Skilled Labour, Employee Ownership, and Firm Risk

by

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Intellectual Property Statement

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Employing highly qualified and skilled workers is crucial for firms in the knowledge economy, as they compete in an increasingly complex and turbulent business environment. Whilst substantial research has focused on the potential benefits of investment in skilled labour, little attention has been given to its downside. This thesis examines one important aspect, namely increases in the firm's equity risk.

The quality of human capital in individual firms is generally unobservable. To bypass this, a labour skill index is constructed using industry-level data, representing the degree to which firms in a given industry rely on skilled labour. The index is calculated annually from 1990 to 2014 across a wide range of industries, and is the main test variable throughout the empirical chapters.

The major findings of this thesis are as follows. First, firms located in more highly skilled industries are perceived by investors as having more volatile fundamentals, reflected in greater idiosyncratic return volatility. The relationship is moderated by the presence of broad-based employee ownership, highlighting the latter's risk management implications. Second, with respect to the level of broad-based employee ownership, it displays an inverted U-shaped relationship with the labour skill index. The positive relationship between the two is reversed only for firms at the top end of the skill spectrum. Third, firms that rely more heavily on skilled labour incur a higher implied cost of equity. This is attributed to increased operating leverage which amplifies firms' exposure to systematic risk.

Summarising, this thesis provides evidence that reliance on skilled labour exacerbates both idiosyncratic and systematic components of the firm's equity risk. In addition, this thesis corroborates broad-based employee ownership as a form of employee governance, and shows that its presence mitigates firm-specific return volatility associated with investment in skilled labour.

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List of Abbreviations

BLS	Bureau of Labor Statistics
CPS	Current Population Survey
CRSP	Center for Research in Security Prices
CUSIP	Committee on Uniform Securities Identification Procedures
DB	Defined Benefit
DC	Defined Contribution
EIN	Employer Identification Number
ERISA	Employee Retirement Income Security Act of 1974
ESOP	Employee Stock Ownership Plan
EU	European Union
I/B/E/S	Institutional Brokers' Estimate System
IPUMS	Integrated Public Use Microdata Series
IRC	Internal Revenue Code
IRS	Inland Revenue Service
NAICS	North American Industry Classification System
NBER	National Bureau of Economic Research
NSB	National Science Board
OECD	Organisation for Economic Co-operation and Development
OES	Occupational Employment Statistics
SIC	Standard Industry Classification
U.K.	United Kingdom
U.S.	United States of America
USDOL	United States Department of Labor

1 Introduction

1.1 Introduction

Since the latter part of the twentieth century, the United States (U.S.) and other major economies have transitioned from a production-based to a knowledge-based economy, where knowledge increasingly supplants traditional factors of production such as physical capital and natural resources[1]. This is reflected by the remarkable growth of intangible-intensive firms, which emphasise human capital as the major source of rents (see Zingales (2000)). These firms operate primarily in high-technology manufacturing and knowledge-intensive services which, as of 2014, accounted for more than a third of private non-farm employment, and nearly 40 percent of the U.S. Gross Domestic Product (GDP) (National Science Board (2016)). Moreover, they are commanding a greater influence in the capital market, by attracting considerable funds from equity investors[2].

The significant human capital that skilled workers acquire prior to entering job market – through years of education, training and experience – allows them to engage in complex learning and innovation, thus developing intellectual human capital that lies at the heart of firms' knowledge base (Zucker et al. (1998)). This underlies a surge in demand for skilled workers over the past few decades, fuelled by technological advances and globalisation[3]. Concurrently, there has been a fall in demand for less-skilled workers as the jobs they typically perform become amenable to automation and global outsourcing. The relative demand shifts have led to growing employment and wage differentials[4].

As firms improve their efforts to attract, motivate, and retain skilled workers, the assumption is that the latter will facilitate conception and implementation of superior strategies. An extensive literature, motivated by the resource-based theory, has examined

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[1] Chapter 2, Section 2.1 provides a detailed account of knowledge economy in the U.S.

[2] For instance, Gupta-Mukherjee (2014) shows that the portfolio concentration of actively managed mutual funds in intangibles (i.e. R&D) increased dramatically over the 1980-2009 period. Specifically, the implicit R&D expense as a share of physical capital expense was less than 10% in the firms held by mutual funds during the early 1980s, but remained above 40% after the early 2000s.

[3] Cf. Beechler and Woodward (2009) on the global "war for talents"

[4] A recent report shows that college premium was at a record high in 2013: amongst young adults aged 25-32, the median annual wage was $45,500 for college graduates, compared to $28,000 for high-school graduates. The gap was more than double that in 1965 (Pew Research Center (2014)).

the strategic merits of human capital[5]. A subset of research focuses on the micro-foundations of human capital-based competitive advantage. Specifically, it is concerned with the attributes of individual workers which determine their rent-generating potential, while also imposing management challenges that must be addressed before rents can be realised (e.g. Coff (1997), Coff and Kryscynski (2011)).

The human capital of skilled workers is particularly likely to be a double-edged sword, given significant ambiguities in their work (Alvesson (2004)) and their mobility (Drucker (1997))[6]. That is, while employment of skilled workers represents a conscious search for higher returns, these may not materialise due to the risky nature of knowledge work – or, if they do, may quickly dissipate as skilled workers become disgruntled or leave the firm.

Numerous studies have highlighted the importance of engaging and retaining workers, especially knowledge workers (Tempoe (1993), Sutherland and Jordaan (2004)). Similarly, researchers in strategic human resource management (HRM) (Wright and McMahan (1992, 2011)) have considered how HRM systems and routines may be leveraged to achieve sustained competitive advantage. However, what seems to be lacking is a detailed understanding of how the implied management challenges associated with skilled workers affect the firm. Related empirical evidence would be useful in at least two respects. First, it contributes to substantiating the trade-off of investing in skilled labour, now ubiquitous across knowledge economies. Second, it contributes to making a stronger case for governance mechanisms or HRM practices aimed to minimise the downside to knowledge-intensive employment.

This thesis analyses the impact of skilled labour on firm risk, with respect to both the idiosyncratic and systematic components of equity risk. Also examined is the relationship between skilled labour and broad-based employee ownership, an increasingly common HRM practice; and whether the latter influences the risk effect of skilled labour. All the analyses are conducted in the U.S. context to exploit detailed data from public sources.

The next section summarises each of the empirical chapters contained in this thesis, and their respective contribution to the literature.

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[5] See Chapter 2, Subsection 2.3.2 for a review

[6] Specifically, "[k]nowledge workers, unlike manufacturing workers, own the means of production: they carry their knowledge in their heads and therefore can take it with them." (Drucker (1997, p.24))

1.2 Overview and Contributions of the Thesis

This thesis starts with a background discussion of the underlying theme, i.e. skilled labour, in Chapter 2. Macroeconomic causes and consequences of the increased demand for skilled labour are presented. The focus then shifts to skill demand at the firm level. Insights are drawn from the resource-based theory to explain the strategic relevance of investment in skilled labour. The chapter concludes by discussing potential issues arising from skill-intensive employment. The first part of Chapter 3 outlines selection criteria for the initial sample, and the distribution of sample firms. The second part of Chapter 3 provides details of the labour skill index (i.e. the main empirical proxy for skilled labour intensity), including its economic rationale, construction, and relationship with firm characteristics. The three empirical chapters (Chapters 4-6) then follow. The thesis concludes with Chapter 7 which summarises the main results, discusses research limitations, and suggests directions for future research.

The remainder of this section describes the motivation, findings and contributions pertaining to each of the three empirical chapters.

1.2.1 First Study

The volatility of firm-level stock returns (i.e. equity risk) can be decomposed into its idiosyncratic and systematic components. Idiosyncratic return volatility, which reflects cash flow uncertainty induced by firm-specific factors, typically accounts for the majority of total return volatility, and is the focus of the first empirical chapter, Chapter 4.

Idiosyncratic risk was deemed irrelevant by traditional asset pricing models, given that it can be eliminated through diversification. However, theoretical and empirical evidence has shown that investors do not always hold a fully diversified portfolio, which leads to idiosyncratic risk being priced (see Goyal and Santa-Clara (2003)). Besides having potential implications for stock returns, idiosyncratic risk matters for various stakeholders: corporate risk managers, employees participating in share schemes, financial analysts, option writers, market makers, active fund managers, and arbitrageurs.

The first research question is: Does idiosyncratic risk increase with firms' reliance on skilled labour? A positive relationship is hypothesised, based on the susceptibility of skill-intensive firms to agency problems and voluntary employee turnover. By relating idiosyncratic risk to skilled labour, the chapter adds to the literature on the determinants of idiosyncratic risk. Although many factors linked to firm fundamentals have been proposed (see Zhang (2010), Bekaert et al. (2012)), no study has yet considered the labour characteristics of the firm. The chapter contributes to closing this gap.

The second research question is: Does broad-based employee ownership (BBEO) moderate the relationship between idiosyncratic risk and firms' reliance on skilled labour? A negative moderating effect is hypothesised, based on the idea that BBEO improves retention and motivation, thus alleviating the management problems in skill-intensive firms. Much of the empirical literature evaluating the effects of BBEO has focused on productivity (e.g. Blasi et al. (1996), Pendleton and Robinson (2010), and Kim and Ouimet (2014)). The chapter contributes by suggesting that BBEO may play a risk management role – beyond its performance implications – through influencing the risk perception of external investors.

The results support both hypotheses: The level of idiosyncratic risk increases with the labour skill index. Moreover, the positive association is moderated by the presence – and in some cases, the level[7] – of BBEO. Both effects are statistically and economically significant.

In providing a self-contained analysis, Chapter 4 also highlights the three themes of this thesis: skilled labour, firm risk, and employee ownership. The links between these themes are further explored in the two remaining empirical chapters.

1.2.2 Second Study

The second empirical chapter, Chapter 5, looks inside the firm, and examines the research question: What is the relationship between BBEO and firms' reliance on skilled labour? Two competing hypotheses are formulated. The first hypothesis posits a positive relationship. This corresponds to the traditional view that BBEO promotes incentive alignment and long-term commitment. To the extent that these benefits are particularly relevant for knowledge-intensive firms – due to significant information asymmetry and competition in the labour market – BBEO would be a positive function of labour skill. The second hypothesis posits an inverted U-shaped relationship, with the inflection point occurring at the higher end of skill distribution. This is based on the insight from the compensation literature, that risk-averse executives are motivated to reduce the volatility of the stock-based share of their wealth (Stulz (1984), Smith and Stulz (1985)). In knowledge-intensive firms where the boundary between executives and non-executives is blurred, and

[7] This applies when BBEO is scaled by total employees (rather than, e.g. market equity), thus more closely linked to employee welfare. The moderating effect disappears, however, when the level of BBEO falls in the top sample quartile, suggesting excessive BBEO.

where risk-taking is required for innovation, excessive BBEO could thus harm growth (cf. Bova, Kolev, Thomas, and Zhang (2015), Chang et al. (2015)). Where the latter concern outweighs the incentive benefits of BBEO, the positive relationship suggested in the first hypothesis would be reversed for high-skilled firms.

Testing the above hypotheses contributes to understanding and explaining stock-based compensation in the knowledge economy (cf. Ittner et al. (2003), Murphy (2003)). Most of the previous empirical work has measured human capital indirectly through growth-related variables, which could capture aspects of firm production unrelated to human capital. The chapter addresses the problem, at least partially, by estimating the labour skill index as the main independent variable.

Consistent with the second hypothesis, the results show a clear inverted U-shaped relationship between BBEO and the labour skill index. That is, investment in skilled labour increases BBEO for less-skilled firms, but decreases it for highly skilled firms. While the chapter focuses mainly on the level of BBEO, which has direct implications for employee wealth, the estimation model (i.e. Heckman's two-step method) allows joint analysis of the presence as well as level of BBEO[8]. Interestingly, while an inverted U-shaped relationship also exists for the presence of BBEO, the positive slope is now less pronounced and the negative slope much steeper. This suggests a greater reluctance to adopt BBEO as firms expand their skill base, possibly due to the costs of establishing and maintaining related schemes. But for firms that already have BBEO, they appear more enthusiastic about the potential benefits of BBEO in managing skilled workers.

Viewed in relation to Chapter 4, the evidence in Chapter 5 may be interpreted as showing an underutilisation of BBEO, given that its mere presence would send a positive signal to outside investors concerned with the bargaining power of skilled workers. On the other hand, the trade-off faced by managers in increasing the level of BBEO appears to be similarly perceived by outside investors (see footnote above).

1.2.3 Third Study

The third empirical chapter, Chapter 6, shifts the focus back to equity risk, particularly its systematic component. Contrasting with idiosyncratic risk, discussed in Chapter 4,

[8] This represents another improvement to the existing empirical literature, which often uses a standard Tobit or OLS model (e.g. Rauh (2006), Even and Macpherson (2008), and Wang et al. (2009)). To ensure that the inferences are not sensitive to model specifications, both Tobit and OLS will be implemented alongside Heckman's model in the main analysis.

systematic risk cannot be eliminated by holding a well-diversified portfolio. This is because it stems from macroeconomic factors that affect all firms in the market. As such, standard asset pricing models posit that firms' stock returns are primarily determined by their exposure to systematic risk, which underlies the cost of equity capital.

The research question examined in this chapter is: Does the cost of equity capital increase with firms' reliance on skilled labour? A positive relationship is hypothesised. This is based on the idea that by reducing operating flexibility, high-skill employment induces operating leverage that amplifies the systematic risk exposure[9]. Recently, a growing literature has explored sources of labour market frictions that increase operating leverage, and thus equity premium (e.g. Danthine and Donaldson (2002), Chen et al. (2011), Ochoa (2013), and Donangelo (2014)). The chapter adds to this literature by considering heterogeneity across firms in terms of skilled labour intensity.

The results strongly support the hypothesis. The positive relationship between the labour skill index and firm-specific cost of equity is both statistically and economically significant. Further analysis shows that the labour skill index correlates positively with the degree of operating leverage, wage rigidity and hiring costs, which substantiates the operating leverage effect.

The evidence presented in Chapter 6 highlights the dilemma faced by firms in the knowledge economy. On the one hand, underinvestment in skilled labour reduces the innovative capacity of the firm, thus inhibiting competitive advantage. On the other hand, investment in skilled labour results in higher risk, making it costlier to raise equity capital, if the potential of such investment to generate higher returns is rationally priced.

[9] Earlier finance works (e.g. Hamada (1972), Rubinstein (1973)) decompose systematic risk into operating and financial risk, arising from the firm's asset and capital structure, respectively. The two risk components are commonly represented by the degree of operating and financial leverage in empirical studies (e.g. Mandelker and Rhee (1984), García-Feijóo and Jorgensen (2010)).

2 Background

This chapter provides general background of the thesis, and is divided into four sections as outlined below.

Section 2.1 discusses the concept of knowledge economy, and how it has come to characterise many developed economies, especially the U.S. (the focus of the present thesis). In evaluating a knowledge economy, the quality of human capital constitutes one of the most important yardsticks.

The salience of human capital in the knowledge economy is taken up further in Section 2.2. Specifically, the section reviews the economic literature for theories that explain the increasing emphasis on skilled labour as production input, alongside technology capital.

Section 2.3 shifts the focus from the wider economy to individual firms. Skill-intensive employment is linked to a firm's conscious pursuit of sustained competitive advantage, by leveraging insights from the resource-based theory.

Section 2.4 consists of two parts. The first part summarises previous sections. The second part discusses the difficulties of managing human capital, especially that of skilled workers. Thus, there is the possibility that economic rents fail to occur and, even if they do, may be short-lived or appropriated by employees. Despite many theoretical contributions to the trade-off of employing skilled labour, empirical evidence about its implications has been scarce. The quantitative studies of this thesis help fill this gap.

2.1 Knowledge Economy

Over the past few decades, advanced industrial nations, including most members of the Organisation for Economic Co-operation and Development (OECD), have transitioned towards a knowledge economy, defined as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence" (Powell and Snellman (2004, p.199))[10]. A prime example is the U.S., whose robust growth in output and productivity in the late 1990s attracted considerable attention (Jorgenson and Stiroh (2000b), OECD (2001)).

[10] A related concept is "new economy", whose development and popularisation has been attributed to the OECD and its decades of research on technology and productivity (Godin (2004)).

Notwithstanding the difficulty to pin down knowledge economy (OECD (1996))[11], Brinkley (2006) suggests three dimensions along which it could be measured: industry, occupation, and innovation. To contextualise the knowledge economy in the U.S., recent evidence corresponding to these dimensions is summarised below.

Within the knowledge economy, some industry sectors are considered more sophisticated than others, given their strong link to science and technology. In particular, they are heavily invested in the production and/or use of information and communications technology (ICT) (e.g. Jorgenson and Stiroh (2000b), Colecchia and Schreyer (2002)). Identifying the share of economic contributions by these industries helps put the knowledge economy into perspective, while facilitating international comparison. The OECD classifies ten groups of knowledge- and technology-intensive (KTI) industries (as cited in the National Science Board (NSB) (2012)). These comprise five high-technology (HT) manufacturing industries (aerospace; pharmaceuticals; computers and office machinery; communications and semiconductors; and testing, control and measuring instruments), and five knowledge-intensive (KI) services (finance; business; information; education; and health). As of 2014, KTI industries accounted for 39 percent of U.S. GDP (NSB (2016))[12]. They also employed 43.4 million workers, representing more than a third of the private non-farm workforce.

As physical capital becomes increasingly commoditised, thus less unique, human capital is emerging as the most valuable asset in the knowledge economy. This is because the production and diffusion of knowledge and technology hinges on intellectual capabilities, as embedded in human capital. Economies with a greater endowment of human capital, therefore, are likely to enjoy more innovation and productivity growth. The emphasis on human capital is reflected in the rapid expansion of tertiary education across OECD economies (Machin and McNally (2007))[13]. As of 2015, 36 percent of the U.S. population aged 25-34 held at least a Bachelor's degree, according to the Current Population Survey (CPS)[14].

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[11] See also Griliches (1994), Dean (1999), Guillickson and Harper (1999), Triplett (1999), and Jorgenson and Stiroh (2000a).

[12] See https://www.nsf.gov/statistics/2016/nsb20161/#/data. The comparative figure was 28.6 percent globally, 33 percent for developed economies and 30 percent for the European Union (EU).

[13] The OECD (2015, p.96) shows that the higher education spending (as a percentage of GDP) in 2011 was higher than that in 2000 for the majority of its member states, including the U.S.

[14] See https://www.census.gov/topics/education/educational-attainment.html. Adopting a broader definition, the OECD reports that in 2015, the share of the 25-34 population with tertiary education was 46.5 percent in the U.S., compared to the OECD average of 42.1 percent – see https://data.oecd.org/eduatt/population-with-tertiary-education.htm.

Using educational attainment as a proxy for knowledge economy is potentially problematic, however. Specifically, college graduates are employed across occupations which differ in skill and technological intensity, and thus salience to the knowledge economy (cf. Machin and McNally (2007)). A more effective proxy would be the share of knowledge-intensive occupations in the economy[15]. The extent of science and engineering (S&E) labour force is a useful indicator. In the U.S., the number of S&E occupations (life scientists; computer and mathematical scientists; physical scientists; social scientists; and engineers) increased from 1 million in 1960 (1.6 percent of all occupations) to above 6 million in 2013 (4.2 percent of all occupations) (NSB (2016)). Alternatively, one may look at the employment of managers, professionals, and technicians and associate professionals – classified by the International Labour Organization (ILO) as high-skill occupations[16]. According to the ILO data, employees in these occupations accounted for 42.2 percent of the U.S. workforce as of 2015[17].

Finally, the knowledge economy can also be measured by its innovation activity, for which the levels of two core inputs, i.e. R&D spending and R&D personnel, provide a useful indication[18]. In the U.S., the gross domestic expenditure on R&D as a percentage of GDP increased from 2.55 percent in 2003 to 2.73 percent in 2013 (OECD (2015, p.97))[19]. Most of U.S. R&D was market driven: 65 percent of the 2013 expenditure was business-funded, with the rest shared between federal government, non-federal government, academic institutions, and non-profit organisations (NSB (2016)). Another innovation-related investment is ICT[20], which accounted for 3.1 percent of U.S. GDP in 2013 – slightly down from 3.4 percent in 2003 but still ahead of most OECD countries (OECD (2015, p.97)). With respect to R&D personnel, the U.S. employed about 1.26 million researchers

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[15] However, this then begs the question of what constitutes "knowledge work" and "knowledge workers", which is a conceptual quagmire (e.g. Blackler et al. (1993) and Alvesson (2004)).

[16] See http://www.ilo.org/ilostat-files/Documents/description_OCU_EN.pdf (Accessed 12 August 2017).

[17] The comparative figure was 18.9 percent globally, 37.8 percent for high-income countries, and 40.8 percent for the EU, and 19.8 percent for the Group of Twenty (G20). See http://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page3.jspx?MBI_ID=12&_afrLoop=431073438037137&_afrWindowMode=0&_afrWindowId=13sm45cp7g_1#!%40%40%3F_afrWindowId%3D13sm45cp7g_1%26_afrLoop%3D431073438037137%26MBI_ID%3D12%26_afrWindowMode%3D0%26_adf.ctrl-state%3D13sm45cp7g_33 (Accessed 12 August 2017).

[18] R&D includes basic research, applied research, and experimental development.

[19] This compares to the OECD average of 2.36 percent, and the EU average of 1.91 percent.

[20] ICT includes IT equipment, communications equipment, and computer software.

(0.87 percent of total employment) in 2012 – up from 0.98 million (0.71 percent of total employment) in 2000 (NSB (2016))[21].

Nevertheless, R&D-based measures may not fully capture the quality of innovation, which depends on the effectiveness with which various innovation inputs – both observed and unobserved – are combined (Fang et al. (2014)). Output-based measures are thus likely to be more informative. In particular, many recent empirical studies have constructed innovation proxies using patent data (e.g. Hirshleifer et al. (2012), Aghion et al. (2013), and Kogan et al. (2017)). According to the U.S. Patent and Trademark Office (USPTO), 140,969 utility patents (i.e. the largest category) of U.S. origin were granted in 2015 – up from 74,637 in 2005 and 55,739 in 1995[22]. Alternatively, one may consider the proportion of firms that have recently realised product, process, marketing, or organisational innovation, as defined in OECD/Eurostat (2005). In the U.S., about 16.9 percent of all firms during the 2008-2010 were "product innovative" firms, meaning they had introduced a new or significantly improved good or service[23].

Thus far, this section has examined the knowledge economy in the U.S. from three aspects: first, the dominance of knowledge-based industries; second, the concentration of knowledge workers; and third, innovation intensity. These aspects are not mutually exclusive, and frequently overlap[24]. They are also not the only yardsticks of knowledge economy. Other measures exist that may be variants of these aspects (e.g. research and innovation in academic institutions), or reliant on qualitative data (e.g. public understanding of science and technology).

The next section zooms in on the second aspect, namely human capital in the knowledge economy, and discusses related theories in the economic literature.

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[21] The comparative figure in 2013 was 0.87 percent for the U.S., 0.78 percent for the OECD, and 0.77 percent for the EU (OECD (2015, p.104)).

[22] See https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm (Accessed 13 August 2017).

[23] See http://www.oecd.org/innovation/inno/inno-stats.htm#definitions (Accessed 13 August 2017).

[24] For instance, a significant share of innovation tends to originate in KTI industries: as of 2012, 53,000 patents were granted to HT manufacturing industries and commercial KI services (NSB (2016)), compared to a total of 132,858 patents of U.S. origin granted that year (see https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm).

2.2 Knowledge Economy and Skilled Labour

The previous section highlights a well-educated and skilled workforce as a defining feature of knowledge economy, and presents relevant statistics for the U.S. What remains underexplored, however, is the economic rationale behind an increased emphasis on skills. This section reviews economic theories that have been developed to explain the growing demand for skilled labour, and its distributional consequences.

2.2.1 Capital-Skill Complementarity

Since Griliches (1969), considerable research has examined the view that physical capital is more complementary to skilled labour than to unskilled labour. The hypothesis of capital-skill complementarity (CSC) suggests that, by raising the level of capital stock, capital investment pushes up the relative demand for skilled labour. Griliches (1969) provides some support for this in the U.S. context (see also Mincer (1989) and Berndt et al. (1992)). Using international data, Fallon and Layard (1975), Flug and Hercowitz (2000), and Duffy et al. (2004) have also found evidence of CSC.

CSC has also been associated with the rising skill premium, i.e. the wage of skilled labour relative to that of unskilled labour, particularly since the 1980s (e.g. Krusell et al. (2000), Lindqvist (2004, 2005), and He and Liu (2008)). This corresponds to the divergent demand trends for the two types of labour. In a recent paper, Parro (2013, p.74) shows that in the U.S., the wage ratio of nonproduction (skilled) to production (less-skilled) workers increased by 3.1 percent over 1990-2007. A common subtheme is the phenomenon of rising college wage premium despite a contemporary expansion of higher education (e.g. Eckstein and Nagypál (2004), and Lindqvist (2005)). A CSC-based explanation would be that significant capital deepening has caused the demand for well-educated workers to increase at a faster rate than their supply.

2.2.2 Skill-Biased Technical Change

Another theory on the employment and wage share of skilled vis-à-vis unskilled labour is skill-biased technical change (SBTC). It refers to "a shift in the production technology that favours skilled… labour over unskilled labour by increasing its relative productivity and, therefore, its relative demand" (Violante (2008, p.520)).

SBTC and CSC are two related but distinct concepts. CSC describes a feature of the production function, where traditional production function assumptions would still apply. Specifically, economy-wide technical changes raise the level of output for given inputs, by increasing the residual, i.e. total factor productivity (TFP) (Solow (1957)). Technical changes are thus "factor-neutral" in the sense that it enhances output without affecting the marginal rates of transformation (MRT) of inputs and their relative prices. However, the assumption has been subject to doubt, given the rising demand and wage inequality between skilled and unskilled labour, coinciding with the proliferation of new technologies such as computers. SBTC considers the possibility that technical changes are "factor-biased" where they increase the productivity of skilled labour relative to that of unskilled labour. The need to deploy capital with more productive labour raises skill demand, and thus skill premium[25].

The theoretical underpinnings of SBTC are technology-skill complementarity (TSC), analogous to CSC (see Goldin and Katz (1996, 1998)). Previous literature has discussed TSC in at least three contexts (Violante (2008)). First, the information technology (IT) revolution has accelerated the declining trend in capital prices, especially with respect to ICT capital (e.g. Berndt and Rappaport (2001), Nordhaus (2001)). The technology-driven price improvement increases capital accumulation in the economy, and thus the demand for skilled labour, consistent with CSC (Krusell et al. (2000)). At the same time, the competitiveness of less-skilled labour as well as ordinary capital is further eroded (cf. Dewan and Min (1997)).

Second, assuming that technological innovations are embodied in new capital, further investments are likely to cause a temporary productivity loss. The potential disruption, however, is alleviated by a skilled workforce for whom learning and adaptation to change is relatively easy (e.g. Greenwood and Yorukoglu (1997), Caselli (1999), and Galor and Moav (2000))[26]. The new technologies developed in recent decades are therefore biased against low-skilled workers, given the emphasis on limiting adoption and learning costs (Jovanovic (1996)).

Third, the prevalence of computer and network technologies – hence the ability to gather, store, analyse, and transmit information more efficiently – has facilitated organisational changes such as flattening of hierarchy, de-layering of managerial functions,

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[25] See, e.g. Bartel and Lichtenberg (1987), Davis and Haltiwanger (1991), Berndt et al. (1992), Bound and Johnson (1992), Katz and Murphy (1992), Sachs and Shatz (1994), Autor et al. (1998), Berman et al. (1998), Chennels and van Reenen (1999), Katz and Autor (1999), and Acemoglu (2002).

[26] In other words, skilled workers are equipped with necessary knowledge and experience to deal with economic disequilibria (cf. Schultz (1975)), such as those induced by technical changes.

broader job definitions, interdependence between units, and an emphasis on flexibility[27]. These stress worker characteristics such as initiative, critical and creative thinking, multi-tasking, teamwork competency, and adaptability (e.g. Bahrami (1992), Larsen and McInerney (2002)). Skilled workers who typically possess these characteristics therefore become more productive, indicating a skill bias in the organisational change induced by technological change (Garicano and Rossi-Hansberg (2004), Bartel et al. (2007)). A recent literature investigates skill-biased organisational change (SBOC), which may or may not be contingent on technological change (e.g. Caroli and van Reenen (2001), Piva et al. (2005)).

2.2.3 Task Approach

Inspired by Autor et al. (2003), a growing literature has applied a task approach to explain demand shifts in the labour market, and the resulting income inequality[28]. Previous studies on SBTC often define "skilled" and "unskilled" labour using binary measures such as college vs. high school graduates. What it is about skilled (unskilled) labour that makes it more (less) compatible with technology, however, remains ambiguous (e.g. Bresnahan et al. (2002)). The task approach provides a deeper explanation for SBTC, by conceptualising work as a set of tasks that require different formal and informal skills. The degree to which a given task is susceptible to automation depends on its repetitiveness and programmability[29]. Based on the task approach, labour skill is thus inferred not from the education level of workers, but from the intensity of routine tasks in their occupations.

Autor et al. (2003) provide U.S. evidence that the employment share of occupations intensive in nonroutine cognitive tasks increased significantly after the 1960s. On the other hand, the employment share of occupations intensive in routine cognitive or manual tasks declined over time. The diverging trends were particularly pronounced in computerising industries, suggesting that computers complement workers in tasks requiring expert thinking and complex communication, while substituting for workers in tasks following precise and well-understood rules (Levy and Murnane (2005)). Similar evidence in Europe is reported by Spitz-Oener (2006) and Goos and Manning (2007).

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[27] See, e.g. Giuliano (1985), Milgrom and Roberts (1990), and Bahrami (1992)

[28] Related studies include Maurin and Thesmar (2004), Autor et al. (2006, 2008), Ingram and Neumann (2006), Spitz-Oener (2006), Goos and Manning (2007), Dustmann et al. (2009), Gathmann and Schönberg (2010), Firpo et al. (2011), Autor and Handel (2013), and Autor and Dorn (2013).

[29] The routineness of a task may also determine its suitability for offshoring (see Autor and Handel (2013, p.61) and references therein).

Recent research has documented polarisation in the labour market – that is, employment and wage growth has concentrated in occupations at both ends of the skill distribution, but contracted in middling occupations – across industrialised economies over the past two or three decades (e.g. Autor et al. (2006, 2008), Goos and Manning (2007), Goos et al. (2009, 2011), Autor (2010), Firpo et al. (2011), and Autor and Dorn (2013))[30]. The task approach is widely employed in explaining the phenomenon. Specifically, the spread of technology has accelerated the displacement of workers in middle-skill, middle-wage occupations characterised by mostly routine-based tasks. By improving the quantity and quality of routine task inputs, it raises the relative demand for nonroutine cognitive tasks (typically associated with high-skill, high-wage occupations) and nonroutine manual tasks (typically associated with low-skill, low-wage occupations), neither of which lend themselves easily to computerisation[31].

This section explains why an increased reliance on skilled labour lies at the core of the knowledge economy, by drawing on economic theories which often complement and reinforce one another. The discussion thus far has concerned the economy as a whole. The next section shifts the focus to individual firms within the economy, and considers the importance of skilled labour from the firm perspective.

[30] Autor et al. (2006) show that the "upper-tail wage inequality" (i.e. the wage gap between occupations at the 90th percentile and the median of skill distribution) increased significantly and almost continuously from 1980 to 2005. On the other hand, the "lower-tail wage inequality" (i.e. the wage gap between occupations at the median and the 10th percentile of skill distribution) surged in the early 1980s, but plateaued – or even contracted – afterwards. The latter observation indicates a twist at the lower half of the wage distribution, otherwise positively correlated with occupational skill.

[31] Note that, although wage polarisation in the higher end of skill distribution is unambiguous – given the increased scarcity of workers with substantial education or experience – its presence in the lower end of skill distribution is harder to explain – given the offsetting effect of the additional supply of labour displaced from routine tasks (cf. Autor et al. (2006)). In a recent paper, Autor and Dorn (2013) divide the least-skilled occupations further into goods-producing and service occupations, and show that both employment and wage growth since the 1980s have occurred mainly in the latter group of occupations.

2.3 Reliance on Skilled Labour by Individual Firms

The previous sections make the point that, for a knowledge economy to achieve continuous innovation and growth, it is imperative to upskill its human capital, by developing a skilled labour force capable of leveraging technology productively. In other words, the knowledge intensity and thus growth potential of an economy depends to a large extent on the skill level of its human capital.

Given that private sector typically accounts for a predominant share of economic activities in advanced nations, increases in aggregate skill demand and increases in skill demand across firms in private industries are two sides of the same coin. However, as the unit of analysis is shifted from the wider economy to individual firms, a different conceptual framework is required to examine the relevance of skilled labour. The resource-based theory, originating in the strategic management literature, offers a useful framework by which to understand how investment in skilled labour may help firms achieve sustained competitive advantage.

This section is divided into two parts: The first part reviews the literature on resource-based theory. The second part associates investment in skilled labour with the creation of human capital-based competitive advantage, which has attracted considerable research attention in recent years.

2.3.1 Resource-Based Theory

The resource-based theory (RBT) centres on the proposition that persistent performance differentials amongst firms can be explained by heterogeneous resources and capabilities owned or controlled by a firm[32]. Thus, it lays out a theory of competitive advantage where a firm is able to conceive of and implement value-enhancing strategies not feasible for current or potential competitors, by leveraging its resource endowments (Barney (1991)).

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32 A firm's resources can be classified into six categories: financial resources, physical resources, human resources, technological resources, organisational resources, and intangible resources (Hofer and Schendel (1978), Grant (1991)). Capabilities, by contrast, refer to "… a firm's capacity to deploy [r]esources, usually in combination, using organizational processes, to effect a desirable end" (Amit and Schoemaker (1993, p.35)). Note that capabilities are sometimes subsumed under a broader definition of resources in the literature (e.g. Barney (1991)).

This leads to the generation of above-normal profits (i.e. rents) which, if not depleted over time, indicates the existence of sustained competitive advantage (SCA) [33].

The RBT is rooted in the strategy literature. As early as the 1950s, researchers have suggested that the strategic choices of firms are conditioned by their resource position (Penrose (1959)). However, it was not until the 1980s and early 1990s that a series of studies emerged that lay the foundation for a resource-based view (RBV) of the firm (e.g. Lippman & Rumelt (1982), Teece (1982), Rumelt (1984), Wernerfelt (1984), Barney (1986a, 1986b, 1991), Dierickx and Cool (1989), Castanias and Helfat (1991), and Conner (1991)). The RBV contrasts with – but does not contradict – theories of competitive advantage based on the structure-conduct-performance (SCP) framework (Porter (1980)). Specifically, it shifts the focus of analysis from firms' external environment (i.e. industry conditions) to within firms' boundaries, highlighting resource heterogeneity and immobility as potential sources of competitive advantage (Barney (1991)).

Not all firm resources contribute to SCA, however, and most are required only for the firm to achieve breakeven. Barney (1991) argues that a resource must be valuable, rare, inimitable, and non-substitutable (VRIN) to be strategically advantageous. The first two criteria are necessary for any competitive advantage to exist; the third and fourth criteria are necessary to prevent the competitive advantage from dissipating to competitors. Similarly, Peteraf (1993) identifies four conditions of strategic resources that must be fulfilled, before economic rents can be generated (heterogeneity), sustained (ex post limits to competition), sustained within the firm (imperfect mobility), and not offset by costs (ex ante limits to competition)[34].

Assuming the existence of rent-generating resources, previous research tends to focus on the sustainability of rents, and proposes resource characteristics that serve as barriers to imitation or "isolating mechanisms" (Rumelt (1984)) [35]. Mahoney and Pandian (1992, pp.372-273) compile a list of such characteristics, and suggest they may be organised under

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[33] Three types of economic rents are often compared in the RBT literature: Schumpeterian (entrepreneurial) rents, which tend to be short-lived due to rapid diffusion of the critical resource; Ricardian rents, which are longer-lived due to fixed or quasi-fixed supply of the critical resource (cf. monopoly rents); and quasi (Pareto) rents, which are appropriable by the focal firm due to resource immobility. See, e.g. Peteraf (1993) and Peteraf and Barney (2003) for a discussion on different types of rents.

[34] Also cf. Dierickx and Cool (1989) and Amit and Schoemaker (1993)

[35] As Peteraf (1993) observes, there is a significant overlap of ideas and subtle differences in terminology across RBV studies. The discussion on resource inimitability is a case in point. For instance, Dierickx (1989) links the concept to "time compression diseconomies", "asset mass efficiencies", "inter-connectedness", "asset erosion", and "causal ambiguity". Barney (1991) links the concept to "unique historical conditions" (i.e. path dependence), "social complexity", and "causal ambiguity". Reed and DeFillippi (1990) focus on causal ambiguity and link it to the "tacitness", "complexity", and "specificity" of the resource.

two alternative pairs of headings: asset specificity/bounded rationality or uniqueness/causal ambiguity.

The versatility of RBV and its potential to develop into a new theory of the firm was noted early on by researchers such as Connor (1991) and Mahoney and Pandian (1992). Barney et al. (2011) suggest RBT has now matured as a theory, by summarising key papers written over the past three decades. Four trends are indicative of this development: first, a more widespread use of the term RBT in the literature; second, the emergence of conceptual variants or "spin-off perspectives"; third, the integration of RBT with other theories; and fourth, the growth in retrospective assessment of the empirical evidence and critiques of RBT. In terms of application, one of the first major impacts RBT had was on the diversification literature[36]. Beyond that, the RBT has been applied to a number of other fields including (but not limited to) HRM, economics and finance, entrepreneurship, marketing, international business, and sustainability[37].

In this subsection, we provide an overview of the RBT, which has long been the elephant in the room when it comes to analysing firm-level competitive advantage. The next subsection zooms in on perhaps the most important resource of a firm, namely human capital, and discusses how investment in skilled labour may contribute to human capital-based competitive advantage.

2.3.2 Human Capital-Based Competitive Advantage[38]

As physical and financial capital becomes more readily and cheaply available, human capital – i.e. knowledge, skills, and abilities embodied in the firm's workers – is increasingly the major source of rents in modern firms (Zingales (2000)). This is facilitated by global competition that raises the demand for process innovation and quality upgrading, carried out mainly by skilled workers. The centrality of human capital in firm-level value creation has long been articulated and tested in the RBT literature (e.g. Coff (1997), Farjoun (1998), Hitt et al. (2001), Hatch and Dyer (2004), Kor and Leblebici (2005), Crook et al. (2011), and Riley et al. (2017))[39].

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[36] See Mahoney and Pandian (1992, pp.367-368) and Peteraf (1993, pp.188-190) for more detail.

[37] See Barney et al. (2001) and Barney et al. (2011) for a description of related studies.

[38] Building on Peteraf and Barney (2003), Coff and Kryscynski (2011, p.1431) define human capital-based competitive advantage as the firm's ability to create greater economic value than the marginal rival firm in the product market, due to its "access to and utilization of employee knowledge, skills, and abilities."

[39] A subset of research has focused on the human capital of specific personnel, e.g. top managers (Castanias (1991, 2001), Mackey et al. (2014), and Buchholtz et al. (2003)), directors (Khanna et al. (2014)), and exceptional employees, i.e. "stars" (Groysberg et al. (2008), Tzabbar and Kehoe (2014)).

Barney's (1991) four criteria (i.e. VRIN) for determining strategic resources help put in context the strategic relevance of human capital. These are discussed one by one in the following paragraphs.

First, human capital is valuable in that it allows firms to devise and implement strategies that exploit opportunities (and neutralise threats) in the external environment, thus continuing as a going-concern. Despite the proliferation of automation technology, the evasion of mass unemployment thus far suggests that human inputs remain crucial in performing many workplace tasks, especially those not easily routinised[40]. The human capital of skilled workers is particularly valuable, given their significant absorptive capacity (Hatch and Dyer (2004)) and complementarity with IT (Powell and Dent-Micallef (1997)).

While valuable resources allow firms to attain competitive parity, they must also be rare for competitive advantage and thus rents to occur (cf. Barney and Wright (1998)). Human capital meets the rarity criterion since its supply – namely, the number of individuals willing and able to perform certain jobs – cannot be expanded rapidly to satisfy demand growth. In other words, human capital constitutes a quasi-fixed productive factor (Peteraf (1993))[41]. The ageing population in developed nations accentuates the scarcity of human capital (cf. Bloom et al. (2010)), partially offset by factors such as immigration, retirement age policies, and international off-shoring. The scarcity of highly skilled workers – relative to less-skilled workers – makes their human capital particularly sought-after, as reflected by the rising college premium (Autor (2010))[42].

To ensure that rents are not transient, isolating mechanisms must be in place to prevent competitors from fully replicating the strategic resources. Human capital is generally inimitable, given that tacit knowledge and complex social relations cannot be pinned down

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[40] As it replaces routine-based jobs, the spread of computer and mobile technologies has also created new jobs which did not exist decades ago, and which are reliant on human inputs (Levy and Murnane (2005), The Economist (2017)).

[41] Here the use of the term "quasi-fixed" is related to the idea of inelastic factor supply. It thus differs slightly from Oi (1962), who was amongst the first to conceptualise labour as a quasi-fixed factor from the demand-side perspective. Specifically, Oi (1962, p.539) defines a quasi-fixed factor as "one whose total employment cost is partially variable and partially fixed." Labour is quasi-fixed in the sense that, the total costs incurred by firms in hiring a given stock of workers comprise both a variable element (wage bills) and a fixed element (hiring and training costs). The two perspectives complement each other, nevertheless, as both suggest that firms cannot expand their employment instantaneously as demand grows.

[42] Autor (2010) shows that, during the period 1979-2008, the real wage growth of people with postgraduate education was even more pronounced than that of college graduates. Again, this may reflect the rarity of the former relative to the latter – see the website of the National Center for Education Statistics (https://nces.ed.gov/programs/digest/d16/tables/dt16_104.20.asp). Note that the skill level of workers may also be defined in relation to their fields, besides nominal educational attainment. Particularly, graduates in science, technology, engineering and math (STEM) tend to be in high demand but short supply, which may explain their wage premium compared to arts and humanities graduates.

precisely (Coff (1997)). Likewise, causal ambiguity (Lippman and Rumelt (1982), Ambrosini and Bowman (2010)) makes it difficult for competitors to trace the source of competitive advantage, which may be individual employees, a team of employees, or the interface between employees and specific technologies and processes. Coff (1997) suggests that as human capital increases in firm-specificity, so does its degree of tacitness, social complexity and causal ambiguity. Firm-specific human capital may refer to idiosyncratic attributes, e.g. the ability to drive innovation using proprietary technologies, or the skilfulness in coordinating firm resources and personnel; alternatively, it may refer to an idiosyncratic skill portfolio in which various general skills are uniquely combined to suit the firm's needs (Lazear (2009))[43]. The human capital of skilled workers is likely to be particularly inimitable. This is due to substantial ambiguities of knowledge-intensive work, which may entail complex intra-firm collaboration or frequent exercise of situational judgement in delivering idiosyncratic client services (Alvesson (2004)). As a result, quality assessment of knowledge work also tends to be subjective and uncertain.

Even when the threat of competitive imitation is minimised, rents may still be short-lived if there are equivalent substitutes for the rent-generating resources that are either not rare or easily replicated. This renders the original resources obsolete as they would no longer add value to the firm (Dierickx and Cool (1989)). Although many previously labour-intensive jobs are now performed by machines, the substitution between technology and human capital is not unequivocal, as highlighted by the task literature (see Subsection 2.2.3). Specifically, the increasing return to non-routine abstract and manual jobs is indicative of continuous demand for human capital suited to these jobs. Based on the U.K. data, a recent Deloitte report shows that since 1992, the contraction of farming and manufacturing jobs has been more than offset by the expansion of caring, teaching, entertainment, technology, and business service jobs (Stewart et al. (2015, p.4)). When it comes to skilled workers, not only is their human capital non-substitutable – due to complex cognitive and social processes in their jobs, which cannot be codified – it is highly complementary with new technologies (e.g. ICT) as production inputs (e.g. Powell and Dent-Micallef (1997), Michaels et al. (2014))[44].

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[43] The conventional view holds that firm-specific human capital is a more potent source of SCA than general human capital. As it is productivity-enhancing mainly for the current employer, firm-specific human capital limits the mobility of employees who cannot be bade away readily by competitors (Klein et al. (1978)). Recently, however, a growing research has explored scenarios in which firm-specific human capital may not lead to sustained rents, while investments in general human capital could be economically valuable (e.g. Campbell et al. (2012), Molloy and Barney (2015), Morris et al. (2017), and Riley et al. (2017)).

[44] On the other hand, high-technology capital neither complements nor substitutes for workers in low-skilled manual and service occupations. This, however, might change with recent developments in areas such as self-driving vehicles (e.g. Leubsdorf (2017)).

Although the idea that human capital contributes to competitive advantage is now widely recognised, theoretical and empirical analysis of human capital-based competitive advantage has been far from linear. Wright et al. (2014) summarise six issues emerging from the research on "strategic human capital" (SHC) under three headings. The first concerns the human capital construct itself, with related issues on the definition of human capital at different levels of analysis, and the characteristics of employees that should be factored into their human capital. The second concerns the antecedents of human capital, with the main issue surrounding investments in human capital, on the part of both firms and employees. The third concerns the consequences of human capital, with related issues on the characterisation of value associated with SHC, the relevance of firm-specificity in value creation by SHC, and the appropriation of value generated by SHC. Combination of insights from different fields – strategy and HRM in particular – and future collaboration between researchers thereof would help resolve these issues (Wright et al. (2014)).

2.4 Summary and Discussion

As knowledge economy increasingly characterises most parts of the developed world, the onus is on individual countries to facilitate the creation and diffusion of new technologies, thus enabling a continuous stream of innovations and, ultimately, economic growth. Developing a skilled labour force well-versed in technology, and capable of using it to accomplish cognitively demanding tasks, lies at the heart of this. Hence the pressing need for countries to upgrade their education and training policies, and expand access to a variety of skills, particularly the capacity to learn (OECD (1996), Levy and Murnane (2005)). These should occur in parallel to investments in research institutions, digital infrastructure (e.g. fibre optic broadband)[45], and the national innovation system (NIS).

The improved effort to upskill the workforce increases the level and quality of a nation's human capital stock – which interacts positively with advanced technologies in generating productivity gains, as predicted by economic theories. Moreover, ensuring that workers are equipped with critical knowledge and skills would guard against the possibility of future rise in unemployment, as induced by robotic breakthroughs[46].

Just as the economy as a whole requires high-quality human capital to thrive, so individual firms in the economy need to acquire, develop and deploy human capital in order to fend off current and potential competition, from both within and outside their immediate industry[47]. A vast literature motivated by the RBT has highlighted the strategic relevance of human capital in determining firm-level competitive advantage. To the extent that the attributes that make human capital a strategic resource (i.e. tacitness, scarcity, and specialisation) are particularly pronounced for highly skilled workers, their human capital is likely to be salient for creating and sustaining superior firm performance.

In recent years, strategic human capital scholars have theorised about the unique challenges posed by human capital, which may constrain the achievement of competitive advantage (e.g. Coff (1997), Coff and Kryscynski (2011), and Campbell et al. (2012)). As opposed to other types of resources (e.g. physical capital), human capital is embodied in

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45 http://www.bbc.co.uk/news/technology-40481561

46 E.g. https://www.wsj.com/articles/next-leap-for-robots-picking-out-and-boxing-your-online-order-1500807601

47 The rise of Amazon.com, for instance, has intensified competition not only for the bookselling industry – in which they were initially competing – but for the retail sector in general (e.g. https://www.nytimes.com/2017/06/16/business/dealbook/amazon-whole-foods.html), as well as delivery, entertainment, and cloud computing.

individuals with free will and perpetual ownership of their human capital (Chadwick (2017)). Thus, employees may expect from their jobs not only economic rewards, but also satisfaction of motivational and social needs. Where any of these expectations fails to be met – or when approached by competitors with greater offers – they may leave the firm and take their human capital with them. This adds to the issue of tacit knowledge which resides in the heads of employees (Felin and Hesterly (2007)), and as such cannot be observed, measured and evaluated.

Coff (1997) highlights the turnover and information problems associated with human capital as two "management dilemmas", given their positive interaction with isolation mechanisms traditionally assumed to create SCA. He then proposes several coping strategies. Coff and Kryscynski (2011) update Coff's (1997) framework, by expressing management dilemmas in terms of three strategic capabilities on which human capital-based competitive advantage is contingent: attraction, motivation, and retention of talented employees. Given that the dilemmas arise from individual-level phenomena, their solutions must consist of both individual- and firm-level components. The need to consider the supply-side of human capital in developing unique and idiosyncratic capabilities – through human resource systems, for instance – underpins the growing research on the "micro-foundations" of human capital-based competitive advantage, which has implications for studies on both strategy and strategic HRM (cf. Huselid and Becker (2011), Wright and McMahan (2011)).

That the human capital of knowledge workers constitutes a double-edge sword has been implied by research in different fields. Specifically, its downside may take the form of an increased likelihood of rent capture (e.g. Coff (1999), Wang et al. (2009), Ambrosini and Bowman (2010), and Toms (2010b)) or voluntary turnover (e.g. Stovel and Bontis (2002), Sutherland and Jordaan (2004), and Joo (2010)). A common research objective has been to suggest solutions to these issues, presumably with a view to narrowing the gap between potential and realised rents associated with human capital. Although theoretical work has shed much light on the trade-off between skill-intensive employment and management conundrums – and the strategic benefits of mitigating the trade-off – there has been a lack of detailed empirical evidence. Ex ante, how does the aforementioned trade-off, both actual and as perceived by, e.g. investors, affect the firm? Can the financial consequences be quantified, thus allowing a more solid case to be made for related coping strategies? The present thesis provides an empirical inquiry into these issues.

3 Sample and Data

This chapter comprises two parts. The first part describes the process of assembling an initial sample of firms, to which further data requirements will be applied in each of the empirical chapters (i.e. Chapters 4 to 6) to address specific research questions. The second part details the construction of the labour skill index, the main test variable in this thesis. Its relationship with a range of firm characteristics is also examined.

3.1 Sample Selection

The core sample of this thesis includes all U.S. firms issuing common stock at the intersection of (1) NYSE/AMEX/NASDAQ return files from the Center for Research in Security Prices (CRSP) and (2) Compustat Annual Industrial Files. Financial and utility firms (SIC 6000-6999 and SIC 4900-4999) are excluded due to their distinct operating strategy and capital structure. All firms must belong to an industry for which the labour skill index can be estimated (see next section). Industries are classified using the first three digits of the SIC code before 2002, and the first four digits of the NAICS code afterwards. Following Donangelo (2014, p.1331), unclassified or miscellaneous industries (i.e. those with a three-digit SIC code or a four-digit NAICS code ending in "9") are not considered, given that firms in these industries are unlikely to draw on a common labour pool. Finally, firm-year observations with missing book assets, market equity, book equity, debt, sales, and employees are dropped.

Table 3-1 summarises the sample selection process, which results in an unbalanced panel of 73,711 firm-year observations from 1990 to 2014. The initial sample covers 8,586 unique firms, distributed across 211 three-digit SIC industries.

Table 3-1 Sample Selection

This table describes construction of the core sample. We begin by identifying all U.S. firms with common shares (CRSP share codes 10 and 11) traded on major stock exchanges, i.e. NYSE/AMEX/NASDAQ (CRSP exchange codes 1, 2, and 3), at the intersection of Compustat Annual Industrial File and CRSP Monthly Stock File. After excluding financial (SIC 6000-6999) and utility (SIC 4900-4999) firms, we match the three-digit SIC codes (for the 1990-2001 period) or four-digit NAICS codes (for the 2002-2014 period) of remaining firms to the Occupational Employment Statistics data required to calculate the labour skill index (see Appendix 1). Sample observations with missing values of the labour skill index are dropped. Finally, we delete firms with missing Compustat data for market equity, book equity, debt, assets, sales, and employees. The selection process results in an unbalanced panel of 73,711 observations, corresponding to 8,586 firms across 211 three-digit SIC industries during the 1990-2014 period.

Criteria	Obs.	Firms	Industries
Firms with Compustat-CRSP data for fiscal years from 1990-2014	114,548	12,961	272
After excluding:			
1. Financial firms	91,035	10,247	247
2. Utility firms	87,193	9,934	240
3. Observations with missing values of labour skill index	76,827	8,846	211
4. Observations with missing values of market equity, book equity, debt, assets, sales, and employees	**73,711**	**8,586**	**211**

To give an overview of the initial sample, Table 3-2 reports the distribution of sample firms by fiscal year and by industry group[48]. The number of firms remained stable over the sample period 1990-2014, but exhibited a hump-shaped pattern that peaked in 1996. The firms are also spread across economic sectors, albeit with a relatively strong representation from manufacturing and services industries, which account for more than three quarters of the sample. The recession in the early 2000s may explain a relatively large reduction in sample size, while the recession during the latter half of the 2000s appeared to have a milder impact on non-financial industries.

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[48] Industries are aggregated into ten major SIC divisions based on two-digit SIC codes (Kahle and Walkling (1996)). These include: Agriculture, Forestry, and Fishing (SIC 01-09), Mining (SIC 10-14), Construction (SIC 15-17), Manufacturing (SIC 20-39), Transportation, Communications, Electric, Gas, and Sanitary Services (SIC 40-49), Wholesale Trade (SIC 50-51), Retail Trade (SIC 52-59), Finance, Insurance, and Real Estate (SIC 60-67), Services (SIC 70-89), and Public Administration (SIC 90-99). See also the website of the U.S. Occupational Safety and Health Administration (OSHA) for a detailed breakdown of these divisions: https://www.osha.gov/pls/imis/sic_manual.html.

