Capital Age and Labor Investment Efficiency

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ABSTRACT

This study examines how capital age affects the efficiency of corporate labor investments. Using a sample of 1,588 US firms from 1991 to 2016, we find that the efficiency of labor investments increases as technology ages. Subsample analysis on labor investment efficiency suggests that old capital decreases labor over- and underinvestment. Our results remain robust to alternative specifications and restricted to small firms and industries requiring high labor skills. These findings add to the growing literature examining how learning affects a variety of phenomena in finance. Managers' increased understanding of their capital over time facilitates the efficiency of corporate labor investments.

KEYWORDS

Capital Age, Investment Efficiency, Labor Investment

JEL Codes: D24, E22, E24

INTRODUCTION

Our paper builds on the literature that examines how learning affects the understanding of a variety of phenomena in finance (e.g., David, 1997; Veronesi, 2000; Pástor & Pietro, 2003; Pástor & Veronesi, 2009; Ai, 2010; Croce et al., 2015; Collin-Dufresne et al., 2016; Lin et al., 2020). Firm managers have imperfect information about the newly installed technology and learn about its productivity over time as capital ages. Following this argument, Li et al. (2023) document that the efficiency of capital allocation, i.e., investment in the net property, plant, and equipment, improves with an increase in the age of capital. As aging technology facilitates efficient capital allocation, we expect to see its impact on labor hiring as well. Therefore, this study examines the relationship between the firm's capital age (as a proxy for managers' learning of technology over time) and the efficiency of corporate labor investments. Labor is one of the important factors of production (Hamermesh, 1996; Pinnuck & Lillis, 2007; Huang & Tarkom, 2022; Habib & Ranasinghe, 2022), and managers' increased understanding of their capital can also facilitate managers' learning about firm-level labor requirements.

Previous studies have examined the role of several firm and macroeconomic factors, such as financial reporting quality (Jung et al., 2014), accounting conservatism (Ha & Feng, 2018), business strategies (Habib & Hasan, 2021), institutional shareholdings (Ghaly et al., 2020), political uncertainty (Luo et al., 2020), oil price uncertainty (Singh, 2022), and economic growth (Singh, 2023) in influencing corporate labor investment decisions. Based on Li et al.'s (2023) argument, if managers' learning about the productivity of their capital increases over time, we may expect capital age to improve firms' labor investment efficiency, as an increased learning of capital productivity may also facilitate managers'

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understanding of optimal labor hiring. In this regard, we conjecture a negative relationship between capital age and suboptimal labor investments. On the other hand, if firms merely substitute irreversible capital investments for labor due to increased learning of capital productivity (Bernanke, 1983), we may also expect a positive relationship between capital age and suboptimal labor investments. This substitution may increase the deviations between the observed and optimal labor hiring. Therefore, there remains a lack of focus on whether the labor investment decisions of US firms respond to aging capital.

Using a sample of 1,588 US firms from 1991 to 2016, we find that the efficiency of labor investments increases with an increase in the age of capital. Capital age facilitates managers’ understanding of firms’ labor hiring requirements, thereby improving the efficiency of labor investments. Our subsample results suggest that labor overinvestment (overhiring of staff) and underinvestment (overfiring of staff) decrease with an increase in the age of capital. Our results remain robust to alternative specifications, such as firm-fixed effects, the system GMM approach, and an alternative measure of labor investment efficiency. We also find that the relationship between capital age and labor investment efficiency is more pronounced for small firms and industries requiring high labor skills.

Our findings add to the literature that examines the implications of learning in finance. For instance, studies like David (1997), Veronesi (2000), Pástor and Pietro (2003), Pástor and Veronesi (2009), Ai (2010), Croce et al. (2015), Collin-Dufresne et al. (2016), and Lin et al. (2020) document the asset pricing implications of learning on financial market returns and their different moments. In particular, while investigating the asset pricing implications, Li et al. (2023) argue that capital allocation efficiency increases with aging capital. Our study extends this line of research by investigating the relationship between capital age and labor investment efficiency. Following Lin et al. (2020) and Li et al. (2023), we use capital age as a proxy for managers' learning of the productivity of their capital. Our findings suggest that labor investment efficiency improves as managers' learning of their capital increases over time. There is a negative relationship between capital age and suboptimal labor investments.

