The Value and Ownership of Intangible Capital

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Intangible capital which relies on essential human inputs, which we will refer to as "organization capital", is an increasingly important part of the US and global capital stock. According to Corrado, Hulten and Sichel (2009), this type of capital is the single largest category of business intangible capital, accounting for about thirty percent of all intangible assets in the US.[1] Two key features of organization capital are: (1) It is partly firm specific, and (2) It is partly embodied in key labor inputs such as managers, engineers, sales people, and research employees.

The distinct ownership structure resulting from these unique features presents a significant challenge for measurement. It has long been recognized that book assets understate corporate intangible assets.[2] However, we believe we are the first to emphasize that a large fraction of the most quantitatively important category of intangible assets will not show up in market values either. Because essential talent is necessary for a firm to efficiently deploy organization capital, the property rights over such capital are quite different from those over physical capital. In particular, it is not possible for capital financiers to fully own cash flows which rely on the inputs of key talent. Instead, the necessary key talent essentially owns the cash flows from intangible capital they generate to the extent that such capital is portable. Cash flows are then allocated between financiers and key talent according to a sharing rule that depends on their outside option and can vary over time and across firms and industries. As a result, one cannot use residuals of market over book values, as in Hansen, Heaton and Li (2005) and Hulten and Hao (2008), since this will understate intangibles. Moreover, because the sharing rule between firms' key talent and financiers varies over time and across industries, we will show that the understatement also varies systematically and significantly.

Considering the joint ownership and property rights governing organization capital is important for understanding aggregate, industry, and firm level market valuations, and has additional implications for the income and wealth distribution, for risk sharing, for the effects of changes in tax policies, for capital structure, and is crucial for understanding investment in organization capital. Measuring the value of organization capital requires a model which captures these unique property rights. We approach the measurement challenges using a model of the sharing rule between a firm's owners and its key talent based on the model in Eisfeldt and Papanikolaou (2013), along with accounting data on expenditures related to organization capital. In that paper, we studied the unique risk characteristics of organization capital. We showed that systematic shocks to the sharing rule imply that organization capital makes firms riskier and raises discount rates by about 4.5%. In this paper, we turn to measuring the fraction of the capital stock which is missing from book and market values of capital in the time series and cross section.

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[1] Our notion of organization capital corresponds to what Corrado, Hulten and Sichel (2009) refer to as the firm-specific resources subcategory of economic competancies. See their table 2.

[2] See the important contributions in Corrado, Haltiwanger and Sichel (2005), Atkeson and Kehoe (2005), McGrattan and Prescott (2010), and Corrado, Hulten and Sichel (2009).

I. Simple dynamic valuation model

Consider a continuum of all equity firms which operate as long as key talent remains with the firm. Each firm is endowed with K_i units of physical capital with efficiency one, and O_i units of organization capital with efficiency ϵ_i.[3] Production is linear in each input and separable, and physical capital can be acquired at unit cost. The total value of the firm is

$$V_{it} = V_{it}^K + V_{it}^O, \tag{1}$$

where V^K is the value of physical capital and V^O is the total value of organization capital. The main focus of Eisfeldt and Papanikolaou (2013) is on variation in discount rates due to the unique risk characteristics of organization capital. For simplicity here we take the discount rate, r as given and leave the full analysis for future work. We will solve for the total value of organization capital, and then examine the fraction of value which is not captured by financiers, and is thus missing from market values.

While in the incumbent firm, organization capital generates cash flows of $\epsilon_i O_i$. Key talent has the option to reallocate their organization capital to the frontier efficiency x, which follows a geometric random walk:[4]

$$dx_t = \sigma x_t dB_t \tag{2}$$

with $x_0 > 0$. Since organization capital is partially firm specific, key talent must pay a reallocation cost $O_i C_R$ to upgrade to the frontier efficiency. Since key talent cannot commit not to leave, prior to upgrading, they must receive compensation at least equal to the outside option of operating their organization capital at the frontier efficiency forever. We assume that the firm's owners cannot commit to higher compensation, and thus financiers promise compensation equal to key talent's outside option. Physical capital can be created or purchased at unit cost, and we normalize the physical capital required for a firm to operate to one unit.