Table 3-2 Sample Distribution

This table provides details on the industry distribution and fiscal year distribution of the sample. Firms are aggregated into major SIC divisions based on 2-digit SIC codes, as described in Kahle and Walkling (1996). The full sample covers 8,586 firms and 73,711 firm-year observations during the 1990-2014 period[49].

Industry Group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Construction	33	31	37	44	44	49	49	50	52	44	40	33	37	36
Manufacturing	1,631	1,658	1,764	1,911	1,983	2,062	2,198	2,186	2,036	1,868	1,804	1,718	1,510	1,453
Mining	165	162	160	185	178	169	171	160	139	137	135	128	126	123
Retail Trade	216	218	265	305	308	311	338	317	293	297	252	226	252	240
Services	463	466	523	568	599	693	845	876	848	936	919	798	734	671
Transportation and Communications	159	157	165	192	204	210	231	216	200	199	192	163	165	175
Wholesale Trade	143	150	150	161	177	183	191	180	174	162	137	124	112	110
Total	**2,810**	**2,842**	**3,064**	**3,366**	**3,493**	**3,677**	**4,023**	**3,985**	**3,742**	**3,643**	**3,479**	**3,190**	**2,937**	**2,809**

Industry Group	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Obs.	Firms	Three-digit SIC
Agriculture	1	1	1	1	1	0	0	0	0	0	0	7	1	1
Construction	36	36	39	35	37	33	36	36	35	40	43	985	104	7
Manufacturing	1,448	1,416	1,376	1,348	1,261	1,216	1,186	1,157	1,117	1,139	1,151	39,597	4,190	109
Mining	125	138	141	148	146	144	137	138	132	133	135	3,655	420	6
Retail Trade	236	228	220	212	197	191	186	185	185	188	188	6,054	673	21
Services	662	635	600	584	557	545	515	489	482	509	527	16,044	2,296	34
Transportation and Communications	171	168	162	150	149	141	133	134	130	133	133	4,232	544	17
Wholesale Trade	109	105	96	93	87	81	82	85	81	80	84	3,137	358	16
Total	**2,788**	**2,727**	**2,635**	**2,571**	**2,435**	**2,351**	**2,275**	**2,224**	**2,162**	**2,222**	**2,261**	**73,711**	**8,586**	**211**

[49] The odd firm in agriculture is due to discrepancy in industry classification. Specifically, the firm records a SIC code of 0700 (i.e. farming-related industries) and a NAICS code of 561730 (i.e. landscaping services). The estimation of labour skill index after 2002 was based primarily on four-digit NAICS industries, thus capturing the firm concerned. It is no longer present in the final sample of each of the empirical chapters, however, after additional selection criteria are applied.

3.2 Measuring Reliance on Skilled Labour

One of the persistent issues in the empirical literature has been to quantify intangibles at the firm level. Numerous proxies have been suggested, including market-to-book ratio, Tobin's Q, R&D expenditure, patent counts, or a combination of different factors using techniques such as the principal component analysis. Most of these variables are linked to the growth prospect of the firm, corresponding to the trend in which firms' competitiveness is increasingly determined by their accumulation of intangible capital.

Human capital is arguably the most important component of firms' intangible capital. It underlies the capacity of firms to engage in research and innovation, and hence the development of other forms of intangible capital. However, evaluating human capital in individual firms presents further challenges, especially in the U.S. context. A main reason is that public firms in the U.S. are not required to disclose labour costs (i.e. wages and benefits) in their annual reports (Ballester et al. (2002), Lajili and Zeghal (2005)). With limited firm-level data, researchers have substituted higher-level data such as the average wage or education level of workers in the firm's industry (e.g. Bartel (1989), Faleye et al. (2013), and Donangelo et al. (2017))[50].

To capture firms' investment in human capital, this thesis constructs an annual measure of labour skill index (SKILL), using industry-level occupational data from the Occupational Employment Statistics of the U.S. Bureau of Labor Statistics (BLS-OES) (see Appendix 1). Specifically, SKILL is estimated as the skill-weighted sum of wage shares of different occupations employed in a three-digit SIC industry (from 1990 to 2001) or four-digit NAICS industry (from 2002 to 2014). The weighting factor is five "job zones", developed by the Occupational Information Network (O*Net) to categorise occupations based on their prerequisite skills (see Appendix 2). Given that job zones are integers between 1 (for the least skilled occupations) and 5 (for the most skilled occupations), SKILL is by construct a continuous variable with a minimum value of 1 (for the least skilled industries) and a maximum value of 5 (for the most skilled industries).

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[50] Similarly, prior research has used industry-level wage rates to infer firm-level labour costs when estimating total factor productivity (e.g. Brynjolfsson and Hitt (2003), İmrohoroğlu and Tüzel (2014)).

Expressed algebraically,

$$\mathrm{SKILL}_{j,t} = \sum_{j}\left[\frac{\mathrm{JOBZONE}_{i} \times \mathrm{EMP}_{i,j,t} \times \mathrm{WAGE}_{i,j,t}}{\sum_{j}(\mathrm{EMP}_{i,j,t} \times \mathrm{WAGE}_{i,j,t})}\right] \tag{3.1}$$

where: i, j, and t denote occupation, industry, and time (year), respectively

$\mathrm{SKILL}_{j,t}$ = The labour skill index assigned to industry j in year t

$\mathrm{JOBZONE}_{i}$ = The job zone to which occupation i belongs

$\mathrm{EMP}_{i,j,t}$ = The number of people working in occupation i in industry j in year t

$\mathrm{WAGE}_{i,j,t}$ = The average annual wage of occupation i in industry j in year t

The rationale behind the labour skill index corresponds to Becker's (1964) human capital model which treats skill – a main aspect of an individual's human capital – as a durable investment good acquired through education or training. The labour skill index thus draws on the micro-foundation of firms' human capital, namely the attributes of individual workers (cf. Coff and Kryscynski (2011)). However, it goes one step further by associating individual workers with their occupations, distinct in terms of the jobs involved. According to the task framework of Autor et al. (2003), jobs differ in their degree of routineness and cognitive exertion. This affects their susceptibility to automation, thus the substitutability of the underlying occupation with technology. The labour skill index applies this concept, by assuming that highly skilled industries (and firms therein) are particularly reliant on highly skilled occupations that require sophisticated knowledge and complex social interaction. This is operationalised by calculating the share of total wage costs in an industry attributed to workers employed in highly skilled occupations.

Note that including $\mathrm{WAGE}_{i,j,t}$ in Equation (3.1) is more advantageous than excluding it – in the latter case, SKILL estimates the employment share, rather than wage share, of skilled workers in an industry (e.g. Ochoa (2013), Belo et al. (2017)) – since it accounts for the cash flow impact of employing a particular occupation. This approach enriches the definition of skilled workers by incorporating the value of their marginal productivity, as manifested in wage rates. Moreover, workers in the same occupation are often paid differently across industries[51]. This indicates that the skill content of an occupation is conditioned by the industry in which it is employed, as well as its basic responsibilities. Including the occupational wage information again accounts for this possibility.

To illustrate how SKILL varies within and across industries, Table 3-3 presents the 15 most skilled and the 15 least skilled three-digit SIC industries based on their SKILL[52]. The results show that over time, SKILL has tended to increase amongst the most skilled industries, but decrease amongst the least skilled industries. For instance, SKILL of the Legal Services industry (SIC 811) grew from 3.987 (in 1990) to 4.178 (in 2002) and to 4.204 (in 2014). In contrast, SKILL of the Taxicabs industry (SIC 412) declined from 1.831 (in 1990) to 1.713 (in 2002) and to 1.674 (in 2014). The observed trends in SKILL may reflect job market polarisation, i.e. a concentration of job opportunities at both ends of the skill-spectrum and a falling demand for middling occupations (Goos and Manning (2007), Autor (2010)). On the one hand, the most skilled firms compete more aggressively for workers to fill highly skilled occupations, thus pushing up wage premiums. On the other hand, the least skilled firms are able to expand by drawing on a larger pool of workers to perform mostly manual jobs, while automating more sophisticated but nonetheless programmable jobs.

[51] For example, in 2000, human resource managers (job zone 4) in the Research, Development, and Testing Services industry (SIC 873) received a mean wage of $83,190, whilst their counterparts in the Video Tape Rental industry (SIC 784) earned $37,010. Sound engineering technicians (job zone 3) in the Advertising industry (SIC 731) received a mean wage of $49,990, whilst their counterparts in the Eating and Drinking Places industry (SIC 581) earned $20,850.

[52] From 2002 onwards, the BLS-OES survey classified industries using four-digit NAICS codes. These are matched to three-digit SIC codes as closely as possible, based on the concordance from the U.S. Census Bureau website (https://www.census.gov/eos/www/naics/concordances/concordances.html). The 30 industries in Table 3-3 are from a group of 324 industries for which SKILL can be estimated each year from 1990 to 2014.

Table 3-3 Most Skilled and Least Skilled Industries

This table reports the skill-weighted share of total wage costs attributed to skilled occupations across industries, represented by the labour skill index (SKILL). Based on the average SKILL over 1990-2014, we identify the 15 most and the 15 least skilled industries from a group of 324 industries for which SKILL can be estimated throughout the 25 years. Industries are classified using three-digit SIC codes.

Industry Title	3-dgt SIC	SKILL			
		'90-'14	1990	2002	2014
15 Most Skilled Industries					
Colleges, Universities, Professional Schools	822	4.170	3.791	4.104	4.277
Legal Services	811	4.140	3.987	4.178	4.204
Offices and Clinics of Doctors of Osteopathy	803	4.082	4.048	3.927	4.168
Title Abstract Offices	654	3.941	3.247	4.178	4.204
Offices and Clinics of Doctors of Medicine	801	3.937	3.013	3.915	4.121
Offices and Clinics of other Health Practitioners	804	3.922	3.761	3.939	4.004
Research, Development, and Testing Services	873	3.779	3.805	3.721	3.803
Engineering, Architectural, and Surveying	871	3.758	3.739	3.717	3.751
Services Allied with the Exchange of Securities	628	3.753	4.458	3.649	3.755
Libraries	823	3.741	3.877	3.521	3.817
Guided Missiles and Space Vehicles and Parts	376	3.740	3.539	3.688	3.814
Elementary and Secondary Schools	821	3.736	3.695	3.723	3.754
Vocational Schools	824	3.707	4.241	3.448	3.579
Computer and Data Processing Services	737	3.676	3.750	3.549	3.680
Security And Commodity Exchanges	623	3.665	3.157	3.578	3.759
15 Least Skilled Industries					
Eating and Drinking Places	581	1.569	1.753	1.541	1.480
Gasoline Service Stations	554	1.664	1.851	1.598	1.445
Retail Bakeries	546	1.714	2.018	1.570	2.107
Taxicabs	412	1.767	1.831	1.713	1.674
Grocery Stores	541	1.839	1.811	1.831	1.882
Dairy Products Stores	545	1.876	1.818	2.249	1.839
Automobile Parking	752	1.955	1.685	1.964	1.965
Liquor Stores	592	1.971	2.150	2.121	1.744
Variety Stores	533	1.992	2.035	1.961	2.021
Video Tape Rental	784	2.000	1.829	2.036	2.344
Logging	241	2.000	2.308	1.787	1.699
Laundry, Cleaning, and Garment Services	721	2.010	2.007	2.027	1.998
Candy, Nut, and Confectionery Stores	544	2.054	1.924	2.324	2.056
Shoe Repair Shops and Shoeshine Parlors	725	2.063	2.248	2.004	2.059
Meat Products	201	2.080	2.208	2.099	2.144

3.3 Reliance on Skilled Labour and Firm Characteristics

This section examines the relationship between the labour skill index and various firm characteristics, organised into six groups: corporate demographics; growth opportunities; debt capacity; liquidity and financial constraints; competition and profitability; and labour-related factors. Appendix 3 provides details on variable construction.

Each year, firms are sorted into five portfolios by SKILL. The top SKILL quintile ("High") comprises firms in the most-skilled industries, and the bottom SKILL quintile ("Low") comprises firms in the least-skilled industries. The median values of the characteristics are calculated for each of the SKILL quintiles and averaged over time. Table 3-4 reports the results of portfolio sorts.

Consider first the corporate demographics. The table shows that firms in more skilled industries are smaller and younger than firms in less-skilled industries. With respect to growth opportunities, all proxies increase across the SKILL portfolios, suggesting a positive link between labour skill and the firm's growth prospects. With respect to debt capacity, firms in more skilled industries tend to raise less debt, possibly due to few collateralisable assets as well as a short credit history. With respect to liquidity and financial constraints, the evidence is somewhat difficult to interpret. On the one hand, the median high-SKILL firm holds more cash than the median low-SKILL firm. On the other hand, the former also generates less operating cash flow each year than the latter, to the extent it hardly covers the interest expense. With respect to competition and profitability, firms in more skilled industries tend to face greater competition for labour as well as sales. This is shown by the distribution of sales and employees across a larger number of firms. Intensified competition squeezes profit margins, which would explain the decreasing profitability measures across the SKILL portfolios. Turn finally to the labour-related factors. As is to be expected, the average wage per employee and the share of college-educated workers both increase across the SKILL portfolios. The labour-to-capital ratio exhibits a U-shaped relationship with SKILL, which may be indicative of job polarisation[53]. Finally, union membership is shown to decrease with SKILL, suggesting a diminishing role of trade union in high-skilled industries.

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[53] Specifically, firms in medium-skilled industries may automate more aggressively than firms in either high- or low-skilled industries, thus increasing the relative importance of capital.

Table 3-4 Labour Skill Index and Firm Characteristics

This table reports time-series averages of median characteristics for portfolios of firms sorted by the labour skill index (SKILL). The top SKILL quintile ("High") comprises firms that operate in the most highly skilled industries, and the bottom SKILL quintile ("Low") comprises firms that operate in the least-skilled industries. The characteristics are grouped into six categories: corporate demographics, growth opportunities, debt capacity, liquidity and financial constraints, competition and profitability, and labour-related factors. A detailed description of all the characteristics is provided in Appendix 3. The sample covers 8,586 firms and 73,711 firm-year observations during the period 1990-2014.

SKILL Quintile	Low	2	3	4	High
Corporate Demographics					
Market Equity ($mn)	258.82	202.36	201.21	152.16	159.80
Assets ($mn)	345.13	230.18	172.48	103.18	96.90
Sales ($mn)	487.75	278.00	139.45	81.24	86.46
Employees (persons)	3,313	1,440	554	375	483
Age – listing (years)	12	12	11	10	7
Age – incorporation (years)	33	27	21	18	16
Growth Opportunities					
Market-to-Book	1.59	1.78	1.93	2.20	2.59
Tobin's Q	1.28	1.40	1.53	1.72	1.94
Sales Growth (%)	6.71	7.83	8.88	10.24	11.63
Hiring (%)	2.25	2.65	3.70	4.29	5.88
Investment (%)	17.82	19.11	22.46	25.33	35.17
R&D (%)	0.00	1.65	7.91	10.46	13.29
Asset Tangibility (%)	34.81	23.97	18.35	12.67	8.93
Debt Capacity					
Book Leverage (%)	23.56	21.48	16.02	11.50	3.69
Market Leverage (%)	21.71	17.72	11.69	6.85	1.81
Interests (%)	1.76	1.56	1.24	0.94	0.53
Collaterals (%)	57.30	45.91	38.05	28.91	12.85
Liquidity and Financial Constraints					
Cash (%)	4.91	6.44	12.76	18.82	26.95
Current Ratio (%)	1.83	2.03	2.29	2.68	2.20
Free Cash Flow (%)	14.94	13.07	12.89	10.49	13.12
Interest Coverage	11.43	9.18	5.58	2.56	0.99
Competition and Profitability					
Sales Dispersion	79.49	78.78	86.10	87.88	90.21
Employee Dispersion	78.22	80.14	87.56	87.96	93.01
Return on Assets (%)	4.52	4.44	2.76	2.29	2.37
Return on Equity (%)	9.63	9.25	5.82	5.15	4.88
Labour-Related Factors					
Annual Wage ($)	27,020	38,877	46,675	48,120	54,143
Labour Share (%)	0.19	0.20	0.21	0.25	0.33
Growth Options	2.79	6.32	14.18	18.96	18.20
Labour Intensity	31.86	30.48	27.11	34.45	58.23
Union (%)	10.10	9.60	5.90	4.50	1.16
College (%)	13.38	23.13	32.20	41.87	60.38

4 Skilled Labour, Idiosyncratic Risk, and Employee Ownership

4.1 Introduction

Employing skilled workers capable of developing intellectual human capital (Zucker et al. (1998)) is high on the agenda of knowledge economy firms (e.g. The Economist (2006)). This reflects a shift of focus from physical assets to intellectual capabilities, encapsulated by Klaus Schwab's remark during his opening address at the 2012 World Economic Forum: "Capital is being superseded by creativity and the ability to innovate – and therefore by human talents – as the most important factors of production. Just as capital replaced manual trades during the process of industrialisation, capital is now giving way to human talent. Talentism is the new capitalism."[54] At the same time, there has been greater recognition of the need to retain and motivate skilled workers after their recruitment[55].

We move beyond the potential benefits of investing in skilled labour and consider, instead, its potential costs. Specifically, we relate a firm's reliance on skilled labour to its cash flow uncertainty as perceived by shareholders. This is reflected by the firm-specific element of stock return volatility, i.e. idiosyncratic risk (Vuolteenaho (2002)). Although idiosyncratic risk could be minimised by holding a well-diversified portfolio, it remains relevant to a number of stakeholders. These include: investors holding a concentrated portfolio; corporate managers whose incentives are tied to stock returns; arbitrageurs exploiting the mispricing of individual stocks; fund managers seeking to distinguish their portfolio returns from indices; and financial analysts issuing risk ratings for investment in particular stocks. Furthermore, since idiosyncratic risk indicates fundamentals uncertainty, high levels of idiosyncratic risk raise concerns about the firm's survival, while hampering strategic initiatives such as divesture or participation in mergers and acquisitions.

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[54] https://www.forbes.com/sites/katinastefanova/2015/10/24/why-amazons-management-practices-will-likely-hurt-its-stock-price-in-the-long-run/#1483577677ef

[55] In the recent editions of Deloitte's Global Human Capital Trends survey – from 2014 to 2017 – the issue of employee engagement was regularly cited by executives and HR professionals around the world as one of the top five challenges facing today's organisations. See https://www2.deloitte.com/uk/en/pages/human-capital/articles/introduction-human-capital-trends.html.

In the first hypothesis, we predict a positive relationship between reliance on skilled labour and idiosyncratic risk based on three related arguments. First, skill-intensive firms undertake more R&D and innovation-related investments, characterised by an extreme risk-return profile and long-term nature (Holmstrom (1989)). This increases investors' perceived risk of the firm's cash flow, due to its uncertainty in both scale and timing (Quinn et al. (1994)). Second, the complexity and ambiguity of knowledge work exacerbates information asymmetry and agency problems in skill-intensive firms (Holmstrom (1979)). In particular, skilled workers may capture a greater share of rents by negotiating higher wages, thus increasing the fluctuation of shareholder cash flows. Third, the centrality of human capital in skill-intensive firms amplifies their susceptibility to employee turnover, as induced by disengagement or competitive poaching (e.g. Groysberg and Abrahams (2006)). The issue is compounded by the high mobility of skilled workers. The heightened threat of losing valuable human capital, and therefore competitive advantage, translates into cash flow uncertainty perceived by the market.

The second hypothesis posits that the positive relationship stated in the first hypothesis is moderated by the presence of broad-based employee ownership (BBEO). This is because investors will perceive less risk of employing skilled labour – hence reduced idiosyncratic volatility – where BBEO addresses the three concerns outlined above. Previous literature has highlighted the role of BBEO in promoting interest-alignment and retention (see Section 4.2), which we argue mitigate those concerns. Specifically, we expect BBEO to increase the chance of success in otherwise risky knowledge projects, reduce opportunistic behaviour on the part of both firms and employees, and foster long-term commitment. Most research on the consequences of BBEO has considered accounting- and market-based measures of financial performance, or productivity gains (e.g. Blasi et al. (1996), Pendleton and Robinson (2010), and Kim and Ouimet (2014)). We make a unique contribution by investigating BBEO as a risk-management device in the knowledge economy.

To test our hypotheses, we build a panel dataset of 31,837 firm-year observations over 1990-2014. Following the literature, we estimate idiosyncratic risk using the residual from Fama and French's (1993) three-factor model. The labour skill index (see Section 3.2) serves as proxy for firms' reliance on skilled labour. The presence of BBEO is represented by an indicator variable which takes the value of one if employees hold an equity stake in the firm through defined contribution (DC) plans (i.e. profit sharing plans, stock bonus plans, 401(k) plans, and employee stock ownership plans (ESOPs)), and zero otherwise.

Portfolio analysis provides preliminary support for our hypotheses. Idiosyncratic risk is significantly higher in the top skill quintile than in the bottom skill quintile. At the same time, it is significant lower for employee ownership firms across all skill quintiles. The multivariate regression continues to show a positive and robust relationship between labour skill index and idiosyncratic risk, and a negative moderating effect of BBEO. Our results hold after including a range of control variables: the level and variance of profitability, size, age, dividend, market-to-book, leverage, returns, industry concentration, and liquidity. The coefficients on the labour skill index and its interaction with BBEO are economically significant: for firms without BBEO, a one-standard-deviation increase in the labour skill index is associated with an increase in idiosyncratic risk by 13.6 percent; the presence of BBEO reduces that by about 5 percent.

We perform several identification tests to further substantiate our results. First, we rerun the regression in an instrumental variable, two-stage least squares model. This potential endogeneity between idiosyncratic risk and BBEO. The instruments used in the first-stage regression are long-term capital gains tax rates in a firm's state and a firm's cash contribution to DC plans. The second-stage regression substitutes the predicted values of employee ownership dummy and the interaction term into the main regression. Our conclusions are qualitatively unchanged, suggesting their robustness to endogeneity concerns.

Second, we check whether the moderating effect of BBEO applies to its level as well as presence. To do so, we construct dummies for quartiles of positive BBEO and substitute them into the regression. The negative interaction terms are significant when the level of BBEO falls in the first two quartiles of the distribution, but become insignificant and even turn positive (but remain insignificant) for higher values. This suggests that, whilst moderate levels of BBEO reduce investor uncertainty about investment in skilled labour, further increases in BBEO raise additional concerns that counteract its moderating effect.

Third, we examine the cross-sectional and time-series variation of our results. Subsample tests show that, while the positive coefficient on labour skill index remains significant across firms and time, the negative coefficient on the interaction term is significant mainly in the post-2000 period, and for large and diversified firms. An interpretation of this is that, since the dot-com bubble crash, more attention has been given to risk management in high-skilled firms – which BBEO is expected to aid. Also, investors' perception of the effectiveness of BBEO may be conditioned by their perception of monitoring difficulty, and thus agency costs faced by the firm.

We conduct three additional robustness checks. First, to determine whether our results are driven by a fraction of firms with particularly risky fundamentals, subsample tests are performed which sequentially exclude: microcap firms, NASDAQ-listed firms, high-tech firms, low-priced firms, distressed firms, and loss-making firms. Similar, we remove sample years coinciding with U.S. recessions (i.e. 1990-1991, 2001, 2007-2008), which may raise idiosyncratic volatility across the board.

Second, to further address omitted variables, we include two sets of additional control variables in the regression. The first are three factors that may influence the trading pattern of a firm's stock: institutional ownership, corporate governance, and earnings quality; the second are seven industry life-cycle characteristics described in Chen et al. (2011): industry age, indicator for old/new economy industries, industry R&D and advertising intensity, industry growth rate, and industry profitability.

Finally, to guard against the possibility of measurement error, we rerun the regression using three alternative proxies for skilled labour (simplified labour skill index, percentage of college-educated workers, and selling, general, and administrative expenses per employee), and five alternative proxies for idiosyncratic risk based on different factor models. The results continue to support both of our hypotheses.

The rest of this chapter proceeds as follows. Section 4.2 reviews related literature and develops testable hypotheses. Section 4.3 presents the data and summary statistics. Section 4.4 reports the main results. Section 4.5 describes several identification tests. Section 4.6 provides supporting evidence from additional robustness tests. Section 4.7 concludes.

4.2 Literature Review and Hypothesis Development

This section discusses related literature and develops our two hypotheses. Subsection 4.2.1 outlines the idiosyncratic risk research. This is followed by Subsections 4.2.2 and 4.2.3 which formulate the first and second hypothesis, respectively.

4.2.1 Idiosyncratic Risk: An Overview

Since the early 2000s, dozens of studies have explored time-series and cross-sectional determinants of idiosyncratic stock return volatility. An important motivation is Campbell et al. (2001) who document that average return volatility in the U.S. stock market increased steadily during the 1962-1997 period. The upward trend is primarily attributed to firm-level volatility, whereas market and industry volatilities remained relatively stable[56]. Notably, after peaking during the internet boom of the late 1990s, aggregate idiosyncratic volatility declined precipitously (to its pre-1990s levels) before spiking again during the 2007-2009 financial crisis (Brandt et al. (2010), Bekaert et al. (2012)).

Understanding factors that influence the volatility of individual stocks is important for several reasons. For undiversified investors (e.g. institutions engaging in active monitoring, employees holding a concentrated position in employer stock), they must bear idiosyncratic risk[57]. Idiosyncratic risk also matters for arbitrageurs whose ability to exploit security mispricing is conditioned by idiosyncratic rather than aggregate volatility; market makers wary of taking positions in high-volatility stocks; fund managers seeking to differentiate from peers and stock indices; corporate managers active in managing equity price risk (Pace (1999)); financial analysts issuing risk ratings linked to individual stocks (Lui et al. (2007)); and option pricing, which depends on total return volatility of a stock, often dominated by its idiosyncratic element[58]. In addition, a high level of idiosyncratic risk may threaten the firm's going-concern status, given that it signals great uncertainty about expected cash flows (Grinblatt and Titman (1998)). Similarly, it may hinder strategic decisions such as divesture

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[56] Kearney and Poti (2008) document an uptrend in both idiosyncratic risk and market risk in euro-area stock markets during 1974-2004.

[57] Moreover, higher levels of idiosyncratic risk increase the number of stocks typically needed to form a well-diversified portfolio (see Campbell et al. (2001)).

[58] Ferreira and Laux (2007) show that on average, idiosyncratic volatility accounts for approximately 85 percent of total individual stock volatility.

or mergers and acquisitions (Clayton et al. (2005)). Finally, in recent years, there has been an ongoing debate on whether idiosyncratic risk is a priced risk factor[59].

The theories used by previous studies to explain cross-sectional as well as temporal variation of idiosyncratic volatility can be classified into three broad categories, namely fundamentals, trading, and business-cycle characteristics. These are described below.

Fundamentals-based theories are rooted in the standard view that stock returns are driven by shocks to firms' underlying cash flows and, to a lesser extent, shocks to the economy's discount rate (Vuolteenaho (2002)). Greater uncertainty about the firm's current and future earnings therefore increases return volatility. Pastor and Veronesi (2003) provide cross-sectional evidence that idiosyncratic risk is negatively (positively) related to the level (variance) of profitability. Wei and Zhang (2006) document a similar relation in the time-series. Moreover, Pastor and Veronesi (2003) develop a valuation model in which investors learn about the firm's average profitability over time. Supporting the model's implications, they show that idiosyncratic risk is higher in younger and non-dividend paying firms for whom learning uncertainty is particularly pronounced.

Prior research has suggested a number of factors that increase firms' cash flow uncertainty, and thus idiosyncratic risk. These include expected earnings growth (Xu and Malikiel (2003)), competition and deregulation (Philippon (2003), Gaspar and Massa (2006), and Irvine and Pontiff (2009)), diversification (Dennis and Strickland (2009)), R&D intensity (Comin and Phillipon (2005)), growth options (Cao et al. (2008), Guo and Savickas (2008)), and IT investment (Chun et al. (2008)).

A related line of research posits that the shifting composition of publicly traded firms represents a "unifying" explanation for the temporal pattern of aggregate idiosyncratic volatility. The idea is that more firms with riskier fundamentals and lower survival rates have become listed in recent decades, facilitated by equity market development (Fama and French (2004), Brown and Kapadia (2007)). One manifestation is a market-wide decline in the average age of firms at their initial public offering (Fink et al. (2010)). Another is the increasing prominence of NASDAQ exchange on which many technology stocks with substantial growth options are traded (Schwert (2002), Xu and Malkiel (2003), and Pastor and Veronesi (2006)). Similarly, Bennett and Sias (2006) document time-varying changes in the share of risky industries and small-cap stocks represented in the market.

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[59] Contributions to this debate include: Goyal and Santa-Clara (2003), Bali et al. (2005), Wei and Zhang (2005), Ang et al. (2006), Bali and Cakici (2008), and Fu (2009).

The trading-related theories are diverse in their focus of analysis, but common in their link to idiosyncratic volatility through the trading behaviour of market participants. Specifically, they build on the positive relation between stock trading volume and volatility documented in extant research (e.g. Karpoff (1987), Schwert (1989), and Gallant et al. (1992)), and consider different sources (or inducements) of trading.

A common theme is the growing institutionalisation of the U.S. equity markets in recent decades (Gompers and Metrick (2001)). Institutional investors differ from retail investors along several dimensions: first, their portfolios are typically much larger; second, they trade more frequently and in higher volumes; and third, they are more likely to herd together due to similar incentives and constraints (Sias (2004), Dennis and Strickland (2009)). The interaction of these makes institutional trading effective in raising stock turnover, and thus volatility. Previous empirical studies generally find a positive relation between institutional ownership (i.e. a proxy for trading by institutional investors) and idiosyncratic risk (e.g. Sias (1996), Bennett et al. (2003), Xu and Malkiel (2003), and Dennis and Strickland (2009)). Chichernia et al. (2015) further suggest that the relationship is conditioned by institutions' investment horizon, which affects their trading intensity. Specifically, the authors provide cross-sectional evidence that idiosyncratic risk increases (decreases) significantly with the proportion of shares held by short-term (long-term) institutional investors. Another view concerns the shifting preferences of institutional investors, particularly towards smaller and riskier stocks (Bennett et al. (2003)). The increases in liquidity and idiosyncratic risk induced by institutional trading are thus more pronounced amongst these stocks.

Another line of research, closely related to the debate on market synchronicity and efficiency, associates idiosyncratic volatility with informed risk arbitrage. Here trading is emphasised as a process in which information is impounded into stock prices. Given that idiosyncratic volatility represents the part of total volatility not explained by public news arrivals, it is induced mainly by the flow of private, firm-specific information (see French and Roll (1986), Roll (1988)). Where risk arbitrageurs are encouraged to collect and trade on such information, idiosyncratic volatility increases relative to systematic volatility, resulting in a lower R^2 from the market model. This is taken to indicate market efficiency, where more firm-level information is capitalised. Morck et al. (2000) find that average R^2 is lower in countries with better property rights protection, which they argue fosters informed arbitrage trading. Jin and Myers (2006) show that countries with a more transparent information environment have a lower R^2, as more firm-specific information is revealed to external investors. Similarly, Bartram et al. (2012) observe that U.S. stocks tend to have higher idiosyncratic volatility, which they attribute to better protection of shareholder rights, equity market development, and innovation. At the firm level, Ferreira and Laux (2007) find that idiosyncratic risk is higher in firms with fewer anti-takeover provisions, indicating openness to the market for corporate control. The relationship becomes stronger when there is institutional trading, especially by arbitrage-active institutions[60].

Recently, however, the view that market synchronicity signals information inefficiency – as stock prices aggregate less firm-specific information – has been challenged. Dasgupta et al. (2010) argue that more transparency should increase, not decrease, return synchronicity. The is because the likelihood of firm-specific events affecting cash flows would have been priced in earlier, leaving little surprise in the future (cf. West (1988)). The authors provide evidence that firms' idiosyncratic volatility is significantly lower following seasoned equity offerings or cross-listings – events at which much firm-specific information is released, thereby enhancing transparency[61]. Similarly, both Piotroski and Roulstone (2004) and Chan and Hameed (2006) document that firms' R^2 increases with the level of analyst coverage (see also Gassen et al. (2016)). Focusing on financial reporting quality, Rajgopal and Venkatachalam (2011) and Chen et al. (2012) report a positive link between discretionary accrual volatility and idiosyncratic risk[62]. Li et al. (2014) reach a similar conclusion, and suggest that discrepancies in previous research (e.g. Morck et al. (2000), Hutton et al. (2009)) may be due to model misspecification.

At the aggregate level, several authors have cast doubt on whether trading-based theories fit the time-series movement of idiosyncratic volatility. Zhang (2010) shows that while both fundamentals- and trading-related variables explain the upward trend in idiosyncratic volatility prior to 2000, the latter lose explanatory power in subsequent years when the trend was reversed. Brandt et al. (2010) argue, instead, that there was no time trend in aggregate idiosyncratic volatility, and that its observed increase in the 1990s was temporary and driven by the speculative behaviour of retail investors.

In a recent paper, Bekaert et al. (2012) demonstrate that aggregate idiosyncratic volatility follows a stationary regime-switching process, switching occasionally to regimes where it

[60] This is consistent with Piotroski and Roulstone (2004) who show that institutional as well as insider trading adds to idiosyncratic volatility, by accelerating the incorporation of firm-specific information into prices.

[61] See also Hou et al. (2006), Teoh et al. (2009), Chan and Chan (2014), and Kelly (2014).

[62] Poor financial reporting (or earnings) quality is taken to indicate greater information asymmetry, which may cause idiosyncratic volatility through two channels: first, it increases investors' learning uncertainty regarding firms' fundamentals, analogous to the firm age effect (Pastor and Veronesi (2003), Dasgupta et al. (2010)); second, trading is based on increasingly divergent beliefs, as market participants (including analysts) place less weight on common earnings signals than on alternative, private sources of information.

temporarily spikes in level, variance, and mean-reversion[63]. Similar to Zhang (2010), Bekaert et al. (2012) find that factors correlated with cash flow volatility outperform those related to trading volume in explaining the time-series variation of idiosyncratic volatility. In addition, they identify another set of factors linked to business cycle and market volatility. The potential explanation for their effect is twofold: first, they may capture aspects of macroeconomic uncertainty not already reflected by firm fundamentals; second, they may capture the discount rate variation not accounted for in the factor model used to obtain idiosyncratic risk measures.

Thus far, this subsection has given an overview of the research on idiosyncratic risk, especially regarding its sources. Despite sometimes conflicting evidence, factors related to firm fundamentals have generally performed well. This is reinforced by studies running a statistical horse-race where various groups of factors are considered simultaneously (Zhang (2010), Bekaert et al. (2012)); the fundamentals-based explanation has held up even with reduced model parsimony. Note, however, that not all fundamentals-related factors are equally distinctive. Most are closely linked, implying that the effect of some would be absorbed by that of others – as revealed by the horse race-type tests. This highlights a need for a deeper explanation for existing factors.

Recent contributions to the fundamentalist research converge on two themes: competition and growth potential. Human capital has largely been absent from the discussion, which is surprising given its centrality in value creation, especially for knowledge firms. It is reasonable to assume that firms' human capital conditions their competitive position and prospect for growth, rather than the other way round. This would make human capital a more basic factor in explaining firm-specific return volatility. The next subsection explores this possibility, and formally develops our first hypothesis.

4.2.2 Skilled Labour and Idiosyncratic Risk

As the quality of firms' human capital is generally unobservable, empirical research has used proxies such as education and wages. Taking both aspects into account, we calculate a labour skill index that estimates the degree to which firms rely on skilled labour (see Section 3.2). As outlined shortly, there are three interrelated reasons for believing that idiosyncratic volatility is higher in skill-intensive firms.

[63] Bekaert et al. (2012) attribute the previous evidence of an upward trend in aggregate idiosyncratic volatility to sample selection. Their analysis is based on an extended sample period from 1964 to 2008 for the U.S. sample (and 1980-2008 for the international sample covering mainly developed economies).

First, given the complementarity between skill and technology (see Section 2.2), skill-intensive firms are particularly exposed to fast-changing technology and customer taste which, in turn, create more growth options. A higher level and variance of growth options increases uncertainty about future cash flows, and thus idiosyncratic volatility (Cao et al. (2008)). This uncertainty is amplified in skill-intensive firms due to their emphasis on projects with considerable elements of intangibility, e.g. innovation. Holmstrom (1989, p.309) describes innovation as a high risk-high return undertaking, characterised also by unpredictability, a long-term and multi-stage structure, labour-intensity, and idiosyncrasy[64]. Evidence abounds of early innovation failures (see Regalado (2014)). Similarly, Alvesson (2004) stresses ambiguity as a salient feature of most tasks and situations in knowledge-intensive firms. The difficulty in agreeing on boundaries and principles and in clarifying goals and outcomes, exacerbated by ineffective organisational design (Dougherty (2006)), could further hinder innovation.

Second, shareholder cash flow may be riskier in skill-intensive firms, given the ability of skilled workers to capture rents in the form of wage premium. The idea that rents are subject to appropriation by stakeholders, including employees, is highlighted in the resource-based literature (e.g. Coff (1999)). Skilled workers, in particular, hold significant bargaining power due to their scarcity and tacit knowledge, which exacerbates information asymmetry. This puts them in a position to negotiate wage rises or resist wage cuts even during economic downturns (cf. Toms (2010b)). Higher (and more fixed) factor payment – labour costs, in this case – increases the possibility of reduced shareholder wealth, which translates into greater idiosyncratic risk.

Third, skill-intensive firms are particularly vulnerable to employees defecting to rival firms or starting a competing venture[65]. Even with buffers such as intellectual property protection, licensing or non-compete clauses (Baldwin and Henkel (2015)), the departure of key employees could significantly undermine competitiveness. As Løwendahl (1997) suggests, skilled workers regularly bring to the firm not just their expertise, but their experience, professional reputation, client relationships, and networks of peer and institutional contacts. The loss of these as well as specific human capital (Becker (1964),

[64] See, e.g. DiMasi et al. (2003) on the case of drug development.

[65] A vast literature in HRM has examined the antecedents and consequences of labour turnover, and discussed various retention strategies – see Sutherland and Jordaan (2004) and references therein. A subset of this literature has focused on engaging and retaining knowledge workers (e.g. Tempoe (1993), Lee and Maurer (1997), Stovel and Bontis (2002), Sutherland and Jordaan (2004), and Benson and Brown (2007)).

Blair (1999)) erodes the firm's knowledge base, thus destroying value. In addition, the firm will incur hiring costs which typically increase with worker skill (Parsons (1986)).

Besides the magnitude of direct and indirect costs, the likelihood of voluntary turnover could be greater for skill-intensive firms. While workplace grievances and disengagement may prompt both high- and low-skilled workers to leave, the former are also a frequent target of competitive poaching. More fundamentally, skilled workers are highly mobile, influenced as much by their shifting career concerns and priorities (e.g. Kunda et al. (2002)) as by the transferability of their skills. Thus, skill-intensive firms regularly compete in the input (i.e. labour) as well as the output market (cf. Maister (1982)).

The three lines of argument presented above suggest that skill-intensive firms have more and riskier growth options, whose realisation is further constrained by significant agency problems and turnover threat. This leads us to posit that idiosyncratic risk increases as firms rely more heavily on skilled labour. Hence our first hypothesis:

Hypothesis 4.1: There is a positive relationship between firms' reliance on skilled labour and the level of idiosyncratic risk.

4.2.3 The Moderating Effect of Employee Ownership

Thus far, we have conceptualised skilled labour as a source of cash flow uncertainty, which exacerbates the firm-specific component of return volatility, and thus idiosyncratic risk. As described in Subsection 4.2.1, a high level of idiosyncratic risk represents a legitimate concern for both firm insiders and market participants.

In reducing skilled labour risk, modifying firms' skill profile per se may be impractical, as it would require changes to the underlying business. It is also difficult to conceive of circumstances where firms actively de-skill their workforce, thus foregoing growth opportunities. A less radical approach would be to manage the extent to which investment in skilled labour increases fundamentals uncertainty, as perceived by outside investors.

In the previous subsection, we suggest three explanations for the skill-volatility link, namely risky growth options, potential rent capture by employees, and costly employee turnover. It can be argued that factors which mitigate any of these issues will, therefore, moderate the trade-off described in Hypothesis 4.1. In the rest of this section, we consider broad-based employee ownership (BBEO) as one such factor.

An extensive literature has examined the role of BBEO as a governance mechanism. A common starting point based on agency theory is that, by making employees part owner of the firm, their interests are aligned with those of shareholders. BBEO thus provides outcome-based incentives, advantageous when it is difficult to evaluate individual efforts, due to teamwork and imperfect task programmability (Holmstrom (1979), Eisenhardt (1989)). Moreover, BBEO induces peer pressure or mutual monitoring amongst employees, thereby substituting for direct monitoring (e.g. Hochberg and Lindsey (2010)). The argument is often used to counter scepticisms about BBEO's incentive effect on the grounds of free-rider and line-of-sight problem (e.g. Prendergast (1999), Hall and Murphy (2003)). That is, concerns over monitoring difficulty are expected to dominate those over moral hazard, with the latter mitigated, in any case, as BBEO fosters cooperation over time through repeated games (cf. Weitzman and Kruse (1990))[66]. Reconciling previous studies, Pendleton (2006) suggests that BBEO, rather than providing group incentives as such, is better viewed as complementing other individual high-powered incentives by promoting trust, long-term perspectives, and a broader performance focus[67].

A subset of the literature highlights BBEO's role in fostering investments in specific human capital (e.g. Blair (1995), Robinson and Zhang (2005), Wang et al. (2009), and Guery and Pendleton (2014))[68]. The rationale is that, due to incomplete contract, employees may not develop skills and knowledge with limited value outside the firm, lest they be exploited or "held up" in the future (Williamson (1985), Hart (1995)). On the other hand, employees may also hold up the firm by threatening to quit, thus eliminating future returns on specific human capital investments. BBEO addresses the issues by granting employees residual control as well as income rights[69]. This is consistent with the property rights theory which suggests that resource ownership should accrue to the transacting party whose specific investments mainly determine the value of the resource, but are difficult to stipulate ex ante (Grossman and Hart (1986), Hart and Moore (1990)).

Another line of research considers the sorting and retention purposes of BBEO (e.g. Oyer (2004), Oyer and Schaefer (2005), Bergman and Jenter (2009), and Kedia and Rajgopal

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66 Previous empirical studies have generally found that larger firms are significantly more likely to have employee ownership schemes, thus casting doubt on the free-rider argument (e.g. Kruse (1996), Jones and Pliskin (1997), and Guery and Pendleton (2014))

67 Prior theoretical work highlighting the complementarity between different types of incentives includes Holmstrom and Milgrom (1994) and Gibbons (1998).

68 Cf. also Fitzroy and Kraft (1986).

69 Specifically, residual control rights deter ex post opportunism by the firm, while residual cash flow rights (i.e. the profit-sharing element) deter ex post opportunism by employees (Robinson and Zhang (2005))

(2009)). The departure point is that, incentives provided by BBEO are often considered too weak to justify transferring extra risk onto employees. The observed increases in stock-based compensation, especially in new economy firms (Ittner et al. (2003)), may therefore constitute an effort to attract risk-tolerant and optimistic employees. Moreover, BBEO aids retention by providing a stream of returns on tenure, unencumbered by contingencies associated with similar schemes such as bonuses and profit sharing (Pendleton and Robinson (2011)). It also indexes deferred compensation to outside opportunities, thus allowing employees to benefit from higher stock prices due to a bullish market as well as increased firm efficiency (Oyer (2004)); at the same time, the firm benefits from a reduced need for wage renegotiation. The vesting and distribution rules imposed by most stock/option plans further reinforce their retention effect[70].

Based on the preceding discussion, we conjecture that shareholder concerns about cash flow uncertainty in skill-intensive firms are mitigated in the presence of BBEO – due to its twin roles of interest alignment and retention. This can be seen in the context of the three mechanisms proposed in Subsection 4.2.2: First, firms are more likely to succeed in otherwise risky innovation projects, which often require complementary investments in specific human capital. BBEO encourages these by addressing hold-up concerns, while promoting cooperation and group optimisation. Second, by making employees residual claimants, BBEO addresses ex ante contractual problems, which underlie rent capture by employees. Increased peer pressure also helps in this regard. Third, the economic and psychological dimensions of BBEO create retention incentives, which reduce voluntary turnover and the associated costs.

The arguments above suggest a potential moderating effect of BBEO. This forms the basis of our second hypothesis, which takes the following form:

Hypothesis 4.2: The relationship between firms' reliance on skilled labour and idiosyncratic risk is negatively moderated by the presence of broad-based employee ownership.

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[70] In line with the retention argument, previous studies suggest that BBEO also encourages corporate entrepreneurship (Garrett (2010)), generates different types of satisfaction (Klein (1987), Pendleton et al. (1998)), and creates a sense of psychological ownership (Pierce et al. (1991)).

4.3 Data and Measures

This section explains the data and key variables of this study. Subsection 4.3.1 describes sample selection and distribution. Subsection 4.3.2 describes the estimation of firm-level idiosyncratic risk. Subsection 4.3.3 explains the construction of an employee ownership dummy, which we interact with labour skill index to test the second hypothesis. Subsection 4.3.4 discusses the control variables. Subsection 4.3.5 presents descriptive statistics.

4.3.1 Sample

To construct the data sample for this chapter, we take the baseline sample (see Section 3.1) and apply additional selection criteria. Specifically, out of the baseline sample, we remove observations with missing values of idiosyncratic risk, employee ownership, and control variables. In addition, we follow Pastor and Veronesi (2003) and exclude firms with fiscal year-end market equity, book equity, or total assets less than $1 million, and market-to-book greater than (less than) 100 (0.01). This is to eliminate potential data errors and mismatches.

Table 4-1 details the sample selection process. The final sample comprises 31,837 firm-year observations during the period 1990-2014. These correspond to 4,104 unique firms across 193 three-digit SIC industries.

Table 4-1 Sample Selection

This table shows the construction of the data set for this chapter. Applying criteria 1-4 leads to the initial sample described in Table 3-1. From the initial sample, we exclude firms that cannot be matched with employee ownership data from Form 5500. Sample observations with missing data requirements for idiosyncratic risk and control variables are also dropped. Finally, we delete observations with market equity, book equity, or total assets less than $1 million, and a market-to-book ratio greater than 100 or less than 0.01. The selection process results in an unbalanced panel of 31,837 observations, corresponding to 4,104 firms across 193 three-digit SIC industries during the period 1990-2014.

Selection Criteria	Obs.	Firms	Industries
Firms with Compustat-CRSP data for fiscal years 1990-2014	114,548	12,961	272
After excluding:			
1. Financial firms	91,035	10,247	247
2. Utility firms	87,193	9,934	240
3. Observations with missing values of labour skill index	76,827	8,846	211
4. Observations with missing values of market equity, assets, sales, employees, book-to-market, and leverage	73,711	8,586	211
5. Observations with missing values of employee ownership	46,137	6,175	208
6. Observations with missing values of idiosyncratic risk	34,720	4,367	206
7. Observations with missing values of control variables	32,029	4,129	193
8. Obs. with market equity, book equity or assets less than $1 million, and market-to-book above (below) 100 (0.01)	**31,837**	**4,104**	**193**

Table 4-2 presents the fiscal year distribution of the full sample, the subsample with zero employee ownership (19,961 observations), and the subsample with positive employee ownership (11,876 observations). With respect to the full sample, its size grew steadily through the 1990s and early 2000s, before peaking in 2005. The number of employee ownership firms began declining slightly earlier, i.e. from 2001 onwards. This might reflect the increased concern about tying employee retirement benefits to firm performance, especially in the light of the Enron bankruptcy.

Table 4-2 Sample Distribution

This table reports the fiscal year distribution of the full sample, the subsample with zero employee ownership (EO=0), and the subsample with positive employee ownership (EO>0). The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Fiscal Year	Full Sample		EO=0		EO>0	
	Obs.	Percent	Obs.	Percent	Obs.	Percent
1990	545	1.71	389	1.22	156	0.49
1991	333	1.05	248	0.78	85	0.27
1992	787	2.47	502	1.58	285	0.90
1993	795	2.50	513	1.61	282	0.89
1994	812	2.55	532	1.67	280	0.88
1995	817	2.57	520	1.63	297	0.93
1996	858	2.69	554	1.74	304	0.95
1997	862	2.71	547	1.72	315	0.99
1998	896	2.81	572	1.80	324	1.02
1999	1,436	4.51	871	2.74	565	1.77
2000	1,686	5.30	984	3.09	702	2.20
2001	1,751	5.50	1,039	3.26	712	2.24
2002	1,726	5.42	1,042	3.27	684	2.15
2003	1,741	5.47	1,041	3.27	700	2.20
2004	1,781	5.59	1,095	3.44	686	2.15
2005	1,829	5.74	1,160	3.64	669	2.10
2006	1,717	5.39	1,084	3.40	633	1.99
2007	1,632	5.13	1,019	3.20	613	1.93
2008	1,518	4.77	966	3.03	552	1.73
2009	1,461	4.59	907	2.85	554	1.74
2010	1,415	4.44	878	2.76	537	1.69
2011	1,418	4.45	889	2.79	529	1.66
2012	1,402	4.40	894	2.81	508	1.60
2013	1,351	4.24	877	2.75	474	1.49
2014	1,268	3.98	838	2.63	430	1.35
Total	**31,837**	**100.00**	**19,961**	**62.70**	**11,876**	**37.30**

4.3.2 Dependent Variable: Idiosyncratic Risk

Consistent with previous empirical studies (e.g. Zhang (2010), Bekaert et al. (2012)), we estimate firm-level idiosyncratic risk based on Fama and French's (1993) three-factor model. Specifically, using monthly return data, we run the following time-series regression with a 60-month rolling window for each firm[71]:

$$(R_{i,t} - R_{f,t}) = \alpha_0 + \beta_{i,m}(R_{M,t} - R_{f,t}) + \beta_{i,s}SMB_t + \beta_{i,h}HML_t + \varepsilon_{i,t} \quad (4.1)$$

where: i and t denote firm and time (month), respectively

$R_{f,t}$ = The return on one-month Treasury bill in month t

$R_{i,t}$ = The stock return of firm i in month t

$R_{M,t}$ = The value-weighted return on all U.S. stocks listed on NYSE/AMEX/NASDAQ in month t

SMB_t = The difference between the value-weighted returns on portfolios of small- and large-capitalisation stocks in month t

HML_t = The difference between the value-weighted returns on portfolios of value (i.e. low book-to-market) and growth (i.e. high book-to-market) stocks in month t

$\varepsilon_{i,t}$ = The stochastic error term

Our annual measure of idiosyncratic risk (IDRSIK) is defined as the sum of squared monthly residuals from Equation (4.1), namely:

$$IDRISK_{i,t} = \sum \varepsilon^2_{1,T} \quad (4.2)$$

To address positive skewness and kurtosis of IDRISK estimates, which may confound statistical inferences (Goyal and Santa-Clara (2003), Xu and Malkiel (2003)), all regressions in the empirical analysis will use the natural logarithm of IDRISK as dependent variable.

[71] The factor portfolio returns and risk-free rates are downloaded from Professor Kenneth French's website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

4.3.3 Interacting Variable: Employee Ownership Dummy

In testing the second hypothesis of this chapter (Hypothesis 4.2), labour skill index will be interacted with an employee ownership dummy (EODUM), which indicates the presence (or absence) of BBEO. Specifically, EODUM takes the value of one if the firm provides own stock through DC plans in a given year, and zero otherwise[72].

Our source of DC plan information is annual Form 5500 filings[73]. Due to its comprehensive plan-level data, Form 5500 has been widely used in the pension literature (Buessing and Soto (2006)). Recently, researchers have also highlighted the usefulness of Form 5500 in studying topics related to BBEO (e.g. Rauh (2006), Even and MacPherson (2008), Bova, Dou, and Hope (2015), and Park (2017)).

As part of data collection, we download raw Form 5500 data for 1999-2014 – including the main report, and Schedule H (Schedule I) which contains financial information and asset allocation of plans covering at least (fewer than) 100 participants – from the U.S. Department of Labor (USDOL) website[74]. Prior to 1999, we retrieve compiled Form 5500 data for 1990-1998 – available only for plans covering at least 100 or more participants – from the Center for Retirement Research at Boston College[75]. Throughout the period 1990-2014, we search the Form 5500 filings of individual sponsors for tax-qualified DC plans allowed to hold employer stock. These include: profit sharing plans, stock bonus plans, 401(k) plans, employee stock ownership plans (ESOP), and money purchase pension plans. Care is taken to include only single-employer plans with complete sponsor information, properly coded benefit features, and nonzero total assets[76].

To estimate employee ownership for U.S. public firms, we match plan-level Form 5500 data to Compustat-CRSP data. Although Form 5500 used to provide the CUSIP number[77]

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72 We discuss BBEO in retirement benefit plans, especially DC plans, in greater detail in Chapter 5.

73 Pursuant to the Internal Revenue Code (IRC) and the Employee Retirement Income Security Act of 1974 (also known as ERISA), all organisations that sponsor or administer an employee benefit plan covered by ERISA must provide annual information on each plan regarding its operations, funding, and investments. The Form 5500 Series, which contains an annual report and various schedules and attachments, was jointly developed by the Inland Revenue Service (IRS), the United States Department of Labor (USDOL), and the Pension Benefit Guaranty Corporation (PBRC) to ensure that plan sponsors and administrators comply with the reporting requirements.

