Japan & The World Economy 65 (2023) 101171

Contents lists available at ScienceDirect

Japan & The World Economy

journal homepage: www.elsevier.com/locate/jwe

Is downsizing a good strategy during the downturn? Evidence from Taiwanese manufacturing firms

Eric S. Lin [a], Chia-Ling Lin [a], Hui-Lin Lin [b], Yi-Chi Hsiao [c,*]

[a] Department of Economics, National Tsing Hua University, Taiwan
[b] Department of Economics, National Taiwan University, Taiwan
[c] Department of Business Administration, National Central University, Taiwan

ARTICLE INFO

Keywords:
R&D
Employment
Downsizing strategy
Financial crisis

ABSTRACT

In response to a crisis, while retrenchments are considered to be an important part of a firm's long-term recovery, research has indicated that downsizing strategies, reducing employment and shrinking the R&D budget, may lead to an erosion of a firm's valuable core competence. Drawing from the literature of organizational turnaround strategies, this study advances the downsizing research by explaining how downsizing strategies affect a firm's long-term performance. Using a uniquely compiled dataset of 2559 Taiwanese manufacturing firms, our research shows that increasing labor employment during a financial crisis can significantly improve a firm's long-term total factor productivity and sales. In other words, employment downsizing may not be the best solution when encountering an economic downturn.

1. Introduction

"*Bad companies are destroyed by crises; good companies survive them; great companies are improved by them.*

By Andrew Grove, former chief executive officer (CEO) of Intel.[1]

A systemic crisis, involving environmental, industry and firm-specific uncertainties simultaneously, gives rise to a continuous deterioration in a firm's performance over a certain period as reflected by financial indicators such as the return on investment (ROI) and return on assets (ROA) (Santana et al., 2017). Therefore, for a firm's competitive advantage (short-term as well as long-term), strategically responding to changes in the external environment are crucial tasks (Porter, 1991; Wernefelt, 1984). When a firm's decline is not properly dealt with, it may result in a firm's eventual disappearance. Therefore, companies should act cautiously and make targeted strategic decisions during the critical phase (Barbero et al., 2017).

When facing unfavorable external shocks, operational retrenchment/downsizing strategies are prevalently adopted by firms in practice to survive the adverse conditions (Datta et al., 2010). The concept of "downsizing" includes any kinds of or combinations of asset reductions, namely, human assets, physical assets (infrastructure, plant and equipment), financial assets or informational assets (Dewitt, 1998; Cascio, 2014).[2] Given the ongoing prevalence of downsizing, however, we cast doubts on its effectiveness for improved performance according to conflicting extant findings. One the one hand, downsizing reduces compensation costs, which increases firm profitability (Cascio, 1993); on the other hand, from the perspective of knowledge-based view of the firm (Grant, 2003), a firm may lose the knowledge embedded in laid-off employees and lead to an erosion of a firm's valuable resources and capabilities, and thus downsizing may negatively impact a firm's long-term performance (Luan et al., 2013). In this regard, a research question is raised: Does downsizing improve firm performance?

The financial tsunami of 2008–2009 initiated by the collapse of Lehman Brothers is a proper context for answering aforementioned inquiry. During that period, a global financial crisis rapidly spread across the world and affected both developed and developing countries. The economic recession led firms to face sluggish demand and further impacted firms' survival. How to survive the global crisis became the main task for firms. This study adopts the lens of organizational turnaround strategies during a crisis (Santana et al., 2017; Wenzel et al., 2020; Amankwah-Amoah et al., 2021) to explore how firms respond to

* Corresponding author.
E-mail addresses: slin@mx.nthu.edu.tw (E.S. Lin), s9972804@m99.nthu.edu.tw (C.-L. Lin), huilin@ntu.edu.tw (H.-L. Lin), ychsiao@ncu.edu.tw (Y.-C. Hsiao).

[1] A. Yu. Creating the Digital Future. Free Press, 1998, p. 93.

[2] One of the most common and pervasive types of downsizing is employment downsizing. Datta et al. (2010) defined employee downsizing as a set of organizational policies and practices through layoffs, voluntary resignations or early retirement to reduce the labor force.

https://doi.org/10.1016/j.japwor.2022.101171
Received 25 August 2021; Received in revised form 10 November 2022; Accepted 6 December 2022
Available online 12 December 2022

the crisis and what the performance implications are for different responding strategies.

We do so by using a uniquely compiled firm-level dataset of 2559 Taiwanese manufacturing firms who experienced the 2008–2009 global financial crisis. Firms' responses to the crisis (e.g., R&D and employment decisions) and post-crisis performance were therefore observed. We found that when encountering the extreme environment shock, most firms took employment downsizing, as the extant literature predicts (Datta et al., 2010). Furthermore, echoing the resource-based view of the firm (Russo and Fouts, 1997; Foss, 1998; Tsang, 1998; Wernerfelt, 1984), we showed that firm size positively moderates the relationships between the financial crisis and employment or R&D decisions. As for the performance implication of downsizing, we observed that increasing labor employment during the financial crisis can significantly improve a firm's long-term total factor productivity and sales. This finding suggests that employment downsizing is not the only possible or recommended course of action when facing a decline.

Our study contributes to the literature on the organizational turnaround strategy by demonstrating importance of human resource policy and the organizations' capabilities to managing the systemic crisis. The remainder of this paper is organized as follows: In Section 2, we provide an overview of extant research on organizational crisis responses, focusing on firms' employment and R&D decisions. We then explain the empirical models in Section 3. We describe the data sources and relevant variables in Section 4. Section 5 presents the descriptive statistics, main findings in this study. We conclude the paper with a summary of key takeaway messages, managerial and policy implications.

2. Literature review

To set the appropriate background, we review the extant literature discussing the downsizing actions of firms and the downsizing effects on firm performance in the context of external environment shocks. First, we review extant studies on how organizations establish turnaround strategies in the face of external environment shocks. Second, we review the mixed empirical findings about firms' operational retrenchment decisions during the crisis and the corresponding post-crisis performance.

2.1. Strategic responses to the crisis

As the novel exogenous shock appears, companies should adopt resilient thinking and forward-looking planning. In the literature on companies' turnaround strategies during a crisis (Santana et al., 2017; Wenzel et al., 2020; Amankwah-Amoah et al., 2021), operational retrenchment strategies are widely discussed (Wenzel et al., 2020). Operational retrenchments include cost retrenchment and asset retrenchment, which are prioritized reaction behaviors of organizations in the face of performance decline (Schmitt and Raisch, 2013; Tao et al., 2020).

Cost retrenchment refers to reducing unnecessary expenses in daily activities, such as travel expenses, advertising fees and labor costs. Companies encountering crisis events must consider controlling costs. Cost retrenchment can conserve firms' resources, support firms' regular production activities, help run daily operations and improve efficiency (Tao et al., 2020). In practice, as a company enters a crisis, the dismissal of people or employee layoffs is the most typical response and is chosen as a universal means of cost retrenchment (Datta et al., 2010; Santana et al., 2017). Therefore, employees are often treated as a cost, and not as valuable internal stakeholders (Tao et al., 2020). Asset retrenchment refers to cutting business or fixed assets for long-term use, such as land, buildings and R&D equipment (Schmitt and Raisch, 2013). Asset retrenchment implies firms engaging in asset reconfigurations to alleviate the urgent need, but may also undermine firms' specific core competencies (Wenzel et al., 2020).

2.2. Existing empirical findings

Among operational retrenchment strategies, reductions in R&D investment expenditures and labor are prioritized responses to financial constraints due to the crisis events. Financial constraints are important to innovative firms and have a huge negative impact on innovative activity (Mohnen et al., 2008).

2.2.1. The financial crisis and labor employment

Most existing studies consider the global financial crisis as having an adverse impact on employment. For example, Kitching et al. (2009) pointed out that many enterprises reduced both their employment, by decreasing working hours or pay, and their investment as sales fell. In addition, Choudhry et al. (2010) used a large panel of 64–86 countries for the period from 1980 to 2005 and concluded that the financial crisis had a significant and negative effect on the employment rate by raising the unemployment rate, especially among vulnerable groups such as females, and old and young workers. Junankar (2011) utilized a large panel dataset for OECD countries and found that the economic crisis led to a decrease in employment, particularly in some industries including manufacturing, construction and finance-related industries. Bernal-Verdugo et al. (2012) used panel data for 97 countries from 1980 to 2008 and found that the global financial crisis led to an increase in unemployment and that the impact was greater for the younger age group.

