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The effects of firm-specific incentives (stock options) on mobility and employee entrepreneurship

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ABSTRACT

We consider the effect of employee stock options on employee mobility and employee entrepreneurship. Employee stock options are firm-specific, long-term, equity-based incentive instruments—attractive properties for affecting employee behaviors and decisions. We argue that employee stock options reduce employee mobility levels. By contrast, we posit that employee stock options increase employee entrepreneurship levels, and even more so when a firm's knowledge scope is narrow. Using the semiconductor industry as the setting, we document not only the negative effect of employee stock options on employee mobility levels but also the positive impact on employee entrepreneurship levels; the positive impact is also more substantial in firms with a narrow knowledge scope. We contribute to the literature that examines the influence of organizational conditions on the origins of entrepreneurship. We also inform research on strategic human capital by explicating the divergent effects of firm-specific incentives on two crucial human capital outcomes for firms.

Executive summary

In many technology-intensive sectors, employees frequently switch jobs or become entrepreneurs in the same industry. Such departures can affect the competitiveness of the former employer because employees can take their valuable knowledge with them, share it with competitors, and create new rivals. To foster employees' commitment, firms can implement policies that influence employees' preferences, experiences, and opportunities, which can impact both the decision to join another firm or become an entrepreneur (Sørensen and Fassiotto, 2011). Notably, incentive policies can play a significant role in this process as they dictate how employees are rewarded and motivated (Chadwick and Dabu, 2009; Gerhart and Rynes, 2003; Lazear, 1999; Mahoney and Kor, 2015; Oyer, 2004). However, existing research remains silent on the effects of firm-specific, long-term, equity-based incentive practices—attributes unique to incentive instruments such as employee stock options (Nyberg et al., 2018) —on employee mobility and employee

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entrepreneurship.

Our goal in this paper is to provide a systematic theoretical and empirical understanding of how the firm policy of granting stock options to non-executive employees affects the firm-level employee mobility and employee entrepreneurship levels. We argue that employee stock options dampen employee mobility levels but increase employee entrepreneurship levels, especially in firms with a narrow knowledge scope. Using data from the U.S. semiconductor industry between 1997 and 2012, we find empirical evidence supporting our theory.

Our study makes several contributions. It contributes to the entrepreneurship literature by illustrating how firm-level policies such as stock options influence employee entrepreneurship levels. It contributes to the literature on strategic human capital by unpacking the distinct effects of employee stock options on two fundamental human capital outcomes. Further, our theory and findings also have practical relevance. Our results provide evidence in support of the retention function that stock options are contemplated to fulfill. In addition, managers can use our theory and results to understand how a firm's incentive practices (i.e., employee stock options) interact with its strategic context (i.e., knowledge scope) to engender employees' transition to entrepreneurship.

1. Introduction

More than ever, firms in technology-intensive sectors rely on the human capital embodied in their employees to create and capture value from innovation (Coff, 1997; Hatch and Dyer, 2004; Ployhart and Moliterno, 2011). However, leveraging human capital comes with challenges (Call and Ployhart, 2021). Principal among these challenges is the limited control of organizations over employees' ability to sever the employment relationship at will and take their human capital with them (Chadwick, 2017; Coff, 1997). Indeed, employees in many technology-intensive sectors frequently move to other firms within the industry (i.e., *employee mobility*) (Agarwal et al., 2009; Almeida and Kogut, 1999; Fallick et al., 2006; Hoisl, 2007) or leave their employment to create their own ventures in the same industry (i.e., *employee entrepreneurship*) (Agarwal et al., 2004; Ganco, 2013; Klepper and Sleeper, 2005).

Firms can secure employee commitment through the design of various elements of their organization—practices, policies, and structure (Baron et al., 1999; March and Simon, 1958). These elements shape employees' preferences, experiences, and opportunities, thereby affecting employee mobility and employee entrepreneurship (Sørensen and Fassiotto, 2011). Prominent among these elements are incentive practices that determine employee rewards (Chadwick and Dabu, 2009; Gerhart and Rynes, 2003; Lazear, 1999; Mahoney and Kor, 2015; Oyer, 2004). Prior work has examined the effects of conventional compensation practices (e.g., pay dispersion and pay-for-performance) on individual level mobility decisions (e.g., Campbell et al., 2012b; Carnahan et al., 2012; Zenger, 1992). This work, however, has remained silent on the impact of incentive practices that are firm-specific, long-term oriented, and equity-based—attributes unique to incentive instruments such as employee stock options (Nyberg et al., 2018). Because of these distinctive attributes, employee stock options can offer unique avenues to address human capital challenges (Garvin, 1983; Manso, 2011; Pakes and Nitzan, 1983), thus making it crucial to develop a deeper theoretical and empirical understanding of their effects on employee mobility and employee entrepreneurship.

To address this gap, we ask the question: how do *employee stock options* affect intra-industry *employee mobility* and *employee entrepreneurship*? Our core theoretical point is that employee stock options carry divergent implications for employee mobility and employee entrepreneurship, implications that follow from stock options' characteristics. Specifically, we contend that employee stock options reduce employee mobility levels because they modify the employees' opportunity costs, making it economically less attractive to leave the firm. By contrast, we argue that employee stock options increase employee entrepreneurship. We theorize that while employee stock options induce employees to experiment (Ederer and Manso, 2013), firms face constraints in adopting the resulting ideas, prompting frustrated employees to pursue their ideas in their own ventures (Garvin, 1983; Klepper, 2009). We further delineate the effect of employee stock options on employee entrepreneurship by conceptualizing the moderating role of knowledge scope, a feature that determines when experiments fit with the firm's strategy (Cassiman and Ueda, 2006; Hellmann, 2007). Specifically, we posit that employee stock options further increase employee entrepreneurship levels when the firm's knowledge scope is narrow.

We test our predictions in the context of the US semiconductor industry between 1997 and 2012 by combining hand-collected data with other proprietary datasets. Taking the firm as the unit of analysis, we define *employee stock options* as the firm's option grants to non-executive employees (Chang et al., 2015; Hochberg et al., 2010) and concentrate on the intra-industry mobility and entrepreneurship of employees with a record of producing innovations (Agarwal et al., 2009; Gambardella et al., 2015; Ganco, 2013; Kim and Steensma, 2017). Because employee stock options relate to firms' design of incentives, it could be endogenous. We implement an instrumental variable approach that relies on the idea that firms' geographic location influences the employee stock option grants (Hochberg et al., 2010; Kedia and Rajgopal, 2009). Our results support the hypothesized relationships. Specifically, we show that employee stock options affect employee mobility levels negatively but impact employee entrepreneurship levels positively. Finally, we also demonstrate that a narrow knowledge scope of the firm accentuates the effect of employee stock options on employee entrepreneurship levels.

A chief contribution of our paper is to the literature on entrepreneurship. A fundamental question in this literature concerns the creation of new ventures (Bhidé, 2003; Douglas and Shepherd, 2000; Sarasvathy, 2004; Shane and Venkataraman, 2000; Shepherd et al., 2021). Turning to existing organizations for answers, entrepreneurship scholars have devoted attention to the organizational factors that drive employees to become entrepreneurs (Agarwal et al., 2004; Gambardella et al., 2015; Ganco, 2013; Klepper and Sleeper, 2005; Sørensen and Fassiotto, 2011; Sørensen and Sharkey, 2014). We contribute to this stream by explicating that employee entrepreneurship arises as a ramification of incentive practices meant to promote innovation in firms. We also illuminate how a firm's incentive practices (i.e., employee stock options) interact with its strategic context (i.e., knowledge scope) to engender employees' transition to entrepreneurship (Burgelman, 1983a; Cassiman and Ueda, 2006; Hellmann, 2007).

We also contribute to the growing literature on strategic human capital (Campbell et al., 2012a; Chadwick, 2017; Coff, 1997; Ployhart, 2021; Wang and Barney, 2006). An important emerging theme in this literature underscores the value of firm-specific incentives to understand better human capital sources of competitive advantage (Kryscynski et al., 2021). We contribute to this nascent stream by theoretically and empirically unpacking the distinct effects of employee stock options, firm-specific incentives popular in many innovative sectors, on two fundamental human capital outcomes (Andersson et al., 2009; Kryscynski et al., 2021). By investigating the moderating effects of the knowledge scope of firms, we also answer the call to go beyond within firm effects of incentives to illuminate the between-firm variation in the effects of firm-specific incentives (Kryscynski, 2021; Kryscynski et al., 2021).

Finally, we contribute to the growing literature on employee stock options (Chang et al., 2015; Lazear, 1999; Nyberg et al., 2018; Oyer, 2004). An emerging line of work in this stream has begun to investigate the implications of employee stock options for firm-level outcomes (Chang et al., 2015; Hochberg and Lindsey, 2010). We extend this work by shedding light on the effects of employee stock options on two crucial firm level outcomes: employee mobility and employee entrepreneurship levels. Our results also provide evidence in support of the retention function that stock options are contemplated to fulfill (Oyer and Schaefer, 2005).

2. Background and hypotheses

In harnessing human capital to drive innovation, firms face two key challenges: (a) align employee behaviors with the organizational objectives; (b) maintain the employment relationship (Campbell et al., 2012b; Chadwick, 2017; Coff, 1997). In this respect, the firms' practices geared to affect human capital play a pivotal role in facilitating human capital accumulation while precluding its seepage to competitors—current and potential—through intra-industry employee mobility and employee entrepreneurship (Campbell et al., 2012b; Coff, 1997; Huselid and Becker, 2011). A primary channel through which these practices affect employee decisions and behaviors is the economic utility they offer. The economic utility can be linked to the effort levels (e.g., salaries), specific outcomes achieved by the individual (e.g., piece rates and bonuses) or the firm (e.g., profit sharing), and the timeframe of these achievements—contemporaneous or long-term (e.g., stock options). More importantly, the economic utility of an incentive mechanism may be uniquely linked to the focal firm, i.e., firm-specificity of the incentives (Kryscynski et al., 2021).