74 See https://www.dol.gov/agencies/ebsa/about-ebsa/our-activities/public-disclosure/foia/form-5500-datasets

75 See http://crr.bc.edu/data/form-5500-annual-reports/

76 In untabulated analysis, we drop DC plans with part of their assets held in common, collective, or master trusts, as asset allocation in these entities is not discernible (e.g. Rauh (2006), Even and MacPherson (2008)). This reduces the sample by nearly 40 percent, but does not change our main inferences.

77 See https://www.sec.gov/answers/cusip.htm

of the parent company of plan sponsors, it was no longer available after 1999. For 1999-2014 (and most of 1990-1998), we therefore link Form 5500 plans to Compustat firms using the Employer Identification Number (EIN)[78]. To minimize unsuccessful matches due to coding errors, we further match the two datasets using a combination of plan sponsors' headquarters state and the first 15 (or 8) letters of their reported names. It is acknowledged that using EIN or sponsor name as the linking variable is not ideal[79]. Amongst other things, a firm can have multiple subsidiaries which are assigned a different EIN – if they choose to file separate income tax returns while remaining consolidated with the parent company (Rauh et al. (2016)). As a result, the EIN and name of the plan sponsor, as reported on Form 5500, will differ from those of the parent company. This causes an underestimation of total plan investment in own stock for firms whose subsidiaries are not fully counted.

After aggregating Form 5500 data to the firm level[80], we sum the market value of firm stock ("emply_sec_eoy" in Form 5500) held across the aforementioned types of DC plans for each firm in each year. EODUM is set to one if the sum is greater than zero – that is, the firm sponsors at least one DC plan that invests in own stock – and zero otherwise.

4.3.4 Control Variables

As described in Subsection 4.2.1, the literature has identified a number of factors that may explain variations in idiosyncratic risk. Failing to control for them in a multivariate setting could lead to incorrect statistical inferences. In this subsection, we explain the control variables used in our baseline model.

Following Pastor and Veronesi (2003) and Wei and Zhang (2006), we estimate current return-on-equity (ROE) and the volatility of return-on-equity (VROE) as proxies for uncertainty about the firm's future cash flows. ROE is the annual ratio of income before extraordinary items available for common stockholders to lagged book equity. VROE is the

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[78] The EIN, also known as a Federal Tax Identification Number, is a business entity identifier assigned by the IRS mainly for tax purposes.

[79] See Gron and Madrian (2003) for a detailed summary of related issues.

[80] In the merged Form 5500-Compustat-CRSP sample – before collapsing to firm level – more than three quarters of *plan-year* observations (i.e. 127,995 out of 163,217) report zero employee ownership. Examining the subsample with positive employee ownership reveals that while ESOPs account for 31 percent of all DC plans, they together hold 73.7 percent of total investment in firm stock, compared to 23.3 percent held across non-ESOPs. The observation is in line with Bova, Dou, and Hope (2015), and highlights the importance of ESOPs as an employee ownership vehicle, despite their relatively small number.

three-year rolling standard deviation of ROE using quarterly data. We expect ROE (VROE) to be negatively (positively) related to IDRISK.

Fundamentals uncertainty is likely to be more pronounced for small and young firms, and firms that pay no dividends. This is because investors are less informed about the prospects of these firms, which amplifies the return impact of firm-specific news (e.g. Pastor and Veronesi (2003), Fink et al. (2010)). Fama and French (2004) document a lower survival rate amongst small, newly listed firms, characterised by low profitability and high growth. We define firm size (SIZE) as the natural logarithm of fiscal year-end market capitalisation from CRSP; firm age (AGE) as the natural logarithm of the number of years since the firm first appeared on CRSP; and a dividend dummy (DIVDUM) that takes the value of one if the firm pays dividends during the fiscal year, and zero otherwise. We expect SIZE, AGE, and DIVDUM to be negatively related to IDRISK.

Prior research has found a positive link between growth options and idiosyncratic volatility (e.g. Cao et al. (2008), Brandt et al. (2010), and Zhang (2010)). This can be explained by greater intangible assets, delayed cash flow realisation, or speculative exuberance. In this chapter, we use the market-to-book ratio (MB) as proxy for the firm's growth options, and expect its coefficient to yield a positive sign. MB is calculated annually as the fiscal year-end market equity divided by book equity.

We also control for financial leverage (BKLEV), defined as the ratio of long-term debt to book assets at the fiscal year-end. Theoretically, leveraged firms should have greater idiosyncratic volatility (Black (1976), Christie (1982)). This is because leverage amplifies changes in the firm's asset value as they are passed through to the firm's equity, while also increasing the firm's distress risk (Merton (1974), Dennis and Strickland (2009)). Recent empirical evidence has been ambiguous, however, with several studies reporting either a negative or insignificant effect of leverage[81].

As with Wei and Zhang (2006) and Chen et al. (2012), we include the firm's stock return performance (RETURN), estimated as the continuous compounded monthly return in the previous fiscal year. This is to control for the positive contemporaneous relationship between stock return and stock return volatility (Duffee (1995)).

Another potential determinant of idiosyncratic risk is competitive pressure faced by the firm, stemming from product market rivalry, deregulation or trade liberalisation (Philippon (2003), Gaspar and Massa (2006), and Irvine and Pontiff (2009)). Specifically, idiosyncratic

[81] See, e.g. Pastor and Veronesi (2003), Chun et al. (2008), and Bouslah et al. (2013)

volatility is expected to be higher for firms with less market power. This is because of their limited ability to pass on idiosyncratic cost shocks to customers, thereby smoothing out cash flow fluctuations. Also, investors may perceive greater uncertainty about the average profitability of firms in dispersed, fast-changing industries. To control for the effect of competition, we estimate a Herfindahl index (INDCONC) for each three-digit SIC industry using annual sales data[82].

Finally, to adjust for the trading volume effect, we use Amihud's (2002) illiquidity measure (ILLIQUID) as an inverse proxy for stock liquidity. Specifically, we calculate daily ratios of absolute stock return to dollar volume traded using CRSP data, averaged for each firm in each fiscal year. For presentation purposes, we multiply ILLIQUID by 10,000 in out empirical analysis (e.g. Han and Lesmond (2011)).

To avoid spurious inferences due to extreme observations, we winsorise all firm-level continuous variables (except log-transformed ones) at the top and bottom 0.5 percent.

4.3.5 Descriptive Statistics

Table 4-3 reports descriptive statistics. The original value of our dependent variable, IDRISK, is positively skewed with a mean (median) of 1.297 (0.801)[83]. In untabulated analysis, we find that idiosyncratic volatility represents, on average, more than 75 percent of total volatility of individual stocks. Given that the values of SKILL range between 1 and 5 by construct, our average sample firm is relatively skilled with a mean SKILL of 3.083. Due to the data requirement for IDRISK (see Subsection 4.3.2), all our sample firms will have been listed for at least five years, with a mean and median of 21 and 16 years, respectively[84]. With respect to other control variables, our average sample firm tends not to pay dividends; is left-skewed in profitability and right-skewed in earnings volatility and growth; and has stock that is traded frequently. Also, it tends to operate in less concentrated industries, which indicates strong competitive pressure.

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82 Specifically, INDCONC measures the degree of sales concentration within an industry, thus representing an inverse measure of competition

83 IDRISK has a skewness and kurtosis of 3.510 and 19.720. After log-transformation, Ln(IDRISK) is more normally distributed, with a skewness and kurtosis of 0.160 and 3.059.

84 Some of our oldest sample firms include Chevron, Coca-Cola, DuPont, Exxon Mobil, and IBM. By the end of our sample period (i.e. 2014), about 90 years will have passed since their first CRSP record.

Table 4-3 Descriptive Statistics

This table reports descriptive statistics. The dependent variable, firm-specific idiosyncratic volatility (IDRISK), is the sum of squared residuals from the Fama-French (1993) three-factor model. The main independent variables are the labour skill index (SKILL), the employee ownership dummy (EODUM), and the interaction term between SKILL and EODUM (SKILL×EODUM). SKILL is demeaned. Control variables include: quarterly return on equity (ROE), volatility of return on equity (VROE), the natural logarithm of market capitalisation (SIZE), the natural logarithm of the number of years since the firm's IPO (AGE), a dividend dummy (DIVDUM), market-to-book ratio (MB), book leverage (BKLEV), the prior-year stock return (RETURN), competitive pressure (INDCONC), and an inverse measure of stock liquidity based on Amihud (2002) (ILLIQUID). All continuous controls (except SIZE and AGE) are winsorised at the top and bottom 0.5% of sample observations. Appendix 3 provides details on the control variables. The sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Variable	Obs.	Mean	Std. Dev.	Percentile				
				p1	p25	p50	p75	p99
Dependent Variable								
IDRISK	31,837	1.297	1.559	0.099	0.410	0.801	1.566	8.569
Ln(IDRISK)	31,837	-0.208	0.970	-2.308	-0.892	-0.222	0.449	2.148
Test Variable								
SKILL	31,837	0.000	0.534	-1.349	-0.377	0.068	0.433	0.850
EODUM	31,837	0.373	0.484	0.000	0.000	0.000	1.000	1.000
SKILL×EODUM	31,837	-0.035	0.325	-1.256	0.000	0.000	0.000	0.755
Control Variable								
ROE	31,837	0.029	0.438	-1.696	-0.021	0.087	0.171	1.110
VROE	31,837	0.072	0.173	0.003	0.013	0.028	0.063	0.899
SIZE	31,837	5.901	2.143	1.519	4.342	5.847	7.320	11.165
AGE	31,837	2.831	0.647	1.792	2.303	2.773	3.296	4.394
DIVDUM	31,837	0.369	0.483	0.000	0.000	0.000	1.000	1.000
MB	31,837	2.885	3.336	0.324	1.186	1.924	3.269	18.852
BKLEV	31,837	0.186	0.177	0.000	0.011	0.155	0.305	0.674
RETURN	31,837	0.181	0.665	-0.794	-0.200	0.074	0.381	3.083
INDCONC	31,837	0.203	0.152	0.042	0.087	0.165	0.265	0.818
ILLIQUID	31,837	0.023	0.100	0.000	0.000	0.000	0.003	0.578

4.4 Main Results

In this section, we examine the relationship between firms' reliance on skilled labour and idiosyncratic risk (Hypothesis 4.1), and whether the relationship is moderated by the presence of employee ownership (Hypothesis 4.2). Subsection 4.4.1 presents the portfolio-level evidence. Subsection 4.4.2 explains our multivariate regression model. Subsection 4.4.3 provides the regression results.

4.4.1 Portfolio Sorts

To obtain an indication of how firms' reliance on skilled labour affects idiosyncratic risk, we run a portfolio-level analysis. Besides the full sample, we create two subsamples of firms based on whether they have employee ownership, as in Table 4-2. This allows us to further differentiate the pattern of the skill-volatility relationship (if any) between firms with and without employee ownership. Within the three groups of firms, we form quintile portfolio every year from 1990 to 2014 by sorting firms on SKILL. The mean IDRISK is then calculated and averaged over time for each of the five SKILL portfolios[85]. The results are displayed in Table 4-4.

We first inspect the difference in IDRISK between the top and bottom SKILL quintiles. As the table shows, IDRISK is significantly higher for the mean high-SKILL firm than for the mean low-SKILL firm based on a standard t-test. This result holds for the full sample and both subsamples, thereby providing preliminary support for our first hypothesis that idiosyncratic risk is positively related to the firm's labour skill[86].

Next, we consider whether the presence of employee ownership affects the level and distribution of IDRISK across SKILL portfolios. Specifically, we compare the portfolio sort results between the subsamples with and without employee ownership. Two main observations emerge from the table: First, for the average firm in each of the five SKILL

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[85] For the purpose of this test, IDRISK is winsorised at the top and bottom 0.5 percent.

[86] We note, however, that the increase in IDRISK across SKILL portfolios is not strictly monotonic. In the full sample, the value of mean IDRISK dips slightly between the first and second quintiles, before rising across the remaining ones. A similar pattern occurs for the subsample with positive employee ownership, but not for that with zero employee ownership. Although omitted firm or industry characteristics may explain this – later adjusted for in regressions – we cannot completely rule out a non-linear relationship between SKILL and IDRISK. To address this possibility, in untabulated analysis, we control for squared SKILL in the baseline regression. Its coefficient is statistically insignificant, while the magnitude and significance of the main effects are almost unchanged.

quintiles, IDRISK is significantly lower if the firm has employee ownership, according to the t-test results. Second, the average IDRISK increases more steeply between low- and high-SKILL bands for the zero-ownership subsample (approximately 83.6%) than for the positive-ownership subsample (approximately 42.0%). The observation suggests that employee ownership negatively moderates the relationship between labour skill index and idiosyncratic risk, lending support to our second hypothesis.

Table 4-4 Portfolio Sorts

Each year, firms in the full sample, and subsamples with or without employee ownership (i.e. EODUM = 1 or 0), are sorted into quintile portfolios based on the labour skill index (SKILL). The time-series averages of mean idiosyncratic volatility (IDRISK) are calculated for each of the five portfolios. A standard t-test is performed to assess the equality between the top and bottom SKILL quintiles (the bottom row), and between a given SKILL quintile in both subsamples (the rightmost column). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

SKILL Quintile	Full Sample (Obs.=31,837)		EODUM=0 (Obs.=19,961)		EODUM=1 (Obs.=11,876)		t-stat (EODUM=1/0)
	SKILL	Mean [SE]	SKILL	Mean [SE]	SKILL	Mean [SE]	
Low	2.289	0.936 [0.015]	2.281	1.006 [0.020]	2.300	0.853 [0.022]	-5.246***
2	2.809	0.899 [0.013]	2.812	1.059 [0.019]	2.804	0.696 [0.014]	-14.283***
3	3.191	1.409 [0.020]	3.199	1.681 [0.029]	3.178	0.932 [0.021]	-18.183***
4	3.447	1.613 [0.022]	3.451	1.818 [0.028]	3.438	1.170 [0.030]	-14.186***
High	3.758	1.672 [0.025]	3.762	1.847 [0.031]	3.748	1.211 [0.036]	-11.515***
t-stat (H-L)		26.295***		22.082***		8.971***	

4.4.2 Estimation Framework

The evidence thus far supports a positive association between firms' reliance on skilled labour and idiosyncratic risk, mitigated by employee ownership. However, several other factors could also drive the variation in idiosyncratic risk, thus biasing the results. To isolate our main effects of interest, we now turn to a multivariate analysis. Specifically, we include control variables from Subsection 4.3.4, as well as SKILL and the interaction term between SKILL and EODUM, in a pooled cross-sectional time-series regression given by:

$$\mathrm{Ln(IDRISK)}_{i,j,t} = \alpha_0 + \beta_1 \mathrm{SKILL}_{j,t} + \beta_2 \mathrm{EODUM}_{i,j,t} + \beta_3 \mathrm{SKILL} \times \mathrm{EODUM}_{i,j,t} + \beta_4 \mathrm{CONTROLS}_{i,j,t} + \varepsilon_{i,j,t} \quad (4.3)$$

where i, j, and t index firm, industry, and year, respectively. The dependent variable is log-transformed *IDRISK*. The main independent variables are *SKILL*, *EODUM*, and *SKILL×EODUM*. *CONTROLS* is a vector of control variables described in Section 4.3.4, namely: *ROE*, *VROE*, *SIZE*, *AGE*, *DIVDUM*, *MB*, *BKLEV*, *RETURN*, *INDCONC*, and *ILLIQUID*. We further control for differences in *Ln(IDRISK)* across time and industries, by including dummies for year and major SIC division. All t-statistics are calculated based on robust standard errors, clustered at the three-digit SIC industry level. This addresses the possibility of correlated errors within industries, especially given that SKILL is estimated at the industry level.

4.4.3 Baseline Regression

Table 4-5 reports the results of panel (OLS) regression with year and industry fixed effects. Columns (1)-(3) show the independent effects of SKILL and EODUM, estimated separately and jointly. Consistent with the univariate results, the coefficient on SKILL is positive and significant, even after including an extensive set of control variables. This indicates that, other things being equal, the level of idiosyncratic risk increases with the degree to which firms rely on skilled labour. The negative and significant coefficient on EODUM suggests that the presence of employee ownership leads to lower cash flow uncertainty, as perceived by the market (cf. Bova, Kolev, Thomas, and Zhang (2015)).

To test our second hypothesis, we include the interaction term between SKILL and EODUM in the model. Column (4) shows the results of the fully-specified model. As predicted, the presence of employee ownership mitigates the positive effect that skilled labour has on idiosyncratic risk, as reflected by the negative and significant interaction term (SKILL×EODUM). SKILL continues to load positively and significantly, while yielding a higher point estimate. This is to be expected given its now different interpretation – namely, the coefficient on SKILL captures only its effect in the absence of employee ownership (EODUM = 0), holding other factors constant. Including the interaction term thus facilitates a more comprehensive view of the effect of SKILL. This is because the independent effect, reported in Column (3), would have reflected not only the underlying causal relationship between SKILL and log IDRISK, but also the distribution of EODUM (Brambor et al. (2006)).

In terms of economic significance, the results in Column (4) indicate that for firms without employee ownership, a one-standard-deviation increase in SKILL is associated with a 13.6 percent increase in IDRISK. For firms with employee ownership, however, the increase is reduced to about 8.4 percent.

With respect to the control variables, most of them (except BKLEV and INDCONC) have the predicted signs and are statistically significant in all columns. Specifically, log IDRISK is positively associated with VROE, MB, and RETURN, and is negatively associated with ROE, SIZE, AGE, DIVDUM, and ILLIQUID. In Column (4) where the full model is estimated, the F test (F-stat = 434.84, untabulated) strongly rejects the null hypothesis that the coefficients on all independent variables are jointly zero[87].

Supporting both of our hypotheses, Table 4-5 shows a positive relationship between firms' reliance on skilled labour and idiosyncratic risk, attenuated when there is employee ownership. Previous research has suggested that employee ownership leads to increased productivity and firm performance, through retaining and motivating workers. We take a risk-based view and highlight a signalling role of employee ownership, whereby its presence reduces investor uncertainty as the firm invests in skilled labour.

[87] None of the independent variables has a variance inflation factor (VIF) above 3, suggesting that multicollinearity should not be a serious problem.

Table 4-5 Baseline Regression

This table reports results of the regression of log-transformed idiosyncratic risk (Ln(IDRISK)) on labour skill index (SKILL), employee ownership dummy (EODUM), the interaction term between SKILL and EODUM (SKILL×EODUM), and control variables as previously defined. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Independent Variable	(1)	(2)	(3)	(4)
SKILL	0.206***		0.205***	0.238***
	(5.782)		(5.768)	(6.466)
EODUM		-0.075***	-0.071***	-0.075***
		(-3.828)	(-3.728)	(-4.175)
SKILL×EODUM				-0.087***
				(-2.616)
ROE	-0.166***	-0.175***	-0.165***	-0.164***
	(-15.057)	(-15.427)	(-14.838)	(-14.750)
VROE	0.663***	0.676***	0.660***	0.658***
	(6.368)	(6.319)	(6.259)	(6.189)
SIZE	-0.165***	-0.159***	-0.162***	-0.162***
	(-22.447)	(-22.626)	(-22.414)	(-22.551)
AGE	-0.256***	-0.253***	-0.248***	-0.247***
	(-15.275)	(-14.639)	(-14.996)	(-14.809)
DIVDUM	-0.539***	-0.567***	-0.531***	-0.532***
	(-18.842)	(-18.978)	(-19.172)	(-19.341)
MB	0.013**	0.014***	0.013**	0.012**
	(2.595)	(2.759)	(2.491)	(2.429)
BKLEV	-0.081	-0.149**	-0.066	-0.063
	(-1.291)	(-2.131)	(-1.045)	(-0.992)
RETURN	0.169***	0.167***	0.169***	0.169***
	(13.730)	(13.023)	(13.623)	(13.576)
INDCONC	0.031	-0.111	0.038	0.040
	(0.291)	(-0.929)	(0.353)	(0.370)
ILLIQUID	-0.181**	-0.171**	-0.184**	-0.183**
	(-2.484)	(-2.334)	(-2.518)	(-2.526)
Constant	1.336***	1.323***	1.316***	1.313***
	(14.786)	(13.839)	(14.337)	(14.469)
Year Effects	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y
Observations	31,837	31, 837	31, 837	31, 837
Adjusted R-squared	0.574	0.568	0.575	0.575

To further illustrate the conditional effect, we graphically present the regression results. Specifically, Figure 4-1 graphs the marginal effects of SKILL on log IDRISK for firms with and without employee ownership. This is supplemented by Figure 4-2 which, instead of plotting separate lines, graphs the differences between the predicted values of log IDRISK for firms with and without employee ownership, across the distribution of SKILL; the 95% confidence intervals are superimposed on the fitted line[88].

In Figure 4-1, the fitted line for employee ownership firms (EODUM = 1) exhibits a less positive slope than that for non-employee ownership firms (EODUM = 0), confirming the negative moderating effect of EODUM. What is less obvious, however, is the observation that the moderating effect is not universally significant. Specifically, amongst firms below (roughly) the 9th SKILL percentile, employee ownership firms appear to incur greater idiosyncratic risk than non-employee ownership firms. This is corroborated by Figure 4.2 in which the predicted differences in log IDRISK are positive (i.e. higher when EODUM=1) for low-SKILL firms. The straddling of zero y-axis by the confidence intervals suggests these observations are statistically insignificant, nevertheless. Also in Figure 4.2, the negative moderating effect of EODUM is shown to be significant mainly for firms above (roughly) the 25th SKILL percentile, where the upper and lower bounds of the confidence intervals are both below zero.

Overall, Figures 4-1 and 4-2 support our baseline inferences, while providing a more comprehensive picture of how and when the presence of employee ownership moderates the skill-volatility relationship.

[88] In constructing both graphs, the values of all control variables are held at their mean.

Figure 4-1 Marginal Effects of Labour Skill Index

Figure 4-1 graphs the relationship between labour skill index (SKILL) and log-transformed idiosyncratic risk (Ln(IDRISK)) for firms with employee ownership (EODUM = 1) and those without (EODUM = 0), based on the regression estimates reported in Table 4-5, Column (4). The full sample consists of 31,837 firm-year observations during the period 1990-2014.

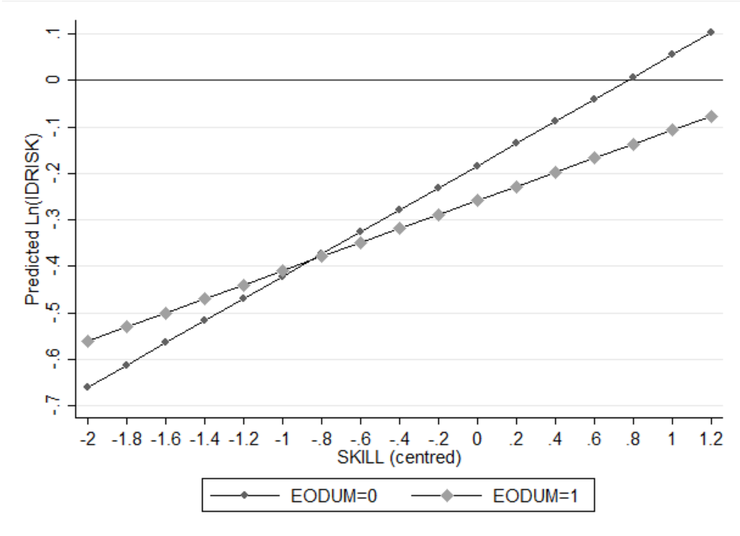
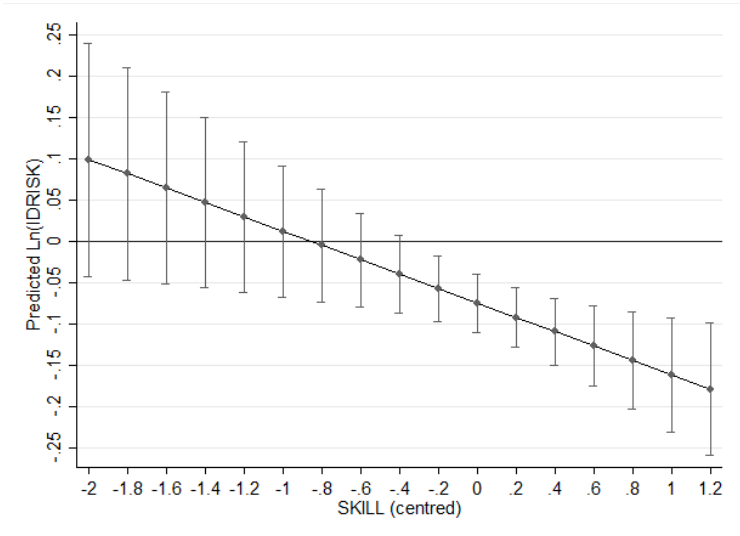


Figure 4-2 Differences between Predicted Values of Idiosyncratic Risk for Firms with and without Employee Ownership

Figure 4-2 graphs the differences in the predicted values of log-transformed idiosyncratic risk (Ln(IDRISK)) between firms with and without employee ownership, across values of labour skill index (SKILL). The graph is constructed based on the regression estimates reported in Table 4-5, Column (4). The fitted line is overlaid with the 95% confidence intervals (vertical lines). The full sample consists of 31, 837 firm-year observations during the period 1990-2014.



4.5 Identification Tests

This section presents the results of identification tests. To address potential endogeneity between employee ownership and idiosyncratic risk, we re-estimate the baseline regression using a two-stage least squares (2SLS) method (Subsection 4.5.1). This is followed by tests in which we substitute the level of employee ownership for its presence in the regression (Subsection 4.5.2); divide sample firms based on the severity of free-riding concerns (Subsection 4.5.3); and, finally, consider the main effects for alternative sub-periods (Subsection 4.5.4).

4.5.1 Instrumental Variable Analysis

In the baseline model, we assume that employee ownership is exogenously determined, and not influenced by the level of idiosyncratic risk. We also assume that omitted variable bias is minimised, due to our extensive set of controls and the inclusion of year and industry fixed effects. Where these assumptions do not hold, and where our employee ownership measure is imprecisely defined, the OLS estimates could be inconsistent due to endogeneity. In particular, we are concerned that the coefficient on SKILL×EODUM (as well as EODUM) may be downward biased, thus overstating the moderating effect. As is common in the literature, we address the endogeneity issue using an instrumental variable approach where we re-estimate the baseline model in a 2SLS framework.

The robustness of 2SLS estimates depends on the choice of instruments. Specifically, they should be significantly related to EODUM, but uncorrelated with the error term in Equation (4.3). In the first-stage regression, we consider two instruments for the presence of employee ownership: the long-term capital gains tax rates in the firm's headquarters state (LTCG)[89], and the firm's cash contributions to DC plans scaled by total assets (CONTRIB). The rationales behind them are described below.

The use of LTCG is motivated by the U.S. pension rule that allows the net unrealised appreciation (i.e. the net increase in the value of a given security while it is being held in a trust) of firm stock in DC plans to be taxed at the preferential capital gains rate – which is typically lower than the ordinary income rate – provided the distribution is made "in-kind" (i.e. in the form of share certificates rather than cash) and not rolled into a taxable brokerage

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[89] The annual state-level data are available from the National Bureau of Economic Research (NBER) website (http://users.nber.org/~taxsim/marginal-tax-rates/).

account (Brown et al. (2006)). The special tax treatment is not available to other asset classes in DC plans. Therefore, we expect that employee ownership through DC plans is more likely for firms in states with lower capital gains rates. This is because employees will be able to retain a greater portion of value of their stockholdings. The use of CONTRIB is motivated by the evidence that equity-based pay tends to supplement, rather than supplant, other forms of compensation (e.g. Brickley and Hevert (1991), Kruse (2002), and Sesil et al. (2007))[90]. In our context, we expect employee ownership to complement a high level of cash-based DC plan contributions in promoting retention, especially given the deferred nature of wealth vested in such plans.

In the baseline model, we examine the moderating effect of EODUM by including its interaction term with SKILL, i.e. SKILL×EODUM. Given that we now relax the exogeneity assumption for EODUM, SKILL×EODUM is by implication also potentially endogenous. To address this additional element of endogeneity, we create two additional instruments based on the interaction between SKILL and LTCG (SKILL×LTCG) and between SKLL and CONTRIB (SKILL×CONTRIB)[91]. All three variables (i.e. SKILL, LTCG and CONTRIB) are demeaned before entering into interaction terms.

The first stage of our 2SLS model is specified as follows:

$$\mathrm{EODUM}_{i,j,t} = \alpha_0 + \beta_1 \mathrm{SKILL}_{j,t} + \beta_2 \mathrm{CONTROLS}_{i,j,t} + \beta_3 \mathrm{LTCG}_{i,j,t} + \beta_4 \mathrm{CONTRIB}_{i,j,t} + \beta_5 \mathrm{SKILL} \times \mathrm{LTCG}_{i,j,t} + \beta_6 \mathrm{SKILL} \times \mathrm{CONTRIB}_{i,j,t} + \varepsilon_{i,j,t} \tag{4.4}$$

$$\mathrm{SKILL} \times \mathrm{EODUM}_{i,j,t} = \alpha_0 + \beta_1 \mathrm{SKILL}_{j,t} + \beta_2 \mathrm{CONTROLS}_{i,j,t} + \beta_3 \mathrm{LTCG}_{i,j,t} + \beta_4 \mathrm{CONTRIB}_{i,j,t} + \beta_5 \mathrm{SKILL} \times \mathrm{LTCG}_{i,j,t} + \beta_6 \mathrm{SKILL} \times \mathrm{CONTRIB}_{i,j,t} + \varepsilon_{i,j,t} \tag{4.5}$$

We obtain the predicted values of EODUM (P_EODUM) and SKILL×EODUM (P_SKILL×EODUM) from estimating Equations (4.4) and (4.5). These are then substituted for their original values in Equation (4.3). This leads to the second stage of our 2SLS model:

90 Also, given the direct and indirect costs of setting up a share ownership plan, its use is likely to trail rather than precede existing compensation practices (Guery and Pendleton (2014, p.8)). However, it is also possible that firms subsequently increase their plan contributions, especially if the plan is adopted mainly to enhance employee benefits (cf. Mauldin (1999)).

91 Bova, Dou, and Hope (2015, p.649) adopt similar procedures, but in a different context.

$$\mathrm{Ln(IDRISK)}_{i,j,t} = \alpha_0 + \beta_1 \mathrm{SKILL}_{j,t} + \beta_2 \mathrm{P\_EODUM}_{i,j,t} + \beta_3 \mathrm{P\_SKILL} \times \mathrm{EODUM}_{i,j,t} + \beta_4 \mathrm{CONTROLS}_{i,j,t} + \varepsilon_{i,j,t} \tag{4.6}$$

Table 4-6 reports the results of 2SLS estimation. The first-stage regressions are shown in Columns (1) and (2). As predicted, EODUM is negatively and significantly related to LTCG, while positively and significantly related to CONTRIB. Similarly, our third and fourth instruments (SKILL×LTCG and SKILL×CONTRIB) correlate significantly with SKILL×EODUM. Of more interest, however, is whether the main effects in Table 4.5 hold after controlling for potential endogeneity associated with EODUM. The second-stage regression in Column (3) suggests that this is the case: SKILL continues to load positively and significantly, while the moderating effect of EODUM remains negative and significant. Intriguingly, the magnitude of the coefficient on SKILL×EODUM (as well as EODUM) is now much larger – to the extent that it more than offsets the positive effect of SKILL. We treat this observation with caution, due to the much higher standard errors yielded by the instrumented variables.

We further examine the strength of instruments in our 2SLS analysis. First, we consider whether they are sufficiently correlated with the endogenous variables. The partial F-statistics of 25.73 (p=0.000) and 26.23 (p=0.000) obtained from Equation (4.4) and Equation (4.5), respectively, strongly reject the null hypothesis that the coefficients on our four instruments are jointly zero in the first stage[92]. Moreover, the weak identification test yields a Wald statistic of 14.861, which exceeds the critical value for weak instruments of 9.93 according to Stock and Yogo (2005). Second, we consider whether the excluded instruments are uncorrelated with the residual in Equation (4.6). The test of overidentifying restrictions (our model is overidentified by two degrees of freedom) yields a Sargan statistic of 4.49 with a p-value of 0.106. This means that we cannot reject the joint null hypothesis that our instruments are valid, i.e. they are distributed independently of the error process and are correctly excluded from the second stage.

Taken together, the findings in Table 4.6 corroborate our baseline results, lending further support to Hypothesis 4.1 and 4.2.

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[92] This is corroborated by the Kleibergen-Paap rk LM statistic of 26.383 (p-value=0.000) which allows us to reject the null hypothesis that the model is underidentified.

Table 4-6 Two-stage Least Squares Regression

This table reports the 2SLS regression results. Columns (1)-(2) show the coefficient estimates from the first stage. Specifically, the employee ownership dummy (EODUM) and the interaction term between the labour skill index (SKILL) and EODUM (SKILL×EODUM) are regressed on SKILL, control variables, and instrumental variables. The instrumental variables include: long-term capital gains tax rates in the firm's state (LTCG), the level of cash contributions to DC plans (CONTRIB), and their interaction terms with SKILL (SKILL×LTCG and SKILL×CONTRIB). Column (3) shows the coefficient estimates from the second stage. Specifically, log idiosyncratic risk (Ln(IDRISK)) is regressed on SKILL, the predicted values of EODUM and SKILL×EODUM (P_EODUM and P_SKILL×EODUM), and control variables. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

	First-stage Results		Second-stage Results
Dependent Variable	EODUM	SKILL×EODUM	Ln(IDRISK)
	(1)	(2)	(3)
SKILL	-0.027	0.385***	0.383***
	(-1.156)	(23.803)	(4.569)
P_EODUM			-0.629***
			(-4.003)
P_SKILL×EODUM			-0.500***
			(-2.614)
ROE	0.007	0.008*	-0.153***
	(0.829)	(1.769)	(-11.579)
VROE	-0.026	-0.016	0.630***
	(-0.935)	(-1.155)	(5.303)
SIZE	0.037***	0.003	-0.144***
	(6.906)	(0.684)	(-18.983)
AGE	0.103***	0.007	-0.181***
	(6.654)	(0.626)	(-7.892)
DIVDUM	0.093***	-0.021**	-0.479***
	(4.577)	(-2.021)	(-13.838)
MB	-0.007***	-0.002	0.008
	(-3.048)	(-1.547)	(1.326)
BKLEV	0.235***	0.015	0.064
	(6.051)	(0.534)	(0.854)
RETURN	-0.005	0.002	0.166***
	(-1.233)	(0.601)	(12.751)
INDCONC	0.069	0.017	0.096
	(1.265)	(0.523)	(0.850)
ILLIQUID	-0.049	0.023	-0.202***
	(-0.948)	(1.060)	(-2.597)
LTCG	-0.949***	-0.077	
	(-4.566)	(-0.639)	
CONTRIB	0.111***	0.002	
	(7.948)	(0.356)	
SKILL×LTCG	-0.080	-1.162***	
	(-0.373)	(-5.825)	
SKILL×CONTRIB	-0.004	0.124***	
	(-0.178)	(7.346)	
Constant	-0.247***	-0.017	1.145***
	(-2.959)	(-0.255)	(10.527)
Year Effects	Y	Y	Y
Industry Effects	Y	Y	Y
Observations	31,837	31, 837	31, 837
Adjusted R-squared	0.140	0.404	0.501

4.5.2 Does the Level of Employee Ownership Matter?

Thus far in the analysis, we have represented employee ownership using a binary variable. The evidence above suggests that if the firm has employee ownership, its investment in skilled labour creates less uncertainty perceived by outside investors. This is reflected by the negative interaction term.

Having established that investors' risk perception may be affected by the presence of employee ownership, a natural follow-up question would be: does its level matters too? To answer this, we interact SKILL with quartile dummies for positive employee ownership (EO) in the baseline model, excluding zero employee ownership (i.e. the inverse of EODUM) as reference. The construction of quartile dummies allows comparison between relatively detailed ranges of EO, thus providing information on whether and to what extent EO moderates the effect of SKILL on IDRISK.

As our main EO measure, we estimate the percentage of the firm's equity market value held in DC plans. The use of market equity as the scaling variable is appropriate to our objective, as it relates employees' shareholding to that of external investors. However, to ensure that our findings are not sensitive to the definition of EO, we apply two alternative scalers, namely firm employees and the total value of DC plan assets.

Table 4-7 reports the regression of log IDRISK on SKILL, interaction terms between SKILL and quartile dummies for non-zero EO (EO_Q1, EO_Q2, EO_Q3, and EO_Q4), and control variables as previously defined. The table shows that for firms with non-zero EO, its level negatively and significantly moderates the effect of SKILL on IDRISK, when falling in the first two quartiles (i.e. the lower half) of the distribution[93]. However, at higher levels of EO, the coefficient on the interaction term loses significance and, in some cases, even switches signs but remains insignificant.

The results of Table 4-7 suggest that moderate levels of employee ownership, besides its presence, continue to reduce firm-specific risk associated with investment in skilled labour. The negative interaction effect, however, disappears in the case of high employee ownership. This suggests that there may be counterbalancing factors, which diminish the perceived role of employee ownership in managing skilled labour risk. Whilst we do not make specific predictions, such factors may include concerns that firms promote high stock

[93] The mid-point of the distribution of positive EO corresponds to 1.26% (of market equity), $2,734.18 (per employee), or 12.4% (of DC plan assets).

ownership for non-incentive-related reasons such as takeover defence (Kim and Ouimet (2014)), or that excessive stockholdings exacerbate the agency problem of underinvestment, as employees become too risk-averse (cf. Smith and Stulz (1985), Guay (1999)).

Table 4-7 Interaction with the Level of Employee Ownership

This table shows the results of main regression where labour skill index is interacted with dummies for quartiles of employee ownership (EO). EO_Q1, EO_Q2, EO_Q3, and EO_Q4 equal one if the level of employee ownership falls in the 1st, 2nd, 3rd, and 4th quartile of the positive values, and zero otherwise. EO is estimated alternatively as: a percentage of equity market value (Column (1)), the dollar value of firm stock per employee (Column (2)), and as a percentage of DC plan assets (Column (3)). All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Independent Variable	% Market Equity	Per Employee	% DC Plan Assets
	(1)	(2)	(3)
SKILL	0.239***	0.236***	0.239***
	(6.366)	(6.294)	(6.451)
EO_Q1	-0.046**	-0.058**	-0.067**
	(-2.019)	(-2.245)	(-2.537)
EO_Q2	-0.066**	-0.079***	-0.055***
	(-2.525)	(-3.519)	(-2.717)
EO_Q3	-0.076***	-0.095***	-0.079***
	(-2.724)	(-4.090)	(-3.475)
EO_Q4	-0.125***	-0.094**	-0.101***
	(-3.787)	(-2.360)	(-2.625)
SKILL×EO_Q1	-0.088**	-0.131***	-0.152***
	(-2.113)	(-2.691)	(-2.750)
SKILL×EO_Q2	-0.162***	-0.071*	-0.121***
	(-3.502)	(-1.844)	(-3.221)
SKILL×EO_Q3	-0.065	-0.065	-0.050
	(-1.498)	(-1.569)	(-1.270)
SKILL×EO_Q4	-0.034	0.044	0.006
	(-0.539)	(0.609)	(0.092)
ROE	-0.164***	-0.164***	-0.164***
	(-14.439)	(-14.452)	(-14.442)
VROE	0.658***	0.658***	0.657***
	(6.229)	(6.189)	(6.204)
SIZE	-0.163***	-0.162***	-0.161***
	(-22.601)	(-22.160)	(-22.346)
AGE	-0.243***	-0.246***	-0.246***
	(-14.347)	(-14.572)	(-14.510)
DIVDUM	-0.529***	-0.530***	-0.530***
	(-19.652)	(-19.706)	(-19.679)
MB	0.012**	0.013**	0.013**
	(2.437)	(2.509)	(2.528)
BKLEV	-0.057	-0.065	-0.068
	(-0.905)	(-1.018)	(-1.068)
RETURN	0.169***	0.169***	0.169***
	(13.727)	(13.552)	(13.550)
INDCONC	0.042	0.042	0.035
	(0.396)	(0.389)	(0.334)
ILLIQUID	-0.186**	-0.181**	-0.180**
	(-2.551)	(-2.473)	(-2.472)
Constant	1.298***	1.305***	1.307***
	(14.898)	(14.249)	(14.653)
Year Effects	Y	Y	Y
Industry Effects	Y	Y	Y
Observations	31,837	31, 837	31, 837
Adjusted R-squared	0.576	0. 576	0. 576

4.5.3 Does the Free-Rider Problem Matter?

So far, our results have supported the moderating role of employee ownership as formulated in Hypothesis 4.2. However, where the effectiveness of employee ownership is conditioned by firm characteristics not already part of the model, the observed moderating effect may vary in the cross-section of firms. In this section, we examine this possibility by re-estimating the baseline regression for subsamples of firms based on their susceptibility to free-rider problems.

As mentioned in Subsection 4.2.3, the literature is divided on BBEO's incentive effect. On the one hand, researchers point to the free-rider problem and associated moral hazard. The issue is likely to be amplified for skill-intensive firms, due to the complex cognitive and social processes underlying their activities. The free-rider argument suggests that the moderating effect of EODUM applies mainly to small firms. On the other hand, BBEO may be useful in large firms where direct monitoring is costly. As with the free-rider problem, monitoring difficulty is likely to be amplified for skill-intensive firms. Similarly, large and complex firms may perceive a greater need to align interests and to promote employee loyalty, as facilitated by BBEO. The counter-argument to the free-rider problem implies that the moderating effect of EODUM is stronger for large firms[94].

We define three proxies for the severity of free-rider problem: first, the firm's total employees; second, a dummy variable equal to one if the firm has more than one business segment, and zero otherwise; and third, a dummy variable equal to one if the firm reports foreign (as well as domestic) sales, and zero otherwise. Each year, we partition the sample firms at the median employment size; into stand-alone and diversified firms; and into domestic and international firms. Specifically, we expect that concerns about *both* free-riding and monitoring difficulty are more pronounced for firms with a larger workforce, and firms that have diversified into different product and geographical markets.

Table 4-8 reports regressions for the three pairs of subsamples. The results are stark: the coefficient on SKILL×EODUM is negative and significant for large and diversified firms (Columns (2), (4), and (6)), but loses significance and even switches signs (but remains insignificant) for small and concentrated firms (Columns (1), (3), and (5)). The point estimates, where significant, are roughly in line with those in the main results. The evidence

[94] It is also possible that the free-rider problem occurs less frequently in skilled firms, given that highly skilled workers are more likely to quit than deliberately underperform when dissatisfied with the firm (cf. Campbell and Kamlani (1997)).

suggests that employee ownership is more effective in reducing investor uncertainty about skilled labour when monitoring costs are high, despite the possibility of free-riding. This reflects a perceived need for outcome-based, rather than behaviour-based, control. A related view is that employee loyalty diminishes as the firm expands (Cohen (2009)), thus making voluntary turnover more likely. This is problematic for skill-intensive firms given their emphasis on human capital. To the extent that employee ownership aids retention, its presence sends a reassuring signal to external investors, especially when the perceived likelihood of turnover is high.

With respect to control variables, the negative effects of both AGE and DIVDUM also display cross-sectional variable between the subsamples, though less prominent and in an opposite manner to that of SKILL×EODUM. Specifically, they are stronger for small and concentrated firms, suggesting that a longer existence and a record of dividend payment are particularly helpful in reducing investor uncertainty about the cash flows of otherwise risky firms (Pastor and Veronesi (2003)). Another interesting observation is the loss of significance of the MB coefficient in Columns (2), (4), and (6). A possible interpretation is that growth options (represented by MB) drive idiosyncratic risk partly through speculative exuberance (Brandt et al. (2010)), which is subdued for relatively established and well-understood firms.

The evidence presented in this section adds nuances to our baseline results. We find that, when it comes to mitigating skilled labour risk, the presence of employee ownership elicits a greater response from investors when there is a trade-off between free-rider problems and agency costs. Specifically, investors perceive the potential benefits of employee ownership (in addressing monitoring difficulty and voluntary turnover) as outweighing the potential costs of free-riding. This casts some doubt on the urgency of free-rider problems noted in the literature, especially in the context of skill-intensive firms.

Table 4-8 Cross-sectional Variation in the Interaction Effect

This table repeats the baseline regression for three pairs of subsamples. Each year, firms are partitioned based on the following characteristics: employment size (Columns (1)-(2)), whether they have single or multiple business segments (Columns (3)-(4)), and whether they have foreign as well as domestic operations (Columns (5)-(6)). All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Independent Var.	No. Employees		Product Diversification		Geographic Diversification	
	Low	High	Stand-alone	Diversified	Domestic	Int'l
	(1)	(2)	(3)	(4)	(5)	(6)
SKILL	0.271***	0.172***	0.258***	0.202***	0.260***	0.197***
	(5.289)	(3.793)	(5.590)	(4.493)	(6.127)	(4.070)
EODUM	-0.067*	-0.064***	-0.060**	-0.101***	-0.074**	-0.066***
	(-1.925)	(-3.090)	(-2.573)	(-3.835)	(-2.301)	(-3.362)
SKILL×EODUM	0.026	-0.086**	-0.041	-0.132***	-0.036	-0.089**
	(0.406)	(-2.413)	(-0.965)	(-2.694)	(-0.674)	(-2.156)
ROE	-0.137***	-0.151***	-0.159***	-0.167***	-0.127***	-0.157***
	(-10.626)	(-4.516)	(-13.378)	(-4.576)	(-7.035)	(-8.010)
VROE	0.565***	0.902***	0.590***	0.868***	0.551***	0.773***
	(4.636)	(10.269)	(4.758)	(9.710)	(3.146)	(12.180)
SIZE	-0.137***	-0.144***	-0.162***	-0.160***	-0.150***	-0.164***
	(-15.060)	(-17.797)	(-21.545)	(-16.168)	(-13.701)	(-17.932)
AGE	-0.296***	-0.198***	-0.264***	-0.196***	-0.264***	-0.223***
	(-11.232)	(-10.007)	(-12.642)	(-8.136)	(-9.662)	(-12.190)
DIVDUM	-0.551***	-0.502***	-0.527***	-0.513***	-0.536***	-0.539***
	(-16.640)	(-12.984)	(-15.847)	(-16.582)	(-13.872)	(-15.240)
MB	0.017***	-0.007	0.016***	-0.002	0.017***	0.008
	(3.310)	(-1.644)	(3.753)	(-0.363)	(3.848)	(1.558)
BKLEV	0.095	-0.089	-0.084	0.034	0.030	-0.120*
	(1.158)	(-1.054)	(-1.298)	(0.306)	(0.293)	(-1.708)
RETURN	0.148***	0.197***	0.166***	0.180***	0.195***	0.159***
	(12.966)	(12.185)	(13.797)	(11.169)	(13.124)	(14.396)
INDCONC	0.128	0.053	0.089	0.023	0.020	0.047
	(1.125)	(0.357)	(0.724)	(0.203)	(0.162)	(0.325)
ILLIQUID	-0.116*	0.160	-0.100	-0.382***	-0.136	-0.073
	(-1.690)	(0.491)	(-1.180)	(-2.751)	(-1.418)	(-0.730)
Constant	1.274***	1.079***	1.213***	1.206***	1.298***	1.194***
	(13.441)	(10.635)	(11.445)	(9.145)	(14.005)	(9.572)
Year Effects	Y	Y	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y	Y	Y
Observations	15,930	15,907	20,307	11,500	10,870	17,387
Adjusted R-squared	0.421	0.539	0.537	0.581	0.498	0.614

4.5.4 Time-Period Effects

In all our analyses so far, we have controlled for year fixed effects. The inclusion of year dummies in the regression model captures the influence of aggregate trends in our variables of interest, caused by unobserved as well as observed macroeconomic factors. This reduces the possibility of spurious relations between the variables concerned, insofar as there is sufficient within-year variation in them.

Nevertheless, given the relatively large time-series dimension in our sample which spans over 25 years, it is possible our results may still vary during the sample period. To examine the time-series variation in our baseline results, we split the sample into five-year intervals and rerun the main regression for each of the five sub-periods. Table 4-9 reports the regression results.

Consider first the variation in SKILL. While its positive effect remains significant in all columns, the magnitude of point estimates differs between sub-periods. Specifically, they are much larger between the latter half of the 1990s and the first half of the 2000s, overtaking the baseline estimates by a factor of about 1.5. This may reflect the rise and fall of the fortunes of technology firms during that time[95]. From the mid-2000s onwards, the positive effect of SKILL on IDRISK (for firms without employee ownership) became less strong, albeit still significant. The declining trend may reflect an improved understanding of firms in the high-tech or "new economy" sectors, resulting in less uncertainty about their cash flow. It may also reflect consolidation within these sectors – due to expansion of the incumbents (The Economist (2017)) and dwindling IPOs[96].

We now turn to the moderating effect of employee ownership. The table shows the negative coefficient on SKILL×EODUM was significant mainly in the post-2000 period. This may reflect a greater awareness of the need to address risk related to investment in skills and technology, especially after the bursting of the internet bubble. The presence of employee ownership in a skill-intensive firm signals to the market that, not only is the firm financially able to set up and maintain related schemes, it is also more likely to retain key talents. This then leads to reduced idiosyncratic volatility. Selection could also play a role:

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[95] The earlier part of this period coincided with a surge in IPOs with riskier fundamentals and lower survival rates (Fama and French (2004)), especially on the tech-heavy NASDAQ exchange (Schwert (2002), Pastor and Veronesi (2006)).

[96] See the IPO statistics compiled by Professor Jay Ritter: https://site.warrington.ufl.edu/ritter/files/2016/03/Initial-Public-Offerings-Updated-Statistics-2016-03-08.pdf

against reduced IPOs (see above), current listed firms in high-technology sectors are in a position to hoard valuable human resources, while diversifying themselves. This reinforces the negative moderating effect of EODUM shown in Table 4-8.

With respect to the control variables, the effects of most remain relatively stable in all columns. The noticeable trends displayed by a few, however, are worth mentioning. Specifically, the (absolute) point estimates of SIZE, RETURN, and ILLIQUID were particularly pronounced after the mid-2000s. This suggests that in recent years, firm size and stock liquidity have become more important determinants of idiosyncratic risk. Likewise, the contemporaneous risk-return relation has been strengthened. Note also that the effect of growth options, reflected by MB, declined monotonically across the sub-periods and practically disappeared towards the latter years of our sample.

Although the results in Table 4-8 and 4-9 continue to support both of our hypotheses, they show that the negative moderating effect of employee ownership varies distinctively over time and in the cross-section of firms. It therefore holds less robustly than the positive effect of labour skill. Nonetheless, we are inclined to view the evidence with a degree of caution, given that subsample analysis relies on a reduced number of observations, and sometimes arbitrary partitioning criteria.

Table 4-9 Subsample Regressions

This table repeats the baseline regression for non-overlapping five-year intervals during our sample period: 1990-1994 (Column (1)), 1995-1999 (Column (2)), 2000-2004 (Column (3)), 2005-2009 (Column (4)), and 2010-2014 (Column (5)). All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations from 1990-2014.

Independent Variable	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
	(1)	(2)	(3)	(4)	(5)
SKILL	0.120***	0.346***	0.418***	0.199***	0.095*
	(2.717)	(5.797)	(7.740)	(3.688)	(1.840)
EODUM	-0.058*	-0.070**	-0.113***	-0.085***	-0.025
	(-1.963)	(-2.514)	(-3.832)	(-3.211)	(-0.903)
SKILL×EODUM	0.007	-0.042	-0.153***	-0.115**	-0.097**
	(0.121)	(-0.846)	(-2.999)	(-2.128)	(-2.023)
ROE	-0.125***	-0.112***	-0.182***	-0.158***	-0.157***
	(-2.666)	(-4.917)	(-8.293)	(-8.143)	(-4.504)
VROE	0.819***	0.742***	0.577***	0.513***	0.726***
	(2.791)	(6.091)	(3.760)	(5.034)	(8.108)
SIZE	-0.145***	-0.145***	-0.095***	-0.207***	-0.228***
	(-9.031)	(-13.126)	(-12.050)	(-23.023)	(-22.312)
AGE	-0.294***	-0.229***	-0.275***	-0.232***	-0.222***
	(-10.088)	(-8.962)	(-13.088)	(-9.670)	(-8.463)
DIVDUM	-0.551***	-0.601***	-0.607***	-0.468***	-0.431***
	(-11.267)	(-12.763)	(-17.584)	(-12.427)	(-12.163)
MB	0.036***	0.021***	0.014**	0.008*	-0.000
	(4.364)	(4.361)	(2.469)	(1.907)	(-0.008)
BKLEV	0.185	-0.068	-0.168*	-0.122*	0.366***
	(1.625)	(-0.766)	(-1.885)	(-1.821)	(2.822)
RETURN	0.164***	0.158***	0.116***	0.216***	0.242***
	(8.851)	(15.826)	(9.734)	(10.790)	(11.124)
INDCONC	-0.067	0.009	-0.174	0.057	0.143
	(-0.514)	(0.061)	(-1.084)	(0.421)	(0.924)
ILLIQUID	0.118	0.093	0.022	-0.525***	-0.338**
	(0.911)	(0.509)	(0.168)	(-4.216)	(-2.140)
Constant	1.686***	1.247***	1.601***	2.273***	1.881***
	(5.707)	(12.974)	(15.885)	(18.344)	(11.412)
Year Effects	Y	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y	Y
Observations	3,272	4,869	8,685	8,157	6,854
Adjusted R-squared	0.579	0.587	0.544	0.562	0.574

4.6 Robustness Tests

This section describes additional robustness checks. First, we conduct a series of subsample tests to examine whether our results are driven by a fraction of particularly risky firms (Subsection 4.6.1). Second, we control for additional factors that may affect the trading of a firm's stock, including institutional ownership, corporate governance, and accounting opaqueness (Subsection 4.6.2). Finally, we rerun the regression using alternative proxies for idiosyncratic risk and reliance on skilled labour (Subsection 4.6.3).

