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NTBFsâ€™ growth modes in the context of the current global crisis. Do changes in sales mirror changes in employment?

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Abstract

Many studies have investigated firms? growth and its determinants. However, while studying how much firms grow, insufficient attention has been paid to how firms grow; namely to the different modes of growth that firms can and do choose.

This paper contributes to the emerging literature on firms? modes of growth by examining the relationship between changes in sales and employment of New Technology-Based Firms (NTBFs) during the current global crisis. Our analysis originally adds to the received knowledge as prior investigations have implicitly assumed a positive growth scenario, in which firms increase their sales and may or may not increase their employees.

We address the following research questions: What are the modes of growth of NTBFs during the crisis? Does a positive and high correlation exist between NTBFs? sales and employment? What factors moderate the allegedly positive correlation between changes in sales and employees?
Building on Transaction Cost Economics, we contend that, in crisis times, a contraction of sales does not lead to a corresponding contraction of employment when i) an NTBF has made specific investments in human capital and ii) employee turnover results in high appropriability hazards. Our hypotheses are tested on a sample of 171 Italian NTBFs.

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Sales and employment changes in the context

of the current global crisis:

NTBFs' growth modes in the context of the current global crisis

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This paper contributes to the emerging literature on firms' *modes of growth* by examining the relationship between changes in sales and employment of New Technology-Based Firms (NTBFs) during the current global crisis. Our analysis originally adds to the received knowledge as prior investigations have implicitly assumed a *positive growth scenario*, in which firms increase their sales and may or may not increase their employees.

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1. Introduction

Beginning with Penrose's seminal book (1959), a large number of studies have investigated firm growth and its determinants. For the most part, the literature regarding firm growth has attempted to explain the heterogeneity in firms' growth rates. Studies testing *Gibrat's Law* (for a review, see Caves, 1998; Sutton, 1999) have shown that conditional on survival, firm growth rates decrease with firm size and age, especially for younger and smaller firms (see e.g., Lotti et al., 2003). In particular, statistical tests have indicated the existence of a significant negative correlation between size and growth rates of new ventures operating in high-tech sectors (Almus and Nerlinger, 1999). However, the explained variance in growth research is notably low (Geroski, 2005), and despite hundreds of studies (see Coad, 2009; Davidsson et al., 2006; Gilbert et al., 2006; MacPherson and Holt, 2007; Shepherd and Wiklund, 2009 for recent reviews), scholars are far from a satisfactory understanding of the factors that influence firms' growth.

In this framework, researchers have become aware that the failure to improve the explained variance has often resulted from treating growth in an over-simplistic manner, thus ignoring its multiform aspects (Davidson and Wiklund, 2000). While using growth as a dependent variable to study *how much* firms grow, scholars have not paid sufficient attention to *how* firms grow. In other words, scholars *have failed to account for the fact that firms can and do choose different modes of growth* (McKelvie and Wiklund, 2010, p. 277). Studies have inherently assumed organic (i.e., internal) growth. However, many firms do not grow organically, while growth resulting from internal and external mechanisms (i.e., through acquisitions) is likely to have differential causes and outcomes (Gilbert et al, 2006). At the same time, when focusing on internal growth, many different growth measures have been used, which are based on sales, number of employees, profitability, and market shares (see Shepherd and Wiklund, 2009, for a comprehensive discussion of these indicators). Although most of the literature treats the choice of the appropriate growth indicator as a methodological technicality, different growth measures are far from being interchangeable.

Specifically, it has recently been contended that changes in sales and employment, the most frequently used growth indicators, are related but somewhat independent constructs. Accordingly, the correlation between the two measures may be lower than expected.[1] As was clearly documented by Delmar et al. (2003), firms exist that exhibit rapid sales growth in the absence of any employment growth, and vice-versa. In accordance with this evidence, it has been argued that sales growth may occur without accompanying employment growth if a firm outsources its activities instead of hiring new employees. Relying on a resource-based framework, Bruneel et al. (2011) have shown how particular growth modes (growth in sales vs. growth in employment) result from structuring resource portfolios to adjust them to environmental demands. Using the lens of real option theory, Bertoni et al. (2011) have found that the receipt of financial resources from an independent venture capital investor generates a positive short-term shock on firms' sales growth, which is substantially larger than the corresponding shock on employment growth. Lastly, Chandler et al. (2009) have examined the relationship between sales growth and employment growth over time by applying reasoning from transaction costs economics (TCE).

The present paper intends to contribute to this emerging literature. In exploring the divergence between the changes in firms' sales and the changes in employment, prior investigations have implicitly assumed a *positive growth scenario*, in which firms increase their sales and may or may not increase the number of their employees. In contrast, our paper analyses growth modes in a severe economic downturn. Specifically, we examine the relationship between the changes in sales and employment in new ventures operating in high-tech sectors in the context of the current global crisis.

[1] For instance, Shepherd and Wiklund (2009) while analysing the population of incorporated companies registered in Sweden during the period from 1994 to 1998, found a mean correlation equal to 0.13 between the growth rates of sales and employment over a seven years period. Conversely, Weinzimmer et al. (1998) show a much higher correlation (0.57) in a sample of publicly traded firms in the U.S. observed between 1987 and 1991.

In line with Bruneel et al. (2011), we focus on typical *high-growth firms*, i.e., young high-tech firms (New Technology-Based Firms, hereafter: NTBFs).[2] Although several studies have documented that many firms are not interested in growth (see e.g., Wiklund et al., 2003), high sales growth rates are fairly common among young, high-tech firms (Cooper and Bruno, 1977; Feeser and Willard, 1990). Moreover, NTBFs often experience rapid increase in the number of employees and thus represent a primary source of new employment (Audretsch, 1995). Therefore, growth of sales and growth in the number of employees tend to be positively correlated for these firms.