2.1. Employee stock options

Employee stock options are contracts that confer a firm's employees the right to purchase equity (i.e., firm shares) at a given price. The rights to purchase the shares come alive only after a set period from the initial grant (i.e., become vested) but expire after a fixed life span. Vesting allows employees to exercise the right to buy the firm's shares and receive monetary value based on its stock performance. The rights are neither tradeable on the open market nor available when employees quit the firm (Gerhart and Rynes, 2003; Nyberg et al., 2018; Oyer, 2004). Gaining wide currency among publicly traded firms, employee stock options are highly prevalent in technology-intensive sectors that invest heavily in innovation (Chang et al., 2015; Oyer and Schaefer, 2005; Sesil et al., 2002). Their prevalence is further indicated by the tenfold increase in stock options grants per capita to non-executive employees between 1992 and 2001, representing 80 % of the total options granted (Hall and Murphy, 2003). This upsurge meant that by 2002 a third of all private sector employees had received stock options equaling 8 % of all the stock in the United States (Gerhart and Rynes, 2003).

Employee stock options possess several properties that possibly make them effective incentive instruments for affecting employee behaviors and decisions (Gerhart and Rynes, 2003; Nyberg et al., 2018; Oyer, 2004). They directly affect employee wealth because they carry monetary value linked to the underlying stock price of the firm. They also make employees residual claimants and give them ownership status in the firm (Nyberg et al., 2018). They provide an asymmetric pay-off structure with unlimited upside but limited downside (Gerhart and Rynes, 2003), encouraging risk-taking in general (Chang et al., 2015). Also, the rights typically vest over a long period, meaning that employees enjoy the value of the options only if they are with the firm until they become exercisable (Oyer, 2004). Taken together, these features bind the value of stock options to employment with the firm, making them firm-specific incentives (Kryscynski et al., 2021). Their long-term orientation as well as firm-specificity distinguish stock options from other generic forms of compensation such as salaries and bonuses provided by firms.

The above properties of stock options make them attractive instruments for incentivizing employees to innovate (Chang et al., 2015). Innovation depends not only on the effort levels but also on the direction of those efforts (Azoulay and Lerner, 2013; Manso, 2011). Also, the outcomes are often uncertain, and the gains do not accrue immediately but over time, thus necessitating continued employee engagement for promoting new knowledge sharing and utilization (Holmstrom, 1989). These distinctive attributes of innovative effort means that conventional financial incentive mechanisms (e.g., bonuses, pay-for-performance) may not be effective in supporting innovation goals. Indeed, experimental evidence suggests that standard pay-for-performance incentives are not necessarily useful in enhancing innovation, indicating that stock options offer a superior means to induce innovation (Ederer and Manso, 2013).

2.2. Employee mobility and employee entrepreneurship

As we mentioned earlier, human capital practices such as employee stock options gain significance because of the challenges firms face in managing human capital. Human capital, unlike other assets of the firm, is not legally tethered to the firm. Instead, it is mobile

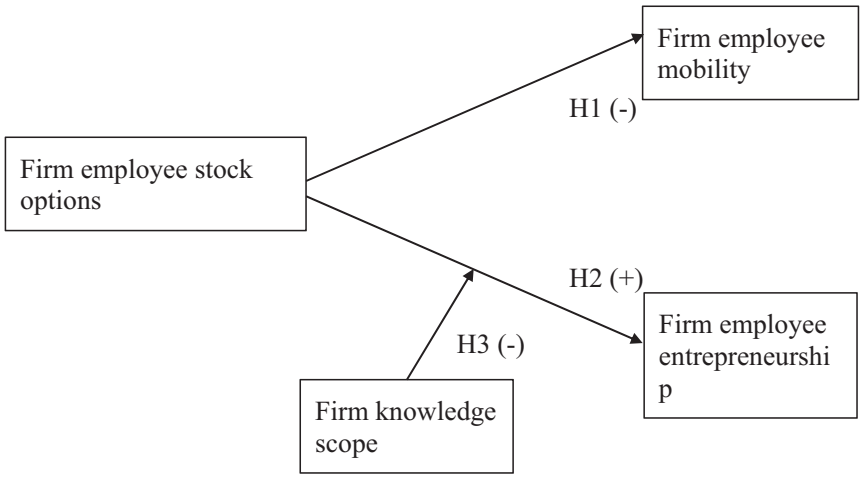

Fig. 1. Conceptual framework of the effects of firm employee stock options on employee mobility and employee entrepreneurship levels.

because employees can quit at will and walk out of the door (Coff, 1997), taking with them a firm's proprietary knowledge (Agarwal et al., 2009, 2004; Almeida and Kogut, 1999; Hoisl, 2007; Palomeras and Melero, 2010; Song et al., 2003). Employee departures give rise to the possibility that firms' privately held, tacit knowledge residing in the minds of the individuals spills out, engendering product market competition (Agarwal et al., 2016; Campbell et al., 2012b; Hoisl, 2007; Palomeras and Melero, 2010).[2] Employee departures also impose the transaction costs of using the labor market to fill the attendant vacant positions. More importantly, employee mobility and employee entrepreneurship can prove costly because they also impose appropriation costs in the form of lost revenues because of increased competition from the recipient firm and/or the newly formed venture (Agarwal et al., 2016; Campbell et al., 2012b; Phillips, 2002).

To the extent that both employee mobility and entrepreneurship can be costly, firms may aim to design and implement human capital practices that attenuate both. However, extant research suggests that human capital practices can affect employee mobility and employee entrepreneurship differently. For example, Campbell et al. (2012b) show that employees' realized earnings in the form of salaries and bonuses—an indicator of their human capital—can exert opposing effects on employee mobility and employee entrepreneurship. Likewise, Carnahan et al. (2012) demonstrates the contrasting effects of compensation dispersion on employee mobility and entrepreneurship. These divergent effects indicate that the impact of the practice of granting stock options to employees can be different for employee mobility and employee entrepreneurship. Given stock options' distinctive features compared to the aforementioned compensation practices as well as their relevance to driving innovation, we develop hypotheses that delineate the effects of employee stock options on employee mobility and employee entrepreneurship (see Fig. 1).

2.3. Employee stock options and employee mobility

Stock options are distinct from other compensation mechanisms in that they are prospective in nature and their value is contingent on the future performance of the firm. While typical pay-for-performance mechanisms reward employees for historical individual performance, stock option grants are forward-looking, meaning that the earnings from stock options are not immediately realized and come with significant uncertainty attached to them. In contrast to the effects of *realized* earnings on mobility (Campbell et al., 2012b), the effects of *prospective* and *uncertain* earnings on mobility are not well understood. In this regard, it is essential to investigate the extent to which such policies play a part, if at all, in employee retention.

A policy of stock option grants to nonexecutive employees can influence their departure decisions because it ties their compensation to the future prospects of the firm (Coff, 1997). To the extent that employees see promise in the firm's prospects, the firm specificity of stock options means that employees derive greater utility from their continued employment with the firm (Kryscynski et al., 2021). The added utility stems from the distinguishing features of stock options. Unlike traditional incentive mechanisms, stock options provide employees a privileged and profitable gateway to enjoying the fruits of the firm's idiosyncratic future growth opportunities. Insofar as future growth opportunities forebode an upward trend in the firm's stock price, employees are apt to find the firm's stock options valuable because of the anticipated stock price appreciation. Further, stock options increase the opportunity costs of employees considering leaving the firm (Oyer and Schaefer, 2005). This is because the rights to purchase the stock get activated not immediately but over time, compelling employees to relinquish the value of unvested stock options when they leave the firm. Besides their monetary value, stock options provide a path to claiming ownership stake in the firm (Oyer, 2004). This sense of formal

[2] Although reverse knowledge flows are also possible (Agarwal et al., 2007; Corredoira and Rosenkopf, 2009), the literature overwhelmingly points to the disruptive consequences of employee departures.

ownership not only enhances employees' psychological ownership but also empowers them by creating a sense of shared success (Blasi et al., 2016; Chi and Han, 2008; Nyberg et al., 2018).

These theoretical reasons receive support from anecdotal accounts suggesting that several companies used employee stock options to tackle the dynamics in the labor markets. Indeed, compensation surveys show that employee retention is a key reason behind employee stock options (Ittner et al., 2003). For example, during the dot-com boom, many major innovative companies such as Cisco, Lucent, Nortel, and Alcatel targeted stock option grants at engineers to provide added incentives and induce them to stay. Some firms even lowered the portion of options granted to the top executives to raise the number of employee stock options (Carpenter et al., 2003). Taken together, the theoretical rationale as well as anecdotal accounts imply that stock option grants alter employees' trade-offs of exiting the firm, thus inducing their continued participation in the ongoing employment relationship and enabling firms to cope with employee turnover. Therefore, we hypothesize that:

Hypothesis 1. The more employee stock options firms grant the lower their employee mobility levels.

2.4. Employee stock options and employee entrepreneurship

Another vital function stock options fulfill is the incentivization of employee behavior that sustains firm innovation. Firms' long-term survival and performance often depend on keeping abreast with the dynamic technological and market conditions through continual innovation (Eisenhardt and Martin, 2000; Teece et al., 1997). To meet innovation demands, firms rely on their employees to create and apply new knowledge by defining and solving new problems, a process that requires firms to encourage employees to experiment (Argote and Ingram, 2000; Nonaka, 1994; Schumpeter, 1983; Von Hippel and Von Krogh, 2016). To this end, in the menu of incentive instruments, stock options offer firms a powerful means to drive innovation by eliciting experimentation (Ederer and Manso, 2013; Manso, 2016, 2011).

