample period is June 1970 to December 2008. We include t-statistics in parentheses computed using the Newey-West estimator allowing for one lag of serial correlation in returns. We annualize numbers by multiplying by 12. All portfolio returns correspond to value-weighted returns by firm market capitalization.

Portfolio	1	2	3	4	5	5 − 1
			Panel A: Fama-French Three-Factor Model			
$\alpha(\%)$	−1.44	−0.47	0.51	1.92	4.48	5.93
	(−1.60)	(−0.54)	(0.62)	(2.17)	(3.62)	(3.61)
β_{MKT}	1.07	1.05	0.97	0.91	0.89	−0.18
	(50.93)	(49.62)	(43.69)	(42.02)	(25.53)	(−3.99)
β_{smb}	−0.05	−0.03	0.01	−0.23	−0.14	−0.09
	(−1.67)	(−0.80)	(0.16)	(−8.52)	(−3.74)	(−1.53)
β_{hml}	0.05	−0.06	0.01	−0.03	0.01	−0.04
	(1.31)	(−1.80)	(0.15)	(−0.51)	(0.22)	(−0.51)
$R^2(\%)$	90.28	91.02	89.44	86.33	78.59	9.15
			Panel B: Carhart Four-Factor Model			
$\alpha(\%)$	−0.85	0.54	−0.09	1.58	3.33	4.18
	(−0.92)	(0.61)	(−0.10)	(1.76)	(2.63)	(2.55)
β_{MKT}	1.06	1.04	0.98	0.92	0.91	−0.15
	(49.20)	(49.34)	(46.85)	(41.18)	(27.37)	(−3.63)
β_{smb}	−0.05	−0.03	0.01	−0.23	−0.14	−0.08
	(−1.78)	(−1.02)	(0.22)	(−8.22)	(−3.80)	(−1.51)
β_{hml}	0.04	−0.09	0.02	−0.02	0.04	0.00
	(0.98)	(−2.56)	(0.45)	(−0.36)	(0.78)	(0.01)
β_{mom}	−0.05	−0.08	0.05	0.03	0.09	0.14
	(−2.06)	(−3.40)	(1.64)	(0.89)	(2.75)	(3.10)
$R^2(\%)$	90.43	91.43	89.62	86.39	79.29	12.92

portfolios based on their univariate beta with the OMK portfolios also leads to differences in risk premia. As we see in Table IV, the average difference in returns between the high- and low-β^{OMK} portfolio is 2.91%, with a t-statistic of 1.16, and the CAPM alpha of this portfolio is 4.89%, with a t-statistic of 2.0 (Table VI).

D. Additional Predictions

Our model offers testable predictions that relate the realized returns of the OMK portfolio to aggregate variables that are positively related to the frontier

Table VI

Asset Pricing: Five Portfolios Sorted on Beta with OMK Portfolio

This table shows asset pricing tests for five portfolios on their univariate beta with the portfolio of high minus low-O/K firms (see the Appendix for construction details). We compute presorting univariate OMK-betas using weekly returns (see the Appendix for more details) and rebalance portfolios in December every year. In Panel A we report average excess returns over the risk-free rate $E[R] - r_f$, standard deviations σ, and Sharpe ratios SR across portfolios. In Panel B we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio. In Panel C we report portfolio alphas and betas of a regression of excess portfolio returns on excess returns of the market portfolio and the OMK portfolio. The sample period is January 1971 to December 2008. All portfolio returns correspond to value-weighted returns by firm market capitalization. We include t-statistics in parentheses computed using the Newey-West estimator allowing for one lag of serial correlation in returns. We annualize numbers by multiplying by 12.