The global crisis has caused a major drop in demand, which has led entrepreneurs and managers to negatively readjust their expectations regarding future sales growth (Agarwal et al., 2009; Filippetti and Archibugi, 2010). We argue that this holds particularly true for NTBFs. Because they are normally fast-growing, these firms share expectations of a rapid and sustained positive change in their sales. However, in times of crisis, their realised sales growth rates are likely to be significantly lower than expected. In turn, their unfulfilled expectations are likely to have an impact on their levels of employment. As far as we are aware, this paper is the first to study this link.

In this framework, we aimed to answer the following research questions. What are the modes of growth of NTBFs in the context of the current global crisis? Do changes in firm's employment mirror changes in sales so that a positive and high correlation exists between the two variables? More importantly, what factors moderate the allegedly positive correlation between changes in sales and employees during the crisis?

Following Chandler et al. (2009), we answer these questions from a TCE perspective. We contend that, in times of crisis, a contraction of sales (with respect to owners-managers' expectations) does *not* lead to a corresponding contraction of employment when i) an NTBF has made *specific investments in human capital* (which include search costs for hiring talented employees) and ii)

[2] Here, we adhere to the *gold standard definition* of a 'new technology-based firm' originally proposed by Arthur D. Little (1977), which identifies an NTBF as an owner-managed firm that is less than 25 years old and active in high-technology industries.

employee turnover results in high appropriability hazards, which are detrimental for NTBFs' competitive advantage. We synthesise our arguments in a set of theoretical hypotheses, which we test on a sample of 171 Italian NTBFs.

The paper proceeds as follows. In Section 2, we develop our TCE-based theoretical hypotheses. Section 3 describes the sample, the data collection procedures, and the variables used in our empirical analysis. Section 4 specifies the econometric models and presents the results of the estimates. Section 5 summarises the main findings of the paper, highlights its contribution to the literature, acknowledges its limitations, discusses opportunities for future research, and presents implications for practitioners.

2. Theoretical hypotheses

Because of the knowledge-based nature of their production processes, human capital is the most important resource of an NTBF. Accordingly, the literature on NTBFs agrees that human capital is the main source of NTBFs' competitive advantage, whereas the distinctive capabilities of these firms coincide with the competences of their workforce (Cooper and Bruno, 1977; Feeser and Willard, 1990).

The TCE perspective suggests that NTBFs face two types of human capital-related transaction costs. First, by alternately firing and rehiring their workforce in accordance with changes in business conditions, NTBFs incur substantial costs because of the loss of the *specific investments* they have made in screening for high human capital individuals and then training them (see Grabowski, 1968, for an early contribution on this theme). Second, NTBFs' employee turnover may cause technological leaks, thus engendering significant *appropriability hazards* (Oxley, 1997, p. 388).[3]

[3] According to Williamson (1979, 1981, 1996), besides *human asset specificity* and *appropriability hazards*, significant transaction costs usually result from *physical asset specificity*. In this study, we do not consider this latter source of

As we will explain later in detail, NTBFs have to make large specific investments in hiring and training their personnel (e.g., Abraham, 1990). TCE states that specific investments in human capital engender high *human asset specificity*, which is the major force linking employees to their firms (Williamson, 1979, 1981). Indeed, the more specific the inputs required in a firm's production processes, the less likely that these inputs will be satisfactorily available from the market (Williamson, 1985). In this framework, employment re-adjustments in accordance with an adverse change in sales in the context of the global crisis would destroy the value of the specific investments an NTBF has made in hiring its employees and training them to effectively contribute to the firm's production processes. The decision to re-adjust the workforce to mirror changes in sales is even more detrimental if the adverse external contingencies are temporary and improved conditions are expected in the future, as is frequently claimed with regard to the current global crisis (see e.g., Cooper and Wills, 2010). In anticipation of recovery, firms tend to *hoard* labour, acknowledging the value of retaining a skilled workforce (Oi, 1961; Fay andMedoff, 1985).

Hiring high human capital employees normally invest time and resources in selecting and attracting these individuals. These investments increase with *uncertainty* about a firm's quality. Indeed, by making it more difficult for candidate employees to evaluate a firm's prospects, this uncertainty raises the costs of obtaining from them the long-term commitments typically associated with employment relationships (Milgrom and Roberts, 1990; Williamson, 1996; see also Klaas et al., 1999, p. 117). This argument is especially pertinent for NTBFs, which are typically characterised by significant quality uncertainty.

Because of their young age, NTBFs lack a track record, whereas the complex nature of their technology-based offerings makes it difficult to evaluate the viability of their business plans. Due to the difficulties outsiders experience in assessing NTBFs' quality, these firms typically encounter problems in obtaining external financial resources (e.g., Carpenter and Petersen, 2002; Hall, 2002)

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transaction costs because scholars agree that, in general, NTBFs do not make large specific investments in physical capital.

or complementary assets through inter-firm alliances (e.g., Rothaermel, 2002). Likewise, NTBFs generally face a *hidden information problem* on the labour market that forces their owner-managers to invest substantial time and resources in persuading high human capital individuals to join the firm. In considering an employment offer from an NTBF, high human capital individuals run into problems in evaluating the quality of the firm. These problems are similar to those experienced by potential financial investors or alliance partners.[4]

Clearly, the higher the uncertainty about a firm's quality, the higher the hidden information problems. These latter, in turn, force an NTBF to make larger specific investments in hiring high human capital employees. These investments would be wasted if the new employees hired at time t_0 would be fired at time t_1 in response to an adverse change in sales.[5]

In summary, the higher the uncertainty about an NTBF's quality, the less that changes in employment would mirror the changes in sales in the context of the global crisis. Hypothesis 1 follows.

Hypothesis 1. Uncertainty about an NTBF's quality is a negative moderator of the relationship between the changes in sales and the changes in employment in the context of the global crisis.

Once an NTBF has hired high human capital individuals, it must make them able to effectively contribute to its production processes, the execution of which requires both *product-* and *firm-specific knowledge*. Indeed, young ventures operating in high-tech sectors usually build their competitive advantage on their ability to offer innovative products and services that differ substantially from those supplied on the market. Producing these innovative products and services requires mastering idiosyncratic and highly specific production processes. In addition, NTBFs are

[4] See Gambardella et al. (2009) for a recent discussion of the role of information asymmetries in the labour market for skilled employees.

