Accounting for Value

Frederico Belo[*]
University of Minnesota

Chen Xue[†]
University of Michigan

Lu Zhang[‡]
The Ohio State University
and NBER

February 2012

Abstract

What are the determinants of firms' market value? We incorporate quasi-fixed labor and intangible capital inputs into the neoclassical model of investment, and estimate the contribution of each input for explaining firms' market value. Using the generalized method of moments, we estimate that, on average, physical capital accounts for 55% of firms value, installed labor force accounts for 20%, and installed intangible capital accounts for the remaining 25%. What explains these empirical findings? In contrast to conventional wisdom, we show that labor inputs are costly to adjust: we estimate that, on average, total labor adjustment costs represent about 4% of firms' annual sales, about half the value that we estimate for physical capital. In addition, total intangible capital adjustment costs represent about 2% of firms' annual sales. Thus the three capital inputs are costly to adjust which explains why the market assigns a large and positive value to the installed stocks of the different capital inputs. We also characterize the time-series and business cycle of properties of the market value of each capital input. We find that the value of labor is more volatile and procyclical than the value of the remaining inputs suggesting that understanding the determinants of the value of labor input is important for understanding the dynamics of firm value.

[*]Finance Department, Carlson School of Management, University of Minnesota, 3-137 CarlSMgmt, 321 19th Avenue South, Minneapolis MN 55455. Tel: (612) 626-7813 and e-mail: fbelo@umn.edu.

[†]Finance Department, Stephen M. Ross School of Business, University of Michigan, 701 Tappan Street, Ann Arbor MI 48109-1234. Tel: (734) 358-9834 and e-mail: xuechen@umich.edu.

[‡]Department of Finance, Fisher College of Business, The Ohio State University, 760A Fisher Hall, 2100 Neil Avenue, Columbus OH 43210; and NBER. Tel: (614) 292-8644 and e-mail: zhanglu@fisher.osu.edu.

1 Introduction

The market value of corporations is determined by the value of all of its installed capital inputs. In the modern economy, a firm is a complex entity composed of several heterogenous types of capital. Naturally, a firm's market value depends partially on the value of its installed physical capital stock such as machines and plants. In addition, if it is costly to hire and train employees, the value of a firm should also reflect the value of its labor force. Finally, when it is costly to develop effective production practices (knowledge capital), create a brand name, or expand a firms' customer base, the value of the firm should also includes the value of these intangible capital stocks. In this paper, we extend the standard model of investment (q-theory) and use the generalized method of moments (GMM) to quantify the relative importance of the different capital inputs for firm value.

We incorporate quasi-fixed labor inputs and intangible capital inputs into the neoclassical model of investment and estimate the value of each installed capital input via structural estimation. The basic intuition from the model that we use to decompose the value of the firm follows from standard q-theory. At the optimum, firms invest in each capital input until the marginal benefit of an additional unit of capital equals the present value of the benefits. As such, from the optimal investment decision of the firm, we can infer the shadow price of each capital input. Given data on the stock of each capital input across firms, we can then evaluate the value of each installed capital input as the product of the shadow price and the corresponding stock variables.

Our economic question is important. In asset pricing, unlike expected returns, valuation is virtually a virgin territory. Reflecting on the surprising lack of valuation research, Cochrane (2011, p. 1063) writes: "[W]e have to answer the central question, what is the source of price variation? When did our field stop being 'asset pricing' and become 'asset expected returning'? Why are betas exogenous? A lot of price variation comes from discount-factor news. What sense does it make to 'explain' expected returns by the covariation of expected return shocks with market market return shocks? Market-to-book ratios should be our *left-hand* variable, the thing we are trying to explain, not a sorting characteristic for expected returns (original emphasis)." We address this question.

Our estimation procedure is as follows. Under constant returns to scale, the weighted average of stock returns and bond returns equals the weighted average of physical investment return, labor hiring returns, and intangible capital investment returns. In addition, firms' Tobin's Q (the market value of equity and debt divided by the replacement value of total assets) is linked to the marginal benefits of investment in the three capital inputs. We use GMM to match the observed average stock returns and average Tobins' Q with the corresponding moments implied by the model.