Sort	1	2	3	4	5	5 − 1
			Panel A: Portfolio Moments			
$E[R] - r_f$ (%)	3.85	5.42	6.22	6.62	6.76	2.91
	(1.07)	(1.80)	(2.43)	(2.64)	(2.50)	(1.16)
σ (%)	22.34	18.64	15.87	15.53	16.82	15.56
SR	17.23	29.08	39.19	42.63	40.19	18.70
			Panel B: CAPM			
α(%)	−3.08	−0.41	1.13	1.78	1.81	4.89
	(−2.27)	(−0.37)	(1.54)	(1.79)	(1.36)	(2.01)
β_{MKT}	1.31	1.10	0.96	0.92	0.94	−0.38
	(37.19)	(35.02)	(58.80)	(38.96)	(27.29)	(−5.85)
R^2(%)	86.59	87.77	92.56	87.29	77.97	14.58
			Panel C: Two-Factor Model			
α(%)	−0.02	1.47	1.27	0.01	−1.20	−1.18
	(−0.01)	(1.50)	(1.65)	(0.01)	(−1.11)	(−0.64)
β_{MKT}	1.21	1.04	0.96	0.98	1.04	−0.16
	(46.81)	(44.18)	(60.74)	(51.67)	(33.47)	(−3.31)
β_{OMK}	−0.53	−0.32	−0.02	0.31	0.52	1.05
	(−13.21)	(−6.65)	(−0.62)	(7.84)	(10.08)	(13.67)
R^2(%)	90.84	90.05	92.58	90.22	85.17	48.92

shock x, such as the aggregate level of executive compensation, the rate of reallocation, and the amount of investment in organization capital. In this section, we explore these predictions directly.

D.1. Executive Compensation

In our model, the level of aggregate executive compensation is increasing in the frontier technology shock, as we see in equation (34). To test this prediction directly, we obtain data from Frydman and Saks (2010) on the aggregate time series of executive compensation. We focus on two measures of aggregate compensation, namely the mean and median level of compensation of the top three

Table VII

OMK Portfolio Returns and Executive Compensation

This table reports the relation between aggregate executive compensation $\bar{w}$ and the returns of the OMK portfolio, in the data (Panel A) and in the model (Panel B). The OMK portfolio is defined as the portfolio long firms with high organization capital and short (minus) firms with low organization capital to assets. See Section III, notes to Table III, and the Appendix for more details. Data on executive compensation are from Frydman and Saks (2010) and cover the 1970 to 2008 period. Standard errors are computed using the Newey-West estimator allowing for three lags of serial correlation. The last column presents the results of an F-test of whether the sum of the coefficients on the contemporaneous and lagged $-R_t^{OMK}$ are jointly equal to zero.

Compensation to key talent ($\Delta \bar{w}_t$)	$-R_t^{OMK}$	$-R_{t-1}^{OMK}$	R_t^{MKT}	R_{t-1}^{MKT}	$\Delta \bar{w}_{t-1}$	R^2	$p(\mathcal{F})$ OMK=0
Panel A: Data							
Compensation of top three officers, average	−0.172	1.107			0.036	0.353	0.008
	(−0.67)	(4.29)			(0.27)		
	−0.329	1.017	0.189	0.191	0.002	0.428	0.049
	(−1.29)	(3.98)	(1.53)	(1.55)	(0.02)		
Compensation of top three officers, median	0.168	0.418			0.221	0.263	0.004
	(1.11)	(2.82)			(1.63)		
	0.182	0.316	−0.036	0.138	0.230	0.341	0.014
	(1.18)	(2.12)	(−0.50)	(1.95)	(1.78)		
Panel B: Model							
Compensation to key talent, average	1.013	0.986			−0.067	0.403	0.016
	(2.95)	(2.38)			(−0.36)		
	1.113	1.231	0.178	0.261	−0.143	0.484	0.002
	(3.35)	(2.75)	(0.37)	(0.48)	(−0.76)		

executives. Given these two measures of log aggregate executive compensation $\bar{w}_t$, we estimate

$$\Delta \bar{w}_t = a_0 - b_0\, R_t^{OMK} - b_1\, R_{t-1}^{OMK} + c_0 R_t^{MKT} + c_1 R_{t-1}^{MKT} + \rho \Delta \bar{w}_{t-1} + e_t. \tag{38}$$

We estimate the above equation via OLS and report the estimated coefficients, along with Newey-West standard errors, in Panel A of Table IV. We report results with and without controlling for returns to the market portfolio (Table VII).