Our study also contributes to the growing labor investment efficiency literature. Prior studies have examined the role of financial reporting quality (Jung et al., 2014), stock price informativeness (Ben-Nasr & Alshwer, 2016), accounting conservatism (Ha & Feng, 2018), business strategies (Habib & Hasan, 2021), CEO-Director ties (Khedmati et al., 2020), employee-friendly policies (Cao & Rees, 2020), institutional shareholdings (Ghaly et al., 2020), equity compensation (Sualihu et al., 2021), political uncertainty (Luo et al., 2020), shareholder litigation rights (Do & Le, 2022), oil price uncertainty (Singh, 2022), economic growth (Singh, 2023), and stock liquidity (Ee et al., 2022) in influencing the efficiency of corporate labor investments. In this regard, our results support that capital age is another important determinant of labor investment efficiency. Managers' learning of their capital over time facilitates efficient labor investment decisions.

The rest of the paper is organized as follows. Section 2 reports the empirical framework, section 3 discusses our main finding, and section 4 concludes the paper.

EMPIRICAL FRAMEWORK

Our annual financial data for US firms is obtained from the Compustat database from 1991 to 2016 based on data availability. We exclude financial and utility firms due to their unique business operations. We obtain capital age data from Lin et al. (2020), defined as the number of quarters since the firm’s last technology adoption in terms of its investment in the net property plant, and equipment. Following prior studies, e.g., Cao and Rees (2020), Ghaly et al. (2020), Ee et al. (2022), Singh (2022), and Singh (2023), we follow the two-step approach of Jung et al. (2014) for labor investment efficiency. First, the predicted (optimal) values of labor investment are determined by regressing change in hiring against the firm's economic fundamentals, using the following regression model:

$$Changehire_{i,t} = \alpha_0 + \alpha_1 SalesGrowth_{i,t-1} + \alpha_2 SalesGrowth_{i,t} + \alpha_3 \Delta ROA_{i,t} + \alpha_4 \Delta ROA_{i,t-1} + \alpha_5 ROA_{i,t} + \alpha_6 Return_{i,t} + \alpha_7 Size\_P_{i,t-1} + \alpha_8 Liq_{i,t-1} + \alpha_9 \Delta Liq_{i,t-1} + \alpha_{10} \Delta Liq_{i,t} + \alpha_{11} Lev_{i,t-1} + \alpha_{12} LossBin1_{i,t-1} + \alpha_{13} LossBin2_{i,t-1} + \alpha_{14} LossBin3_{i,t-1} + \alpha_{15} LossBin4_{i,t-1} + \alpha_{16} LossBin5_{i,t-1} + \delta_k + \varepsilon_{i,t} \quad (1)$$

Where *i* and *t* represent firm and fiscal years, respectively, and $Changehire$ is the percentage change in employees from year *t-1* to *t*. Sales growth (*SalesGrowth*), return-on-assets (*ROA*), annual stock returns (*Return*), size ranks (*Size_P*), liquidity (*Liq*), leverage (*Lev*), and loss bins (*LossBin*) are our set of control variables. δ_k represents industry dummies (3-digit SIC codes), and ε is the error term. The error term captures suboptimal labor investment, i.e., deviations between the observed and optimal levels of labor investment. A positive (negative) value means labor overinvestment (labor underinvestment). Second, we consider the absolute values of the error term, i.e., ($|Ab\_hire|$), as our measure of labor investment inefficiency. A higher value of $|Ab\_hire|$ indicates greater labor investment inefficiencies. We use the following baseline regression to examine the relationship between capital age and labor investment inefficiency:

$$|Ab\_hire|_{i,t} = \alpha_0 + \alpha_1 Log\_CapitalAge_{i,t-1} + \alpha_2 Controls_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

Where *i* and *t* represent firm and fiscal years, respectively, $|Ab\_hire|$ denotes labor investment inefficiencies from Equation (1), *Log_CapitalAge* is the age of capital, i.e., the number of quarters since the firm's last adoption of technology, expressed in the logarithm terms, and *Controls* include a set of control variables, such as market-to-book ratio (*M/B*), firm size (*Size*), leverage (*Lev*), liquidity (*Liq*), tangibility, dividend payments (*Divd*), loss indicator (*Loss*), institutional ownership (*Insti*), labor intensity (*Labint*), abnormal non-labor investments (*Invest*), and the five-year rolling standard deviation of sales (*SD_Sales*), operating cash flows (*SD_CFO*) and *Changehire* (*SD_Changehire*). ε is the error term. We also append industry and year fixed effects in Equation (2) to account for time-invariant and time-varying unobserved factors across our sample industries and years, respectively. We winsorized our continuous variables at the 1% and 99% levels. After excluding missing observations, there are 10,878 firm-year observations for our sample firms. Table A1 (in the appendix) reports all the variable definitions.