4.6.1 Potential Confounding Effects

As mentioned in Subsection 4.2.1, researchers have attributed time variation in aggregate idiosyncratic volatility to the changing composition of stock market indices (e.g. Brown and Kapadia (2007), Fink et al. (2010)). Specifically, a greater representation of listed firms with riskier fundamentals is deemed responsible for the observed increase in idiosyncratic volatility over time in the U.S. Whilst not focusing on firm fundamentals per se, the trading literature complements this view by suggesting that the shifting preferences of institutional investors (Bennett et al. (2003)) or speculative behaviour of retail traders (Brandt et al. (2010)) may overweight the inherently risky stocks.

To isolate the main effects of interest, we include a number of control variables in the regression. However, it is difficult to completely rule out correlated omitted variables. In particular, our results might be driven by a fraction of sample firms with particularly risky stocks, which also happen to be in high-skill industries or sponsor employee ownership. To address this, we rerun the baseline analysis in which we drop firms with characteristics typically linked to cash flow uncertainty and/or intensive trading (informed or speculative).

Specifically, we sequentially exclude the following types of firms: first, "microcap" firms with a market capitalisation below the bottom 20th NYSE percentile (Fama and French (2008))[97]; second, firms listed on the NASDAQ exchange (Schwert (2002), Xu and Malkiel (2003)); third, firms in the high-technology industries as classified by Francis and Schipper (1999, p.343)[98]; fourth, firms with a fiscal year-end stock price less than five dollar

[97] Alternatively, we also tried including a dummy for microcap firms in the regression, or running the baseline model as a weighted least squares regression using log market capitalisation to determine the weight. Both specifications leave our main conclusions unaffected.

[98] Specifically, high-technology industries have the following three-digit SIC codes: 283, 357, 360-368, 481, 737, and 873.

(Falkenstein (1996), Brandt et al. (2010)); fifth, financially distressed firms, defined as those that have an Altman's Z-score below 1.81 (Altman (1968))[99]; and sixth, loss-making firms, defined as those that have a pre-tax loss and net operating loss carry-forwards in each of the previous three years (see Core and Guay (2001)). In addition, we remove sample years that coincided with recessions in the U.S. (i.e. 1990-1991, 2001, and 2008-2009), based on the National Bureau of Economic Research (NBER) recession indicators[100]. This accounts for the likelihood that the effects of observed and unobserved risk factors are exacerbated in times of crisis (Bekaert et al. (2012)).

Table 4-10 reports the subsample regressions. Across all columns, the results are consistent with those reported above, with EODUM continuing to negatively moderate the effect of SKILL on log IDRISK. The reduced significance level of the coefficient on SKILL×EODUM, however, indicates a somewhat weakened moderating effect when highly risky firms are excluded from the sample.

99 We compute Altman's Z-score as follows: (3.3×earnings before interest and taxes + 0.999×sale + 1.4×retained earnings + 1.2×working capital)/total assets + 0.6×(market equity/total debt)

100 See http://www.nber.org/cycles.html

Table 4-10 Exclusion of Risky Firms

This table repeats the baseline regression, removing potential confounding effects. Column (1) excludes microcap firms, defined as those with a market cap below the bottom 20th NYSE percentile in a given year. Column (2) excludes NASDAQ-listed firms. Column (3) excludes firms in high-tech industries as defined by Francis and Schipper (1999). Column (4) excludes firms with a fiscal year-end stock price below $5. Column (5) excludes firms in financial distress, defined as those with an Altman's Z-score below 1.81. Column (6) excludes firms with a pre-tax loss and net operating loss carry-forwards in each of the past three years. Column (7) excludes sample years that coincided with recessions in the U.S. (i.e. 1990-1991, 2001, and 2008-2009). All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Independent Var.	Adjusting for Potential Confounding Effects						
	Excl. Microcap (1)	Excl. NASDAQ (2)	Excl. High-tech (3)	Excl. Low-price (4)	Excl. Distress (5)	Excl. Loss (6)	Excl. Recession (7)
SKILL	0.218***	0.157***	0.142***	0.203***	0.190***	0.219***	0.238***
	(5.680)	(3.347)	(3.891)	(5.656)	(5.217)	(5.977)	(6.130)
EODUM	-0.081***	-0.056**	-0.069***	-0.072***	-0.073***	-0.073***	-0.075***
	(-4.591)	(-2.253)	(-3.045)	(-4.129)	(-3.941)	(-4.105)	(-4.158)
SKILL×EODUM	-0.063*	-0.078*	-0.084**	-0.065**	-0.064*	-0.078**	-0.073**
	(-1.850)	(-1.937)	(-1.974)	(-2.116)	(-1.904)	(-2.495)	(-2.184)
ROE	-0.153***	-0.148***	-0.121***	-0.137***	-0.137***	-0.079***	-0.154***
	(-11.494)	(-4.922)	(-5.903)	(-8.062)	(-5.780)	(-4.479)	(-13.441)
VROE	0.674***	0.732***	0.755***	0.693***	0.799***	0.764***	0.667***
	(6.211)	(7.976)	(11.093)	(8.236)	(7.448)	(11.068)	(6.619)
SIZE	-0.170***	-0.156***	-0.174***	-0.143***	-0.152***	-0.156***	-0.163***
	(-17.974)	(-12.767)	(-21.895)	(-17.188)	(-18.980)	(-19.811)	(-21.862)
AGE	-0.225***	-0.151***	-0.215***	-0.244***	-0.250***	-0.240***	-0.257***
	(-13.104)	(-7.592)	(-12.120)	(-13.522)	(-13.027)	(-13.351)	(-14.969)
DIVDUM	-0.520***	-0.496***	-0.478***	-0.511***	-0.512***	-0.508***	-0.547***
	(-17.350)	(-14.141)	(-19.645)	(-16.977)	(-18.151)	(-18.186)	(-20.021)
MB	0.011*	-0.003	0.006	0.009	0.012*	0.006	0.012**
	(1.819)	(-0.680)	(1.108)	(1.636)	(1.830)	(1.116)	(2.436)
BKLEV	-0.074	0.091	0.051	-0.093	-0.219***	-0.067	-0.061
	(-1.135)	(0.975)	(0.529)	(-1.264)	(-2.737)	(-0.937)	(-0.911)
RETURN	0.169***	0.201***	0.200***	0.191***	0.187***	0.179***	0.167***
	(12.606)	(11.394)	(13.086)	(13.371)	(16.803)	(13.970)	(13.025)
INDCONC	0.043	0.098	0.144	0.057	0.047	0.082	0.045
	(0.351)	(0.970)	(1.633)	(0.522)	(0.434)	(0.762)	(0.405)
ILLIQUID	-0.591	0.303*	-0.169**	-0.768***	-0.184*	-0.182**	-0.155*
	(-1.532)	(1.813)	(-2.104)	(-4.111)	(-1.720)	(-2.326)	(-1.814)
Constant	1.323***	1.013***	1.207***	1.190***	1.328***	1.242***	1.425***
	(13.107)	(8.865)	(12.404)	(13.077)	(13.661)	(14.607)	(14.477)
Year Effects	Y	Y	Y	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y	Y	Y	Y
Observations	23,474	13,448	20,780	25,400	26,245	28,481	26,229
Adj. R-squared	0.573	0.554	0.549	0.539	0.558	0.549	0.577

4.6.2 Additional Control Variables

In the previous subsection, we address the omitted variable problem by excluding firms with a particularly risky profile, which may not be fully accounted for in the baseline model. In this subsection, we augment the baseline regression by including additional control variables. The rationale is similar: if the main effects continue to hold, their previous significance is less likely to be an artefact of alternative explanations.

So far, we have relied on Amihud's (2002) illiquidity measure (i.e. ILLIQUID) to control for the positive trading-volatility link. As mentioned in Subsection 4.2.1, recent research has suggested several factors that may affect trading volume, and thus idiosyncratic volatility. We separately consider three of these in extending the baseline model.

First, we control for institutional trading by including the percentage of the firm's outstanding shares held by institutional investors (IO) at the beginning of the year, and its absolute change during the year (ΔIO) (e.g. Piotroski and Roulstone (2004), Chichernia et al. (2015))[101,102]. We also estimate IO and ΔIO for both short-term institutions (i.e. SIO and ΔSIO) and long-term institutions (i.e. LIO and ΔLIO), using the classification scheme from Professor Brian Bushee's website[103]. This is based on the idea that the two types of institutions exhibit different trading behaviour (Chichernia et al. (2015)).

Second, we control for corporate governance in terms of the firm's openness to the market for corporate control (Ferreira and Laux (2007)). Two inverse proxies are used: the Governance Index (GINDEX) (Gompers et al. (2003))[104] and the Entrenchment Index (EINDEX) (Bebchuk et al. (2009))[105]. Both indices are available for 1990-2006[106].

Third, we control for information opacity using two inverse proxies for the firm's accruals quality as described in Rajgopal and Venkatachalam (2011). The first is the five-

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[101] The decomposition of total institutional ownership into its lagged levels and year-on-year changes controls for the demand shocks and informed trading associated with institutional investors, respectively (Gompers and Metrick (2001)).

[102] We obtain quarterly institutional holdings data from Thomson-Reuters 13F, and match them to the most recent fiscal year-end of each firm based on Compustat.

[103] See http://acct.wharton.upenn.edu/faculty/bushee/IIclass.html

[104] We download the Governance Index from Professor Andrew Metrick's website: http://faculty.som.yale.edu/andrewmetrick/data.html

[105] We download the Entrenchment Index from Professor Lucian Bebchuk's website: http://www.law.harvard.edu/faculty/bebchuk/data.shtml

[106] The data for GINDEX and EINDEX are available every two or three years: 1990, 1993, 1995, 1998, 2000, 2002, 2004, and 2006. We follow Park (2017, p.13) and replace missing values with those from the most recent year, assuming that the index remains unchanged in the short-term.

year standard deviation of the residual from the augmented model of Dechow and Dichev (2002) (DD); the second is the annual squared residual from the modified Jones (1991) model (ABACC2)[107]. Both DD and ABACC2 are winsorised at the 0.5% level to reduce the influence of extreme observations.

Table 4-11, Panel A presents the baseline regression with additional control variables linked to the trading of firm stock. The results again support the negative moderating effect of EODUM, which holds in all specifications, albeit at a reduced significance level. With respect to the extra controls, most yield the correct signs and are statistically significant. Similar to Chichernia et al. (2015), we find that IDRISK correlates positively with SIO and negatively with LIO. This reflects more frequent trading by short-term institutions than by long-term institutions. The negative coefficients of GINDEX and EINDEX are also as expected. Ferreira and Laux (2007) argue that investors are more likely to collect and trade on private information if the firm is less insulated from takeovers; the enhanced information flow increases idiosyncratic volatility. Finally, IDRISK is found to increase with both DD and ABACC2, suggesting a positive correlation between information asymmetry and idiosyncratic volatility. This is consistent with both Rajgopal and Venkatachalam (2011) and Chen et al. (2012).

It is possible that our baseline results are driven by omitted industry characteristics, beyond those captured by the major SIC-division dummies. The concern is particularly relevant given that SKILL is an industry-level variable. One scenario is that the coefficients on both SKILL and SKILL×EODUM may reflect an industry life-cycle effect, where the maturity of an industry systematically affects the cash flow uncertainty of constituent firms. We control for a number of industry life-cycle characteristics as described in Chen et al. (2011). These include the log-transformed age of the oldest firm in an industry (INDAGE); an indicator variable for "new economy" industries (NEWECON) with the following SIC codes: 3570-3579, 3661, 3674, 5045, 5961, and 7370-7379; an indicator variable for "old economy" industries (OLDECON), which have an SIC code less than 4000 and are not part of new economy industries; the median ratio of R&D expense to sales in an industry (INDRDEXP); the median ratio of advertising expense to sales in an industry

[107] In estimating both DD and ABACC2, we run an annual cross-sectional regression across the 48 industry groups classified by Fama and French (1997). With respect to DD, total current accruals (i.e. changes in current assets minus changes in current liabilities minus changes in cash plus changes in short-term debt) are regressed on lagged, current, and leading operating cash flows, changes in sales, and fixed assets. With respect to ABACC2, total accruals (i.e. total current accruals less depreciation and amortisation) are regressed on the difference between changes in sales and changes in receivables, fixed assets, and return on assets. All regression variables are scaled by two-year average assets, and winsorised at the 1% level. The residuals from both regressions are obtained for every firm-year in each of the 48 industry groups.

(INDADVEXP); the median annual percentage change in assets in an industry (INDGRWTH); and the median return on assets in an industry (INDPROF). In line with SKILL, the above industry variables are estimated at the three-digit SIC level.

Table 4-11, Panel B presents the baseline regression in which we sequentially add the industry life-cycle characteristics just described. Our main inferences are again unaffected, with the positive (negative) coefficient on SKILL (SKILL×EODUM) being significantly different from zero in all specifications. Note also that the additional industry controls improve the model's explanatory power only marginally. This is reflected by an increase in adjusted R-squared by no more than 1.5 percent. Amongst the extra variables, OLDECON, NEWECON, INDGRWTH, and INDPROF appear to be important determinants of IDRISK. In contrast, INDAGE, INDRDEXP, and INDADVEXP yield either insignificant or inconsistent coefficient estimates.

Taken together, the evidence presented in this subsection shows that our results are robust to a less parsimonious model specification. This complements evidence from the subsample analysis, and further guards against the possibility of omitted variable bias.

Table 4-11 Additional Control Variables

Panel A reports the results of baseline regression after controlling for trading- and information-related factors. Column (1) includes lagged institutional ownership (IO) and its absolute year-on-year change (ΔIO). Column (2) includes corresponding values for short-term institutions (SIO and ΔSIO) and long-term institutions (LIO and ΔLIO). Columns (3)-(4) include the Governance Index from Gompers et al. (2003) (GINDEX) and the Entrenchment Index from Bebchuk et al. (2009) (EINDEX). Columns (5)-(6) include the five-year standard deviation of discretionary accruals based on Dechow and Dichev (2002) (DD), and the squared abnormal accruals based on Jones (1991) (ABACC2). Panel B reports the results of baseline regression after controlling for industry life-cycle characteristics described in Chen et al. (2011). These include: industry age (INDAGE), dummies for new economy industries (NEWECON) and old economy industries (OLDECON), industry R&D intensity (INDRDEXP), industry advertising intensity (INDADVEXP), industry growth (INDGRWTH), and industry profitability (INDPROF). All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014.

Panel A. Trading and information-related variables

Independent Variable	Institutional Trading		Governance		Earnings Quality	
	(1)	(2)	(3)	(4)	(5)	(6)
SKILL	0.224***	0.232***	0.292***	0.291***	0.207***	0.224***
	(5.918)	(6.300)	(6.586)	(6.614)	(5.743)	(6.063)
EODUM	-0.067***	-0.058***	-0.057***	-0.055**	-0.072***	-0.079***
	(-3.939)	(-3.664)	(-2.617)	(-2.561)	(-4.107)	(-4.424)
SKILL×EODUM	-0.068**	-0.081**	-0.066*	-0.066*	-0.069**	-0.072**
	(-2.098)	(-2.482)	(-1.841)	(-1.860)	(-2.187)	(-2.115)
ROE	-0.174***	-0.189***	-0.253***	-0.252***	-0.163***	-0.163***
	(-8.619)	(-9.673)	(-6.791)	(-6.814)	(-13.452)	(-14.825)
VROE	0.598***	0.552***	0.666***	0.665***	0.483***	0.611***
	(5.474)	(4.569)	(4.914)	(4.919)	(4.523)	(5.297)
SIZE	-0.136***	-0.140***	-0.132***	-0.135***	-0.140***	-0.157***
	(-16.420)	(-16.475)	(-9.065)	(-9.598)	(-17.491)	(-20.138)
AGE	-0.251***	-0.223***	-0.213***	-0.219***	-0.246***	-0.251***
	(-13.993)	(-12.485)	(-9.527)	(-9.998)	(-13.530)	(-14.275)
DIVDUM	-0.528***	-0.493***	-0.538***	-0.540***	-0.513***	-0.533***
	(-18.864)	(-16.665)	(-12.731)	(-12.783)	(-19.500)	(-19.133)
MB	0.008*	0.007	0.009*	0.009*	0.008	0.011**
	(1.658)	(1.512)	(1.748)	(1.731)	(1.571)	(2.072)
BKLEV	0.007	0.033	-0.107	-0.106	-0.028	-0.085
	(0.104)	(0.502)	(-1.168)	(-1.177)	(-0.425)	(-1.326)
RETURN	0.174***	0.198***	0.133***	0.134***	0.162***	0.165***
	(13.382)	(16.120)	(6.832)	(6.949)	(12.667)	(13.037)
INDCONC	0.045	0.085	-0.090	-0.094	0.016	0.026
	(0.415)	(0.779)	(-0.610)	(-0.643)	(0.141)	(0.225)
ILLIQUID	-0.160*	-0.298***	1.950*	1.830*	-0.165**	-0.184**
	(-1.796)	(-2.695)	(1.901)	(1.801)	(-2.186)	(-2.515)
IO	-0.282***					
	(-5.799)					
ΔIO	1.017***					
	(13.908)					
SIO		0.677***				
		(6.819)				
ΔSIO		0.097				
		(1.075)				
LIO		-0.751***				
		(-14.252)				
ΔLIO		0.346***				
		(3.715)				
GINDEX			-0.012***			
			(-2.689)			
EINDEX				-0.026***		
				(-2.660)		
DD (×100)					0.030***	
					(12.529)	
ABACC2 (×100)						0.038***
						(7.965)
Constant	1.168***	1.180***	1.285***	1.274***	0.834***	1.153***
	(11.077)	(11.486)	(10.696)	(10.660)	(6.779)	(9.487)
Year Effects	Y	Y	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y	Y	Y
Observations	15,994	14,404	8,764	8,764	28,788	29,016
Adjusted R-squared	0.600	0.599	0.604	0.605	0.595	0.581

Panel B. Industry life-cycle characteristics				
Independent Variable	(1)	(2)	(3)	(4)
SKILL	0.231***	0.191***	0.122***	0.112***
	(6.464)	(4.255)	(3.389)	(3.304)
EODUM	-0.073***	-0.066***	-0.061***	-0.062***
	(-4.153)	(-3.801)	(-3.535)	(-3.624)
SKILL×EODUM	-0.085**	-0.074**	-0.062*	-0.063*
	(-2.506)	(-2.183)	(-1.847)	(-1.904)
ROE	-0.163***	-0.164***	-0.140***	-0.133***
	(-14.260)	(-13.311)	(-11.957)	(-12.952)
VROE	0.657***	0.658***	0.634***	0.626***
	(6.149)	(6.487)	(5.516)	(5.510)
SIZE	-0.163***	-0.167***	-0.170***	-0.170***
	(-22.199)	(-28.162)	(-23.514)	(-23.977)
AGE	-0.251***	-0.246***	-0.237***	-0.235***
	(-15.852)	(-13.947)	(-15.469)	(-15.478)
DIVDUM	-0.532***	-0.519***	-0.505***	-0.501***
	(-19.440)	(-20.161)	(-20.340)	(-20.350)
MB	0.012**	0.013**	0.010***	0.010***
	(2.435)	(2.512)	(2.692)	(2.697)
BKLEV	-0.062	-0.032	-0.038	-0.039
	(-0.964)	(-0.474)	(-0.558)	(-0.584)
RETURN	0.169***	0.169***	0.166***	0.166***
	(13.636)	(13.212)	(15.184)	(15.124)
INDCONC	0.073	0.104	0.235**	0.257**
	(0.703)	(1.086)	(2.428)	(2.599)
ILLIQUID	-0.187**	-0.187**	-0.175**	-0.168**
	(-2.581)	(-2.579)	(-2.454)	(-2.334)
INDAGE	0.042	0.039	-0.011	-0.006
	(0.984)	(0.835)	(-0.251)	(-0.120)
OLDECON		-0.150***	-0.148**	-0.170***
		(-2.645)	(-2.556)	(-2.931)
NEWECON		0.062	0.121**	0.111**
		(0.990)	(2.254)	(2.174)
INDRDEXP			0.418***	0.132
			(7.011)	(1.161)
INDADVEXP			-0.369	-0.463
			(-0.570)	(-0.743)
INDGRWTH				0.531***
				(3.815)
INDPROF				-0.939***
				(-2.637)
Constant	1.172***	1.296***	1.580***	1.572***
	(6.814)	(8.223)	(8.977)	(9.074)
Year and Effects	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y
Observations	31,837	31, 837	29,458	29,458
Adjusted R-squared	0.575	0.579	0.587	0.588

4.6.3 Measurement Error

The main empirical issue throughout this thesis is that SKILL is an industry-level variable. Using it in a firm-level analysis therefore introduces measurement error. To mitigate biases in regression estimates, we have taken measures such as clustering standard errors and including industry dummies. The previous subsection also addresses the issue by controlling for industry life-cycle characteristics. Our results have thus far been proved robust.

The first part of this subsection further examines the sensitivity of baseline results to different definitions of skilled labour intensity. Specifically, we estimate three alternative proxies and substitute them for SKILL in Equation (4.3). The first proxy, SKILL2, resembles SKILL but excludes wage inputs in Equation (3.1). It thus measures the employment share, rather than wage share, of skilled occupations in an industry. Analogous to SKILL2, the second proxy, COLLEGE, measures the percentage of college-educated workers in the firm's Census industry (roughly equivalent to three-digit SIC). The education level of workers, and the industry in which they are employed, are from the U.S. Current Population Survey (CPS)[108]. The third proxy, SGAEMP, is the log ratio of selling, general, and administrative (SG&A) expense to firm employees[109]. This is motivated by Bova, Kolev, Thomas, and Zhang (2015, p.136) who suggest that SGAEMP is positively related to the degree of employee sophistication.

Table 4-12, Panel A reports the results of baseline regression, replacing SKILL with SKILL2, COLLEGE, and SGAEMP. All the alternative skill proxies load positively and significantly, while the interaction terms (i.e. SKILL2×EODUM, COLLEGE×EODUM, and SGAEMP×EODUM) load negatively and significantly. In terms of economic significance, a one-standard-deviation increase in SKILL2 is associated with an increase in IDRISK by about 13 percent for firms without employee ownership, and 8.6 percent for firms with employee ownership. A 10 percent increase in COLLEGE is associated with an increase in IDRISK by about 7.9 percent for firms without employee ownership, and 5.5 percent for firms with employee ownership. Finally, a 10 percent increase in SG&A expense per employee is associated with an increase in IDRISK by about 0.9 percent for firms without employee ownership, and 0.4 percent for firms with employee ownership.

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108 We obtain CPS data from the Integrated Public Use Microdata Series (IPUMS) of the Minnesota Population Center (https://cps.ipums.org/cps-action/faq) (King et al. (2010)).

109 SGAEMP is log-transformed to account for skewness in the data.

As a final robustness check, we address potential measurement error in the dependent variable, IDRISK, using five alternative settings. Specifically, we calculate the residual sum of squares from three alternative models: first, the traditional Capital Asset Pricing Model (CAPM) in which monthly stock returns are regressed on value-weighted market returns, using five years of data; second, the conditional CAPM in which monthly stock returns are regressed on current and lagged market returns, and current and lagged two-digit SIC industry returns, for each firm-year observation[110]; and third, the Carhart (1997) four-factor model, which is Fama and French's (1993) three-factor model plus a momentum factor[111]. In the fourth setting, we include an additional control for systematic volatility in Equation (4.3) [112], thus recasting the dependent variable as relative, rather than absolute, idiosyncratic volatility (see Chun et al. (2008), Li et al. (2014)). In the last setting, we estimate a benchmark measure of total volatility, namely the standard deviation of daily stock returns over the previous year.

Table 4-12, Panel B reports the results of baseline regressions, using alternative definitions of idiosyncratic risk. Columns (1)-(3) show that calculating IDRISK based on different asset pricing models does not alter our inferences. Specifically, both the positive coefficient on SKILL and the negative coefficient on SKILL×EODUM remain strongly significant, with their point estimates in line with those in Table 4-5. Column (4) shows that, after controlling for absolute systematic variation, the point estimates of the test variables are considerably lower, albeit still statistically significant. Lastly, Column (5) shows that the main effects still hold, when using a simpler (i.e. not model-dependent) and more broadly defined volatility measure as the dependent variable. This corresponds to the observation that idiosyncratic volatility tends to dominate total volatility.

Overall, the evidence in this subsection further substantiates our baseline results, by highlighting their robustness to alternative definitions of the main variables.

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110 The inclusion of lagged terms adjusts for nonsynchronous price movements (Dimson (1979)). The issue is particularly relevant for the estimation of short-horizon betas in conditional CAPM, which otherwise relaxes the assumption of time-invariant betas (Lewellen and Nagel (2006)).

111 The momentum factor data are from Professor Kenneth French's website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

112 Systematic volatility is defined as the log-transformed explained sum of squares from the same three-factor model used to estimate IDRISK.

Table 4-12 Alternative Variable Definitions

Panel A repeats the baseline regression using alternative labour skill proxies. Column (1) shows the adjusted labour skill index (SKILL2), derived by omitting the wage term from Equation (3.1). Column (2) shows the share of college graduates in the firm's industry (COLLEGE). Column (3) shows the log ratio of selling, general, and administrative expense to total employees (SGAEMP). Panel B repeats the baseline regression using alternative models for estimating idiosyncratic risk. Column (1) applies the sum of squared residuals from the market model (CAPM). Column (2) applies the sum of squared residuals from the conditional CAPM, adjusted for industry returns (CAPM+IND). Column (3) applies the sum of squared residuals from Fama and French's (1993) three-factor model plus a momentum factor (FF3+MOM). Column (4) retains the original idiosyncratic risk measure, but controls additionally for systematic volatility (SYSVOL), defined as the explained sum of squares from the three-factor model. Column (5) applies the standard deviation of daily stock returns over the previous year (RETVOL). All idiosyncratic risk proxies and SYSVOL are log-transformed. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,104 firms and 31,837 firm-year observations during the period 1990-2014

Panel A. Alternative proxies for firms' reliance on skilled labour

Independent Variable	Alternative Labour Skill Proxies (SKILL')		
	SKILL2	COLLEGE	SGAEMP
	(1)	(2)	(3)
SKILL'	0.236***	0.757***	0.090***
	(5.933)	(5.535)	(8.492)
EODUM	-0.075***	-0.075***	-0.073***
	(-4.051)	(-4.038)	(-4.004)
SKILL'×EODUM	-0.075**	-0.219**	-0.049***
	(-1.984)	(-2.022)	(-3.191)
ROE	-0.166***	-0.154***	-0.144***
	(-14.888)	(-12.964)	(-8.739)
VROE	0.660***	0.646***	0.717***
	(6.258)	(5.624)	(14.078)
SIZE	-0.162***	-0.164***	-0.163***
	(-22.251)	(-20.561)	(-29.171)
AGE	-0.248***	-0.239***	-0.235***
	(-14.814)	(-15.094)	(-15.189)
DIVDUM	-0.536***	-0.533***	-0.537***
	(-18.662)	(-18.351)	(-25.696)
MB	0.012**	0.010**	0.008***
	(2.429)	(2.536)	(3.001)
BKLEV	-0.069	-0.050	-0.074
	(-1.112)	(-0.756)	(-1.463)
RETURN	0.169***	0.171***	0.180***
	(13.562)	(14.061)	(28.057)
INDCONC	0.020	0.075	-0.017
	(0.176)	(0.658)	(-0.281)
ILLIQUID	-0.185**	-0.180**	-0.163**
	(-2.527)	(-2.487)	(-2.109)
Constant	1.297***	1.445***	1.276***
	(14.094)	(14.694)	(13.575)
Year Effects	Y	Y	Y
Industry Effects	Y	Y	Y
Observations	31,837	31, 837	29,492
Adjusted R-squared	0.575	0.576	0.567

Panel B. Alternative measurements of idiosyncratic risk

Independent Variable	Alternative Models for Idiosyncratic Risk				
	CAPM	CAPM+IND	FF3+MOM	FF3 (Relative)	RETVOL
	(1)	(2)	(3)	(4)	(5)
SKILL	0.248***	0.236***	0.242***	0.118***	0.053***
	(6.718)	(6.178)	(6.637)	(3.757)	(6.437)
EODUM	-0.075***	-0.062***	-0.075***	-0.042***	-0.014***
	(-4.047)	(-3.943)	(-4.126)	(-3.500)	(-3.795)
SKILL×EODUM	-0.097***	-0.120***	-0.088***	-0.036*	-0.016**
	(-2.854)	(-3.335)	(-2.649)	(-1.864)	(-2.301)
ROE	-0.174***	-0.276***	-0.162***	-0.062***	-0.089***
	(-15.038)	(-13.958)	(-14.893)	(-5.681)	(-15.000)
VROE	0.653***	0.633***	0.644***	0.454***	0.175***
	(6.171)	(8.156)	(6.214)	(8.417)	(8.914)
SIZE	-0.158***	-0.184***	-0.164***	-0.174***	-0.040***
	(-23.280)	(-24.801)	(-23.115)	(-36.713)	(-16.687)
AGE	-0.245***	-0.202***	-0.249***	-0.160***	-0.043***
	(-14.010)	(-10.916)	(-14.894)	(-12.919)	(-12.101)
DIVDUM	-0.530***	-0.464***	-0.529***	-0.333***	-0.093***
	(-19.223)	(-15.856)	(-19.389)	(-13.467)	(-16.512)
MB	0.012**	0.008**	0.013***	0.018***	0.002***
	(2.415)	(2.055)	(2.742)	(5.120)	(2.927)
BKLEV	-0.061	0.074	-0.083	-0.031	0.012
	(-0.944)	(1.140)	(-1.346)	(-0.695)	(0.816)
RETURN	0.168***	0.354***	0.166***	0.132***	0.043***
	(13.631)	(27.197)	(13.917)	(14.657)	(11.011)
INDCONC	0.026	0.102	0.032	0.099	0.007
	(0.228)	(1.005)	(0.305)	(1.162)	(0.239)
ILLIQUID	-0.238***	-0.011	-0.177**	0.142***	0.765***
	(-3.190)	(-0.130)	(-2.449)	(2.648)	(19.044)
SYSVOL				0.362***	
				(27.267)	
Constant	1.415***	-1.334***	1.303***	1.304***	0.883***
	(14.230)	(-9.792)	(14.853)	(21.715)	(40.173)
Year Effects	Y	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y	Y
Observations	31,837	31,829	31, 837	31, 837	31, 837
Adjusted R-squared	0.575	0.456	0.580	0.716	0.580

4.7 Conclusion

We investigate the relation between firms' reliance on skilled labour and idiosyncratic risk, and whether it is moderated by the presence of employee ownership. The contribution of this study is twofold. First, prior research explaining variation in idiosyncratic risk has given little attention to firms' labour force attributes. We focus on skilled labour intensity as one such attribute, and hypothesise that idiosyncratic risk is higher for skill-intensive firms. Second, research on the consequences of employee ownership has mainly considered productivity and other accounting- and market-based performance metrics. In this study, we explore a risk management role of employee ownership in which it affects cash flow uncertainty of high-skilled firms, as perceived by shareholders. Specifically, we hypothesise that the presence of employee ownership reduces idiosyncratic risk associated with firms' reliance on skilled labour.

For the empirical analysis, we construct a large panel of U.S. public firms between 1990 and 2014. Consistent with both of our hypotheses, we find that: First, idiosyncratic risk increases with the degree to which firms rely on skilled labour, represented by a labour skill index. Second, the positive relation is moderated by the presence of employee ownership through DC plans. Both findings hold after controlling for factors known to predict idiosyncratic risk, and are robust to endogeneity concerns. Subsample tests reveal that our results display cross-sectional and time-series variation. With respect to labour skill index, its point estimate is larger for small firms, and for the period from the mid-1990s to the mid-2000s. The significance level of its coefficient is otherwise fairly consistent. The negative coefficient on the interaction term, on the other hand, appears less stable: it is significant primarily for large firms, and for the post-2000 period. This weakens support for our second hypothesis, but nonetheless makes economic sense. Specifically, it is possible that the role of employee ownership in reducing skilled labour risk was amplified after the 2000 tech bust. The greater monitoring difficulty in large firms may also increase the perceived usefulness of employee ownership, despite potential free-rider problems.

In knowledge economies like the U.S. where intellectual capital increasingly takes precedence over other traditional forms of capital, investment in skilled labour is often a strategic decision taken to create growth opportunities while capturing existing ones. We argue that, besides a potential source of competitive advantage, investment in skilled labour constitutes a source of fundamentals uncertainty which exacerbates idiosyncratic risk. Our results support this. Moreover, we identify a signalling role of employee ownership where its presence alleviates investor uncertainty about skilled labour. This suggests a less obvious benefit of employee ownership as a risk management instrument, especially for knowledge-intensive firms.

5 Skilled Labour and the Level of Employee Ownership

5.1 Introduction

Employee ownership has become an important part of the economic landscape in the U.S. According to the 2014 General Social Survey (GSS)[113], an estimated 22.9 million employees, or 19.5 percent of the U.S. private sector workforce own stock in their firm. For publicly-held firms, the corresponding figure is 34.9 percent.

Two major trends underlie the prevalence of employee ownership. One is the continuous growth in employees' financial participation in capitalist enterprises, where their compensation or wealth is tied to firm performance through arrangements such as ownership plans. This trend, in turn, reflects the concept of "shared capitalism" (e.g. Gates (1998), Kruse et al. (2010)) which has gained momentum due to its political appeal (Economist (2015)). The other trend is the transformation of corporate-sponsored retirement plans from defined benefit (DB) plans to defined contribution (DC) plans, which began in the early 1980s (Cobb (2015)). This long-term shift has blurred the distinction between plans designed to provide pension benefits and plans designed to promote employee ownership (Mitchell and Utkus (2004)). The latest estimate of the National Center of Employee Ownership (NCEO) shows that as of 2014[114], there were 6,717 DC plans intended as an employee ownership vehicle[115]. A total of 14.1 million employees participated in these plans, together holding assets worth $1.31 trillion. Although a fraction of these plans (roughly 8.5%) are sponsored by publicly-held firms, they account for nearly 80 percent of total participants and 83 percent of total assets.

Investing DC plan assets in the stock of a single firm is inherently risky, as it raises the volatility of employee retirement wealth, thus harming retirement safety. The under-diversification risk is exacerbated by the correlation between the value of employees' human capital and firm stock performance (Poterba (2003)). The financial and welfare costs of

[113] See https://www.nceo.org/articles/widespread-employee-ownership-us (Accessed 27 February 2017)

[114] See http://www.nceo.org/articles/esops-by-the-numbers

[115] These include Employee Stock Ownership Plans (ESOPs) and KSOPS, plans that combine ESOPs and 401(k) features.

holding firm stock in DC plans are highlighted by academic papers (e.g. Poterba (2003), Ramaswamy (2004), Meulbroek (2005), and Cohen (2009)), and major corporate bankruptcies such as Enron, Lehman Brothers, and more recently, Radioshack (Lieber (2015)). Moreover, by allowing DC investments in own stock, sponsor firms may incur higher risk of litigation due to fiduciary breach (DiCarlo (2006))[116] as well as extra filing requirements (e.g. Form 11-K) (Huberman and Sengmueller (2004)).

Given the many downsides, why do firms still encourage employee ownership in DC plans, by making discretionary stock contributions or directing matching contributions (in the case of 401(k) plans) to be invested in own stock? Previous literature has explored a number of rationales, which can be roughly divided into two groups: those related to improving employee incentives, and those unrelated.

This chapter falls into the first group, addressing the following question: does firms' reliance on skilled labour affect employee stockholding in DC plans? The answer is important for several reasons. First, it sheds light on whether (and how) firms' labour force characteristics affect their provision of stock-based compensation. Second, it contributes to understanding the pattern of employee ownership in a knowledge economy, where intellectual capital is essential to achieving competitive advantage. Finally, it guides policy decisions about curbing undue stockholding in retirement portfolios. Whilst the Pension Protection Act of 2006 has facilitated DC plan diversification, it is deemed ineffective in reducing the overall exposure to firm stock in DC plans, due to limited restrictions on firms (e.g. Choi et al. (2009), Park (2017)).

We test two competing hypotheses regarding the link between firms' reliance on skilled labour and employee stockholding. The first posits a positive linear relationship, by drawing on the governance theory which views stock ownership as an employee governance device. Specifically, by mitigating contractual hazards and agency conflicts, employee ownership facilitates and protects investments in specific human capital (Blair (1995, 1999)). Recent empirical studies support this argument, by modelling valuable human capital in terms of firm-level training coverage (Robinson and Zhang (2005), Guery and Pendleton (2014)) or patent stocks (Wang et al. (2009)). We depart from them, by focusing on ex ante skill heterogeneity across firms, rather than ex-post human capital investment. Specifically, we expect skill-intensive firms to have greater employee ownership, given their propensity and need to develop strategically valuable human capital.

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116 See also Palumbo et al. (2014)

The second hypothesis predicts a nonlinear relationship in which an otherwise positive relationship, as stated in the first hypothesis, is reversed for the most skilled firms. The downward slope of the resulting inverted-U curve arises from the concern that excessive stockholding may discourage risk-taking. This argument was initially developed with respect to executives (e.g. Stulz (1984), Smith and Stulz (1985)), and later applied to non-executives (e.g. Bova, Kolev, Thomas, and Zhang (2015)). To the extent that ordinary employees in skill-intensive firms have an influence over strategic as well as operational risk, and that the growth of these firms depends on risky investments (e.g. innovation), increased risk-aversion will be undesirable. Also, the personal attributes and mobility of skilled workers may cause indifference towards owning firm shares, especially through retirement plans that penalise early departure. Recognising this, skill-intensive firms may substitute other forms of compensation for firm stock in DC plans.

Using a sample of 4,839 public firms from 1990-2014, we find evidence of an inverted U-shaped relationship between firms' reliance on skilled labour, represented by a labour skill index, and the level of employee ownership, represented by the per-employee value of firm stock in DC plans. Portfolio test shows that employee stockholding increases across the first four skill quintiles, and decreases between the last two. Multivariate regressions support the portfolio sorts. To address the substantial fraction of observations with zero employee ownership, we implement Heckman's (1976) two-step method. By separately modelling the incidence (first-step) and level (second-step) of employee ownership[117], the method improves on the commonly used Tobit and OLS which conflate the two decision mechanisms. The second-step Heckman estimates reveal a negative and significant effect of the squared labour skill index, which indicates an inverted U-shaped relationship. The results hold after controlling for various factors related to *both* the firm and employees. To ensure that the results are not sensitive to model specification, we adopt two approaches: First, we rerun the quadratic regression based on Tobit and OLS, following previous studies. Second, we estimate piecewise regressions using Heckman's, Tobit, and OLS models. The inverted U-shaped relationship remains significant in all specifications, with the inflection point occurring at the higher end of the skill spectrum.

We perform four robustness tests. First, we rerun the main regression using employee ownership data from non-participant directed DC plans only, where the plan trustee makes all the investment decisions. This removes the potentially confounding effects of employee

[117] The second-step estimates are the most relevant to this chapter. Nevertheless, in the results section, we also comment on the first-step estimates which show a slightly different pattern.

incentives. The inverted U-shaped relationship is strengthened as a result: increases (decreases) in employee ownership become more pronounced for less-skilled (highly skilled) firms, as they invest further in skilled labour.

Second, we examine the cross-sectional variation of the main effect, by interacting labour skill index with retention proxies in the regression. The results show that highly skilled firms are less concerned about increasing employee ownership when retention needs are high – specifically, when labour competition in their industry is strong, when they have a large stock of organization capital, and when they employ a high share of contingent labour.

Third, to reduce measurement error of employee ownership, we expand its estimation to include the Black-Scholes value of outstanding employee options (based on Compustat data from 2004-2014). Given that the convex payoffs of stock options induce risk-taking, highly skilled firms may substitute options for stock to a degree, thereby reducing the downward slope of the inverted-U curve. The results confirm this.

Finally, to verify that our results are robust to measurement error in the labour skill index, we substitute three alternative proxies (a simplified labour skill index, percentage of college-educated workers, and selling, general, and administrative expenses per employee) in the baseline regression. The results continue to support our conclusion.

The rest of this chapter proceeds as follows. Section 5.2 provides the institutional background. Section 5.3 discusses employee ownership in DC plans. Section 5.4 develops research hypotheses. Section 5.4 describes data and sample selection. Section 5.5 presents the main results. Section 5.6 describes additional tests. Section 5.7 concludes.

5.2 Institutional Background

In the U.S., corporate-sponsored retirement plans are a major source of retirement income for most employees. Over the last three decades, these private retirement arrangements have undergone a significant shift, from once dominant DB plans which promise a fixed retirement income to DC plans (e.g. Scholes et al. (2002), Munnell and Soto (2007), and Cobb (2015))[118]. In DC plans, employees as well as the firm make regular pre-tax contributions to an individual account set up for each plan participant. These are allocated amongst a menu of investment options, selected by the firm or its appointed plan trustee. Employees' retirement wealth accumulation is thus a function of total contributions and investment performance. Whilst the plan trustee is normally responsible for the investment of plan assets, it has become increasingly common for employees to determine how their account balances are allocated (Papke (2003)).

All U.S. private-sector retirement plans are governed by the Employee Retirement Income Security Act of 1974, or ERISA. The law establishes three fiduciary principles regarding the investment of retirement assets: The plan fiduciaries are obliged to manage the plan exclusively for the benefit of the participants and beneficiaries ("exclusive purpose" rule); to act with the "care, skill, prudence, and diligence" of a prudent person acting in a like capacity ("prudent man" rule); and to diversify plan investments to minimise the risk of large losses ("diversification" rule) (ERISA §404(c)). Notably, DC plans that allow investment in firm stock are exempt from the diversification requirements otherwise imposed on DB plans – which include a 10 percent limit of plan assets invested in employer stock (ERISA §407(b)(1))[119]. Furthermore, in participant-directed DC plans where participants can make their own asset allocation decisions, the firm is generally relieved of fiduciary responsibility for any investment losses (i.e. "safe harbour" provision)[120].

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[118] DC plans have also contributed significantly to the financial market. According to Sialm (2015, p.805), between 1995 and 2013, the value of assets held in DC plans increased from $1.7 trillion to $5.9 trillion. As of 2013, DC plans accounted for 23 percent of total mutual fund assets, and 27 percent of equity fund assets in the U.S (Investment Company Institute (2014), as cited in Sialm (2015, p.805)).

[119] This is because, as Mitchell and Utkus (2004) explain, at the time of the passage of ERISA, DB plans were the primary retirement income vehicle, while DC plans were often supplemental plans used to provide variable contributions or to encourage employee ownership. Lobbying by large and successful employers with DC plans investing in own stock also played an important role (Benartz et al. (2007)).

[120] For a firm to be exempted from the fiduciary duties, the DC plan must also offer a minimum of three diversified investment options, with each having "materially different risk and return characteristics" (ERISA §404(c)). See also the Internal Revenue Service (IRS) website: https://www.irs.gov/retirement-plans/plan-participant-employee/retirement-topics-participant-directed-accounts (Accessed 28 February 2017).

Most DC plans are "qualified plans" which adhere to the rules established under Section 401(a) of the Internal Revenue Code (IRC), as well as ERISA. The compliance with IRC §401(a) unlocks several tax advantages. These include tax deductibility of contributions made by the firm; deferral of taxes on employee contributions and investment gains until distribution; and favourable tax treatment of distributions. Amongst the most widely used tax-qualified DC plans are: profit-sharing plans, stock bonus plans, cash or deferred arrangements (also known as 401(k) plans), Employee Stock Ownership Plans (ESOPs), and money purchase pension plans. These are outlined below.

In a profit-sharing plan, the firm makes discretionary contributions to the plan trust, which should be "recurrent and substantial". These are allocated to individual participant accounts based on a "definite predetermined formula" which must be equitable to all employees. A stock bonus plan resembles a profit-sharing plan, except that firm contributions are delivered in the form of stock.

In a 401(k) plan, employees are allowed to have the firm transfer part of their regular compensation, i.e. as an "elective contribution", to their individual accounts[121]. The firm usually commits to making a matching contribution, either in cash or stock. Contributions to 401(k) plans are subject to certain limits intended to prevent discrimination in favour of highly compensated employees. Rather than stand-alone plans, many 401(k) plans are "combination" plans which mix 401(k) features with a profit-sharing plan or stock bonus plan (Mitchell and Utkus (2004)).

An ESOP is a stock bonus plan which can borrow money and is designed to invest primarily in employer stock. This usually means that the plan must hold at least 50 percent of its assets in employer stock (Scholes and Wolfson (1990))[122]. Similar to the 401(k) plan, ESOP may be set up as an entire plan or as a component of other DC plan[123].

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121 Huberman and Sengmueller (2004) estimate that in 1997, 70 percent of new 401(k) contribution originated from employees' deferred compensation.

122 While profit-sharing plans, stock bonus plans, and ESOPs all share the same rules regarding eligibility, allocation, and vesting, they differ in several important aspects. Besides its ability to raise debt to purchase employer stock, ESOP is qualified for additional tax benefits (see Subsection 5.3.1). However, ESOPs are often subject to more restrictive rules on distribution, asset valuation, diversification, and required holdings of employer stock – see the NCEO website (https://www.nceo.org/articles/esops-profit-sharing-stock-bonus-plans) (Accessed 28 February 2017).

123 For instance, an increasing number of public companies have adopted 401(k) plans with an embedded ESOP structure, also known as "KSOP", whereby employees are allowed to invest part or all of their salary deferrals in employer stock.

In a money purchase pension plan, the firm is required to make annual contributions based on a fixed percentage of employee compensation. As with DB plans, money purchase plans are subject to the statutory 10 percent cap on investment in own stock.

Originally, DC plans were not intended as a retirement income vehicle designed to maximise retirement security (see footnote above). Rather, they were often implemented to promote financial participation by rank-and-file employees, especially in the form of stock ownership[124]. Moreover, although ESOPs used to be the main channel through which firms provide employee ownership, the majority of new employee ownership since the 1990s has occurred through 401(k) plans and their combination with other DC plans (e.g. KSOPs). These allow employees to direct their voluntary contributions and, in most cases, the firm's matching contributions to be invested in firm stock. This trend has contributed to blurring the distinction between plans designed to provide retirement security and those designed to foster employee ownership (Mitchell and Utkus (2004)).

[124] Perhaps as a consequence, stand-alone ESOPs impose relatively strict diversification rules: in public companies, phased diversification from employer stock is only allowed for employees who have reached 55 years of age, and participated in the plan for at least ten years (Tax Reform Act of 1986). By contrast, there is generally no diversification restriction in profit-sharing and stock-bonus plans, facilitated by the Pension Protection Act of 2006 (see Engelhardt (2011)). However, plan sponsors retain the option to impose a precondition of three years' service before participants can diversify from employer stock linked to employer contributions.

5.3 Employee Ownership in Defined Contribution Plans

An extensive literature spanning multiple disciplines has explored motives behind broad-based employee ownership (BBEO), which refers to the holding of a firm's stock or options by non-executives as well as executives. Most of the times, the extent of BBEO is determined by the incentives of the firm. However, with respect to BBEO through retirement plans, the incentives of employees also matter. This is because most DC plans now allow participants to direct their own investments, and to diversify out of firm stock associated with firm contributions. The strength of employee influence is nevertheless ambiguous, given that employees rarely rebalance their portfolio and trade infrequently – due to inertia and status quo bias (e.g. Choi et al. (2001), Madrian and Shea (2001), and Huberman and Sengmueller (2004)). Moreover, prior research has found that employees' investment choices are affected by retirement plan design (e.g. Benartzi (2001), Benartzi and Thaler (2001), Choi et al. (2001), Liang and Weisbenner (2002), Choi et al. (2004), Huberman and Jiang (2006), and Cohen (2009)). This suggests that the otherwise independent decision-making by employees may still be subject to firm influence.

This section provides a detailed discussion of motivations for BBEO, particularly through DC plans, with respect to both the firm (Subsection 5.3.1) and employees (Subsection 5.3.2).

5.3.1 Firm Incentives

The BBEO literature has developed in parallel with the managerial ownership literature which focuses on company executives. The analysis of both types of employee ownership is traditionally rooted in agency theory (Jensen and Meckling (1976)) which describes a conflict of interests between principal and agent, exacerbated by information asymmetry. Employee stock ownership contributes to interest-alignment between employees (agent) and shareholders (principal), by linking employee compensation to firm performance (Jensen and Murphy (1990), Mehran (1995)). Given that not only executives, but rank-and-file employees may pursue objectives which deviate from enhancing shareholder wealth, BBEO serves to provide incentives across a firm's hierarchical levels, and not limited to top managers. In addition, BBEO reduces the need for direct monitoring, by encouraging cooperation and peer pressure within the firm (e.g. Kandel and Lazear (1992), Hochberg and Lindsey (2010)). In previous surveys, potential gains in employee morale and productivity were cited by employers as a main reason for encouraging DC plan investment in own stock (General Accounting Office (1986), Benartzi et al. (2007)).

However, the effectiveness of BBEO in providing incentives may be undermined by the free-rider problem, which concerns the limited influence of rank-and-file employees on stock price, and a dilution of their share of gains as the firm grows larger (e.g. Hall and Murphy (2003)); and the related "line-of-sight" problem, which concerns a disconnect between the efforts of rank-and-file employees and the receipt of additional rewards (e.g. Jones et al. (2010)). Moreover, since employees are typically risk-averse and under-diversified, the incentives provided by BBEO may be too weak to justify transferring extra firm risk onto employees (e.g. Oyer (2004)). Empirical verification of BBEO's incentive effect has been problematic due to unobserved risk preference and marginal return to effort of employees (Oyer and Schaefer (2005)). There are also confounding factors such as uncertainty within the firm (Prendergast (2002)) and monitoring costs (e.g. Core and Guay (2001), Kroumova and Sesil (2006)). Although prior research has found an overall positive effect of BBEO schemes on employee productivity (Kruse (2002)), it is not always clear-cut and may be moderated by firm size (Blasi et al. (1996), Kim and Ouimet (2014)), or employee involvement (Pendleton and Robinson (2010)).

Due to the inconclusive debate, researchers have considered alternative motivations for BBEO which depart from the traditional agency model. These are outlined below:

First, Pendleton (2006) suggests that, rather than serve as an incentive instrument per se, BBEO complements other single high-powered incentives. Specifically, by fostering trust and cooperative attitudes, BBEO helps mitigate the adverse consequences of individual incentives such as short-termism, goal displacement, and intra-firm rivalry.

Second, the sorting theory suggests that BBEO may be used to attract optimistic and risk-tolerant employees, who tend to value employer stock or options more highly (Hall and Murphy (2003), Lazear (2003))[125].

Third, the vesting and distribution requirements of most BBEO schemes contribute to employee retention, an objective further achieved as BBEO indexes employee compensation to outside opportunities (Oyer (2004))[126]. Similarly, Garrett (2010) argues that

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125 The sorting argument has been used to explain the mixed evidence regarding the effect of financial constraints on broad-based option grants (see discussion later in the text).

126 The wage indexation theory has received support from recent empirical studies (e.g. Kedia and Rajgopal (2009), Bova, Kolev, Thomas, and Zhang (2015)).

BBEO encourages development of corporate entrepreneurship, which substitutes for entrepreneurial ventures employees would otherwise pursue outside the firm.

Fourth, BBEO is viewed as an employee governance mechanism. Specifically, by mitigating the hold-up problem associated with incomplete contract and asset specialisation, BBEO fosters investments in firm-specific human capital (see Chapter 4, Subsection 4.2.3 for additional detail). These may occur through participation in training (Robinson and Zhang (2005), Guery and Pendleton (2014)), or development of necessary skills to absorb and apply proprietary knowledge (Wang et al. (2009))[127].

The literature has identified three additional reasons for firms' provision of BBEO, which do not concern employees. As outlined shortly, these include advantageous tax treatment, cash conservation, and corporate control motives.

The passage of the Tax Reform Act of 1986 allows ESOP sponsors to deduct any dividends passed through to plan participants, or used to repay an ESOP loan (in the case of leveraged ESOP) (Scholes and Wolfson (1990), Beatty (1995))[128]. The Growth and Taxpayer Relief Reconciliation Act of 2001 further makes dividends which are voluntarily reinvested in ESOP by participants tax-deductible (Mitchel and Utkus (2004)). Therefore, dividend-paying firms may deduct both the dividends paid on ESOP shares and the value of these shares from their initial contributions, i.e. a "double dip" (Brown et al. (2006))[129]. Although the tax break associated with deductible dividends was originally intended for ESOPs, it has benefited many sponsors of traditional 401(k) plans which can be readily converted into a KSOP (Mitchell and Utkus (2004)). The value of tax savings, in turn, depends on the firm's marginal tax rate (Rauh (2006)) and dividend yield (Benartzi et al. (2007)). In the survey of Benartzi et al. (2007), tax savings are ranked by employers as the second most important factor – after employee motivation – in their decision to contribute stock to DC plans.

[127] Section 5.4 describes these studies in more detail.