We find that, consistent with our model, the estimated coefficients $\hat{b}_1$ are positive and statistically significant across the measures of aggregate compensation and specifications. In contrast, the estimated coefficients $\hat{b}_0$ and $\hat{c}_0$ are not statistically different from zero. One possible explanation for this pattern is that compensation is a flow variable that is observed at the end of the year but may be decided at the beginning of the year. Hence, compensation is correlated with lagged rather than contemporaneous returns to the OMK and market portfolio. The sum of the two coefficients $\hat{b}_0$ and $\hat{b}_1$ is always positive, and statistically different from zero, as we see from the result of an F-test in the last column. We obtain similar results if we control for output growth instead of market returns, or if we focus on CEO compensation only. Panel B illustrates that the corresponding estimates on simulated data from the model are comparable to the results obtained in the data. In the model, a 1% increase in the returns to the OMK portfolio is associated with a 1% decrease in executive compensation in the model, compared to a 0.3% to 1.1% increase in the data.

D.2. Reallocation

Next, we explore how measures of reallocation or restructuring of existing firms are correlated with the realized returns to the OMK portfolio:

$$X_t = a_0 - b_0\, R_t^{OMK} - b_1\, R_{t-1}^{OMK} + c_0 R_t^{MKT} + c_1 R_{t-1}^{MKT} + \rho \hat{X}_{t-1} + e_t. \tag{39}$$

One difficulty is that our model is silent as to the exact form of this reallocation. For example, organization and physical capital may be reallocated to a new firm that starts at the frontier level of efficiency. Alternatively, key talent can buy the old firm from existing shareholders and restructure its organization to upgrade to the frontier level x. Therefore, we examine a variety of measures of physical and human capital reallocation: data on capital reallocation from Eisfeldt and Rampini (2006); data on CEO turnover from Execucomp; data on new public offerings from Ibbotson, Sindelar, and Ritter (1994); and data on new management buyouts from Haddad, Loualiche, and Plosser (2011). Since these last two measures are count variables, we estimate equation (39) using a Poisson count regression. We report the estimated coefficients in Table IV, Panel A. We report results with and without controlling for returns to the market portfolio (Table VIII).

We find that all measures of reallocation are negatively correlated with the realized returns of the OMK portfolio. In the case of capital and CEO reallocation, the estimated coefficients $\hat{b}_0$ are not statistically different from zero. However, the sum of the two coefficients $\hat{b}_0$ and $\hat{b}_1$ is always positive, and statistically different from zero, as we see from the result of an F-test in the last column. With the exception of the number of new IPOs, our findings are robust to controlling for returns to the market portfolio. We obtain similar results if we control for output growth instead of market returns. Panel B illustrates that the empirical results are qualitatively consistent with the model, since both the frequency of new firm creation, as well as the rate of capital reallocation are negatively correlated with returns of the OMK portfolio.

D.3. Investment in Organization Capital

In our model, the optimal level of investment in organization capital is increasing in the level of the frontier level of technology x, as we see in equation (30). We test this prediction by estimating

$$i_{Oit} = a_0 + a_1\, \hat{x}_{t-1} + a_2\, Q_{it-1} + a_3\, \Delta y_{it-1} + a_4\, ROE_{it-1} + \gamma_i + e_{it}. \tag{40}$$

Table VIII

OMK Portfolio Returns and Reallocation

This table reports the relation between measures of capital reallocation and the returns of the OMK portfolio, in the data (Panel A) and in the model (Panel B). See Section III, notes to Tables III and VII, and the Appendix for more details. Data on capital reallocation rate are from Eisfeldt and Rampini (2006) and cover the 1970 to 2008 period; data for CEO turnover are from Execucomp and cover the 1992 to 2008 period; data on initial public offerings are from Ibbotson, Sindelar, and Ritter (1994) and cover the 1975 to 2008 period; data on management buyouts are from Haddad, Loualiche, and Plosser (2011) and cover the 1982 to 2008 period. In Panel A, the first three sets of rows report results using OLS, where the standard errors are computed using the Newey-West estimator allowing for three lags of serial correlation. The last two sets of rows in Panel A report results using a Poisson count regression, with robust standard errors. The last column presents the results of an F-test of whether the sum of the coefficients on the contemporaneous and lagged $-R_t^{OMK}$ are jointly equal to zero.