[5] Hidden information problems between two contracting parties are usually alleviated by credible signals of a firm's quality (Spence, 1973). Both venture capital investments (Stuart, 1998) and technological achievements (Hsu and Ziedonis, 2008) might provide a *certification effect*, which reduces hidden information problems between owner-managers and candidate high human capital employees. However, these signals become noisy if a firm is navigating difficult circumstances.

bundles of *firm-specific* human and technological resources (e.g., Autio and Yli-Renko, 1998). To effectively integrate with this bundle, newcomers must learn how to collaborate with incumbent talented scientists and engineers as well as charismatic managers. At the same time, the new employees must develop an in-depth acquaintance with the firm's technological trajectories.

When hiring high human capital individuals, NTBFs gamble on their potential abilities to rapidly acquire this product- and firm-specific knowledge. Then, NTBFs invest in training the newcomers to realise this potential. The full benefits of these investments in training can be realised only so long as the relationship between the firm and its employees is durable. In addition, as long as high human capital individuals are engaged in a firm's operations, they climb the learning curve. Learning by doing further increases human asset specificity (Williamson, 1981, p. 1546), thereby strengthening the linkages between an NTBF and its employees.

Based on the above arguments, we argue that for an NTBF that experiences an adverse change in sales during the global economic crisis, the higher the human capital of its employees, the less likely it will be to re-adjust its employment accordingly. Having participated in the NTBFs' production processes, high human capital employees have climbed the learning curve. Moreover, they are likely to have received formal and informal training. The specific competencies that these employees have acquired from training and learning by doing would be lost in case of employee turnover. Hence, we put forth Hypothesis 2.

Hypothesis 2. Employees' human capital is a negative moderator of the relationship between the changes in sales and the changes in employment in the context of the global crisis.

In addition to the competencies of their workforce, NTBFs typically build their competitive advantages on proprietary technological information not possessed by their competitors (e.g., Cassiman and Veugelers, 2006). Therefore, these firms face significant *appropriability hazards* (Gans et al., 2002; Zhang et al., 2007) and in contracting with third parties must be cautious about the potential for leakage of valuable intellectual property. Appropriability hazards figure

prominently when firms' establish technological alliances (Teece, 1986; Oxley, 1997). Employment contracts with individuals who are involved in technology-intensive production processes engender similar appropriability hazards. For instance, Levin et al. (1987, p. 806) show that hiring *R&D employees from innovating firms* is an important source of technological leakages.

Appropriability hazards are particularly relevant for NTBFs. Patenting is largely not viable for these firms. A large number of NTBFs operate in the service sector (e.g., in software), where patent protection is of only minor importance (Hipp and Grupp, 2005; Blind et al., 2003). Patents are widely used in high-tech manufacturing sectors, but the limited resources of NTBFs disadvantage them in obtaining and making use of patent protection (Acs and Audretsch, 1990). First, patenting involves significant application costs (including filing fees and examination fees) that exceed the financial resources of most NTBFs. More importantly, NTBFs lack the financial resources to protect their patents from infringement (Aroundel, 2001). Therefore, NTBFs cannot credibly commit to protecting their patented technologies, thus triggering imitation by competitors. Second, resource scarcity prevents NTBFs from resorting to strategic appropriability mechanisms, such as moving quickly down the learning curve or reducing lead time to bring products to market (Levin et al., 1987).

If employees who possess secret technological information leave the firm, they may use this knowledge to their personal advantage and to the detriment of the firm (Zeng and Chen, 2003). For instance, they might be later hired by a competitor or create their own enterprise. The associated technological leakages may erode the technology-based competitive advantage of the focal NTBF.

These appropriability hazards increase the more the firm relies on secrecy to protect its relevant technological information. In the context of the global crisis, we conclude that the greater the importance of maintaining proprietary information through secrecy, the lower the likelihood that an NTBF will re-adjust its employment to adapt to negative changes in its sales.

Hypothesis 3. The importance of secrecy is a negative moderator of the relationship between the changes in sales and the changes in employment in the context of the global crisis.

3. Data and methodology

3.1. The sample

We studied the relationship between changes in sales and changes in employment in the context of the current global crisis using a sample of 171 Italian owner-managed NTBFs drawn from the 2010 release of the *RITA* (*Research on Entrepreneurship in Advanced Technologies*) *directory*. The sample NTBFs operate in the following manufacturing and service industries: computers; electronic components; telecommunication equipment; optical, medical and electronic instruments; biotechnology; pharmaceuticals; advanced materials; equipment and components for energy production; aerospace; robotics and process automation equipment; software; Internet; telecommunication services; environmental services; and R&D and engineering services. Developed at Politecnico di Milano by the *RITA Observatory* research team, the RITA directory is the most reliable source of data presently available on Italian NTBFs. As of January 1, 2009, it contained information on 1,790 NTBFs representative of the Italian population of high-tech start-ups by both industry and geographical area. The RITA directory includes data on firms' characteristics, including employment, obtained through periodic surveys and interviews with the firms' owner-managers, and accounting data from the CERVED commercial database.

To study the effects of the current global crisis on Italian NTBFs, between January and March 2010 a questionnaire was sent to the 1,724 RITA directory firms that operate in the industries listed above and that had survived as independent firms until January 1, 2010. The questionnaire was e-mailed to the personal e-mail address of one of each firm's owner-managers who acted as the firm's contact for the RITA Observatory team. The respondents were asked to provide the amount of sales in 2009, the number of employees at the end of 2009, and other information on firms' strategies.

The responses were cross-checked by research assistants and compared with information obtained from the firm's website and other public sources. Phone interviews helped eliminate discrepancies, thereby assuring that the data were reliable. We obtained data on 171 firms. Table 1 presents the distribution across industries, geographical areas, and sales (in 2009), employment (on December 31, 2009), and age classes of the 171 sample firms. The majority of sample firms operate in ICT services (38% of the sample) and ICT manufacturing (29.8%), and is located in the highly developed regions in the Northwest (40.9%) and Northeast (26.9%) of the country. The size distribution is highly skewed, with most firms having less than 2 million € sales (73.1%) and less than 10 employees (61.4%). Most firms are between 5 and 15 years old (53.2%).