Fostering experimentation can augment firm-level innovation (Chang et al., 2015), but it also comes with ramifications. These ramifications trace their origins to the inherent nature of experimentation. Fundamentally, experimentation is a trial-and-error process that proceeds in cycles of generating and testing new alternatives (Thomke et al., 1998), thus creating new knowledge and illuminating new opportunities (Lee et al., 2004). The fruits of the trial-and-error process—new knowledge and opportunities—are often only partially appropriated by firms because of internal selection hurdles (Burgelman and Grove, 1996). First, firms can only embrace a few of the many potential opportunities owing to the availability of resources (Damanpour and Wischnevsky, 2006; Pérez-Luño et al., 2011). Second, firms may not assimilate fully the knowledge generated because much of it is tacitly embedded in the experimenters, requiring laborious socialization, explication, and transfer processes (Nonaka, 1994; Szulanski, 1996; Von Hippel, 1998). These assimilation challenges also mean that new ideas may not receive adequate attention to secure organizational support (Burgelman, 2002, 1983b; Stein, 2002). Finally, firms may face structural and cognitive barriers in processing and evaluating the value of the new knowledge and opportunities (Henderson and Clark, 1990; Tripsas and Gavetti, 2000). While a handful of the experimentation-induced ideas survive the organizational rigidities and selection processes (Burgelman, 1991; Leonard-Barton, 1992), many others tend to be left out under-appreciated and under-explored (Agarwal et al., 2007).

Insofar as inducing experimentation results in employees producing knowledge and ideas that remain underutilized, employees may pursue their ideas through entrepreneurship. Indeed, new ventures are frequently the product of founders capitalizing on the discoveries made at incumbent firms (Bhidé, 2003). Such founders may find entrepreneurship an effective and conducive path to continue their experiments and bring their ideas to the market (Kerr et al., 2014). Employees may depart to form their own ventures because the knowledge they discover in the trial-and-error process may equip them to view the opportunity landscape differently than the employing firm (Thomke et al., 1998). Moreover, to the degree that the firms exercise their right to abandon or switch projects (McGrath, 1999), prospective founders may seek the freedom of their new ventures for refining and advancing their experiments (Klepper, 2007). Yet another reason is that employees may experience negative emotions from the failure to get past the organizational selection hurdles, weakening their organizational commitment and making the pursuit of entrepreneurship attractive (Murnieks et al., 2014; Shepherd et al., 2011). Taken together, to the extent that stock options incentivize employees to experiment, we expect to observe a positive relationship between firms' employee stock options and employee entrepreneurship levels. We thus hypothesize that:

Hypothesis 2. The more employee stock options firms grant the higher their employee entrepreneurship levels.

2.5. The moderating effect of the knowledge scope of the firm

In the previous hypothesis, the argument hinges on internal obstacles impeding the adoption of new opportunities that arise from incentivizing employee experimentation. To further elaborate this reasoning, the next hypothesis develops a moderating effect argument that considers knowledge scope. Knowledge scope is a firm's definitive characteristic because it delineates a firm's knowledge and activity domains (Brusoni et al., 2001; Conner and Prahalad, 1996; Kogut and Zander, 1992; Teece, 1980). The range of a firm's knowledge domains is the manifestation of the strategy a firm pursues and the selection mechanisms it enacts to maintain coherence (Burgelman, 2002, 1991; Teece et al., 1994). These foundational ideas suggest that the knowledge scope of the firm serves as a powerful indicator of the internal selection hurdles experimental ideas have to cross in order to gain acceptance.

Considering firms' knowledge scope, we distinguish between firms whose scope is narrow relative to those whose scope is broad. We expect that the effect of employee stock options on employee entrepreneurship will be stronger in firms with narrow knowledge scope than in firms with a broad scope. This expectation builds on the idea that the selection forces impacting experimental ideas are

stronger in firms with narrow knowledge scope. A narrow knowledge scope may signify a firm's *ex ante* commitment to a focused strategy that values innovations only in a core set of areas (Hellmann, 2007; Rotemberg and Saloner, 1994). Also, a firm with a narrow knowledge scope will likely reject a new opportunity and wait for a *future* innovation that fits its capabilities better (Cassiman and Ueda, 2006). A narrow knowledge scope can make it challenging for the organization to appreciate and exploit new knowledge and opportunities generated through experimentation because of an absorptive capacity deficit (Cohen and Levinthal, 1990; Tzabbar, 2009; Zahra and George, 2002). Finally, a narrow knowledge scope means that managers are likely to view new opportunities from a narrow lens and thus fail to recognize their value (Corner et al., 1994; Prahalad, 2004). These arguments, taken together, suggest that a narrow knowledge scope of the firm compounds the frustration employees face in obtaining organizational approval for the ideas arising from the experimentation encouraged by employee stock options (Klepper and Thompson, 2010). Thus, such firms' employees are more likely to leave and pursue their ideas in their own ventures.

Hypothesis 3. When the knowledge scope of the firm is narrow, the more employee stock options firms grant even higher are their employee entrepreneurship levels.

3. Methods

3.1. Data and sample

We tested our hypotheses in the context of the U.S. Semiconductor industry between 1997 and 2012. A sector that lent Silicon Valley its name, semiconductors naturally attracted the attention of scholars investigating human capital, incentives, innovation, and entrepreneurship (Almeida and Kogut, 1997; Campbell, 2013; Corredoira and Rosenkopf, 2009; Ganco, 2013; Klepper, 2010). An archetypal high-technology industry, it is known for its demands of technical knowledge and innovation pace—aspects that make human capital a vital asset for firms in the industry (Brown and Linden, 2005; Dibiaggio, 2007). Human capital movement has played a pivotal role in the evolution and growth of the industry (Brittain and Freeman, 1986; Corredoira and Rosenkopf, 2009; Garvin, 1983; Klepper, 2009). Not surprisingly, semiconductor firms commonly implement practices to incentivize and retain individuals (Carpenter et al., 2003; Hatch and Dyer, 2004; Ittner et al., 2003). These features offer a fertile setting for our study.

We assembled our dataset using several archival sources. We obtained a list of all publicly traded semiconductor firms domiciled in the United States and their financials from the Compustat database through the Wharton Research Data Services (WRDS). Data on the technological characteristics of the firms and inventors, came from the United States Patent Office's (USPTO) patentsview initiative (www.patentsview.org). To capture intra-industry employee entrepreneurship, we relied on proprietary data from Pinestream Consulting Group (Pinestream). Pinestream has been tracking new entrants in the semiconductor industry since 1997 to build a comprehensive database documenting details about the new entrants including their founding year, the founders, and the founders' previous employment (Adams et al., 2016). Data from other sources—ThompsonOne's VentureXpert, VentureSource, and Small Business Innovation Research (SBIR) program—assisted in cross-validating the data on new entrants. LinkedIn is another important source that helped track founders and their employment histories.

Data on employee stock options is not available separately in standard databases. To overcome this challenge, we combined and triangulated data from multiple data sources (for details see Measures section below). From the Center for Research in Security Prices (CRSP), we obtained annual data on the firm's total new stock options granted and stock option grants accumulated from previous years outstanding at the end of the fiscal year. To redress CRSP's uneven coverage, we filled the gaps using the annual 10-K filings retrieved from the Securities and Exchange Commission's Electronic Data Gathering, Analysis and Retrieval (EDGAR). Our measure of employee stock options also required data on stock options granted to top executives, which we obtained from the ExecuComp database through WRDS. We replenished ExecuComp's gaps using data from DEF14A filings retrieved from EDGAR.

Further, we obtained data on firms' litigation histories from USPTO. We tracked the firms' merger and acquisition activity using data from the Securities Data Company (SDC). The data on human resource policies came from the Morgan Stanley Capital International's (MSCI) KLD database. We also obtained data on firms' institutional ownership from Thomson Reuters Stock Ownership dataset (13Fs). Finally, we derived data on the geography of industry activity from the US Bureau of Labor Statistics (www.bls.gov), and data on non-compete enforcement from Ewens and Marx (2018).

Our sample design is informed by the analytic approach required to test our hypotheses. Our core relationships link employee stock options with the mobility and entrepreneurship of employees with a record of producing innovations (i.e., inventors). A chief concern in testing this relationship is that unobserved attributes of the firm may impact firm human resource policies as well as employee mobility and employee entrepreneurship. To account for this potential endogeneity, we implemented a two-stage procedure as described in the section below.

Our analysis sample is an unbalanced firm-year panel. The first stage sample drew from the population of semiconductor firms defined as per the North American Industry Classification System (NAICS) and publicly listed in the United States between 1997 and 2012. The second stage sample is obtained from intersecting the sample from the first stage with the information gathered from Pinestream and other data sources. After accounting for missing values, our first stage sample contained 287 firms and 2659 firm-year observations. Nested in the first stage sample, the second-stage sample contained 101 firms and 1138 firm-year observations.

3.2. Measures

3.2.1. Dependent variables

To measure the first dependent variable, *Employee mobility*, we followed prior research that uses patent data to track mobility (Agarwal et al., 2009; Almeida and Kogut, 1999; Corredoira and Rosenkopf, 2009; Ganco, 2013; Palomeras and Melero, 2010; Song et al., 2003). This stream of work pioneered the use of patent data to track mobility, particularly in high-tech sectors such as semiconductors that patent exceedingly (Hall and Ziedonis, 2001; Ziedonis, 2004). Based on this established precedent, we identified mobility events by tracking the assignees of the patent applications filed by inventors.[3] The value of the variable *Employee mobility* for a firm in a given year is the count of the inventors who appear on the patent applications of the focal firm in a given year but appear on the patent applications of another firm in the next year.

To measure the second dependent variable, *Employee entrepreneurship*, we followed prior work that defines employee entrepreneurship as the intra-industry founding of a new venture (i.e., spin-out) by former employees of an existing firm in the industry (Agarwal et al., 2004; Ganco, 2013; Garvin, 1983; Klepper, 2001). First, to identify spin-outs, we compiled a comprehensive list of all new ventures in the US semiconductor industry since 1997. Second, we identified the founders' names for every new venture and constructed their employment histories (using the sources mentioned above). Third, we matched the founders' prior employers' names with the names of the firms in our sample to identify the employee entrepreneurship events of these firms. Using founder *LinkedIn* profiles as well as data from *Execucomp*, we could track the positions founders held at incumbent firms. Using this information, we measured *Employee entrepreneurship* as the number of inventors leaving to form a new venture in the semiconductor industry. As an alternative measure, we also track the number of distinct spin-outs formed in a given year and label this variable as *Spin-outs*. This alternative measure of employee entrepreneurship allows us to test the robustness of the effects of employee stock options on employee entrepreneurship.