Reallocation X_t	$-R_t^{OMK}$	$-R_{t-1}^{OMK}$	R_t^{MKT}	R_{t-1}^{MKT}	X_{t-1}	R^2	$p(\mathcal{F})$ OMK=0
Panel A: Data							
Capital reallocation	0.002	0.089			0.949	0.832	0.030
rate	(0.07)	(2.53)			(13.21)		
	−0.001	0.034	0.008	0.022	0.942	0.884	0.088
	(−0.03)	(1.94)	(0.90)	(2.45)	(15.93)		
CEO Turnover	0.009	0.091			0.374	0.462	0.006
	(0.36)	(3.35)			(1.63)		
	0.004	0.14	0.018	−0.034	0.471	0.545	0.012
	(0.12)	(3.35)	(0.87)	(−1.37)	(2.02)		
Number of new initial	2.189	1.267			0.002		0.008
public offerings	(2.66)	(1.10)			(4.40)		
(Poisson regression)							
	0.911	1.18	1.184	1.188	0.002		0.142
	(0.78)	(1.02)	(1.53)	(1.62)	(3.61)		
Number of new	1.073	−0.461			0.024		0.042
management buyouts	(2.87)	(−1.38)			(7.00)		
(Poisson regression)	1.365	0.793	0.077	−0.942	0.025		0.012
	(2.43)	(1.38)	(0.25)	(−2.68)	(19.66)		
Panel B: Model							
Reallocation frequency	0.214	0.186			0.797	0.737	0.011
	(2.51)	(2.50)			(7.30)		
	0.223	0.176	−0.021	−0.001	0.797	0.777	0.011
	(2.56)	(2.43)	(−0.31)	(−0.11)	(7.31)		
Capital reallocation rate,	0.204	0.179			0.785	0.690	0.023
sale of physical capital	(2.35)	(2.32)			(7.03)		
K to new firms	0.214	0.182	−0.012	−0.002	0.785	0.721	0.023
	(2.31)	(2.42)	(−0.12)	(−0.01)	(7.12)		

We proxy for the level of the frontier shock x using the accumulated relative realized returns of the OMK portfolio $\hat{x}_t = -\sum_{l=0}^{L} R_{t-l}^{OMK}$. We choose a lag length of $L = 3$, but varying L between two and six has little quantitative impact on our results. We proxy for the firm-specific productivity shock ε_i using the firm's Tobin's Q, sales growth Δy, and return on assets ROA. We include firm fixed effects γ_i, winsorize all variables every year at the 1% level to remove the effect of outliers, and cluster the standard errors by firm and year.

We present the results in Table IX. The left panel (A) shows the estimation results in actual data. The estimated coefficient a_1 of investment in organization capital on our return-based proxy for the frontier shock x is positive and statistically significant across specifications. In addition, the coefficients a_2 to a_4 are positive and statistically significant, implying that firms invest more in organization capital when they are more productive, more profitable, and when Tobin's Q is high. The right panel (B) of Table IX shows that replicating our empirical procedure in simulated data yields quantitatively similar results.

D.4. Operating Leverage

Our model implies that the sensitivity of firm earnings to firm output is increasing in the ratio of organization to physical capital O/K. By contrast, the sensitivity of firm earnings to aggregate output is similar for all firms. We explore this implication by estimating

$$\Delta \log E_{it} = a_0 + z_i + a_1 \Delta z_{it} + \sum_{d=2}^{5} a_d D_{dt-1} \times \Delta z_{it} + e_{it}, \tag{41}$$

where E_{it} equals operating cash flows; $z_{it} \in [y_{it}, \bar{y}_t, y^I_{it}]$ is log firm sales y_{it}, log aggregate output $\bar{y}_t$, or log total industry sales y^I_{it}; D_{dt} is a dummy taking the value of one if the firm belongs in quintile d at time t in terms of its ratio of organization capital to assets O/K; and z_i are firm fixed effects. We cluster the standard errors by firm and year.

Table X shows that the empirical results are consistent with the model. Firms with higher ratios of organization to physical capital O/K have greater sensitivity of earnings to firm sales. In contrast, all firms have the same sensitivity of earnings to aggregate shocks. The estimated coefficients a_d are not statistically significantly different from zero, regardless of whether we measure aggregate output by GDP or industry sales. This lack of differential sensitivity to changes in aggregate output helps exclude alternative explanations for our asset pricing results that rely on the interpretation of SG&A expenditures as fixed costs. Replicating our empirical procedure in simulated data leads to quantitatively similar results, as we see in Panel B of Table X.