[128] Prior to 1996, sponsors of a leveraged ESOP enjoyed another source of tax savings, associated with the interest exclusion for ESOP loans. Specifically, lending institutions were allowed to deduct up to half of the interests paid on an ESOP loan (IRC §133), which provide tax arbitrage opportunities for the plan sponsors when they repurchase shares for the plan. However, Scholes and Wolfson (1990) suggest that the present value of this benefit is likely to be insignificant.

[129] Note, however, that the deductibility of ESOP contributions does not provide any incremental benefit, since cash-based compensation is also deductible from taxable income.

For financially constrained firms, contributing stock to DC plans may help conserve cash (e.g. Ward (2001), Hawthorne (2002))[130]. There are at least two caveats, however. First, whilst an immediate cash outlay is avoided by making contributions from new shares, for firms that repurchase shares and transfer them to the plan, cash is still spent (Benartzi (2001), Benartzi et al. (2007)). Second, any cost savings must be weighed against other costs, e.g. the dilution of existing shareholder interests (Mitchell and Utkus (2004)) and reduced diversification of employees' retirement portfolio. Furthermore, contributing stock in lieu of cash implies using employees as an inexpensive source of financing[131], similar to the use of stock options (Ittner et al. (2003), Oyer and Schaefer (2005)). For the cost advantage to hold, employees will therefore need to be highly optimistic for them not to demand a risk premium (Rauh (2006), Bergman and Jenter (2007)).

Finally, management entrenchment hypothesis posits that incumbent managers may increase BBEO, thus placing stock in "friendly hands". Combined with the ownership stakes of managers and affiliated blockholders, this could significantly reduce the possibility of a hostile takeover. The managerial control motives are aided by two factors. First, the voting rights on stock held in most DC plans (except ESOPs) are not required to be passed through to participants, meaning they are delegated to the plan trustee. Since plan trustees are appointed by the firm, they are likely to vote in support of management (Park (2017)). Second, even when employees are allowed to direct the voting of allocated shares[132], they may still side with the managers, given their primary concerns about job security and fixed wage claims (Faleye et al. (2006)). This leads to a labour-management alliance (Pagano and Volpin (2005)). A number of studies have identified takeover defence as an important rationale behind BBEO, especially through ESOPs[133]. Note, however, that the above argument is potentially weakened due to a typically small share of firm's market value held by employees (Benartzi et al. (2007))[134].

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130 As Brown et al. (2006) note, contributing in own stock could also save administrative fees which are typically higher for other investment options.

131 This may appeal to cash-strapped firms which also have limited access to external capital due to information asymmetry – which is likely to be lower within firms.

132 Most plan documents require the plan trustee to vote and tender unallocated shares in the same proportion as the allocated shares are voted and tender by employees (Chaplinsky and Niehaus (1994)).

133 See, e.g. Scholes and Wolfson (1990), Gordon and Pound (1990), Shivdasani (1993), Beatty (1994), and Chaplinsky and Niehaus (1994). A more recent study by Rauh (2006) focuses on DC plans in general.

134 Bova, Dou, and Hope (2015, p.664) suggest that there has been no incidence of ESOP being used to fight a takeover battle since the late 1990s.

5.3.2 Employee Incentives

Prior research suggests that it is advantageous for employees to invest in a diversified equity fund. This is because aggregate returns are often uncorrelated with occupational incomes, thus augmenting them (e.g. Davis and Willen (2000), Baxter (2001)). Holding significant firm stock in DC plans deprives employees of the diversification benefits, and exposes retirement wealth to idiosyncratic risk. Moreover, due to a positive correlation between employees' human capital and the firm's prospects (Poterba (2003), Berk et al. (2010)), employees risk losing their job and a large part of retirement income if the firm goes bankrupt. These disadvantages, however, have not deterred employees from investing in firm stock. Besides a common unawareness of under-diversification risk, revealed by prior surveys (e.g. Benartzi (2001), John Hancock Financial Services (2001), Vanguard Group (2001), and Benartzi et al. (2007)), several factors could play a role.

First, as with the firm, employees enjoy certain tax benefits of holding firm stock in DC plans. In particular, only the cost basis of firm stock is subject to ordinary income tax upon distribution. The net unrealised appreciation is taxed at the preferential capital gains rate, which is usually lower[135]. All other plan assets are excluded from this advantage, thus taxed at the ordinary income rates (Brown et al. (2006)). However, due to its obscure nature, how much of the aforementioned tax benefit is factored in employees' initial allocation decisions is unclear (Mitchell and Utkus (2004), Benartzi et al. (2007)).

Second, employees may invest more in firm stock if they possess insider knowledge that allows them to earn excess returns. This information hypothesis, however, has been questioned on several grounds[136]. First, the level of superior information required to justify forgoing diversification benefits, and the capacity to determine which information has already been priced, may be beyond regular employees. Second, any insider advantage enjoyed by employees is unlikely to persist. This is because employee investment in firm stock is disclosed annually through 11-K, which the firm files with the Securities and Exchange Commission (SEC). Third, prior research has found no evidence that employee investment in firm stock positively affects subsequent stock returns.

Third, employees may prefer firm stock for behavioural/psychological reasons. For instance, Klein (1987) finds that extrinsic and instrumental satisfaction positively affects employee attitude at ESOP-sponsoring firms. Using British data, Pendleton et al. (1998)

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[135] See Chapter 4, Subsection 4.5.1 for additional detail

[136] See, e.g. Benartzi (2001), Huberman and Sengmueller (2004), and Cohen (2009)

find that share ownership generates intrinsic and instrumental satisfaction. Familiarity with the firm may also matter. Huberman (2001) suggests that employees are subject to geographical bias – that is, physical proximity to the firm affects their perceived information and thus inclination to hold firm stock. Considering the influence of loyalty, Cohen (2009) shows that employees in stand-alone or concentrated firms (assumed to be more loyal) direct more 401(k) contributions to firm stock than those in diversified firms (assumed to be less loyal). Excessive extrapolation is another possible explanation. Specifically, high past returns may induce employees to purchase more firm stock, in anticipation that the high returns will persist into the future (Benartzi (2001), Huberman and Sengmueller (2004))[137]. Yet another research examines DC plan design and features, and how they sway employees in their investment choices[138]. For example, where the firm directs matching contributions to its own stock, employees may perceive it as an implicit endorsement, thus increasing their allocations to firm stock. Finally, the personal attributes of employees (e.g. age, gender, education, income, and tenure) may also affect their investment decisions (e.g. Lee et al. (2008), Utkus and Young (2014)).

[137] As Huberman and Sengmueller (2004) also note, employees react asymmetrically to past stock performance: relative to some historical benchmark, while high current prices induce investment in firm stock, low current prices do not cause a reversal of these investments. The authors attribute this to employees' passivity and tendency to maintain a status quo.

[138] See, e.g. Benartzi (2001), Benartzi and Thaler (2001), Choi et al. (2001), Liang and Weisbenner (2002), Choi et al. (2004), Huberman and Jiang (2006), and Cohen (2009)

5.4 Hypothesis Development

The alternative lines of research described in Subsection 5.3.1, which relate BBEO to the firm's need to attract, motivate and retain employees, all imply a positive link between the importance of human capital and BBEO. We consider a setting in which this relationship can be empirically tested, namely firms' reliance on skilled labour. The governance view of BBEO, which provides a useful basis for integrating different perspectives on BBEO, serves as our theoretical framework.

As previously explained, BBEO facilitates and safeguards investments in specific human capital, by addressing contractual hazards in the transaction cost economics. The resource-based literature has emphasised firm-specific human capital as a source of competitive advantage (e.g. Hatch and Dyer (2004), Kor and Leblebici (2005), and Wang et al. (2009)). Thus, BBEO aligns the interests of employees and shareholders in its role as a governance mechanism. Moreover, by creating peer pressure and group optimisation, BBEO addresses the problem of information asymmetry and fosters collective human capital. The retention effect of BBEO may also be incorporated as part of its governance function. Specifically, by engendering long-term commitment and notions of equity, BBEO contributes to the sustainability of human capital-based competitive advantage.

Closest to this chapter are recent empirical studies that verify the governance implications of BBEO, by associating it with firm-level demand for valuable human capital. Wang et al. (2009) calculate the share of patent self-citations as proxy for firm-specific knowledge, and thus the need for complementary human capital that is equally idiosyncratic. It is shown to increase the level of BBEO, based on a panel of U.S. manufacturing firms. Robinson and Zhang (2005) and Pendleton and Robinson (2011) utilise cross-sectional survey data on British workplaces, and show that employer-sponsored training positively correlates with the presence of share ownership plan. Guery and Pendleton (2014) obtain similar results using French data.

Prior research typically links the importance of human capital to its degree of firm specificity, arising from the acquisition of idiosyncratic knowledge and skills. In this chapter, we shift the focus to the attributes of employees' underlying human capital, particularly their skill level. Here we define skilled labour as employees in occupations that require extensive *prior* human capital investments, including education and work-related experience. Thus, firms' reliance on skilled labour refers to the relative emphasis on high-skilled occupations in their production process[139].

Our focus on skilled labour is motivated by the knowledge economy which now characterises most developed nations, and which places great emphasis on intellectual capabilities embodied in skilled workers. By implication, individual firms in the knowledge economy also face increasing pressure to upskill their labour force in order to compete more effectively[140]. The expectation, as well as the urgency, to develop strategic human capital is likely to be particularly pronounced for skill-intensive firms. Hence a greater need for employee governance mechanisms in these firms. BBEO serves this end.

The characteristics of skill-intensive employment amplify the usefulness of BBEO. First, information asymmetry related to human capital is exacerbated for skilled workers, due to the cognitive and social complexity of their jobs. This increases the likelihood of rent appropriation by skilled workers, who can leverage their information advantage (cf. Toms (2010b)). Hence the need to align their incentives more closely. Second, as skilled workers frequently collaborate in long-term intellectual projects such as innovation (Holmstrom (1989), Dougherty (2006)), retention and trust-building will be particularly relevant to value creation. Third, organisational reforms such as decentralised decision-making and flat hierarchy tend to be adopted to accommodate skilled workers[141]. Thus, there is a closer link between the individual efforts of non-executive employees and firm performance, which increases the effectiveness of outcome-based incentives.

Ex ante, it is difficult to determine which of the firm's incentives to attract, motivate, and retain employees dominates in generating cross-sectional variation in BBEO. Moreover, modelling specific incentives is empirically challenging, and any proxies based on financial data are open to interpretations unrelated to labour. As described above, conceptualising BBEO as an employee governance mechanism removes the need to discriminate between incentives. In this chapter, we consider a key feature of firms' workforce, namely their reliance on skilled labour. We argue that the potential and pressure

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139 Both Robinson and Zhang (2005) and Guery and Pendleton (2014) include a skill variable ("skills acquisitions") as well as training (i.e. the main test variable) in the regression. It represents the survey respondent's estimate of the time required for a new hire to become as productive as her experienced peer. As the skill variable estimates human capital acquired after recruitment, it is comparable to training. However, we acknowledge that it potentially overlaps with our definition of labour skill. This is because skilled workers are typically more difficult to replace (see discussion later in the text).

140 See Chapter 2 for a detailed discussion of knowledge economy, and the implications of skilled labour both for the wider economy and for individual firms.

141 See Chapter 2, Subsection 2.2.2 for additional detail and references.

to develop strategic human capital increases with the degree to which firms rely on skilled labour. This leads to a higher level of BBEO. Hence our fist hypothesis:

Hypothesis 5.1: There is a positive relationship between firms' reliance on skilled labour and the level of broad-based employee ownership.

The literature on the determinants of BBEO has generally predicted and tested for linear relationships. Departing from this assumption, reflected in our first hypothesis, we consider the possibility that labour skill may have a nonlinear effect on BBEO. Specifically, we explore the scenario in which excessive BBEO creates disincentives to take risk. This reduces the firm's growth potential, especially for skill-intensive firms. The implication is an inverted U-shaped relationship, where the increasing trend of BBEO is tempered or even reversed for firms at the higher end of skill spectrum. As outlined below, two factors may contribute to this pattern.

The first factor is related to employees' risk preferences. Extant research shows that, due to a concave utility function associated with risk aversion, executives with a high proportion of wealth tied to firm stock are motivated to reduce stock price volatility, thus maximising their expected income (Stulz (1984), Smith and Stulz (1985))[142]. This implies a negative relation between executive stock ownership and risk-taking incentives. Bova, Kolev, Thomas, and Zhang (2015) argue that the relation can be extended to non-executives who are sensitive to corporate risk and are, too, in a position to influence it. Specifically, Bova, Kolev, Thomas, and Zhang (2015, p. 121) distinguish two types of corporate risk: strategic investment risk and operational risk. Executives mainly influence the former, by determining particular investments; non-executives mainly influence the latter, by implementing and executing the decisions of executives. Whilst it is generally desirable to reduce operational risk, avoiding taking strategic risk could leave shareholders worse off in the long term.

Increases in BBEO are likely to affect mainly operational risk, by eliciting greater commitments from non-executives. However, where non-executives can influence strategic decisions, besides just enacting them, this may cause the firm to deviate from value maximisation. This is because risk-increasing projects are passed up despite their positive net present value (cf. Smith and Stulz (1985)). The situation is exacerbated for firms in which employees have a significant voice in corporate governance (Faleye et al. (2006)), or

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142 See May (1984) and Tufano (1985) for related empirical evidence.

firms in which employees are regularly consulted on decisions that affect them. The latter correspond to skill-intensive firms, characterised by a flat organisational structure and worker autonomy. As these firms often derive most of their value from risky investments (e.g. innovation), they are particularly vulnerable to undue risk aversion by employees. Therefore, we expect high-skilled firms to hold back on BBEO as they seek to deepen their knowledge base.

The second factor concerns employees' work preferences, which may affect their attitude towards stock ownership. Specifically, we expect skilled workers to be less amenable to owning large amounts of firm stock, thus being bound to a single firm for most of their career. As explained below, this is linked to their relatively young age and increased willingness (and opportunities) to undertake contingent work.

As skill-intensive firms often operate in high-tech and "new economy" industries[143], they are less established and have a workforce that is relatively young (Ouimet and Zarutskie (2014)). For young workers, cash wages are usually preferable to deferred stock compensation given the latter's illiquidity and the associated postponement of consumption (Scholes et al. (2002, p.215)). Moreover, young workers tend to switch employers relatively frequently, being at the early stage of their career (Topel and Ward (1992)). Literature has suggested a number of reasons for this "job shopping" behaviour: limited awareness of own abilities, preferences and working conditions (Johnson (1978)); shifting work-life priorities (Kossek and Ozeki (1998)); human and social capital accumulation (Feldman (2002)); low cognitive costs of learning (Kanfer and Ackermann (2004)); and a looser connection between personal identity and a single employer (Faw (2012)). Where significant stock ownership inhibits the mobility of young workers, it might generate disincentives which lead to reduced morale and productivity.

Over the past few decades, both supply- and demand-side factors have led to a wider use of contingent labour in skilled occupations, through contracting, outsourcing, and other employment services (Silverstone et al. (2015)). For skilled workers, contingent work offers potential rewards such as enhanced income, work autonomy, development of new skills, and flexibility (Kunda et al. (2002)). For skill-intensive firms, which compete in a turbulent business environment, employing contingent labour has strategic advantages such as flexibility, agility, and access to a wider range of talents (Harrison and Kelley (1993), Silverstone et al. (2015)). The upward trend in high-end contingent employment reflects an

143 Ittner et al. (2003, p.90) define new economy firms as firms that are part of the computer, software, internet, telecommunications, or networking industries.

emphasis on mobility by skilled workers, aided by an increased demand for their service and modern work arrangements. As with the age factor, this discounts BBEO's retention effect for skill-intensive firms. The latter may also perceive less need for BBEO, due to greater availability of skilled contingent labour[144].

The discussion above suggests that the positive relationship between skilled labour intensity and the level of BBEO, posited by Hypothesis 5.1, may be diminished or even reversed for skill-intensive firms. This is related to concerns that significant stockholdings may create perverse incentives for skilled workers. Hence our second research hypothesis:

Hypothesis 5.2: There is an inverted U-shaped relationship between firms' reliance on skilled labour and the level of broad-based employee ownership.

[144] However, a counterargument can be made that reliance on skilled contingent labour actually leads to high-skilled firms providing more BBEO. This is to pre-empt lower productivity and increased voluntary turnover of skilled regular (or core) employees – due to feelings of inequity (as their contingent peers might earn significantly more through compensating wage differentials), and a greater awareness of opportunities in the external labour market (through interaction with their contingent peers) (see David (2005)).

5.5 Data and Measures

This section details the data and key variables of this study. Subsection 5.5.1 outlines sample selection and distribution. Subsection 5.5.2 describes the estimation of the dependent variable, namely the level of employee ownership. Subsections 5.5.3 and 5.5.4 discuss the control variables. Subsection 5.5.5 presents descriptive statistics.

5.5.1 Sample

To construct the data sample for this chapter, we take the baseline sample (see Section 3.1) and apply additional selection criteria. Specifically, out of the baseline sample, we remove observations with missing values of employee ownership and control variables.

Table 5-1 details the sample selection process. The final sample comprises 37,192 firm-year observations during the period 1990-2014. These correspond to 4,839 unique firms across 192 three-digit SIC industries.

Table 5-1 Sample Selection

This table shows the construction of the data set for this chapter. Applying criteria 1-4 leads to the initial sample described in Table 3.1. From the initial sample, we exclude firms that cannot be matched with employee ownership data from Form 5500 filings. Sample observations with missing data requirements for control variables are also dropped. The selection process results in an unbalanced panel of 37,192 observations, corresponding to 4,839 firms across 192 three-digit SIC industries during 1990-2014.

Selection Criteria	Obs.	Firms	Industries
Firms with Compustat-CRSP data for fiscal years 1990-2014	114,548	12,961	272
After excluding:			
1. Financial firms	91,035	10,247	247
2. Utility firms	87,193	9,934	240
3. Observations with missing values of labour skill index	76,827	8,846	211
4. Observations with missing values of market equity, assets, sales, employees, book-to-market, and leverage	73,711	8,586	211
5. Observations with missing values of employee ownership	46,137	6,175	208
6. Observations with missing values of control variables	**37,192**	**4,839**	**192**

Table 5-2, Panel A presents the fiscal year distribution of the full sample, the subsample with zero employee ownership (24,244 observations), and the subsample with positive employee ownership (12,948 observations). Similar to the trend reported in previous literature, the number of firms with employee ownership in DC plans grew during the 1990s and peaked in the early 2000s (e.g. Rauh (2006), Bova, Dou, and Hope (2015), and Park (2017)). The subsequent decline might reflect the increased concern about holding firm stock in retirement plans, especially after the Enron bankruptcy.

Table 5-2, Panel B presents the industry distribution of the sample. While the sample is distributed across a range of industries, there is a relatively high concentration of firms in the following industries: Chemical and Allied Product (SIC 28), Industrial Machinery and Equipment (SIC 35), Electronic and Other Electric Equipment (SIC 36), Instruments and Related Products (SIC 38), and Business Services (SIC 73). They together account for 59.5 percent of the sample. It is also within these industries and Transportation Equipment (SIC 37) and Communications (SIC 48) – collectively referred to as high-technology industries in the literature (e.g. Carter and Lynch (2004), Loughran and Ritter (2004)) – that a majority of observations with positive employee ownership can be found.

The last finding indicates that firms in high-skilled industries are more likely to provide employee ownership. This is similar to the previous observation that broad-based stock options are widely used in new economy firms (Ittner et al. (2003), Oyer and Schaefer (2005)). On the other hand, note that the share of employee ownership firms in the aforementioned industries is relatively low, despite their large (absolute) number. This, along with the fact that two-digit SIC codes are still relatively broad, suggests that drawing any conclusion at this stage would be premature.

Table 5-2 Sample Distribution

This table shows the distribution of sample firms by fiscal year (Panel A) and two-digit SIC industry (Panel B). The final sample consists of 37,192 firm-year observations during the period 1990-2014.

Panel A. Fiscal year distribution of sample firms

Fiscal Year	Full Sample		Zero Employee Ownership		Positive Employee Ownership	
	Obs.	Percent	Obs.	Percent	Obs.	Percent
1990	704	1.89	517	1.39	187	0.50
1991	407	1.09	309	0.83	98	0.26
1992	891	2.40	584	1.57	307	0.83
1993	919	2.47	598	1.61	321	0.86
1994	966	2.60	647	1.74	319	0.86
1995	1,049	2.82	692	1.86	357	0.96
1996	1,130	3.04	756	2.03	374	1.01
1997	1,114	3.00	741	1.99	373	1.00
1998	1,145	3.08	771	2.07	374	1.01
1999	1,854	4.98	1,199	3.22	655	1.76
2000	2,132	5.73	1,345	3.62	787	2.12
2001	2,094	5.63	1,307	3.51	787	2.12
2002	2,058	5.53	1,295	3.48	763	2.05
2003	2,131	5.73	1,372	3.69	759	2.04
2004	2,064	5.55	1,340	3.60	724	1.95
2005	1,992	5.36	1,285	3.46	707	1.90
2006	1,869	5.03	1,209	3.25	660	1.77
2007	1,802	4.85	1,170	3.15	632	1.70
2008	1,740	4.68	1,152	3.10	588	1.58
2009	1,657	4.46	1,069	2.87	588	1.58
2010	1,580	4.25	1,014	2.73	566	1.52
2011	1,537	4.13	981	2.64	556	1.49
2012	1,487	4.00	959	2.58	528	1.42
2013	1,466	3.94	973	2.62	493	1.33
2014	1,404	3.78	959	2.58	445	1.20
Total	**37,192**	**100.00**	**24,244**	**65.19**	**12,948**	**34.81**

Panel B. Industry distribution of sample firms

2-digit SIC	Industry Name	Obs.	%	EO>0	%	2-digit SIC	Industry Name	Obs.	%	EO>0	%
10	Metal, Mining	96	0.26	33	0.09	39	Misc. Manufacturing	143	0.38	45	0.12
12	Coal Mining	67	0.18	29	0.08	40	Railroad Transportation	125	0.34	36	0.10
13	Oil & Gas Extraction	1,308	3.52	694	1.87	42	Trucking & Warehousing	453	1.22	202	0.54
14	Nonmetallic Minerals	67	0.18	29	0.08	44	Water Transportation	74	0.20	16	0.04
15	General Bldg Contractors	333	0.90	152	0.41	45	Transportation by Air	337	0.91	171	0.46
16	Heavy Construction	127	0.34	40	0.11	47	Transportation Srvc	169	0.45	58	0.16
17	Special Trade Contractors	55	0.15	15	0.04	48	Communications	823	2.21	337	0.91
20	Food & Kindred Products	959	2.58	349	0.94	50	Wholesale - Durable Goods	1,085	2.92	447	1.20
21	Tobacco Products	25	0.07	17	0.05	51	Wholesale - Nondurable Goods	467	1.26	150	0.40
22	Textile Mill Products	225	0.60	105	0.28	52	Bldg Materials & Gardening	86	0.23	48	0.13
23	Apparel & Other Textile	224	0.60	32	0.09	53	General Merchandise Stores	176	0.47	101	0.27
24	Lumber & Wood	153	0.41	62	0.17	54	Food Stores	348	0.94	195	0.52
25	Furniture & Fixtures	338	0.91	247	0.66	55	Automative Dealers & Srvc Stn	241	0.65	104	0.28
26	Paper & Allied	440	1.18	193	0.52	56	Apparel & Accessory Stores	599	1.61	203	0.55
27	Printing & Publishing	581	1.56	263	0.71	57	Furniture & Homefurnishings	243	0.65	136	0.37
28	Chemical & Allied	3,828	10.29	1,354	3.64	58	Eating & Drinking Places	825	2.22	269	0.72
29	Petroleum & Coal	213	0.57	128	0.34	59	Misc. Retail	707	1.90	282	0.76
30	Rubber & Misc Plastics	540	1.45	301	0.81	70	Hotels & Lodging Places	113	0.30	34	0.09
31	Leather & Leather	177	0.48	34	0.09	73	Business Srvc	5,393	14.50	1,267	3.41
32	Stone, Clay, & Glass	187	0.50	100	0.27	75	Auto Repair, Srvc & Parking	69	0.19	63	0.17
33	Primary Metal	589	1.58	290	0.78	78	Motion Pictures	144	0.39	26	0.07
34	Fabricated Metal	509	1.37	249	0.67	79	Amusement & Recreation Srvc	37	0.10	0	0.00
35	Industrial Machinery & Eqmt	3,182	8.56	1,015	2.73	80	Health Srvc	605	1.63	183	0.49
36	Electronic & Other Electric Eqmt	4,225	11.36	1,131	3.04	81	Legal Srvc	7	0.02	0	0.00
37	Transportation Eqmt	1,157	3.11	466	1.25	83	Social Srvc	9	0.02	1	0.00
38	Instruments & Related	3,511	9.44	950	2.55	87	Engineering & Mgmt Srvc	798	2.15	296	0.80
						Total		**37,192**	**100.00**	**12,948**	**34.81**

5.5.2 Dependent Variable: The Level of Employee Ownership

The dependent variable of this study is broad-based employee ownership through DC plans. Our source of DC plan information is the annual Form 5500 filings. Chapter 4, Subsection 4.3.3 provides a detailed account of the data collection process, and how we match the plan-level Form 5500 data to Compustat/CRSP.

While Chapter 4 considers employee ownership mainly in terms of its presence (i.e. a binary variable), this chapter focuses on its level (i.e. a continuous variable). We follow the procedure of Bova, Dou, and Hope (2015, pp.646-647) in estimating the level of employee ownership for individual firms. Specifically, after summing the market value of firm stock held across DC plans sponsored by a given firm in a given year, we divide the figure by total employees ("emp" in Compustat) to create a firm-specific measure of employee ownership (hereafter EO).

The per-capita measure of EO is useful in the context of this study, as it is directly related to employee welfare and is subject to managerial discretion. It is also consistent with previous studies that estimate broad-based option grants (or their implied incentives) on a per employee basis[145]. Despite the relevance of the measure, it is worth noting that EO should ideally be measured as a proportion of employee wealth, the data for which are often unavailable (Bova, Kolev, Thomas, and Zhang (2015)). Since EO is calculated in dollar terms, its distribution is heavily skewed[146]. To address this issue, EO is log-transformed through the empirical analysis.

5.5.3 Control Variables: Firm Incentives

The level of BBEO is likely to differ between large and small firms. Theoretical arguments are ambiguous, however. On the one hand, agency theory suggests that large firms benefit more from group incentives due to monitoring difficulty. On the other hand, free-rider problem suggests that such incentives are less effective in large firms. Despite the conflicting hypotheses, empirical evidence has generally supported a positive size effect on

145 See, e.g. Core and Guay (2001), Hillegeist and Penalva (2003), Bergman and Jenter (2007), Hochberg and Lindsey (2010), and Chang et al. (2015).

146 The mean and median value of EO is $8,679 and $2,558, respectively, for firms in the final sample that have a strictly positive EO.

BBEO (e.g. Kruse (1996), Rauh (2006), and Even and MacPherson (2008))[147]. We use the natural logarithm of net sales to control for firm size[148].

The firm's growth prospects may also influence BBEO. Specifically, high-growth firms are likely to encourage BBEO, due to significant information asymmetry that limits access to external capital. In addition, they may use BBEO to attract and retain optimistic and risk-tolerant employees. Two growth proxies are estimated, namely the three-year average Tobin's Q and sales growth rate.

High past returns are expected to increase BBEO, due to both firms and employees. With respect to firms, they may reward the efforts of current employees by granting them more stock or options (Ittner et al. (2003)). They may also exploit the positive effect of stock return on employee sentiment, and increase BBEO to attract optimistic individuals (Begman and Jenter (2007)). With respect to employees, they may be motivated to invest more DC plan assets in firm stock, expecting that high returns will persist into the future (Benartzi (2001), Huberman and Sengmueller (2005)). We calculate three-year average annualised compounded returns as proxy for firm stock performance.

The perception of both firms and employees on return volatility may also interact to influence BBEO. With respect to firms, the negative risk-incentive relationship posited by agency theory suggests that BBEO should be lower in high-volatility firms. Moreover, as volatile returns make stock price a less consistent performance measure, the outcome-based control of BBEO becomes less effective. In the context of DC plans, volatile firms may further refrain from increasing BBEO, as it subjects retirement benefits to greater downside risk and raises the possibility of fiduciary breach (Brown et al. (2006)). This carries over to risk-averse employees who, on their part, may reduce allocations to or diversify from volatile firm stock. We estimate return volatility as the standard deviation of daily stock returns in the previous fiscal year.

Regarding firm risk, we define an additional indicator of whether the firm sponsors at least one DB plan in addition to DC plans. Given that DB plans promise a stated retirement benefit, and are insured by the Pension Benefit Guaranty Corporation (PBGC), their presence should reduce the concerns of both firms and employees about retirement security, leading to more BBEO (e.g. Brown et al. (2006), Even and MacPherson (2008)).

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[147] The evidence is mixed for broad-based option grants. While some studies find a positive effect of firm size (e.g. Core and Guay (2001), Ittner et al. (2003), and Kroumova and Sesil (2006)), others find a negative effect (e.g. Oyer and Schaefer (2005), Bergman and Jenter (2007), and Hochberg and Lindsey (2010)).

[148] The results are qualitatively similar using other size proxies, such as total assets or market equity.

Tax savings are an oft-cited factor behind firms' stock contribution to DC plans. In particular, firms are allowed to exclude the value of dividends paid on own stock held in DC plans – subject to certain conditions (see Subsection 5.3.1) – from taxable income. The value of tax savings, in turn, increases with firms' marginal tax rates (Rauh (2006)). As proxy for tax incentives, we construct three indicator variables, namely whether the firm pays dividends in a given year, and whether the firm is classified as having high or low marginal tax rates based on Core and Guay (2001, p.260).

Liquidity constraints may lead firms to increase BBEO, since contributing own stock to DC plans substitutes for cash contribution and is often cheaper than other investment options (Mitchell and Utkus (2004), Brown (2006)). Another advantage is the inexpensive source of finance it provides, which supports firms with high capital needs and severe cash constraints. However, as mentioned in Subsection 5.3.1, firms must also contend with several issues which could offset cost savings (Rauh (2006)). Empirical evidence on the effect of firm liquidity on BBEO has been mixed (e.g. Brown et al. (2006), Rauh (2006))[149]. To account for the liquidity of individual firms, we estimate their three-year average cash-to-asset ratio and book leverage[150].

Based on management entrenchment hypothesis, incumbent managers may encourage BBEO that puts stock in "friendly hands". This leads to a labour-management alliance, which helps deter hostile takeovers (e.g. Pagano and Volpin (2005). By this reasoning, where there is already some form of takeover protection in place, managers may engage in less self-serving, resulting in less BBEO (cf. Rauh (2006)). To account for managerial control motives, we define an indicator variable for the possible existence of multiple traded share classes (e.g. dual-class shares) based on Gompers et al. (2010, p.1055).

5.5.4 Control Variables: Employee Incentives

An important issue with BBEO in DC plans is that *employees as well as firms* can influence the level of plan assets held in firm stock. Although some of the control variables above straddle both firms and employees, they are unlikely to fully account for employee effects. Given that this chapter focuses on firms, we control for three additional factors related to employee incentives.

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[149] The debate on the liquidity effect originated in the context of employee option grants, which also do not require a contemporary cash outlay. Findings in this research are similarly inconclusive (e.g. Core and Guay (2001), Ittner et al. (2003), Oyer and Schaefer (2005), Jones et al. (2006), and Bergman and Jenter (2007)).

[150] Note that in the case of leveraged ESOP, firms may raise debt to purchase shares for the plan. This is accounted for by including leverage as a control variable.

The first concerns taxes. As explained in Subsection 5.3.2, firm stock in DC plans qualifies for certain tax advantages. Particularly, upon its distribution, employees can elect to have the net unrealised appreciation taxed at the long-term capital gains rate, rather than the ordinary income rate which is usually higher. Therefore, we expect employees of firms in states with relatively low long-term capital gains rates to direct more DC plan assets to firm stock. This leads to increased BBEO.

The second concerns age. Mitchell and Utkus (2004) note that as employees approach retirement, they are likely to become more conscious of the downside risk associated with firm stock in DC plans. This is reflected in the ESOP rule that employees aged 55, and with ten years of participation, must be allowed to diversify up to half of firm stock over six years. Thus, we expect firms with an old workforce to have less BBEO. To control for worker age, we define a dummy variable for whether the average worker age in the firm's Census industry falls in the top quartile (cf. Even and MacPherson (2008)).

Finally, we also estimate the percentage of female workers in the firm's Census industry. This variable controls for potential gender-based risk aversion (e.g. Croson and Gneezy (2009), Charness and Gneezy (2012)) and other behavioural biases that might affect DC allocation to firm stock (e.g. Lee et al. (2008), Utkus and Young (2014)).

5.5.5 Descriptive Statistics

Table 5-3 presents descriptive statistics. For the full sample, EO is skewed to the right even after log transformation. This is to be expected given a large number of observations with zero EO. The empirical literature typically addresses the issue by implementing Tobit-type models (see next section). For the subsample with strictly positive EO, the distribution of log EO is much smoother with a mean and median of 7.646 and 7.84, respectively. The main test variable, SKILL, is slightly left-skewed as the mean of 3.097 is lower than the median of 3.172. The properties of control variables are generally in line with those reported in previous studies.

Table 5-3 Descriptive Statistics

This table reports descriptive statistics. The dependent variable is the aggregate value of firm stock in defined contribution plans, scaled by total employees (EO). The main independent variable is the labour skill index (SKILL). Control variables include: the natural logarithm of sales (SIZE), the three-year average Tobin's Q (TOBINQ), the three-year average sales growth rate (SALGR), the three-year average stock return (RETURN), the annual standard deviation of daily stock returns from previous fiscal year (RETVOL), a defined benefit plan dummy (DBPLAN), a dividend dummy (DIVDUM), a high-marginal-tax dummy (HTAX), a low-marginal-tax dummy (LTAX), the three-year average cash ratio (CASH), the three-year average book leverage (BKLEV), a dummy variable indicating the possible existence of multiple traded share classes (MULTICLASS), the long-term capital gains rates in the firm's state (LTCG), a dummy variable indicating a relatively old workforce (OLDEMP), and the percentage of female workers in the firm's industry (FEMALE). All firm-level continuous controls are winsorised at the top and bottom 0.5% of sample observations. Appendix 3 provides details on the control variables. The sample covers 4,839 firms and 37,192 firm-year observations during the period 1990-2014.

Variable	Obs.	Mean	Std. Dev.	Percentile				
				p1	p25	p50	p75	p99
Dependent Variable								
Ln(1+EO) (EO≥0)	37,192	2.666	3.820	0.000	0.000	0.000	6.757	10.777
Ln(EO) (EO>0)	12,948	7.646	1.962	1.719	6.564	7.847	8.972	11.428
Test Variable								
SKILL	37,192	3.097	0.534	1.734	2.720	3.172	3.526	3.932
Control Variable								
SIZE	37,192	5.745	2.076	0.616	4.316	5.684	7.122	10.720
TOBINQ	37,192	2.036	1.494	0.686	1.152	1.539	2.332	8.574
SALGR	37,192	0.178	0.456	-0.282	0.011	0.089	0.207	2.262
RETURN	37,192	0.184	0.683	-0.793	-0.206	0.071	0.383	3.182
RETVOL	37,192	0.578	0.321	0.167	0.351	0.500	0.712	1.773
DBPLAN	37,192	0.250	0.433	0.000	0.000	0.000	1.000	1.000
DIVDUM	37,192	0.329	0.470	0.000	0.000	0.000	1.000	1.000
HTAX	37,192	0.535	0.499	0.000	0.000	1.000	1.000	1.000
LTAX	37,192	0.131	0.338	0.000	0.000	0.000	0.000	1.000
CASH	37,192	0.198	0.208	0.001	0.037	0.118	0.299	0.839
BKLEV	37,192	0.199	0.194	0.000	0.029	0.160	0.311	0.859
MULTICLASS	37,192	0.174	0.379	0.000	0.000	0.000	0.000	1.000
LTCG	37,192	0.231	0.047	0.139	0.197	0.234	0.260	0.327
OLDEMP	37,192	0.250	0.433	0.000	0.000	0.000	0.000	1.000
FEMALE	37,192	0.356	0.146	0.082	0.266	0.340	0.438	0.782

5.6 Main Results

This section examines the relationship between firms' reliance on skilled labour and the level of employee ownership. Subsection 5.6.1 presents the results of portfolio-level analysis. Subsections 5.6.2 specifies the multivariate regression model based upon Heckman's two-step method. Subsection 5.6.3 provides the regression results.

5.6.1 Portfolio Sorts

Each year, we sort sample firms that record strictly positive EO into SKILL quintiles. The top quintile ("High") comprises firms with the most reliance on skilled labour, and the bottom quintile ("Low") comprises firms with the least reliance on skilled labour. We then calculate the time-series mean and median log EO for each of the five SKILL portfolios.

Table 5-4 reports the portfolio sorts. The mean (median) value of log EO is 7.631 (7.825) for the most skilled firms, and 6.986 (7.199) for the least skill firms. The mean and median difference between top and bottom SKILL quintiles are both statistically significant, as indicated by the results of a t-test and Wilcoxon rank-sum test, respectively.

At first sight, the results support Hypothesis 5.1, namely that employee ownership increases with firms' reliance on skilled labour. On closer examination, however, the relationship reveals a non-linear pattern. Specifically, log EO rises sharply for the least skilled firms, and tails off as firms become more highly skilled. For firms near the top end of skill spectrum, log EO declines with further increases in SKILL. It nevertheless remains above that of firms in the bottom SKILL quintile. The observation lends support to Hypothesis 5.2. That is, employee ownership displays an inverted U-shaped relationship with firms' reliance on skilled labour.

Table 5-4 Portfolio Sorts

Each year, firms with positive employee ownership (i.e. EO>0) are sorted into quintile portfolios based on the labour skill index (SKILL). The time-series averages of mean and median log EO are calculated for each of the five portfolios. The standard errors of the estimated medians are bootstrapped based on 1,000 replications. A standard t-test and Wilcoxon rank-sum test (i.e. z-test) are performed to assess the equality between neighbouring quintiles, as well as between the top and bottom SKILL quintiles. The corresponding p-values are shown in square brackets. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers the period 1990-2014.

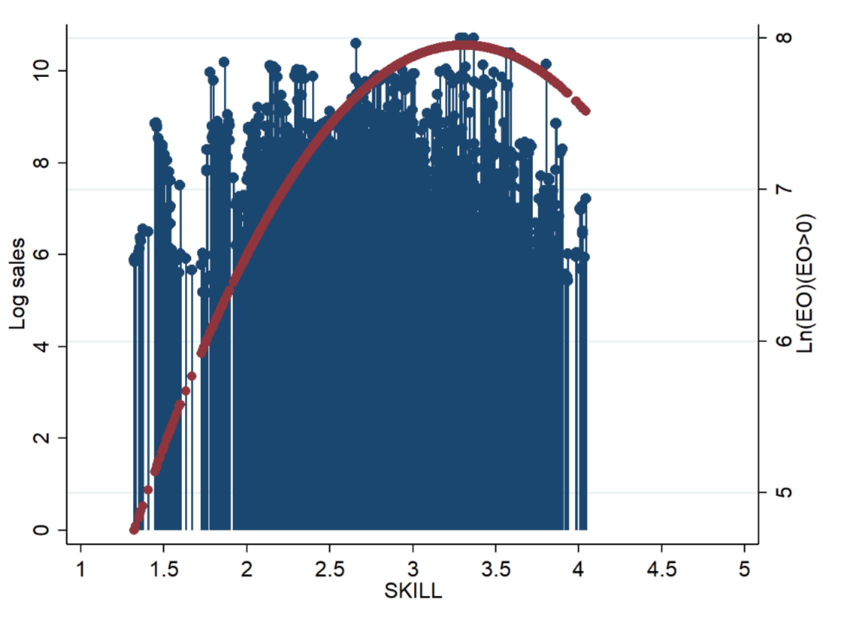
SKILL Quintile	SKILL	Ln(EO) (Obs.=12,948)			
		Mean [SE]	t-stat [p-stat]	Median [SE]	z-stat [p-stat]
Low	2.234	6.986		7.199	
		[0.039]		[0.047]	
2	2.715	7.647	11.947***	7.935	13.051***
		[0.040]	[0.000]	[0.055]	[0.000]
3	3.025	7.809	2.948***	7.917	1.750*
		[0.038]	[0.003]	[0.048]	[0.080]
4	3.354	8.152	6.583***	8.307	7.011 ***
		[0.036]	[0.000]	[0.037]	[0.000]
High	3.677	7.631	-10.089***	7.825	-10.357***
		[0.037]	[0.000]	[0.038]	[0.000]
t-stat (H-L)			12.068***		12.415***
			[0.000]		[0.000]

Complementing Table 5-4, Figure 5-1 graphs the relationship between SKILL and EO for sample firms with strictly positive EO. We plot against SKILL the fitted values from a quadratic regression of log EO on SKILL and its squared term. SKILL is demeaned before being squared and entered into the regression. Consistent with the portfolio evidence, the level of EO exhibits an inverted U-shaped relationship with SKILL. Specifically, log EO increases with SKILL until peaking around 3.202 in SKILL, i.e. above the 60^{th} percentile, and turning into a downward trend. That the inflection point occurs at the upper end of SKILL distribution suggests that the negative slope applies mainly to highly skilled firms.

Also featured in Figure 5-4 is a dropline plot, which shows the average firm size in terms of log sales, corresponding to different values of SKILL. It reveals a similar inverted U-curve, where mid-skill firms appear larger than either high- or low-skill firms. This suggests that the size effect may contribute to non-linearity in the SKILL-EO relationship, and should be controlled for in a multivariate setting.

Figure 5-1 Fitted Plot

Figure 5-1 plots against SKILL the fitted values from a quadratic regression of log EO on SKILL and its squared term, for sample firms with positive EO. The subsample consists of 12,948 firm-year observations during the period 1990-2014.



5.6.2 Estimation Framework

The portfolio sorts in the previous subsection appear to corroborate Hypothesis 5.2. However, high-skilled firms may differ from low-skilled firms across several other dimensions, which contribute to variation in BBEO. To ensure that the observed relationship between SKILL and EO is not spurious, we now turn to multivariate tests. This subsection specifies our baseline regression model.

An important empirical issue in this study is the many observations of zero EO. In situations where the dependent variable is zero for a large part of the sample, but has positive (continuous) values for the rest, linear models could yield inconsistent estimates. To address the issue, prior research typically runs a Tobit model that uses a latent variable approach (e.g. Rauh (2006), Even and MacPherson (2008))[151]. While Tobit model is often associated with censored data, note that zero employee ownership in DC plans is legitimate and observable. The issue we face is therefore one of "corner solution response", where the dependent variable (y) piles up at one or two focal points – zero, in our case – and is

[151] The latent variable measures the desired, rather than observed, level of employee ownership. Therefore, it may take negative values, especially when the net benefit of employee ownership is minimal.

continuously distributed over strictly positive values (Wooldridge (2010, p.667))[152]. Applying a Tobit model in the corner-solution context may thus involve taking the natural logarithm of one plus the dependent variable (y), to ensure the possibility of observing zero y is always positive.

The standard (or "type I") Tobit model (Amemiya (1985)) suffers from shortcomings due to the restrictive structure it imposes. Specifically, it assumes that both the probability of a non-zero y ("participation decision") and the positive level of y ("amount decision") are determined by the same set of variables with the same signs. In addition, the relative effects of two continuous independent variables, say x_a and x_b, are assumed to be identical in both decision mechanisms – that is, equal to β_a/β_b.

In this chapter, we consider an extension to the standard Tobit model, namely the exponential type II Tobit (ET2T) model or Heckman's (1976) method (see Wooldridge (2010, p.697-703))[153]. Specifically, it relaxes the assumptions above, and distinguishes between participation and amount decisions through two steps: First, a standard probit model estimates the probability of non-zero y. Second, an OLS regression is run where log-transformed y is regressed on X (a vector of independent variables) for observations with strictly positive y. The error term from both regressions, say u and v, are assumed to follow a bivariate normal distribution. They are also allowed to be correlated, reflecting the possibility that both decision mechanisms may be affected by the same unobserved factors[154]. This is operationalized by deriving the inverse Mills ratio from probit estimates, and including it in the OLS regression as an additional control. To avoid poorly identified coefficients in the second step, Heckman's method further assumes that at least one exclusion restriction exists – that is, the covariates used in the OLS regression (i.e. X) should be a strict subset of those used in the probit model.

Below we specify the two-step procedure in Heckman's method, as applied to the present study.

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152 As Wooldridge (2010) notes, there has been confusion in literature between models aimed to address corner responses, censored responses, and sample selection, despite their similar underlying techniques.

153 Note that type II Tobit (T2T) model (without specifying a log-likelihood function) is originally proposed by Heckman to address sample selection problem. As this study focuses on observed y, rather than desired y that allows negative outcomes, a version of T2T model that applies to log-transformed y – hence the label "exponential" – is adopted.

154 This differentiates Heckman's method from the lognormal version of "two-part model" (Wooldridge (2010, p.694-696)), which assumes that the two error terms are independent conditional on the observed X.

In the first step, a probit model is estimated where the probability of observing positive EO at firm i in year t (i.e. Pr (EO>0)) is determined by:

$$D_{it}^* = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + u_{it}$$

$$D_{it} = 1 \text{ if } D_{it}^* > 0 \tag{5.1}$$

$$D_{it} = 0 \text{ if } D_{it}^* <= 0$$

where i and t index firm and year, respectively. D* is a latent variable representing the net benefit of holding firm stock in DC plans, β_0 is a constant term, X is a vector of covariates used in both first- and second-step equations, Z is a vector of identification variables exclusive to the first-step equation, and u is an error term. Note that the net benefit of holding firm stock in DC plans is unobservable. However, whether EO is positive for a given firm in a given year can be observed. It is expressed here by a binary variable D, which equals one when the net benefit is greater than zero, and zero otherwise.

The coefficient estimates β_1 and β_2 are then used to calculate the inverse Mills ratio (or Heckman's lambda) as below:

$$D_{it} = 1: \lambda_{it} = \frac{\varphi\,(X\beta_1 + Z\beta_2)}{\phi(X\beta_1 + Z\beta_2)} \tag{5.2a}$$

$$D_{it} = 0: \lambda_{it} = \frac{-\varphi\,(X\beta_1 + Z\beta_2)}{1 - \phi(X\beta_1 + Z\beta_2)} \tag{5.2b}$$

where λ is the inverse Mills ratio, and φ and ϕ denote the probability density function and cumulative density function, with zero mean and unit variance, respectively.

In the second step, an OLS regression is performed where the natural logarithm of EO is regressed on X and the inverse Mills ratio, for observations with strictly positive EO. Expressed algebraically:

$$Ln(EO_{it}) = \gamma_0 + \gamma_1 X_{it} + \gamma_2 \lambda_{it} + v_{it} \tag{5.3}$$

where EO is the market value of firm stock held in DC plans divided by the firm's employees, Ln(·) denotes the natural logarithm operator, γ_0 is a constant term, X is a vector of covariates used in both first- and second-step equations, λ is the inverse Mills ratio derived from the first-step equation, and v is an error term.

For independent variables in both probit (first step) and OLS (second step) regressions (i.e. X), we include SKILL, its squared term (SKILLSQ), and the control variables from Subsections 5.5.3 and 5.5.4. We also adjust for differences in EO across industries and time, by including dummies for major SIC divisions and year. Heteroscedasticity-robust standard errors are computed throughout the analysis.

To avoid poorly identified Heckman estimators in the second step, the first-step regression requires at least one identification variable with nonzero coefficient. We include industry unionisation rate (UNION), defined as the percentage of unionised workers in the firm's Census industry[155], in the probit model and exclude it from the OLS model. The use of UNION is based on the assumption that in industries with strong organised labour, firms are less likely to expose retirement wealth to business-cycle risk by sponsoring DC plans that allow investment in own stock. This is indirectly supported by recent literature which shows that powerful unions inhibit firms from terminating or freezing DB plans (in favour of DC plans)[156]. Similarly, unions may be concerned about workers being co-opted into ownership plans that lead to entrenched management (Pagano and Volpin (2005)), reduced union influence (Rosen et al. (1986)), or decreases in labour solidarity (McElrath and Rowan (1992)). Previous U.S. studies have found a negative and significant relationship between unionisation and the incidence of BBEO (e.g. Kroumova and Sesil (2006), Even and MacPherson (2008)). Where firms already have positive EO, however, we expect its level to be less related to the share of unionised workers in the firm's industry[157].

5.6.3 Baseline Regression

Table 5-5, Panel A shows the baseline results based on Heckman's method. Columns (1) and (2) report probit (first-step) estimates and the marginal effects. The Wald test (χ^2=4,611.12, not tabulated) strongly rejects the null hypothesis that the regression coefficients are jointly zero. The negative and significant coefficient on SKILLSQ (-0.098) suggests an inverted U-shaped relationship between SKILL and Pr(EO>0), while the

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155 Unionisation data across Census industries are downloaded from the Union Membership and Coverage Database (www.unionstats.com), maintained by Barry Hirsch and David MacPherson.

156 See, e.g. Kapinos (2009), Shivdasani and Stefanescu (2010), Beaudoin et al. (2010), and Phan and Hegde (2013b).

157 Using very similar data to this study, Bova, Dou, and Hope (2015, p.657) show that industry unionisation rate has a positive but statistically insignificant effect on firm stock in DC plans.

negative and significant coefficient on SKILL (-0.060) suggests a steep downward slope beyond the inflection point, which occurs at 2.791 in SKILL[158].

Despite evidence of an inverted parabola, which otherwise complements the univariate results – that is, *the incidence as well as the level* of positive EO shows an inverted U-shaped relationship with SKILL – the probit results are surprising due to the early inflection point, i.e. slightly below the 30th percentile of SKILL distribution. This suggests that investment in skilled labour already lowers the likelihood of BBEO for relatively low-skilled firms. A possible explanation is that the costs of adopting and maintaining a stock ownership plan are prohibitive for most firms[159]. Where workforce upskilling coincides with high capital and investment needs, firms may delay committing to BBEO.

Regarding control variables, the negative and significant coefficient on UNION is as expected. That is, stronger union presence reduces the likelihood of BBEO. Also, Pr(EO>0) is positively and significantly associated with SIZE, TOBINQ, DBPLAN, DIVDUM, BKLEV, and MULTICLASS, and OLDEMP, while negatively and significantly associated with SALGR, VOLAT, CASH, and LTCG. The patterns suggest that BBEO in DC plans, irrespective of its level, tends to occur at firms which are relatively established and perceived as less risky. The insignificant coefficients on RETURN, HMT, and LMT indicate that past stock performance and marginal tax rates have little or no influence on the presence of firm stock in DC plans.

Column (3) reports the OLS (second-step) estimates for observations with strictly positive EO. Specifically, log EO is regressed on SKILL, SKILLSQ, control variables, and the inverse Mills ratio (INVMILLS) based on probit (first-step) results. The F test (F-stat = 92.80, not tabulated) strongly rejects the null hypothesis that the coefficients on all independent variables are jointly zero. Moreover, the R-squared (24.2%) suggests that the variables have significant explanatory power for the level of EO. SKILLSQ (-0.315) loads negatively and significantly – indicating that log EO is a concave function of SKILL – while SKILL (0.392) loads positively and significantly. The inflection point of the inverted-U curve, based on both parameters, occurs at around 3.612 in SKILL, which is near the 90th

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158 This is calculated as: 3.097 (i.e. mean SKILL for the full sample)-(-0.060/(2*-0.098))

159 As described in Guery and Pendleton (2014), such costs may include arrangements to fulfil employees' participation, voting and information rights, in addition to initial structuring and communication of the plan, appointment of plan trustee and administrator, and liaison with union representatives. In the U.S., setting up an ESOP typically costs at least $50,000, depending on the size and complexity of the transactions. In our sample comprised entirely of listed companies, more than 90 percent employ at least 100 people, with the median firm having a staff of 1,324. Note that the criterion for a "large" retirement plan, which is subject to more filing requirements (e.g. 11k), is whether it has at least 100 participants.

percentile of SKILL distribution[160]. The finding thus supports Hypothesis 5.2. Namely, BBEO through DC plans generally increases with firms' reliance on skilled labour. The trend is, however, reversed for already high-skilled firms.

It is possible to reconcile the first- and second-step regression results. Although investment in skilled labour, as part of firms' effort to deepen their knowledge base, may initially deter cost-conscious firms from providing BBEO – as suggested by the probit model – where related schemes have been in place, the need to motivate and retain skilled workers translates into higher levels of BBEO (up to a certain point) – as suggested by the OLS model. In this chapter, we focus on this latter aspect, towards which most of the subsequent analysis will be orientated.

Regarding control variables, their signs and significance levels largely resemble those in the probit model, suggesting an overlap between the two decision mechanisms. This is reflected by the positive and significant coefficient on INVMILLS[161]. However, note that whilst the decision to provide BBEO (i.e. first-step) rests primarily with the firm, the level of BBEO (i.e. second-step) is at the discretion of employees as well as firms (see Section 5.3). There is also the possibility that firms may weigh the same factors differently in different contexts. Hence the usefulness of Heckman's method, as it separately considers the two otherwise related decisions. The divergence in the effects of several variables – in addition to SKILL – demonstrates the point. For instance, the now positive and significant coefficient on RETURN may arise from excessive extrapolation of past returns by employees (Benartzi (2001), Huberman and Sengmueller (2004)). The now negative and significant coefficients on OLDEMP and FEMALE suggest that older and female employees may prefer a more diversified retirement portfolio (Even and MacPherson (2008), Lee et al. (2008)), thereby reducing EO. Also, the flipped sign on MULTICLASS lends support to a substitution between BBEO and other forms of managerial protection (Brown et al. (2006), Rauh (2006)).

