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Human capital resource strategies in times of technological change

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ABSTRACT

The adoption of new technologies is important for firm performance and competitive advantage. But what workforce strategies do firms deploy when they invest in new technologies? What strategies are most beneficial in the longer term? Drawing on the resource-based view of the firm and a longitudinal data set of all firms in the Swedish manufacturing industry between 2000 and 2020, this study quantifies the occurrence and outcomes of workforce strategies when firms invest in new technologies. Results show that investments are associated with labour growth and stabilizing workforce strategies, rather than labour-saving and radical reconfiguration strategies. Firms using a stabilizing strategy when making investments record better chances for survival. These findings contribute to debates in the field of strategic human resource management and the literature that discuss the contribution of human capital resources to sustained competitive advantage. The results also have important practical implications for HR managers responsible for formulating workforce strategies in times of technological change.

KEYWORDS

Investments; technology; workforce strategy; strategic HRM; human capital resources

1. Introduction

Few strategic human resource management (SHRM) scholars would dispute the claim that the adoption of new technology is important for firm performance and competitive advantage. Yet, SHRM scholars have largely ignored asking what HR strategies firms deploy when they invest in new technologies. Rather, most SHRM scholars submit to the view that technological change requires radical reconfiguration of the workforce (Hashemi-Petroodi et al., 2021; Kozlowski, 1987; Teece, et al., 1997). From this perspective, the primary task for HR departments in firms

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exposed to technological change is to engage in well-planned strategy processes (Ulrich et al., 2009) and to initiate knowledge- or talent management practices (Schweyer, 2004; Whysall et al., 2019) to attract the talent necessary to adopt the new technologies.

Instead, investigations of the link between technology and jobs take place in other fields, primarily labour economics. Here, technologies are often conceptualized as labour saving or regarded as increasing the demand for skilled labour according to the "skills-biased-technological change" (SBTC) hypothesis (Aghion, et al., 2023). This literature has grown increasingly theoretically and methodologically sophisticated over recent years (Acemoglu et al., 2022; Card & DiNardo, 2002; Mondolo, 2022). However, it does not provide much guidance as to which HR strategies firms should deploy in times of technological change. Most importantly, technologies are seen as having the same or similar implications for all firms: either technologies save or substitute labour (Restrepo, 2024), or they incentivize firms to discard workers with obsolete skills and hire new workers with relevant ones (for example Brynjolfsson & McAfee, 2014, World Economic Forum, 2019). Such assumptions not only tend to overlook the agency of firms to deploy different workforce strategies. They also overlook that firms have different possibilities to collect resources, as well as different possibilities to change the use of their existing resources. As pointed out by Barney (1991), firms constitute bundles of heterogeneous resources which are not perfectly mobile. Conventional views on technology and work tend to ignore this variation among firms, and that firms will have very different prerequisites for adopting and implementing new technologies.

This neglect possibly explains why studies on the impact of technology on employment have failed to provide conclusive evidence for labour-saving effects at the firm level. Instead, a growing body of studies have found technologies to be associated with employment growth in firms (Aghion et al., 2023; Domini et al., 2021; Klenert et al., 2023). Such observations have led scholars to theorize why firm employment often increases, despite investments in labour-saving technologies (Calvino & Virgillito, 2018; Dosi et al., 2021). It has been shown that such effects can originate from productivity improvements (Domini et al., 2021), from which follows better ability for firms to compete and take market shares, the so-called "business stealing effect" (Dosi & Mohnen, 2019).

However, such a view says little about the underlying changes in the workforce that contribute to the increase in employment following technological investments. As Aghion et al. (2023) point out, positive effects reflect either a net job creation and/or lower separation rates among firms investing in new technologies. But most importantly, the literature provides little guidance as to what changes in the workforce firms should

pursue to achieve the most successful outcomes in times of technological change.

The purpose of this article is to create a better understanding of the link between technological change and strategic human resource management. It does so by empirically analysing which workforce strategies firms deploy when they invest in technologies, and which workforce strategies are most beneficial for the firm in the longer term.

Theoretically, this study draws on a stream of research originating in the resource-based view of the firm (RBV; Barney, 1991) that allows for an analysis of how human capital resources contribute to firm sustained competitive advantage (Boon et al., 2018; Campbell et al., 2012; Crook et al., 2011; Gerhart & Feng, 2021). It holds that any attempt to analyse how firms achieve sustained competitive advantage through human capital resources must acknowledge how firms actively create (Ray, et al., 2023) firm specific human capital resources by deploying workforce strategies that modify the flows of workers to and from the firm.

Consequently, this article aims to answer the question: How do firms achieve sustained competitive advantage from human capital resources when they invest in new technologies?

Empirically, the focus is set on the manufacturing sector, where firms can be expected to compete by investing in new technologies, and where discussions regarding the impact of automation and robots on employment have been particularly important in recent years (Acemoglu et al., 2020). Empirical evidence is derived from a data set of technological investments and matched employer-employee data on all manufacturing firms in Sweden between 2000 and 2020. The structure of the data provides an opportunity to identify the workforce strategies, in terms of flows of workers to and from firms, that firms deploy when investing in new technologies. The longitudinal nature of the data set also allows to measure which workforce strategies are most beneficial for firms.

The findings confirm previous studies showing that investments in new technologies are most often associated with a (modest) general expansion of the workforce. However, growth strategies are not only associated with carefully increasing hiring rates, but especially with reduced worker exit rates. Those firms which are most successful in terms of survival combine investments with modest growth and workforce stability: careful employment growth and reduced worker flows and churning.

This study contributes to the literature on strategic human resource management in at least three different ways.

First, as far known, this article offers a first attempt to empirically analyse which workforce strategies are most commonly used by firms when they invest in new technologies, and which of these strategies that

are most beneficial for the firms. The findings stress the importance of firm specific human capital resources, as suggested by human capital theory (Becker, 1964), but also the ability of firms to modify the flows of workers in a way that strengthens the use of, or incrementally creates, firm-specific human capital resources (Campbell et al., 2012) in times of technological change.