E. The Market Price of Frontier Technology Shocks

The key parameter in our model that determines the difference in risk premia between physical and organization capital is the price of risk of the frontier technology shock γ_x. Here, we obtain an alternative estimate of γ_x by estimating the SDF implied by our model

$$m = a - \gamma_m R_{MKT} - \gamma_x \ \Delta x, \tag{42}$$

Table IX

Investment in Organizational Capital

This table shows estimates of a regression of the investment rate in organizational capital i_{Ot} on lagged values of: minus the accumulated returns of the OMK portfolio $R_t^x \equiv -\sum_{l=1}^{3} R_{t-l}^1 - R_{t-l}^5$, log Tobin's Q, log sales growth $\Delta \log Y_{it}$, and profitability ROA_{it-1}. See Section III and the Appendix for more details. Depending on the specification we include firm fixed effects. Panel A shows the empirical results in the data, where the sample period is January 1970 to December 2008. Panel B shows results in simulated data, where we report the median estimated coefficient and t-statistic across simulations. We winsorize all firm-specific variables at the 1% and 99% level every year. Standard errors are clustered by firm and year.

	Panel A: Data					Panel B: Model				
i_{Ot}	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
R_{t-1}^x	0.177	0.171	0.149	0.177	0.103	0.145	0.158	0.149	0.153	0.144
	(2.81)	(3.95)	(2.16)	(2.70)	(2.00)	(4.39)	(4.57)	(4.43)	(4.52)	(4.41)
$\log Q_{it-1}$		0.059			0.034		0.009			−0.008
		(13.04)			(6.30)		(10.00)			(−2.50)
$\Delta \log Y_{it-1}$			0.134		0.076			0.013		0.008
			(14.90)		(14.94)			(5.02)		(2.98)
ROA_{it-1}				0.024	0.034				0.033	0.049
				(1.86)	(2.60)				(15.93)	(7.59)
Obs.	49,523	49,523	49,523	49,523	49,523	52,500	52,500	52,500	52,500	52,500
R^2	0.004	0.071	0.113	0.005	0.578	0.137	0.191	0.177	0.241	0.360
Firm FE	–	–	–	–	Y	–	–	–	–	Y

Table X

Organizational Capital and Operating Leverage

This table compares estimates of operating leverage across the five O/K portfolios in the data and in the model. Panel A shows the estimation results in the data, where the sample period is January 1970 to December 2008. Panel B shows the estimation results in simulated data, where we report the median estimated coefficient and t-statistic across simulations. We compute operating leverage with respect to idiosyncratic shocks as the slope coefficient of a regression of change in log earnings before taxes and depreciation, $\Delta \log E_{it}$, on change in log firm output $Y_{it} = \text{SALES}_{it}$. We compute operating leverage with respect to aggregate shocks as the slope coefficient of a regression of change in log earnings $\Delta \log E_{it}$ on change in log aggregate output or average industry sales $Y_{it} = \{GDP_t, I\text{SALES}_t\}$. We interact firm and aggregate output with O/K-quintile dummies, where breakpoints vary by industry. We use the 17-industry classification of Fama and French (1997). In simulated data from the model, firm output y_{it} is given by equation (16); aggregate output $y_t = \int y_{it}\, di$ and earnings are output minus compensation to key talent w. We include firm and O/K-quintile dummies in all specifications. We winsorize all firm-specific variables at the 1% and 99% level every year. Standard errors are clustered by firm and year. See Section III, notes to Table III, and the Appendix for more details.

	Panel A: Data			Panel B: Model	
		Systematic		Firm-Specific	Systematic
$\Delta \log E_{it}$	Firm-specific (Sales)	(GDP)	(ISales)	(y_{it})	(y_t)
$\Delta \log Y_{it}$	1.117	2.954	0.140	1.081	0.963
	(24.84)	(5.28)	(2.44)	(196.91)	(24.24)
$D_2(O/K) \times \Delta \log Y_{it}$	0.108	0.004	−0.024	0.091	−0.005
	(1.99)	(0.01)	(−0.36)	(6.83)	(−0.14)
$D_3(O/K) \times \Delta \log Y_{it}$	0.184	0.001	0.050	0.127	−0.005
	(3.16)	(0.00)	(0.50)	(7.50)	(−0.10)
$D_4(O/K) \times \Delta \log Y_{it}$	0.289	−0.292	0.029	0.178	−0.003
	(5.22)	(−0.66)	(0.34)	(7.85)	(−0.04)
$D_5(O/K) \times \Delta \log Y_{it}$	0.303	0.027	0.032	0.255	−0.001
	(3.82)	(0.06)	(0.41)	(8.16)	(−0.01)
Observations	52,035	52,035	52,035	58,465	58,465
R^2	0.288	0.147	0.141	0.833	0.112