Even though most studies show a negative relationship between the economic crisis and employment, there are few studies presenting the opposite outcome. For instance, Leitner and Stehrer (2012) used data for five new EU member countries and also Turkey and found that labor hoarding was a common human resource strategy for innovative firms whose search and training costs were high. Besides, several other studies observed that there were not many fluctuations in German employment during the financial crisis and that labor hoarding took place in Germany (Dietz et al., 2010; Bohachova et al., 2011; Tijdens et al., 2011; Bellmann et al., 2015).

2.2.2. The financial crisis and R&D investment

Numerous existing studies also indicate that the global financial crisis had an adverse impact on firms' R&D investments. For example, Savignac (2008) found that financial constraints significantly reduced the possibility for firms to engage in innovative activities. Furthermore, Paunov (2012) used firm-level data for eight Latin American countries during 2008 and 2009 and showed that many firms put ongoing innovation projects on hold because of the financial crisis. Giebel and Kraft (2015) used German establishment panel data from the Institute for Employment Research (IAB) to discuss how the global financial crisis affected investment decisions in innovative versus non-innovative firms. They concluded that due to the difficulty in obtaining external capital, it was more likely that innovative firms would suffer from the financial crisis and further curtail their investment expenditures; Campello et al. (2010) also showed that enterprises that were facing financial constraints or difficulties would cut their technology investment, employment and capital spending.

Even though some studies have shown that the financial crisis had an adverse influence on firms' innovation activities, there are still some studies that present different views. For example, Alfranseder and Dzhamalova (2014) analyzed US data for about 1569 publicly traded high-tech firms from 1998 to 2012 and confirmed that the financial crisis did not have a significant effect on corporates' R&D expenditures. Voigt and Moncada-Patern`o-Castello (2009) found that the impact of the financial crisis on R&D activities differed across sectors, so that there was no unique strategy for firms facing the crisis. (Archibugi et al., 2013a,b) concluded that the financial crisis caused different reactions among the firms: some reduced their spending in innovation, while some even enlarged their investment.

2.2.3. Performance implications of operational retrenchment strategies

The typical objective of operational downsizing is an improvement in the firm's performance. Despite its detrimental effects for affected employees, operational downsizing is deemed necessary for the greater good of the firm (Molinsky and Margolis, 2005). But is that so? Previous studies show, operational retrenchment strategies (e.g., labor or R&D investment retrenchments) make mixed contributions to business turnaround (Wenzel et al., 2020). Some studies consider operational retrenchment strategies to be important factors in the long-term recovery of firms, as they stabilize performance declines (Pearce and Robbins, 1994), improve the focus on existing activities (Benner and Zenger, 2016), and provide a solid basis for strategic renewal. Other studies argue that operational retrenchment strategies might result in continual underperformance (Wenzel et al., 2020). For example, the OECD (OECD, 2012) found that the global financial crisis had a negative effect on firms' innovation and R&D spending. Once the unemployment of skilled labor rose and public support for innovation decreased, there would be long-term damage to firms' innovation systems. In a study on Asian manufacturing firms during the economic crisis in 1997, Chakrabarti (2015) found that firms engaging in operational retrenchments were more likely to suffer from performance disruptions and faced a higher risk of failure. His study showed that radically retrenching operational expenditures in times of crisis was not always the superior response and even augmented the adverse effect of the economic shock on firm performance and survival.

3. Econometric method

3.1. Models

In this research, we shall use several methodologies based on the questions we are seeking to answer. By using two-period panel data, we first plan to adopt the fixed-effects model after performing the Hausman Test to discuss the determinants of firms' R&D and employment strategies. However, due to the existence of time-invariant dummy variables such us the industry dummy, adopting the fixed-effects model could lead to biased estimates. To reflect within-industry variation, we will take advantage of the correlated random-effects (CRE) model proposed by Mundlak (1978) and Chamberlain (1982, 1984). The correlated random-effects model relaxes the assumption by allowing individual-specific heterogeneity. In other words, through the correlated random-effects model, we could obtain estimates identical to those obtained by the fixed-effects model for a variable that varies between and within clusters. At the same time, we also estimate the time-invariant variables because they will be absorbed into the unobserved errors. The estimation method is presented as follows:

$$\ln \text{Labor}_{it} = x'_{1it}\beta_1 + \gamma_1 \bar{x}'_{1i} + \nu_{1i} + u_{1it} \quad (1)$$

$$\ln \text{RD}_{it} = x'_{2it}\beta_2 + \gamma_2 \bar{x}'_{2i} + \nu_{2i} + u_{2it} \quad (2)$$

where $\ln\text{Labor}_{it}$ and $\ln\text{RD}_{it}$ are two main dependent variables, representing firm i's absolute level of labor employment and R&D intensity in period t after taking natural logarithm. β_1, β_2, γ_1 and γ_2 are the parameters that we are interested in. The x_{1it} and x_{2it} are the vectors of independent variables that vary for firm i and period t. The $\bar{x}'_{1i}$ and $\bar{x}'_{2i}$ are the vectors of independent variables that are time-invariant. ν_{1i} and ν_{2i} are the true random effects, and u_{1it} and u_{2it} are the random error terms.

The second methodology we are going to use in this study is the stochastic dominance test to find the ordering between a pair of distributions of firm performance. According to Elliott and Zhou (2013), the traditional parametric analysis considers only the mean of the productivity distribution instead of the whole distribution. However, the distribution of firm-level productivity is not always identical to the mean. Using the first moment to find the relationship may yield inaccurate conclusions because of the productivity differences across firms. In order to more accurately compare firms' performances by considering the whole distribution, we will adopt the first-order stochastic dominance test. The stochastic dominance test was first proposed by Anderson (1996), and is a nonparametric test that uses distributions of economic variables to test the differences in social welfare. This method is also applied in other fields such as international economics and portfolio investment.

If we divide the samples into two groups based on the employment level, we have two distributions of productivity G and H. We can obtain the associated cumulative distribution functions F_G and F_H. G first-order stochastically dominants H based on the definition that for all random variables z, $F_G(z) \leq F_H(z)$. In other words, $F_G(z) - F_H(z) \leq 0$ holds for all $z \in R$ and for some observations the inequality holds. In this stage, we will adopt two-sided and one-sided two-sample Kolmogorov-Smirnov tests to test the equality of distribution functions and first-order dominance. We plan to divide our samples into two groups based on the change in employment (decreasing and non-decreasing) and the change in R&D intensity (decrease and non-decrease), respectively. The following are the null hypotheses for the two-sided and one-sided Kolmogorov-Smirnov tests.

For the two-sided Kolmogorov-Smirnov test:

$$H_0: F_G(z) - F_H(z) = 0 \text{ for all } z \in R \quad (3)$$

H_1: $F_G(z) - F_H(z) \neq 0$ for all z ∈ Rand for the one-sided Kolmogorov-Smirnov test:

$$H_0: F_G(z) - F_H(z) \leq 0 \quad (4)$$

H_1: $F_G(z) - F_H(z) > 0$ for at least one z.

After determining the order of the two distributions of productivity, the final methodology applied is to estimate the size of the productivity premium. The productivity premium is commonly used in international economics to compare the difference in productivity between exporters and non-exporters. The main purpose for us in adopting the productivity premium is to find the percentage difference in terms of a firm's performance such as total factor productivity and labor productivity between the groups with different employment decisions and R&D investment strategies. To this end, we will use the traditional OLS method (Bernard et al., 2010; Temouri et al., 2013) to regress the productivity variables on the decision dummy variables and a set of control variables, and the productivity premium model is as follows:

$$\ln \text{TFP}_i = \delta_0 + \delta_1 \text{sameEmployment}_i + \delta_2 \text{inEmployment}_i + \quad (5)$$
$$\delta_3 \text{sameRD}_i + \delta_4 \text{inRD}_i + \delta_5 \text{Control}_i + u_{i5}$$

$$\ln \text{LP}_i = \theta_0 + \theta_1 \text{sameEmployment}_i + \theta_2 \text{inEmployment}_i + \quad (6)$$
$$\theta_3 \text{sameRD}_i + \theta_4 \text{inRD}_i + \theta_5 \text{Control}_i + u_{i6}$$

$$\ln \text{Sales}_i = \tau_0 + \tau_1 \text{sameEmployment}_i + \tau_2 \text{inEmployment}_i + \quad (7)$$
$$\tau_3 \text{sameRD}_i + \tau_4 \text{inRD}_i + \tau_5 \text{Control}_i + u_{i7}$$

where TFP_i is the total factor productivity of firm i, LP_i is the labor productivity of firm i, Sales_i is the sale revenue of firm i, $sameEmployment_i$ and $inEmployment_i$ are treatment variables indicating that firm i maintains the same or increases its employment level during the crisis, respectively; $sameRD_i$ and $inRD_i$ are treatment variables representing that firm i maintains the same or increases the level of its R&D investment; $Control_i$ is the set of control variables, δ_k ($k = 1,\cdots, 5$), θ_k ($k = 1,\cdots, 5$) and τ_k ($k = 1,\cdots, 5$) are the parameters that describe the effects of different decision strategies and other control variables on the dependent variables, while the u_{ik} ($k = 5, 6$ and 7) are the random error terms.