Our main empirical findings can be summarized as follows. On average, physical capital accounts for 55% of firms' market value, the installed labor force accounts for 20%, and intangible capital accounts the remaining 25%. The relative importance of physical capital for valuation partially explains the success of the one-capital-good neoclassical model in matching asset pricing facts (e.g., Liu, Whited and Zhang, 2009). The quantitative importance of the other capital inputs, however, also makes it clear that a full understanding of the determinants of hiring decisions as well as intangible capital investment is necessary to fully understand the determinants of firms' market value.

What explains our empirical findings? We show that the three capital inputs that we consider are subject to economically large adjustment costs, which mean that these installed capital stocks are valued in the stock market. At the heart of the investment model is the notion that the capital inputs are costly to adjust. For example, if labor can be freely adjusted and labor markets are perfectly competitive and frictionless, labor inputs are paid their marginal product, and firm managers do not extract any rents from labor. In this case, labor hiring decisions are not forward looking (as in a standard capital stock variable) and labor inputs are chosen every period to equate the one period marginal benefit to the one period marginal cost (wage). As a result, the stock of installed labor force does not contribute to the firms' market value. On the other hand, if it is costly to adjust labor inputs (e.g. due to cost of training and hiring, or due to search frictions) then the firms' market value will reflect the value of its installed labor force. A worker inside the firm is a valuable input because, in addition to contribute to the production of output, it avoids adjustment costs in the future. The same logic applies to the other capital inputs like intangible capital.

Our empirical result show that, in contrast to conventional wisdom (e.g., Hall, 2004) but consistent with Merz and Yashiv (2007), it is costly for a firm to adjust its labor force. In particular, we estimate that a firm' annual labor adjustment costs represent on average about 4% of total annual sales. Although smaller than total physical capital adjustment costs (about 8% of total annual sales), this value is economically large. Similarly, our results suggest that it is costly to adjust the stock of intangible capital. Our estimates show that a firm' intangible capital adjustment costs represent on average about 2.5% of total annual sales.

A large literature on labor demand and investment investigates the importance of capital and labor adjustment costs to explain investment and hiring dynamics.[1] The estimated economic magnitude of adjustment costs is subject to debate. For example, Shapiro (1986) shows that large estimates of labor adjustment costs are important to match investment and hiring dynamics (for non production workers, but not for production workers). Merz and Yashiv (2007) consider the production decision problem of an aggregate representative firm, and find that adding labor adjustment costs substantially improves the fit of the model in matching the time series properties of aggregate stock market prices. Hall (2004), however, estimates both capital and labor adjustment costs to be negligible at the two-digit SIC industry level. We add to this literature by using stock market data (both firm value and stock returns) and structural estimation. In addition, we use a portfolio-based approach that mitigates the measurement error issue that generates problems in this literature.

Our paper is also related to the asset pricing literature on intangible capital and firm risk. Eisfeldt and Papanikolaou (2010) show that firms with more organizational capital are riskier than

[1] See, for example, on capital: Cooper and Haltiwanger (1997), Caballero, Engel and Haltiwanger (1995), Cooper, Haltiwanger and Power (1999) and Cooper and Haltiwanger (2003); on labor: Hamermesh (1989), Bertola and Bentolila (1990), Davis and Haltiwanger (1992), Caballero and Engel (1993), Caballero, Engel and Haltiwanger (1997), Cooper, Haltiwanger and Willis (2004); on joint estimation of capital and labor adjustment costs Shapiro (1986), Galeotti and Schiantarelli (1991), Hall (2004), Merz and Yashiv (2007) and Bloom (2008). Bond and Van Reenen (2007) survey the literature and Hamermesh (1993) reviews a set of direct estimates of the labor adjustment costs.

firms with less organizational capital. Hansen, Heaton, and Li (2004) study the risk characteristics of intangible capital. Li and Liu (2010) and Vitorino (2011) study the importance of intangible capital in a q-theory model via structural estimation. We extend their work by considering a more general model that includes not only intangible capital, but also frictions in the labor inputs. This extension is important to obtain a more accurate assessment of the contribution of each capital input for firm value. Chen, Lakonishok, and Sougiannis (2001) documents a positive relation between R&D intensity and firms' future stock returns, and Li (2007) shows that this positive relation is only present in R&D intensive firms.

The theoretical approach in this paper is related to the work of Merz and Yashiv (2007) who builds upon earlier work of Cochrane (1991). Merz and Yashiv consider an aggregate representative firm in a setup in which, as in our model, the firm faces adjustment costs in both capital and labor and focus on the estimation of the production and adjustment cost function. We extend Merz and Yashiv setup to the cross section, and by also including intangible capital. Extending the model to the firm level allows us to use not only time-series data but also cross-sectional data.