3.2.2. Independent variables

Our primary explanatory construct is the firms' employee stock options — the stock options granted to the organization's tier below the executive level (Hochberg and Lindsey, 2010; Kedia and Rajgopal, 2009; Oyer and Schaefer, 2006). In measuring employee stock options, the challenge we face is that firms are not required to disclose the number of new stock options granted to non-executive employees. We overcame this challenge using a method frequently employed in the finance and accounting literatures (Core and Guay, 2001; Hochberg and Lindsey, 2010; Kedia and Rajgopal, 2009). Following this method, we recovered the number of new options granted to non-executive employees by subtracting the number of new options granted to the executive team from the total number of new options granted by the firm. We then calculated our first explanatory variable, *Option grants per employee*, by dividing the firm's number of non-executive options granted by the number of employees during the year (Bergman and Jenter, 2007; Chang et al., 2015).

Our third hypothesis proposes the firm's knowledge scope as a moderating variable. This variable requires us to measure the breadth of firms' knowledge capabilities. Firms with a broad knowledge scope are better placed to utilize the output of employees' experimentation (Hellmann, 2007). To construct this measure, we began with the premise that the semiconductor sector turns to patents for appropriating returns to R&D (Hall and Ziedonis, 2001; Ziedonis, 2004) and that the classification of patents in various technological classes marks the position of firms in the knowledge space (Jaffe, 1989). Equipped with information on firms' patent portfolios as well as all the listed patent classes (per the Cooperative Patent Classification Scheme), we calculated the variable *Knowledge scope* as an entropy index using the distribution of patents across various technology classes in the patent portfolio of the firm for each firm-year observation (Jacquemin and Berry, 1979; Zahra and Garvis, 2000).[4] This measure of *Knowledge scope* allows us to capture both the number of classes and their relative size.

3.2.3. Control variables

We included several variables related to firm-level characteristics—including innovation, business, financial position, human resource practices, and location—aspects plausibly associated with employee mobility and employee entrepreneurship as well as employee stock options. We lagged all control variables by one year. Our first set of control variables captures firms' innovation characteristics linked to employee mobility and employee entrepreneurship. Firms with high quality knowledge base are apt to implement incentive policies that encourage experimentation. Such firms also tend to spawn spin-outs (Agarwal et al., 2004). To account for these effects, we included *Knowledge stock quality*, measured as the citations received by patents in the first five years after their grant (log-transformed) (Lanjouw and Schankerman, 2004). We considered patents granted to the firm using a 15-year moving window. Prior research documents the effects of a firm's reputation as a tough legal enforcer of its intellectual property rights on mobility and employee entrepreneurship (Agarwal et al., 2009; Ganco et al., 2015). To control for these effects, we included *Litigiousness*, calculated as the logarithm of the number of unique patent infringement lawsuits filed by the firm.

Our second set of controls addresses the business characteristics of the firm. We controlled for firm size because larger firms could make greater use of employee stock options (Core and Guay, 2001) and have more employees who could exit (Franco and Filson, 2006). To account for firm size effects, we included *Employees*, measured as the log of the number of employees (Core and Guay, 2001).

[3] We took several steps to account for mass exits because of layoffs and business combinations. We searched news articles and press releases for layoffs and excluded these observations from our sample. Second, we examined whether the mobility events were linked to a merger or an acquisition and excluded these observations from our sample.

[4] We use the formula $\Sigma_i\ [-p_i{*}\log(p_i)]$ where p_i is the proportion of patents in technology i in the patent portfolio.

Firm's extent of business diversification can play a role in its ability to retain employees (Klepper and Sleeper, 2005). Firms with *downstream* product market diversity can offer more product-market outlets for employees to exploit their knowledge, thus reducing their inclination to do so elsewhere. To control for these effects, we included *Diversification*, measured as the Herfindahl–Hirschman index of the firm's annual number of business segments (Gompers et al., 2005). Mergers and acquisitions are disruptive events that frequently lead to high levels of employee mobility and employee entrepreneurship (Kim, 2022). To control for these effects, we included *Acquisitions*, measured as the three-year moving sum of the number of mergers and acquisitions a firm has completed. Because investments in R&D activities can influence employee turnover, we controlled for *R&D intensity*, measured as the ratio of R&D expenditures to net sales (Ganco et al., 2015).

Our third set of control variables considers the human resource practices of the firm. Granting stock options to incentivize and retain employees can impose additional costs on the firm, which can affect the number of stock options firms grant to their employees (Guay et al., 2003). To account for these costs, we included the variable *Implied option cost*, which represents the decrease in net income attributed to the added expense of stock options-based compensation. Implied option cost represents the fair value of option grants and thus indicates the opportunity costs employees are likely to face when leaving the firm. Because the friendliness of the human resource practices can influence employees' propensity to leave, we included *Employee friendliness*, measured as the firms' number of employee relations strengths provided by the MSCI KLD dataset. This measure captures several employee relations dimensions that account for various human resource practices for building strong relations with employees, including a no-layoff policy, retirement benefits, union relations, cash profit sharing, employee involvement, health and safety, and others (Coombs and Gilley, 2005). A firm's reputation as a good employer can also play a role in retaining employees (Kryscynski et al., 2021). To control for these effects, we included *Employer reputation*, measured as a firm's rank in Fortune's best companies to work for. Naturally, not all firms in our sample appear in Fortune's ranking. We assigned a rank of 101 for all such firms and included a dummy variable, *Unranked employer*, which takes the value of one when a firm does not appear in Fortune's list and zero otherwise. This variable captures the average effect of firms outside Fortune's list.

Our fourth set of control variables accounts for the firm's financial position. Granting employee stock options allows firms to compensate employees without using cash and may be attractive to firms with a weak liquidity position (Hall and Murphy, 2003); a weak cash position, portending bankruptcy, may also impact firms' ability to retain and incentivize employees. So, we included *Liquidity position*, defined as the cash-to-current assets ratio. Employee mobility and entrepreneurship may also depend on firms' capital structure (Titman, 1984). For instance, a highly leveraged firm may not have the slack to invest in new projects arising from employee experimentation. Hence, we controlled for *Financial leverage*, measured using long term debt-to-equity ratio, to account for the effects of capital structure on employee mobility and employee entrepreneurship as well as employee stock options (Chang et al., 2015). Firm performance can influence mobility and employee entrepreneurship levels as employees may exit firms performing strongly to form spin-outs, or flee sinking ships (Klepper and Thompson, 2010); strongly performing firms may also distribute the gains of their performance more broadly through employee stock options (Sesil et al., 2002). We thus controlled for *Return on assets*, the ratio of net income to total assets (Hochberg and Lindsey, 2010). Corporate governance could influence the practice of granting employee options and employee exits. Specifically, institutional investor ownership can decrease the proclivity of firms to use employee stock options (Eisenhardt, 1988) but increase the degree of project rejections because of short-termism (Graves, 1988), thus affecting mobility and employee entrepreneurship. We included the variable *Institutional investor ownership*, measured as the four-quarter moving average of the quarterly total institutional ownership scaled by the percent of shares outstanding. Firms' stock price volatility relative to competitors can shape employee stock options by affecting their value and employees' decision to exit.[5] We thus included *Relative volatility*, the ratio of a firm's annualized variance of its daily stock returns relative to the industry average in the preceding fiscal year.

Finally, our fifth set of control variables addresses firms' location characteristics. The regional concentration of firms from the same industry can influence firms' practice of granting stock options to employees (Kedia and Rajgopal, 2009). Such concentration can affect the market for human capital and other resources, thus impacting employees' movement to other employers as well as to entrepreneurship (Duranton and Puga, 2004; Pe'er and Vertinsky, 2008). To account for these effects, we included *Cluster strength*, measured using the location quotient of semiconductor industry establishments. Measured at the county level, a firm's location quotient is the ratio of the share of semiconductor industry establishments in the firm's location to the share of the semiconductor industry establishments nationwide (Delgado et al., 2014; Fernhaber and Li, 2013; Pe'er and Vertinsky, 2008). In addition, non-compete agreements can restrict mobility and employee entrepreneurship (Garmaise, 2011; Marx et al., 2009). Firm-fixed effects (see below) capture the time-invariant effects of the non-compete regime but not the effects arising from changes in the regime. To account for these dynamics, we included *Non-compete enforcement*, an indicator for whether non-compete enforceability strengthened (+1), weakened (−1), or remained the same (0) in the state of a firm's location (Ewens and Marx, 2018). Finally, we incorporated year-fixed effects to control for idiosyncratic shocks over time and firm-fixed effects to control for unobserved firm-level attributes that tend to remain stable over time.

3.2.4. *Instrumental variable*

As mentioned earlier, the main empirical challenge we face is that the firm's employee stock options could be endogenous. For example, unobserved factors such as a negative shock to the technological position of the firm may encourage employees to depart and impact the issuance of stock options to employees. To address potential endogeneity concerns, we employ an instrumental variable approach.

[5] We thank an anonymous reviewer for this suggestion.

A suitable instrumental variable affects employee stock option grants but does not affect employee mobility or employee entrepreneurship levels. To construct such an instrumental variable, we built on previous literature that suggests that firms tend to mimic their neighbors (Lieberman and Asaba, 2006). Specifically, prior research shows that firms tend to imitate the stock options practices of other firms in the same geographic neighborhood (Glaeser et al., 1996; Hochberg and Lindsey, 2010; Kedia and Rajgopal, 2009). Motivated by these findings, we adopted a geography-based approach to construct our instrumental variable. Specifically, we relied on the employee stock option grants of proximate firms that fall outside the semiconductor and associated industries to construct our instrument for two reasons. First, the practice of granting stock options to employees may propagate to firms co-located in a geographic area even when they operate in other industries. For example, Kedia and Rajgopal (2009) quote a senior executive of a Seattle-based retail firm saying the retail firm grants options to non-executive employees because Microsoft (also located in Seattle) does so. Second, the factors that can commonly impact firms in the semiconductor industry as well as the associated industries in the region threaten the violation of exclusion restrictions.