FINDINGS

Table 1 reports the descriptive statistics of our undertaken variables. On average, labor investment inefficiency, i.e., |*Ab_hire*| is 11%, and the age of capital is 25 quarters (or about six years) since the firm's last adoption of technology. Table 2 provides our baseline regression results. We cluster our standard errors by firms, and the test-statistic values are reported in parentheses. Column (1) includes only capital age along with industry and year fixed effects, Column (2) includes control variables along with capital age and industry and year fixed effects, and Column (3) also includes a linear trend to account for any existing trend in labor investment inefficiency. Across all the columns, our findings report that labor investment inefficiency decreases with an increase in the age of capital. A one standard deviation increase in capital age is associated with a 0.010 points reduction in labor investment inefficiency (-0.0234*0.4129), equivalent to about 9% of average labor investment inefficiency.

Table 1. Descriptive Statistics

Variables	N	Mean	SD	p25	p50	p75
|Ab_hire|	10,878	0.11	0.14	0.03	0.06	0.13
CapitalAge (Quarters)	10,878	24.72	10.08	17.21	23.44	31.02
M/B	10,878	2.65	3.01	1.15	1.90	3.14
Size	10,878	5.65	2.09	4.11	5.69	7.11
Lev	10,878	0.21	0.19	0.05	0.19	0.32
Liq	10,878	1.49	1.44	0.68	1.11	1.79
Tangibility	10,878	0.28	0.19	0.14	0.24	0.38
SD_Sales	10,878	0.20	0.17	0.08	0.14	0.24
SD_CFO	10,878	0.06	0.06	0.03	0.05	0.08
SD_Changehire	10,878	0.20	0.27	0.07	0.12	0.22
Divd	10,878	0.43	0.50	0.00	0.00	1.00
Loss	10,878	0.22	0.41	0.00	0.00	0.00
Insti	10,878	0.50	0.31	0.24	0.50	0.76
Labint	10,878	0.01	0.01	0.00	0.01	0.01
Invest	10,878	0.09	0.08	0.03	0.07	0.11

Note: This table reports the descriptive statistics of our undertaken variables. All the variable definitions are provided in the appendix.

In Table 3, we further check the robustness of our findings. Column (1) includes firm-fixed effects to account for time-invariant unobserved factors across our sample firms, Column (2) employs a system GMM model, and Column (3) considers an alternative definition of labor investment inefficiency. One could argue that managers can introduce a change in their capital investment plans in anticipation of labor investments, i.e., labor investment inefficiency could also influence capital age. Therefore, we employ a system GMM model, using one-year lagged values of labor investment inefficiency ($|Ab\_hire|_{i,t-1}$) and capital age ($Log\_CapitalAge_{i,t-1}$) as endogenous variables. In particular, we use the following regression specification:

$$|Ab\_hire|_{i,t} = \alpha_0 + \alpha_1 Log\_CapitalAge_{i,t-1} + \alpha_2 |Ab\_hire|_{i,t-1} + \alpha_3 Controls_{i,t-1} + \varepsilon_{i,t} \qquad (3)$$

Further, we consider an alternative definition of labor investment inefficiency, considering the absolute values of the difference between the observed change in hiring and industry-median change in hiring each year as our proxy for the optimal labor hiring (Jung et al., 2014). Our findings remain consistent across all the specifications.[1] Labor investment inefficiency decreases with an increase in the age of capital. Like capital allocation efficiency (Li et al., 2023), aging capital improves the efficiency of labor investment decisions in US firms.

To understand the effect of capital age specifically on the type of labor investment inefficiency, we also examine its impact on labor over- and underinvestment. We further categorize labor overinvestment into staff overhiring and underfiring and labor underinvestment into staff overfiring

[1] One could argue that firms with high capital age could fundamentally be different from low capital age firms. Therefore, we also employ a propensity score matching (PSM) model. In un-tabulated results, our findings remain consistent after using a PSM model, considering third-tercile industry-year values of capital age as treatment and other values as control observations.