2 The Model of the Firms

This section describes the q-theory framework that we use to decompose the value of a firm. Time is discrete and the horizon infinite. Firms choose costlessly adjustable inputs each period, while taking their prices as given, to maximize operating profits (revenues minus the expenditures on these inputs). Taking these operating profits as given, firms optimally choose physical capital and intangible capital investment, hiring and and debt to maximize the market value of equity.

2.1 Technology

The operating profits function for firm i at time t is $\Pi_{it} \equiv \Pi(K_{it}, N_{it}, U_{it}, X_{it})$, in which K_{it} is physical capital, U_{it} is the stock of intangible capital, N_{it} is the number of employees, and X_{it} is a vector of exogenous aggregate and firm-specific shocks. We assume that the firm has a Cobb-Douglas production function with constant returns to scale, meaning that $\Pi_{it} = K_{it}\partial\Pi_{it}/\partial K_{it} + N_{it}\partial\Pi_{it}/\partial N_{it} + U_{it}\partial\Pi_{it}/\partial U_{it}$.

Physical capital depreciates at an exogenous rate of δ_{it}^K, which is firm-specific and time-varying:

$$K_{it+1} = I_{it}^K + (1 - \delta_{it}^K)K_{it}, \tag{1}$$

in which I_{it}^K is investment. Similarly, the law of motion for the stock of intangible capital is given by:

$$U_{it+1} = I_{it}^U + (1 - \delta_i^U)U_{it}, \tag{2}$$

in which δ_i^U is the intangible capital depreciation rate, and I_{it}^U is the firm's expenditures in intangible capital. Finally, the firm's labor force evolve as:

$$N_{it+1} = H_{it} + (1 - \delta_{it}^N)N_{it}, \tag{3}$$

in which δ_{it}^N is the employee quit rate and H_{it} is the firm's gross hiring.

Firms incur adjustment costs when investing. The augmented adjustment costs function, denoted $C_{it} \equiv C(I_{it}^K, K_{it}, H_{it}, N_{it}, I_{it}^U, U_{it})$, is increasing and convex in investment/hiring, decreasing in the capital stocks, and has constant returns to scale. We consider the following functional form:

$$C_{it} = \frac{1}{\nu_K}\left(\theta_K \frac{I_{it}^K}{K_{it}}\right)^{\nu_K} K_{it} + \frac{1}{\nu_U}\left(\theta_U \frac{I_{it}^U}{U_{it}}\right)^{\nu_U} U_{it} + \frac{1}{\nu_N}\left(\theta_N \frac{H_{it}}{N_{it}}\right)^{\nu_N} W_{it}N_{it},$$

in which W_{it} is the wage rate, which the firm takes as given, $\theta_K, \theta_U, \theta_N > 0$ are the slope adjustment cost parameters, and $\nu_K, \nu_U, \nu_N > 1$ are the curvature adjustment cost parameter. Labor adjustment costs as proportional to the firms' wage bill, as in Bloom (2009).

2.2 Taxable Profits and Firm's Payout

We allow firms to finance investment with debt. At the beginning of time t, firm i issues amount of debt, denoted B_{it+1}, which must be repaid at the beginning of time $t+1$. Let r_{it}^B denote the gross corporate bond return on B_{it}. We can write taxable corporate profits as operating profits minus depreciation, adjustment costs, and interest expense: $\Pi_{it} - I^U_{it} - W_{it}N_{it} - \delta^K_{it}K_{it} - C_{it} - (r^B_{it} - 1)B_{it}$.

Let τ_{it} be the corporate tax rate. We define the payout of firm i as:

$$D_{it} \equiv (1-\tau_t)[\Pi_{it} - C_{it} - I^U_{it} - W_{it}N_{it}] - I^K_{it} + B_{it+1} - r^B_{it}B_{it} + \tau\delta^K_{it}K_{it} + \tau_t(r^B_{it} - 1)B_{it}, \quad (4)$$

in which $\tau_t\delta^K_{it}K_{it}$ is the depreciation tax shield and $\tau_t(r^B_{it} - 1)B_{it}$ is the interest tax shield. Adjustment costs are expensed, consistent with treating them as foregone operating profits.