Our instrument plausibly meets the exclusion restriction requirement for the following reasons. The semiconductor industry requires highly specialized knowledge to such an extent that even knowledge domains within the sector can exhibit sharp boundaries (Dibiaggio, 2007; Macher and Mowery, 2004). Such highly specialized knowledge can erect significant barriers for individuals to switch across domains, let alone switch sectors (e.g., Ganco, 2013). These steep barriers mean that individuals may find it highly unprofitable to switch sectors when moving to other firms or starting their own ventures (Carrington, 1993; Neal, 1995). Thus, employees in the semiconductor industry are more likely to capitalize on their expertise by entrenching in rather than exiting the industry. Consequently, we expect employee stock option grants of neighborhood firms in other sectors to not impact systematically inter-industry employee mobility and employee entrepreneurship.

Table 1
Variable descriptions and summary statistics.

Variables	Descriptions	Mean	S.D.
Dependent variables			
Employee Mobility	Number of inventors that left the focal firm in year *t* to work for another firm in year *t + 1*	5.10	11.63
		0.37	1.18
Employee Entrepreneurship	Number of inventors that left the focal firm in year *t* to form a new venture in the semiconductor industry in year *t + 1*	0.37	1.18
Spin-outs	Number of semiconductor startups created by ex-employees of the focal firm in year *t + 1*	0.21	0.59
Main explanatory variables			
Option grants per employee	Ratio of the number of options granted to non-executive employees to the number of employees	3.96	7.54
Knowledge scope	Entropy index using the distribution of patents across technology classes in the patent portfolio of the firm for each firm-year obs	5.01	2.08
Controls			
Knowledge stock quality	Moving sum of the number of citations received in a five-year window after grant by patents granted to the firm from year *t-1* to year *t-15* (log-transformed)	5.64	2.71
Litigiousness	Moving sum of the number of patent infringement lawsuits filed by the firm from year *t-1* to year *t-5* (log transformed)	0.62	0.86
Employees	Number of employees (log transformed)	0.32	1.59
Diversification	HHI index of the number of business segments	0.95	0.12
Acquisitions	Moving sum of the number of mergers and acquisitions completed by the firm from year *t-1* to year *t-3*	1.82	2.81
R&D intensity	Ratio of the research and development expenditures to net sales	0.24	0.18
Implied option cost	Pro forma net income minus net income (represents the decrease in net income due to the costs of stock-option based compensation)	0.07	0.54
Employee friendliness	Number of human resource policies aimed at building strong employee relations	0.44	0.94
Employer reputation	Rank of the firm in Fortune's list of best companies to work for	0.01	0.01
Unranked employer	A dummy variable set to 1 if the firm is not ranked in Fortune's list of best companies to work for, and 0 otherwise	0.96	0.19
Liquidity position	Ratio of cash to current assets	0.60	0.19
Financial leverage	Ratio of long-term debt to equity	0.16	2.31
Return on assets	Ratio of net income to total assets	−0.07	0.53
Institutional ownership	Moving average of the quarterly total institutional ownership scaled by the percentage of shared outstanding (quarter *t-1* to quarter *t-4*)	0.58	0.26
Relative volatility	Ratio of firm's annualized variance of its daily stock returns relative to the industry average in the previous year	−0.58	0.76
Cluster strength	Ratio of the share of semiconductor industry establishments in the firm's location to the share of semiconductor industry establishments nationwide	1.42	0.83
Non-compete enforcement	An indicator for whether non-compete enforceability strengthened (+1), weakened (−1), or remained the same (0) in the state of the firm's location (as listed in Ewens & Marx, 2018)	0.00	0.09
Instrumental variable			
Near firm option grants per employee	Moving average of the non-executive options outstanding per employee for all companies that lie within a 100-mile radius from the focal firm and that fall outside the semiconductor and from year *t-1* to year *t-3*	1.02	0.76

Table 2
Correlations table.

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Employee Mobility																						
2	Employee entrepreneurship	**0.25**																					
3	Spin-outs	**0.26**	**0.92**																				
4	Option grants per employee	**−0.08**	0.02	0.03																			
5	Near firm option grants per empl.	**0.06**	−0.02	−0.02	−0.01																		
6	Knowledge scope	**0.38**	**0.20**	**0.21**	**−0.08**	**0.14**																	
7	Knowledge stock quality	**0.50**	**0.19**	**0.21**	**−0.10**	**0.35**	**0.70**																
8	Litigiousness	**0.51**	**0.19**	**0.21**	**−0.10**	**0.08**	**0.44**	**0.56**															
9	Employees	**0.52**	**0.20**	**0.22**	**−0.30**	0.03	**0.31**	**0.43**	**0.46**														
10	Diversification	**−0.14**	−0.03	−0.03	−0.02	**0.10**	**−0.14**	**−0.08**	**−0.17**	**−0.08**													
11	Acquisitions	**0.29**	**0.25**	**0.27**	−0.05	0.01	**0.19**	**0.24**	**0.29**	**0.42**	**−0.08**												
12	R&D intensity	**−0.07**	**0.05**	**0.07**	**0.34**	**0.10**	−0.02	0.01	**−0.10**	**−0.35**	**0.09**	−0.03											
13	Implied option cost	−0.03	0.01	0.03	**0.10**	**−0.06**	0.00	−0.03	−0.04	**−0.09**	0.03	−0.02	**0.29**										
14	Employee friendliness	**0.51**	**0.18**	**0.20**	**−0.07**	**0.13**	**0.29**	**0.43**	**0.38**	**0.45**	**−0.04**	**0.33**	**−0.05**	−0.02									
15	Employer reputation	**0.06**	**0.05**	**0.08**	−0.01	0.00	**0.09**	**0.12**	**0.10**	**0.09**	**−0.09**	**0.13**	−0.01	0.00	**0.21**								
16	Unranked employer	**−0.32**	**−0.22**	**−0.24**	0.02	0.03	**−0.21**	**−0.24**	**−0.32**	**−0.25**	**0.16**	**−0.33**	0.03	0.01	**−0.39**	**−0.56**							
17	Liquidity position	−0.02	0.05	**0.07**	**0.17**	**0.24**	**0.06**	**0.15**	0.04	**−0.14**	**0.08**	−0.01	**0.44**	**0.09**	**0.08**	0.04	**−0.05**						
18	Financial leverage	0.00	0.00	0.00	0.00	0.01	0.00	0.01	−0.02	0.02	0.01	0.01	−0.02	0.00	0.00	0.00	0.00	−0.02					
19	Return on assets	**0.08**	0.01	0.02	**−0.38**	0.01	0.03	**0.08**	**0.12**	**0.20**	0.02	0.01	**−0.40**	**−0.15**	**0.08**	0.03	**−0.05**	0.00	0.01				
20	Institutional ownership	**0.07**	0.02	**0.04**	**−0.17**	**0.28**	**0.30**	**0.39**	**0.26**	**0.42**	**0.06**	**0.23**	**−0.15**	**−0.09**	**0.25**	**0.05**	**−0.05**	**0.19**	0.03	**0.17**			
21	Relative volatility	**−0.25**	**−0.04**	**−0.05**	**0.20**	**−0.17**	**−0.22**	**−0.28**	**−0.25**	**−0.37**	**0.12**	**−0.11**	**0.24**	**0.09**	**−0.24**	−0.03	**0.12**	**0.06**	0.04	**−0.23**	**−0.34**		
22	Cluster strength	0.02	**0.12**	**0.15**	**0.11**	**0.26**	**0.09**	**0.14**	0.03	0.01	**0.12**	**0.05**	**0.11**	−0.03	**0.08**	0.04	−0.03	**0.21**	−0.01	0.01	**0.16**	0.04	
23	Non-compete enforcement	**0.05**	−0.01	0.00	−0.01	0.01	0.01	0.02	**0.04**	0.00	0.02	0.01	−0.02	−0.01	0.03	0.00	0.01	−0.01	0.00	0.01	0.01	−0.02	**−0.06**

Note. Coefficients in bold are significant at $p < 0.05$.

Table 3
First stage results of the near firm option grants per employee (instrument) on option grants per employee.

Variables	DV = Option grants per employee
Near firm option grants per employee	**0.227**
	(0.094)
	[0.016]
Technology scope	−0.019
	(0.032)
	[0.545]
Knowledge stock quality	0.051
	(0.026)
	[0.052]
Litigiousness	0.175
	(0.073)
	[0.016]
Employees	−0.449
	(0.043)
	[0.000]
Diversifications	−0.129
	(0.312)
	[0.679]
Acquisitions	0.061
	(0.018)
	[0.001]
R&D intensity	1.143
	(0.297)
	[0.000]
Implied option cost	−0.034
	(0.015)
	[0.021]
Employee friendliness	0.125
	(0.058)
	[0.030]
Employer reputation	3.663
	(4.202)
	[0.383]
Unranked employer	−0.113
	(0.278)
	[0.685]
Liquidity position	1.298
	(0.210)
	[0.000]
Financial leverage	0.005
	(0.002)
	[0.006]
Return on assets	−0.379
	(0.098)
	[0.000]
Institutional ownership	−0.528
	(0.191)
	[0.006]
Relative volatility	0.238
	(0.062)
	[0.000]
Cluster strength	0.266
	(0.052)
	[0.000]
Non-compete enforcement	0.065
	(0.254)
	[0.798]
Constant	−0.376
	(0.434)
	[0.387]
Year FE	Included
Observations	2659
Log likelihood	−4279

Note. Clustered (firm-level) robust standard errors in parentheses; p-values in brackets.

Table 4
Main and second stage results of the effects of employee stock options on employee mobility.