To verify that our results are not sensitive to model specifications, we adopt two approaches. First, we rerun the regression for the full sample, based on a Tobit model and an OLS model[162]. The natural logarithm of *one plus EO* is used as the dependent variable in

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[160] This is calculated as: 2.990 (i.e. mean SKILL for the subsample with positive EO)-0.392/(2*-0.314)

[161] A positive and significant coefficient on INVMILLS means that the same set of unobserved factors may affect the probability of non-zero EO and the positive level of EO in a similar manner.

[162] It is worth noting that since SKILL has a rather limited distribution (i.e. between 1 and 5), its coefficients might still be consistently estimated by OLS in the corner solution context – irrespective of the probabilistic attributes of the dependent variable (see Wooldridge (2010)). The OLS estimators, however, are likely to be suppressed, given that the probability of observing positive EO is less than one.

both specifications. This is to represent the overall level of EO without dropping observations with zero values (Bova, Dou, and Hope (2015)). The independent variables remain the same as in the second-step Heckman specification, except for the exclusion of INVMILLS. Column (4) and (5) report the Tobit and OLS results, respectively. The signs and significance of independent variables are in line with those in Column (3), indicating the robustness of baseline results. Particularly, the SKILLSQ coefficient remains negative and strongly significant. The coefficient on SKILL also remains positive, albeit reduced in magnitude[163]. This is likely due to the fact that both methods conflate the two decision mechanisms mentioned before – which might explain why some of the control variables also behave more like the first-step Heckman estimates.

Second, we estimate a piecewise regression. Specifically, we partition SKILL into three intervals representing low, medium, and high values of SKILL – denoted by LSKILL, MSKILL, and HSKILL, respectively – whereby the regression now fits a different slope on SKILL for each tercile[164]. By allowing between-group comparison, this approach represents a useful alternative to applying a quadratic term in testing for non-linearity between two variables. Panel B of Table 5-5 reports the piecewise regression estimates based on all three models in Panel A: Heckman (Columns (1)-(3)), Tobit (Column (4)), and OLS (Column (5)). In Columns (3)-(5), an inverted U-shaped relationship between SKILL and log EO is again manifested – this time in the positive and significant coefficients on LSKILL and MSKILL, and negative and significant coefficients on HSKILL. The pattern corresponds to the inferences of the quadratic regression[165].

The results of this section support Hypothesis 5.2, namely that BBEO displays an inverted U-shaped relationship with firms' reliance on skilled labour. Specifically, investment in skilled labour generally increases BBEO for less-skilled firms, but the positive relationship is reversed for highly skilled firms. The sign change may reflect the concern of highly skilled firms that excessive stockholdings create perverse incentives for highly skilled workers, thus harming firm prospects.

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[163] The inflection point of the inverted-U curve based on Tobit and standard OLS models are 3.097 and 3.355, respectively, which corresponds roughly to the 46th and 62nd percentile of SKILL distribution.

[164] This is achieved through the "mkspline" command in Stata. The decision to use terciles is, admittedly, arbitrary. The main inferences remain unaffected, however, using median-segmenting, quartiles, or quintiles.

[165] Note that in both Tobit and OLS models, the negative HSKILL loading is much larger than the positive LSKILL/MSKILL loadings, compared to the second-step Heckman estimates. As mentioned before, this could be a result of mixing the effects of SKILL on the presence and level of positive EO.

Table 5-5 Baseline Regression

Panel A reports the results of quadratic regression of employee ownership (EO) on the labour skill index (SKILL), its squared term (SKILLSQ), and control variables as previously defined. Panel B reports the results of piecewise regression of EO on the tercile values of SKILL – indicating low SKILL (LSKILL), medium SKILL (MSKILL), and high SKILL (HSKILL) – and control variables as previously defined. In both Panel A and Panel B, Columns (1)-(3) describe Heckman's two-step procedure (the baseline specification), and Column (4) and (5) describe a standard Tobit and OLS model, respectively. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 4,839 firms and 37,192 firm-year observations during the 1990-2014 period.

Panel A. Quadratic regression

Independent Variable	Heckman's Two-step Method			Tobit	OLS
	Pr(EO>0)	Marg. Effects	Ln(EO)	Ln(1+EO)	Ln(1+EO)
	(1)	(2)	(3)	(4)	(5)
SKILL	-0.060***	-0.022	0.392***	0.068	0.147***
	(-2.943)		(8.576)	(0.481)	(2.843)
SKILLSQ	-0.098***	N.A	-0.315***	-0.757***	-0.285***
	(-4.050)		(-5.283)	(-4.387)	(-4.761)
SIZE	0.097***	0.035	0.114***	0.677***	0.238***
	(18.662)		(3.893)	(18.129)	(17.245)
TOBINQ	0.012**	0.004	0.297***	0.209***	0.095***
	(1.993)		(18.214)	(4.417)	(6.751)
SALGR	-0.131***	-0.048	-0.230***	-1.080***	-0.203***
	(-5.101)		(-3.062)	(-5.150)	(-5.710)
RETURN	-0.018	-0.007	0.404***	0.047	0.059**
	(-1.557)		(14.920)	(0.523)	(2.241)
RETVOL	-0.353***	-0.129	-1.576***	-3.113***	-0.996***
	(-10.555)		(-12.438)	(-12.189)	(-14.216)
DBPLAN	0.226***	0.083	0.336***	1.522***	0.768***
	(11.579)		(4.868)	(11.191)	(13.425)
DIVDUM	0.303***	0.111	0.979***	2.384***	1.150***
	(16.762)		(11.195)	(18.462)	(22.173)
HTAX	0.004	0.001	0.207***	0.154	0.059
	(0.222)		(5.828)	(1.292)	(1.335)
LTAX	0.043	0.016	0.234***	0.278	0.204***
	(1.544)		(3.027)	(1.242)	(3.448)
CASH	-0.774***	-0.283	-1.279***	-6.184***	-1.700***
	(-14.209)		(-4.703)	(-14.374)	(-14.384)
BKLEV	0.075*	0.027	0.213**	0.442	0.134
	(1.740)		(2.192)	(1.399)	(1.248)
MULTICLASS	0.065***	0.024	-0.097**	0.424***	0.070
	(3.472)		(-2.132)	(3.171)	(1.427)
LTCG	-2.073***	-0.758	-2.441***	-14.984***	-4.682***
	(-8.891)		(-3.134)	(-8.750)	(-7.615)
OLDEMP	0.042**	0.015	-0.077*	0.127	0.013
	(2.080)		(-1.787)	(0.880)	(0.239)
FEMALE	-0.046	-0.017	-0.508***	0.439	0.056
	(-0.779)		(-4.146)	(1.080)	(0.382)
UNION	-0.688***	-0.251			
	(-6.940)				
INVMILL			2.125***		
			(5.175)		
Constant	-0.321***		3.747***	-3.192***	1.904***
	(-2.825)		(7.234)	(-3.884)	(6.741)
Year Effects	Y		Y	Y	Y
Industry Effects	Y		Y	Y	Y
Observations	37,192		12,948	37,192	37,192
Adjusted R-squared			0.242		0.154
Pseudo R-squared	0.115			0.049	

Panel B. Piecewise regression					
Independent Variable	Heckman's Two-step Method			Tobit	OLS
	Pr(EO>0)	Marg. Effects	Ln(EO)	Ln(1+EO)	Ln(1+EO)
	(1)	(2)	(3)	(4)	(5)
LSKILL	0.033	0.012	0.803***	0.790***	0.465***
	(0.917)		(10.025)	(3.234)	(5.137)
MSKILL	0.048	0.017	0.547***	0.909***	0.402***
	(1.005)		(5.288)	(2.683)	(3.277)
HSKILL	-0.441***	-0.159	-0.671***	-3.091***	-0.956***
	(-4.747)		(-2.584)	(-4.411)	(-4.120)
SIZE	0.097***	0.035	0.129***	0.680***	0.239***
	(18.684)		(4.337)	(18.184)	(17.327)
TOBINQ	0.012*	0.004	0.298***	0.206***	0.095***
	(1.957)		(18.281)	(4.369)	(6.719)
SALGR	-0.131***	-0.047	-0.256***	-1.086***	-0.205***
	(-5.119)		(-3.377)	(-5.170)	(-5.760)
RETURN	-0.018	-0.006	0.402***	0.048	0.059**
	(-1.544)		(14.814)	(0.536)	(2.247)
RETVOL	-0.352***	-0.127	-1.628***	-3.113***	-0.996***
	(-10.537)		(-12.666)	(-12.185)	(-14.219)
DBPLAN	0.229***	0.083	0.368***	1.548***	0.776***
	(11.705)		(5.204)	(11.358)	(13.554)
DIVDUM	0.304***	0.110	1.020***	2.396***	1.155***
	(16.837)		(11.444)	(18.541)	(22.248)
HTAX	0.004	0.001	0.206***	0.152	0.059
	(0.223)		(5.820)	(1.277)	(1.337)
LTAX	0.043	0.016	0.235***	0.279	0.207***
	(1.543)		(3.043)	(1.245)	(3.484)
CASH	-0.787***	-0.284	-1.420***	-6.283***	-1.730***
	(-14.373)		(-5.090)	(-14.547)	(-14.559)
BKLEV	0.065	0.023	0.190*	0.365	0.107
	(1.505)		(1.953)	(1.155)	(0.998)
MULTICLASS	0.065***	0.024	-0.082*	0.431***	0.073
	(3.523)		(-1.782)	(3.220)	(1.490)
LTCG	-2.108***	-0.761	-2.764***	-15.218***	-4.763***
	(-9.032)		(-3.478)	(-8.893)	(-7.748)
OLDEMP	0.039*	0.014	-0.076*	0.116	0.007
	(1.957)		(-1.759)	(0.802)	(0.137)
FEMALE	-0.108*	-0.039	-0.667***	-0.128	-0.136
	(-1.745)		(-4.998)	(-0.299)	(-0.880)
UNION	-0.654***	-0.236			
	(-6.579)				
INVMILL			2.337***		
			(5.577)		
Constant	-0.393**		1.167*	-5.341***	0.583
	(-2.564)		(1.943)	(-5.004)	(1.542)
Year Effects	Y		Y	Y	Y
Industry Effects	Y		Y	Y	Y
Observations	37,192		12,948	37,192	37,192
Adjusted R-squared			0.242		0.155
Pseudo R-squared	0.115			0.049	

5.7 Robustness Tests

We perform four additional tests to extend the main results. These include: a subsample analysis which restricts Form 5500 data to DC plans that do not permit participants to direct their own investments (Subsection 5.7.1); an interaction analysis which examines the moderating effect of retention proxies (Subsection 5.7.2); the incorporation of broad-based stock options in the estimation of EO (Subsection 5.7.3); and the use of alternative proxies for firms' reliance on skilled labour (Subsection 5.7.4).

5.7.1 Non-Participant-Directed Defined Contribution Plans

As detailed in Section 5.3, both firms and employees may have a vested interest in BBEO through DC plans. This highlights the need to control for incentives and characteristics of both parties when studying the determinants of BBEO. Regressions in this context are prone to omitted variable bias, where correlation between the error term and independent variable(s) leads to inconsistent coefficient estimates. Despite the extensive set of controls used in our baseline model, we cannot completely rule out the possibility that correlated omitted variables may have driven our results.

Given our focus on firm incentives, we consider a setting which precludes alternative explanations based on employee incentives. Specifically, we drop participant-directed (PDIR) plans (in which participants exercise independent control over investment of their account balances) from Form 5500 data, before aggregating the remaining non-PDIR plans (in which the plan trustee makes all the investment decisions) to firm level. Since employees influence firm stock in DC plans mainly through the self-direction feature[166], we expect that with non-PDIR plans, the effects of firm incentives will dominate. After removing PDIR plans, the sample covers 6,345 observations, or roughly 17 percent of the initial sample. The reduction highlights an overrepresentation of PDIR plans[167].

Table 5-6 repeats the baseline regression, using EO based exclusively on non-PDIR DC plans. The quadratic regression in Panel A supports the main results: across all specifications, the SKILLSQ coefficient remains significantly negative, while the SKILL

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[166] Papke (2003) provides evidence that employees in participant-directed DC plans are more likely to make an annual contribution, purchase more equities (which may include employer stock), defer a greater part of their salary, and have a larger overall balance in their account.

[167] Inspection of Form 5500 data for public firms reveals that the share of DC plans allowing participant direction rose steadily, from less than 50 percent in the early 1990s to more than 90 percent in 2014.

coefficient remains significantly positive. The inflection points occur at 3.381 (Heckman), 3.331 (Tobit), and 3.413 (OLS) – all are above the 75th percentile of SKILL distribution. We note that the point estimates of SKILLSQ exceed their counterparts in Table 5-5, by a factor of at least 1.5. This implies greater concavity of the inverted U-shaped curve, i.e. the upward (downward) slope before (after) the inflection point has become steeper. The piecewise regression in Panel B gives further evidence. Specifically, the positive MSKILL loadings increase substantially (about 4.5 to 6 times larger than in Table 5.5); the negative HSKILL loadings also show an overall increase. Changes in the positive LSKILL loadings, however, are somewhat mixed.

The findings in Table 5-6 suggest that BBEO in DC plans is highly valued by medium-skilled (and to a lesser extent, low-skilled) firms as they invest in skilled labour, whereas high-skilled firms are more acutely concerned about the disincentives created by excessive BBEO. Since the current setting largely removes the effect of employee incentives, it is interesting to note that medium- and high-skilled *employees* appear to display opposite risk preferences to medium- and high-skilled *firms*. Specifically, the former are wary of holding firm stock in DC plans, whereas the latter are keener. This would explain the less pronounced inverted-U curve in the baseline results.

The increase in the main effects carries over to most of the control variables. Several divergences from the baseline results are worth noting. The coefficients on SIZE and RETURN decline or turn negative, suggesting that firm size and past performance mainly affect employee incentives. Similarly, the loss of significance of DBPLAN suggests that the existence of DB plan matters more for employees in increasing stockholdings. The positive and significant slopes on DIVDUM and HMT, and the negative and insignificant slopes on LMT, highlight the strength of tax-saving incentives where the firm has considerable discretion over firm stock in DC plans. Liquidity constraints, proxied by CASH and BKLEV, also appear more relevant for EO in non-PDIR plans. Finally, the now positive coefficient on LTCG (but with mixed significance) suggests that income tax exemption mainly bears on employee incentives.

By using employee ownership data drawn exclusively from non-PDIR DC plans, the above test gives a sharper assessment of the effect of firm incentives, which motivates this chapter. Overall, the evidence in Table 5-6 adds robustness to the baseline results.

Table 5-6 Non-Participant-Directed Defined Contribution Plans

This table repeats the analysis of Table 5-5, using employee ownership (EO) calculated based on non-participant-directed defined contribution plans. Panel A reports the results of quadratic regression, and Panel B reports the results of piecewise regression. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 1,623 firms and 6,345 firm-year observations during the period 1990-2014.

Panel A. Quadratic regression					
Independent Variable	Heckman's Two-step Method			Tobit	OLS
	Pr(EO>0)	Marg. Effects	Ln(EO)	Ln(1+EO)	Ln(1+EO)
	(1)	(2)	(3)	(4)	(5)
SKILL	0.129***	0.051	0.611***	0.925***	0.546***
	(2.961)		(4.364)	(3.911)	(4.572)
SKILLSQ	-0.202***	N.A.	-0.656***	-1.168***	-0.571***
	(-3.347)		(-3.183)	(-3.571)	(-3.483)
SIZE	0.019*	0.008	-0.116***	-0.008	-0.029
	(1.665)		(-4.049)	(-0.118)	(-0.813)
TOBINQ	0.052***	0.021	0.584***	0.555***	0.336***
	(3.014)		(10.506)	(5.099)	(5.611)
SALGR	-0.099	-0.039	-0.488**	-0.740	-0.378
	(-1.182)		(-2.219)	(-1.364)	(-1.550)
RETURN	-0.088***	-0.035	0.302***	-0.248	-0.052
	(-2.860)		(2.890)	(-1.303)	(-0.592)
RETVOL	-0.241***	-0.096	-1.957***	-2.291***	-1.099***
	(-3.131)		(-6.832)	(-4.740)	(-5.400)
DBPLAN	-0.002	-0.001	0.129	0.097	0.023
	(-0.043)		(1.455)	(0.408)	(0.184)
DIVDUM	0.382***	0.152	1.260***	2.302***	1.256***
	(9.425)		(4.024)	(9.958)	(10.499)
HTAX	0.095**	0.038	0.776***	0.863***	0.477***
	(2.217)		(6.459)	(3.543)	(3.826)
LTAX	-0.063	-0.025	-0.099	-0.418	-0.207
	(-0.697)		(-0.380)	(-0.722)	(-0.824)
CASH	-0.889***	-0.354	-2.852***	-5.809***	-2.817***
	(-5.940)		(-3.414)	(-6.128)	(-6.344)
BKLEV	0.093	0.037	0.495**	0.564	0.280
	(0.810)		(2.086)	(0.853)	(0.844)
MULTICLASS	0.076*	0.030	0.018	0.295	0.053
	(1.821)		(0.164)	(1.245)	(0.432)
LTCG	0.214	0.085	4.630***	3.316	2.933*
	(0.393)		(3.973)	(0.991)	(1.814)
OLDEMP	-0.186***	-0.074	-0.553***	-0.941***	-0.522***
	(-3.821)		(-3.441)	(-3.610)	(-3.613)
FEMALE	-0.139	-0.055	-0.494	-0.652	-0.310
	(-1.011)		(-1.631)	(-0.863)	(-0.824)
UNION	-0.071	-0.028			
	(-0.366)				
INVMILL			4.354***		
			(3.144)		
Constant	-1.134***		-0.469	-5.854***	0.295
	(-4.747)		(-0.219)	(-4.025)	(0.421)
Year Effects	Y		Y	Y	Y
Industry Effects	Y		Y	Y	Y
Observations	6,345		3,198	6,345	6,345
Adjusted R-squared			0.262		0.158
Pseudo R-squared	0.102			0.041	

Panel B. Piecewise regression

Independent Variable	Heckman's Two-step Method			Tobit	OLS
	Pr(EO>0)	Marg. Effects	Ln(EO)	Ln(1+EO)	Ln(1+EO)
	(1)	(2)	(3)	(4)	(5)
LSKILL	0.170*	0.068	0.456**	1.012*	0.462*
	(1.663)		(1.974)	(1.856)	(1.704)
MSKILL	0.665***	0.265	2.980***	4.193***	2.359***
	(4.924)		(4.864)	(5.519)	(6.045)
HSKILL	-0.562***	-0.224	-2.059***	-3.203***	-1.599***
	(-4.176)		(-3.591)	(-4.065)	(-4.052)
SIZE	0.022*	0.009	-0.102***	0.007	-0.021
	(1.849)		(-3.463)	(0.099)	(-0.587)
TOBINQ	0.050***	0.020	0.585***	0.539***	0.326***
	(2.840)		(11.091)	(4.940)	(5.420)
SALGR	-0.104	-0.041	-0.540**	-0.772	-0.391
	(-1.228)		(-2.438)	(-1.412)	(-1.594)
RETURN	-0.089***	-0.035	0.282***	-0.251	-0.054
	(-2.890)		(2.742)	(-1.320)	(-0.611)
RETVOL	-0.245***	-0.098	-2.036***	-2.307***	-1.109***
	(-3.157)		(-7.133)	(-4.765)	(-5.442)
DBPLAN	-0.003	-0.001	0.127	0.091	0.020
	(-0.082)		(1.421)	(0.382)	(0.158)
DIVDUM	0.381***	0.152	1.327***	2.278***	1.251***
	(9.390)		(4.500)	(9.880)	(10.499)
HTAX	0.103**	0.041	0.833***	0.910***	0.501***
	(2.401)		(6.893)	(3.741)	(4.017)
LTAX	-0.054	-0.022	-0.082	-0.365	-0.176
	(-0.595)		(-0.315)	(-0.629)	(-0.701)
CASH	-0.896***	-0.357	-3.125***	-5.849***	-2.843***
	(-5.955)		(-3.839)	(-6.170)	(-6.411)
BKLEV	0.069	0.028	0.392*	0.407	0.203
	(0.600)		(1.663)	(0.617)	(0.614)
MULTICLASS	0.090**	0.036	0.087	0.374	0.100
	(2.141)		(0.758)	(1.576)	(0.813)
LTCG	0.184	0.073	4.671***	3.199	2.807*
	(0.337)		(4.001)	(0.957)	(1.741)
OLDEMP	-0.187***	-0.075	-0.579***	-0.922***	-0.514***
	(-3.834)		(-3.743)	(-3.537)	(-3.557)
FEMALE	-0.278*	-0.111	-1.218***	-1.624**	-0.824**
	(-1.960)		(-3.168)	(-2.040)	(-2.103)
UNION	-0.024	-0.010			
	(-0.125)				
INVMILL			4.745***		
			(3.594)		
Constant	-1.676***		-2.628	-9.048***	-1.211
	(-4.604)		(-1.060)	(-4.405)	(-1.209)
Year Effects	Y		Y	Y	Y
Industry Effects	Y		Y	Y	Y
Observations	6,345		3,198	6,345	6,345
Adjusted R-squared			0.265		0.161
Pseudo R-squared	0.104			0.042	

5.7.2 Interaction Analysis

To further reduce concerns about omitted variabls, we examine cross-sectional variation in the SKILL-EO relationship. The rationale is that, if the main relationship can be shown to vary across firms in the manner predicted by theory, it is less likely to be driven by alternative explanations. This is because the omitted factors will now have to explain both the main relationship and its observed variation.

The evidence thus far shows that increases in SKILL, when it is already high, lead to decreased EO. As explained in our hypothesis development, this reversal of an otherwise positive relationship may be linked to firms' concerns about the risk and work preferences of skilled workers. In this subsection, we posit that the downward trend observed for high-skilled firms is mitigated, when the need to retain employees is particularly strong. As outlined below, we consider three retention proxies which will be included in the baseline model as an interacting variable.

The first proxy is the degree of employee dispersion (EMPDISP), which we define as one minus a Herfindahl index of employee concentration in three-digit SIC industries (cf. Kim and Ouimet (2014))[168]. We expect competition for labour to be fiercer in industries where employees are dispersed across a larger number of firms. As employees enjoy more outside opportunities, firms are likely to perceive greater retention needs.

The second proxy is organisation capital (ORGCAP) as embedded in firms' employees – namely, capital that is "intangible, specific, and closely tied to labor inputs" (Eisfeldt and Papanikolaou (2013, p.1380)). Following Eisfeldt and Papanikolaou (2013, 2014), we implement a perpetual inventory method, which constructs ORGCAP recursively using the deflated values of selling, general and administrative (SG&A) expenses[169]. We expect firms with a larger stock of organisation capital to focus more on retention, due to their vulnerability to the departure of key employees.

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[168] This is analogous to the common proxy of product market competition, which is based on a Herfindahl index of sales concentration within an industry (e.g. Hou and Robinson (2006)).

[169] Algebraically, $\mathrm{ORGCAP}_{i,t} = (1-\delta)\mathrm{ORGCAP}_{i,t-1} + \theta \frac{\mathrm{SG\&A}_{i,t}}{\mathrm{cpi}_t}$, where ORGCAP denotes organisation capital, SG&A denotes selling, general and administrative expenses, δ denotes the depreciation rate, θ denotes the fraction of SG&A related to investment in organisation capital, and cpi denotes the consumer price index. The initial stock of organisation capital is expressed as: $\mathrm{ORGCAP}_0 = \theta \frac{\mathrm{SG\&A}_1}{g+\delta}$, where g denotes the average real growth rate of SG&A. As in Eisfeldt and Papanikolaou (2014), we set δ to 20%, θ to 30%, and g to 10%. For the purpose of this analysis, organisation capital is scaled by total assets.

The third proxy is contingent labour use (PTEMP), represented by a dummy variable that equals one if the firm employs at least 10 percent of its workers on a part-time or seasonal basis, and zero otherwise (Hanka (1998))[170]. Two opposing arguments can be made regarding the retention effect of PTEMP. On the one hand, greater reliance on contingent labour implies fewer retention efforts. On the other hand, the firm may find it more urgent to retain core, permanent employees. This dilemma resembles the one raised in Section 5.4, i.e. whether skilled contingent labour reduces the relevance of BBEO as a retention device. Examining how the effect of SKILL – particularly for high-skilled firms – is moderated by PTEMP helps resolve the dilemma.

To distinguish between the moderating effects for firms in different skill bands, we run the same piecewise regression as in Panel B, Table 5-5, and interact the retention proxies with LSKILL, MSKILL, and HSKILL simultaneously[171]. Table 5-7 reports the second-step Heckman estimates. Similar to the baseline results, both LSKILL and MSKILL load positively and significantly while HSKILL loads negatively and significantly. Of more interest here, however, are the slopes on interaction terms. These are interpreted below.

With respect to high-skilled firms, all three interaction terms (i.e. between HSKILL and retention proxies) load positively and significantly, supporting our conjecture. That is, as high-skilled firms invest more in skilled labour, they may still be motivated to hold back BBEO, but at a slower pace, especially when they face intense labour competition, have significant organisation capital, or rely on contingent labour. The positive and significant coefficient on HSKILL×PTEMP is instructive: it suggests that as high-skilled firms hire more contingent labour, they perceive more, not less, need to retain regular employees through, e.g. BBEO (cf. David (2005)). Moreover, it implies that the rise of skilled contingent labour is unlikely to have made retention less important for high-skilled firms.

Intriguingly, with respect to low- and medium-skilled firms, some of the interaction terms (i.e. between LSKILL/MSKILL and retention proxies) yield an opposite sign to their counterparts for high-skilled firms. The negative and significant coefficient on LSKILL×ORGCAP, for instance, suggests that organisation capital may substitute for BBEO where less-skilled employees are concerned. The negative and significant coefficients on LSKILL×PTEMP and MSKILL×PTEMP suggest that reliance on

[170] The information is from the employee footnote in Compustat ("emp_fn"). Specifically, PTEMP takes the value of 1 if emp_fn records "IE", and 0 otherwise.

[171] All variables involved in interactions except PTEMP, i.e. LSKILL, MSKILL, HSKILL, EMPDISP, and ORGCAP, are demeaned before entering into regression.

contingent labour does not necessarily make retaining regular employees more urgent for low- and medium-skilled firms.

Overall, the results in Table 5-7 provide further support for Hypothesis 5.2, while highlighting some interesting patterns of cross-sectional variation in the relationship between firms' reliance on skilled labour and employee ownership in DC plans.

Table 5-7 Interaction Analysis

This table shows piecewise regressions including interaction terms. Employee ownership (EO) is regressed on three ranges of values of labour skill index (SKILL) – indicating low SKILL (LSKILL), medium SKILL (MSKILL), and high SKILL (HSKILL) – their interaction terms with employee retention proxies, and control variables as previously defined. The interacting variables include: the degree of labour competition in the firm's industry (EMPDISP), firm-level organisation capital (ORGCAP) based on Eisfeldt and Papanikolaou (2013), and a dummy variable, PTEMP, that takes the value of one if at least 10 percent of the firm's workforce are employed on a part-time or seasonal basis. The second-step OLS estimates, based on Heckman's two-step method, are reported. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,839 firms and 37,192 firm-year observations during the period 1990-2014.

Independent Variable	Interacting Variables		
	EMPDISP	ORGCAP	PTEMP
	(1)	(2)	(3)
LSKILL	0.802***	0.766***	1.363***
	(9.809)	(9.097)	(12.158)
MSKILL	0.458***	0.488***	0.515***
	(4.330)	(4.524)	(4.570)
HSKILL	-0.590**	-0.962***	-1.155***
	(-2.295)	(-3.452)	(-4.167)
EMPDISP	0.263*		
	(1.834)		
ORGCAP		-0.290***	
		(-3.015)	
PTEMP			-0.278***
			(-5.589)
LSKILL×EMPDISP	1.539***		
	(3.954)		
MSKILL×EMPDISP	-2.539***		
	(-3.684)		
HSKILL×EMPDISP	3.201*		
	(1.855)		
LSKILL×ORGCAP		-1.732***	
		(-4.356)	
MSKILL×ORGCAP		-0.950*	
		(-1.677)	
HSKILL×ORGCAP		1.656**	
		(2.315)	
LSKILL×PTEMP			-1.321***
			(-7.879)
MSKILL×PTEMP			-0.589**
			(-2.340)
HSKILL×PTEMP			2.756***
			(6.332)
SIZE	0.107***	0.174***	0.144***
	(3.787)	(5.304)	(4.932)
TOBINQ	0.296***	0.317***	0.306***
	(17.993)	(18.660)	(18.632)
SALGR	-0.224***	-0.352***	-0.289***
	(-3.038)	(-4.333)	(-3.874)
RETURN	0.407***	0.404***	0.397***
	(15.051)	(14.032)	(14.639)
RETVOL	-1.548***	-1.645***	-1.684***
	(-12.523)	(-12.049)	(-13.220)
DBPLAN	0.336***	0.372***	0.402***
	(4.961)	(4.919)	(5.781)
DIVDUM	0.971***	1.121***	1.067***
	(11.487)	(11.294)	(12.145)

HTAX	0.205***	0.215***	0.217***
	(5.762)	(5.636)	(6.134)
LTAX	0.224***	0.312***	0.224***
	(2.903)	(3.870)	(2.903)
CASH	-1.240***	-1.724***	-1.622***
	(-4.843)	(-5.762)	(-5.804)
BKLEV	0.199**	0.056	0.193**
	(2.040)	(0.539)	(1.992)
MULTICLASS	-0.098**	-0.040	-0.056
	(-2.151)	(-0.799)	(-1.233)
LTCG	-2.337***	-3.773***	-3.320***
	(-3.056)	(-4.600)	(-4.168)
OLDEMP	-0.071	-0.094**	-0.080*
	(-1.641)	(-2.035)	(-1.870)
FEMALE	-0.684***	-0.934***	-0.614***
	(-5.033)	(-6.038)	(-4.590)
INVMILL	2.035***	2.820***	2.617***
	(5.174)	(5.977)	(6.324)
Constant	3.826***	3.105***	3.207***
	(7.666)	(4.936)	(6.213)
Year Effects	Y	Y	Y
Industry Effects	Y	Y	Y
Observations	12,948	11,681	12,948
Adjusted R-squared	0.243	0.245	0.247

5.7.3 Including Stock Options in Employee Ownership Measure

In this chapter, we have defined BBEO in relation to firm stock held in DC plans. However, firms may also provide equity compensation through *nonretirement* plans such as stock option plans, stock purchase plans, and restricted stock plans.

Employee stock options give employees the right to purchase stock at a predetermined price. Most options are subject to vesting requirements and, once vested, they must be exercised prior to expiry (usually within 10 years). Upon exercising the options, employees may choose to purchase the shares themselves, or have the firm purchase the shares on their behalf and reimburse them the spread (i.e. the difference between grant and exercise price) net of income tax[172]. This latter arrangement is also known as a "cash-free exercise".

Employee stock purchase plans (ESPPs) allow employees to purchase firm stock at a discounted price, using their after-tax payroll deductions. Shares are usually purchased at the end of an offering period during which wage deferrals are accumulated. Most ESPPs are organised under IRC §423, meaning that they are generally broad-based and provide special tax benefits for employees.

Restricted stock plans offer employees either shares of stock directly, or the right to purchase them at market price or a discount. After accepting the offer – which sometimes demands a payment – employees do not enjoy full right to the stock until the lapse of pre-determined restrictions, which may be time-based or contingent on the achievement of certain performance goals.

The equity incentives provided by retirement plans and those provided by nonretirement plans differ in two respects, namely liquidity and scope (Frye (2004)). Whereas firm stock in DC plans is typically distributed after retirement or termination of contract, employees usually have full ownership of stock acquired through nonretirement plans once it is vested – which can then be sold at any time. Thus, nonretirement plans offer greater liquidity and, at the same time, shorter-term incentives. Huddart and Lang (1996) note that early exercise of stock options is pervasive amongst lower-level employees[173], which may reflect their risk aversion and liquidity needs. Regarding scope or plan coverage, except for ESPPs, most nonretirement plans are non-qualified, and thus may not abide by rules precluding them

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172 Unlike with executives, non-executives are exempted from reporting their option exercises by the SEC.

173 These, in turn, are often converted into cash immediately, either from cashless exercise or selling the shares upon purchase (Huddard and Lang (1996, p.19)).

from discriminating in favour of high earners. A 1999 BLS survey documents a monotonic increase in the incidence of option grants across salary groups: for all private-sector establishments, options were granted to 0.7 percent of employees earning less than $35,000, compared to 12.9 percent of those earning more than $75,000[174]. The gap has since reduced, however, as broad-based option grants have become increasingly common (Hallock and Olson (2008)). The 2014 General Social Survey shows that 4.2 percent of employees earning less than $30,000 were covered by an option plan, compared to 19.6 percent of those earning more than $75,000[175].

Since firm stock held in DC plans is generally illiquid and non-discriminatory in nature, our EO measure should capture a significant part of the involuntary stockholding by employees (Bova, Kolev, Thomas, and Zhang (2015)). It therefore fulfils our aim of investigating how the skill level of firms' overall workforce affects their provision of long-term equity incentives.

Nevertheless, to address potential measurement error, we adjust the estimation of EO to incorporate employee option holdings. This takes into account the growing popularity of stock options as an ownership vehicle, particularly in "new economy" firms (e.g. Ittner et al. (2003), Murphy (2003)); and the fact that the timing and level of option grants, similar to stock contribution to DC plans, is generally at the discretion of the firm.

Another motivation is that, we suspect the inclusion of stock options in EO will mitigate the downward slope of the inverted U-shaped curve. The conjecture is based on the argument that stock options promote risk-taking incentives due to their convex payoffs (Murphy (2003)). In a recent study, Chang et al. (2015) find that non-executive option holdings have a positive effect on corporate innovation, by encouraging and rewarding risk-taking. To the extent that stock options make employees more risk-seeking, this counteracts the risk-reducing incentives from excessive stockholding, leading to a less negative SKILL-EO relationship for high-skilled firms.

Incorporating employee options in our analysis is limited by the unavailability of large-scale data prior to 2004. This reduces our sample period, by more than half, to 2004-2014. Also, to evaluate outstanding options with the Black-Scholes (1973) formula, modified by Merton (1973) to account for dividends, several assumptions have to be made. Specifically, without data on individual option grants, we assume the options outstanding ("optosey") constitute a single tranche with a weighted-average exercise price ("optprcey") and an

[174] See https://www.bls.gov/ncs/ocs/sp/ncnr0001.txt (accessed 24 February 2017)

[175] See https://www.nceo.org/assets/pdf/articles/GSS-2014-data.pdf (accessed 24 February 2017)

average remaining life of four years. For other Black-Scholes model inputs, we use the U.S. Treasury constant maturity rate as the risk-free rates, fiscal year-end price ("prcc_f") as the price of underlying stock, standard deviation of daily stock returns from previous fiscal year as expected return volatility, and the most recent dividend yield, based on Compustat data, as the expected dividend yield over the life of the option. The total Black-Scholes value of options outstanding is added to the aggregate value of firm stock in DC plans. The sum is scaled by total employees to obtain the adjusted EO.

As nearly 95 percent of observations in the 2004-2014 subsample record positive EO, using Heckman's two-step or Tobit model is less justified. Instead, we run a simple OLS model where the natural logarithm of adjusted EO is used as the dependent variable. Table 5-8 reports the results of both quadratic and piecewise regressions. Columns (1)-(2) include in EO firm stock from all DC plans; Columns (3)-(4) include in EO firm stock from non-PDIR DC plans, as in Subsection 5.7.1.

Whilst the negative coefficient on SKILLSQ in Column (1) again indicates an inverted U-shaped relationship between SKILL and EO, we find that the inflection point lies beyond the possible range of SKILL values, which effectively makes the relationship a linear one. This is supported by the piecewise regression results in Column (2), which show a positive, albeit insignificant, coefficient on HSKILL. The effect of options is exacerbated when we source firm stock exclusively from non-PDIR plans. As shown in Column (3), the coefficient on SKILLSQ is no longer significant, making EO a positive linear function of SKILL. Taken together, the results in Table 5-8 imply that as high-skilled firms contribute less stock to DC plans, they may increase option grants at the same time – possibly to maintain a desired level of risk-taking amongst skilled workers.

The evidence in this subsection presents a more detailed view of BBEO's usefulness as an employee governance tool. Specifically, for firms whose growth depends on the commitment of skilled labour to risky projects, it is important to minimise the costs associated with BBEO while still reaping its benefits. This may be achieved by diversifying the channels through which BBEO is provided.

Table 5-8 Inclusion of Stock Options in Employee Ownership Measure

This table reports the results of OLS regression using both quadratic and piecewise models. The dependent variable is log-transformed employee ownership (EO), expanded to include the Black-Scholes value of outstanding employee options from 2004-2014. In the quadratic model, log EO is regressed on the labour skill index (SKILL), its squared term (SKILLSQ), and control variables as previously defined. In the piecewise model, EO is regressed on the tercile values of SKILL – indicating low SKILL (LSKILL), medium SKILL (MSKILL), and high SKILL (HSKILL) – and control variables as previously defined. For the stock component of EO, Columns (1)-(2) use data from both participant-directed (PDIR) and non-PDIR DC plans, whilst Columns (3)-(4) use data from only non-PDIR DC plans. All regressions include year and major industry fixed effects. Robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers the period 2004-2014.

Independent Variable	Using all DC Plans		Non-PDIR DC Plans	
	Quadratic	Piecewise	Quadratic	Piecewise
	(1)	(2)	(3)	(4)
SKILL	0.704***		0.659***	
	(22.723)		(7.678)	
SKILLSQ	-0.090**		-0.030	
	(-2.251)		(-0.211)	
LSKILL		0.825***		0.409
		(13.853)		(1.527)
MSKILL		0.810***		1.266***
		(12.158)		(4.086)
HSKILL		0.206		-0.174
		(1.551)		(-0.457)
SIZE	-0.008	-0.007	-0.160***	-0.156***
	(-0.987)	(-0.862)	(-6.292)	(-6.079)
TOBINQ	0.431***	0.431***	0.512***	0.510***
	(44.448)	(44.486)	(11.376)	(11.313)
SALGR	0.226***	0.223***	0.879***	0.832***
	(7.011)	(6.934)	(3.556)	(3.368)
RETURN	0.738***	0.738***	0.648***	0.658***
	(33.316)	(33.337)	(7.776)	(7.895)
RETVOL	-0.732***	-0.731***	-1.062***	-1.106***
	(-11.611)	(-11.593)	(-4.733)	(-4.906)
DBPLAN	-0.050	-0.044	0.077	0.089
	(-1.621)	(-1.419)	(0.842)	(0.987)
DIVDUM	-0.105***	-0.104***	0.085	0.072
	(-3.518)	(-3.472)	(1.043)	(0.888)
HTAX	-0.065***	-0.065***	0.220**	0.241***
	(-2.728)	(-2.720)	(2.575)	(2.802)
LTAX	-0.062*	-0.062*	-0.378*	-0.371*
	(-1.656)	(-1.645)	(-1.748)	(-1.716)
CASH	1.686***	1.669***	0.794**	0.733**
	(24.347)	(24.072)	(2.528)	(2.293)
BKLEV	-0.188***	-0.203***	-0.376	-0.350
	(-2.763)	(-2.982)	(-1.274)	(-1.195)
MULTICLASS	-0.047	-0.046	-0.360***	-0.343***
	(-1.490)	(-1.441)	(-2.998)	(-2.812)
LTCG	3.685***	3.646***	6.542***	6.204***
	(10.295)	(10.155)	(4.754)	(4.418)
OLDEMP	-0.059**	-0.064**	-0.164*	-0.166*
	(-2.154)	(-2.327)	(-1.869)	(-1.903)
FEMALE	-0.606***	-0.718***	-0.085	-0.380
	(-6.931)	(-7.680)	(-0.288)	(-1.152)
Constant	8.697***	6.143***	9.258***	8.006***
	(56.824)	(27.194)	(16.868)	(8.109)
Year Effects	Y	Y	Y	Y
Industry Effects	Y	Y	Y	Y
Observations	17,451	17,451	1,232	1,232
Adjusted R-squared	0.467	0.468	0.478	0.480

5.7.4 Alternative Labour Skill Proxies

As a final robustness check, we examine whether our results are sensitive to the estimation of firms' reliance on skilled labour. Since SKILL is an industry-level variable, it is likely to introduce measurement error into a firm-level analysis. To address this, we replicate the approach in Chapter 4, Subsection 4.6.3 and substitute three alternative proxies for SKILL in the baseline model. These include the adjusted labour skill index (SKILL2), the share of workers with a college degree in the firm's Census industry (COLLEGE), and the log ratio of selling, general, and administrative expenses to total employees (SGAEMP).

Table 5-9 reports the second-step Heckman estimates, using alternative measures of skilled labour intensity. Consistent with the baseline results using SKILL, all three skill proxies load positively and significantly, while their respective squared terms load negatively and significantly. This again confirms the inverted U-shaped relationship stated in Hypothesis 5.2. In all columns, the inflection point of the inverted-U curve occurs above the 90^{th} percentile of the SKILL distribution.

The results in Table 5-9 show that our results are robust to different definitions of the test variable, thereby mitigating the concern about measurement error.

Table 5-9 Alternative Labour Skill Proxies

This table repeats the baseline regression using alternative labour skill proxies. Column (1) shows the adjusted labour skill index (SKILL2), derived by omitting the wage term from Equation (3.1). Column (2) shows the share of college graduates in the firm's industry (COLLEGE). Column (3) shows the log ratio of selling, general, and administrative expense to total employees (SGAEMP). The second-step OLS estimates, based on Heckman's two-step method, are reported. All regressions include year and major industry fixed effects. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 4,839 firms and 37,192 firm-year observations during the period 1990-2014.

Independent Variable	Alternative Labour Skill Proxies (SKILL')		
	SKILL2	COLLEGE	SGAEMP
	(1)	(2)	(3)
SKILL'	0.546***	1.743***	0.472***
	(12.149)	(13.073)	(20.560)
SKILLSQ'	-0.356***	-2.067***	-0.071***
	(-5.607)	(-4.019)	(-5.492)
SIZE	0.125***	0.140***	0.027
	(4.235)	(4.391)	(0.848)
TOBINQ	0.297***	0.290***	0.247***
	(18.168)	(17.886)	(13.175)
SALGR	-0.255***	-0.281***	-0.189*
	(-3.372)	(-3.602)	(-1.855)
RETURN	0.404***	0.395***	0.420***
	(14.922)	(14.462)	(15.157)
RETVOL	-1.625***	-1.708***	-1.288***
	(-12.644)	(-12.327)	(-10.280)
DBPLAN	0.359***	0.437***	0.163**
	(5.136)	(5.653)	(2.413)
DIVDUM	1.021***	1.076***	0.660***
	(11.469)	(10.832)	(7.396)
HTAX	0.204***	0.214***	0.206***
	(5.764)	(6.004)	(5.848)
LTAX	0.232***	0.187**	-0.159*
	(3.013)	(2.428)	(-1.816)
CASH	-1.459***	-1.727***	-1.580***
	(-5.266)	(-5.513)	(-4.733)
BKLEV	0.237**	0.220**	-0.204**
	(2.441)	(2.248)	(-2.117)
MULTICLASS	-0.095**	-0.070	-0.194***
	(-2.073)	(-1.505)	(-4.264)
LTCG	-2.707***	-3.317***	-2.060**
	(-3.451)	(-3.876)	(-2.564)
OLDEMP	-0.085**	-0.086**	0.005
	(-1.984)	(-1.982)	(0.112)
FEMALE	-0.327***	-0.655***	-0.775***
	(-2.656)	(-5.079)	(-6.079)
INVMILL	2.298***	2.625***	0.938**
	(5.511)	(5.648)	(2.185)
Constant	3.511***	3.853***	6.012***
	(6.688)	(7.029)	(11.279)
Year Effects	Y	Y	Y
Industry Effects	Y	Y	Y
Observations	12,948	12,948	12,046
Adjusted R-squared	0.244	0.241	0.298

5.8 Conclusion

Employee ownership has become a widespread phenomenon in corporate America. An extensive literature has associated employee ownership with firms' desire to attract, motivate and retain employees, thus fostering investment in strategically valuable human capital. Despite considerable efforts to model the need to improve employee incentives, few studies have addressed the underlying characteristics of firms' workforce. This chapter fills the gap by focusing on one such characteristic, namely skilled labour intensity. Specifically, we examine whether and how firms' reliance on skilled labour affects the level of employee ownership.

Using a large panel of firms from 1990 to 2014, we find that employee stockholdings, particularly through DC plans, exhibit an inverted U-shaped relationship with firms' reliance on skilled labour. The upward trend is reversed for high-skilled firms, which may indicate their concerns about potential disincentives created by excessive employee stockholding. The results remain significant after controlling for various factors known to affect employee ownership, and are robust to model specifications.

The inverted U-shaped relationship is strengthened in subsample tests that utilise only non-participant directed DC plans. This setting minimises the confounding effects of employees when they can make their own investment decisions. Interaction analysis shows that the downward slope for high-skilled firms is reduced when the firm faces strong labour competition, has significant organisation capital, or relies on contingent labour. These are situations in which retention is likely to be salient, making it worthwhile to maintain employee stockholding above a certain level. Similarly, the downward slope becomes less steep when the definition of employee ownership is expanded to include option holdings. This suggests that high-skilled firms may substitute stock options for stock contribution to DC plans – to promote a desired level of risk-taking amongst employees while not sacrificing the benefits of employee ownership in its broad sense.

Collectively, the evidence presented in this chapter highlights ex ante skill heterogeneity across firms as an important determinant of employee ownership. This, along with the novel finding of a non-linear relationship, advances the recent empirical research on the governance role of broad-based employee ownership (e.g. Robinson and Zhang (2005), Wang et al. (2009), and Guery and Pendleton (2014)).

A common problem of studying rationales behind employee ownership is the difficulty to disentangle alternative hypotheses, which could contradict as well as complement each other. The matter is complicated by an increasing overlap in the U.S. between plans designed to secure retirement wealth and plans designed to promote shared capitalism, especially in the form of employee ownership. That most employees now have autonomy over the allocation of plan assets means their incentives and characteristics must be taken into account, besides those of the firm. While there are certainly other determinants of employee ownership not considered in this chapter, our analysis has made a relatively thorough attempt to control for various factors discussed in the literature.

6 Skilled Labour and the Cost of Equity Capital

6.1 Introduction

Significant human capital is increasingly recognized as a key source of competitive advantage. As firms seek higher returns through employment of skilled labour, such investment, if rationally priced, should also result in higher risk. To examine this proposition further, we investigate the relationship between firms' reliance on skilled labour and equity risk. Notwithstanding the importance of this relationship, to date it has not been examined more thoroughly. This is likely due to an absence of firm-specific data on labour skill, which creates considerable measurement challenges. This chapter responds to these challenges.

To do so, we apply industry-level labour data to a firm-level analysis. We follow similar approaches in previous empirical studies on labour-related topics, including unionisation (Matsa (2010), Chen et al. (2011), and Bova, Dou, and Hope (2015)), total factor productivity (Brynjolfsson and Hitt (2003), İmrohoroğlu and Tüzel (2014)), labour mobility (Donangelo (2014)), and labour share (Donangelo et al. (2017)).

Our study adds to the literature exploring the risk implications of firms' operating structure. Hamada (1972) and Rubinstein (1973) are amongst the first to decompose systematic risk into operating and financial risk, associated with the firm's asset and capital structure, respectively. Subsequent empirical studies have generally found a positive relationship between operating leverage, which arise from fixity in the firm's operating structure, and systematic risk (e.g. Lev (1974), Mandelker and Rhee (1984), Lord (1996)). In recent contributions to the production-based asset pricing literature that focuses on the real investment behaviour of firms, operating leverage has also been used as the explanation for value premium, i.e. the return difference between value and growth stocks (e.g., Carlson et al. (2004), Zhang (2005), and Cooper (2006)).[176]

The discussions to date have tended to omit the consideration of labour, however, despite its centrality as a factor of production. This has been attributed to the common assumption of a frictionless labour market – that is, labour is freely adjustable and wage rates correlate perfectly with the marginal product of labour – in standard production

[176] See also the related empirical work of García-Feijóo and Jorgensen (2010) and Novy-Marx (2011)

models (Danthine and Donaldson (2002), Favilukis and Lin (2016a, 2016b)). We relax this assumption and search for channels through which labour frictions may arise. In particular, we focus on an important aspect of firms' labour force, namely skilled labour intensity, and investigate whether it contributes to firms' equity risk by inducing operating leverage.

Since Danthine and Donaldson (2002), a small but growing research has considered the asset pricing implications of different labour market factors, often utilizing the concept of operating leverage. Factors that have been discussed fall into two groups. The first concerns labour frictions (search frictions, labour adjustment costs, and wage rigidities) directly, while the second explores factors that give rise to the aforementioned frictions (e.g. unionisation, labour mobility). Our focus on the labour skill variation between firms pertains to the latter. We argue that reliance on skilled labour does not constitute a friction per se, but nonetheless increases the firm's systematic exposure, and therefore cost of equity, due to the associated wage smoothness and high replacement costs.

For the empirical analysis, we construct a labour skill index as proxy for firms' reliance on skilled labour (see Chapter 3, Section 3.2). Our dependent variable is implied cost of equity, which has been widely used in recent accounting and finance research[177]. By incorporating forward-looking information (e.g. analyst earnings forecasts) in its estimation, implied cost of equity is considered a closer proxy for the unobservable ex ante expected returns than ex post realized returns. For the purpose of this study, we adopt the residual income model of Gebhardt et al. (2001) as our main implied cost of equity model.

Using a sample of 24,567 firm-year observations from 1990 to 2014, we show that labour skill index has a positive and significant effect on the implied cost of equity, consistent with our prediction. The positive relationship persists after controlling for known risk factors. It is also economically significant: ceteris paribus, a one-standard-deviation increase in labour skill index increases the implied cost of equity by about 16.4 basis points. Under reasonable assumptions, this translates into a value erosion of approximately 3.3 percent, or $34 million for our median sample firm. This highlights a trade-off between the benefits of employing skilled labour and the costs of reduced equity values, due to a higher expected return

We implement several identification strategies to support our baseline results. First, we provide portfolio evidence that labour skill index is positively related to firms' degree of

[177] See Lee et al. (2017) for a detailed list of relevant studies.

operating leverage, a common empirical proxy for operating leverage[178]. We also show that it correlates positively with measures of wage rigidity and labour adjustment costs in terms of hiring costs. The results suggest that investment in skilled labour translates into a labour-induced form of operating leverage (cf. Donangelo (2014)), which leads to increased equity risk, and therefore cost of equity capital.

Next, to mitigate concerns about correlated omitted variables, we examine cross-sectional variation in the main relationship. Specifically, we interact labour skill index with retention proxies in the regression, and find that the positive effect of labour skill index on implied cost of equity is stronger when the firm faces greater pressure, both external and internal, to retain employees.

Third, we estimate the baseline regression for subsamples divided along cross-sectional dimensions. We find that: First, labour skill premium is more pronounced for debt-laden firms, suggesting the operating leverage effect in skill-intensive firms may be amplified by a high level of financial leverage. An implication is that firms could therefore address skilled labour risk by managing their debt. Second, labour skill premium is also more pronounced for firms with broad-based employee ownership. This result is somewhat unexpected, and suggests that granting equity stakes and the associated control rights to employees may add to fixity in contractual claims, thereby increasing operating leverage due to labour.

Finally, we address potential measurement error in our core variables. In the first part of the analysis, we calculate alternative proxies for firms' reliance on skilled labour. In addition, we rerun the regression at the industry level, by collapsing firm-level variables into industry averages. Our main inferences are unchanged. In the second part of the analysis, we estimate the implied cost of equity using a number of alternative specifications. This again does not change our main conclusion.

The rest of this chapter is organised as follows. Section 6.2 reviews related literature. Section 6.3 explains the data and variables. Section 6.4 reports the main regression results. Section 6.5 presents identification tests. Section 6.6 describes additional robustness checks. Section 6.7 concludes.

[178] We calculate degree of operating leverage based on the time-series regression method of Mandelker and Rhee (1984). Variants of this method has been used in a number of empirical studies such as Rosett (2001), Ho et al. (2004), Albuquerque (2009), García-Feijóo and Jorgensen (2010), and Chen et al. (2011).

6.2 Literature Review

In this section, we review prior literature that motivates our hypothesis, namely that firms' reliance on skilled labour increases equity risk in terms of cost of equity. The section is comprised of two parts. Subsection 6.2.1 discusses how employment of skilled labour reduces firms' operating flexibility, by increasing labour adjustment costs and wage rigidity. This is expected to generate operating leverage, which is considered in greater detail in Subsection 6.2.2.

6.2.1 Skilled Labour and Operating Flexibility

6.2.1.1 Labour Adjustment Costs

The standard neoclassical model typically treats labour as a variable production factor, which firms may adjust at any time without costs (Merz and Yashiv (2007)). Oi (1962) argues that labour is in fact a "quasi-fixed" factor, and that the fixed element of labour costs arises from hiring and training[179]. Thus, a parallel may be drawn between investment in human capital and investment in physical capital, given that the replacement of the latter also entails fixed costs such as installation, configuration and temporary productivity loss.