2.3 Equity Value and Stock Returns

Firm i takes the stochastic discount factor, denoted M_{t+1}, from period t to $t+1$ as given when maximizing its cum-dividend market value of equity:

$$V_{it} \equiv \max_{\{I^K_{it+\triangle t}, K_{it+\triangle t+1}, I^U_{it+\triangle t}, U_{it+\triangle t+1}, H_{it+\triangle t}, N_{it+\triangle t+1}, B_{it+\triangle t+1}\}^{\infty}_{\triangle t=0}} E_t\left[\sum_{\triangle t=0}^{\infty} M_{t+\triangle t}D_{it+\triangle t}\right], \quad (5)$$

subject to a transversality condition given by $\lim_{T\to\infty} E_t[M_{t+T}B_{it+T+1}] = 0$.

Let $P_{it} \equiv V_{it} - D_{it}$ be the ex-dividend equity value. Firms' value maximization implies that:

$$P_{it} + B_{it+1} = q^K_{it}K_{it+1} + q^N_{it}N_{it+1} + q^U_{it}U_{it+1}, \quad (6)$$

in which

$$q^K_{it} \equiv 1 + (1-\tau_t)\theta_K^{\nu_K}\left(\frac{I^K_t}{K_t}\right)^{\nu_K - 1} \quad (7)$$

$$q^N_{it} \equiv (1-\tau_t)W_{it}\theta_N^{\nu_N}\left(\frac{H_t}{N_t}\right)^{\nu_N - 1} \quad (8)$$

$$q^U_{it} \equiv (1-\tau_t)\left[1 + \theta_U^{\nu_U}\left(\frac{I^U_{it}}{U_{it}}\right)^{\nu_U - 1}\right] \quad (9)$$

The variables q^K_{it}, q^N_{it}, and q^U_{it} measure the shadow prices of physical capital, labor force, and intangible capital, respectively. These prices are a function of the investment rates, and allow us to infer the value of each capital input in the data.

In addition, the first-order conditions imply that $E_t[M_{t+1}r^I_{it+1}] = 1$, $E_t[M_{t+1}r^U_{it+1}] = 1$ and

$E_t[M_{t+1}r^H_{it+1}] = 1$, in which r^I_{it+1}, r^U_{it+1}, and r^H_{it+1}, are the physical capital investment return, intangible capital investment return, and labor hiring return, respectively. These returns are defined as:

$$r^I_{it+1} \equiv \frac{\begin{array}{c}(1-\tau_{t+1})\left[\alpha_K \frac{Y_{it+1}}{K_{it+1}} + \frac{\nu_K - 1}{\nu_K}\left(\theta_K \frac{I^K_{it+1}}{K_{it+1}}\right)^{\nu_K}\right] + \delta^K_{it+1}\tau_{t+1} \\ +(1-\delta^K_{it+1})\left[1 + (1-\tau_{t+1})\theta_K^{\nu_K}\left(\frac{I^K_{it+1}}{K_{it+1}}\right)^{\nu_K - 1}\right]\end{array}}{1 + (1-\tau_t)\theta_K^{\nu_K}\left(\frac{I^K_{it}}{K_{it}}\right)^{\nu_K - 1}} \tag{10}$$

$$r^U_{it+1} \equiv \frac{\begin{array}{c}(1-\tau_{t+1})\left[\alpha_U \frac{Y_{it+1}}{U_{it+1}} + \frac{\nu_U - 1}{\nu_U}\left(\theta_U \frac{I^U_{it+1}}{U_{it+1}}\right)^{\nu_U}\right] \\ +(1-\delta^U_i)(1-\tau_{t+1})\left[1 + \theta_U^{\nu_U}\left(\frac{I^U_{it+1}}{U_{it+1}}\right)^{\nu_U - 1}\right]\end{array}}{(1-\tau_t)\left[1 + \left(\theta_U \frac{I^U_{it}}{U_{it}}\right)^{\nu_U - 1}\right]} \tag{11}$$

$$r^H_{it+1} \equiv \frac{\begin{array}{c}(1-\tau_{t+1})\left[\alpha_N \frac{Y_{it+1}}{N_{it+1}} + \frac{\nu_N - 1}{\nu_N}\left(\theta_N \frac{H_{it+1}}{N_{it+1}}\right)^{\nu_N} - W_{it}\right] \\ +(1-\delta^N_{it+1})(1-\tau_{t+1})\theta_N^{\nu_N}\left(\frac{H_{it+1}}{N_{it+1}}\right)^{\nu_N - 1}\end{array}}{(1-\tau_t)\theta_N^{\nu_N}\left(\frac{H_{it}}{N_{it}}\right)^{\nu_N - 1}} \tag{12}$$