Variables	(1)	(2)	(3)
Option grants per employee		**−0.021**	**−0.059**
		(0.012)	**(0.024)**
		[0.074]	**[0.016]**
Technology scope	−0.009	−0.010	−0.024
	(0.077)	(0.077)	(0.076)
	[0.908]	[0.892]	[0.757]
Knowledge stock quality	0.581	0.567	0.568
	(0.141)	(0.135)	(0.130)
	[0.000]	[0.000]	[0.000]
Litigiousness	−0.081	−0.081	−0.079
	(0.059)	(0.058)	(0.057)
	[0.172]	[0.160]	[0.163]
Employees	0.183	0.155	0.117
	(0.152)	(0.156)	(0.155)
	[0.229]	[0.321]	[0.449]
Diversifications	−0.103	−0.113	−0.111
	(0.310)	(0.297)	(0.301)
	[0.741]	[0.704]	[0.712]
Acquisitions	0.011	0.011	0.018
	(0.007)	(0.006)	(0.008)
	[0.094]	[0.067]	[0.029]
R&D intensity	−0.461	−0.545	−0.064
	(0.401)	(0.398)	(0.505)
	[0.250]	[0.171]	[0.899]
Implied option cost	−0.063	−0.031	−0.048
	(0.070)	(0.042)	(0.067)
	[0.373]	[0.461]	[0.437]
Employee friendliness	0.094	0.096	0.104
	(0.040)	(0.040)	(0.041)
	[0.020]	[0.016]	[0.011]
Employer reputation	−1.476	−1.403	−0.785
	(1.143)	(1.232)	(1.277)
	[0.196]	[0.255]	[0.539]
Unranked employer	0.008	0.011	0.022
	(0.063)	(0.063)	(0.065)
	[0.899]	[0.856]	[0.740]
Liquidity position	0.336	0.330	0.408
	(0.231)	(0.229)	(0.231)
	[0.146]	[0.150]	[0.078]
Financial leverage	0.004	0.004	0.005
	(0.002)	(0.002)	(0.002)
	[0.115]	[0.120]	[0.044]
Return on assets	−0.011	−0.114	−0.186
	(0.072)	(0.097)	(0.131)
	[0.875]	[0.242]	[0.154]
Institutional ownership	−0.238	−0.273	−0.360
	(0.171)	(0.178)	(0.187)
	[0.162]	[0.127]	[0.054]
Relative volatility	−0.192	−0.184	−0.174
	(0.069)	(0.068)	(0.068)
	[0.006]	[0.007]	[0.011]
Cluster strength	0.142	0.145	0.196
	(0.259)	(0.256)	(0.267)
	[0.582]	[0.570]	[0.463]
Non-compete enforcement	0.085	0.080	0.075
	(0.096)	(0.098)	(0.097)
	[0.376]	[0.414]	[0.440]
First stage residual			0.043
			(0.019)
			[0.030]
Year FE	Included	Included	Included
Firm FE	Included	Included	Included
Observations	1054	1054	1054
Log likelihood	−1611	−1607	−1601

Note. Clustered (firm-level) robust standard errors in parentheses; p-values in brackets.
The significance is already in square brackets. The row is in bold because it is the variable of interest.

Table 5
Main and second stage results of the effects of employee stock options on employee entrepreneurship—DV is employee entrepreneurship.

Variables	(1)	(2)	(3)	(4)	(5)
				Technology scope	
				Narrow	Broad
Option grants per employee		**0.042**	**0.046**	**0.259**	**0.001**
		(0.017)	**(0.016)**	**(0.112)**	**(0.021)**
		[0.014]	**[0.005]**	**[0.020]**	**[0.957]**
Technology scope	−0.250	−0.240	−0.241	0.797	−0.491
	(0.167)	(0.169)	(0.169)	(0.459)	(0.290)
	[0.135]	[0.155]	[0.153]	[0.082]	[0.091]
Knowledge stock quality	0.148	0.171	0.161	−0.237	0.405
	(0.164)	(0.169)	(0.173)	(0.232)	(0.240)
	[0.367]	[0.313]	[0.351]	[0.307]	[0.091]
Litigiousness	−0.427	−0.395	−0.383	0.080	−0.790
	(0.206)	(0.208)	(0.204)	(0.470)	(0.334)
	[0.038]	[0.057]	[0.061]	[0.864]	[0.018]
Employees	0.782	0.917	0.918	1.281	1.298
	(0.266)	(0.268)	(0.264)	(0.521)	(0.290)
	[0.003]	[0.001]	[0.001]	[0.014]	[0.000]
Diversifications	0.445	0.405	0.467	3.998	0.237
	(0.871)	(0.885)	(0.876)	(2.777)	(1.080)
	[0.609]	[0.647]	[0.594]	[0.150]	[0.826]
Acquisitions	0.006	0.005	0.003	0.260	−0.019
	(0.029)	(0.029)	(0.028)	(0.070)	(0.028)
	[0.849]	[0.868]	[0.915]	[0.000]	[0.495]
R&D intensity	0.449	0.727	0.568	3.288	0.339
	(0.591)	(0.639)	(0.688)	(2.210)	(0.696)
	[0.447]	[0.255]	[0.409]	[0.136]	[0.626]
Implied option cost	0.030	0.006	0.007	−1.012	0.028
	(0.027)	(0.029)	(0.030)	(1.276)	(0.037)
	[0.269]	[0.841]	[0.805]	[0.427]	[0.447]
Employee friendliness	0.144	0.128	0.125	0.027	0.246
	(0.175)	(0.182)	(0.180)	(0.339)	(0.190)
	[0.410]	[0.481]	[0.487]	[0.936]	[0.195]
Employer reputation	−1.446	−1.198	−1.143	−34.032	14.637
	(3.779)	(3.715)	(3.718)	(12.895)	(7.697)
	[0.702]	[0.747]	[0.759]	[0.008]	[0.057]
Unranked employer	−0.115	−0.107	−0.133	−3.965	0.304
	(0.366)	(0.372)	(0.365)	(1.289)	(0.400)
	[0.754]	[0.773]	[0.716]	[0.002]	[0.447]
Liquidity position	−0.512	−0.527	−0.519	−3.330	0.649
	(0.784)	(0.826)	(0.810)	(1.629)	(1.015)
	[0.514]	[0.523]	[0.522]	[0.040]	[0.523]
Financial leverage	0.060	0.055	0.057	−0.046	0.183
	(0.040)	(0.037)	(0.038)	(0.103)	(0.070)
	[0.131]	[0.132]	[0.141]	[0.657]	[0.009]
Return on assets	0.009	0.259	0.013	3.468	−0.459
	(0.341)	(0.268)	(0.543)	(1.377)	(0.569)
	[0.978]	[0.335]	[0.980]	[0.011]	[0.419]
Institutional ownership	0.765	0.807	0.836	6.295	−1.177
	(0.730)	(0.749)	(0.745)	(1.838)	(1.424)
	[0.295]	[0.281]	[0.262]	[0.000]	[0.408]
Relative volatility	0.064	0.050	0.044	0.330	0.034
	(0.159)	(0.160)	(0.161)	(0.366)	(0.245)
	[0.686]	[0.754]	[0.782]	[0.368]	[0.890]
Cluster strength	−1.155	−1.236	−1.259	−10.204	0.481
	(1.063)	(1.099)	(1.092)	(3.820)	(1.133)
	[0.277]	[0.261]	[0.249]	[0.008]	[0.671]
Non-compete enforcement	0.470	0.510	0.499	−0.548	0.485
	(0.971)	(0.969)	(0.962)	(1.184)	(1.069)
	[0.628]	[0.599]	[0.604]	[0.643]	[0.650]
First stage residual			0.001	−0.097	0.0006
			(0.001)	(0.110)	(0.001)
			[0.229]	[0.378]	[0.459]
Year FE	Included	Included	Included	Included	Included
Firm FE	Included	Included	Included	Included	Included
Observations	957	957	957	358	469
Log likelihood	−575.7	−570.5	−569.9	−117.6	−340.1

Note. Clustered (firm-level) robust standard errors in parentheses; p-values in brackets.
The significance is already in square brackets. The row is in bold because it is the variable of interest.

Table 6
Main and second stage results of the effects of employee stock options on employee entrepreneurship—DV is the number of spin-outs.