using GMM. We report first-stage GMM estimates of γ_m and γ_x using the identity matrix to weigh moment restrictions, and adjust the standard errors using the Newey-West procedure with a maximum of three lags.

As moment restrictions, we impose the condition that the SDF in equation (42) should price the cross-section of industry portfolios, following the advice of Lewellen, Nagel, and Shanken (2010) and Daniel and Titman (2012). Doing so has two key advantages. First, as these authors point out, the industry portfolios do not display a strong factor structure. Second, our O/K portfolios are constructed by sorting firms within industries. In contrast, the empirical estimate of γ_x in (42) depends on the between industry dispersion in average returns and risk loadings. Hence, the results of this exercise provide an independent estimate of the price of risk of frontier shocks γ_x.

We use three sets of proxies for the frontier shock Δx. The first set of proxies is based on the change in the log average (median) executive compensation $\Delta \bar{w}^a$

Table XI

Estimating the Market Price of Risk of Frontier Shocks Using Industry Portfolios

This table presents GMM estimates of the parameters of the stochastic discount factor $m = a - b_m R_{MKT} - b_x \Delta x$, using the cross-section of 30 industry portfolios (excluding the "Other" industry). We use three sets of proxies for the frontier shock Δx: first, the change in log average (median) executive compensation Δw^a (Δw^m) from Frydman and Saks (2010); second, the change in log total reallocation Δra from Eisfeldt and Rampini (2006); third, minus the returns to the OMK portfolio (see Section III for details). For executive compensation and reallocation we follow the literature on consumption-based asset pricing (see, e.g., Campbell (2003)) and adopt the convention that executive compensation is determined at the beginning of the period, for example, $\Delta x_t = \Delta w_{t+1}$. We normalize a so that $E[m] = 1$ (see, e.g., Cochrane (2001)). We normalize R_{MKT} and Δx to zero mean and unit standard deviation. We report HAC t-statistics computed using errors using the Newey-West procedure adjusted for three lags. As a measure of fit, we report the sum of squared errors (SSQE).

Factor Price	(CAPM)	(1)	(2)	(3)	(4)
R_{MKT}	0.45	0.56	0.67	0.66	0.49
	(4.07)	(4.93)	(5.15)	(4.60)	(4.39)
Δw^a		−0.45			
		(−2.28)			
Δw^m			−0.67		
			(−2.41)		
Δra				−0.57	
				(−2.18)	
$-R_{OMK}$					−0.42
					(−2.49)
SSQE	2.17	1.05	1.07	1.44	1.33

($\Delta \bar{w}^m$) from Frydman and Saks (2010). Second, we use the change in the log total reallocation from Eisfeldt and Rampini (2006). Given our findings in Table IV, we adopt the convention that executive compensation and reallocation are determined at the beginning of the period. Hence, for example, $\Delta x_t = \Delta \bar{w}_{t+1}$. Third, we proxy for the frontier shock using minus the returns to the OMK portfolio $\Delta x_t = -R_{OMKt}$. We normalize R_{MKT} and all proxies for Δx to zero mean and unit standard deviation. We show the results in Table IV.

The estimates of the price of risk of the frontier shock are negative and statistically significant across specifications (Table XI). As a result, including measures of the frontier technology shock improves upon the ability of the CAPM to price the cross-section of industry portfolios, reducing the sum of squared errors by 30% to 50%. More importantly, the point estimates of γ_x range from −0.42 to −0.67, and are close to the value we use in our calibration (−0.53) and (minus) the Sharpe ratio of the OMK portfolio (−0.45). We conclude that our calibrated price of risk is consistent with the data.