The first-order condition with respect to B_{it+1} implies that $E_t[M_{t+1}r^{Ba}_{it+1}] = 1$, in which $r^{Ba}_{it+1} \equiv r^B_{it+1} - (r^B_{it+1} - 1)\tau_{t+1}$ is the after-tax corporate bond return. Let $r^S_{it+1} \equiv (P_{it+1} + D_{it+1})/P_{it}$ be the stock return and $\chi_{it} \equiv B_{it+1}/(P_{it} + B_{it+1})$ be the market leverage. Define $\mu^K_{it} \equiv q^K_{it}K_{it+1}/(P_{it} + B_{it+1})$ as the value-weight of physical capital in the firm value, and $\mu^N_{it} \equiv q^N_{it}N_{it+1}/(P_{it} + B_{it+1})$ as the value-weight of labor value. Let the asset return, denoted r^A_{it+1}), be the value-weighted average of physical capital investment returns, intangible capital investment returns, and hiring returns:

$$r^A_{it+1} \equiv \mu^K_{it} r^I_{it+1} + \mu^N_{it} r^H_{it+1} + (1 - \mu^K_{it} - \mu^N_{it}) r^U_{it+1}. \tag{13}$$

Using a similar argument as in Liu, Whited, and Zhang (2009, Appendix A), we can show that the asset return is equal to the leverage-weighted average of the stock return and the after-tax corporate bond return:

$$r^A_{it+1} = \chi_{it} r^{Ba}_{it+1} + (1 - \chi_{it}) r^S_{it+1}. \tag{14}$$

Rearranging terms, equation (14) implies that the stock return equals the levered asset return:

$$r_{it+1}^{S}=\frac{r_{it+1}^{A}-\chi_{it}r_{it+1}^{Ba}}{1-\chi_{it}}. \tag{15}$$

Equations (6) and (15) express the firm's market value and stock return as functions of firm characteristics, respectively. These two equations provide the key testable predictions that we explore empirically. To a first approximation, stock returns can be seen as the first-difference of firm value (e.g., Cochrane (1991)). Examining equations (6) and (15) simultaneously allows us to evaluate the fit of the model both in levels and in first differences.

3 Econometric Methodology

We provide the moment conditions that we test via GMM, and describe the sample construction.

3.1 Moment Conditions

Equation (6) links firm value to the value of its capital inputs. Because firm value is not stationary, it is necessary to scale this variable for estimation. Dividing both sides of equation (6) by the firm's total assets (A_{it}), we obtain the firm's valuation ratio (Tobin's Q, $Q_{it}\equiv\left(P_{it}+B_{it+1}\right)/A_{it}$) as:

$$Q_{it}=q_{it}^{K}\frac{K_{it+1}}{A_{it}}+q_{it}^{N}\frac{N_{it+1}}{A_{it}}+q_{it}^{U}\frac{U_{it+1}}{A_{it}}. \tag{16}$$

To estimate the model, we test if the average Tobin's Q observed in the data equals the average Q predicted in the model:

$$E\left[Q_{it}-\left(q_{it}^{K}\frac{K_{it+1}}{A_{it}}+q_{it}^{N}\frac{N_{it+1}}{A_{it}}+q_{it}^{U}\frac{U_{it+1}}{A_{it}}\right)\right]=0. \tag{17}$$

in which the q_{it}^{K}, q_{it}^{N}, and q_{it}^{U} are given by equations (7), (8), and (9), respectively.

We also test if the average stock return in the data equals the average levered asset return in the model:

$$E\left[r^S_{it+1} - \frac{r^A_{it+1} - \chi_{it} r^{Ba}_{it+1}}{1-\chi_{it}}\right] = 0. \tag{18}$$

in which r^A_{it+1} is given by equation (13).