Variables	(1)	(2)	(3)	(4)	(5)
				Technology scope	
				Narrow	Broad
Option grants per employee		**0.047**	**0.049**	**0.208**	**0.014**
		(0.015)	**(0.016)**	**(0.099)**	**(0.017)**
		[0.002]	**[0.002]**	**[0.036]**	**[0.398]**
Technology scope	−0.096	−0.079	−0.080	0.777	−0.167
	(0.140)	(0.140)	(0.140)	(0.477)	(0.205)
	[0.494]	[0.571]	[0.565]	[0.104]	[0.416]
Knowledge stock quality	0.162	0.179	0.174	−0.042	0.434
	(0.153)	(0.156)	(0.158)	(0.223)	(0.228)
	[0.290]	[0.252]	[0.270]	[0.852]	[0.057]
Litigiousness	−0.392	−0.358	−0.353	−0.010	−0.753
	(0.192)	(0.193)	(0.191)	(0.485)	(0.385)
	[0.041]	[0.063]	[0.065]	[0.983]	[0.051]
Employees	0.706	0.858	0.860	0.869	1.242
	(0.275)	(0.283)	(0.282)	(0.466)	(0.405)
	[0.010]	[0.002]	[0.002]	[0.062]	[0.002]
Diversifications	0.749	0.776	0.808	3.219	0.740
	(0.724)	(0.725)	(0.723)	(2.635)	(0.844)
	[0.301]	[0.285]	[0.263]	[0.222]	[0.381]
Acquisitions	0.006	0.004	0.003	0.210	−0.028
	(0.031)	(0.031)	(0.030)	(0.058)	(0.028)
	[0.840]	[0.891]	[0.924]	[0.000]	[0.310]
R&D intensity	0.853	1.080	0.980	3.704	0.618
	(0.564)	(0.578)	(0.617)	(1.820)	(0.447)
	[0.130]	[0.062]	[0.112]	[0.042]	[0.167]
Implied option cost	0.045	0.021	0.022	−1.295	0.049
	(0.023)	(0.022)	(0.023)	(1.063)	(0.028)
	[0.049]	[0.346]	[0.338]	[0.223]	[0.083]
Employee friendliness	0.152	0.134	0.132	−0.040	0.250
	(0.133)	(0.140)	(0.139)	(0.366)	(0.150)
	[0.255]	[0.339]	[0.342]	[0.914]	[0.097]
Employer reputation	0.969	0.913	0.957	−27.479	18.969
	(5.384)	(5.079)	(5.110)	(12.291)	(5.763)
	[0.857]	[0.857]	[0.851]	[0.025]	[0.001]
Unranked employer	−0.246	−0.257	−0.271	−2.527	−0.094
	(0.225)	(0.225)	(0.218)	(1.340)	(0.232)
	[0.275]	[0.252]	[0.213]	[0.060]	[0.687]
Liquidity position	−0.278	−0.329	−0.323	−2.312	0.136
	(0.700)	(0.719)	(0.713)	(1.403)	(1.132)
	[0.692]	[0.647]	[0.651]	[0.099]	[0.904]
Financial leverage	0.042	0.040	0.040	−0.006	0.144
	(0.033)	(0.030)	(0.031)	(0.069)	(0.063)
	[0.195]	[0.189]	[0.195]	[0.925]	[0.022]
Return on assets	0.137	0.340	0.178	3.340	−0.556
	(0.402)	(0.232)	(0.465)	(1.305)	(0.461)
	[0.734]	[0.143]	[0.701]	[0.010]	[0.228]
Institutional ownership	1.032	1.093	1.103	4.406	−0.423
	(0.708)	(0.721)	(0.713)	(1.438)	(1.682)
	[0.145]	[0.129]	[0.122]	[0.002]	[0.801]
Relative volatility	−0.003	−0.030	−0.031	0.304	−0.049
	(0.161)	(0.162)	(0.162)	(0.313)	(0.247)
	[0.984]	[0.854]	[0.850]	[0.331]	[0.843]
Cluster strength	−1.867	−1.979	−1.985	−8.050	−0.460
	(1.120)	(1.142)	(1.135)	(3.077)	(1.241)
	[0.096]	[0.083]	[0.080]	[0.009]	[0.711]
Non-compete enforcement	0.991	1.042	1.030	−0.898	1.327
	(1.098)	(1.102)	(1.097)	(1.219)	(1.285)
	[0.367]	[0.344]	[0.348]	[0.461]	[0.302]
First stage residual			0.001	−0.078	0.001
			(0.001)	(0.094)	(0.001)
			[0.295]	[0.407]	[0.194]
Year FE	Included	Included	Included	Included	Included
Firm FE	Included	Included	Included	Included	Included
Observations	957	957	957	358	469
Log likelihood	−362.4	−358.4	−358.2	−86.10	−213.3

Note. Clustered (firm-level) robust standard errors in parentheses; p-values in brackets.
The significance is already in square brackets. The row is in bold because it is the variable of interest.

Based on the rationale outlined above, we used the variable labeled *Near-firm option grants per employee* to instrument for the focal firm's employee stock option grants. We defined geographically proximate firms as those that lie within a 100-mile radius of the focal firm (Chatterji et al., 2016) using Vincenty's ellipsoid distance method. For robustness, we also used a 50-mile radius. For each firm-year observation in our sample, we calculated a three-year moving average of the non-executive options outstanding per employee for all companies outside the semiconductor and associated sectors. An assumption implicit in the implementation of our instrumental variable approach is that there is no systematic movement of inventors from the semiconductor industry to other industries in the region even as firms tend to imitate their neighbors in terms of incentive policies. To mitigate concerns about any systematic employee movements, we took care in assembling the set of industries in the neighborhood. We used the NAICS classification to exclude not only all firms in the semiconductor industry broadly defined but also other related industries such as information, research services, and telecommunications-based (Delgado et al., 2010).

3.3. Estimation approach

Our estimation proceeded in two stages. We used a control function approach that alleviates bias in various non-linear regression models with endogenous explanatory variables (Wooldridge, 2014). In the first stage, we regressed the endogenous variable on the instrumental variable and other covariates and recovered the residuals, which then entered the second stage estimation as an additional regressor (Rivers and Vuong, 1988; Wooldridge, 2015). In this approach, the coefficient of the residual term allows us to directly perform a heteroskedasticity-robust Hausmann test for the exogeneity of the corresponding endogenous variables (Rivers and Vuong, 1988; Wooldridge, 2015). We employed a fixed effects Poisson model in our second-stage estimations because all our dependent variables take integer values. The fixed effects Poisson model possesses strong robustness properties and gives consistent estimates with under or over-dispersed variables (Wooldridge, 1999). We also report robust standard errors corrected for the two-stage estimation procedure (Murphy and Topel, 2002; Terza, 2016).

4. Results

Table 1 reports variable descriptions and summary statistics, and Table 2 the correlation matrix. Multicollinearity diagnostics reveal that the mean Variance Inflation Factor (VIF) is 1.5, and the maximum VIF is 2.7. These VIF values fall below the levels that raise multicollinearity concerns (James et al., 2013). We begin the discussion of results by turning to the first stage model presented in Table 3. Because the first-stage dependent variable *Options grants per employee* is non-negative and positively skewed, we employ a generalized linear model with a logarithmic link function and gamma distribution (McCullagh and Nelder, 2019). To ascertain the fitness of this model, we compared the Akaike information criteria (AIC) of this model with a Gaussian distribution. This comparison revealed that the gamma model outperformed the Gaussian model by over 3 AIC units, indicating the superior fitness of the gamma model (Burnham and Anderson, 2004).

In Table 3, column (1) shows the estimates of the model in which *Near-firm options per employee* is the instrumental variable. Our expectation is that neighborhood firms from other sectors are apt to affect focal firms' *Options grants per employee*. Consistent with this expectation, the coefficient of *Near-firm options per employee* is positive and significant ($p = 0.013$). We conducted several tests to detect any weakness of the instrument, a problem that can affect inference. To this end, we compared the full model with the instrument included and a restricted model imposing the constraint that the instrumental variable coefficient is zero (Stock et al., 2002). A Lagrange multiplier test comparing these two models rejected the null hypothesis that the coefficient of the instrumental variable is zero ($\chi^2 = 32.29$; $p < 0.001$). Following the advice of Andrews et al. (2019) to judge instrument strength using effective F-statistic (Montiel-Olea and Pflueger, 2013), we recovered the first stage effective F-statistic (=356), which is well above the diagnostic threshold of 23 (Xu, 2021). Taken together, these tests did not reveal any concerns regarding the strength of our instruments.

4.1. Effects of employee stock options on employee mobility

We now turn to second-stage estimations that test our hypotheses on the effects of employee stock options on employee mobility. In Table 4, column (1) reports the model with controls only, column (2) the naive model without the correction for endogeneity, and column (3) the second stage residual inclusion model. In hypothesis 1, we argued that employee stock options bind employees to firms, predicting a negative relationship between the firm's employee stock option grants and employee mobility levels. The coefficient of *Option grants per employee* is negative and significant in the naive model in column (2) ($p = 0.074$) as well as the two-stage model in column (3) ($p = 0.016$). The coefficient of *Option grants per employee* in column (3) implies that *Employee mobility* decreases by 44.5 % for a one standard deviation increase in the employee option grants per capita. Alternatively, for every 100,000 additional stock option grants per capita to non-executive employees, 30 fewer inventor employees are likely to depart the firm. These results support hypothesis 1.

4.2. Effects of employee stock options on employee entrepreneurship

Our second and third hypotheses consider the effects of employee stock options on employee entrepreneurship. Tables 5 and 6 report the estimates for these effects—Table 5 presents the analyses for *Employee entrepreneurship* and Table 6 for the number of *Spin-outs,* our two measures of employee entrepreneurship. In these two tables, column (1) reports the model with controls only, column (2) the naive model without the correction for endogeneity, and column (3) the second stage residual inclusion model. The estimates in

columns (2) and (3) provide a test for hypothesis 2. Specifically, hypothesis 2 posited a positive relationship between a firm's employee stock options and employee entrepreneurship levels. We found support for this hypothesis in the models for *Employee entrepreneurship* as well as *Spin-outs*. In Table 5 showing the effects on *Employee entrepreneurship*, the coefficient of *Option grants per employee* is positive and significant in the naive model in column (2) ($p = 0.014$) as well as the two-stage model in column (3) ($p = 0.005$). Similarly, in Table 5 showing the effects on *Spin-outs*, the coefficient of *Option grants per employee* is positive and significant in the naive model in column (2) ($p = 0.002$) as well as the two-stage model in column (3) ($p = 0.002$). Based on these coefficient estimates of *Option grants per employee*, we infer that on average there is nearly a 35 % increase in employee entrepreneurship for one standard deviation increase in the number of employee option grants per capita. In other words, for every 100,000 additional stock option grants per capita to non-executive employees, 2 more employees are likely to depart to found new ventures. Overall, these results support hypothesis 2.

4.3. Moderating effects of knowledge scope

In hypothesis 3, we argued that *Knowledge scope* moderates the relationship between employee stock options and employee entrepreneurship. To test this hypothesis, we perform a split sample analysis. This approach allows us to simplify the complexity of interpreting the interaction effects in a setup such as ours (e.g., Shaver, 2007; Albino-Pimentel, Dussauge & Shaver, 2018). We split our sample at the mean value of *Knowledge scope* and ran separate analyses in the two sub-samples. In columns (4) and (5), we report the estimates from the two-stage analysis of the "narrow" and "broad" subsamples in which *Knowledge scope* is below and above the mean, respectively. We compared the coefficient of *Option grants per employee* between the two sub-samples to test hypothesis 3. In Table 5, we note that the coefficient of *Option grants per employee* is positive and significant ($p = 0.020$) in the "narrow" *Knowledge scope* sub-sample, i.e., column (4), but is not significant ($p = 0.957$) in the "broad" *Knowledge scope* sub-sample, i.e., column (5). Comparing the coefficients, we find that the coefficient in the "narrow" sub-sample is significantly different from that in the "broad" sub-sample ($p = 0.021$). Likewise, in Table 6, the estimates from column (4) and column (5) reveal a similar pattern—the coefficient of *Option grants per employee* is positive and significant in the "narrow" *Knowledge scope* sub-sample in column (4) ($p = 0.036$), but is not significant ($p = 0.398$) in the "broad" *Knowledge scope* sub-sample in column (5). Comparing the coefficients, we find that the coefficient in the "narrow" sub-sample is significantly different from that in the "broad" sub-sample ($p = 0.052$). Together, these results support hypothesis 3.