3.2. Measurement

3.2.1. Dependent variables

In the correlated random-effects model (Eqs. 1 and 2).

$\ln\text{Labor}_{it}$ and $\ln\text{RD}_{it}$ are two main dependent variables, measured by

firm i's absolute level of labor employment and R&D intensity in period t after taking natural logarithms.

In the productivity premium model (Eqs. 5–7):

For the total factor productivity (TFP_i), we utilize the estimation method developed by Levinsohn and Petrin (2003) to consider the simultaneity problem in the firm's production function. They measure output with sales or value-added, capital stock as proxied by the tangible fixed assets in the firm, intermediate goods as proxied by material or electricity costs, and labor as measured by the number of employees. Here, we consider the case where the output is measured as value added and electricity is the intermediate input. We also adopt labor productivity (LP_i) and sales revenue ($Sales_i$) such that it is easier for us to compare the results with related studies. Besides, we follow the definition provided by Griffith et al. (2006) and Syverson (2016)) that labor productivity is the ratio of real value-added to the labor input, and we consider the total workforce used in the production process or delivery of a service as the labor input.

3.2.2. Independent variables

In the correlated random-effects model (Eqs. 1 and 2):

In Eq. (1), the x_1 vector of regressors includes all the variables that affect the firms' employment decisions, i.e., the firm characteristics. As for the firm characteristics, the first part is firm i's main market. There are six categories of main market dummy variables: *Domestic*, *China*, *Asia* (excluding China), *Europe*, *America* and other, and we use the domestic market as the reference group. Huang et al. (2010) find that a highly educated employee is positively correlated with being an in-house R&D performer. We also add the variable *Highedu* representing the proportion of employees with a university degree or above to overall employees. This variable is often used to explore the linkage between higher education and the tendency to engage in R&D activities, and we wish to know whether it influences a firm's employment.

Besides, it is important to find out how a firm's production type affects its strategies, and so we consider three dummy variables: *OEM* (Original Equipment Manufacturer), *ODM* (Original Design Manufacturer) and *OBM* (Original Brand Manufacturer). According to Lin et al. (2016), there are three main and common production models in the outsourcing of manufacturing: original equipment manufacturer (OEM), original design manufacturer (ODM), and original brand manufacturer (OBM). The so-called original equipment manufacturers produce goods from semi-products to finished commodities and provide full-package supply. Original design manufacturers not only design products for and/or co-design products with the customers, but also sometimes sell the products to OEMs and others. As for original brand manufacturers, in accordance with the literal meaning they design, manufacture, and sell their own branded merchandise.

Moreover, firm size is another common characteristic of firms and it is often related to a firm's ability to hire more employees and to engage in R&D activities. So we include the variable firm size, which is measured by the number of employees that are hired in each period. To avoid having only a few observations in each category, we classify firm size into three groups following the approach in Lin et al. (2016), which include *Small* (less than 50 employees), *Medium* (50–199 employees), and *Large* (over 200 employees). We also care about how financial support from outside the firm impacts a firm's employment and R&D strategies. We add an additional dummy variable (*Fund*) to represent the support from government or other resources. More importantly, we seek to analyze how firms make decisions regarding their employment and R&D investments during a financial crisis. To do this, it is necessary to consider the dummy variable *Financial* which is equal to 1 if a firm is facing the period in crisis, and 0 otherwise. In addition, we include the following interaction terms: *oemfinancial*, *odmfinancial*, *obmfinancial*, *smallfinancial*, *mediumfinancial* and *largefinancial* to further examine the actions of different types of firms taken during the financial crisis.

Furthermore, the variable ν_{1i} represents the variable that varies across different observations, but it does not change over time. In this study, we find that the industry variables describe important characteristics of firms and are time-invariant. We use the 8th Standard Industrial Classification revised by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan in 2006 as the main industry classification, and divide our observations into 12 industries, including the food, beverage and tobacco (*did1*), textile and leather (*did2*), paper making and publishing (*did3*), petroleum, plastic and chemical product (*did4*), non-metal product (*did5*), basic metal (*did6*), metal product (*did7*), electric and electronics (*did8*), mechanical equipment (*did9*), transportation equipment (*did10*), furniture manufacturing (*did11*) and other manufacturing (*did12*) industries. Here, we take the food, beverage and tobacco as the reference industry. The explanatory variables (x_2) and ν_{2i} used in Eq. (2) are exactly the same as those used in Eq. (1) because we observe that these variables are also important factors that affect a firm's R&D strategy.

In the productivity premium model (Eqs. 5–7):

According to strategic management, the goal of a manager in formulating strategy is to design the set of key choices in a way that directs the firm toward competitive advantage, which is the expected long-term profitability of the firm within its market (Porter, 1980; Ghemawat, 1991). Therefore, instead of focusing on absolute levels of strategic actions, researchers or practitioners are interested in a firm's strategic choices, binary or multinomial ones,[3] and how they shape performance (i.e., the strategic treatment effects). Hence, following aforementioned perspective, we do not adopt the actual amount of employees or R&D expenditures. Instead, we create four treatment variables in the models: $sameEmployment_i$, $inEmployment_i$, $sameRD_i$ and $inRD_i$, where $sameEmployment_i$ is coded as 1 if firm i maintains the same employment level, and coded as 0 otherwise; $inEmployment_i$ is coded as 1 if firm i increases the employment level, and coded as 0 otherwise; $sameRD_i$ is coded as 1 if firm i maintains the same level of R&D investment, and coded as 0 otherwise; and $inRD_i$ is coded as 1 if firm i increases the level of R&D investment, and coded as 0 otherwise. Furthermore, the group in which firm i decreases the employment level or R&D investment is treated as a reference.

3.2.3. Control variables

The variable *Control* in the productivity premium model (Eqs. 5–7) includes a set of explanatory variables that may affect a firm's performance. We first consider a firm's characteristics such as its main markets (*Domestic*, *China*, *Asia*, *Europe*, *America* and other), *Highedu*, production types (OEM, ODM and OBM), firm size (*Small*, *Medium* and *Large*), and *Fund* and industry dummy variables (*did1*,⋯, *did12*). Since according to a large number of studies (Lichtenberg and Siegel, 1991; Hall and Mairesse, 1995; Mairesse and Mohnen, 2005; Parisi et al., 2006; Hall et al., 2009; Mairesse and Robin, 2010; Polder et al., 2010; Lin et al., 2016) there is a high degree of correlation between different types of innovation and firms' performances, we include two additional dummy variables *prodinno* and *procinno* to indicate whether a firm engages in product innovation or process innovation or not.