Second, the analyses advance research in strategic human resource management inspired by the resource-based view of the firm (Barney, 1991) through empirically investigating the link between physical capital resources (technology), human capital resources and firm sustained competitive advantage. This contributes to the emerging literature that speaks of the contribution of human capital resources for sustained competitive advantage (Boon et al., 2018; Campbell et al., 2012; Crook et al., 2011; Gerhart & Feng, 2021). By introducing measures of flows of workers as well as workforce volatility (Burgess et al., 2000) in relation to technology investments of firms, this article also contributes to studies in labour economics exploring the impact of technologies on work and employment at the firm level (Aghion et al., 2023; Domini et al., 2021; Klenert et al., 2023).

Lastly, the findings have important practical implications, and offer suggestions for HR managers on what workforce strategies to deploy when firms invest in new technologies.

The article opens with a description of the foundations of the RBV and how it conceptualizes physical and human capital resources as sources of sustained competitive advantage. Hypotheses regarding the link between technology investments and workforce strategies and survival are derived. Section 3 describes the methods used to analyse the longitudinal data set. In section 4, the results of regressions regarding the link between technology investments and changes in the workforce in Swedish manufacturing firms are reported. The article concludes with a discussion on possible further studies investigating the link between strategic HRM and technological change.

2. Theoretical background and hypotheses

2.1. Resource based view, technology and human capital resources

In the strategic human resource management (SHRM) literature, RBV is primarily associated with Jim Barney who focused attention on the role of each firm's unique and valuable resources to sustain competitive advantage. Barney (1991) makes a distinction between three different types of resources: *physical capital resources* (which include the physical technologies used in a firm, infrastructure, buildings, its geographical location, and access to raw materials), *organizational capital resources*

(which include a firm's formal and informal planning, control and coordinating systems) and *human capital resources* (which include the training, experience, judgment, intelligence, relationships and insights of individual managers and workers in a firm).

Barney (1991) argued that it is reasonable to assume that resources controlled by firms are heterogeneous and will not be perfectly mobile. This implies that firms have different starting points when implementing strategies. Similar external conditions also have different implications across firms, and firms may have varying possibilities to collect resources as well as different possibilities to change their existing resources. Thus, firms cannot expect to obtain sustained competitive advantage when strategic resources are highly mobile and evenly distributed across all competing firms.

In Barney's terminology, production technology is a physical resource, which under some conditions may contribute to sustained competitive advantage. When firms invest in new production technologies, they do so for a number of reasons; for example to meet new demands in the product market, to differentiate their products, to reduce costs, to increase productivity and efficiency, and, ultimately, to be able to survive. They may also invest in new technologies because they see an opportunity in the market, and as part of an effort to expand the business. However, while technologies can add value to a firm, this does not necessarily mean that technologies are sources of sustained competitive advantage (Mata et al., 1995). To provide sustained competitive advantage, physical resources need to be valuable, rare, imperfectly imitable and imperfectly substitutable (Barney, 1991). If a firm possesses a resource that is not currently possessed by competing firms, the condition of resource heterogeneity is met, and a firm obtains at least a temporary competitive advantage (Mata et al., 1995).

Many production technologies are possible to acquire on the market, but investing in new production technologies not only comes with installing a new machine; it also implies embedding the new technology in existing production processes. This requires substantial efforts in terms of planning, coordination and preparation until the new technology is operable. One of the reasons why new technologies can provide competitive advantage, is that they are not trivial for other firms to duplicate (Brynjolfsson et al., 2002). Firms that are more skilled in managing their investments face fewer technical and market risks than less skilled firms (Mata et al., 1995). These more skilled firms will be able to pursue investments in ways that are not available to others. Consequently, even if a new technology is available for all competing firms to buy off the shelf, the ability to adopt and integrate the new technology to the existing resources, what Cohen & Levinthal (1990) call "absorptive capacity", may be a source of competitive advantage.

2.2. Human capital resources and sustained competitive advantage

Most studies within the field of strategic HRM have been concerned with how and to what extent HR practices and policies, i.e. organizational capital resources, contribute to sustained competitive advantage (Huselid, 1995). Questions have been raised, though, concerning the contribution of HR policies and practices as sources to sustained competitive advantage, since they are easily imitated and substituted (Becker & Huselid, 1998; Wright et al., 1994). A growing stream of research therefore explores exactly how the human capital resources of firms can contribute to sustained competitive advantage (Boon et al., 2018; Campbell et al., 2012; Crook et al., 2011; Gerhart & Feng, 2021) and how organizational capital resources, such as high commitment- or high-performance HR practices, are linked to human capital resources and achieving sustained competitive advantage (Collins, 2021; Delery & Roumpi, 2017).

Yet, the link between investments in physical capital resources and human capital resources, and its relevance for sustained competitive advantage, is relatively unexplored.

According to the RBV, human capital resources can be a source of sustained competitive advantage if they are valuable, rare and can be kept from rivals (Campbell et al., 2012). Similar to technologies, firms employing new workers do so in the context of an already established labour pool, including a unique constellation of workers with skills and experiences related to the already existing production process. Hiring new workers implies embedding them in the existing pool of workers, a process which is not easily duplicated by competing firms. This has led scholars to emphasize *firm specific human capital* as a source of sustained competitive advantage. Firm specific human capital refers to worker level knowledge, skills and abilities that have limited applicability outside the firm (Campbell et al., 2012). They are considered important because certain skills and abilities that can only be learned inside the firm are complementary to the firm's technology or intangible assets, such as its stock of R&D knowledge (Eriksen, 2014). Firm specific human capital is seen as a source of sustained competitive advantage because it constrains employee mobility and is difficult for rivals to imitate (Hatch and Dyer, 2004). Several studies find a positive link between firm specific human capital resources and performance (Crook et al., 2011; Hatch & Dyer, 2004).

However, recent developments in strategic human resource management suggest that there are situations when *general* human capital resources can generate sustained competitive advantage. To understand the contribution of human capital resources to sustained competitive advantage, Campbell et al. (2012) argue, it is necessary to take into

consideration that firms act in two human capital markets, both the demand side and the supply side. On the demand side employers may design practices and policies that limit other firms' ability or willingness to hire their workers, even if workers are willing to move. Firms may for example design non-compete clauses to legally deter rival firms from hiring experienced workers. On the supply side, employers may design jobs and compensation packages in ways as to reduce workers' willingness or ability to leave, even if external demand for their labour exists. In effect, workers may be willing to supply their labour, show more commitment and loyalty even if they would be offered better wages by other employers. In this way also workers with *general* human capital resources can be turned into a source of sustained competitive advantage. Thus, it is not only the type of human capital that is important. Sustained competitive advantage can also be achieved through the implementation of HR policies and practices that constrain the mobility of workers. Hence, it seems possible that firms achieve sustained competitive advantage when they invest in new technologies by implementing HR policies and practices that influence the mobility of workers.