Table 2. Baseline Results

Variables	(1) |*Ab_hire*|	(2) |*Ab_hire*|	(3) |*Ab_hire*|
Log_CapitalAge	*-0.0357**** *(-6.11)*	*-0.0234**** *(-4.36)*	*-0.0230**** *(-4.24)*
M/B		*0.00354**** *(4.53)*	*0.00354**** *(4.54)*
Size		*-0.00635**** *(-4.08)*	*-0.00633**** *(-4.06)*
Lev		*-0.00841* *(-0.72)*	*-0.00840* *(-0.72)*
Liq		*0.00546**** *(3.04)*	*0.00550**** *(3.04)*
Tangibility		*-0.0164* *(-0.87)*	*-0.0163* *(-0.87)*
SD_Sales		*0.00293* *(0.20)*	*0.00262* *(0.18)*
SD_CFO		*0.199**** *(4.16)*	*0.198**** *(4.15)*
SD_Changehire		*0.0320**** *(2.74)*	*0.0319**** *(2.74)*
Divd		*0.000712* *(0.17)*	*0.000934* *(0.22)*
Loss		*0.0144**** *(3.21)*	*0.0143**** *(3.20)*
Insti		*0.00403* *(0.50)*	*0.00395* *(0.49)*
Labint		*0.0868* *(0.30)*	*0.0887* *(0.31)*
Invest		*0.127**** *(4.98)*	*0.127**** *(4.98)*
Trend			*-0.000166* *(-0.44)*
Constant	*0.216**** *(11.40)*	*0.167**** *(7.01)*	*0.167**** *(7.01)*
Observations	*8,775*	*8,775*	*8,775*
Industry FEs	*Yes*	*Yes*	*Yes*
Year FEs	*Yes*	*Yes*	*Yes*
Adjusted R^2	*0.08*	*0.11*	*0.11*

Note: This table reports the baseline regression results for capital age and labor investment inefficiency. Column (1) includes only capital age along with industry and year fixed effects, Column (2) includes control variables along with capital age and industry and year fixed effects, and Column (3) also includes a linear trend to account for any existing trend in labor investment inefficiency. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Robustness

Variables	*Firm Fixed Effects*	*System-GMM Model*	Alternative Measure
Log_CapitalAge	*-0.0154** *(-1.71)*	*-0.0297*** *(-2.55)*	*-0.0349**** *(-5.46)*
$\|Ab\_hire_{t-1}\|$		*-0.184* *(-0.93)*	
Controls	*Yes*	*Yes*	*Yes*
Observations	*8,583*	*8,789*	*8,811*
Firm FEs	*Yes*	*No*	*No*
Industry FEs	*No*	*No*	*Yes*
Year FEs	*Yes*	*No*	*Yes*
Adjusted R^2	*0.20*		*0.09*
AR(2)		*-1.55* *[0.122]*	
Sargan Test		*39.91* *[0.519]*	

Note: This table reports the robustness results for capital age and labor investment inefficiency. p-values are reported in the square brackets. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

and underhiring (Jung et al., 2014; Ee et al., 2022). Table 4 reports the regression results for capital age and labor over- and underinvestment subsamples.

Table 4. Labor Overinvestment V/S Labor Underinvestment

Variables	Overinvestment	Overhiring	Underfiring	Underinvestment	Overfiring	Underhiring
Log_CapitalAge	*-0.040**** *(-4.15)*	*-0.041**** *(-3.90)*	*0.001* *(0.09)*	*-0.0083** *(-1.94)*	*-0.020**** *(-2.90)*	*-0.0024* *(-0.40)*
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*3,668*	*3,299*	*220*	*5,077*	*2,942*	*1,742*
Industry FEs	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year FEs	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Adjusted R^2	*0.11*	*0.12*	*0.17*	*0.16*	*0.15*	*0.26*

Note: This table reports the results for capital age and labor investment inefficiency after considering labor over- and underinvestment subsamples. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

We find that this improvement in labor investment efficiency exists for both labor over- and underinvestment subsamples. In particular, labor investment inefficiency for staff overhiring and overfiring subsamples decrease with an increase in the age of capital, supporting an improvement in the overall labor investment efficiency. Lastly, we also undertake cross-sectional tests based on firm size and labor skills to examine the relationship between capital age and labor investment inefficiency. We gathered data related to the industry's requirement for high and low labor skills from Belo et al. (2017). We categorize firms into small and big groups based on the median value of firm size. Table 5 reports our subsample regression results. Our results show that labor investment inefficiency decreases for small firms and industries requiring high labor skills subsamples. It implies that old capital facilitates managers' understanding of labor requirements in relatively small firms and industries requiring workers with a high level of training and preparation. Overall, our findings suggest that it is relatively easier for managers in small firms to understand the productivity of their capital and make optimal labor investment decisions, particularly in industries requiring high labor skills.