4. Data

In order to precisely capture Taiwanese manufacturing firms' R&D investment strategies and employment strategies during a financial crisis, we combine two data sources and produce a rich panel dataset. The first dataset is the Taiwan Technological Innovation Survey (TTIS) compiled by the National Science and Technology Council of Taiwan. In the early 1990 s, the European Union (EU) cooperated with the Organization for Economic Co-operation and Development (OECD) to develop a Community Innovation Survey (CIS) to investigate industrial innovation activities and capture the production, circulation and

[3] For example, Lin et al. (2015) analyzed the impact of different outward FDI strategies on productivity and innovation growth.

application of new technology. In order to fully understand the industrial innovation activities, two Taiwanese government agencies (the National Science and Technology Council and the Ministry of Economic Affairs) coincidentally announced they would conduct the national innovation survey in 2001. The first Taiwan Technological Innovation Survey (TTIS) was conducted in 2001 and 2002. We utilized the second wave (2004–2006) and the third wave (2007–2010) innovation surveys to construct the longitudinal data. We decided to use TTIS-II and TTIS-III because these two surveys consist of large samples and can provide us with more individual firm information to explore the determinants of a firm's R&D and employment decisions. More importantly, by utilizing panel data, we can have a better understanding of specific firms that experienced both survey periods in regard to how they dealt with the economic crisis. The questionnaires and sampling procedures are based on the fourth edition of the European Community Innovation Survey (CIS4) and the OSLO Manual 2005 published by OECD. After combining the two innovation surveys, we have 2649 firms appearing in both surveys.

The second data source is the Industry, Commerce and Service Census (ICSC), which is compiled by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan of Taiwan every five years. The first census was conducted in 1954, and the purpose was to collect data for industry, commerce and service industries including operations, resource distribution, capital utilization, industrial structure and other industry-related activities so that the government could formulate the appropriate industrial policies. Due to the matching of the survey periods, we will use the information for intermediate inputs from ICSC in 2006 and 2011 to calculate the total factor productivity for our subsequent research. After combining these two data sources and excluding some unreasonable samples, we have a total of 2559 observations for our panel data.

5. Empirical results

5.1. Descriptive statistics

Table 1 presents the summary statistics for the whole sample. (Log) labor and (log) rd describe the absolute levels of labor employment and R&D intensity after taking natural logarithms. The average (log) labor is 5.010, and the maximum and minimum are 9.961 and 0. Similarly, the sample mean for (log) RD intensity is 2.260, and there is a larger gap between the maximum (4.615) and the minimum (−9.210). As for the performance measurement, the average (log) TFP, (log) LP and (log) Sales are 6.529, 7.162 and 13.478, respectively. We find that 60.70 % of the observations focus on the domestic market. The second largest main market is China, and it accounts for 14.70 %. Only 11.4 % and 4.4 % of the firms' main markets are respectively America and Europe, which suffered more from the financial crisis. Among the common production types, since a firm can select more than one production type, OEM, ODM and OBM have shares of 48.00 %, 36.40 % and 28.40 %, respectively. This coincides with the common thought that Taiwanese manufacturing firms are OEM-oriented. 41.80 % of the firms in our sample are large firms with more than 200 employees and can usually afford R&D and innovation activities. 39.70 % of the firm observations are classified as medium-sized firms, while only 18.60 % are small firms that have less than 50 employees. As for the proportion of employees with a university level or above education, the average proportion is 41.11 %. Only 26.80 % of the firms in our sample received funding from the government or other financial institutions. Besides, we observe that more than half of the firms engaged in innovation activities, with 56.60 % of firms engaging in product innovation and 61.90 % in process innovation. Among the twelve industry dummy variables, the electric & electronics industry accounted for the largest portion (38.00 %). The main industries that followed were the petroleum, plastic and chemical product (15.20 %) and metal product (8.90 %) industries. Furthermore, in terms of a firm's employment and R&D strategies, we found that very few firms chose to maintain the same level of labor employment or R&D intensity (1.60 % and 3.20 %, respectively). It is not surprising that more firms (53.30 %) decided to curtail their labor employment, while 45.00 % of firms increased their employment. At the same time, almost half (49.90 %) of the firms reduced their R&D intensity, while 46.90 % of firms increased their R&D intensity.

Table 1
Summary statistics.

	Mean	Std. Dev.	Min	Max
Log(Labor)	5.010	1.506	0	9.961
Log(RD)	2.260	1.225	-9.210	4.615
Log(TFP)	6.529	0.782	1.856	9.832
Log(LP)	7.162	0.799	2.657	10.582
Log(Sales)	13.478	1.950	5.609	20.157
Main market				
Domestic	0.607	0.488	0	1
China	0.147	0.354	0	1
Asia	0.066	0.248	0	1
Europe	0.044	0.205	0	1
America	0.114	0.318	0	1
Other	0.015	0.122	0	1
Production types				
OEM	0.480	0.480	0	1
ODM	0.364	0.481	0	1
OBM	0.284	0.451	0	1
Firm size				
Small	0.186	0.389	0	1
Medium	0.397	0.489	0	1
Large	0.418	0.493	0	1
Highedu	41.11	23.60	0	100
Fund	0.268	0.443	0	1
Financial	0.611	0.488	0	1
Prodinno	0.566	0.496	0	1
Procinno	0.619	0.486	0	1
Employment decision				
deEmployment	0.533	0.499	0	1
sameEmployment	0.016	0.126	0	1
inEmployment	0.450	0.498	0	1
R&D decision				
deRD	0.499	0.500	0	1
sameRD	0.032	0.177	0	1
inRD	0.469	0.499	0	1
Industry dummies				
food, beverage & tobacco	0.035	0.185	0	1
textile & leather	0.068	0.252	0	1
paper making & publishing	0.028	0.166	0	1
petroleum, plastic & chemical product	0.152	0.359	0	1
non-metal product	0.033	0.180	0	1
basic metal	0.065	0.247	0	1
metal product	0.089	0.285	0	1
electric & electronics	0.380	0.486	0	1
mechanical equipment	0.067	0.250	0	1
transportation equipment	0.063	0.243	0	1
furniture manufacturing	0.004	0.064	0	1
other manufacturing	0.014	0.118	0	1

5.2. Estimation results

Tables 2–5 present the estimation results for the different stages. In the first stage, we were concerned with the factors that affect a firm's employment or R&D intensity decisions. Considering that some explanatory variables are time-invariant, we adopted the correlated random-effects model that not only gave rise to the same coefficients as the fixed-effects model, but also helped us to solve the problem of some variables being time-invariant, and the results are presented in Table 2. There are three panels in Table 2. Panel (A) shows the estimates of the complete specification, panel (B) represents the outcomes without the variable *Highedu*, and panel (C) states the results when we exclude the variable *Fund*. In panel (A), the issue that we are most interested in is whether the external impact (i.e., the financial crisis dummy: *Financial*) influences a firm's resources allocation decisions. From the coefficients for *Financial*, it can be clearly seen that most Taiwanese manufacturing

Table 2
Estimation results of the correlated random-effects model.