4.4. Robustness and additional analyses

Our main results demonstrate support for our main hypotheses after accounting for the potential endogeneity of our main explanatory variable and unobservable firm-level effects. In addition to these analyses, we performed several additional tests to further check the robustness of our results (available on request). First, our core explanatory variable corresponds to firms' incentive policies. In this respect, it is possible that the base compensation levels may exert an effect on the employees' decision to depart. To alleviate this concern, absent direct information about base compensation levels, we controlled for the intensity of general administrative expenses—the income statement item under which base compensation expenses are aggregated— measured as the ratio of general administrative expenses to sales. Our results remain unaltered. Second, we controlled for the vesting life of the stock option grants and our results remain unaltered. Third, we verified whether our results are influenced by outliers by winsorizing the variables at the first and the 99th percentiles. Our results and conclusions remain invariant.

Our main Results section employed a split sample analysis to test our third hypothesis. We also tested this hypothesis using an interaction analysis and found consistent results. Specifically, we created a dummy variable that equals one for firms with "narrow" knowledge scope as described earlier and zero otherwise. As expected, the coefficient of the interaction term of *Option grants per employee* and this indicator variable is positive and significant in the models of *employee entrepreneurship* ($p = 0.025$) and *spin-outs* ($p = 0.046$). Furthermore, we disentangled the effects of stock options on employee mobility in firms with narrow and broad knowledge scope. We found that the negative effect of a policy of stock option grants on mobility is stronger in firms with broad technological scope. These effects add support to the experimentation hypothesis in the following way. To the extent that stock option grants induce experimentation, firms with broad technological scope provide enhanced opportunities within the firm to continue to pursue new ideas resulting from experimentation and thus reduce the likelihood of mobility in general.

5. Discussion

Firms in technology-intensive sectors extensively rely on human capital to drive innovation but face the classic appropriability problem because employees can leave for other firms or to start their own ventures (Agarwal et al., 2009; Corredoira and Rosenkopf, 2009; Ganco, 2013; Hoisl, 2007; Palomeras and Melero, 2010; Phillips, 2002; Wezel et al., 2006). Human capital practices, particularly incentive mechanisms, have become focal to addressing the problems of inducing innovative behavior from employees as well as binding employees to the firm to prevent knowledge loss (Campbell et al., 2012a; Hatch and Dyer, 2004; Wang et al., 2009; Wang and Barney, 2006). In this regard, employee stock options possess attractive properties that could tackle these human capital challenges effectively (Kryscynski et al., 2021; Oyer and Schaefer, 2005). We extend this line of work by investigating the impact of employee stock options on two crucial human capital outcomes: employee mobility and employee entrepreneurship.

Our investigations build on the idea that stock options are distinct from other incentive mechanisms (e.g., pay-for-performance) examined in prior work (Campbell et al., 2012b; Carnahan et al., 2012) because they are firm-specific, long-term, and equity-based. These distinctive attributes make it essential to develop a deeper theoretical and empirical understanding of how employee

stock options affect employee mobility and employee entrepreneurship. We argue that employee stock options have a divergent effect on employee mobility and employee entrepreneurship levels. We predict that employee stock options have a negative effect on employee mobility levels. We maintain that the employee stock options possess unique properties that increase the employees' opportunity costs of quitting. But we posit that employee stock options exert a positive impact on employee entrepreneurship levels. Further, we argue that this effect is stronger when firms' knowledge scope is narrow. Knowledge scope becomes a constraint naturally because of the concerns of fit with the firms' strategy (e.g., Hellmann, 2007). Our results support our predictions, showing that employee stock options lower employee mobility, but increase employee entrepreneurship levels. They also reveal that the positive effect of employee stock options on employee entrepreneurship is even stronger in firms with a narrow knowledge scope.

Our theory and findings make several contributions to the literature. Our principal contribution is to the literature on entrepreneurship. Characteristics of existing organizations have been crucial for better understanding the provenance of entrepreneurs (Bhidé, 2003; Burton et al., 2002; Klepper, 2001; Rocha et al., 2018; Shepherd et al., 2021; Sørensen and Sharkey, 2014). Sørensen and Fassiotto (2011) succinctly capture this view: "organizations beget organizations." We advance this literature by emphasizing the importance of firm-specific, long-term, equity-based incentives provided through employee stock options. Our theoretical framework and findings highlight how and when employee stock options, meant to induce innovation, lead to employee entrepreneurship. In doing so, they also illuminate the interactions among organizational factors that lead to the creation of new ventures outside the firm (Burgelman, 2002, 1991; Burgelman and Grove, 2007).

We also contribute to the growing literature on strategic human capital. A central concern in this body of work is related to the practices firms employ to develop and deploy human capital to gain competitive advantage (Campbell et al., 2012a; Chadwick, 2017; Coff, 1997; Ployhart, 2021). Specifically, recent research suggests that firm-specific incentives offer an alternative means for firms to derive competitive advantage (Kryscynski, 2021; Kryscynski et al., 2021). Taking the macro-level perspective of the firm, we extend this line of work by theoretically and empirically examining the divergent effects of employee stock options, a crucial firm-specific incentive mechanism. These retention effects provide evidence in support of the argument that rent-sharing strategies enable firms to limit the loss of human capital to competitors (Campbell et al., 2012b; Coff, 1997). We also extend recent research that seeks to understand the distinct drivers of employee mobility and employee entrepreneurship (Campbell et al., 2017, 2012b; Carnahan et al., 2012; Ganco, 2013). We do so by showing that firm-specific, long-term, equity-based incentives through employee stock options exert divergent effects on employee mobility and employee entrepreneurship.

Finally, our theory and findings also have implications for the developing literature on employee stock options (Chang et al., 2015; Core and Guay, 2001; Hall and Murphy, 2003; Hochberg and Lindsey, 2010; Oyer, 2004). We extend this literature by showing that employee stock options have divergent implications on crucial human capital outcomes—implications that follow from stock options' retention and incentive purposes. We also add to this work by highlighting the importance of other intervening organizational factors, thus contributing to a better understanding of the effects of stock options on firm-level outcomes.

5.1. *Limitations and future research*

Although our study sheds new light on the role of employee stock options for employee mobility and employee entrepreneurship levels, it also has limitations that offer avenues for future research. A key challenge in addressing a research question like ours is that detailed micro-level data on the incentive practices of firms is difficult to obtain. Previous work circumvented this challenge by either employing data from a single firm or aggregating incentive mechanisms (Core and Guay, 2001; Hall and Murphy, 2003; Hochberg and Lindsey, 2010; Kryscynski, 2021). We overcame this data challenge by focusing on the firm level. This approach enabled us to achieve our research goals of isolating the effects of employee stock options and illuminating the interactive effects of other firm facets—an endeavor that requires firm-level heterogeneity. Whereas this approach allows us to recover the partial effects of employee stock options at the macro level of the firm, it does not allow us to ascertain how individual-level characteristics interact with firm-level employee stock option grants to determine employee mobility and employee entrepreneurship. Individual-level variation in preferences and aspirations could play a part in determining idiosyncratic individual-level responses to firms' policy to grant stock options. Future research could examine these effects by gathering qualitative insights and by designing suitable experiments. For example, Hales et al. (2015) demonstrate the effect of disposition optimism of individuals and how they respond to equity-linked compensation.

Further, the firm-level focus of our study limits us from unmasking individual dynamics that may be of interest from a theoretical and an empirical standpoint. For instance, at the individual level, base compensation levels as well as the vesting schedules can play a part in whether and when employees depart. Employees may generate an idea as part of the innovation process but time their departure based on the vesting schedule of the option grants they own. Future work can use granular data at the individual level to ascertain the extent to which vesting schedules determine *when* employees are likely to depart.

Other limitations of our study also indicate areas for future research. While the semiconductor industry offers a suitable and interesting context for examining our research question, it is characterized by high rates of R&D intensity, employee mobility, employee entrepreneurship (Sporck, 2001), and employee stock option grants (Sesil et al., 2002)—factors that may limit the generalizability of our results. We would expect employee stock options to be an important driver of mobility and employee entrepreneurship in other technology-intensive industries such as disc drive, laser, biotech, and medical device industries. However, the results could be less generalizable to settings such as the professional service industry. Another concern is linked to the way we operationalize employee mobility. While we followed the established precedent of using patent-based measures (Agarwal et al., 2009; Corredoira and Rosenkopf, 2009; Ganco, 2013; Hoisl, 2007), a drawback of this approach is that a mobility event is not detected when an inventor moves from one firm to another without being listed as an inventor in the patents of both firms. Although we have no reason to expect this limitation to systematically affect our results, future research could compare the effects obtained from patent-based measures with

more refined ones.

Finally, our paper focuses on how firms retain and motivate talent but remains silent on the mechanisms by which stock options help obtain talent. Examining this aspect can cast light on how firms can leverage external human capital through spill-ins (Agarwal et al., 2007; Corredoira and Rosenkopf, 2009; Kim and Steensma, 2017).

6. Conclusion

In summary, we analyzed the effect of employee stock options on employee mobility and employee entrepreneurship. As firm-specific, long-term, equity-linked compensation instruments, employee stock options can influence the utility employees derive from continuing their employment with the firm. Our study shows that employee stock options bear divergent implications for employee mobility and employee entrepreneurship such that stock options reduce employee mobility but increase employee entrepreneurship levels. It also demonstrates that employee stock options further increase employee entrepreneurship levels in firms with narrow knowledge scope. Finally, it underscores the significance of organizational conditions, such as incentives, to understand the antecedents of entrepreneurship.

CRediT authorship contribution statement

Vilma Chila: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review & editing, Visualization. **Shivaram Devarakonda:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Data availability

Data will be made available on reasonable request.

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