Key talent balances the gains from reallocating to the frontier efficiency vs. reallocation costs and the option to wait to upgrade. The solution to their problem is equivalent to the solution to the problem of maximizing the total value of organization capital since if the surplus from continuation was greater than the surplus from separation, shareholders would increase the payment to key talent so that they would want to stay. In other words, there are no inefficient separations. Homogeneity implies this problem scales with $\frac{O_i}{r}$, thus the total value of organization capital is $V_i^O = f(x)\frac{O_i}{r}$ where $f(x)$ is the solution to:

$$\max_{\tau} E_t\left[\epsilon_i + e^{-r\tau}\left(x_\tau - rC_R - \epsilon_i\right)\right]. \tag{3}$$

In words, the total value of a unit of organization capital is the value of the cash flows from operating at the incumbent firm's efficiency forever, plus the expected present value of upgrading net of reallocation costs and the foregone cash flows at the incumbent organization. The solution to this optimal stopping problem $f(x)$ solves the familiar option pricing ODE, simplified by our zero drift assumption:

$$rf(x) = \frac{1}{2}\sigma^2 x^2 f_{xx}(x). \tag{4}$$

Using the standard value matching, smooth pasting, and no bubble conditions, we have the following solution for V_i^O:

$$V_{it}^O = \frac{O_i}{r}\left[\epsilon_i + (\bar{x}_i - \epsilon_i - rC_R)\left(\frac{x_t}{\bar{x}_i}\right)^\gamma\right] \tag{5}$$

[3] For simplicity, we do not consider investment here. See Eisfeldt and Papanikolaou (2013) and Zhang (2013).

[4] This is in the spirit of Atkeson and Kehoe (2005), who study the determinants of the rents earned by incumbent concerns, but do not consider the sharing of rents amongst constituents. Lustig, Syverson and Van Nieuwerburgh (2011) extend this work by considering the optimal risk sharing contract for dividing rents between owners and managers. Eisfeldt and Papanikolaou (2013) introduces a stochastic evolution of the frontier efficiency and studies the effects of variation in labor's outside option on systematic cash flow risk. Zhang (2013) considers overall cash flow risk in a model with optimal investment and labor market clearing.

where

$$\bar{x}_i = \frac{(rC_R + \epsilon_i)^\gamma}{\gamma - 1} \text{ and } \gamma = \frac{1 + \sqrt{1 + \frac{8r}{\sigma^2}}}{2}. \tag{6}$$

Organization capital will reallocate to the frontier efficiency once the frontier efficiency exceeds that of the incumbent firm by enough to recoup the reallocation cost and to outweigh the benefit of waiting. We denote this firm specific reallocation threshold for the frontier efficiency by $\bar{x}_i$. The total value of organization capital is the value of operating at the incumbent firm's efficiency forever, plus the value of operating at the frontier efficiency after reallocation, less the opportunity costs at the incumbent efficiency and reallocation costs. The final term in the value of organzation capital represents how far in or out of the money key talent's option is.

Organization capital's compensation is:

$$V_{it}^{OL} = \frac{O_i}{r}\left(x_t - rC_R\right).$$

Note that this compensation is proportional to the level of organization capital in the firm, with a constant of proportionality that varies with the level of the frontier efficiency. We will exploit this relationship in our measurement exercise below. We can now express the value of the shareholders' claim to firm value net of organization capital's claim as:

$$\begin{aligned} V_{it}^{OS} &= \frac{O_i}{r}\left[\epsilon_i + (\bar{x}_i - \epsilon_i - rC_R)\left(\frac{x_t}{\bar{x}_i}\right)^\gamma\right] \\ &- \left(x_t - rC_r\right)]. \end{aligned} \tag{7}$$