	(A)		(B)		(C)	
	lnLabor	*lnRD*	*lnLabor*	*lnRD*	*lnLabor*	*lnRD*
Main market (*ref.: Domestic*) China	0.045	-0.164	0.042	-0.158	0.047	-0.185*
	(0.03)	(0.11)	(0.03)	(0.10)	(0.03)	(0.11)
Asia	-0.035	-0.155	-0.027	-0.167	-0.032	-0.196
	(0.05)	(0.16)	(0.05)	(0.15)	(0.05)	(0.16)
Europe	0.063	-0.039	0.057	-0.013	0.065	-0.068
	(0.05)	(0.18)	(0.05)	(0.18)	(0.05)	(0.18)
America	0.007	-0.006	-0.001	-0.014	0.010	-0.038
	(0.03)	(0.12)	(0.03)	(0.12)	(0.03)	(0.12)
Other	0.063	-0.159	0.078	-0.181	0.066	-0.201
	(0.11)	(0.33)	(0.10)	(0.32)	(0.11)	(0.34)
Highedu	-0.001	-0.000	–	–	-0.000	-0.001
	(0.00)	(0.00)			(0.00)	(0.00)
OEM	0.009	-0.124	0.015	-0.103	0.016	-0.182
	(0.03)	(0.12)	(0.03)	(0.12)	(0.03)	(0.12)
ODM	-0.001	-0.121	-0.003	-0.093	0.004	-0.149
	(0.03)	(0.12)	(0.03)	(0.12)	(0.03)	(0.12)
OBM	-0.025	-0.165	-0.037	-0.153	-0.018	-0.216
	(0.05)	(0.17)	(0.04)	(0.17)	(0.04)	(0.17)
Firm size (*ref.: Small*)	0.927***	-0.286	0.923***	-0.268	0.926***	-0.274
Medium						
	(0.08)	(0.18)	(0.08)	(0.18)	(0.08)	(0.18)
Large	1.585***	-0.611**	1.566***	-0.559**	1.582***	-0.584**
	(0.10)	(0.25)	(0.10)	(0.25)	(0.10)	(0.25)
Fund	0.029	-0.273***	0.019	-0.250***	–	–
Financial	(0.03)	(0.09)	(0.02)	(0.09)	-0.222***	0.572***
	-0.221***	0.557***	-0.217***	0.597***		
	(0.06)	(0.15)	(0.06)	(0.15)	(0.06)	(0.15)
oemftnancial	-0.008	0.018	-0.019	-0.017	-0.013	0.060
	(0.04)	(0.18)	(0.04)	(0.18)	(0.04)	(0.18)
odmftnancial	-0.059	-0.172	-0.057	-0.217	-0.055	-0.229
	(0.05)	(0.18)	(0.05)	(0.17)	(0.05)	(0.18)
obmftnancial	0.035	0.090	0.029	0.055	0.030	0.120
	(0.04)	(0.15)	(0.04)	(0.15)	(0.04)	(0.16)
mediumftnancial	0.183***	0.277*	0.185***	0.318**	0.185***	0.262*
	(0.06)	(0.16)	(0.05)	(0.15)	(0.06)	(0.16)
largeftnancial	0.251***	0.518***	0.261***	0.536***	0.254***	0.499***
	(0.05)	(0.14)	(0.05)	(0.14)	(0.06)	(0.14)
Industry dummies						
(*ref.: food, beverage & tobacco*) textile & leather	0.099	-0.347**	0.094	-0.306**	0.099	-0.336**
	(0.14)	(0.14)	(0.14)	(0.15)	(0.14)	(0.14)
paper making & publishing	-0.031	-0.323*	-0.040	-0.280	-0.032	-0.314*
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
petroleum, plastic & chemical product	0.323***	-0.243*	0.317**	-0.214	0.324***	-0.242*
	(0.12)	(0.14)	(0.13)	(0.14)	(0.12)	(0.14)
non-metal product	0.336**	-0.377**	0.327**	-0.338**	0.336**	-0.372**
	(0.15)	(0.17)	(0.15)	(0.17)	(0.15)	(0.17)
basic metal	0.297**	-0.440***	0.289**	-0.398***	0.297**	-0.437***
	(0.13)	(0.14)	(0.13)	(0.15)	(0.13)	(0.14)
metal product	0.109	-0.635***	0.099	-0.596***	0.108	-0.628***
	(0.13)	(0.16)	(0.13)	(0.16)	(0.13)	(0.16)
electric & electronics	0.310**	-0.299**	0.307**	-0.257**	0.310**	-0.297**
	(0.12)	(0.13)	(0.12)	(0.13)	(0.12)	(0.13)
mechanical equipment	0.060	-0.304*	0.048	-0.260*	0.060	-0.299*
	(0.14)	(0.16)	(0.14)	(0.16)	(0.13)	(0.15)
transportation equipment	0.181	-0.128	0.172	-0.085	0.181	-0.120
	(0.14)	(0.16)	(0.14)	(0.16)	(0.14)	(0.16)
furniture manufacturing	-0.091	-0.077	-0.088	0.061	-0.089	-0.091
	(0.16)	(0.30)	(0.16)	(0.30)	(0.16)	(0.30)
other manufacturing	0.150	-0.150	0.120	-0.133	0.149	-0.135
	(0.15)	(0.24)	(0.15)	(0.23)	(0.15)	(0.24)
obs	2559	1973	2630	2005	2559	1973

firms will significantly decrease labor employment during the financial crisis. In response to a crisis, operational retrenchment, referring to "reductions in costs, assets, products, product lines, and overhead" (Pearce & Robbins, 1993; p. 614), is a widely observable strategic response to a crisis (Santana et al., 2017; Wenzel et al., 2020). This finding coincides with the existing results from downsizing studies (Datta et al., 2010). Regarding the impact of the financial crisis on firms' R&D intensity, we found that firms' R&D intensity is increased along with the crisis. This finding implies that comparing to the flexibility of employment adjustment decision, R&D investment projects are relatively long-term plans and not easy to change. During the crisis, firms take measures to sustain R&D activities through *persevering* (Schmitt and Raisch, 2013; Wenzel, 2015; Wenzel et al., 2020). Thus, given the trend of decline in firms' revenue and profit levels, we observe the higher R&D intensity during the crisis.

With respect to the correlation between firms' attributes and their strategic responses, we found that firms' main markets (*Domestic, China, Asia, Europe, America and Other*), production strategies (*OEM, ODM,*

Table 3
Tests for first-order stochastic dominance - Labor employment decision.

	Log (TFP)			Log (LP)			Log (Sales)	
H_0: No	H_1: One Type Dominates		H_0: No	H_1: One Type Dominates		H_0: No	H_1: One Type Dominates	
Difference Between Two Distributions	$H_{1.1}$: *Employment decrease dominates*	$H_{1.2}$: *Employment non-decrease dominates*	*Difference Between Two Distributions*	$H_{1.1}$: *Employment decrease dominates*	$H_{1.2}$: *Employment non-decrease dominates*	*Difference Between Two Distributions*	$H_{1.1}$: *Employment decrease dominates*	$H_{1.2}$: *Employment non-decrease dominates*
0.098	0.098	-0.008	0.060	0.060	-0.013	0.198	0.198	-0.0003
(0.004)[1]	(0.002)	(0.957)	(0.194)	(0.097)	(0.902)	(0.000)	(0.000)	(1.000)

1 p-value in brackets.

Table 4
Tests for first-order stochastic dominance - R&D decision.

	Log (TFP)			Log (LP)			Log (Sales)	
H_0:	H_1: One Type Dominates		H_0:	H_1: One Type Dominates		H_0:	H_1: One Type Dominates	
No Difference Between Two Distributions	$H_{1.1}$: *R&D intensity decrease dominates*	$H_{1.2}$: *R&D intensity non-decrease dominates*	*No Difference Between Two Distributions*	$H_{1.1}$: *R&D intensity decrease dominates*	$H_{1.2}$: *R&D intensity non-decrease dominates*	*No Difference Between Two Distributions*	$H_{1.1}$: *R&D intensity decrease dominates*	$H_{1.2}$: *R&D intensity non-decrease dominates*
0.045	0.011	-0.045	0.053	0.013	-0.053	0.063	0.008	-0.063
(0.545)[1]	(0.927)	(0.278)	(0.341)	(0.904)	(0.171)	(0.150)	(0.960)	(0.075)

1 p-value in brackets.

OBM), and proportion of high-quality human resource (*Highedu*) do not have significant effects on firms' employment or R&D intensity. As for firm size, we found that medium-sized and large firms tend to have more employees than small firms, but large firms have less R&D intensity. This may be because R&D intensity is based on the ratio of R&D expenditures to the total number of employees. In terms of the interaction terms with the crisis dummy (i.e., *smallfinancial*, *mediumfinancial* and *largefinancial*), we observed that firm size positively moderates the relationships between the financial crisis and employment or R&D decisions. That is, compared to small firms, medium-sized and large firms are inclined to hire more employees and increase their R&D intensity during the crisis, and the possibilities for large firms are much greater. This results in medium-sized and large firms experiencing higher total factor productivity than small firms in the post-crisis stage. This finding echoes the resource-based view of the firm (Russo and Fouts, 1997; Foss, 1998; Tsang, 1998). A distinct stream of research suggests that bundles of organizational attributes such as leadership, management, resources and capabilities, and organization age are highly correlated with organizational strategic responses to a crisis (Dang et al., 2018; Amankwah-Amoah et al., 2021). This stream of research emphasizes the influence of organizational resources and capabilities in determining the turnaround strategy selection and the survival chances of organizations during crisis events. For example, from the resource-based perspective, due to a lack of financial, managerial and technological resources, small firms are required by financial institutions to pay higher premiums to compensate for credit risk, especially when in crisis (Cowling et al., 2012; Tao et al., 2020). Therefore, to alleviate the urgent need to improve operational continuance, small firms are more likely to adopt cost or asset retrenchments than resourceful medium-sized and large firms during crisis events.