F. Robustness Checks and Alternative Explanations

In this section, we briefly describe a number of robustness tests and explore a number of alternative explanations. The full set of results is available in the

Internet Appendix. Our results are quantitatively similar when we employ the following robustness tests: (i) forming equal—rather than value-weighted—portfolios; (ii) sorting firms into portfolios unconditionally based on organization capital to book assets, as opposed to within industry; (iii) scaling the stock of organization capital by property, plant, and equipment (PPE) or the replacement value of capital as in Salinger and Summers (1983) instead of book assets; and (iv) measuring investment in organization capital as SG&A expenses minus advertising expenditures, restricting the sample to the set of firms that report advertising expenses as a line item.

We also explore whether sorting firms on other accounting variables produces similar results. We find that sorting firms on accumulated sales leads to comparable differences in risk premia. Since firm expenditures on organization capital are increasing in firm output y, this pattern is consistent with our model. We find that sorting firms in portfolios according to accumulated sales over assets leads to quantitatively similar results in model simulated data. To disentangle the two effects empirically, we sort firms on the ratio of organization capital to accumulated sales. This sort leads to portfolios' significant differences in risk premia, once exposure to other factors is accounted for. The high minus low portfolio has a Fama and French (1993) and Carhart (1997) alpha of 6% and 4.3%, respectively.

A number of alternative mechanisms such as investment irreversibility or operating leverage could imply that high-O/K firms are riskier than low-O/K firms in bad times. Under the assumption that the market price of risk is countercyclical, both of these alternative explanations imply that the conditional CAPM should price the cross-section of O/K portfolios. However, we find no evidence that high-O/K firms are riskier than low-O/K firms at times when the conditional equity premium is high. The correlation between the market beta of the OMK portfolio β_t^{OMK} and the conditional equity premium estimated using the methodology of Petkova and Zhang (2005) is negative and ranges from -37.5% to -7.1% depending on the specification. These results also distinguish the mechanism in our model from that in Donangelo (2011), who studies the asset pricing implications of variation in operating leverage induced by heterogeneity in labor mobility across industries.

IV. Conclusion

Our paper considers the appropriate discount rate investors should use to value organization capital. In our model, organization capital is embodied in key talent. As a result, investing in firms with high levels of organization capital exposes shareholders to additional risks because shareholders do not own all of the cash flows from organization capital.

The share of cash flows from organization capital that shareholders can capture varies systematically with the outside option of the firm's key talent. In our model, this outside option is driven by the frontier efficiency at which organization capital can be deployed in new firms. When the efficiency of organization capital in new firms improves, shareholders must offer higher compensation to induce key talent to remain with the firm. As a result, cash flows to shareholders from organization capital are negatively correlated with the frontier technology shock.

Our calibrated model quantitatively matches the dispersion in firm characteristics and risk premia associated with organization capital. In our calibration, we assume that the frontier shock leads to high marginal valuation states. This choice is motivated by the fact that an increase in the rate of reallocation will reduce current output, since restructuring is costly. As a result, shareholders demand a higher risk premium to invest in firms with more organization capital because these firms drop in value when more resources are lost to restructuring.

Finally, our model delivers a set of testable predictions that are supported by the data. Our model relates the realized returns of firms with high and low organization capital to the aggregate level of executive compensation, measures of reallocation, and investment in organization capital. Moreover, it offers predictions about the sensitivity of firm cash flows to idiosyncratic and aggregate shocks.

Initial submission: July 5, 2010; Final version received: January 22, 2013
Editor: Campbell Harvey

Appendix: Data Construction

Our sample includes all firms in Compustat with December fiscal year (fyr = 12); nonfinancial firms (excluding SIC 6000-6799); firms with common shares (shrcd = 10 and 11); firms traded on NYSE, AMEX, and NASDAQ (exchcd=1, 2, and 3); firms with nonmissing SIC codes; and firms with nonzero values of organization capital. All variables are from Compustat, unless otherwise noted. After each variable we include in parentheses the Compustat item code, as well as the model equivalent when available.