The introduction of new technologies in the workplace may also have effects on worker mobility, serving as, what Campbell et al. (2012) call, a complementary nonhuman asset. Investments in new technologies may have an impact on the firm's employer attractiveness. High tech investments create an image among prospective employees of a fast moving, modern employer with great prospects for the future, making it easier for firms to attract highly qualified workers. Investments in technology are also likely to have effects on existing workers. The introduction of new technologies risk creating feelings of job insecurity and stress (Yam et al., 2023) which may increase job-turnover (Brougham & Haar, 2020). Other workers will find interest in working with the new technology, and are therefore less likely to leave to other employers even if they would be offered higher wages. Genz et al. (2021) found, for example, that workers in firms adopting new technologies benefited from improved employment stability, higher wage growth, and increased cumulative earnings. Similarly, Chao and Kozlowski (1986) found that investments in technologies reduced turnover intentions among workers in high tech environments simply because working with new technologies were part of what they wanted to do.

2.3. Hypothesis development

In the following section hypotheses are developed, related to workforce strategies and how they may contribute to sustained competitive advantage. Empirically, these strategies are not all mutually exclusive, and some of them will be combined in firms.

Theoretically, one of the main rationales for technology investments is to increase productivity. A *labour-saving strategy* can be executed in different ways. Employers let go of older workers who are about to retire or selectively lay off workers who are no longer needed. Employers can also stop hiring, and instead reallocate jobs among existing workers.

It can be questioned, however, whether these strategies are commonly used. Many recent studies find that investments in new technologies are associated with a general increase in employment at the firm level (Aghion et al., 2023; Domini et al., 2021; Klenert et al., 2023), suggesting that it is more likely that firms deploy a *labour growth strategy* when investing in new technologies. Firms invest in new technologies because they see an opportunity in the market and as part of an effort to expand business. A labour growth strategy will be executed by implementing HR policies to enhance commitment and loyalty among existing workers, and to reduce the risk that workers leave to other employers. A labour growth strategy may, thus, be implemented by intensifying hiring activities, possibly combined by reducing the outflow of workers (see Aghion et al., 2023; Domini et al., 2021).

The choice of how to execute a labour growth strategy is dependent on the availability of skilled labour on the labour market. Since highly qualified workers who are able to work with new technologies is a rather scarce resource, it is more likely that firms deploy a labour growth strategy by primarily reducing exits rates, rather than increasing hiring rates. This leads to the formulation of a first hypothesis:

> H1: Firms investing in technologies primarily deploy a labour growth strategy by reducing exit rates.

When firms invest in new technologies, changes in the human capital resource pool may not only be associated with adapting the quantity of workers. Firms can also deploy strategies to modify the workforce in the qualitative dimension. Due to technological developments, new technologies may require workers with a lower level of skills, simply because technologies are easier to use and adapt to the existing production system (Helpman & Rangel, 1999; Lepak & Shaw, 2008). Thus, investments in new technology may be associated with a *deskilling strategy*, requiring workers with lower skills levels.

Several studies, on the other hand, show that investment in new technologies increases the demand for highly educated workers (Bartel & Lichtenberg, 1987), implying a shift in the labour force with an increasing share of highly educated workers (Autor et al., 2003), something that could be called a *reskilling strategy*. Such processes are often referred to as skilled-biased technological change (Acemoglu & Autor, 2011). A common explanation to this is that new technologies replace primarily

low skilled manual workers, while jobs left require more advanced skills to serve, operate and maintain the new technology. Another possible reason for such a shift is that the adoption of new technologies require the "ability to learn" (Cohen & Levinthal, 1990). Individuals high in cognitive ability are more able to learn job-relevant knowledge than those low in cognitive ability (Wright et al., 1994), and higher educated workers are often seen as bringing more advanced cognitive skills. Workforce strategies may also be concerned with employing more people to prepare and coordinate the technology investment process itself. Therefore, investment in technologies can be associated with a strategy of employing more workers with a higher education:

> H2: Firms that invest in technologies increase the share of skilled workers by deploying a reskilling strategy and hiring more workers with higher education.

A common assumption in studies of SHRM is that firms in times of rapid technological change need the capacity to reconfigure resources and functional competences, to achieve congruence with the changing business environment (Teece et al., 1997). Firms may reconfigure the skill-mix of workers, by replacing jobs of one skill-type with jobs of another skill type (Bauer & Bender, 2004). Disruptive technological change is often associated with a significant uncertainty regarding the ability of existing workers to adopt the new technology, and a belief that radically new technologies require completely different skills. Firms may therefore want to deploy a *reconfiguration strategy* where they reconfigure the skills mix, replacing one type of jobs (tasks and skills sets) with another (Burgess et al., 2001). Firms acquire new resources to compete in new markets, recombine them to create new capabilities and at the same time divest resources that are not likely to contribute to develop or maintain competitive advantage (Sirmon et al., 2007). Consequently, firms hire new workers to fit the expected requirements of the new technology and release or let go of those workers who are seen as no longer needed (World Economic Forum, 2019). A reconfiguration strategy is associated with workforce volatility: a general increase in the flows of workers to and from the firm, both new entrants and more exits. A labour reconfiguration strategy is also be associated with an increased churning, because employers change the job requirements or restructure the production process as new technologies are adopted (Bachmann et al., 2021).