The fraction of firm value that is missing from market values is then $\frac{V_{it}^{HL}}{V_{it}} =$

$$\frac{\frac{O_i}{K_i}\left(x_t - rC_R\right)}{1 + \frac{O_i}{K_i}\left[\epsilon_i + (\bar{x}_i - \epsilon_i - rC_R)\left(\frac{x_t}{\bar{x}_i}\right)^\gamma\right]} \tag{8}$$

which, it is easily shown, is increasing in the fraction of the capital stock comprised by organization capital, increasing in the level of the frontier efficiency relative to that of the incumbent firm, and decreasing in reallocation costs. The cost of reallocation includes technological costs such as organization capital specificity and retooling costs, but also represents the cost of financing new, frontier efficiency firms.[5] Thus, the missing fraction will be high when organization capital is an important part of the capital stock, when the frontier efficiency improves and increases the moneyness of key talent's option, and, crucially, when there is a liquid market for reallocation, restructuring, and new firm financing since this increases the value of key talent's outside option net of costs. Finally, we note that if the volatility of the frontier shock is higher, the value of key talent's option increases but since they will wait longer to exercise, the fraction of capital which is missing declines.

II. Measurement

We use the methodology in Eisfeldt and Papanikolaou (2013) to construct firm level proxies for the book stock of organization capital using the perpetual inventory method and accounting data related to expenditures on organization capital. We then use these firm level variables to study the change in the fraction of the capital stock that is missing from market values over time and across industries. Specifically, we apply the law of motion

$$O_{it} = (1 - \delta)O_{it-1} + \theta\frac{SGA_{it}}{cpi_t} \tag{9}$$

where SGA is the firms Selling and General Administrative expense, and cpi is the consumer price index. We set $O_0 = \frac{\theta SGA_1}{g+\delta}$ and use $\delta = 15\%$, $g = 10\%$, and $\theta = 30\%$.[6]

[5] As in Eisfeldt and Papanikolaou (2013) we are silent here as to the form of reallocation, which can happen through new firm creation or equivalently by restructuring the existing firm.

[6] Hulten and Hao (2008) and Zhang (2013) use $\delta = 0.20$ and $\theta = 0.30$. We set $g = 10\%$ as in Eisfeldt and Papanikolaou (2013). Falato, Kadyrzhanova and Sim (2013) also use SG&A data to measure intangibles in a study of capital structure and cash holdings. Lev and Radhakrishnan (2005) use a flow measure of the SGA expense to consider the annual contribution of organization capital to output growth in a measurement exercise resembling standard TFP regressions.

Eisfeldt and Papanikolaou (2013) and Eisfeldt and Papanikolaou (2012) contain detailed support for using SGA to proxy for investments in organization capital using survey data, 10-K filings, and other firm characteristics. For example, those papers document a strong correlation between accumulated SGA and several measures of productivity residuals. They also document that organization capital measured in this way is correlated with the firm level survey measure of managerial capital from Bloom and Van Reenen (2007), and with firm level survey data on investment in information technology. Firms with high fractions of this measure of organization capital are also more than twice as likely as firms with low fractions of organization capital to list loss of key personnel as an important risk factor for future performance in their 10-K.

Figure 1 plots the aggregate ratio of book organization capital to property, plant and equipment. We drop the first five years of data to mitigate the effect of initial values in the perpetual inventory method, and also normalize the series by its 1975 value. Aggregate organization capital relative to physical capital grows 2% over the time period 1975 to 2012. The peak level is in 1993, when organization to physical capital was 19% higher than in 1975. Although there is steady growth in investment in organizaiton capital in the early half of the sample, investment declines after 1993. We will show that a greater share of the gains from investment in organization capital have flowed to key talent in recent years, and this can be consistent with a lower investment rate if financiers control investment decisions.