Labour adjustment costs tend to increase with the skill level of workers[180]. This is because the selection of suitable candidates to fill skilled positions, and the post-hire induction and training, is often expensive and time-consuming. Moreover, replacing skilled workers may entail a significant loss of firm-specific human capital, manifested in the ability to exploit firm-specific technologies, in-depth knowledge of firm resources and routines, and a rich set of personal and professional contacts (Morris et al. (2017)). This could erode the firm's intangible capital base, and thus its competitive position.

The more costly it is to replace workers, the more reluctant firms may be to scale down their labour force, even during economic downturns. As firms incur a similar level of employee compensation regardless of current market conditions, this amplifies the impact on profits of sales changes, thus increasing the volatility of residual cash flows. This mechanism is known in the literature as operating leverage (see Subsection 6.2.2).

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[179] See footnote 41 in Subsection 2.3.2

[180] See Belo et al. (2017, p.3673) and references therein

6.2.1.2 Wage Costs

The employment of skilled labour also impacts on firm-level wage costs in terms of their level and rigidity. As previously explained[181], advances in technology have raised the relative demand for skilled workers, whose human capital complements technology as production inputs, and whose productivity is boosted by investment in technology such as ICT. This has resulted in a widening pay gap between skilled and less-skilled workers. Therefore, skill-intensive firms are likely to incur significant wage bills as part of their operating costs.

The efficiency wage hypothesis (EWH) provides further insights into skill premium, by positing that firms may offer wages in excess of market-clearing to increase worker productivity. Researchers have considered various explanations for the proposed link: the gift-exchange model (Akerlof (1982)) suggests that efficiency wage leads to employee gratification, and thus increased work efforts; the shirking model (Shapiro and Stiglitz (1984), MacLeod and Malcomson (1998)) suggests that efficiency wage increases the penalty of dismissal, thereby deterring shirking, especially in situations of imperfect monitoring; the turnover model (Stiglitz (1974), Schlicht (1978), and Salop (1979)) suggests that efficiency wage aids retention, by increasing the cost of leaving the firm; and the adverse selection model (Weiss (1980)) suggests that efficiency wage helps reduce adverse selection with respect to employee quits as well as hiring[182].

All the above models indicate that skilled workers will receive a wage premium. This is because of the significant information asymmetry associated with their work, which makes direct monitoring extremely difficult. Facilitated by the great demand for their labour, skilled workers also tend to be highly mobile, which makes retention particularly important for knowledge-intensive firms.

Wage rates are rigid when they do not correlate perfectly with output. From a number of labour market theories, a positive link between wage rigidity and the skill level of workers can be inferred. These are outlined below.

The EWH-related models can again be used to explain wage rigidity. Specifically, where firms are committed to attracting, motivating and retaining skilled workers, they will be reluctant to cut wages, thus retracting the efficiency wage, even after negative demand shocks. In a similar vein, the fair wage-effort hypothesis (Akerlof and Yellen (1990)) explains that if wages fall below a threshold perceived as fair by employees, they might seek

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181 See Chapter 2, Subsection 2.2.2

182 Specifically, it is likely that the most productive employees in a firm are also those most likely to quit after wage cuts.

alternative employment. Lindbeck and Snower (1988) describe an insider-outsider model, where firms' decision to exploit labour market slack and replace current workers (insiders) with new hires (outsiders) at lower wage rates may be met by insiders' refusal to cooperate. This causes particular concerns for knowledge-intensive firms, since their typical projects tend to require extensive communication and collaboration within the firm.

Two other models concern the contractual relationship between firms and workers: The contract model (Taylor (1979), Fischer (1997)) links wage rigidity to long-term employment contracts, which feature predetermined wage rates not subject to frequent renegotiation. The implicit contract model (Bailey (1974), Azariadis (1975), and Stiglitz (1984)) suggests that workers are risk-averse and favour stable wages. An implicit understanding of this leads firms to provide a smooth wage stream, shielding workers from business cycle risk. Thus, wage rigidity serves as a form of worker insurance against productivity shocks. As skilled workers often perform tasks that require long-term commitment, there is an increasing need to retain them through explicit and/or implicit contractual agreements (see, e.g. Franz and Pfeiffer (2006), Lagakos and Ordonez (2011)).

The rigid wages of skilled workers, along with their high replacement costs, reduce the operating flexibility of firms by contributing to smoothness of their overall operating costs. This is reflected by an increased level of operating leverage, which amplifies firms' exposure to systematic risk.

In the next subsection, we begin by elaborating on operating leverage and its equity risk implications. We then discuss the concept of labour-induced operating leverage, and link it to our context of firms' reliance on skilled labour.

6.2.2 Skilled Labour and Systematic Risk Exposure

6.2.2.1 Operating Leverage

Operating leverage, defined as the degree of fixity in operating costs, is analogous to financial leverage which arises from fixed interest costs. By amplifying the impact of sales changes on profits, as costs become less sensitive to demand shocks, these two types of leverage make the transfers to residual claimants (i.e. shareholders) increasingly risky.

Prior research in finance explains that managerial decisions regarding the firm's asset structure and capital structure give rise to operating risk and financial risk, respectively, which are the two main components of systematic risk (Hamada (1972), Rubinstein (1973)).

By adding to operating risk and financial risk, operating leverage and financial leverage therefore constitute two real-asset determinants of systematic risk.

Much discussion has focused on the empirical measurement of operating leverage. Earlier studies such as Rubinstein (1973) and Percival (1974) argue that operating leverage is captured by contribution margins, while Lev (1974) suggests that variable cost per unit output serves as a better proxy. To more explicitly account for fixed costs, Gahlon (1981) proposes an elasticity-based measure of degree of operating leverage (DOL), which estimates the sensitivity of operating cash flow to percentage changes in sales. Gahlon and Gentry (1982) adopt a similar approach in estimating degree of financial leverage (DFL), defined as the sensitivity of residual cash flow to percentage changes in operating cash flow. In their model, DOL and DFL are jointly linked to systematic risk, expressed as a function of sales variability, its magnification by both operating and financial leverage, and a correlation coefficient between cash flow and the dollar return from the market portfolio. Mandelker and Rhee (1984) further substantiate the positive joint effect of DOL and DFL on systematic risk[183]. Subsequent empirical studies have generally found a positive relationship between DOL and systematic risk (e.g. Chung (1989), Li and Henderson (1991), Lord (1996), Ho et al. (2004), and García-Feijóo and Jorgensen (2010)), whilst the evidence is more mixed with respect to DFL.

A recent line of research has proposed a risk-based explanation for value premium, i.e. the empirical observation that value stocks tend to earn higher returns than growth stocks, using the concept of operating leverage (e.g. Carlson et al. (2004), Zhang (2005), and Cooper (2006)). Specifically, it attributes value premium to the increased operating leverage of capital-intensive firms, rather than financial distress as suggested in earlier studies (Fama and French (1996), Chen and Zhang (1998)). According to Zhang (2005), operating leverage makes assets in place riskier than growth options, especially during downturns, due to costly capital divestment and countercyclical price of risk. To the extent that value stocks have higher operating leverage, their returns will be more susceptible to aggregate shocks.

Empirical studies have corroborated the risk-based explanation of value premium. For instance, García-Feijóo and Jorgenson (2010) show that DOL is positively associated with book-to-market, stock returns, and systematic risk. Similarly, Novy-Marx (2011) finds that operating leverage predicts expected returns in the cross-section. However, he also

[183] Another important contribution of Mandelker and Rhee (1984) is their proposal of a time-series regression approach to estimate DOL and DFL.

demonstrates that the positive link between operating leverage and value premium exists within, but not across industries.

6.2.2.2 Labour-induced Operating Leverage

The preceding discussion highlights operating leverage as a systematic risk factor. When it comes to the source of operating leverage, however, prior research mostly focuses on firms' capital investment decisions. In particular, capital-heavy firms are expected to be stuck with unproductive assets during downturns. The resulting operating leverage is exacerbated when the capital equipment is highly specialised, making it both expensive to acquire and illiquid on the external market. This argument underlies the research on risk-based value premium, as described above.

Despite the critical role of capital, it is not the only production factor employed by firms. Labour contributes just as much, if not more, to firm-level value creation, especially in a knowledge economy where intellectual capabilities are increasingly the dominant source of competitive advantage (see Chapter 2, Section 2.3). To the extent that the employment of labour, as well as capital, entails fixed costs as previously explained, operating leverage should also arise from labour.

Danthine and Donaldson (2002) are perhaps the first to consider operating leverage as induced by labour. They argue that operating leverage, and the associated residual volatility, arises from the twin facts that employees are senior claimants to stockholders and that wage shares often display a counter-cyclical pattern. The latter, in turn, can be attributed to firms' intention to shield employees from part of business cycle risk. In Gourio's (2007) formulation of labour leverage, wage smoothness is combined with the assumption of productivity heterogeneity between firms. Specifically, the impact of wage smoothness on the relative pro-cyclicality between revenue and cost is more pronounced for less productive firms, due to their narrower revenue-cost gap. Since value firms tend to be unproductive relative to growth firms, they are particularly susceptible to labour leverage, which leads to their equity premium. In critical accounting, Toms (2010a) argues for an extension of the classical theory of value to include the effects of risk which, as well as value, originates from the imperfectly observable labour process. Such risk is reflected by a growing degree of fixity in firms' underlying cost structure, which leads to residual volatility. The author constructs a labour beta measure, which captures the fixity of labour costs, and shows that it is positively related to systematic risk.

Recent empirical studies have considered the implications of various labour-related factors for asset pricing. For instance, Merz and Yashiv (2007) and Belo et al. (2014)

incorporate labour as well as capital adjustment costs into a production-based asset pricing model, and show that firms' hiring and investment decisions jointly affect their market value and stock returns. Chen et al. (2011) find that firms in more unionised industries incur a higher cost of equity, as they are constrained in making both labour- and capital-related decisions. In Donangelo (2014), firms in industries with a more mobile labour force (i.e. workers can easily move between industries) are shown to have higher expected returns.

Closest to our study are Ochoa (2013) and Belo et al. (2017) who examine, respectively, the direct and indirect effect of labour-force heterogeneity on stock returns. Ochoa (2013) finds that firms in industries with a larger share of skilled workers earn higher returns, with the positive relationship strengthened in times of higher aggregate volatility. He attributes this to the high replacement costs of skilled workers. Belo et al. (2017) show that the negative hiring-expected return spread, described in Belo et al. (2014), is moderated by skilled labour intensity. Specifically, the spread is steeper for firms in industries with a larger concentration of skilled workers. Similar to Ochoa (2013), the authors argue that significant labour adjustment costs make the hiring rate less responsive to discount rate changes.

Our study complements Ochoa (2013) and Belo et al. (2017) by explicitly verifying the operating leverage mechanism. In addition, we follow recent empirical studies and calculate firm-specific implied cost of equity as our dependent variable. By utilising forward-looking information, e.g. analysts' earnings forecasts, implied cost of equity addresses the issue of extrapolating ex ante expected returns from ex post realised returns, raised in previous literature. In terms of empirical setting, our study thus bears more similarity to Chen et al. (2011) and Donangelo (2014).

The hypothesis to be tested in this chapter is:

Hypothesis 6.1: There is a positive relationship between firms' reliance on skilled labour and the cost of equity capital.

6.3 Data and Measures

This section details the data and key variables of this study. Subsection 6.3.1 outlines sample selection and distribution. Subsection 6.3.2 describes the estimation of the dependent variable, namely the implied cost of equity. Subsections 6.3.3 discusses the control variables. Subsection 6.3.4 presents descriptive statistics.

6.3.1 Sample

To construct the data sample for this chapter, we take the baseline sample (see Section 3.1) and apply additional selection criteria. Specifically, out of the baseline sample, we remove observations with missing values of implied cost of equity and control variables. In addition, we follow Hecht and Vuolteenaho (2006) and exclude firms with fiscal year-end market equity less than $10 million, and market-to-book greater than (less than) 100 (0.01). This is to eliminate potential data errors and mismatches.

Table 6-1 details the sample selection process. The final sample comprises 24,567 firm-year observations during the period 1990-2014. These correspond to 3,314 unique firms across 199 three-digit SIC industries.

Table 6-1 Sample Selection

This table shows the construction of the data set for our first empirical chapter. Applying criteria 1-4 leads to the initial sample described in Table 3.1. From the initial sample, we exclude firms with missing data requirements for implied cost of equity based on Gebhardt et al. (2001) and control variables. Finally, we delete observations with market equity less than $10 million, and a book-to-market ratio greater than 100 or less than 0.01. The selection process results in an unbalanced panel of 24,567 observations, corresponding to 3,314 firms across 199 three-digit SIC industries during the period 1990-2014.

Selection Criteria	Obs.	Firms	Industries
Firms with Compustat-CRSP data for fiscal years from 1990-2014	114,548	12,961	272
After excluding:			
1. Financial firms	91,035	10,247	247
2. Utility firms	87,193	9,934	240
3. Observations with missing values of labour skill index	76,827	8,846	211
4. Observations with missing values of market equity, assets, sales, employees, book-to-market, and leverage	73,711	8,586	211
5. Observations with missing values of implied cost of equity	43,409	6,157	207
6. Observations with missing values of control variables	24,609	3,323	199
7. Observations with market equity less than $10 million, and book-to-market greater than 100 or less than 0.01	**24,567**	**3,314**	**199**

Table 6-2 presents the sample distribution by fiscal year and by industry group. The number of annual observations ranges from a minimum of 790 in 1990 to a maximum of 1,174 in 2004. The sample is also spread across economic sectors, albeit with a relatively strong representation from manufacturing and services. Firms in these two industry groups account for nearly three quarters of the sample.

Table 6-2 Sample Distribution

This table provides details on the industry distribution and fiscal year distribution of the sample. Firms are aggregated into major SIC divisions based on 2-digit SIC codes, as described in Kahle and Walkling (1996)[184]. The full sample covers 3,314 firms and 24,567 firm-year observations during the period 1990-2014.

Industry Group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Construction	7	10	13	12	9	9	15	17	23	21	15	15	22	24
Manufacturing	503	539	563	563	567	570	623	645	649	575	541	536	527	567
Mining	30	30	25	35	31	43	52	56	47	38	35	35	48	47
Retail Trade	68	82	87	94	88	96	100	108	118	110	97	101	129	130
Services	88	108	108	107	100	103	126	137	147	147	136	177	215	249
Transportation and Communications	55	60	58	59	58	59	55	59	63	56	51	61	67	72
Wholesale Trade	39	38	43	41	39	42	43	40	46	42	38	38	37	39
Total	**790**	**867**	**897**	**911**	**892**	**922**	**1,014**	**1,062**	**1,093**	**989**	**913**	**963**	**1,045**	**1,128**

Industry Group	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Obs.	Firms	Three-digit SIC
Construction	22	23	22	16	17	20	23	22	19	25	24	445	51	7
Manufacturing	591	582	546	527	454	472	485	469	439	450	392	13,375	1,699	107
Mining	59	61	53	56	54	61	60	51	55	56	43	1,161	159	6
Retail Trade	125	131	122	116	99	117	115	107	102	99	88	2,629	318	20
Services	267	251	225	235	227	230	232	230	220	196	186	4,447	742	31
Transportation and Communications	72	69	71	63	54	56	63	67	61	63	56	1,528	219	13
Wholesale Trade	38	38	37	40	35	36	42	43	34	40	34	982	126	15
Total	**1,174**	**1,155**	**1,076**	**1,053**	**940**	**992**	**1,020**	**989**	**930**	**929**	**823**	**24,567**	**3,314**	**199**

[184] See Chapter 3, Section 3.1 for additional detail

6.3.2 Dependent Variable: Implied Cost of Equity

The dependent variable of this study is firm-level implied cost of equity (ICOE), defined as the internal rate of return that equates the current stock price to the present value of expected future cash flows. A higher ICOE suggests that the stock is riskier. This is because the market expects a higher rate of return, which it implicitly uses to discount the stream of future cash flows. Since market expectations are unobservable, asset pricing literature has traditionally used realised returns as a proxy for expected returns. However, this approach often yields imprecise estimates of the cost of equity (Fama and French (1997)), due to information surprises that do not cancel out over time or across firms (Elton (1999), Lundblad (2007)). Without a fairly long time-series, unavailable for most stocks, realised returns are prone to deviation from expected returns (Stulz (1999)).

Rather than rely on historical return data, ICOE models incorporate forward-looking information (e.g. earnings forecasts by sell-side analysts) and contemporaneous stock prices. This makes ICOE theoretically closer to the ex ante expected return. The empirical study of Pastor et al. (2008) shows that ICOE outperforms ex-post realised returns in estimating the intertemporal risk-return trade-off.

In this chapter, we adopt the residual income valuation model of Gebhardt et al. (2001) as our baseline model for estimating ICOE. Appendix 4 specifies the underlying formula, and describes key assumptions. The Gebhardt et al. model has been shown to produce credible cost-of-equity estimates (Gode and Mohanram (2003), Guay et al. (2011)), and is the preferred model in the empirical literature[185]. Following previous studies, we calculate ICOE at the end of June each year to capture analysts' earnings forecasts and stock prices simultaneously across firms. This is analogous to forming a portfolio at the same point in time, thereby aligning price data in the cross section and facilitating period-to-period comparison. The choice of June as estimation month is motivated by the observation that most U.S. firms have a December fiscal year-end[186]. That is, a firm's book value and

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[185] Previous studies that apply Gebhardt et al.'s (2001) model as their primary ICOE model include: Pastor et al. (2008), Lee et al. (2009), Chava and Purnanandam (2010), Campbell et al. (2012), Hann et al. (2013), Donangelo (2014), and İmrohoroğlu and Tüzel (2014).

[186] Approximately 64 percent of our sample firms (2,113 out of 3,314) have December as the last month of their fiscal year.

accounting earnings will have become public knowledge and incorporated into stock price by June in the following year[187].

6.3.3 Control Variables

To isolate the effect of SKILL on ICOE, we include a number of control variables in our regressions based on prior research. These are outlined below.

As in Fama and French (1992), we control for firm size, book-to-market and CAPM beta. Firm size (SIZE) is defined as the natural logarithm of market capitalisation in June from CRSP; book-to-market (BM) is defined as the ratio of book to market value of equity at the end of previous fiscal year; and CAPM beta (BETA) is estimated as the slope coefficient from a time-series regression of monthly stock returns on current and lagged value-weighted market returns, using five years of data.

We further control for three firm-level factors, namely financial leverage, analyst forecast dispersion, and long-term earnings growth. Financial leverage (MKTLEV) is defined as the ratio of total debt to the sum of total debt and market equity; analyst forecast dispersion (DISPERSION) is the natural logarithm of one plus the standard deviation of one-year-ahead earnings-per-share (EPS) forecasts from I/B/E/S[188]; and long-term earnings growth (LTWGRWTH) is the forecasted long-term EPS growth rate from I/B/E/S. These additional controls are motivated by the theoretical work of Hughes et al. (2009) who demonstrate that, given stochastic stock returns, the difference between ICOE and expected return is a function of leverage, cash flow growth, and the volatility of, and correlation between, cash flows and expected returns. In regressions that use ICOE as the dependent variable, controlling for leverage, volatility, and growth thus addresses potential measurement error associated with ICOE (e.g. Campbell et al. (2012), Hann et al. (2013), and Hwang et al. (2013)).

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187 However, as Guay et al. (2011) point out, this leads to potential measurement error for firms without a December fiscal year-end. Specifically, for firms whose fiscal year ends between January and June, their book equity from previous fiscal year may not be available by June; for firms whose fiscal year ends between July and November, their book equity from previous fiscal year may become outdated information by June. We address the issue as part of our final robustness test (see Subsection 6.6.4).

188 Adding one before log-transformation is to avoid losing observations with zero standard deviation, which occurs when there is only one EPS forecast figure during the month.

6.3.4 Descriptive Statistics

Table 6-3 reports descriptive statistics. The distribution of ICOE is slightly right-skewed with a sample mean and median of 9.18 percent and 8.80 percent, respectively. The main test variable, SKILL, has a mean and median of 3.04 and 3.06, respectively. Given that the possible values of SKILL range between 1 and 5, the results indicate that our average firm is relatively high-skilled. With respect to control variables, their properties are largely in line with those reported in previous empirical studies.

Table 6-3 Descriptive Statistics

This table reports descriptive statistics. The dependent variable is firm-specific implied cost of equity (ICOE) based on the residual income model of Gebhardt et al. (2001). The main independent variables is the labour skill index (SKILL). Control variables include: the natural logarithm of market capitalisation (SIZE), book-to-market ratio (BM), CAPM beta (BETA), market leverage (MKTLEV), the dispersion of analysts' earnings forecasts (DISPERSION), and the long-term earnings growth forecast (LTGROWTH). All firm-level controls are winsorised each year at the top and bottom 0.5% of the distribution. Appendix 3 provides details on the control variables. The sample covers 3,314 firms and 24,567 firm-year observations during the period 1990-2014.

Model Variable	Obs.	Mean	Std. Dev.	Percentile				
				p1	p25	p50	p75	p99
Dependent Variable								
ICOE	24,567	9.175	3.438	3.280	7.373	8.796	10.464	18.715
Test Variable								
SKILL	24,567	3.033	0.545	1.734	2.647	3.049	3.490	4.009
Control Variable								
SIZE	24,567	7.077	1.740	3.635	5.837	6.952	8.181	11.583
BM	24,567	0.534	0.380	0.058	0.282	0.448	0.687	1.865
BETA	24,567	1.387	0.829	0.097	0.803	1.243	1.807	4.053
MKTLEV	24,567	0.182	0.186	0.000	0.020	0.131	0.283	0.741
DISPERSION	24,567	0.079	0.118	0.000	0.020	0.039	0.086	0.615
LTGROWTH	24,567	0.161	0.081	0.023	0.112	0.148	0.197	0.477

6.4 Main Results

6.4.1 Estimation Framework

In this section, we examine our main hypothesis that firms relying more on skilled labour incur a higher cost of equity. Specifically, we implement a fixed effects regression model to control for unobserved firm heterogeneity and time-invariant selection bias. The following equation is estimated:

$$\mathrm{ICOE}_{i,j,t} = \beta_0 + \beta_1 \mathrm{SKILL}_{j,t} + \beta_2 \mathrm{CONTROLS}_{i,j,t} + d_t + \eta_i + \varepsilon_{i,j,t,}, \tag{6.1}$$

where i, j and t index firm, industry and year, respectively. The dependent variable is firm-specific ICOE based on Gebhardt et al. (2001). The main test variable is SKILL assigned to the firm's three-digit SIC (or four-digit NAICS) industry. CONTROLS is a vector of control variables described in Subsection 6.3.3, namely: SIZE, BM, BETA, MKTLEV, DISPERSION, and LTGRWTH. d_t, η_i, and $\varepsilon_{ij,t,}$ denote year fixed effects, firm fixed effect, and the random disturbance, respectively. Robust standard errors are calculated and clustered by firms throughout the empirical analysis

6.4.2 Baseline Regression

Table 6-4 reports the results of panel data regression with year fixed effects. We first consider the restricted version of the baseline model in which ICOE is regressed only on SKILL. Column (1) shows a positive and significant coefficient on SKILL (0.411), which supports our hypothesis. Columns (2)-(4) show the regression results as control variables are sequentially added to the model. We continue to find a positive and robust relation between SKILL and ICOE, even after controlling for known risk factors. In Column (4) where the full set of controls is used, the SKILL coefficient (0.388) remains strongly significant at the 1% level, despite reduced magnitude of its point estimate. The F-test (F-stat = 77.32, untabulated) strongly rejects the null hypothesis that the coefficients on all independent variables are jointly zero. The adjusted R-squared of 17.7% indicates that the variables in our baseline model explain a significant part of variation in ICOE. To check that our results are not sensitive to model specification, we rerun the baseline regression in a standard OLS model (Column (5)) and a random effects model (Column (6)), including dummies for major SIC divisions in lieu of individual firms. Our main inferences remain unaltered.

The positive effect of SKILL on ICOE is also economically significant: a one-standard-deviation increase in SKILL creates an associated increase in ICOE of approximately 16.4 basis points. Under reasonable assumptions, this translates into a reduction in firm value of about 3.3%, or $34 million for our median sample firm with a market capitalisation of $1.045 billion[189].

Regarding control variables, ICOE is negatively related to SIZE and positively related to BM. This is consistent with Gebhardt et al. (2001) and Botosan and Plumlee (2005), and confirms the size and value effects originally reported in Fama and French (1992). The coefficients on both BETA and MKTLEV are positive but statistically insignificant[190]. As in previous studies (e.g. Callahan et al. (2012), Hann et al. (2013)), we find that DISPERSION, which reflects information uncertainty (Zhang (2006)), is positively and significantly related to ICOE. Finally, the negative loading on LTGRWTH is similar to that observed by Campbell et al. (2012) and Hann et al. (2013).

Overall, Table 6-4 shows that equity risk, as represented by ICOE, increases with the degree to which firms rely on skilled labour, as represented by SKILL. The results support our main hypothesis (Hypothesis 6.1). We argue, in Section 6.2, that the positive effect of SKILL works through the operating leverage mechanism. Specifically, skilled labour amplifies operating leverage of the firm, by inducing greater wage rigidity and labour adjustment costs. The next section further substantiates this argument.

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189 In obtaining this, we follow the procedure of Chen et al. (2011) and Chen et al. (2013). Specifically, we assume that a constant growth model holds, i.e. $V = \frac{E}{(r-g)}$ (V: firm value; E: expected earnings in year one; r: cost of equity; g: permanent earnings growth rate), with the difference between r and g no greater than 5 percent. Next, we denote V_H (r_H) and V_L (r_L) as the value (cost of equity) of a firm with a high SKILL and that of a firm with a low SKILL, and assume that E and g are the same for both firms. The resulting relation $\frac{V_L}{V_H} = 1 + \frac{(r_H - r_L)}{(r_L - g)}$ implies that $\frac{V_L}{V_H} \geq 1.033$ when $r_H - r_L = 0.164\%$ and $r_L - g \leq 5\%$.

190 In untabulated analysis, we find that after removing SIZE and BM from the regression, BETA and MKTLEV now load positively and significantly. This suggest that their effects on ICOE may be absorbed by the size and value effects.

Table 6-4 Baseline Regression

This table describes panel data regression of implied cost of equity (ICOE) on labour skill index (SKILL) and control variables as previously defined. Columns (1)-(4) shows the results based on a fixed effects model. Column (5) shows the results based on a standard OLS model. Column (6) shows the results based on a random effects model. Year fixed effects are included in all columns. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers 3,314 firms and 24,567 firm-year observations from 1990-2014.

Independent Var.	Fixed Effects				OLS	Random Effects
	(1)	(2)	(3)	(4)	(5)	(6)
SKILL	0.411***	0.366***	0.359***	0.388***	0.201**	0.256***
	(3.898)	(3.727)	(3.673)	(3.972)	(2.110)	(3.275)
SIZE		-0.806***	-0.777***	-0.820***	-0.220***	-0.615***
		(-9.657)	(-8.263)	(-9.068)	(-5.458)	(-10.198)
BM		1.620***	1.535***	1.440***	2.117***	1.535***
		(8.999)	(8.737)	(7.788)	(15.190)	(8.938)
BETA			0.011	0.009	0.111***	0.019
			(0.270)	(0.213)	(2.711)	(0.510)
MKTLEV			0.579	0.496	2.635***	1.193***
			(1.425)	(1.251)	(9.630)	(3.791)
DISPERSION				3.604***	4.371***	3.825***
				(6.440)	(8.170)	(7.270)
LTGROWTH				-0.633	-0.427	-0.853*
				(-1.233)	(-0.850)	(-1.837)
Constant	8.716***	12.483***	12.245***	12.401***	8.768***	12.537***
	(25.113)	(20.425)	(17.958)	(18.734)	(19.520)	(19.355)
Year Effects	Y	Y	Y	Y	Y	Y
Industry Effects	N	N	N	N	Y	Y
Firm Effects	Y	Y	Y	Y	N	N
Observations	24,567	24,567	24,567	24,567	24,567	24,567
Adjusted R^2	0.072	0.165	0.165	0.177	0.208	0.173 (Overall R^2)

6.5 Identification Tests

In this section, we empirically verify the operating leverage mechanism, which we argue underlies the positive effect of SKILL on ICOE. Subsection 6.5.1 examines the relationship between SKILL and the degree of operating leverage, particularly that arising from rigid wages. Subsection 6.5.2 examines the relationship between SKILL and labour adjustment costs.

6.5.1 Operating Leverage due to Labour

As explained in Section 6.2, skilled labour may contribute to operating leverage by increasing fixity of the firm's operating cost structure. Particularly, employment of skilled workers often leads to higher and more rigid wages (i.e. they tend not to be adjusted downwards even during recessions) which are a major cost category.

To get a first impression of how SKILL reduces the sensitivity of firms' operating costs to demand conditions, we calculate the degree of operating leverage (DOL), using the time-series regression method of Mandelker and Rhee (1984) (hereafter, MRDOL). MRDOL measures the elasticity of operating profits with respect to sales, represented by the slope from a time-series regression of log operating profits on log sales, using past ten years of data[191]. A higher MRDOL means that operating profits are more sensitive to demand shocks in terms of sales changes. This indicates greater operating risk, and thus systematic risk. To ensure that MRDOL is robust to the definition of demand shocks, we consider industry- and economy-wide shocks by substituting log industry sales and log GDP, respectively, for log firm sales in the time-series regression (cf. Eisfeldt and Papanikoalou (2013)). All MRDOL estimates are log-transformed to account for outliers.

Each year, we sort the sample firms into SKILL quintiles and calculate time-series mean MRDOL for each of the five portfolios. Table 6-5, Panel A reports the portfolio sorts. As expected, SKILL correlates positively with MRDOL. Specifically, MRDOL is significantly higher for the average high-SKILL firm than for the average low-SKILL firm based on a standard t-test. The result holds regardless of the definition of demand shocks.

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[191] For firms with at least one negative observation of operating profits in a given ten-year interval, we approximate MRDOL by running a similar regression of operating profits on net sales (without log transformation of either variable), and multiplying the slope coefficient by the ratio of average net sales to average operating profits during the same period.

Next, we examine whether SKILL increases operating leverage through rigid wages. Specifically, we follow Chen et al. (2011) and define a measure of operating leverage due to labour (LDOL), by substituting labour costs for operating profits on the left-hand side of the MRDOL equation[192]. The slope coefficient is taken as LDOL. A higher (lower) LDOL means that wages are more (less) responsive to changes in firm sales. LDOL is thus an inverse measure of wage rigidity, which is expected to increase MRDOL. This is because, by increasing the fixity of overall operating costs, wage rigidity makes operating profits more volatile, reflected by a higher MRDOL.

Since U.S. public firms are not required to disclose labour costs in annual reports (Ballester et al. (2002)), LDOL can only be estimated for a small fraction of firms, after excluding those in the financial and regulated industries[193]. To address potential selection bias, we re-estimate LDOL by using industry wage rates (from BLS) to infer firm-level wage costs[194]. In addition, we define an industry-level LDOL (INDLDOL) as the slope from a time-series regression of annual changes in total wages on annual changes in total factor productivity. The estimation of INDLDOL relies on the data for 459 detailed manufacturing industries from the NBER-CES Manufacturing Industry Database[195]. We exploit the long time-series of the database and calculate INDLDOL using alternative rolling window lengths of 10, 20, and 30 years. Despite different estimation procedures, INDLDOL is otherwise interpreted in the same manner as LDOL.

Similar to before, we examine the relation between SKILL and LDOL in a portfolio analysis. Due to data constraints in estimating LDOL, we partition the sample firms each year at median SKILL, rather than applying quintiles. The time-series mean LDOL is computed for both portfolios. The results are presented in Table 6-5, Panel B. As expected, SKILL correlates negatively with LDOL, using both firm and industry data. The difference between the two portfolios is statistically significant at the 1% level. The results are similar

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192 Labor costs are firm-level staff expenses (xlr), which include both wages and benefits. However, benefits are not always counted: where the staff expenses footnote (xlr_fn) shows "XB", it means benefits are excluded from xlr. To ensure that labor costs are limited to wage costs, where xlr_fn does not show "XB", we multiply xlr by the ratio of wages to total compensation in the firm's two-digit SIC industry, using data from the U.S. Bureau of Economic Analysis (BEA).

193 During 1990-2014, 20 percent of all Compustat firms report non-missing xlr for at least one year. Amongst them, roughly 60 percent are in the financial or utilities industries.

194 We supplement BLS data with data from the NBER-CES Manufacturing Industry Database (http://www.nber.org/nberces/), which compiles production-related information for detailed manufacturing industries at four-digit SIC (or six-digit NAICS) level during 1958-2011.

195 This approach is inspired by Donangelo (2014) who uses broad industry data (114 industries in total), instead, from the KLEMS/BLS database.

at the industry level[196], i.e. SKILL is negatively related to INDLDOL. Moreover, the difference in mean INDLDOL between "High" and "Low" portfolios becomes more significant as a longer rolling window is used in the regression. This is reassuring, since a longer rolling window potentially yields more accurate estimates of INDLDOL, by smoothing out irregular trends over shorter periods.

Overall, the evidence above shows that skilled labour may contribute to firm-level operating leverage, thus systematic risk, through sticky wage costs. This is not the only component of labour-induced operating leverage, however. As explained in Section 6.2, costly labour adjustment may also increase operating leverage. This is because firms are less able to adapt their workforce to the current economic environment. The next subsection investigates the link between SKILL and labour adjustment costs.

[196] We first match the SKILL data (based on three-digit SIC) to detailed manufacturing industries (based on four-digit SIC), before repeating the rest of the estimation procedure.

Table 6-5 Labour Skill Index and Degree of Operating Leverage

Panel A compares mean degree of operating leverage based on Mandelker and Rhee (1984) (MRDOL) across five portfolios of firms sorted on the labour skill index (SKILL). Three types of demand shocks are considered in estimating MRDOL: firm-level, industry-level, and economy-wide. All MRDOL estimates are log-transformed to reduce skewness in the data. Panel B compares mean degree of operating leverage due to labour (LDOL) between two portfolios of firms sorted on SKILL. The first two columns show LDOL based on Chen et al. (2011) (LDOL_CKO). Both firm and industry wage rates are used in estimating LDOL_CKO. The last three columns show an industry-level measure of LDOL (LDOL_IND), estimated for a subsample of detailed manufacturing industries. The last row in both Panel A and Panel B reports the t-statistic for the difference in means between high- and low-SKILL portfolios. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A. SKILL and the degree of operating leverage

SKILL Portfolio	MRDOL		
	Firm Shock	Industry Shock	Economy Shock
Low	0.292	0.524	0.747
	[0.012]	[0.015]	[0.016]
2	0.337	0.627	0.830
	[0.013]	[0.015]	[0.015]
3	0.399	0.800	1.084
	[0.015]	[0.016]	[0.016]
4	0.332	0.854	1.106
	[0.015]	[0.016]	[0.016]
High	0.435	0.883	1.235
	[0.015]	[0.018]	[0.018]
t-stat (High-Low)	7.366***	15.491***	20.918***

Panel B. SKILL and the degree of operating leverage due to labour

SKILL Portfolio	LDOL_CKO		LDOL_IND		
	Firm Wage Rate	Industry Wage Rate	10-yr	20-yr	30-yr
Low	-0.270	-0.332	0.155	0.119	0.095
	[0.015]	[0.005]	[0.006]	[0.005]	[0.004]
High	-0.343	-0.399	0.108	0.072	0.057
	[0.018]	[0.006]	[0.006]	[0.004]	[0.003]
t-stat (High-Low)	-3.217***	-8.037***	-5.463***	-7.545***	-7.558***

6.5.2 Skilled Labour and Turnover Costs

A major problem in testing the theories about labour adjustment costs is that data for them are often unavailable. To quantify the link between SKILL and labour adjustment costs, we follow Dolfin (2006) and Ochoa (2013) and utilise the 1980 survey (the latest available version) from the Employment Opportunities Pilot Project (EOPP)[197]. The EOPP survey provides detailed information from nearly 6,000 employers about their most recent recruitment. This includes both the characteristics of the new hire, and various types of costs incurred during the hiring process.

Following Ochoa (2013), we define four variables as proxies for the costs of replacing an average worker: the number of days between the beginning of recruitment and the time the new employee starts work (RECRUIT), the number of applicants interviewed (INTERVIEW), total hours spent on training the new employee during her first month of employment (TRAINING)[198], and productivity loss (PRODLOSS), measured as the difference between the productivity of the new employee during her second week of employment and that of her predecessor.

As EOPP survey also provides detailed SIC codes, we match SKILL to the respondent firms based on their SIC industry. This allows us to make cross-sectional comparison between SKILL and the replacement cost proxies above. The results should be treated with caution, however, due to outdatedness of the survey. As we are unable to calculate SKILL prior to 1990, we resort to linking the 1990 SKILL data to the 1980 EOPP survey. This is justifiable to the extent that changes in SKILL generally follow a smooth trend (see Table 3.3). For the purpose of this analysis, we assume that the most recent vacant position at high-skilled firms is, on average, relatively skilled.

Table 6-6, Panel A presents descriptive statistics of the four measures of labour adjustment costs. The figures closely resemble those reported in Ochoa (2013, p.38). An average employer that recently filled a vacancy spent 18 days on the recruitment process, interviewed 5 applicants, and spent 33 hours orienting the new recruit during her first month of employment. Moreover, during her second week of employment, the new hire was on average 15.7% less productive than her predecessor.

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[197] The EOPP data are available from the Cornell Institute for Social and Economic Research at Cornell University (https://www.ciser.cornell.edu/asps/search_athena.asp?IDTITLE=427).

[198] As in Ochoa (2013), we sum the hours spent by both HR and non-HR staff on training the new recruit.

Next, we examine the relationship between SKILL and labour adjustment costs. Each year, we partition the sample firms at median SKILL, and calculate time-series means of replacement cost proxies for both SKILL portfolios. Table 6-6, Panel B reports the portfolio sorts. Consistent with prediction, we find that the cost of replacing an average employee increases with the skill level of the firm's labour force.

The results in this subsection suggest that skill-intensive firms incur higher labour adjustment costs. These contribute to operating leverage in pretty much the same way as capital adjustment costs, discussed in the investment-based asset pricing research.

Taken together, the evidence presented in both Subsections 6.5.1 and 6.5.2 supports our hypothesis that firms' reliance on skilled labour translates into a form of labour-induced operating leverage, which underlies higher equity risk.

Table 6-6 Labour Skill Index and Labour Adjustment Costs

Panel A presents descriptive statistics of replacement cost proxies. These include the number of days lapsed during the recent recruitment (RECRUIT), the number of applicants interviewed for the position (INTERVIEW), the number of hours spent training the new hire during her first month of employment (TRAINING), and the difference between the productivity of the new hire during her second week of employment and her predecessor on the job (PRODGAP). Panel B compares the mean hiring costs between two portfolios of firms sorted on SKILL. The t-test results are reported in the last row. *, ** and *** denote statistical significance at 10%, 5% and 1% level, respectively.

Panel A. Descriptive statistics of hiring cost proxies

Variable	Obs.	Mean	Std. Dev.	Percentile		
				p25	p50	p75
RECRUIT	2,487	17.87	36.77	4.00	7.00	14.00
INTERVIEW	3,606	4.62	8.84	0.00	2.00	5.00
TRAINING	3,473	32.80	36.95	5.00	20.00	45.00
PRODGAP	3,568	15.71	18.79	0.50	15.00	25.00

Panel B. Portfolio sorts

Skill Portfolio	SKILL	Hiring Cost Proxies			
		RECRUIT	INTERVIEW	TRAINING	PRODGAP
Low	2.15	15.03	4.04	29.41	14.81
High	3.12	20.78	5.04	36.43	16.65
High-Low		5.75	1.01	7.02	1.84
t-value (High-Low)		3.71***	3.41***	5.37***	2.81***

6.6 Robustness Tests

We perform four additional tests to extend our results. These include: an interaction analysis which examines the moderating effect of retention proxies (Subsection 6.6.1); subsample tests which partition the sample firms based on two criteria: indebtedness and broad-based employee ownership (Subsection 6.6.2); addressing measurement error in the labour skill index by estimating alternative proxies, and running an industry-level regression (Subsection 6.6.3); and, finally, addressing measurement error in the implied cost of equity by considering a range of alternative estimation models (Subsection 6.6.4).

6.6.1 Interaction Analysis

Estimating our baseline model in a fixed effects framework captures within- or cross-firm variations, thus controlling for firm heterogeneity that remains fixed over time. While this addresses omitted variable bias, we cannot completely rule out the possibility of correlated omitted variables that are time-variant. To ensure that our results are not spurious, we examine cross-sectional variation in labour skill premium caused by retention needs. Specifically, we predict that increased pressure to retain employees constrains firms' ability to cut jobs or lower wages. This exacerbates labour-induced operating leverage, reflected by the positive effect of SKILL on ICOE.

To test the prediction, we interact SKILL in Equation (6.1) with three retention proxies. The first proxy is organisation capital (ORGCAP), estimated using the perpetual inventory method of Eisfeldt and Papanikolaou (2013, 2014). Specifically, we construct ORGCAP recursively using firm-level selling, general, and administrative expenses, and scale it by total assets[199]. The second proxy is unionisation (UNION), defined as the share of unionised workers in the firm's Census industry. The third proxy is the non-compete agreement enforcement index (NONCOMP) from Garmaise (2011), which measures the enforceability of non-compete agreements across U.S. states from 1990-2006.

We expect ORGCAP and UNION to positively moderate the SKILL-ICOE relationship. With respect to ORGCAP, as firms invest in organisation capital, they become more vulnerable to the loss of employees in whom organisation capital is embedded. This applies particularly to knowledge firms where intangible assets are the primary driver of

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[199] See Chapter 5, Subsection 5.7.2 for more detail.

competitive advantage. With respect to UNION, an increased ability to exert collective pressure strengthens the bargaining power of employees. This again may force the hand of knowledge firms more, given the relatively high costs of industrial action and the scarcity of skilled workers.

Regarding the retention implications of NONCOMP, two opposing arguments can be made. On the one hand, firms in states that rigorously enforce non-compete agreements may perceive less turnover threat, thus retention needs (cf. Kedia and Rajgopal (2009))[200]. On the other hand, they may feel compelled to step up retention/engagement to address talent migration to other states (cf. Marx et al. (2015)). Both scenarios are particularly relevant for knowledge firms, due to their emphasis on human capital. Ex ante, we do not make prediction about the direction of the moderating effect of NONCOMP.

Table 6-7 presents the baseline regression with interaction terms[201]. As in Table 6.4, SKILL loads positively and significantly in all columns. Of more interest here, however, are the interaction effects. All three interaction terms (i.e. SKILL×ORGCAP, SKILL×UNION, and SKILL×NONCOMP) yield a positive and significant coefficient. The results suggest that the effect of SKILL on ICOE is more pronounced for firms for which employee retention is particularly urgent, either due to external pressure (UNION and NONCOMP) or internal pressure (ORGCAP).

The evidence above adds robustness to our main results, by reducing concerns about omitted variables. This is because such variables will now need to explain not only the positive effect of SKILL on ICOE, but its variation across firms, as reported in Table 6-7.

200 However, where strict enforcement of non-competes leads firms to undertake more risky projects such as R&D (e.g. Conti (2014)), the threat of turnover and employee disengagement becomes real again.

201 SKILL, ORGCAP, UNION, and NONCOMP are centered each year (i.e. the annual mean of these variables to zero) before forming interaction terms.

Table 6-7 Interaction Analysis

This table shows the baseline regression incorporating interaction terms. Implied cost of equity (ICOE) is regressed on the labour skill index (SKILL), its interaction terms with retention proxies, and control variables as previously defined. The interacting variables include: the level of organisation capital (ORGCAP), the proportion of unionised workers in the firm's Census industry (UNION), and the non-compete agreement enforcement index (NONCOMP) for the firm's headquarters state from 1990-2006. Year fixed effects are included in all columns. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 3,314 firms and 24,567 firm-year observations during the period 1990-2014.

Independent Variable	Interacting Variables		
	ORGCAP	UNION	NONCOMP
	(1)	(2)	(3)
SKILL	0.351***	0.514***	0.257**
	(3.367)	(4.175)	(2.276)
ORGCAP	-2.927***		
	(-5.944)		
SKILL×ORGCAP	0.746*		
	(1.766)		
UNION		3.233***	
		(2.948)	
SKILL×UNION		4.351**	
		(2.078)	
NONCOMP			-0.118
			(-1.521)
SKILL×NONCOMP			0.133***
			(2.742)
SIZE	-0.924***	-0.849***	-1.481***
	(-8.948)	(-9.453)	(-12.155)
BM	1.392***	1.402***	0.635***
	(6.583)	(7.478)	(2.889)
BETA	0.033	0.015	-0.086
	(0.787)	(0.364)	(-1.610)
MKTLEV	0.209	0.482	-0.060
	(0.470)	(1.214)	(-0.126)
DISPERSION	3.636***	3.749***	3.646***
	(6.026)	(6.512)	(5.915)
LTGROWTH	-0.798	-0.515	0.428
	(-1.634)	(-1.052)	(0.496)
Constant	14.191***	13.815***	17.737***
	(20.063)	(21.951)	(21.921)
Year Effects	Y	Y	Y
Observations	22,284	24,178	12,958
Number of firms	3,017	3,260	2,590
Adjusted R-squared	0.187	0.179	0.185

6.6.2 Subsample Analysis

Thus far in the analysis, we have found general support for our hypothesis that equity risk, in terms of cost of equity capital, increases with the degree to which firms rely on skilled labour. This raises the question: can firms do anything to mitigate skilled labour risk? This subsection examines the influence of two factors across firms: first, the level of indebtedness; and second, the use of broad-based employee ownership (BBEO).

Consider first the level of indebtedness. Based on the idea that operating and financial risk interact to determine firms' exposure to systematic risk, we expect the positive SKILL-ICOE relationship to be more pronounced for more indebted firms. This is because the operating leverage effect, associated with skilled labour, is amplified by financial leverage (Bhattacharjee et al. (2015)). To test this prediction, we define three proxies for indebtedness: market leverage, book leverage, and interest expense scaled by assets. Each year, we partition the sample firms at the median of these proxies, and run the baseline regression for the resulting three pairs of subsamples.

Table 6-8, Panel A reports the regression results. As predicted, the point estimate of SKILL is consistently larger for the subsample of high-debt firms (Columns (2), (4), and (6)) than for the subsample of low-debt firms (Columns (1), (3), and (5)). It otherwise yields the correct sign and is statistically significant across all columns. An implication of the findings is that, skill-intensive firms could hedge against skilled labour risk by borrowing less. This builds on the trade-off hypothesis (van Horne (1977)) that managers actively balance between operating and financial leverage, through combining different policies related to the asset and capital structure of the firm. This allows them to achieve a desired degree of overall leverage and thus firm risk.

In a similar spirit to Chapter 4, we next examine whether and, if so, how BBEO affects the cost-of-equity effect of skilled labour. Two scenarios are possible. First, employees in BBEO firms may be more willing to countenance pay cuts during economic downturns. This implies less sticky wages, which lead to reduced operating leverage, and therefore systematic risk of the firm's stock. The rationale is that BBEO aligns the interests of employees and shareholders, while also fostering long-term perspectives and a broader performance focus (e.g. Pendleton (2006)). This increases the likelihood of employees sacrificing part of their contractual claims (i.e. wages and benefits) for the sake of the firm.

Second, BBEO may, instead, add to wage rigidity. This exacerbates operating leverage due to labour, especially for high-skilled firms. The rationale is that employees may exploit their corporate governance rights (in the form of voting rights or board representation), granted by BBEO, and maximise the combined value of their residual and contractual claims (Faleye et al. (2006)). Given that employees tend to prioritise contractual claims, which form the major part of their wealth, they are likely to focus primarily on protecting their human capital and ensuring that their current pay level is maintained (cf. Jensen and Meckling (1979)). Voluntary investment in firm stock by employees, particularly through 401(k) plans, may further induce a sense of entitlement, leading to expectations of greater workplace benefits (Dunford et al. (2015))[202]. This potentially makes wage cuts more difficult in employee ownership firms. Moreover, self-serving managers may use BBEO to garner voting support from employees (Pagano and Volpin (2005)). In return, they might promise higher wages or refrain from future wage cuts.

The discussion above suggests that ex ante, no clear prediction can be made about BBEO's implications for skilled labour risk. In the current test, we follow previous chapters and define BBEO in relation to firm stock held in defined contributions (DC) plans. The data on DC plans are from annual Form 5500 reports[203]. We consider the influence of BBEO in two related ways. First, we divide the sample firms each year based on whether they provide BBEO. Second, we remove sample firms with zero BBEO, and partition the rest annually at the median BBEO. The level of BBEO is defined, alternatively, as the aggregate value of firm stock in DC plans scaled by total employees, DC plan assets, and the firm's equity market value. The baseline regression is estimated for each of the four pairs of subsamples.

The results, presented in Table 6-8, Panel B, are stark. While SKILL loads positively throughout, its point estimate is markedly larger for the BBEO subsample (Column (2)) than for the non-BBEO subsample (Column (1)). Similarly, amongst firms with BBEO, the positive coefficient on SKILL is more pronounced for the high-BBEO subsamples (Columns (4), (6), and (8)) than for the low-BBEO subsamples (Columns (3), (5), and (7)). The findings contrast with, but do not necessarily contradict, those in Chapter 4. Whereas BBEO negatively moderates the effect of skilled labour on idiosyncratic risk, it positively moderates the effect of skilled labour on systematic risk, which underlies the cost of equity. The latter may reflect the fact that BBEO, as a variable form of employee compensation, often complements rather than substitutes for fixed wages. Indeed, it might even lead to

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202 As cited on the Academy of Management website (http://aom.org/News/Press-Releases/Buying-company-stock-increases-workers%E2%80%99-sense-of-responsibility-to-boost-profits-%E2%80%93-but-also-fosters-feelings-of-entitlement,-study-finds.aspx) and in Economist (2015).

203 See Chapter 4, Subsection 4.3.3 for more detail

wages becoming more rigid, thus less responsive to demand shocks. Hence greater exposure of the firm's stock to systematic risk.

Table 6-8 Subsample Analysis

This table reports the results of subsample analysis. In Panel A, firms are partitioned each year by the median of market leverage (Columns (1)-(2)), book leverage (Columns (3)-(4)), and interest expense scaled by book assets (Columns (5)-(6)). The baseline regression is repeated for each of the three pairs of subsamples. In Panel B, firms are divided each year into two groups, those with broad-based employee ownership (BBEO) through defined contribution (DC) plans, and those without (Columns (1)-(2)). For firms with positive BBEO, they are partitioned each year by the median value of BBEO. The level of BBEO is defined in three alternative ways: the aggregate value of firm stock in DC plans scaled by total employees (Columns (3)-(4)), by DC plan assets (Columns (5)-(6)), or by the firm's equity market value (Columns (7)-(8)). The baseline regression is repeated for each of the four pairs of subsamples. Year fixed effects are included in all regressions. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 3,314 firms and 24,567 firm-year observations during the period 1990-2014.

Panel A. Partitioning the sample based on the level of indebtedness

Independent Variable	Market Leverage		Book Leverage		Interest Expense	
	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
SKILL	0.347**	0.498***	0.291**	0.628***	0.237*	0.544***
	(2.287)	(4.027)	(2.111)	(4.909)	(1.655)	(3.455)
SIZE	-1.024***	-0.719***	-1.069***	-0.751***	-1.032***	-0.724***
	(-10.520)	(-3.968)	(-12.745)	(-4.062)	(-11.022)	(-4.330)
BM	0.830***	1.596***	0.617***	1.548***	0.861***	1.591***
	(4.275)	(6.599)	(3.879)	(5.817)	(3.876)	(6.299)
BETA	-0.054	0.058	-0.075	0.045	0.002	0.073
	(-1.149)	(0.856)	(-1.562)	(0.653)	(0.043)	(1.035)
MKTLEV	2.635***	-0.351	1.900***	0.262	1.482***	0.075
	(3.205)	(-0.469)	(3.306)	(0.326)	(2.805)	(0.109)
DISPERSION	4.385***	3.314***	3.630***	3.524***	2.949***	3.653***
	(6.194)	(4.860)	(5.955)	(5.260)	(3.769)	(5.347)
LTGROWTH	-0.062	-0.983	-0.471	-1.202	-0.768	-0.781
	(-0.093)	(-1.394)	(-0.884)	(-1.552)	(-1.264)	(-0.998)
Constant	13.227***	12.409***	14.021***	11.905***	13.739***	12.064***
	(17.483)	(9.422)	(21.907)	(8.512)	(18.603)	(10.713)
Year Effects	Y	Y	Y	Y	Y	Y
Observations	12,290	12,277	12,290	12,277	11,486	11,471
Number of firms	2331	2159	2377	2141	2255	2081
Adjusted R-squared	0.159	0.183	0.180	0.180	0.214	0.185

Panel B. Partitioning the sample based on broad-based employee ownership

Independent Variable	Presence of BBEO		Per employee		% DC assets		% Market Equity	
	No	Yes	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SKILL	0.126	0.847***	0.369**	1.866***	0.386	1.162***	0.545**	1.364**
	(0.808)	(3.784)	(2.266)	(2.874)	(1.595)	(2.803)	(2.477)	(2.391)
SIZE	-1.016***	-0.881***	-1.252***	-0.400	-1.183***	-0.720***	-0.972***	-0.771***
	(-9.517)	(-6.266)	(-7.676)	(-1.537)	(-6.587)	(-2.633)	(-6.614)	(-2.854)
BM	1.178***	1.403***	0.834***	2.138***	1.151***	1.766***	1.729***	1.289***
	(3.316)	(5.578)	(2.966)	(7.969)	(3.392)	(4.621)	(7.253)	(4.327)
BETA	0.005	0.015	-0.073	0.183*	-0.031	0.085	0.130	0.062
	(0.078)	(0.210)	(-0.689)	(1.896)	(-0.274)	(0.951)	(1.532)	(0.692)
MKTLEV	0.496	0.268	-0.147	0.641	-0.302	0.866	-0.438	1.130
	(0.936)	(0.402)	(-0.271)	(0.453)	(-0.501)	(0.592)	(-0.677)	(0.923)
DISPERSION	2.188**	3.613***	3.395**	3.781***	3.679***	2.932***	4.046***	3.038***
	(2.232)	(4.722)	(2.237)	(3.776)	(3.130)	(2.677)	(4.322)	(2.697)
LTGROWTH	0.540	-0.929*	-0.981	-0.527	-1.442*	-0.440	-0.230	-0.859
	(0.831)	(-1.833)	(-1.234)	(-0.849)	(-1.885)	(-0.644)	(-0.328)	(-1.420)
Constant	13.883***	11.506***	15.316***	4.454	15.437***	8.670***	12.381***	9.194**
	(16.532)	(7.945)	(12.492)	(1.201)	(11.055)	(2.851)	(9.508)	(2.577)
Year Effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	10,189	7,735	3,874	3,861	3,874	3,861	3,874	3,861
Number of firms	2,067	1,193	845	695	849	689	823	676
Adjusted R-squared	0.173	0.255	0.306	0.227	0.292	0.222	0.289	0.246

6.6.3 Measurement Error: Labour Skill Index

The use of industry-level SKILL as proxy for firm-level reliance on skilled labour represents the major limitation of this chapter as well as preceding ones. This is because it introduces measurement error into the regression model. In particular, we are concerned that the positive coefficient on SKILL, observed thus far in the analysis, may have been overstated. This would have biased our results in favour of the main hypothesis. In this subsection, we address this possibility by adopting two approaches, as outlined below.