A reconfiguration strategy is challenging for firms to manage. Firms need to implement HR policies and practices that enhance the ability attract new workers, while at the same time implementing HR practices that ensure that existing workers with obsolete skills are willing to leave without discontent. Also, taking into account resent research on the value

of firm specific human capital, the configuration strategy does not stand unrivalled. Firms investing in technologies may rather deploy *a stabilizing strategy*, defined as a reduced volatility in the workforce. Such a strategy will be driven by labour shortage or other difficulties in attracting qualified labour in the external labour market, alternatively that the firm have reasons to use already existing workers with firm specific human capital more efficiently. Also, a stabilizing workforce strategy does not require dramatic changes in the way human resources are managed. Firms may make minor incremental improvements, such as requiring existing employees to attend a specified number of training hours per year to keep their knowledge and skills up to date (Sirmon et al., 2007). To reduce the risk that valuable employees leave to competitors, firms may also deploy HR practices that create demand side mobility constraints (Campbell et al., 2012), increasing the costs for workers to search for and switch to new jobs, for example by retraining or on-the-job training and making use of existing workers rather than hiring new workers to meet new demands (Delery & Roumpi, 2017). To avoid turnover, firms can also implement policies and practices that increase their attractiveness as employers, for example by offering higher pay or create other benefits that reduce the likelihood that employees will leave. Such policies can also involve offering career opportunities, more interesting work tasks or other benefits making it less interesting for employees to move to other jobs (Yousaf et al., 2018). Thus, investments in new technologies may be combined with enhanced match quality between workers and jobs indicated by reduced volatility in the workforce. Therefore:

H3: Firms that invest in technologies primarily deploy a stabilizing strategy indicated by reduced workforce volatility.

It is not obvious which of these strategies is most beneficial for the firm. A reconfiguration of the workforce may be necessary to adopt new technologies, especially during fundamental shifts (Teece, et al., 1997). According to Li et al. (2018), a churning workforce force can update the knowledge reservoir by infusing new knowledge, reduce organizational stagnation, increase flexibility, enhance openness to divergent solutions and improve innovation. However, substantial volatility in the workforce is likely to have a negative impact on firm performance and labour productivity (De Winne, et al., 2019). Hatch & Dyer (2004), for example, found that firms with high turnover significantly underperformed their rivals and firms that attempted to obtain human capital by hiring operators with experience in rival firms suffered significant performance losses. A more volatile workforce also comes with increasing costs for recruiting and introducing new employees. It may take time until newly recruited workers are productive and contribute to firm performance.

Turnover results in a loss of knowledge and training that leads to significant increases in defects and quality problems in the production process (Hatch & Dyer, 2004), and high levels of workforce volatility may render HR planning practices ineffective (Huselid, 1993). In addition, initiating outward flows of workers, for example by laying off workers with obsolete skills, may induce considerable costs which may have a negative impact on performance (Schenkel & Teigland, 2017). It may also create sentiments of job insecurity among the remaining workers, which in turn reduces work satisfaction and productivity (Brockner et al., 1992). In practice, it becomes difficult, albeit not impossible in firms in great need of renewal, to see how a reconfiguration strategy is likely to contribute to sustained competitive advantage.

A stabilizing workforce strategy, on the other hand, achieves sustained competitive advantage by exploiting the capacity of already existing workers possessing firm specific human capital. As Cohen & Levinthal (1990) pointed out, existing employees who are both competent in their fields and familiar with the firm are vital for the firm to be able to integrate complex and sophisticated technologies successfully. Stabilizing the human capital pool is a way to extend and elaborate the use of firm specific human capital. Mobilizing existing workers in the adoption of new technologies enhances learning and creates significant cost advantages. As operators are integrated into the firm's problem-solving activities, their tacit knowledge is added to the effort and moves the technology to a significantly lower learning curve relative to firms that do not deploy operator knowledge in problem solving (Hatch & Dyer, 2004). The use of existing workers may also elevate their status, strengthening employee loyalty and commitment, which may be positive for productivity (Macky & Boxall, 2007). In short, a stabilizing workforce strategy may lead to better performance not only through the use of firm specific human capital, but because it is based on unique internal processes that are difficult for rivals to duplicate.

A stabilizing workforce strategy is also likely to contribute to better performance in other ways. Workers may experience greater trust in management and the firm as an employer (Guest, 1999). Stable working conditions may enhance team learning and a working climate characterized by greater psychological safety (Edmondson, 1999), implying that employees to a greater extent feel that they are able to speak up about errors or problems, asking for help or clarification, and feel that they can suggest new ideas and challenge existing practices constructively. In other words, stabilizing strategies may be beneficial for firms because it supports micro level mechanisms that contribute to a firm's ability to learn and adopt the new technology, i.e. their absorptive capacity (Cohen & Levinthal, 1990) through existing workers with firm specific human capital. Therefore:

H4: A stabilizing strategy indicated by lower levels of workforce volatility following investments in technologies is more beneficial for firm survival in the longer term.

3. Material and methods

The hypotheses are tested on employer-employee matched datasets from Statistics Sweden (SCB) that cover all firms and employees in the Swedish manufacturing sector during the period 2000–2020. The data sets link all individuals with their employer firms. This makes it possible to study how the inflows and outflows of workers are associated with various production-related variables at the firm level.

The database consists of 73,696 firm-year observations, on average 3,684 per year. According to the Swedish legislation firms with fewer than 5 employees are subject to simplified statistical reporting procedures. Firms with fewer than 5 employees are therefore excluded from this study.

3.1. Measures

Technological change: Following and Barbieri et al. (2019) and Aghion et al. (2023), annual gross investments in machinery and equipment is used as measure of technological change. The indicator is a good measure of a firm's commitment to technological change for three main reasons. First, it comes very close to what other scholars denote embodied technological change (Aghion et al., 2023; Barbieri et al., 2019; Huggett & Ospina 2001). Second, according to the Swedish accounting protocols, registered investments in machinery and equipment need to be substantial and intended for long-term use (over three years). Third, this measure does not make any assumptions about what type of technology or what kind of machines firms find valuable in their efforts to sustain competitive advantage. A drawback of the measure is that it does not guarantee that investments made are in *new* embodied technologies. Yet, in an economy with high labour costs, such as Sweden's, it is unlikely that firms would invest in machines and equipment that embody inferior technologies.

Workforce strategies: Burgess et al. (2000) provide a useful conceptual framework for analysing and measuring the mobility of workers at the firm level. The benefit of their measures is that they allow for an analysis of realized (Mintzberg, 1978) workforce strategies in terms of how human capital resources are modified and changed over time. A realized workforce strategy is defined as the observed changes in the number, flows and churning of workers between two time periods. Workforce strategies are measured as follows.

Employment change, measured as the total number of workers in the firm between year combinations, is used as an indicator of a labour-saving or a labour growth strategy. A positive firm-employment development effect from investment is taken to indicate a labour growth strategy, while a negative employment development to be more in line with a labour-saving strategy.