[Table 1 around here]

Data on sales growth of the sample firms indicate that Italian NTBFs were severely affected by the global crisis. This is apparent from the changes in the total sales of the sample firms between 2007 and 2009 (see Figure 1). Before the crisis the sample NTBFs were growing fast. Total sales had increased by 26.1% between 2007 and 2008. Conversely, between 2008 and 2009, they decreased by 17.1%. Fifty-six per cent of the sample firms registered sales reductions during this period.

[Figure 1 around here]

In line with the view that NTBFs hoard labour in anticipation of future recovery, the change in total employment differed from that of sales. Between 2008 and 2009, the total number of employees increased (5.9%). Moreover, only 34% of the sample firms registered a decrease in the number of employees during the crisis.

3.2. Variables

Table 2 provides definitions of the variables included in our econometric models. In Table 3, we report descriptive statistics and the correlation matrix.

[Table 2 around here]

[Table 3 around here]

Our dependent variable was the growth rate of employment in 2009 (*EmplGrowthRate*), which was computed as the difference between the logarithms of the number of employees in full-time equivalents in 2009 and 2008. As explanatory variables, we first included the sales growth rate in 2009 (*SalesGrowthRate*), which was computed as the difference between the logarithms of firms' sales in 2009 and 2008. We expected the coefficient of *SalesGrowthRate* to be positive.

The econometric models also included three moderating variables of the relationship between changes in sales and changes in employment. To create a proxy for uncertainty about firms' quality, we had access to the database on European initial public offerings (IPO) that was jointly developed by Politecnico di Milano and Tilburg University. This database includes data on 482 IPOs that occurred between 1996 and 2001 in five European new stock markets (Neuer Markt, Nuovo Mercato, Nouveau Marchè, Euro NM, and Nmax). *Uncertainty* is a industry-level proxy of firms' quality uncertainty (see Colombo et al., 2004). It measures the industry average of the normalised standard deviation of the market price of newly listed firms in the 50 days following the IPO. Great variability of post-IPO stock prices in an industry signals high ex ante uncertainty on the quality of newly listed firms. The human capital of a firm's workforce was measured by the share of employees with a university degree out of the total workforce (*GraduatesShare*). Finally, the importance of secrecy as a mechanism for technology protection was again measured at industry level. Following Levin et al. (1987), it is calculated as the industry average of the score attributed by the owner-managers of RITA directory NTBFs to the importance in their industry of secrecy in protecting the new or improved products, services, and processes (*Secrecy*). Following our theoretical hypotheses, we expected the interactive terms *SalesGrowthRate*×*Uncertainty*, *SalesGrowthRate*×*GraduatesShare*, and *SalesGrowthRate*×*Secrecy* to exhibit negative coefficients.

Several control variables were included in the model specifications. We considered the (logarithm of the) age (*LnAge*) and size (logarithm of employees) of the firms (*LnEmployees*) as well as

dummies for industries and geographical areas. Lastly, we included a control for the alleged survivorship bias. As is usual with data collected through a survey, our sample suffers from a survivorship bias, as firms that did not survive through the crisis are not included in our study. Some unobserved factors may be correlated with both a firm's exit (through either bankruptcy or mergers and acquisitions) in 2009 and employment growth. In particular, a negative relationship presumably exists between growth and failure, as firms that grow less are more likely to fail. Conversely, high-growth firms are likely to be especially attractive as an acquisition target. This may influence the investigated relationship between sales and employment changes. We do have data on the 66 firms included in the RITA directory on January 1st, 2009 that did not exist as independent firms on January 1, 2010. Therefore, we were able to correct for the survivorship bias through the Inverse Mills Ratio approach (Heckman, 1979). In particular, based on the RITA sample of 1,790 surviving and independent firms at the beginning of 2009, we estimated a Probit model on the exit of firms in 2009. We used the following firm-specific characteristics as independent variables: firm age, a dummy that equalled 1 if the firm was as a university spin-off (*DSpinOff*), and dummies indicating the types of corporate vehicles chosen by the entrepreneurs (*DSrl* and *DSpA* are equal to 1 if the firm is a limited liability company or a joint-stock company, respectively). We also inserted the industry and geographic area dummy variables into the model specifications. The estimates are shown in Appendix Table A1. Based on these estimates, we computed the *InverseMills* control factor, i.e., the hazard rate of exit during 2009, for the 171 sample firms considered in this work using the standard formula (Wooldridge, 2002, p. 522), and we included *InverseMills* in our models.

4. Specifications and results of the econometric models

Our theoretical hypotheses are tested through the estimation of the following OLS model:

$$EmplGrowthRate_i = \alpha + \beta SalesGrowthRate_i + \gamma SalesGrowthRate_i \times Var_i + \delta Var_i + \eta Z_i + \varepsilon_i \qquad (1)$$

where $EmplGrowthRate_i$ and $SalesGrowthRate_i$, respectively, capture changes in employment and sales of firm *i*; Var_i refers to the three moderating variables of the relationship between employment changes and sales changes (*Uncertainty*, *GraduatesShare*, and *Secrecy*) that are inserted in Models 1, 2, and 3, respectively. Z_i indicates the control variables, and ε_i is the error term.

The results of the econometric analysis are illustrated in Tables 4 and 5. Table 4 presents the estimates of Equation (1) for the full sample. Table 5 shows the estimates for the NTBFs that experienced a sales reduction (95 firms) or a sales increase (76 firms) between 2008 and 2009. We split the sample because the theoretical arguments presented in Section 2 hold true for the NTBFs that registered sales lower than expected. As NTBFs are normally fast-growing, we are confident that all the NTBFs that experienced a sales reduction in 2009 are likely to have achieved results below their expectations. Hence, our hypotheses should be strongly confirmed for this former group of firms. As to the group of NTBFs that experienced sales increases in 2009, we cannot argue whether their growth expectations were unfulfilled; thus, our hypotheses may not be confirmed for these firms. Estimates for this latter group are shown for comparative purposes.