Although equations (6) and (15) are exact relations, measurement errors in variables are likely to invalidate them in practice (e.g., Cochrane (1991) and Erickson and Whited (2000)). To construct a formal test of the moment conditions, define the model errors from their empirical moments as:

$$e^Q_i \equiv E_T\left[Q_{it} - \left(q^K_{it}\frac{K_{it+1}}{A_{it}} + q^N_{it}\frac{N_{it+1}}{A_{it}} + q^U_{it}\frac{U_{it+1}}{A_{it}}\right)\right], \tag{19}$$

$$e^R_i \equiv E_T\left[r^S_{it+1} - \frac{r^A_{it+1} - \chi_{it} r^{Ba}_{it+1}}{1-\chi_{it}}\right] \tag{20}$$

in which $E_T[\cdot]$ is the sample mean of the series in brackets. We call e^Q_i the valuation error and e^R_i the return error. The key identification assumption for estimation and testing is that both model errors have a mean of zero. This assumption seems standard in most Euler equation tests.

3.2 Estimation Method

We estimate the model adjustment cost parameter $\theta_K, \theta_N, \theta_U$, and ν_K, ν_N, ν_U, as well as the total share $\alpha \equiv \alpha_K + \alpha_N + \alpha_U$ using one-stage GMM to minimize a weighted average of e^Q_i, a weighted average of e^R_i, or a weighted average of both e^Q_i and e^R_i. When valuation and the stock return moments are estimated separately, we use the identity weighting matrix in one-stage GMM to preserve the economic structure of the testing portfolios. However, the valuation errors, e^Q_i, can often be larger than the return errors, e^R_i, by an order of magnitude. As such, when we estimate the stock return and Tobin's Q moments simultaneously, we adjust the weighting matrix such that the weights for different sets of moments make their model errors comparable in magnitude as in Belo, Chen and Zhang (2011). Specifically, we multiply the valuation moments by a factor of $\sum_i \left|\widehat{e^Q_i}\right| / \sum_i \left|\widehat{e^R_i}\right|$, in which $\widehat{e^Q_i}$ is the portfolio i's valuation error obtained from estimating only the valuation moments, and $\widehat{e^R_i}$ is the portfolio i's return error obtained from estimating only the return moments. In most of our applications, $\sum_i \left|\widehat{e_i^Q}\right| / \sum_i \left|\widehat{e_i^R}\right|$ is about 0.10. When conducting inferences, we use a standard Bartlett kernel with a window length of five to calculate the optimal weighting matrix. To test whether all of the model errors are jointly zero, we use Hansen's (1982, lemma 4.1) χ^2 test.

To reduce the impact of measurement error, we perform the estimation at the portfolio-level, following the approach in Liu, Whited and Zhang (2009).

Once we estimate the parameters of the model, we can compute the fraction of firm value that is attributed to each capital input as follows:

$$\mu_{it}^K = \frac{q_{it}^K K_{it+1}}{q_{it}^K K_{it+1} + q_{it}^N N_{it+1} + q_{it}^U U_{it+1}} \tag{21}$$

$$\mu_{it}^N = \frac{q_{it}^N N_{it+1}}{q_{it}^K K_{it+1} + q_{it}^N N_{it+1} + q_{it}^U U_{it+1}} \tag{22}$$

$$\mu_{it}^U = \frac{q_{it}^U U_{it+1}}{q_{it}^K K_{it+1} + q_{it}^N N_{it+1} + q_{it}^U U_{it+1}} \tag{23}$$

3.3 Data

Our sample consists of all common stocks on NYSE, Amex, and Nasdaq from 1976 to 2008. The firm-level data are from the Center for Research in Security Prices (CRSP) monthly stock file and the annual Standard and Poor's Compustat files. We delete firm-year observations with missing data or for which total assets, gross capital stock, or sales are either zero or negative. We include only firms with fiscal year ending in the second half of the calendar year. We also exclude firms with primary standard industrial classifications between 4900 and 4999 and between 6000 and 6999 because q-theory is unlikely to apply to regulated or financial firms.

Intangible Capital Stock

We measure the intangible capital stock as follows. Investment in intangible capital given by the R&D expenditures (compustat data item XRD), following Li and Liu (2010). Following the literature on intangible capital, we then construct the stock of intangible capital from past expenditures data and using the perpetual inventory method:[2]

$$U_{t+1} = \left(1 - \delta^U\right) U_t + I_t^U \tag{24}$$

To implement the law of motion in equation (24) we must choose an initial stock and a depreciation rate. Using the perpetual inventory method, we choose the initial stock according to:

$$U_0 = \frac{I_0^U}{g^U + \delta^U}.$$

where I_0^U is the firms' investment in intangible capital in the first year in the sample. For the three intangible capital stocks, we use a depreciation rate of 20%. We choose g^U to match the average growth rate of the investment in intangible capital, which in our sample is about 10%. The intangible capital investment rate is then given by the ratio of the current period investment and the beggining of the period corresponding intangible capital stock I_t^U/U_t.