Labour-growth and labour-saving strategies can be achieved through different combinations of *worker flows*. To capture the different changes in the workforce, the measures devised by Burgess et al. (2000) are used (see Table 1 for the definition of each item and basic descriptives). The employment change in a particular time period can be measured through the combination of the inflow and outflow of workers (Burgess et al., 2001). For example, a labour growth strategy is achieved either by increased hires and a reduction of the number of exits, or with a sustained number of exits. The combination is important. This paper explores not only whether technology investments are associated with a labour growth strategy or a labour-saving strategy, but also the underlying worker flows behind the strategies in terms of both hires and exits in firms. To test H2, these variables are also calculated for workers with a higher education as well as workers with no higher education.

Worker flow rates and churning rates are used as measures of the degree of *workforce volatility* the year following an investment in technology (Burgess et al., 2000). A labour reconfiguration strategy is defined as one where firms intensify hiring and firing activities, indicated by higher worker flow rates and churning rates. A labour reconfiguration strategy is indicated by greater workforce volatility. Therefore, this is measured as the combination of a higher worker flow rate and a higher churning rate. A stabilizing workforce strategy is one where workforce volatility decreases, indicated by reduced worker flow rates and churning rates. A stabilizing strategy is operationalized by the same indicators, but in the opposite direction (Table 2). "Rate" signals that the real flows are relative, divided by the total employment of the firm.

Firm survival as is used as a measure of *sustained competitive advantage* (SCA). A competitive advantage is sustained if it continues to exist after efforts to duplicate that advantage have ceased (Barney, 1991). Firms that exit the market after implementing a strategy can be regarded as having lost their competitive advantage due to other firms' successful duplication, or because the implemented strategy did not provide the benefits necessary for survival. Therefore, firm survival is a relevant indicator of SCA. For each firm, three survival dummy variables are generated (0 = exit, 1 = survived): whether the firm was still active the following year ($t+1$), in 3 years ($t+3$) as well as in 5 years ($t+5$) from the time of

Table 1. Variable definitions.

Characteristic	Variable name	Definition	Median	Mean
Dependent variables				
Employment	Employment change rate	Firm employment year 1 - firm employment year 0	0	.0003417
Flow indicator	Hiring rate	Number of people not working in the firm in t but in $t+1$, as rate of average firm size those two years	.1265823	.1523602
	Exit rate	Number of people working in the firm in t but not in $t+1$, as rate of average firm size those two years	.125	.1503283
Flow indicators of (no) higher education	Hiring rate high education	Rate of people entering the firm's workforce that has a higher education of at least 2 years	0	.0184954
	Exit rate higher education	Number of people exiting the firm's workforce that has a higher education of at least 2 years	0	.0166772
	Hiring rate no higher education	Rate of people entering the firm's workforce that does not have a higher education of at least 2 years	.1085271	.1338648
	Exit rate no higher education	Rate of people exiting the firm's workforce that does not have a higher education of at least 2 years	.1111111	.133651
Workforce volatility indicator	Worker flow rate	Number of people entering + number of people exiting, as rate of average firm size those two years	.2686567	.3026885
	Job change rate	Number of people entering - number of people exiting, as rate of average firm size those two years	0	.0020319
	Churning rate	Worker flow – Job change, as rate of average firm size those two years	.25	.3006565
Independent variables				
Main	Investment	Annual gross investments made by firms in machines and equipment (logged)	6.035481	2.219895
Control	Firm size	Number of people employed by the firm (logged)	3.135494	3.383439
Control	Productivity	Value added / number of people employed (logged)	6.223568	6.227355

observation *t*. The survival indicator is constructed by following the official organisational ID.

Controls for firm size (total number of employees in the firm) and firm labour productivity are included in the regressions. In addition, year and firm fixed effects are included in the panel regressions (Tables 2 and 3) to control for unobserved heterogeneity across firms and time. Robustness checks are run by splitting the data into two time periods (2000–2007 and 2010-1018), to test whether excluding the economic shocks during the time period studied changed the results. For the last set of regressions on sustained competitive advantage, firm fixed effects were used, as well as controls for the underlying business performance (as outlined in next section).

Table 2. Firm fixed effects models for employment change and worker flows.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Employment change rate	Hiring rate	Exit rate	Hiring rate higher education	Hiring rate No higher education	Exit rate Higher education	Exit rate No higher education
Investment	0.000541***	0.000186***	−0.000298***	0.0000329*	0.000153**	−0.00000900	−0.000289***
	(7.17)	(3.41)	(-5.86)	(2.09)	(3.03)	(-0.61)	(-6.04)
Firm size	−0.239***	−0.119***	0.112***	−0.0108***	−0.108***	0.00916***	0.103***
	(-52.68)	(-34.97)	(39.36)	(-15.08)	(-34.72)	(15.55)	(38.59)
Productivity	0.0771***	0.00410	−0.0716***	0.00223***	0.00187	−0.00768***	−0.0639***
	(20.90)	(1.94)	(-25.87)	(3.90)	(0.97)	(-13.33)	(-25.32)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
r2	0.168	0.0910	0.120	0.0160	0.0868	0.0184	0.114
r2_b	0.00432	0.00803	0.00419	0.00850	0.0161	0.0233	0.000721
N	73696	73696	73696	73696	73696	73696	73696

The dependent variable is indicated on the second row. t-statistics in parentheses. Source: own elaborations on data from statistics Sweden.
Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.2. Analytical strategy

To test the hypotheses, panel regressions are estimated in three steps.

In step 1 (H1), fixed effects panel regressions are calculated in seven specifications to identify the main effects of investments (the independent variable) on the worker flow indicators (the dependent variables). As a robustness test, the estimations are calculated without panel structure (pooled OLS) but with firm fixed effects and weighted to control for previous firm performance. The weight is based on a propensity score approach (Domini et al., 2021) to control for the underlying business performance that will impact both worker flows, technology investments and survival. First, a treatment dummy variable is calculated, which in this case indicates that a firm belongs to the top 25th percentile in terms of investments in machines and equipment, in relation to firm turnover. Second, an industry-specific score (p) is estimated based on the employment change from last year (this is essentially similar to a probit estimation). Third, weights are generated: for treated firms $1/p$ and non-treated firms $1/(1\text{-}p)$. Finally, these weights are used in the regressions to control for the overall past performance and investments in machinery and equipment, adjusting for the latent propensity for a firm to invest in the first place. To further ensure causality between the variables, one-year time windows are used to capture the relationship between investments in technology and worker flows.