The next stage is to test for first-order stochastic dominance based on employment and R&D intensity decisions. We adopt three performance measurements: total factor productivity (*TFP*), labor productivity (*LP*) and sales (*Sales*). For each performance measurement, the strategies are divided into two groups: decrease and non-decrease. We first compare whether the two distributions are different or not, and the null hypothesis is that there is no difference between the two distributions. Once the null hypothesis is rejected, we further test which group is dominant. Table 3 presents comparisons of the performance distributions under different labor employment decisions (i.e., labor decreasing or non-decreasing). In the cases of performance measured by *TFP* and *Sales* (panels one and three of Table 3), it is obvious that the performance distributions under different labor employment decisions are not the same and thus H_0 is rejected. We also reject the hypothesis $H_{1.1}$ that the labor retrenchment decision first-order stochastically dominates the labor non-decreasing decision. That is to say, maintaining the same level or increasing labor employment stochastically dominates decreasing the labor employment ($H_{1.2}$). While with respect to performance measured by LP, we cannot reject the null hypothesis (H_0) that a difference exists between performance distributions under two labor employment decisions.[4] Similarly, Table 4 provides comparisons of the performance distributions under different R&D decisions (i.e., R&D decreasing or non-decreasing). Our results show that no matter how performance is measured,

we cannot reject the null hypothesis (H_0) that the performance distributions under different R&D decisions are the same. This implies that firms' R&D decisions during the crisis are not highly relevant to firms performance.

Table 5 presents the estimation results for the third stage – the productivity premium model. Each decision is broken down into three types: decrease, same level and increase. There are two panels in Table 5. Panel (A) considers all the possible independent variables that may affect a firm's performance, and panel (B) excludes the influence of a firm's funding. In both panel (A) and panel (B), we find that an increase in employment during the financial crisis will significantly increase the total factor productivity, and this finding is in accordance with the stochastic dominance test that the labor non-decrease dominates the labor decrease.

In practice, as the company enters a crisis, the dismissal of people is often deemed necessary to improve the financial condition of the company (Datta et al., 2010; Santana et al., 2017). The finding of Table 5, however, suggests that employee downsizing is not the only possible or

[4] Since a firm' TFP and sales reflect the efficiency and effectiveness of value activities (e.g., operation, logistics, marketing, customer service) in a firm, this result indicates that although increasing labor employment during a crisis could not improve the operation efficiency (i.e., increasing labor productivity), but still can make positive contributions to other value activities, and therefore increase a firm TFP and sales.

Table 5
Estimation results of the productivity premium model.

	(A)			(B)		
	lnTFP	*lnLP*	*lnSales*	*lnTFP*	*lnLP*	*lnSales*
Employment decision (*ref.: deEmployment*) sameEmployment	-0.097	-0.154	-0.841**	-0.097	-0.154	-0.841**
	(0.15)	(0.15)	(0.33)	(0.16)	(0.15)	(0.35)
inEmployment	0.074*	0.048	0.131*	0.073*	0.047	0.130*
	(0.04)	(0.05)	(0.07)	(0.04)	(0.04)	(0.07)
R&D decision (*ref.: deRD*)						
sameRD	-0.201	-0.187	-0.109	-0.192	-0.179	-0.103
	(0.11)	(0.12)	(0.18)	(0.12)	(0.12)	(0.19)
inRD	-0.036	-0.031	-0.064	-0.031	-0.027	-0.061
	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)	(0.08)
Main market (*ref.: Domestic*) China	0.045	0.025	0.175*	0.043	0.023	0.173*
	(0.06)	(0.07)	(0.10)	(0.06)	(0.07)	(0.10)
Asia	-0.023	-0.010	-0.165	-0.025	-0.011	-0.166
	(0.08)	(0.08)	(0.17)	(0.08)	(0.08)	(0.17)
Europe	0.033	0.022	0.014	0.031	0.021	0.014
	(0.10)	(0.11)	(0.16)	(0.10)	(0.10)	(0.16)
America	-0.038	-0.060	0.099	-0.042	-0.064	0.097
	(0.07)	(0.07)	(0.11)	(0.07)	(0.07)	(0.11)
Other	-0.152	-0.094	-0.618**	-0.161	-0.101	-0.624**
	(0.12)	(0.18)	(0.26)	(0.12)	(0.17)	(0.25)
Highedu	0.0002	0.0003	-7.63e-06	0.0001	0.0002	-0.0001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
OEM	0.018	0.026	0.119	0.014	0.023	0.117
	(0.05)	(0.05)	(0.09)	(0.05)	(0.05)	(0.09)
ODM	0.148***	0.158***	0.158*	0.138***	0.150***	0.152*
	(0.05)	(0.06)	(0.09)	(0.05)	(0.05)	(0.08)
OBM	0.028	0.028	-0.002	0.026	0.026	-0.003
	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)	(0.09)
Firm size (*ref.: Small*) Medium	0.163**	0.063	1.944***	0.160**	0.061	1.942***
	(0.06)	(0.07)	(0.12)	(0.07)	(0.07)	(0.12)
Large	0.390***	0.217***	3.689***	0.387***	0.214***	3.686***
	(0.07)	(0.07)	(0.13)	(0.07)	(0.07)	(0.12)
Fund	-0.049	-0.038	-0.029	–	–	–
	(0.06)	(0.06)	(0.10)			
Prodinno	0.005	-0.005	0.141*	0.002	-0.007	0.139*
	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)	(0.08)
Procinno	0.084*	0.081*	0.002	0.085*	0.082*	0.003
	(0.04)	(0.05)	(0.08)	(0.04)	(0.05)	(0.08)
Industry dummies (*ref.: food, beverage & tobacco*)						
textile & leather	-0.031	-0.078	-0.084	-0.020	-0.070	-0.078
	(0.12)	(0.13)	(0.25)	(0.13)	(0.12)	(0.23)
paper making & publishing	0.068	0.026	-0.041	0.062	0.021	-0.045
	(0.13)	(0.14)	(0.31)	(0.14)	(0.13)	(0.30)
petroleum, plastic & chemical product	0.666***	0.689***	0.867***	0.679***	0.699***	0.875***
	(0.11)	(0.13)	(0.24)	(0.11)	(0.12)	(0.22)
non-metal product	0.283*	0.284*	0.317	0.293*	0.292*	0.323
	(0.15)	(0.17)	(0.36)	(0.16)	(0.16)	(0.33)
basic metal	0.479***	0.539***	1.196***	0.483***	0.541***	1.198***
	(0.11)	(0.12)	(0.26)	(0.11)	(0.12)	(0.24)
metal product	0.264**	0.221*	0.154	0.268**	0.224*	0.157
	(0.11)	(0.11)	(0.26)	(0.11)	(0.11)	(0.23)
electric & electronics	0.488***	0.390***	0.136	0.495***	0.396***	0.140
	(0.09)	(0.10)	(0.23)	(0.10)	(0.10)	(0.21)
mechanical equipment	0.208*	0.125	-0.179	0.221*	0.136	-0.171
	(0.12)	(0.13)	(0.24)	(0.12)	(0.13)	(0.21)
transportation equipment	0.289**	0.186	0.054	0.303***	0.197*	0.062
	(0.11)	(0.12)	(0.26)	(0.11)	(0.12)	(0.24)
furniture manufacturing	-0.291	-0.387*	-0.365	-0.281	-0.379	-0.358
	(0.21)	(0.24)	(0.37)	(0.21)	(0.23)	(0.33)
other manufacturing	0.186	0.087	-0.358	0.194	0.094	-0.353
	(0.23)	(0.22)	(0.30)	(0.22)	(0.22)	(0.30)
obs	1149	1150	1181	1149	1150	1181

recommended course of action when facing a decline. Although employee downsizing may yield immediate reductions in direct labor costs, it also increases the search costs of experienced employees and the training costs. In addition, continued retrenchment may lead to an erosion of a firm's valuable resources, capabilities, and culture (Leitner and Stehrer, 2012; Ndofor et al., 2013). Therefore, the finding of Table 5 goes beyond the mainstream firm's "decline-layoffs" thinking, which regarded employees as a cost, reveals the vital role of employees in an organizational turnaround (Tao et al., 2020). It hints at a new human resource management strategy when organizations come across a downturn.

Moreover, the finding that increasing labor employment during the financial crisis improves a firm's long-term total factor productivity has useful policy implications. During recessions, unemployment subsidies are practically important components of active social benefits (Steuerle, 1996). However, existing studies have shown that during crisis events

firms have more incentives to lay off more workers under the unemployment subsidy scheme (Meneses, 2019), which in turn might reduce the long-term productivity of firms according to our finding. Therefore, instead of providing subsidies to the unemployed, the alternative policy to consider might be to design tax systems to encourage firms to preserve their human resources during the crisis.