[Table 4 around here]

Model 0 in Table 4 includes only the control variables. The coefficient of *SalesGrowthRate* is positive and significant at 95% as was expected. This indicates that an employment increase (reduction) accompanies a sales increase (reduction). The significant coefficients of *LnEmployees* and *LnAge* show that *Gibrat's Law,* which argues that, conditional on survival, firm growth rates are independent of firm age and size, is rejected. Our results are consistent with the evidence indicating that smaller firms grow faster than their larger counterparts (see e.g., Lotti et al., 2003). Indeed, during the crisis larger NTBFs experienced larger decline in employment growth rates than smaller NTBFs. Moreover, more mature NTBFs were less affected by the downturn than their

younger peers.[6] *InverseMills* has a negligible impact on employment growth. Lastly, the industry and geographic area dummies are generally not significant.

We now consider the role of the three moderating variables of the relationship between changes in sales and changes in employment in the context of the current global crisis. In accordance with hypothesis 2, we find empirical support for the negative moderating effect of employee human capital (see model 2). The coefficient of *SalesGrowthRate*×*GraduatesShare* is negative and significant at 95% confidence level. Moreover, the null hypothesis that the coefficient of this interactive term and the corresponding moderating variable jointly equal 0 is rejected at 99% (the F-tests is reported at the bottom of Table 4). Conversely, the estimates for the full sample do not support Hypothesis 3 on the negative moderating effect of secrecy. The coefficient of *SalesGrowthRate*×*Secrecy* is indeed negative, but it is not significant at conventional confidence levels. As to Hypothesis 1, the coefficient of *SalesGrowthRate*×*Uncertainty* is negative and significant (at 95%) as was expected. Nonetheless the null hypothesis that *Uncertainty* does not affect employment growth is not rejected by the F-test at conventional confidence levels.

[Table 5 around here]

Models 1a, 2a, and 3a, in Table 5, in accordance with our expectations regarding the firms that reduced their sales during 2009, show support for hypotheses 1 and 2. The larger the share of employees with a university degree out of total firm employment and the greater the uncertainty regarding firm performance in the industry in which a NTBF operates, the more the NTBF will abstain from firing employees in the face of a sales reduction. Conversely, we do not find support for Hypothesis 3. Again, the coefficient of *SalesGrowthRate*×*Secrecy* is negative, but it is not significant.

[6] The Gibrat law empirical literature has provided mixed evidence on the relation between firms' age and growth rates. While the majority of these studies show a negative relationship (see again Sutton, 1997; Caves, 1998), there are exceptions (e.g. Shanmugam and Bhaduri, 2002).

5. Discussion and conclusions

In this paper, we have used the lens of TCE to analyse the relationship between changes in sales and changes in employment in high-growth firms in the context of the current global economic crisis. Theoretical hypotheses on the moderators of the sales-employment relationship during a severe economic downturn have been tested on a sample of 171 Italian NTBFs. Results from econometric models suggest that NTBFs that tend to retain their workforce in crisis times are those that have a large share of high human capital employees and operate in sectors in which uncertainty regarding a firm's quality is high. In other words, according to our findings and in line with the TCE perspective (Williamson, 1985, 1996), during an economic crisis, changes in employment are increasingly disconnected from adverse changes in sales when human asset specificity is *high* because of the costs of screening for potential employees and training new hires (Williamson, 1979, 1981). Contrary to our expectations, contractual hazards in the form of appropriability hazards (Oxley, 1997) play a negligible role in moderating the relationship between employment and sales reduction. It may be the case that in our sample of NTBFs, the effectiveness of secrecy in protecting technological knowledge is only weakly related to personnel turnover, or appropriability hazards are regarded by the sample NTBFs as less important than one might expect.

We are aware of the limitations of our work, which open up avenues for future research. First, the study is based on a rather small sample of Italian firms. A dataset including a larger number of NTBFs from multiple countries would allow for better generalisability of the results. In particular, it would allow to test whether appropriability hazards have a more substantial moderating effect of the sales-employment relationship in specific industries or countries.

Second, in our empirical analysis, we measured human asset specificity by the share of employees with a university degree out of a firm’s total employment. That is, we use a traditional, firm-level measure of human capital: employees’ education levels. However, the literature has documented the multi-faceted nature of human capital (Becker, 1975). The human capital endowment of NTBFs

does not depend only on the overall education of their personnel; employees' previous work experience also plays a role (Cooper et al., 1994). Moreover, employees may have graduated in different subjects (e.g., electronic engineering or biochemistry), and have work experience in different functions (e.g. technical or commercial functions). Moreover, their work experience may refer to the same industry of the focal NTBFs or to other industries. Previous studies have shown that for NTBFs, the type of human capital influences growth (e.g., Colombo and Grilli, 2005). We do not have such fine-grained information regarding the diverse human capital components of the NTBFs included in our sample. If these data were available, it would also be possible to investigate the effects of complementarities among employees with different types of human capital on a firm's decision to re-adjust its personnel during times of crisis. Complementarities increase the costs engendered by human asset specificity as synergies within the workforce are destroyed by employee turnover (e.g., Lado and Wilson, 1994) and are difficult to rebuild in anticipation of recovery. Hence, one could test whether a workforce with heterogeneous and complementary competencies is less prone to be dismissed when a firm navigates difficult economic times.

Third, supply-side effects may influence the costs of firing and re-hiring employees. It is reasonable to suppose that the costs of screening and training high human capital individuals differ depending on the sector in which the firms operate. Sectoral specificities in the labour market are magnified by the fact that skilled labour is rather *inter-sectorally immobile*. An individual may become an electronic engineer or a biochemist; the acquisition of any of these skills can be assumed to be initially equally costly, but the decision is a permanent one and cannot be undone (Wildasin, 2000).