Labor and Physical Capital

The labor market data on wage rate and labor separation rate is not available at the firm level (the firm level wage bill data in COMPUSTAT is missing for more than 80% of the firms on our sample). We measure these variables at the industry level.

Wage per Worker

We measure W_{it} using annual data from the Bureau of Economic Analysis (BEA), GDP-by-Industry accounts. We compute the industry level (annual) wage rate per worker as the ratio of the total compensation of employees (which includes wage and salary accruals and supplements to wages and salaries) to the total number of full time employee in the industry. This data is available at the 2 digits Standard Industry Classification (SIC) level and is available from 1949 to 1997. From 1987 to 2006, this data is available at the 2 digits North American Industry Classification (NAICS)

[2]See also Lev et al (1999), Papanikolaou and Eisfeldt (2010), and Li and Liu (2010) for similar applications. The Bureau of Economic Analysis uses a similar methodology to construct a stock of Research and Development capital, see Sliker (2007).

level. We assign the industry level annual wage rate to the firm level using the firm level SIC code (before 1987) and the firm level NAICS code (after 1987) reported in COMPUSTAT (whenever available) or in CRSP.

Employee Separation Rate

We measure annual employee separation rate δ_{it}^{N} using data for 16 major industry groups based on NAICS codes from the Job Openings and Labor Turnover Survey (JOLTS) available from the Bureau of Labor Statistics (BLS). Because this data is only available since 2001, we proceed as follows. First, for each major industry group we compute the average annual labor separation rate over the period from 2001 to the present. Then, we assign this average value to each firm in our sample for the entire period, using the firm level NAICS code. This procedure thus allows us to capture some heterogeneity in the employee separation rate across industries, but it does not capture variation over time. Since there is no NAICS data in Compustat before 1985, we convert the NAICS code into a SIC code in order to assign the labor separation data to the firm level for this earlier period.

The physical capital stock, K_{it}, is net property, plant, and equipment (Compustat annual item PPENT), and investment, I_{it}, is capital expenditures (item CAPX) minus sales of property, plant, and equipment (item SPPE). The capital depreciation rate, δ_{it}^{K}, is the amount of depreciation (item DP) divided by capital stock.

Additional Variables

Total debt, B_{it+1}, is long-term debt (item DLTT) plus short term debt (item DLC). The market value of equity, P_{it}, is the closing price per share (item PRCC_F) times the number of common shares outstanding (item CSHO). We measure the tax rate, τ_t, as the statutory corporate income tax (from the Commerce Clearing House, annual publications). For corporate bond return, r_{it+1}^{B}, we first follow Blume, Lim, and Mackinlay (1998) to impute the credit ratings for firms with no rating data from Compustat (item SPLTICRM), then assign the corporate bond return for a given credit rating (from Ibbotson Associates) to all firms with the same rating, and finally compute the equal-weighted corporate bond returns from July of t to June of year $t+1$ for each testing portfolio. The after-tax bond return, r^{Ba}_{it+1}, is computed from r^{B}_{it+1} using the average of tax rates in year t and $t+1$ to deal with timing mismatch. The labor stock, N_{it}, is number of employees (item EMP) adjusted by the Consumer Price Index (CPI). Stock variables subscripted t ($t+1$ for debt) are measured and recorded at the end of year t, while flow variables subscripted t are measured over the course of year t and recorded at the end of year $t+1$. All variables are expressed in real terms by adjusting by the CPI.

3.4 Summary Statistics

To be added

4 Estimation Results

To be added

5 Conclusion

To be added

References

Abel, Andrew B., 1982, Dynamic effects of permanent and temporary tax policies in a q model of investment, *Journal of Monetary Economics* 9, 353 − 373

Abel, Andrew B., and Janice C. Eberly, 2001, Investment and q with fixed costs: An empirical analysis, Working paper, University of Pennsylvania

Barclay, Michael J., Clifford W. Smith, and Ross L. Watts, 1995, The determinants of corporate leverage and dividend policies, *Journal of Applied Corporate Finance* 7 (4), 4–19.