Table 5. Cross-Sectional Heterogeneity

	Firm Size		Industry Labor Skills	
Variables	**Small**	**Big**	**Low**	**High**
Log_CapitalAge	*-0.0265**** *(-3.76)*	*-0.0118* *(-1.35)*	*-0.0126* *(-1.38)*	*-0.0201*** *(-2.50)*
Controls	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*4,166*	*4,589*	*3,268*	*4,136*
Industry FEs	*Yes*	*Yes*	*Yes*	*Yes*
Year FEs	*Yes*	*Yes*	*Yes*	*Yes*
Adjusted R^2	*0.12*	*0.11*	*0.10*	*0.11*

Note: This table reports the results for capital age and labor investment inefficiency after considering firm size and industry labor skills. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

CONCLUSION

This study examines how the age of capital based on a firm's last adoption of technology affects the efficiency of corporate labor investments. Using a sample of 1,588 US firms from 1991 to 2016, we find that labor investment efficiency improves as capital ages. This improvement in labor investment efficiency exists for both labor over- and underinvestment subsamples. As managers' understanding of capital increases over time staff overhiring and overfiring come down. Our results remain robust to alternative specifications and restricted to small firms and industries requiring high labor skills.

Our findings add to the growing literature on how learning affects a variety of phenomena in finance. Prior studies have mainly examined the asset pricing implications of learning. In particular, while investigating the asset pricing implications of aging capital, Li et al. (2023) argue that managers' increased understanding of their capital over time contributes to higher capital allocation efficiency. Our study extends this line of research by documenting the response of corporate labor investment decisions to aging capital. Managers' learning of their capital contributes not only to increased capital allocation efficiency but also decreases suboptimal labor investments. Aging capital facilitates the efficiency of corporate labor investments.

Our study also contributes to a growing debate over technology adoption (particularly automation) and how that could influence corporate labor investment decisions (e.g., Autor & Dorn, 2013; Zhang, 2019; Knesl, 2023). Given that aging capital facilitates managers' understanding of labor hiring requirements, one main inference that we can draw from this study is that while devising plans to adopt new technology, firm managers should also consider the importance of old capital in terms of its learning role. It is because constant automation or newly installed technology effectively reduces the capital age, thereby influencing managers' learning of capital productivity and the efficiency of corporate labor investments.

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APPENDIX

Table A1. Variable Definitions

Variables	Definitions
Changehire	*Percentage change in employees from t-1 to t*
SalesGrowth	*Percentage growth rate of sales from t-1 to t*
ROA	*Net income to total assets at t-1*
ΔROA	*Change in ROA*
Return	*Annual stock return*
Size	*Natural logarithm of the market capitalization*
Size_P	*Percentile rank of the Size*
Liq	*Ratio of cash & short-term investments plus receivables to current liabilities at t-1*
ΔLiq	*Change in Liq*
Lev	*Total debt (long-term and short-term debt) to total assets*
LossBin	*An indicator variable equal to 1 if ROA is less than zero. There are five loss bins indicating ROA falling between an interval of 0.005 from 0 to -0.025*
Ab_hire	*Residuals obtained from Equation (1)*
|Ab_hire|	*Absolute values of Ab_hire*
Log_CapitalAge	*Log(1+Capital Age)*
M/B	*Market-to-book ratio*
Tangibility	*Net property, plant, and equipment to total assets*
SD_Sales	*Rolling standard deviation (five-years) of sales divided by total assets*
SD_CFO	*Rolling standard deviation (five-years) of operating cash flows divided by total assets*
SD_Changehire	*Rolling standard deviation (five-years) of Changehire*
Divd	*An indicator variable equal to 1 if a firm paid dividends, and 0 otherwise*
Loss	*An indicator variable equal to 1 if a firm reported a loss, and 0 otherwise*
Insti	*Ownership by institutional investors*
Labint	*Number of employees to total assets at t-1*
Invest	*Absolute values of the residuals obtained from the investment efficiency model of Biddle et al. (2009)*
Overhiring	*Changehire and Ab_hire are greater than 0*
Underfiring	*Changehire is less than 0 but Ab_hire is greater than 0*
Overfiring	*Changehire and Ab_hire are less than 0*
Underhiring	*Changehire is greater than 0 but Ab_hire is less than 0*