First, as in previous chapters[204], we substitute alternative proxies for SKILL in the baseline regression. The first proxy is the adjusted labour skill index, SKILL2, which resembles SKILL but without wage inputs in Equation (3.1)[205]. The second and third proxies, INDWAGE and FIRMWAGE, are the log-transformed mean (annual) wage per employee at the industry- and firm-level, respectively. This is based on the assumption of positive returns to skill in terms of employee compensation. Whereas using INDWAGE leaves the sample size unchanged, keeping non-missing FIRMWAGE results in a much reduced sample of 2,373 observations due to data restrictions (see Subsection 6.5.1).

Table 6-9, Panel A reports the regression results using alternative labour skill proxies. Our main inferences are qualitatively unchanged, indicated by the positive and significant coefficients on SKILL2 (0.661), INDWAGE (0.920) and FIRMWAGE (0.207). Inspecting the effects of INDWAGE and FIRMWAGE suggests that, a 10 percent increase in the industry (firm) wage rate is associated with an 8.8 (2.0) percent increase in ICOE, which is economically significant.

Second, we re-estimate Equation (6.1) at the industry level. Specifically, we collapse all firm-specific variables in the model (i.e. ICOE, SIZE, B/M, BETA, MKTLEV, DISPERSION, and LTGRWTH) into three-digit SIC industry averages, on both equal- and value-weighted basis. The value-weighted approach potentially yields more reliable estimates, by avoiding overweighting small-capitalisation firms. The recalibration results in a narrower sample of 3,850 industry-year observations across 199 three-digit SIC industries from 1990-2014. We control for year fixed effects in the regression, and cluster robust standard errors by three-digit SIC industries.

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[204] See Chapter 4, Subsection 4.6.3 and Chapter 5, Subsection 5.7.4.

[205] See Section 3.2 for more detail.

Table 6-9, Panel B reports the industry-level regression results. Columns (1)-(2) show the equal-weighted regression estimates, while Columns (3)-(4) show the value-weighted regression estimates. Consistent with the firm-level evidence, SKILL loads positively and significantly, both alone and after including the complete set of control variables. The magnitude of SKILL loading is more pronounced in the value-weighted specification than in the equal-weighted specification. The direction and significance levels of control variables are mostly in line with those in Table 6-4.

Taken together, the evidence above lends further support to our baseline results, by mitigating concerns about measurement error in SKILL.

Table 6-9 Measurement Error in Labour Skill Index

Panel A repeats the baseline regression using alternative labour skill proxies. Column (1) shows the adjusted labour skill index (SKILL2). Column (2)-(3) show the mean annual wage for the industry (INDWAGE) and the firm (FIRMWAGE), respectively. Panel B reruns the baseline model at the industry level, by collapsing all firm variables into three-digit SIC industry averages. Columns (1)-(2) show the results based on equal-weighted variables; Columns (3)-(4) show the results based on value-weighted variables. Year fixed effects are included in all regressions. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. In Panel A, the full sample covers 3,314 firms and 24,567 firm-year observations from 1990-2014. In Panel B, the full sample covers 199 three-digit SIC industries and 3,850 industry-year observations from 1990-2014.

Panel A. Alternative measures of firms' reliance on skilled labour

Independent Variable	Alternative Labour Skill Proxies (SKILL')		
	SKILL2	INDWAGE	FIRMWAGE
	(1)	(2)	(3)
SKILL'	0.661***	0.920***	0.207*
	(3.409)	(5.177)	(1.774)
SIZE	-0.818***	-0.831***	-1.366***
	(-9.048)	(-9.230)	(-6.757)
BM	1.442***	1.431***	1.133***
	(7.802)	(7.759)	(2.764)
BETA	0.009	0.009	-0.017
	(0.236)	(0.215)	(-0.126)
MKTLEV	0.476	0.504	-0.033
	(1.201)	(1.273)	(-0.045)
DISPERSION	3.645***	3.560***	1.081
	(6.479)	(6.407)	(0.876)
LTGROWTH	-0.625	-0.584	0.190
	(-1.220)	(-1.136)	(0.226)
Constant	11.731***	4.203**	15.371***
	(14.941)	(2.125)	(9.260)
Observations	24,567	24,567	2,373
Number of firms	3,314	3,314	331
Adjusted R-squared	0.178	0.178	0.312

Panel B. Industry-level regression

Independent Variable	Equal-weighted		Value-weighted	
	(1)	(2)	(3)	(4)
SKILL	0.495*	0.411*	0.688**	0.600**
	(1.926)	(1.670)	(2.319)	(2.205)
SIZE		-0.341*		-0.229
		(-1.912)		(-1.218)
BM		2.135***		2.711***
		(5.122)		(5.530)
BETA		0.361**		0.336**
		(2.148)		(2.038)
MKTLEV		1.502**		1.567
		(2.022)		(1.493)
DISPERSION		2.519***		4.196***
		(3.212)		(3.593)
LTGROWTH		-1.203		-1.962
		(-0.884)		(-1.371)
Constant	8.686***	8.339***	7.841***	6.814***
	(12.657)	(4.365)	(9.912)	(3.387)
Observations	3,850	3,850	3,850	3,850
Number of industries	199	199	199	199
Adjusted R-squared	0.120	0.264	0.084	0.221

6.6.4 Measurement Error: Implied Cost of Equity

While ICOE is considered a closer approximation of the true, unobservable cost of equity than measures based on realised returns, its estimation is not free from bias. In particular, measurement error may arise from inaccurate analysts' earnings forecasts or parameter assumptions across different ICOE models (Botosan and Plumlee (2005), Easton and Monahan (2005), and Guay et al. (2011)). In this subsection, we addresses potential measurement error in ICOE using three approaches. These are described below.

First, we respond to the concern that fixing the ICOE estimation to June each year may cause problems for firms without a December fiscal year-end. This is because their book equity from previous fiscal year may either be unavailable or outdated by June[206]. Specifically, we employ two methods: first, keeping only firms whose fiscal year ends in December (FYE=12); and second, estimating ICOE at the fiscal year-end plus six months for all firms (FYE+6), regardless of their fiscal year-end month.

Second, we implement three modified versions of the Gebhardt et al. (2001) model: in two of them, we substitute regression-based earnings forecasts for analyst forecasts in the model, following the techniques of Hou et al. (2012) (HDZ) and Tang et al. (2014) (TWZ); in the third, we retain analyst forecasts, but correct for possible sluggishness using the portfolio approach of Guay et al. (2011) (GKS).

Third, we implement five alternative ICOE models proposed in the literature: the residual income model by Claus and Thomas (2001) (CT); the abnormal earnings model by Gode and Mohanram (2003) (GM); the finite-horizon model by Gordon and Gordon (1997) (GG); the price-to-earnings growth ratio, as operationalized by Botosan and Plumlee (2005) (PEG); and a benchmark price-to-forward earnings ratio (PE Ratio)[207].

Table 6-10 reports the regression results using alternative ICOE definitions. Reassuringly, SKILL yields the correct sign in all columns, and remains statistically significant with respect to all but one specifications of ICOE. The magnitude of the coefficient estimate is also in line with the baseline results. Overall, the evidence presented in Table 6-10 confirms that our findings are not sensitive to the estimation of ICOE.

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206 See footnote 188 in Subsection 6.3.2 for more detail

207 Appendix 4 details the alternative ICOE models implemented for the current test.

Table 6-10 Alternative Measures of Implied Cost of Equity

This table addresses potential measurement error in implied cost of equity (ICOE). In Column (1), the baseline regression is rerun for firms with a December fiscal year-end (FYE=12). In Column (2), ICOE is estimated at the fiscal year-end plus six months (FYE+6), regardless of the fiscal year-end month. In Columns (3)-(5), the Gebhardt et al. (2001) model is modified using the methods of Hou et al. (2012) (HDZ), Tang et al. (2014) (TWZ), and Guay et al. (2011) (GKS), respectively. In Columns (6)-(10), five different ICOE models are implemented: the residual income model of Claus and Thomas (2001) (CT); the abnormal earnings model of Gode and Mohanram (2003) (GM); the finite-horizon model of Gordon and Gordon (1997) (GG); the price-earnings growth ratio (PEG) as operationalised in Botosan and Plumlee (2005); and a benchmark price-earnings ratio (PE Ratio). See Appendix 4 for details on alternative measures of ICOE. Year fixed effects are included in all regressions. Robust t-statistics are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The full sample covers 3,314 firms and 24,567 firm-year observations during the period 1990-2014.

Independent Var.	FYE=12	FYE+6	Modified Gebhardt et al. (2001) Model			Alternative ICOE Models				
			HDZ	TWZ	GKS	CT	GM	GG	PEG	PE Ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SKILL	0.501***	0.390***	0.358***	0.355***	0.335***	0.306***	0.144	0.300**	0.279**	0.364***
	(3.085)	(3.832)	(3.196)	(3.039)	(2.690)	(2.804)	(1.381)	(2.484)	(2.100)	(2.623)
SIZE	-0.632***	-0.710***	-1.355***	-1.078***	-0.450***	-0.939***	-1.355***	-1.092***	-1.183***	-0.772***
	(-4.487)	(-7.888)	(-16.351)	(-12.850)	(-3.842)	(-9.534)	(-12.178)	(-10.039)	(-12.023)	(-7.513)
BM	1.637***	1.372***	2.038***	3.300***	1.370***	-1.003***	0.104	-0.720***	-0.806***	-0.942***
	(7.761)	(8.491)	(9.024)	(12.227)	(6.270)	(-6.107)	(0.580)	(-4.128)	(-3.866)	(-5.484)
BETA	0.081	0.027	-0.169***	-0.340***	0.008	-0.059	-0.054	-0.129**	-0.040	-0.256***
	(1.518)	(0.696)	(-4.026)	(-7.501)	(0.139)	(-1.241)	(-1.138)	(-2.491)	(-0.611)	(-4.440)
MKTLEV	0.661	0.727*	-1.021**	-3.876***	0.635	1.921***	3.224***	2.200***	1.325***	0.879*
	(1.117)	(1.810)	(-2.433)	(-10.140)	(1.286)	(4.181)	(6.340)	(4.369)	(2.723)	(1.925)
DISPERSION	3.420***	3.116***	2.795***	2.384***	2.996***	2.638***	6.643***	3.551***	3.660***	4.191***
	(4.380)	(5.538)	(6.927)	(5.986)	(4.682)	(4.132)	(7.976)	(4.959)	(4.294)	(5.733)
LTGROWTH	-0.667	-1.167**	-5.717***	-5.824***	-1.063	8.603***	10.762***	7.988***	35.036***	-5.051***
	(-1.069)	(-2.295)	(-10.260)	(-9.726)	(-1.631)	(11.181)	(13.594)	(9.621)	(27.621)	(-8.515)
Constant	10.886***	12.037***	15.029***	12.664***	9.758***	15.255***	19.565***	14.535***	14.198***	11.894***
	(10.372)	(18.354)	(23.429)	(19.139)	(10.944)	(21.885)	(24.382)	(19.024)	(19.232)	(14.287)
Year Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs.	15,208	24,447	22,963	22,784	20,032	24,037	22,648	24,188	23,967	23,061
No. Firms	2,155	3,298	3,196	3,196	3,002	3,286	3,124	3,288	3,291	3,137
Adj. R^2	0.162	0.165	0.264	0.260	0.090	0.197	0.232	0.142	0.310	0.095

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6.7 Conclusion

This chapter examines the relationship between firms' reliance on skilled labour and the cost of equity capital. We argue that as firms invest more heavily in skilled labour, their operating structure becomes less flexible due to rigid wages and costly labour adjustment. This raises the volatility of residual cash flow, and therefore equity risk premium. To verify this, we construct a labour skill index that captures the average skill level of an industry, and find that firms operating in more skilled industries incur a higher implied cost of equity. The positive coefficient on labour skill index remains both statistically and economically significant, even after controlling for known risk factors.

We perform a number of tests to extend our main results. First, portfolio-level analysis shows that labour skill index correlates positively with proxies of operating leverage, wage rigidity, and hiring costs. This supports our contention that skilled labour increases operating leverage of the firm, particularly by influencing labour costs. This amplifies the firm's systematic risk exposure, leading to a higher cost of equity.

Second, we find that the cost-of-equity effect of skilled labour is positively moderated by retention needs faced by the firm. These may be linked to the firm's stock of organisation capital, as embedded in key workers; the level of unionisation in the firm's industry; and the enforcement of non-compete agreements in the firm's state.

Third, subsample tests show that the positive effect of labour skill index is more pronounced for highly indebted firms, indicating a positive interaction between operating and financial leverage in affecting equity risk. Perhaps surprisingly, the effect is also markedly stronger for firms with broad-based employee ownership in terms of both its presence and level. We interpret the results to suggest that employee ownership may increase fixity in wage claims, thus exacerbating operating leverage due to labour.

Finally, we provide evidence that our main results are generally robust to measurement error in both labour skill index and implied cost of equity.

Our paper advances the literature in two respects: First, we show that skilled labour intensity constitutes another labour-related source of operating leverage, which increases systematic risk and thus cost of equity. An important implication of our research is that firms need not be capital intensive to incur high operating leverage, as implied by investment-based asset pricing research. Specifically, firms that invest heavily in skilled labour but remain capital-light – as is the case for most high-technology start-ups and new economy firms – may also experience reduced operating flexibility due to significant employment costs. Second, our results highlight the riskiness of investment in skilled labour, which must be balanced against its otherwise value-enhancing potential. This is particularly relevant as intellectual human capital is increasingly emphasised as the main source of growth in the knowledge economy. How a firm can mitigate skilled labour risk so as to optimise returns on human capital investment remains an interesting topic for future research.

7 Discussion and Conclusion

7.1 Thesis Background

The global shift towards a knowledge economy has made the acquisition and development of superior human capital, often embodied in highly educated and skilled workers, increasingly central to firm viability and success. Despite potential strategic benefits, investing in skilled labour is costly and not without risk to firms. Specifically, the characteristics which render human capital a critical firm resource also create significant management challenges. Empirical evidence on the implications of these challenges, however, has been lacking.

A main purpose of this thesis is to substantiate the trade-off of employing skilled labour, by quantifying its effect on firm-level equity risk. Another purpose is to explore whether broad-based employee ownership addresses the concerns of both managers and investors about skilled labour. The empirical analysis is performed for a sample of U.S. public firms from 1990 to 2014. To quantify firms' reliance on skilled labour, a labour skill index is calculated each year using industry-level data from the BLS-OES survey.

This thesis examines the interaction between skilled labour, broad-based employee ownership (BBEO), and equity risk in terms of four research questions. In doing so, the thesis draws attention to human capital risk, while also highlighting the usefulness of BBEO in the knowledge economy. The first two research questions are addressed in Chapter 4: (i) Does idiosyncratic risk increase with firms' reliance on skilled labour? (ii) Does BBEO moderate the relationship between firms' reliance on skilled labour and idiosyncratic risk? The third research question is addressed in Chapter 5: (iii) What is the relationship between firms' reliance on skilled labour and the level of BBEO? The fourth research question is addressed in Chapter 6: (iv) Does the cost of equity capital increase with firms' reliance on skilled labour?

Section 7.2 summarises findings related to the four research questions. Section 7.3 discusses contributions to the literature. Section 7.4 outlines further implications and limitations of the thesis, while suggesting directions for future research.

7.2 Summary of Findings

7.2.1 Reliance on Skilled Labour Positively Affects Idiosyncratic Risk

Chapter 4 provides evidence that idiosyncratic risk increases with the degree to which firms rely on skilled labour. The positive relationship remains significant after including an extensive set of control variables.

The finding is consistent with the idea that as firms deepen their knowledge base, they increasingly undertake risky and firm-specific investments such as innovations. At the same time, skill-intensive firms are more susceptible to agency problems and employee turnover. These increase the volatility of firms' underlying cash flows, reflected by greater idiosyncratic risk.

Given that idiosyncratic risk typically dominates total return risk, and has potential implications for a firm's going concern status (Fama and French (2004)) and risk ratings by financial analysts (Lui et al. (2007)), it is important for corporate risk managers to understand sources of idiosyncratic risk. The chapter contributes to that understanding.

7.2.2 The Positive Relationship between Reliance on Skilled Labour and Idiosyncratic Risk Is Moderated by the Presence of Employee Ownership

In the model of Chapter 4, labour skill index is interacted with the presence of BBEO. This allows examination of whether the perceived skilled labour risk is mitigated when there is BBEO. The hypothesis is supported by a negative and significant interaction term. For employee ownership firms, the increase in idiosyncratic risk associated with a one-standard-deviation increase in labour skill index is 5 percent lower. Thus, the presence of BBEO appears to signal to the market an increased likelihood of the firm capitalising on investment in skilled labour, despite related management challenges.

Further analysis shows that relatively low levels of BBEO also moderate the effect of labour skill index on idiosyncratic risk. At higher levels of BBEO, however, the interaction effect becomes statistically insignificant. This suggests that excessive employee ownership may raise additional concerns, which counteract its perceived effectiveness in addressing management problems related to skilled labour.

In addition to highlighting the perceived risk of investment in skilled labour, Chapter 4 suggests that such risk may be attenuated by making employees part owners of the firm.

7.2.3 The Level of Employee Ownership Exhibits an Inverted U-Shaped Relationship with Reliance on Skilled Labour

Chapter 5 documents an inverted U-shaped relationship between firms' reliance on skilled labour and the level of BBEO. The inflection point occurs near the high end of the skill distribution, beyond which further investment in skilled labour is associated with reduced employee stockholding. The results remain significant after controlling for factors that capture the incentives of employers and employees alike.

The chapter corroborates the role of BBEO in fostering strategic human capital (Robinson and Zhang (2005), Wang et al. (2009)). Its usefulness is reflected by the upward slope in the inverted-U curve, indicating greater employee ownership as firms invest in skilled labour. However, for already highly skilled firms, the incremental benefit of employee ownership is potentially outweighed by excessive risk-aversion (cf. Bova, Kolev, Thomas, and Zhang (2015), Chang et al. (2015)). This leads to reversal of an otherwise positive relationship between labour skill and BBEO, highlighted by the downward slope in the inverted-U curve.

The evidence presented in this chapter indicates a balancing approach to BBEO in the knowledge economy. On the one hand, firm managers exploit the benefits of BBEO in worker retention and motivation – which is particularly relevant for skill-intensive firms. On the other hand, firm managers are aware that excessive employee ownership, especially in the form of stockholding, may create disincentives for risk-taking – which is particularly detrimental to skill-intensive firms.

7.2.4 Reliance on Skilled Labour Positively Affects Cost of Equity Capital

Chapter 6 provides evidence of a positive relationship between firms' reliance on skilled labour and the cost of equity capital, measured by the implied cost of equity. The positive relationship remains significant after controlling for common risk factors. A one-standard deviation increase in the labour skill index translates into an increase in the implied cost of equity of about 16.4 basis points.

Further analysis shows that labour skill index correlates positively with the firm's operating leverage, wage rigidity, and hiring costs. This supports the proposition that by reducing operating flexibility – particularly through the labour cost channel – investment in skilled labour increases the systematic risk exposure of the firm, thus its cost of equity. The chapter thus adds to the recent literature exploring sources of labour market frictions and their asset pricing implications (e.g. Chen et al. (2011), Donangelo (2014)).

While Chapter 4 focuses on the volatility of underlying cash flows due to firm-specific factors, this chapter focuses on the sensitivity of underlying cash flows to systematic shocks, which lies at the core of asset pricing research. The two chapters complement each other, however, in highlighting the trade-off of employing skilled labour. Both lead to the conclusion that firms' equity risk is significantly influenced by their labour force characteristics, particularly the relative emphasis on highly skilled workers.

7.3 Contributions to the Literature

This thesis proposes that resource heterogeneity may arise from firms' differential reliance on skilled labour in their production. Despite the relative scarcity of skilled workers, their human capital is of a general form which, in the traditional resource-based view, precludes it from creating mobility barriers and thus preserving rents (Peteraf (1993)). However, given that building a well-educated and trained workforce lays the foundation for developing idiosyncratically advantageous human capital at the firm level (cf. Ployhart and Moliterno (2011)), employing skilled workers remains an important prerequisite for achieving sustained competitive advantage. This is particularly likely to be the case in the knowledge economy, where an increased focus on technology investment and collaborative intellectual work allows high-skill firms to reap significant synergistic benefits through co-specialised human capital (Molloy and Barney (2015)).

The strategic human capital research has focused almost exclusively on the benefits of human capital. Reflecting this, previous empirical studies have constructed proxies of firm-specific human capital and related them to firm-level performance (Crook et al. (2011)). Most have identified a positive relationship, perpetuating the view that rents arise primarily from firm-specific rather than general human capital, which is not always warranted (e.g. Campbell et al. (2011), Riley et al. (2015)). Moreover, fixating on the performance effect suppresses discussion of the possibility that rents may not be created in the first place and, even if they are, may be captured by informationally advantaged employees (Coff (1999), Frank and Obloj (2014)).

Theoretical contributions to micro-foundations of competitive advantage suggest that, due to workers' free will and perpetual ownership of their human capital (Chadwick (2017)), characteristics that underlie the strategic potential of human capital also cause unique management challenges (e.g. Coff (1997), Coff and Kryscynski (2011)). The resulting uncertainty of rents accruing to shareholders is not easily gleaned from single measures of firm performance. In contrast, examining equity risk, under semi-strong form market efficiency, conveys both the economic value of human capital and the likelihood that abnormal returns may fail to materialise.

Investing in a highly skilled workforce exacerbates the existing management problems, thereby shifting the balance of bargaining power from capital to labour. Coupled with the possibility of knowledge-intensive work not bearing fruit, this leads to increased uncertainty of residual cash flows. Coff (1999) argues that a comprehensive resource-based theory should predict not only when rents will be created, but when they will be appropriated (and by whom). By drawing on the risk-return trade-off which underpins most of the finance literature, and empirically testing the risk effect of skilled labour, this thesis deepens the resource-based literature. Concurrently, by identifying resource (i.e. labour) heterogeneity as a source of value and risk (cf. Toms (2010), Frank and Obloj (2014)), this thesis broadens the finance literature which has focused largely on observed financial variables – whose underlying causes remain under-explored.

Another contribution of this thesis is to the employee ownership literature. To the extent that employee ownership addresses management problems associated with human capital, it potentially improves productivity and firm performance, corresponding to the key themes in strategic human capital. Reflecting this overlap, most empirical studies have examined the performance implications of employee ownership, either individually or in conjunction with other HRM practices (e.g. Pendleton and Robinson (2010), Kim and Ouimet (2014), and Richter and Schrader (2017)). However, the underlying mechanism, namely the moderation of human capital risk with respect to value creation and value capture, has received limited attention. This thesis represents an effort to redress this imbalance. Specifically, we consider how the risk management role of employee ownership is perceived by shareholders – which affects the tension between capital and labour – and by managers – which affects firms' use of employee ownership (and, thus, employees' stock-based wealth), as human capital grows in importance for value creation.

Several remarks can be made of our findings: First, employee ownership appears to be perceived as mediating human capital-based competitive advantage, thus contributing to strategic human capital development (cf. Wang et al. (2009), Mahoney and Kor (2015)). Second, though not tilting the bargaining power back towards shareholders as such, employee ownership may be perceived as tempering the intermittently perpetual process of wage negotiation. This is likely to reduce the perceived need for formal governance and monitoring mechanisms. Third, the dissipation of perceived strategic benefit of skilled labour, as employee ownership becomes excessive, challenges the linear assumption (i.e. "more is better") implicit in the traditional HR-performance research.

Finally, this thesis contributes methodologically to the literature, by objectively quantifying human capital for a cross-section of firms through the labour skill index. Previous empirical work, particularly in the macrolevel organisational research, has been plagued by the problem of measuring firms' human capital (Crook et al. (2011)), which is inherently unobservable. This has called into question the validity of different proxies, often deployed individually (Armstrong and Shimizu (2007)). Reflecting the measurement challenge, there has been limited empirical work in finance that directly models human capital. Moreover, a common preoccupation amongst researchers with the specific-general human capital divide tends to obscure two more fundamental issues, namely the attributes of individual workers salient to firms' overall human capital, and the aggregation of individual human capital at the firm level (Wright et al. (2014)). Whilst both issues have received increased attention in recent years (e.g. Ployhart et al. (2014)), their application for empirical research remains elusive.

By aggregating individuals across firm hierarchy based on their detailed occupation, labour skill index substitutes for single, arbitrary proxies of individual human capital, while offering a comprehensive view of the firm's human capital. This is because occupations serve as a natural composite as well as delimitation of individual human capital. Specifically, individuals are expected to have acquired a certain portfolio of skills from previous human capital investments, which enable them to perform a certain portfolio of tasks in their jobs. It is these tasks that then create economic value. The logic behind labour skill index thus draws on both the traditional human capital theory (Becker (1964)) and the emerging task literature (Autor et al. (2003)). While the skill level of occupations is exogenously determined (i.e. through the O*Net job zones), the relative dependence on high-skill occupations is endogenously determined by the idiosyncratic mix of tasks that shape firms' production process (cf. Lazear (2009)). This leads to cross-firm heterogeneity with respect to human capital. Note also that we consider the relative wage costs of skilled workers, instead of just their relative number. This augments the skill index, by factoring in firms' expectations of future cash flows – which underlie sustained competitive advantage – associated with a high-skill workforce.

As reiterated below, our estimation of labour skill index is limited by the unavailability of firm-level occupational data. This means that, even with the substitution of detailed industry data, it is unable to capture firm-specific heterogeneities. However, this does not nullify the labour skill index itself, and it is left to future research to verify its generalisability through collecting firm-level data and/or running cross-country analyses.

7.4 Implications, Limitations, and Future Research

Besides theoretical contributions, this thesis has implications for various stakeholders of the firm. For investors, diversified or undiversified, Chapters 4 and 6 highlight labour force heterogeneity, in terms of the relative emphasis on skilled workers, as a source of firm-level equity risk. For financial managers seeking to raise equity capital, Chapter 6 suggests that the market considers firms' reliance on skilled labour when discounting their expected future cash flows. Likewise, for risk managers seeking to understand and manage stock return risk, Chapters 4 and 6 show that both of its components (i.e. systematic and unsystematic) are affected by the degree to which firms rely on skilled workers.

Rather than deskilling the workforce, however, providing right incentives for current and future employees appears a more sensible approach to the skilled labour dilemma. This highlights the role of human resource managers whom the findings of Chapter 4 should help in making a more convincing case for BBEO. For employees, Chapter 5 provides clues as to how managers determine the level of stock-based compensation, thus helping them anticipate their wealth components. For regulators, Chapter 5 may also be of interest. Prior to designing policies to encourage (or discourage) employee ownership, it is important to obtain as complete a picture as possible of factors influencing firms' willingness to offer stock to employees. The results in Chapter 5 help in this regard.

The analysis of the presented studies is subject to several limitations. With respect to data, the main challenge concerns the quantification of firms' reliance on skilled labour. While the labour skill index is conceptually valid (see previous Subsection), estimating it at the firm level is not possible given the lack of occupational breakdown of employment across firms. Using industry-level data introduces measurement error, thus biasing the regression estimates where the dependent variable is firm-specific. Despite various efforts to address the issue, our results should be viewed cautiously. Another data problem concerns the definition of BBEO (Chapters 4 and 5), based primarily on firm stock held in DC plans. Researchers have highlighted the difficulty of merging plan-level Form 5500 data with firm-level Compustat data (e.g. Gron and Madrian (2003)), which may induce false non-matches and an underestimation of related variables (Phan and Hegde (2013a)). The potential selection bias and measurement error is compounded by the exclusion of other sources of employee ownership, i.e. non-retirement plans.

With respect to theory, Chapters 4 and 5 posit that investment in skilled labour exacerbates perceived agency and turnover problems, which increase the relevance of

BBEO as a governance tool. Direct verification of the proposed mechanisms was omitted, however, given the well-known difficulty of modelling agency costs (Ang et al. (2000)) and the lack of data on worker replacement costs. Similarly, it is empirically fraught to pin down BBEO's incentive effects precisely (Oyer and Schaefer (2005)). While the interaction and subsample tests in both Chapters support the theory indirectly, the possibility of alternative explanations cannot be overlooked.

In completing the thesis, several issues and questions arise which are worth pursuing in future research. First in Table 5-7: while the results confirm our conjecture that greater retention needs attenuate the decrease in BBEO amongst high-skilled firms, as they invest further in skilled labour, the opposite signs on the interaction terms for low- and middle-skilled firms are surprising. This suggests that BBEO's retention incentives may not be as pronounced for firms relying on less-skilled workers, and that such firms may seek to retain their workers in other ways. We do not offer a specific hypothesis at this juncture.

Second, we note a possible conflict between the inferences from Chapters 4 and 5. On the one hand, Chapter 4 suggests that idiosyncratic risk arises from the perceived management challenges associated with skilled labour, which is better mitigated – as the presence of BBEO appears to do. On the other hand, Chapter 5 suggests that the decreasing trend in the level of BBEO for high-skilled firms is due to concerns about employee risk aversion. In this case, idiosyncratic risk is viewed in a more positive light.

The two observations need not be contradictory. Bartram et al. (2012) distinguish between "good" and "bad" stock return volatility, arising from factors that increase and decrease shareholder wealth, respectively. Recall that in Chapter 4, the tendency of high-skilled firms to undertake risky projects forms part of the explanation for a positive skill-volatility relationship. Where such projects are initiated with a view to enhancing long-term shareholder wealth, the associated increase in idiosyncratic risk is favourable. By contrast, the increase in idiosyncratic risk associated with shareholder concerns about rent appropriation and voluntary turnover is unfavourable, as the reason tends to diminish shareholder well-being. Thus, the downward slope of the inverted-U curve in Chapter 5 may reflect managers' incentive to encourage, rather than inhibit, "good" volatility. While the results in Chapter 4 appear to concern mainly "bad" volatility, it is difficult to verify due to limitations mentioned above. Specifically, it would be interesting to know how much of idiosyncratic risk induced by skilled labour is due to value-creating or value-destroying reasons; and what type of idiosyncratic risk is being moderated by the presence of BBEO. Future research that disentangles the channels through which skilled labour affects equity risk would be helpful.

Third, and more straightforwardly, future research could examine what other factors moderate skilled labour risk. Particularly, if HRM practices other than BBEO and certain governance tools are shown to reduce equity risk associated with skilled labour, there will be more reason, financially and strategically, for their adoption. Another interacting variable worth exploring is egalitarianism, in terms of wage inequality between top and average employees[208]. We suspect that lower intrafirm inequality creates a sense of fairness, thus promoting trust and cooperation; this would moderate idiosyncratic risk in a similar manner to BBEO. Whether it makes employees more willing to accept pay cuts during recessions, thus reducing operating leverage and systematic risk, however, remains an empirical issue.

[208] See https://www.sec.gov/news/pressrelease/2015-160.html

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Appendices

Appendix 1: Occupational Employment and Wage Data

The Occupational Employment Statistics (OES) is a federal-state cooperative programme, administered by the U.S. Bureau of Labor Statistics (BLS) and State Workforce Agencies (SWAs). The programme conducts semi-annual surveys of 200,000 non-farm establishments to produce employment and wage estimates for about 800 occupations[209]. The occupational estimates are compiled at the national, state, metropolitan/non-metropolitan area, and industry levels.

For this thesis, we download industry-level OES data for the 1988-2015 period from the BLS website (https://www.bls.gov/oes/tables.htm). Prior to 1997, each industry was surveyed every three years, and annually afterwards. To ensure a continuous coverage for all industries, we use the same industry data for three consecutive years during earlier periods. Specifically, the 1990 data combine those from 1988-1990, the 1991 data combine those from 1989-1991, and so on until 1995. Since no survey was conducted in 1996, the data from 1993-1995 are used for both 1995 and 1996. The data limitation means our sample can only start from 1990. Another issue is that, from 2002 onwards, the OES survey reference period changed from the calendar year end to May each year. In order to avoid look-ahead bias, we use the May 2003 data for 2002 (instead of 2003), the May 2004 data for year 2003 (instead of 2004), and so on until 2014 for which the May 2015 data are used.

Between 1988 and 1998, the OES programme classified occupations using its own taxonomy. From 1999 onwards, it switched to the Standard Occupational Classification (SOC) system which was updated in 2010. For consistency, we convert all occupational codes to the 2010 version of SOC, using crosswalk files provided by the National Crosswalk Service Center (NCSC) (http://www.xwalkcenter.org/). With respect to industry definition, the OES programme adopted the Standard Industrial Classification (SIC) system from 1988 to 2001, and switched to the North American Industry Classification System (NAICS) after 2002. During our sample period (i.e. 1990-2014), the NAICS was updated twice in 2007 and in 2012. For consistency, we convert all NAICS codes to the 2002 version,

[209] Every survey cycle lasts over three years, whereby data are collected from a total of 1.2 million non-farm establishments.

using concordance files available from the United States Census Bureau website (https://www.census.gov/eos/www/naics/concordances/concordances.html) [210].

Since the OES programme began supplying occupational wage estimates only after 1997, for earlier years (i.e. 1990-1996) we follow Donangelo (2014) and aggregate household-level data from the Current Population Survey (CPS), conducted monthly by the United States Census Bureau[211]. As the CPS data apply a different set of industry and occupation classifications, we match them with the OES data as closely as possible, using the crosswalk files from the United States Census Bureau website (https://www.census.gov/people/io/methodology/) and Professor David Dorn's website (http://www.ddorn.net/data.htm). Otherwise, we manually collect average hourly wages for broad occupations within broadly defined industry groups from the BLS's Employer Costs for Employee Compensation (ECEC) news releases[212]. The average annual wages are then inferred from the hourly rates, by assuming 2,087 working hours per annum.

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[210] Using the 2002 NAICS also facilitates converting NAICS codes into SIC codes (and vice versa), given the existing SIC-NAICS concordances, also available on the Census Bureau website.

[211] We obtain the CPS data from the Integrated Public Use Microdata Series (IPUMS) database operated by the University of Minnesota (www.ipums.org) (King et al. (2015)).

[212] The annual ECEC newsletters from 1990 to 1996 disclosed average hourly wages for nine broad occupations: (1) Professional specialty and technical; (2) Executives, administrative, and managerial; (3) Sales; (4) Administrative support including clerical; (5) Precision production, craft, and repair; (6) Machine operators, assemblers, and inspectors; (7) Transportation and material moving; (8) Handlers, equipment cleaners, helpers, and laborers; and (9) Service. These are available across three broadly defined industries: (1) Goods-producing, manufacturing industries; (2) Goods-producing, non-manufacturing industries (i.e. Mining and Construction); and (3) Service-producing industries (i.e. Transportation, communication, and public utilities; Wholesale trade; Retail trade; Finance, insurance, and real estate; and Services).

Appendix 2: Job Zones

The Occupational Information Network (O*Net) is a free online database (https://www.onetcenter.org/) that details a total of 974 occupations across the world of work[213]. Its development during the 1990s was sponsored by the Employment and Training Administration of United States Department of Labor. Replacing the Dictionary of Occupational Titles which was last updated in 1991, O*Net has been the primary source of occupational information in the United States.

Pertinent to the empirical analysis of this thesis is the Job Zone section of O*Net (https://www.onetonline.org/find/zone), which groups a spectrum of occupations into one of five categories (i.e. "job zones") based upon the level of education, experience, and training typically required to perform the occupation. Job Zone 1 comprises occupations for which little or no preparation is needed (e.g. baristas, cashiers, and food preparation workers), whilst Job Zone 5 comprises occupations for which extensive preparation is necessary (e.g. surgeons, lawyers, and mathematicians). Other occupations are assigned into Job Zones 2-4, in ascending order of requisite human capital investment.

[213] The O*Net programme classifies occupations using the 2010 version of SOC, which we use to link between the O*Net database and occupational employment and wages from the OES surveys (see Appendix A).

Appendix 3: Variable Details

Panel A details variables used for the portfolio-level analysis in Chapter 3, Section 3.3 (Table 3-4). Panel B details control variables used for the multivariate regression analysis in Chapters 4-6. When not otherwise specified, the bracketed letters are Compustat mnenomics.

Panel A. Firm/Industry characteristics in Table 3-4

Variable	Definition	Data Source
Corporate Demographics		
Market Equity	The product of common shares outstanding ("csho") and closing price at fiscal year-end ("prcc_f")	Compustat
Assets	Total assets ("at")	Compustat
Sales	Net sales ("sale")	Compustat
Employees	Total employees ("emp")	Compustat
Age – listing	The number of years since the firm was publicly listed	Websites of Jay Ritter[214] & Boyan Jovanovic[215]
Age – founding	The number of years since the firm was founded	Websites of Jay Ritter & Boyan Jovanovic
Growth Opportunities		
Market-to-Book	The ratio of market equity ("csho"×"prcc_f") to book equity. Book equity is defined as stockholders' equity ("seq" or "ceq"+"pstk" or "at"-"lt", in that order) minus preferred stock ("pstkl" or "pstkrv or "pstk", in that order) plus deferred taxes and investment tax credit ("txditc") if available.	Compustat
Tobin's Q	The ratio of market assets to book assets ("at"). Market assets are defined as book assets ("at") plus market equity ("csho"×"prcc_f") minus common equity ("ceq") plus balance sheet deferred taxes ("txdb") if available.	Compustat
Sales Growth	The annual percentage change in net sales ("sale")	Compustat

214 https://site.warrington.ufl.edu/ritter/ipo-data/

215 http://www.nyu.edu/econ/user/jovanovi/whywait.xls

Variable	Definition	Data Source
Hiring	The annual percentage change in total employees ("emp")	Compustat
Investment	The ratio of capital expenditure ("capx"-"sppe") to lagged property, plants, and equipment ("ppent")	Compustat
R&D	The ratio of research and development expense ("xrd") to net sales ("sale")	Compustat
Asset Tangibility	The ratio of property, plant and equipment ("ppent") to total assets ("at")	Compustat
Debt Capacity		
Book Leverage	The ratio of total debt ("dltt"+"dlc") to total assets ("at")	Compustat
Market Leverage	The ratio of total debt ("dltt"+"dlc") to the sum of total debt and market equity ["dltt"+"dlc"+("csho"×"prcc_f")]	Compustat
Interests	The ratio of interest and related expense ("xint") to total assets ("at")	Compustat
Collaterals	The ratio of collateralisable assets to total assets ("at"). Collateralisable assets are constructed as property, plant and equipment plus inventories ("invt")	Compustat
Liquidity and Financial Constraints		
Cash	The ratio of cash and short-term investments ("che") to total assets ("at")	Compustat
Current Ratio	The ratio of current assets ("act") to current liabilities ("lct")	Compustat
Free Cash Flow	The ratio of free cash flow to total assets ("at"). Free cash flow is constructed as net cash flow from operating activities ("oancf") minus total dividend ("dvc"+"dvp") minus net cash flow from investing activities ("ivncf")	Compustat
Interest Coverage	The ratio of operating income before depreciation ("oibdp") to interest and related expense ("xint")	Compustat
Competition and Profitability		
Sales Dispersion	One minus a three-year average Herfidahl-Hirschman Index that measures the degree of sales concentration in the firm's three-digit SIC industry, multiplied by 100	Compustat
Employee Dispersion	One minus a three-year average Herfidahl-Hirschman Index that measures the degree of employee concentration in the firm's three-digit SIC industry, multiplied by 100	Compustat
Return on Assets	The ratio of income before extraordinary items ("ib") to lagged total assets ("at")	Compustat
Return on Equity	The ratio of income before extraordinary items available for common shareholders ("ibcom") to lagged book equity (see above)	Compustat

Variable	Definition	Data Source
Labour-related Factors		
Annual Wage	The average annual wage per worker in the firm's three-digit SIC (or four-digit NAICS) industry	BLS-OES
Labour Share	The ratio of wage expense to net sales. Wage expense is constructed as average annual wage per worker in the firm's three-digit SIC (or four-digit NAICS) industry, multiplied by total employees ("emp")	BLS-OES, Compustat
Growth Options	The difference between market and book equity (see above), scaled by total employees ("emp")	Compustat
Labour Intensity	The ratio of total employees ("emp"×1,000) to property, plant and equipment ("ppent")	Compustat
Union	The percentage of workers in the firm's three-digit Census industry who are member of a trade union	Union Membership and Coverage Database
College	The percentage of workers in the firm's three-digit Census industry who have a college degree	IPUMS-CPS

Panel B. Control variables for empirical chapters

Variable	Definition	Data Source
Chapter 4		
ROE	See "Return on Equity" in Panel A	
VROE	The three-year rolling standard deviation of return on equity, using quarterly data	Compustat
SIZE	The natural logarithm of fiscal year-end market capitalisation from CRSP, defined as price ("prc") multiplied by shares outstanding ("shrout"/1,000)	CRSP
AGE	The natural logarithm of "Age – listing" in Panel A	Websites of Jay Ritter & Boyan Jovanovic
DIVDUM	A dummy variable equal to 1 if the firm pays dividend (i.e. "dvpsx_f">0) during the year, and 0 otherwise	Compustat
MB	See "Market-to-Book" in Panel A	Compustat
BKLEV	See "Book Leverage" in Panel A	Compustat
RETURN	The average continuously compounded monthly return ("ret") over the previous year	CRSP
INDCONC	A three-year average Herfidahl-Hirschman Index of sales concentration in the firm's three-digit SIC industry	Compustat
ILLIQUID	The daily ratios of absolute stock return ("ret") to dollar volume traded ("prc" ×"vol"), averaged for each firm in each fiscal year. It is multiplied by 10,000 throughout the analysis for expositional purposes.	CRSP
Chapter 5		
SIZE	The natural logarithm of "Sales" in Panel A	Compustat
TOBINQ	The three-year average of "Tobin's Q" in Panel A	Compustat
SALGR	The three-year average of "Sales Growth" in Panel A	Compustat
RETURN	See above in this Panel	CRSP
RETVOL	The standard deviation of daily stock return ("ret") over the previous year	CRSP
DBPLAN	A dummy variable equal to 1 if the firm sponsors at least one defined benefit pension plan, and 0 otherwise	Form 5500
DIVDUM	See above in this Panel	Compustat
HTAX	A dummy variable equal to 1 if the firm has positive pre-tax income ("pi") and no net operating loss carry-forwards ("tlcf") in any of the three previous years, and 0 otherwise	Compustat
LTAX	A dummy variable equal to 1 if the firm has negative pre-tax income ("pi") and net operating loss carry-forwards ("tlcf") in each of the three previous years, and 0 otherwise	Compustat
CASH	The three-year average of "Cash" in Panel A	Compustat

Variable	Definition	Data Source
BKLEV	The three-year average of "Book Leverage" in Panel A	Compustat
MULTICLASS	A dummy variable equal to 1 if multiple traded share classes are likely, and 0 otherwise. Two criteria are used: first, a firm with CRSP issues identical in the first 6 digits of CUSIP, but different in the last 2 digits; second, the difference between a firm's fiscal year-end share counts from CRSP and from Compustat exceeds 1%.	Compusta, CRSP
LTCG	The average marginal long-term capital gains tax rate in the firm's headquarters state	NBER
OLDEMP	A dummy variable equal to 1 if the average worker age in the firm's three-digit Census industry is in the top sample quartile, and 0 otherwise	IPUMS-CPS
FEMALE	The percentage of female workers in the firm's three-digit Census industry	IPUMS-CPS
Chapter 6		
SIZE	The market capitalisation from CRSP (see above in this Panel) estimated for June each year	
BM	The inversion of "Market-to-Book" in Panel A	
BETA	The slope from a five-year rolling regression of monthly stock return on current and lagged market returns	CRSP
MKTLEV	See "Market Leverage" in Panel A	
DISPERSION	The natural logarithm of one plus the standard deviation of one-year-ahead earnings per share forecasts	I/B/E/S
LTGROWTH	The forecasted long-term growth rate of earnings per share	I/B/E/S

Appendix 4: Measures of Implied Cost of Equity

Panel A outlines alternative models for estimating ICOE. Panel B describes three methods used to modify the Gebhardt et al. (2001) model.

Panel A. Alternative estimation models of ICOE

ICOE Model	Formula	Key Assumptions
Gebhardt et al. (2001) (baseline model)	$$P_0 = B_0 + \sum_{i=1}^{11} \frac{E_0[(ROE_i - R_0)B_{i-1}]}{(1+R_0)^i} + \frac{E_0[(ROE_{12} - R_0)B_{11}]}{R_0(1+R_0)^{11}}$$ - P_0: Stock price in June - B_0: Book value per share in June, defined as book equity from the most recent fiscal year, divided by common shares outstanding in June - B_i: Book value per share in year i, defined as $B_{i-1} + EPS_i - DPS_i$ following clean surplus accounting. EPS_i is forecasted earnings per share in year i from I/B/E/S. DPS_i is forecasted dividend per share in year i, defined as EPS_i multiplied by the payout ratio from the most recent fiscal year. - ROE_i: Forecasted return on equity in year i	Between year 4 and year 12, firm-level ROE mean-reverts to industry-level ROE, defined as the moving median of ROEs from all firms in the same Fama-French (1997) 48 industry over at least 5 and up to 10 years. Observations with negative ROE are not considered in estimating industry-level ROE.
Claus and Thomas (2001, CT)	$$P_0 = B_0 + \sum_{i=1}^{5} \frac{E_0[EPS_i - R_0 \times B_{i-1}]}{(1+R_0)^i} + \frac{(EPS_5 - R_0 \times B_4)(1+\gamma)}{(R_0-\gamma)(1+R_0)^4}$$ - P_0: Stock price in June - B_0: Book value per share in June, defined as book equity from the most recent fiscal year, divided by common shares outstanding in June - B_i: Book value per share in year i, defined as $B_{i-1} + EPS_i - DPS_i$ following clean surplus accounting. EPS_i is forecasted earnings per share in year i from I/B/E/S. DPS_i is forecasted dividend per share in year i, defined as EPS_i multiplied by the payout ratio from the most recent fiscal year. - EPS_i: Forecasted earnings per share in year i from I/B/E/S - γ: The return on ten-year Treasury bonds minus 3 percent	After year 5, abnormal earnings, i.e. earnings less a capital charge, grow at the expected inflation rate, and is set equal to the long-term risk-free interest rate less 3 percent.

ICOE Model	Formula	Key Assumptions
Gode and Mohanram (2003, GM)	$R_0 = \frac{1}{2}\left((\gamma - 1) + \frac{DPS_1}{P_0}\right) + \sqrt{[\frac{1}{2}\left((\gamma - 1) + \frac{DPS_1}{P_0}\right)]^2 + \frac{EPS_1}{P_0}\left(\frac{\frac{EPS_2 - EPS_1}{EPS_1} + LTG}{2} - (\gamma - 1)\right)}$ - P_0: Stock price in June - EPS_i: Forecasted earnings per share in year i from I/B/E/S - DPS_i: Forecasted dividend per share, defined as EPS_i multiplied by the payout ratio from the most recent fiscal year. - LTG: Forecasted long-term growth rate of earnings per share from I/B/E/S - γ: The return on ten-year Treasury bonds minus 3 percent	
Gordon and Gordon (1997, GG)	$P_0 = \sum_{i=1}^{4} \frac{E_0[DPS_i]}{(1 + R_0)^i} + \frac{E_0[EPS_5]}{R_0(1 + R_0)^4}$ - P_0: Stock price in June - EPS_i: Forecasted earnings per share in year i from I/B/E/S - DPS_i: Forecasted dividend per share, defined as EPS_i multiplied by the payout ratio from the most recent fiscal year.	After year 4, firm-level ROE reverts to the implied cost of equity.
Botosan and Plumlee (2005, BP)	$R_0 = \sqrt{\frac{EPS_5 - EPS_4}{P_0}}$ - P_0: Stock price in June - EPS_i: Forecasted earnings per share in year i from I/B/E/S	
Price-to-earnings ratio (PEG)	$R_0 = \frac{EPS_1}{P_0}$ - P_0: Stock price in June - EPS_1: Forecasted one-year-ahead earnings per share from I/B/E/S	

Panel B. Modifications of the Gebhardt et al. (2001) model

<table>
<tr><th>Methods</th><th>Formula</th><th>Key Assumptions</th></tr>
<tr><td>Hou et al. (2012, HDZ)</td><td>$$E_{i,t+\tau} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 D_{i,t} + \alpha_3 DD_{i,t} + \alpha_4 E_{i,t} + \alpha_5 NegE_{i,t} + \alpha_6 AC_{i,t} + \varepsilon_{i,t+\tau}$$
- $E_{i,t+\tau}$: Earnings available for common shareholders in year t+τ (τ=1, 2, and 3)
- $A_{i,t}$: Total assets in year t
- $D_{i,t}$: Dividend in year t
- $DD_{i,t}$: A dummy variable equal to one if the firm pays dividend in year t, and zero otherwise
- $E_{i,t}$: Income before extraordinary items available for common shareholders in year t
- $NegE_{i,t}$: A dummy variable equal to one if the firm reports negative earnings in year t, and zero otherwise
- $AC_{i,t}$: Total accruals in year t, defined as changes in non-cash working capital minus changes in current liabilities excluding changes in short-term debt and changes in income tax payable minus depreciation</td><td>The forecasted earnings are divided by the number of shares outstanding in June to obtain EPS for the upcoming three years, which are substituted into the baseline model.</td></tr>
<tr><td>Tang et al. (2014, TWZ)</td><td>$$ROE_{i,t+\tau} = \alpha_0 + \alpha_1 LogBM_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 NegE_{i,t} + \alpha_4 ROE_{i,t} + \alpha_5 NegAC_{i,t} + \alpha_6 PosAC_{i,t} + \alpha_7 ATGR_{i,t} + \alpha_8 ZeroD_{i,t} + \alpha_9 D/B_{i,t} + \varepsilon_{i,t+\tau}$$
- $ROE_{i,t+\tau}$: Return on equity in year t+τ (τ=1, 2, and 3), defined as the ratio of earnings available for common shareholders to book equity
- $LogBM_{i,t}$: The natural logarithm of book-to-market ratio in year t, defined as the ratio of book equity to market equity
- $SIZE_{i,t}$: The natural logarithm of fiscal year-end market capitalisation in year t from CRSP
- $NegE_{i,t}$: A dummy variable equal to one if the firm reports negative earnings in year t, and zero otherwise
- $ROE_{i,t}$: Return on equity in year t
- $NegAC_{i,t}$: Total accruals divided by book equity in year t, multiplied by -1 for negative accruals (zero otherwise).
- $PosAC_{i,t}$: Total accruals divided by book equity in year t for positive accruals (zero otherwise)
- $ATGR_{i,t}$: The annual percentage change in total assets
- $ZeroD_{i,t}$: A dummy variable equal to one if the firm does not pay dividend, and zero otherwise
- $D/B_{i,t}$: The ratio of dividend to book equity in year t</td><td>The one-year-ahead ROE is multiplied by book equity per share from previous fiscal year to obtain one-year-ahead EPS; it is then used to obtain one-year-ahead book equity per share based on clean surplus accounting. The two- and three-year-ahead EPS and book equity are similarly derived, and substituted into the baseline model.</td></tr>
<tr><td>Guay et al. (2011, GKS)</td><td>The “portfolio median approach” is used to address near-term analyst sluggishness. Specifically, firms are sorted into twelve stock return portfolios in June every year. These include ten deciles, with the top and bottom deciles being further halved. The time-series medians of portfolio median forecast errors (i.e. the difference between forecasted and actual values, scaled by assets per share from the most recent fiscal year) are estimated, and subtracted from the firm’s one- and two-year-ahead earnings forecasts.</td><td></td></tr>
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