Next, we look at organization capital across industries and over time within each industry. We define six industries. We start with the Fama and French (1997) 5-industry classification, and use their definition of Consumer Goods, Manufactuirng, and Health Products. We refine the definition of the "High Tech" industry using the BEA *Industry Economic Accounts*. Finally, we assign firms in the Fama-French 48 industries of Banking and Trading to the "Finance" industry. All other firms are classified as other.[7]

Figure 2 plots the ratio of organization capital to property, plant and equipment for the five industries, excluding "other". All industries except for Manufacturing have accumulated more organization capital than physical capital over our sample. The ordering of the industries in terms of growth rates of organization capital highlight the important role of organization capital in the high tech, finance, and health industries. Our estimates also indicate that these industries have higher levels of book organization capital and are growing as a share of the overall US capital stock. Moreover capital reallocation rates in these industries are higher, grow faster over our sample, and are more volatile. Although we do not exploit this in our calibration below, doing so would increase the fraction of total value missing from the market value of financiers' claims.

Finally, we present a calibrated time series for the fraction of missing capital. Table I presents results describing the fraction of capital missing from market values for a firm with the aggregate measured $\frac{O}{K}_t$ in each decade of our sample, and the economy wide mean level of organizational efficiency. We use the parameters from the calibrated model in Eisfeldt and Papanikolaou (2013) and set $r = 4\%$, $\sigma_x = 20\%$, and $C_R = 1.75$.[8] At each date, we let $\epsilon = 1 + e^y$, where y is distributed normally with mean zero and standard deviation 0.45. A key additional input is the ratio $\frac{x_t}{\bar{x}}$, which determines how far out of the money key talent's option is for this firm. We use the reallocation rate from Eisfeldt and Rampini (2006) to find the x_t that implies that the fraction of firms with a $\bar{x}_i$ less than x_t equals the observed reallocation rate, given the distribution for ϵ_i.[9]

[7] We use the "High Tech" industry classification from Zhang (2013). See `http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/changes_ind.html` for the Fama-French industry definitions.

[8] All data is included in the online appendix. We leave a full calibration with entry to future work since our simple model with an analytical solution is non-stationary, includes a one-time option only, and does not feature investment.

[9] Eisfeldt and Rampini (2008) documents the high

In column 1, we report the aggregate ratio of $\frac{O}{K}$ for each decade. In column two, we report the reallocation rate. Columns three and four report the implied frontier efficiency given our calibration and the observed reallocation rate, and the implied moneyness of key talent's option, respectively. Columns five reports the implied fraction of total value which is missing from measured market values in each decade, and column six reports this fraction holding the reallocation rate fixed at its 1975 level. Finally, columns seven through nine report relative values for the fraction of missing capital. Studying relative values ameliorates the effects of our specific measurement choices somewhat.

The fraction of missing capital is sizable. Our calibration implies that it is about 50% on average. This is not surprising as most studies estimate that intangibles exceed tangible assets, and key talent must be compensated for the *frontier* outside option. Indeed, variation in key talent's outside option induces quantitatively important variation in the fraction of value missing from market values. In 2005, including the effect of the high observed reallocation rate increases the fraction missing by 18%. Figure 3 shows that although the book ratio of organization to physical capital peaked in 1993, the fraction of missing capital peaked in 2000 at 30% higher than the 1975 baseline. In general the higher reallocation rates in the second half of our sample illustrate how more liquid markets for talent reallocation increase the fraction of intangible capital that is owned by key talent and does not appear in market valuations. Accordingly, Figure 3 also plots executive compensation relative to physical capital for the largest firms.[10] We note the striking similarity between these two series, which provides independent support for the idea that when measuring intangible capital, key talent's claim to that capital in the form of compensation is a quantitatively important consideration. The correlation between the two series is 0.85, despite the fact that executive compensation data was not used to construct the missing value series. Accordingly, we argue that considering the sharing rule between financiers and key talent may have important implications for understanding fluctuations in aggregate, industry, and firm level market values, and we plan to explore this quantitatively in future work.

correlation between CEO turnover and capital reallocation, however the capital reallocation series is available for a longer and larger sample.

[10] We use the series for compensation in large firms from Frydman and Saks (2010) and extend that series using the Execucomp variable tdc2 for the years 2005-2012.

REFERENCES

Atkeson, Andrew, and Patrick J. Kehoe. 2005. "Modeling and Measuring Organization Capital." *Journal of Political Economy*, 113(5): 1026–1053.