When considering the R&D decision, however, we have the unanimous finding with the stochastic dominance test that there is no significant difference between the R&D intensity decrease and non-decrease. Among the three production strategies, ODM-type firms have a significant and greater total factor productivity. Besides, compared to small firms, medium-sized and large firms have higher total factor productivity. Since according to the aforementioned findings, medium-sized and large firms are inclined to hire more employees and increase their R&D intensity during the crisis, these strategic actions suggest that medium-sized and large firms have higher propensity to experience higher total factor productivity than small firms in the post-crisis stage (Lin et al., 2016). In the case of labor productivity, we show that maintaining the same employment or R&D intensity or increasing it will not have a significant influence on labor productivity, which is the same outcome as the result in the second stage. We also conclude that ODM firms have higher labor productivity. The remaining estimation results are similar as those of total factor productivity.

The estimation results for the log of sales and those for total factor productivity are similar. It is shown that increasing labor employment is helpful to enhancing a firm's sales. Besides, if a firm's main market is China, this is also beneficial to its sales. This is reasonable because China is a much larger market than the domestic market. Nevertheless, differing from process innovation, which has a positive effect on a firm's productivity, only product innovation can improve a firm's sales. Dwyer and Mellor (1993) also show that product innovation can generate sales, profits and growth.

6. Conclusion

Relationships between adoption of different downsizing strategies and firms' performance have been a topic of interest to management research (Datta et al., 2010). In face of the external shock, operational downsizing is commonly adopted and deemed necessary for the greater good of the firm (Molinsky and Margolis, 2005). However, extant studies contain the conflicting research findings of the effectiveness of downsizing strategies (e.g., Datta and Basuil, 2015; Datta et al., 2010).

This study comprehensively uncovers the relationships between downsizing and firms' performance by using a uniquely compiled dataset of 2559 Taiwanese manufacturing firms who experienced the 2008–2009 global financial crisis. We showed that most firms took employment downsizing during the crisis, as the extant literature predicts (Datta et al., 2010). In addition, we found that firm size positively moderates the relationships between the financial crisis and employment or R&D decisions. This finding consists with the prediction of the resource-based view of the firm (Russo and Fouts, 1997; Foss, 1998; Tsang, 1998; Wernerfelt, 1984). As for the post-downsizing performance, we observed that increasing labor employment during the financial crisis can significantly improve a firm's long-term total factor productivity and sales. This finding suggests that employment downsizing is not the only possible or recommended course of action when facing a decline.

This study makes contributions to the literature on the organizational turnaround strategy. First, the field of downsizing research is dominated by large scale, cross-industry studies of public firms (House and Steel, 2022). Therefore, extant research results are vulnerable to the sample selection problem. That is, results may not fully generalize to small, non-public firms (House and Steel, 2022). Our study takes advantage of the large amount of data (i.e., the Industry, Commerce and Service Census) recorded by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan of Taiwan, which includes over-all size of firms. Thus, our findings are less vulnerable to the sample selection problem. Second, there are also relatively fewer downsizing studies in emerging economies or regions outside the developed western areas (House and Steel, 2022). In this regard, we contribute the literature by providing the example of how Taiwanese firms respond to the crisis and the post-crisis performance implication in the context of small open emerging economies.

This study also provides managerial and policy implications. First, regarding the managerial implication, we showed that increasing labor employment during the financial crisis has a significantly positive effect on a firm's long-term performance. This finding implies that the downsizing strategy by reducing employment should not be seen as a panacea to improved performance, but instead be viewed as a defensive strategy to ensure short-term survival. Second, regarding the policy implication, we found that small or un-resourceful firms are more likely to adopt operational downsizing during the crisis. Since a well-founded human resources structure is important to firms' long-term competitiveness, the governmental authorities may introduce the tax system to encourage firms to preserve their human resources during the crisis.

Despite those academic and practical contributions, this study has the limitation. As with all studies on downsizing's firm-level outcomes, the findings of this study might contain survivor bias, since performance variables (i.e., productivity, sales revenue) can only be measured in firms who continue to exist. If this is the case, survivor bias could result in an upward bias in the estimate of productivity premium of the employment retention (Zorn et al., 2017). Future research may focus not only on surviving firms, but also on bankrupt firms.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Alfranseder, E. and V. Dzhamalova , 2014. The impact of the financial crisis on innovation and growth: evidence from technology research and development, Knut Wicksell Working Paper 2014:8.

Amankwah-Amoah, J., Khan, Z., Wood, G., 2021. COVID-19 and business failures: the paradoxes of experience, scale, and scope for theory and practice. Eur. Manag. J. 39 (2), 179–184.

Anderson, G., 1996. Nonparametric tests of stochastic dominance in income distributions. Econometrica 64, 1183–1193.

Archibugi, D., Filippetti, A., Frenz, M., 2013a. The impact of the economic crisis on innovation: evidence from Europe. Technol. Forecast. Soc. Change 80, 1247–1260.

Archibugi, D., Filippetti, A., Frenz, M., 2013b. Economic crisis and innovation: is destruction prevailing over accumulation?". Res. Policy 42, 303–314.

Barbero, J.L., Di Pietro, F., Chiang, C., 2017. A rush of blood to the head: temporal dimensions of retrenchment, environment and turnaround performance. Long. Range Plan. 50 (6), 862–879.

Bellmann, L., Gerner, H.D., Laible, M.C., 2015. The German labor market puzzle in the great recession. In: Askenazy, Ph, et al. (Eds.), Productivity Puzzles Across Europe. Oxford University Press, Oxford (forthcoming).

Benner, M.J., Zenger, T., 2016. The lemons problem in markets for strategy. Strategy Sci. 1 (2), 71–89.

Bernal-Verdugo, L.E., D. Furceri and D. Guillaume , 2012. Crises, Labor Market Policy, and Unemployment, IMF Working Paper WP/12/65.

Bernard, A.B., Jensen, J.B., Redding, S.J., Schott, P.K., 2010. Wholesalers and retailers in US trade. Am. Econ. Rev. 100 (2), 408–413.

Bohachova, O., B. Boockmann and C.M. Buch , 2011. Labor demand during the crisis: what happened in Germany?" IZA DP No. 6074.

Campello, M., Graham, J.R., Harvey, C.R., 2010. The real effects of financial constraints: evidence from a financial crisis. J. Financ. Econ. 97, 470–487.

Cascio, W.F., 1993. Downsizing: what do we know? What have we learned? Acad. Manag. Perspect. 7 (1), 95–104.

Cascio, W.F. , 2014. Alternatives to downsizing: efforts in responsible restructuring, In D. Marschall (Chair), Cooperative employment relations to preserve jobs: Responsible restructuring practices and shared work. Symposium conducted at the meeting of the Labor and Employment Relations Association, Portland, OR. Available at:http://50.87.169.168/OJS/ojs-2.4.4–1/index.php/EPRN/article/view/1853.

Chamberlain, G., 1982. Multivariate regression models for panel data. J. Econ. 18, 5–46.

Chamberlain, G., 1984. Panel data. In: Griliches, Z., Intriligator, M. (Eds.), Handbook of Econometrics, Vol. II. North-Holland, Amsterdam, pp. 1248–1318.