At the same time, the availability of skilled individuals to be hired by young innovative start-ups varies substantially among geographical areas (see e.g., Storper and Scott, 2009 for a recent contribution). For instance, NTBFs in metropolitan areas can more easily find candidates than those in peripheral areas, and thus face lower costs in adjusting their workforce in response to sales

declines. Thus, their changes in employment may be relatively less costly than those of their more peripheral peers.

Finally, we have assumed that due to their limited resources, NTBFs have problems in using patents and other traditional mechanisms of intellectual property protection. However, in sectors in which IPRs are effective mechanisms for protecting intellectual property, some NTBFs, such as those backed by venture capital investors, may have the financial resources needed to credibly commit to an aggressive protection strategy. As a consequence, reduce the risk of technological leakages from employee turnover would be reduced. These firms would then be able to more easily re-adjust their workforce in response to a drop in sales.

In spite of the above limitations, this study advances the received knowledge in several respects. The paper responds to the call for more research devoted to the study of *how* firms grow instead of *how much* they grow. Growth scholars have recently evinced the need for a better understanding of firms' *modes of growth* (McKelvie and Wiklund, 2010). Specifically, it has been noted that growth in sales can occur without an accompanying growth in employment if firms outsource their production processes. In turn, TCE reasoning has been applied to predict when sales growth will (or will not) be accompanied by employment growth (Chandler et al., 2009). However, results from the emerging literature on firms' modes of growth implicitly refer to a favourable macroeconomic scenario. The originality of our paper lies in its examination of the relationship between changes in sales and changes in employment in the context of the current global crisis, that is, in the case of a severe economic downturn. We have shown that a crisis scenario, the higher the specific investments in human assets, the higher the probability that an NTBF will *hoard labour* while waiting for better times to come.

In embracing the TCE perspective to analyse how NTBFs re-adjust their workforce in response to negative trends in sales, this paper also responds to the general call for more theorising on the growth of firms (see again McKelvie and Wiklund, 2010). Moreover, recent contributions (e.g.,

Bruneel et al., 2011) have argued that different firms' growth modes can depend on diverse external environments. By focusing on the link between the allegedly negative effect the current global crisis has engendered on NTBFs' sales and the ensuing reduction of their workforce, our paper takes a further step in the understanding of the impact of external contingencies on firms' growth modes.

This paper also contributes to the debate on the role of NTBFs in employment creation (Almus and Nerlinger, 1999). Scholars agree that NTBFs are high-growth firms that, in booming phases of the economic cycle, are powerful sources of new jobs. Our paper provides evidence that the jobs for high human capital individuals created by NTBFs during booming periods can resist the pressures created by economic crises. In other words, NTBFs can cushion the economic systems during economic downturns. This holds particularly true when high human capital employees comprise the greater proportion of an NTBFs' workforce and thus are more difficult to replace.

Finally, the paper extends the crisis-management literature by providing quantitative evidence regarding the ways in which high-growth firms react to a crisis of substantial intensity and breadth. The crisis-management literature has generally focused on locally relevant events analysed through qualitative methodologies (see for instance the well-known study of Weick, 1988, on the Bhopal disaster). On the contrary, this paper examines how high-growth firms respond to a major macroeconomic shock that simultaneously affects multiple industries in many countries. The recent financial crisis and the subsequent economic downturn are among the most important economic events affecting modern economic systems since the Great Depression of the 1930s. However, to date, the debate regarding the origins of the crisis and the ways to cope with it have mainly been framed within the traditions of macroeconomic discourse. Thus, conversations about the crisis have been dominated by discussions regarding the proper fiscal and monetary policy interventions (Agarwal et al., 2009). Studies at the micro-level have mainly focused on firms' innovation processes (Filippetti and Archibugi, 2010) or financial constraints (Campello et al., 2010). In contrast, issues related to *how* high-growth firms, which normally contribute significantly to

economic development, have handled the global crisis have remained relatively under-reported up to now (see Colombo et al., 2010 for a recent exception).

In addition to being of scholarly interest, our findings have important practical implications. Our results indicate that, in accordance with the predictions of TCE, high-growth firms that have a high human capital workforce tend to *hoard labour* during a crisis while waiting for better times to come. Awareness of the costs inherent in firing skilled workers can help managers more clearly evaluate the pros and cons of the decision to readjust employment of their firms when facing negative external contingencies.

Figure 1: Changes in the average number of employees and sales of the sample NTBFs: 2007-2009