In step 2, to test H2, another round of panel regressions is calculated with year fixed effects. For these, the dependent variables are limited to inflow and outflow of workers with higher and lower education levels. The same control variables are used.

Step 3 tests the hypotheses regarding the link between technological change, workforce volatility, and survival (H3). The investment variable enters as a baseline, the main workforce volatility indicators (worker flow rate, job change rate and churning rate) and the interaction between them in seven OLS models. The OLS models include firm and year fixed effects as well as the weighting strategy described above to control for the overall firm and industry specific performance. For the SCA variable (survival), binary specifications are used. While probabilities of binary variables are typically analysed using logistic regression, Mood (2010) demonstrated that this estimator is more intricate than commonly assumed due to unobserved heterogeneity. In alignment with Mood, the models used are estimated using linear regression (OLS). The focus of the analysis lies not on the non-linearity of the relationship, but rather on assessing the average effect and its significance.

4. Results

The scatterplots in Figure 1 illustrate the different worker flows initiated when firms invest in new technologies. Each scatterplot records investments

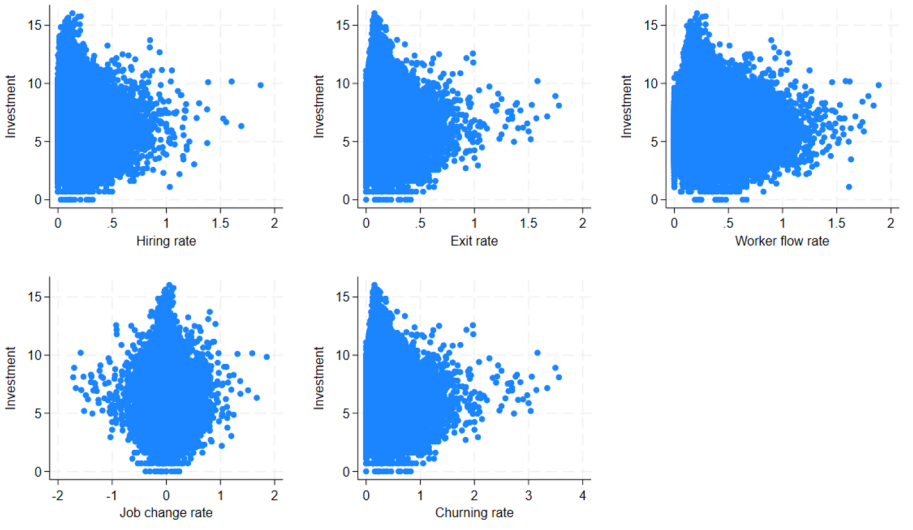

Figure 1. Scatterplots between investments and all flow and workforce volatility indicators for all observations with investment > 0. Source: own elaborations on data from Statistics Sweden.
Notes: investments are logged

on the y-axis, with the flow indicators on the x-axis, and each dot represents a firm. Three key observations can be made. First, manufacturing firms deploy very different workforce strategies when they invest in new technologies. Some firms deploy a labour-saving strategy, while others deploy a labour growth strategy. This is indicated by the relatively evenly distributed negative and positive job change rates. Second, the different workforce strategies have relatively small effects. The job change rate varies between −1,7 and 1,9%, and investments are associated with relatively small changes in hiring and exit rates. Only a few firms show a hiring or exit rate beyond 1%. Third, the triangular shape of the scatterplots indicates that few firms combine small investments with extensive worker flows and churning rates. However, with increasing investments worker flow and churning rates also increase. Yet, the highest investments are met with more stability in the labour pool, indicated by relatively low worker flow rates, job change rates and churning rates.

In sum, descriptives show that firms investing in new technologies are deploying both labour-saving and labour growth strategies. Strategies to reconfigure the workforce are also common when investing in new technologies, but volatility in the workforce tends to be less common in firms with the highest investment levels.

Table 2 shows the results of panel regressions to test the hypotheses regarding the relation between technology investments and workforce strategies. There is an expected positive and significant link between investments and employment change rate (model 1). Thus, technology

investments are closely associated with a labour growth strategy. In real terms, the coefficient is small (0.000541 on the employment change rate for a doubling of investments; employment change standard deviation 0.17). Thus, even if some firms deploying a labour-saving strategy, it is not the most common strategy when firms invest in new technologies.

Models 2 and 3 show how employment growth is achieved in relation to investment in new technology (H1). The positive and significant link between investments in technology and hiring rate of new employees the subsequent year remains in model 2. More importantly though, there is a negative association between investments and exit rates (model 3), which is almost twice the size of the hiring coefficient. Technology investments significantly reduce the degree to which workers leave firms, with an impact on the exit rate (mean 0.15) of −0.000298 for a doubling of investments. The size of the coefficient is almost twice the size of hiring but is still relatively small, even considering that investments span across a huge spectrum in size.

In sum, firms investing in technologies expand employment by recruiting new workers, but they also reduce the flow of workers from the firm, suggesting an increasing emphasis on firm specific human capital. H1 is supported.

H2 expects firms to deploy a reskilling strategy when they invest in new technologies, where they increase the share of skilled workers by hiring more workers with higher education. The evidence in favour of this hypothesis is, however, not convincing. The estimations of Table 3 show a positive link between hiring rates and investments in technology (model 4–5), but the effect for workers without a higher education is stronger (model 5). In contrast to expectations, there is a higher and more robust association with technology investment for workers with a lower education. The strongest effect on the skills composition of the workforce is on the exit side, in particular for workers without a higher

Table 3. Firm fixed effects models for workforce volatility. t statistics in parentheses.