Bloom, Nicholas, and John Van Reenen. 2007. "Measuring and Explaining Management Practices Across Firms and Countries." *The Quarterly Journal of Economics*, 122(4): 1351–1408.

Corrado, Carol, Charles Hulten, and Daniel Sichel. 2009. "Intangible Capital and U.S. Economic Growth." *The Review of Income and Wealth*, 55: 661–685.

Corrado, Carol, John Haltiwanger, and Daniel Sichel, ed. 2005. *Measuring Capital in the New Economy.* National Bureau of Economic Research, Inc.

Eisfeldt, Andrea L., and Adriano A. Rampini. 2006. "Capital reallocation and liquidity." *Journal of Monetary Economics*, 53(3): 369–399.

Eisfeldt, Andrea L., and Adriano A. Rampini. 2008. "Managerial Incentives, Capital Reallocation and the Business Cycle." *Journal of Financial Economics*, 87: 177–199.

Eisfeldt, Andrea L., and Dimitris Papanikolaou. 2012. "Organizaiton Capital and the Cross-Section of Expected

Returns, Online Appendix." *Technical Appendix, Authors' Websites*.

Eisfeldt, Andrea L., and Dimitris Papanikolaou. 2013. "Organization Capital and the Cross-Section of Expected Returns." *The Journal of Finance*.

Falato, Antonio, Dalida Kadyrzhanova, and Jae W. Sim. 2013. "Rising Intangible Capital, Shrinking Debt Capacity, and the US Corporate Savings Glut." *Working Paper*.

Fama, Eugene F., and Kenneth R. French. 1997. "Industry costs of equity." *Journal of Financial Economics*, 43(2): 153–193.

Frydman, Carola, and Raven E. Saks. 2010. "Executive Compensation: A New View from a Long-Term Perspective, 1936–2005." *Review of Financial Studies*, 23(5): 2099–2138.

Hansen, Lars Peter, John C. Heaton, and Nan Li. 2005. "Intangible Risk." In *Measuring Capital in the New Economy. NBER Chapters*, 111–152. National Bureau of Economic Research, Inc.

Hulten, Charles, and Xiaohui Hao. 2008. "What is a Company Really Worth? Ingangible Capital and the "Market to Book Value" Puzzle." *NBER Working Paper*, 14548.

Lev, Baruch, and Suresh Radhakrishnan. 2005. "The Valuation of Organization Capital." In *Measuring Capital in the New Economy. NBER Chapters*, 73–110. National Bureau of Economic Research, Inc.

Lustig, Hanno, Chad Syverson, and Stijn Van Nieuwerburgh. 2011. "Technological change and the growing inequality in managerial compensation." *Journal of Financial Economics*, 99(3): 601–627.

McGrattan, Ellen R., and Edward C. Prescott. 2010. "Technology Capital and the US Current Account." *American Economic Review*, 100: 1493–1522.

Zhang, Mindy Xiaolan. 2013. "Who Bears Firm-Level Risk? Implications for Cash Flow Volatility." *Working Paper*.

FIGURE 1. ORGANIZATION TO PHYSICAL CAPITAL: AGGREGATE

This figure plots the aggregate ratio of organization capital to property, plant and equipment, normalized by the 1975 ratio.