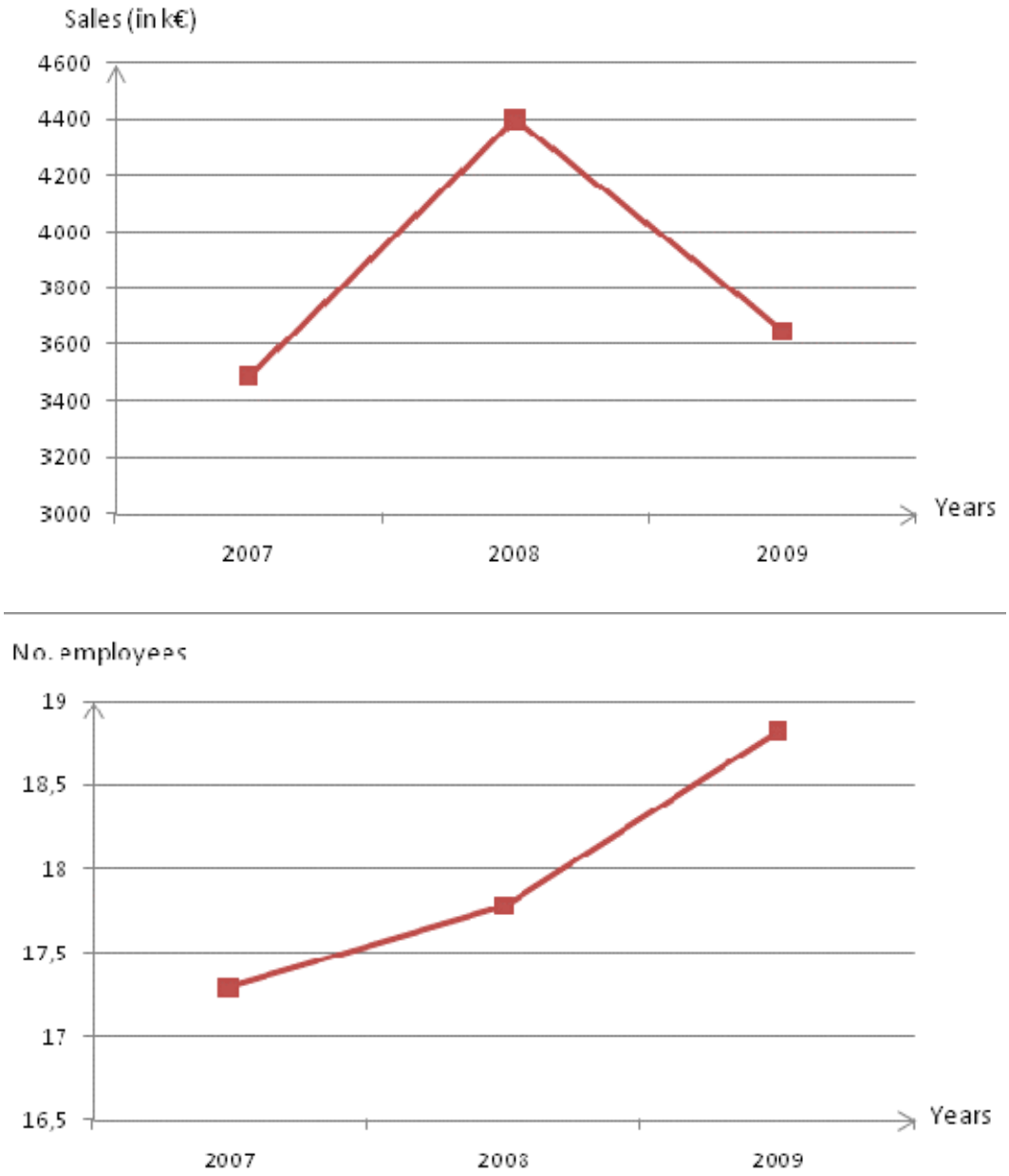

Table 1: The distribution by industry and geographical area of the firms in the RITA directory and of the sample NTBFs

	No.	*%*
Industry		
ICT manufacturing	51	29.8
Other high-tech manufacturing	42	24.6
ICT services	65	38.0
Other high-tech services	13	7.6
Total	*171*	*100.0*
Geographical area		
Northwest	70	40.9
Northeast	46	26.9
Centre	31	18.1
South and islands	24	14.5
Total	*171*	*100.0*
Sales in 2009		
≤2.000 k€	125	73.1
2.001 – 10.000 k€	35	20.5
10.001 – 50.000 k€	8	4.7
>50.000 k€	3	1.8
Total	*171*	*100.0*
Employees at December 31, 2009		
≤10	105	61.4
11-50	53	31.0
51-250	11	6.4
>250	2	1.2
Total	*171*	*100.0*
Age class		
≤5	17	9.9
6-10	42	24.6
11-15	49	28.6
16-20	28	16.4
>20	35	20.5
Total	*171*	*100.0*

Legend: ICT manufacturing includes computers; electronic components; telecommunication equipment; and optical, medical, and electronic instruments. Other high-tech manufacturing includes biotechnology, pharmaceuticals, equipment and components for energy production, advanced materials, aerospace, and robotics and process automation equipment. ICT services include software, Internet, and telecommunication services. Other high-tech services include environmental services and R&D and engineering services.

Table 2: Definition of the explanatory variables

Variable	*Description*
SalesGrowthRate	Growth rate of sales calculated as the difference of the logarithm of the sales in 2009 and 2008.
Uncertainty	Industry average of the normalised standard error of the market price of newly listed firms in the 50 days following the IPO calculated on all IPOs in the European stock market in the relevant industries in the period 1996-2001 (source: Giudici and Roosenboom, 2002).
GraduatesShare	Share of employees with a university degree in full-time equivalents out of the total employment.
Secrecy	Industry average of the scores assigned by RITA respondents to the importance of secrecy in appropriating the benefits of their new or improved products, services or processes in their industry on a Likert scale from 1 to 6. Greater values indicate tighter secrecy. Source: RITA database.
LnAge	Logarithm of firm's age in 2009.
LnEmployees	Logarithm of firm's number of employees in 2008 in full-time equivalents.

Table 3: Descriptive statistics and the correlation matrix of the explanatory variables

Variable		*No. obs.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
(1)	*SalesGrowthRate*	171	-0.024	0.375	-1.239	1.412	1.000				
(2)	*Uncertainty*	157	0.381	0.337	0.000	1.000	0.065	1.000			
(3)	*GraduatesShare*	144	0.033	0.001	0.030	0.039	-0.060	0.043	1.000		
(4)	*Secrecy*	144	3.579	0.510	3.071	5.500	-0.195	-0.050	0.321	1.000	
(5)	*LnAge*	171	2.464	0.523	1.099	3.219	0.018	-0.086	-0.215	-0.148	1.000
(6)	*LnEmployees*	171	2.215	1.069	0.693	5.638	0.036	-0.085	-0.103	-0.077	0.362