	Model 8	Model 9	Model 10
	Worker flow rate	Job change rate	Churning rate
Investment	−0.000112	0.000483***	−0.000595***
	(-1.47)	(6.64)	(-5.86)
Firm size	−0.00706	−0.231***	0.224***
	(-1.59)	(-52.25)	(39.36)
Productivity	−0.0675***	0.0757***	−0.143***
	(-20.11)	(21.01)	(-25.87)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
r2	0.0343	0.164	0.120
r2_b	0.161	0.00394	0.00419
N	73696	73696	73696

Source: own elaborations on data from statistics Sweden.
Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

education. According to models 6 and 7, there is a negative link between exit rates and investments in technology, but only a strongly significant negative effect for workers without a higher education. Technology investments have a stabilizing effect for all workers, but even more so in relation to employees without a higher education. Rather than deploying a reskilling strategy, firms investing in technologies expand the workforce by retaining existing workers without a higher education. To the extent that it is possible to peak of a skill-biased technological change, it is in favour of workers without a higher education. It should be noted, however, that manufacturing firms in Sweden nowadays employ relatively few workers without vocational or upper secondary education.[1]

Table 3 shows the results of panel regressions testing H3, whether firms deploy a stabilization strategy when investing in new technologies. The analysis shows that there is a negative association between investment and worker flow rates (model 8). The association with job change rate (model 9) is positive, leading to the conclusions that firms investing in new technologies create new jobs and at the same time deploy a stabilization strategy. The indications pointing towards a stabilizing strategy are strengthened by model 10, which shows a significant negative correlation between technology investments and churning rate. H3 is confirmed. Firms investing in technologies tend to deploy a stabilizing workforce strategy indicated by reduced worker flow and churning rates.

The descriptive evidence in Figure 1 records the different workforce strategies that firms deploy when they invest in technology, and the analysis in Table 3 revealed that a common outcome for firms investing in technology is a stabilizing workforce strategy. From H4, it is expected that a stabilizing workforce strategy, indicated by lower levels of workforce volatility following investments, would be most beneficial for firm survival. An ordinary least square (OLS) is estimated to test the likelihood of a firm to survive another 3 years after having invested and deployed its workforce strategies, with firm fixed effects and weighted to control for previous firm performance. The outcomes of this analysis can be found in the Appendix 1.

As a summary, Figure 2 plots the predictive margins calculated from Appendix 1 on the firm's probability to survive another 3-years, from the effect from the volatility indicators: job change rate, worker flow rate and churning rate (lower-left), in combination with different levels of investments (main and interaction effect combined). Firms that deploy a labour growth strategy record better chances of survival (firm survival increases as job change rate increases). Also, a stabilizing workforce strategy indicated by lower levels of workforce volatility contributes to sustained competitive advantage, measured in terms of firm survival. However, this is not significantly differentiated by the level of investment as expected

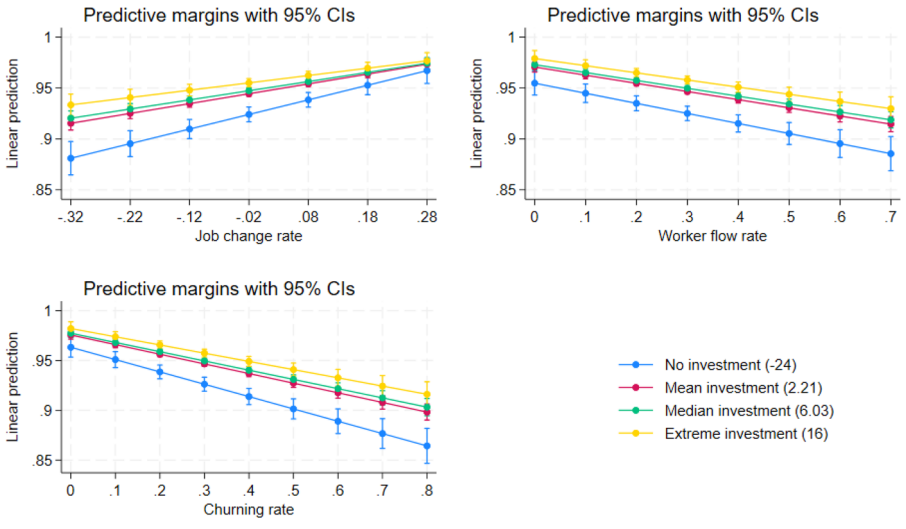

Figure 2. Predictive margins on the firm's probability to survive another 3-years, from the effect from job change rate (upper-left) and worker flow rate (upper-right) and churning rate (lower-left) in combination with different levels of investment (logged), from the highest (yellow), median (green), mean (red), to no investments at all (blue). Red and green lines represent the mean and median respectively of investments level made by the firms in this population, while blue shows the relationship for firms making no investments at all and yellow firms with extremely high investment. Source: own elaborations on data from Statistics Sweden.

from H4. Instead, the main differencing feature connecting investments to survival and workforce strategies, is whether firms invest at all, and to some extent if they record extreme investment rates. The most positive margins are shown by extreme investors that record low levels of worker flow and churning. On the other extreme, firms that record no investments and high worker flow and churning are the ones worst off in terms of survival. H5 is partially corroborated as investments and stabilization strategies are linked to survival, although the relationship is only distinguishable towards the tails of the investment spectrum.

5. Conclusion and implications

5.1. Concluding discussion

The purpose of this study is to create a better understanding of the complex links between technological change and strategic human resource management. Drawing upon investment and matched employer-employee data for manufacturing firms in Sweden between 2000 and 2020, the article explores the different workforce strategies that firms deploy when investing in new technologies, which strategies are most commonly used, and which strategies are most beneficial for firms in terms of survival.

The results are empirically limited to the Swedish manufacturing sector but contribute to previous studies in the field of strategic human resource management, as well as to debates regarding the impact of new technology on employment more generally, in three distinct ways.

First, despite the importance of technology adoption for firm performance and competitive advantage, little attention has been paid, within the field of strategic human resource management, to what workforce strategies firms deploy when they invest in new technologies. As far known, this paper offers a first attempt to empirically analyse not only what workforce strategies are commonly used by firms when they invest in new technologies, but also which workforce strategies are most beneficial for the firms. This is made possible by the conceptual developments regarding the measurement of worker flows (Burgess et al., 2000) and a longitudinal data set that allows to trace firm level changes in the human resource pool over a longer period of time.

The findings show that the workforce strategies of firms investing in technologies are not limited to labour-saving or reskilling. Firms deploy a wide range of strategies. The dominant strategy is to expand employment, primarily through a reduced exit rate not only for workers with a higher education, but also for workers without. In contrast to the commonly held belief that technological change requires radical reconfiguration of the workforce, it is found that such workforce strategies are neither the most common, nor very beneficial. Firms that deployed a stabilizing strategy in times of technological change, had greater chances for survival.