Choudhry, M.T., Marelli, E., Signorelli, M. , 2010. Financial crises and labor market performance, Paper presented at the 69th International Atlantic Economic Conference Prague, Czech Republic.
Chakrabarti, A., 2015. Organizational adaptation in an economic shock: the role of growth reconfiguration. Strateg. Manag. J. 36 (11), 1717–1738.
Cowling, M., Liu, W., Ledger, A., 2012. Small business financing in the UK before and during the current financial crisis. Int. Small Bus. J. 30 (7), 778–800.
Dang, C., Li, Z.F., Yang, C., 2018. Measuring firm size in empirical corporate finance. J. Bank. Financ. 86, 159–176.
Datta, D.K., Basuil, D.A., 2015. Does employee downsizing really work? The empirical evidence. Human Resource Management Practices. Springer, pp. 197–221.
Datta, D.K., Guthrie, J.P., Basuil, D., Pandey, A., 2010. Causes and effects of employee downsizing: a review and synthesis. J. Manag. 36, 281–348.
Dewitt, R.L., 1998. Firm, industry, and strategy influences on choice of downsizing approach. Strateg. Manag. J. 19 (1), 59–79.
Dietz, M., Stops, M., Walwei, U., 2010. Safeguarding jobs through labor hoarding in Germany. Appl. Econ. Q. 61, 125–166.
Dwyer, L., Mellor, R., 1993. Product innovation strategies and performance of Australian firms. Aust. J. Manag. 18, 159–180.
Elliott, R., Zhou, Y., 2013. State-owned enterprises, exporting and productivity in China: a stochastic dominance approach. World Econ. 36 (8), 1000–1028.
Foss, N.J., 1998. The resource-based perspective: an assessment and diagnosis of problems. Scand. J. Manag. 14 (3), 133–149.
Ghemawat, P., 1991. Commitment: The Dynamic of Strategy. Free press, New York.
Giebel, M., Kraft, K., 2015. The Impact of the Financial Crisis on Investments in Innovative Firms. ZEW Discuss. Pap. No. 15–069.
Grant, R.M., 2003. The knowledge-based view of the firm. Oxf. Handb. Strategy 1, 197–221.
Hall, B.H., Mairesse, J., 1995. Exploring the relationship between R&D and productivity in French manufacturing firms. J. Econ. 65, 263–293.
Hall, B.H., Lotti, F., Mairesse, J., 2009. Innovation and productivity in SMEs: empirical evidence for Italy. Small Bus. Econ. 33, 13–33.
House, A., & Steel, P. ,2022. Downsizing and financial performance: a multi-level and longitudinal meta-analysis. In Academy of Management Proceedings (Vol. 2022, No. 1, p. 10166). Briarcliff Manor, NY 10510: Academy of Management.
Huang, C., A. Arundel and H. Hollanders ,2010. How Firms Innovate: R&D, Non-R&D, and Technology Adoption, UNU-MERIT Working Paper Series 2010–027.
Junankar, P.N. , 2011. The global economic crisis: long-term unemployment in the OECD, IZA Discussion Paper No. 6057.
Kitching, J., R. Blackburn, D. Smallbone and S. Dixon (2009), Business Strategies and Performance During Difficult Economic Conditions, (Project Report) Department for Business Innovation and Skills (BIS), Kingston University, London.
Leitner, S.M., R. Stehrer , 2012. Labor Hoarding during the Crisis: Evidence for Selected New Member States from the Financial Crisis Survey, wiiw Working Paper Series No. 84.
Levinsohn, J., Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. Rev. Econ. Stud. 70, 317–341.
Lichtenberg, F.R., Siegel, D., 1991. The impact of R&D investment on productivity–new evidence using linked R&D-LRD data. Econ. Inq. 29, 203–229.
Lin, C.L., Lin, H.L., Lin, E.S., 2016. Is there a complementary relationship between product and process innovation on productivity in Taiwanese manufacturing firms?". Hitotsubashi J. Econ. 57, 139–173.
Lin, H.L., Hsiao, Y.C., Lin, E.S., 2015. Do different types of FDI strategies spur productivity and innovation capability growth? Evidence from Taiwanese manufacturing firms. J. Bus. Econ. Manag. 16 (3), 599–620.
Luan, C.-j, Tien, C., Chi, Y.C., 2013. Downsizing to the wrong size? A study of the impact of downsizing on firm performance during an economic downturn. Int. J. Hum. Resour. Manag. 24 (7), 1519–1535.
Mairesse, J., Mohnen, P., 2005. The importance of R&D for innovation: a re-assessment using French survey data. J. Technol. Transf. 30, 183–197.
Mairesse, J., Robin, S. , 2010. Innovation and productivity: a firm-level analysis for French manufacturing and services using CIS3 and CIS4 data (1998–2000 and 2002-2004), Paris, France: CREST-ENSAE.
Meneses, C.M. , 2019. Unemployment benefits, unemployment subsidies and labor market dynamics, Working Paper, University of Rochester.
Mohnen, P., Palm, F.C., Schim van der Loeff, S., Tiwari, A., 2008. Financial constraints and other obstacles: are they a threat to innovation activity? De. Econ. 156, 201–214.
Molinsky, A., Margolis, J., 2005. Necessary evils and interpersonal sensitivity in organizations. Acad. Manag. Rev. 30 (2), 245–268.
Mundlak, Y., 1978. On the pooling of time series and cross section data. Econometrica 46, 69–85.
Ndofor, H.A., Vanevenhoven, J., Barker III, V.L., 2013. Software firm turnarounds in the 1990s: an analysis of reversing decline in a growing, dynamic industry. Strateg. Manag. J. 34 (9), 1123–1133.
OECD , 2012, OECD science, technology and industry Outlook 2012, Organisation for Economic Co-operation and Development: Paris.
Parisi, M.L., Schiantarelli, F., Sembenellic, A., 2006. Productivity, innovation and R&D: micro evidence for Italy. Eur. Econ. Rev. 50, 2037–2061.
Paunov, C. (2012), The Global Crisis and Firms' Investments in Innovation, Research Policy, 41, 24–35.Pearce, J. A., II, and D. K. Robbins (1993), Toward Improved Theory and Research on Business Turnaround, Journal of Management, 19(3), 613–636.
Pearce, J.A., Robbins, D.K., 1994. Retrenchment remains the foundation of business turnaround. Strateg. Manag. J. 15 (5), 407–417.
Polder, M. , Van Leeuwen, G.P., Mohnen, Raymond, W. , 2010. Product, process and organizational innovation: drivers, complementarity, and productivity effects, UNU-MERIT Working Paper Series 035.
Porter, M.E., 1980. Competitive Strategy: Techniques for Analyzing Industries and Competitors. Free Press,, New York.
Porter, M.E., 1991. Towards a dynamic theory of strategy. Strateg. Manag. J. 12 (S2), 95–117.
Russo, M.V., Fouts, P.A., 1997. A resource-based perspective on corporate environmental performance and profitability. Acad. Manag. J. 40 (3), 534–559.
Santana, M., R. Valle, and J.-L. Galan (2017), Turnaround Strategies for Companies in Crisis: Watch Out the Causes of Decline Before Firing People, BRQ Business Research Quarterly, 20(3), 206–211.Savignac, F. (2008), Impact of Financial Constraints on Innovation: What Can Be Learned from A Direct Measure?" Economics of Innovation and New Technology, 17(6), 553–569.
Schmitt, A., Raisch, S., 2013. Corporate turnarounds: the duality of retrenchment and recovery. J. Manag. Stud. 50 (7), 1216–1244.
Steuerle, C.E., 1996. How should government allocate subsidies for human capital? Am. Econ. Rev. 86 (2), 353–357.
Syverson, C., (2016) "Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown, Working Paper 21974, National Bureau of Economic Research, February 2016.
Tao, Y., Xu, G., Liu, H., 2020. Compensation gap, retrenchment strategy and organizational turnaround: a configurational perspective. J. Organ. Change Manag. 33 (5), 925–939.
Temouri, Y., Vogel, A., Wagner, J., 2013. Self-selection into export markets by business services firms: evidence from France, Germany and the United Kingdom. Struct. Change Econ. Dyn. 25, 146–158.
Tijdens, K., M. van Klaveren, R. Bispinck, H. Dribbusch and F. Öz , 2011. Employees' experiences of the impact of the economic crisis in 2009 and 2010: A German-Dutch comparison, AIAS Working Paper 11–109.
Tsang, E.W., 1998. Motives for strategic alliance: a resource-based perspective. Scand. J. Manag. 14 (3), 207–221.
Voigt, P. and P. Moncada-Patern`o-Castello, 2009. The global economic and financial downturn: what does it imply for firms' R&D strategies? IPTS Working Paper No. 12/2009.
Wenzel, M., 2015. Path dependence and the stabilization of strategic premises: how the funeral industry buries itself. Bus. Res. 8 (2), 265–299.
Wenzel, M., Stanske, S., Lieberman, M.B., 2020. Strategic responses to crisis. Strateg. Manag. J. 41 (7/18).
Wernerfelt, B., 1984. A resource-based view of the firm. Strateg. Manag. J. 5 (2), 171–180.
Zorn, M.L., Norman, P.M., Butler, F.C., Bhussar, M.S., 2017. Cure or curse: does downsizing increase the likelihood of bankruptcy? J. Bus. Res. 76, 24–33.