Table 4: The relationship between changes in sales and changes in employment

	Variable	Model 0		Model 1		Model 2		Model 3	
η_0	*Constant*	-2.341		-4.542		-1.598		-4.269	
		(3.203)		(4.168)		(2.928)		(4.020)	
η_1	*SalesGrowthRate*	0.443	**	6.666	**	0.893	***	0.588	
		(0.184)		(2.985)		(0.277)		(0.764)	
η_2	*SalesGrowthRate×Uncertainty*	-		-186.569	**	-		-	
				(90.004)					
η_3	*Uncertainty*	-		21.102		-		-	
				(21.856)					
η_4	*SalesGrowthRate×GraduatesShare*	-		-		-1.081	**	-	
						(0.491)			
η_5	*GraduatesShare*	-		-		0.083		-	
						(0.107)			
η_6	*SalesGrowthRate×Secrecy*	-		-		-		-0.032	
								(0.180)	
η_7	*Secrecy*	-		-		-		0.183	***
								(0.061)	
η_8	*LnAge*	0.101	*	0.053		0.131	**	0.106	
		(0.059)		(0.068)		(0.061)		(0.068)	
η_9	*LnEmployees*	-0.105	***	-0.105	***	-0.130	***	-0.112	***
		(0.033)		(0.038)		(0.035)		(0.037)	
η_{10}	*InverseMills*	-3.138		-5.138		-2.117		-4.747	
		(4.170)		(5.231)		(3.738)		(5.191)	
Industry dummies		Yes		Yes		Yes		Yes	
Geographic dummies		Yes		Yes		Yes		Yes	
No. of observations		171		153		157		153	
F		3.60 (10, 160)	***	3.56 (11, 141)	***	3.84 (12, 144)	***	4.00 (11, 141)	***
R^2		0.212		0.273		0.329		0.246	
F- test, Ho: $\eta_2=\eta_3=0$		-		2.15 (2, 141)	***	-		-	
F- test, Ho: $\eta_4=\eta_5=0$		-		-		3.01 (2, 144)	*	-	
F- test, Ho: $\eta_6=\eta_7=0$		-		-		-		5.00 (2, 141)	***

Legend: *Significance level greater than 90%; **significance level greater than 95%; ***significance level greater than 99%. Robust standard errors are in parentheses. For the sake of synthesis, estimated coefficients of industry and geographic area dummies are not reported. Data on the share of employees with a university degree are not available for 14 sample firms. Uncertainty and secrecy data are not available for the following industries: equipment and components for energy production, environmental services, and R&D and engineering services.

Table 5: The relationship between changes in sales and employment distinguishing cases of reduction and cases of increase of sales

	Variable	**Model 1a** *SalesGrowthRate<0*		**Model 1b** *SalesGrowthRate≥0*		**Model 2a** *SalesGrowthRate<0*		**Model 2b** *SalesGrowthRate≥0*		**Model 3a** *SalesGrowthRate<0*		**Model 3b** *SalesGrowthRate≥0*
η_0	*Constant*	-0.581		-0.951		0.429		-2.187		-2.309		0.392
		(6.295)		(3.307)		(3.340)		(4.144)		(5.402)		(4.536)
η_1	*SalesGrowthRate*	22.284	**	7.284	*	1.569	***	0.596		2.588	*	-1.539
		(9.110)		(3.896)		(0.548)		(0.372)		(1.526)		(1.468)
η_2	*SalesGrowthRate×Uncertainty*	-649.453	**	-220.278	*	-		-		-		-
		(277.146)		(118.341)								
η_3	*Uncertainty*	-95.504		46.049		-		-		-		-
		(63.322)		(36.487)								
η_4	*SalesGrowthRate×GraduatesShare*	-		-		-1.904	**	-1.299		-		-
						(0.948)		(0.916)				
η_5	*GraduatesShare*	-		-		-0.311		0.346		-		-
						(0.258)		(0.280)				
η_6	*SalesGrowthRate×Secrecy*	-		-		-		-		-0.424		0.423
										(0.381)		(0.385)
η_7	*Secrecy*	-		-		-		-		0.058		0.107
										(0.125)		(0.089)
η_8	*LnAge*	0.072		-0.013		0.064		0.090		0.153		0.012
		(0.117)		(0.092)		(0.105)		(0.091)		(0.130)		(0.097)
η_9	*LnEmployees*	-0.134	**	-0.086	*	-0.151	***	-0.118	**	-0.166	**	-0.081
		(0.067)		(0.048)		(0.052)		(0.050)		(0.064)		(0.049)
η_{10}	*InverseMills*	-5.017		0.194		-0.139		-2.781		-3.042		0.430
		(7.463)		(4.146)		(4.394)		(5.321)		(6.814)		(5.839)
Industry dummies		Yes		Yes		Yes		Yes		Yes		Yes
Geographic dummies		Yes		Yes		Yes		Yes		Yes		Yes
N. of observations		84		69		89		68		84		69
F		3.10	***	1.37	***	1.84	*	2.11	**	2.30	**	1.38

	(11, 72)		(11, 57)		(12, 76)		(12, 55)		(11, 72)		(11, 57)	
R^2	0.400		0.230		0.417		0.206		0.379		0.208	
F- test, Ho: $\eta_2=\eta_3=0$	3.12 (2, 72)	*	1.81 (2, 57)		-		-		-		-	
F- test, Ho: $\eta_4=\eta_5=0$	-		-		2.47 (2, 76)	*	1.03 (2, 55)		-		-	
F- test, Ho: $\eta_6=\eta_7=0$	-		-		-		-		3.11 (2, 72)	*	3.99 (2, 57)	**

Legend: *Significance level greater than 90%; **significance level greater than 95%; ***significance level greater than 99%. Robust standard errors are in parentheses. For the sake of synthesis, estimated coefficients of industry and geographic area dummies are not reported. Data on the share of employees with a university degree are not available for 14 sample firms. Uncertainty and secrecy data are not available for the following industries: equipment and components for energy production, environmental services, and R&D and engineering services.

Table A1: Determinants of exit in 2009 among NTBFs in the RITA directory

	Variable	**Probit model of exit**	
μ_0	*Constant*	-2.382	***
		(0.498)	
μ_1	*Age*	-0.018	*
		(0.01)	
μ_2	*DSpinOff*	0.017	
		(0.172)	
μ_3	*DSrl*	0.110	
		(0.146)	
μ_4	*DSpA*	0.463	*
		(0.251)	
Industry dummies		Yes	
Geographical dummies		Yes	
No. of observations		1733	
χ^2		22.835 (10)	

Legend: *Significance level greater than 90%; **significance level greater than 95%; ***significance level greater than 99%. Robust standard errors are in parentheses. For the sake of synthesis, estimated coefficients of industry and geographic area dummies are not reported.

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