Second, this article contributes to studies in the field of labour economics exploring the impact of technologies on work and employment on the firm level (Aghion et al., 2023; Domini et al., 2021; Klenert et al., 2023). While many studies find a positive net employment effect from investments in new technologies, most such studies cannot capture whether the net effects reflect net increased hiring rates or reduced exit rates (Aghion et al., 2023). Following the flows of jobs and workers at the firm level (Burgess et al., 2000), provides an opportunity to capture how human capital resources may be re-allocated both externally and internally, something that can easily pass by unnoticed in studies focusing solely on changes in net employment (Bauer & Bender, 2004). As shown, a reduced exit rate of workers is a crucial element in understanding how firms grow following technology investments, not only because it offers an alternative way of understanding the impact of technology on employment at the firm level, but also because it problematizes the conceptualization of technology as labour saving or inherently skills biased. The findings demonstrate that a focus on the replacement effect of technology, skills bias and other conceptualizations drawn from labour economics are generally too limited to fully understand the link between

technologies and human capital resources and how they together may contribute to sustained competitive advantage of firms.

Third, this analysis advances research in strategic human resource management inspired by resource-based view of the firm (Barney, 1991), by empirically testing the link between human capital resources and firm sustained competitive advantage. Previous studies within the field of strategic HRM inspired by the RBV have been concerned with how and to what extent HR practices and policies, i.e. organizational capital resources, contribute to sustained competitive advantage (Huselid, 1995). Questions have been raised, though, concerning the contribution of HR policies and practices as sources to sustained competitive advantage, since they are easily imitated by rivals (Becker & Huselid, 1998; Wright et al., 1994). An emerging stream of research has theorized how human capital resources can contribute to sustained competitive advantage (Boon et al., 2018; Campbell et al., 2012; Crook et al., 2011; Gerhart & Feng, 2021; Ployhart et al., 2014), but there are few studies that provide empirical evidence of this relationship, partly due to the difficulties in finding relevant data. Matched employer-employee data allows this article to examine how investments in technologies are associated with changing flows of workers at the firm level, offering an opportunity to explore sustained competitive advantage in terms of reduced mobility of human capital resources leading to the creation (Ray et al., 2023) of firm specific human capital resources. This study thus responds to Gerhart and Feng's (2021) call for empirical studies of the link between human capital resources and sustained competitive advantage and on the role of worker mobility for firm value creation. As shown, firms that deployed a stabilizing strategy, indicated by reduced volatility and churning rates, had greater chances for survival in the longer term. These effects show the importance of paying attention to the flows of workers when studying the contribution of human capital resources to sustained competitive advantage. It also has important theoretical implications, indicating that technologies can serve as complementary assets in introducing supply side mobility constraints (Campbell et al., 2012) that stabilizes and limits the flows of workers from the firm. Paying attention to how HR practices modify and shape the flows of workers, provides an interesting route for further studies of strategic human resource management inspired by the RBV.

5.2. Limitations

This study also several limitations that call for further research.

First, it is not able to measure the impact of specific technologies on the flows of workers at the firm level. Future studies could fruitfully explore whether firms deploy different workforce strategies for different types of

technologies and whether firms can achieve sustained competitive advantage by selectively applying different strategies for different types of technologies.

Second, while emphasising the importance of following the flows of workers at the firm level, this study is unable to assess whether the reduced exit rates were driven by voluntary or involuntary worker turnover. Future studies would benefit from exploring whether investment in technology reduces voluntary turnover and, similarly, whether firms not investing in new technologies tend to have significantly higher incidence of voluntary turnover.

Third, the empirical findings are limited to workforce strategies deployed in the manufacturing sector. In less technology intensive sectors, investment in new technologies may initiate other workforce strategies, and employees may to a greater extent regard the implementation of new technologies as a threat, contributing to technostress or increasing job turnover (see for example Boyer-Davis, 2019). Studies that allow for comparisons of workforce strategies deployed by firms in different sectors or industries could further the understanding of the link between technological change and workforce strategies on the firm level.

Fourth, results are limited to the specific institutional conditions of the Swedish labour market. In Sweden, employment protection legislation is relatively restrictive, which results in high costs for employers to terminate employment contracts. Such legal requirements provide incentives for employers to deploy workforce strategies that reduce the volatility of employment relationships when investing in new technologies. Stringent employment protection legislation also disincentivises employers to invest in new technologies with the purpose to reduce labour costs and save labour. Studies of the link between technology investments and flows of workers in other national contexts will therefore also provide important theoretical contributions to the understanding of the role of national or sector level institutions in shaping supply and demand side mobility constraints.

5.3. Managerial implications

The analysis in this article contributes to recent discussions about the impact of new technologies on jobs and employment, and more specifically how firms should manage the workforce when investing in new technologies. Contrary to expectations that the adoption of new technologies require firms to radically change the composition of the workforce, often promoted in popular strategic HRM literature (Ulrich et al., 2009) or more profound strategic management literature (see e.g. Teece et al., 1997), the analysis indicates that those firms in the Swedish manufacturing sector that deployed stabilizing workforce strategies combined with

careful growth strategies when they invested in new technologies, were better off than those who deployed workforce strategies that radically reconfigure the human capital pool. Rather than primarily focusing on employing new workers with different skills sets and make workers with seemingly "obsolete" skills redundant, this study teaches that HR managers faced with technological change should pay attention to how existing employees can be re-trained or supported to adopt new technologies. At least, such an approach reduces the dependence on external labour markets in times of labour shortage. It seems to be better to fight the war for talent on the home turf.

Note

1. Separate regressions were run for two sub-periods (2000–2007 and 2010–2018) to exclude major shocks. The main results are consistent with Table 2. The effect of investment on employment change rate (Model 1) remains positive and statistically significant at $p<0.001$ in both periods. For the other investment coefficients originally significant at $p<0.001$ (Models 2, 3, and 7), the sign remains the same, but significance is lower in the earlier period (but still statistically significant at $p<0.05$ and $p<0.01$ levels). For the later period Model 2 loses significance, but both Model 3 and 7 are significant at $p<0.001$.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The firm micro data used in this study is confidential. Researcher access can only be granted access following application to Statistics Sweden and through Statistics Sweden's servers.

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