Bazdresch, Santiago, Frederico Belo and Xiaoji Lin, 2010, Labor hiring, investment and the stock return predictability in the cross section, Working Paper, University of Minnesota and London School of Economics and Political Science

Belo, Frederico and Xiaoji Lin, 2011, The inventory growth spread, *Review of Financial Studies*, forthcoming

Caballero, Ricardo J., and Robert S. Pindyck, 1996, Uncertainty, investment, and industry evolution, *International Economic Review* 37, 641–662

Cochrane, John, 1991, Production-based asset pricing and the link between stock returns and economic fluctuations, *Journal of Finance* 461, 209 − 237

Cochrane, John, 2001, *Asset Pricing* (Princeton University Press, NJ)

Chan, Louis, Josef Lakonishok and Theodore Sougiannis, 2001, The stock market valuation of research and development expenditures, *Journal of Finance* 56, 2431 − 2456

Eisfeldt, Andrea and Dimitris Papanikolaou, 2011, Organizational capital and the cross-section of expected returns, Working paper, Northwestern University

Fama, Eugene F. and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3–56.

Fama, Eugene F., and Kenneth R. French, 1995, Size and book-to-market factors in earnings and returns, *Journal of Finance* 50, 131–155

Gourio, François and Leena Rudanko, 2010, Customer Capital, Working Paper, Boston University

Griliches, Z. ,1979, Issues in assessing the contribution of research and development to productivity growth, The Bell Journal of Economics, 10, 92–116.

Hall, Bronwyn H., 1993, The stock market's valuation of R&D investment during the 1980's, *American Economic Review* 83, 259–264

Hall, Bronwyn H., and Robert E. Hall, 1993, The value and performance of U.S. corporations, *Brookings Papers on Economic Activity* 1, 1–34

Hall, Robert E., 2001, The stock market and capital accumulation, *American Economic Review* 91, 1185-1202

Hansen, L. P., Heaton, J. C. and Li, N. ,2004, Intangible risk?, Working paper

Hayashi, Fumio, 1982, Tobin's marginal and average q: A neoclassical interpretation, *Econometrica* 50 (1), 213-224

Hennessy, Christopher A., and Toni M. Whited, 2005, Debt dynamics, *Journal of Finance* 60 (3), 1129–1165

Jermann, Urban J, 1998, Asset pricing in production economies, *Journal of Monetary Economics,* 41(2), 257-275

Lev, B., 2001, Intangibles: management, measurement, and reporting, Brookings Institution Press.

Lev, B. and S. Radhakrishnan, 2004, The valuation of organization capital, Working paper, NYU Stern School of Business

Li, Dongmei, 2010, Financial constraints, R&D investment, and stock returns, *Review of Financial Studies*, forthcoming

Li, Erica X. N., and Laura Xiaolei Liu, 2010, Intangible assets and cross-sectional stock returns: evidence from structural estimation, Working paper, University of Michigan

Lin, Xiaoji, 2010, Endogenous technological progress and the cross section of stock returns, *Journal of Financial Economics*, forthcoming

Liu, L. X., Whited, T. M. and Zhang, L., 2009, Investment-based expected stock returns, *Journal of Political Economy,* 117(6): 1105-1139.

Lundholm, Russell J., and Rochard G. Sloan, 2007, Equity valuation and analysis, 2nd ed., McGraw-Hill Irwin

McGrattan, E. R. and E. C. Prescott, 2000, Is the stock market overvalued? Federal Reseve Bank of Minneapolis Quarterly Review 24, 20-40

Penman, Stephen H., 2010, Financial statement analysis and security valuation, 4th ed., McGraw-Hill Irwin

Porter, Michael E., 1992, Capital disadvantage: America's failing capital investment system, *Harvard Business Review* 70, 65–82

Sliker, B. K. ,2007, R&D satellite account methodologies: R&D capital stocks and net rates of return, *R&D satellite account background paper*, Bureau of Economic Analysis/National Science Foundation

Summers, Lawrence, 1981, Taxation and corporate investment: a Q-theory approach, Brookings Papers on Economic Activity

Tuzel, Selale, 2010, Corporate real estate holdings and the cross-section of stock returns, *Review of Financial Studies 23, 2268-2302*

Xing, Yuhang, 2009, Interpreting the value effect through the Q-theory: an empirical investigation, *Review of Financial Studies*, 21, 1767-1795