- We rank firms on organization to physical capital relative to their industry peers as follows. We first sort firms into 17 industries, given the Fama and French (1997) classification. Then, within each industry, we sort firms into five subportfolios based on the ratio of organization capital to book assets. We then pool the subportfolios across industries to form five portfolios of firms sorted on O/K, where the breakpoints are industry specific. Thus, portfolio 1 includes all the firms in the bottom quintile in terms of organization capital to assets in industry 1 through 17, etc.
  We construct value-weighted portfolio returns for five portfolios sorted on the ratio of organization capital to book assets O/K. We use monthly portfolio returns and rebalance portfolios in June every year.
- We estimate beta-OMK using weekly data. Specifically, we use 1 year of nonoverlapping weekly returns to estimate presorting betas with respect to the OMK portfolio. Then, we sort all non-financial firms in CRSP into five portfolios based on their beta with the OMK portfolio. We rebalance

the portfolios in January every year. Similar to our benchmark results, we compute breakpoints within the Fama and French (1997) 17 industries.

- The Solow residual u_{it} is the residual of a regression of log sales (data: sale, model y_{it}) on log physical capital K (data: ppegt; model: $c_q\theta_t K_{it}$) and log labor L (data: emp; model $L = 1$),

$$\ln \text{Sales}_{it} = a_{It} + \beta_{It} \ln K_{it} + \gamma_{It} \ln L_{it} + u_{it},$$

where we allow the coefficients a_{It}, β_{It}, and γ_{It} to depend on industry (I) and time (t). In the data, we use the Fama-French 17-industry classification, while in the model we assume that all firms belong to the same industry.
- Firm size is market capitalization (data: December market capitalization from CRSP; model: V_{it}^S).
- Tobin's Q is the ratio of market capitalization (data: December market capitalization from CRSP plus the book value of debt (dltt + dlc) plus the book value of preferred shares (cshpri), minus inventories (invt) divided by the book value of assets (at); model: shareholder value of the firm (V_{it}^S) divided by replacement cost of capital ($c_q\theta_t K_{it}$)).
- The ratio of executive compensation to assets equals the ratio of total executive compensation (data: tdc2 from Compustat's Execucomp; model: w_{it}) divided by the book value of assets.
- Physical capital investment rate is the ratio of capital expenditures divided by the book value of capital (data: capx divided by ppegt; model: i_{Kit}).
- The stock of organization capital equals accumulated investment in organization capital minus depreciation (data: see Section II.A; model O_{it}).
- Organization capital investment rate is the ratio of SG&A divided by accumulated organization capital (data: see Section II.A; model i_{Oit}).
- Firm productivity is the ratio of firm sales (data: sale; model y_{it}) to book value of assets (data: at; model: $c_q\theta_t K_{it}$).
- Firm profitability (ROA) is the ratio of firm earnings before income, tax, and depreciation (data: ib + dp; model $y_{it} - w_{it}$) to book value of assets (data: at; model: $c_q\theta_t K_{it}$). This definition is closest in spirit to measuring cash flows as income minus operating costs, before capital depreciation. However, our measure of investment in organization capital (SG&A expenses) is treated as a cost given current accounting rules. Hence, an alternative definition of earnings in the model could be $y - w - C_O$. Our simulation results are qualitatively and quantitatively similar under this alternative definition of earnings.
- Capital reallocation is the ratio of capital sales to total capital stock (data: from Eisfeldt and Rampini (2006); model: $\int \mathbf{1}_{\varepsilon_{it} \leq \varepsilon^*(x_t)} K_{it}\, di / \int K_{it}\, di$).
- CEO turnover is constructed using CEO turnover events from Execucomp. If the Exceutive ID for the CEO in year t is different from the ID in year $t + 1$, we record this as a turnover event in year t.

- Labor expenses per employee equals Compustat xlr deflated by cpi and divided by emp.
- IT expenditure data are from the 1995 and 1996 *Information Week* 500 Survey online at http://i.cmpnet.com/infoweek/545/graphics/iw500u.pdf and http://i.cmpnet.com/infoweek/596/graphics/biggest.pdf.
- The remaining variables are computed as follows: financial leverage is the ratio of book value of debt to total assets, asset tangibility is the ratio of book value of capital (item ppegt) to book value of assets, and the log capital-labor ratio is the log ratio of book value of physical capital (ppegt) to number of employees (emp).

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Appendix S1: Internet Appendix.