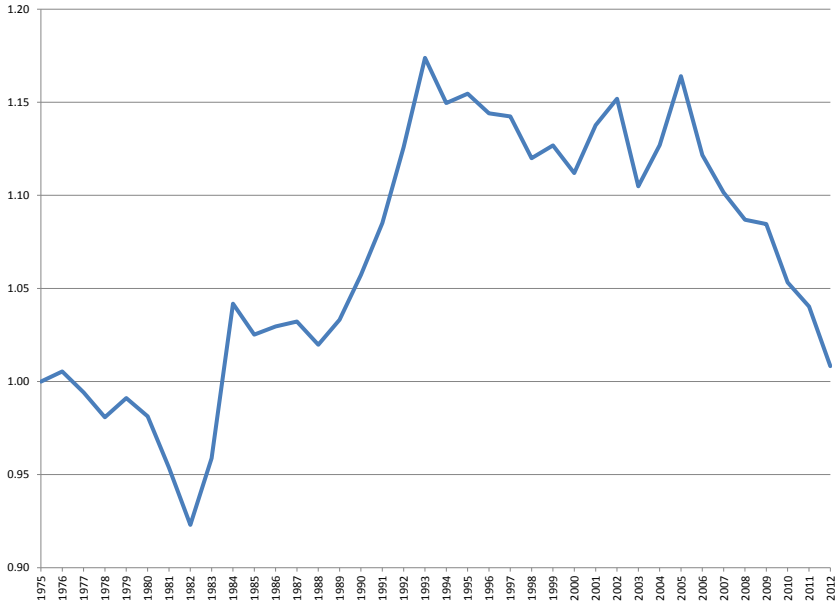

TABLE 1—CALIBRATED TIME SERIES: FRACTION OF VALUE MISSING FROM MEASURED MARKET VALUE OF CAPITAL.

					levels		relative to 1975		
Variable	$\frac{O}{K}$	$\frac{R}{K}$	x_t	$\frac{x_t}{\bar{x}_a}$	$\frac{V_{it}^{HL}}{V_{it}}$		$\frac{O}{K}$	$\frac{V_{it}^{HL}}{V_{it}}$	
1975	0.50	1%	1.96	46%	**42%**	42%	1.00	**1.00**	1.00
1985	0.51	4%	2.27	53%	**48%**	43%	1.03	**1.14**	1.01
1995	0.57	5%	2.29	53%	**51%**	45%	1.15	**1.21**	1.07
2005	0.58	7%	2.43	57%	**53%**	45%	1.16	**1.26**	1.07
2012	0.50	5%	2.29	53%	**48%**	43%	1.01	**1.14**	1.01
$\frac{R}{K}$					actual	1%		actual	1%

FIGURE 2. ORGANIZATION TO PHYSICAL CAPITAL: INDUSTRY LEVEL

This figure plots the aggregate ratio of organization capital to property, plant and equipment, normalized by the 1975 ratio.

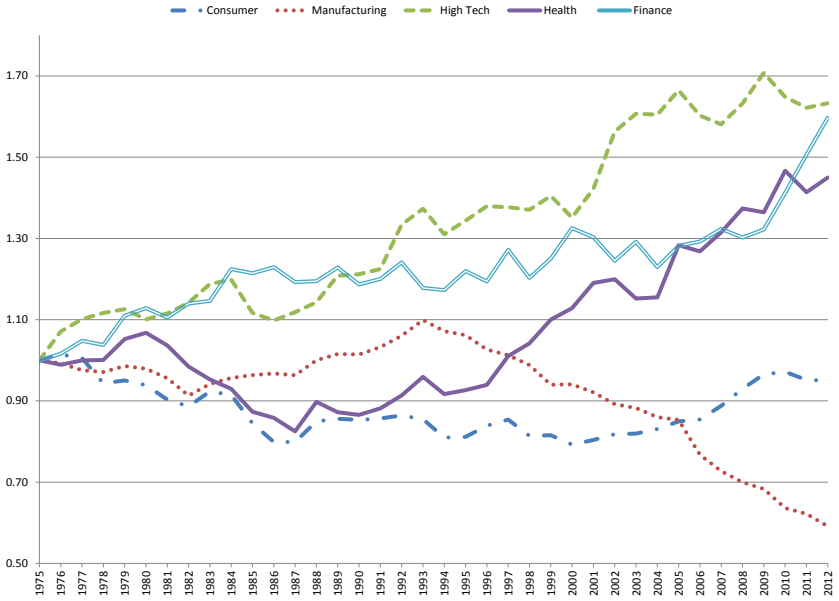

FIGURE 3. FRACTION OF MISSING VALUE

This figure plots the fraction of missing value (right axis) and the ratio of executive compensation to property, plant, and equipment (left axis) relative to their 1975 values.