CM2 : The right name for author no. 1 is S. Rocchetta . Surname: Rocchetta and first name: Silvia

# Innovation has the power: the case of the Italian automotive sector during economic downturns

INTERNATIONAL JOURNAL OF LOGISTICS RESEARCH AND APPLICATIONS

R. SILVIA AND N. B. UPADHAYAY

Silvia Rocchetta[a] [Q1] Neha B. Upadhayay[b]

[a] Enterprise and Innovation Group, DCU Business School, Dublin, Ireland

[b] ERUDITE, Université Paris Est, Créteil, France [Q2]

**CONTACT** Silvia Rocchetta silvia.rocchetta@dcu.ie

**History :** received : 2021-5-30 accepted : 2021-10-5



**ABSTRACT**

The COVID 19 pandemic has exposed businesses to high uncertainty through a number of channels. While the magnitude of this economic disruption is much larger than the 2008–2009 global financial crisis, there are pertinent learnings from the latter which can accelerate the recovery envisaged after the current crisis. To identify that, in this paper, we analyse the determinants of firms' ability to maintain positive performance during an unexpected downturn. We do this by using a multinomial logit analysis on Italian automotive industry firm-level data covering the years before and after the 2008 financial crisis. The most significant results are that innovation and intangible assets play a key role in shaping the degree of firm ability to face external shocks. Our findings provide insights into solutions that have practical importance for companies pertaining to a mature industry like automotive. Learning from the economic downturn faced in 2008–2009, which we highlight in this study, can act as the first step into a green and sustainable recovery desired in the aftermath of the COVID 19 pandemic.

**Keywords**

- Innovation
- firm growth
- intangibles
- crisis
- automotive

## 1. Introduction

The world has witnessed several economic disruptions since the end of the World War II. In more recent decades, the crises have taken a global dimension since the inter-linkages of economies and business make it difficult for an economy to be unscathed by an ongoing global turmoil. The financial crisis of 2008 serves as an example in recent times of a recession that started in the USA and snow-balled into a global phenomenon that marked considerably the European corporate landscape.[1]

In more recent times, the world has been reeling under the effects of the COVID-19 related economic downturn that has left no economy untouched. To protect health and lives required isolation and lockdowns, and these have had severe impacts on economic activity. Amidst perils of an uncertain recovery, the International Monetary Fund (IMF) predicted a contraction of 3% for the global economy, much worse than during the financial crisis of 2008.

The COVID-19 pandemic, which first broke out in China, followed by Italy, and then spread throughout the world, triggered a process of re-evaluation of commercial and industrial activities. The causes and consequences of the 2008 financial crisis and COVID-19 sanitary crisis are quite different. 'The Great Lockdown', which was not a feature in the financial crisis of 2008, weighs heavily on the side of the scale that brings growth down. Also, while the 2008 mortgage meltdown reflected infection of the financial system due to excess leverage and poor-quality mortgage loans (endogenous shock), the recent crisis reflects a substantial global economic shock to contain the viral outbreak of the coronavirus (exogenous shock). The COVID-19 crisis has put the real economy out of action immediately and completely – evaporating supply and demand simultaneously. In contrast, the 2008 financial crisis began with disruption to the US real estate and financial markets and spread to financial and real economy in the rest of the world after a certain time delay. Despite these differences, the financial and medical systems share

many elements, such as opacity and interconnectedness as well as adequate buffers and reserves (Spatt 2020). Additionally, the two crises have similarities in economic terms with respect to uncertainty, collapsing financial markets and reaction by stock-markets and industry as a whole. Foroni, Marcellino, and Stevanovic (2020) suggest that in terms of the size of the implied demand and supply shocks, the 2008 crisis is the most similar event to the COVID-19 crisis in the past decades.

Events like the financial crisis of 2008, have proven to be climacteric points, warranting a shift in government policies and firm strategy in planning recovery agendas (Barbier 2020). During these events, governments of most advanced economies have responded with a diverse and sizeable set of support instruments. These actions from governments are grounded in economic theory and a large body of empirical research, which support the idea that business dynamic is central for growth (Fareed and Overvest 2021). Consequently, in this paper, we focus our attention on investigating the complex mix of firm characteristics that trigger firms' ability to exhibit good performances during an unexpected shock. In particular, the question we address is whether the firms, which are able to grow during recessionary shocks, differ in terms of structural characteristics, such as their degree of innovation, their profitability, their financial conditions and geographical location, when compared to the firms experiencing decline over the crisis. Seeking the answer to this question involves important policy implications. Institutions may want to understand whether firms that are able to cope with recessionary shocks are also those who can trigger the overall sector, region or country level of adaptability during economic downturn. This becomes particularly pertinent in the current scenario where governments, institutions as well as firms are struggling for a post-COVID 19 recovery that is grounded in circular economy (Jabbour et al. 2019).

To begin with, a large body of evolutionary literature attributes a key role to innovation in shaping firm performances during sudden disturbances (Coad 2009; Geroski and Gregg 1996; Nelson and Winter 1977). In general, evolutionary scholars put a considerable emphasis on the firms' ability to the create new knowledge as it is considered the main driver of industries evolution. Following this line of inquiry, Geroski and Walters (1995) indicate that innovative firm are less affected by negative business cycles than non-innovators. Teece et al. (1997) stress that companies that invested in intangible assets in the pre-crisis period have better chances to withstand unexpected shocks. Also, small organisations performing innovatively and supplying technologically upgraded as well as quality products at a cheaper rate can be a boon for the larger enterprise in the supply chain (Gupta and Barua 2018). According to Nelson and Winter (1977, 1982), this is arguably due to the fact that innovation involving mechanisms of search, imitation, and implementation of internal knowledge and skills determine the amount of available opportunities and affects the firms' growth rate (Cimoli and Dosi 1995; Pavitt 1984).

Several studies have also shown the significant positive relationship between innovation and green recovery aided by practices like internal environmental management, eco-design and investment recovery (Choi et al. 2017; Lee et al. 2014). Innovative practices – especially, technological improvements that save energy, prevent pollution, or enable waste recycling and can include green product design and corporate environmental management – have positive effects on a firm's financial, social, and environmental outcomes (Aguilera-Caracuel and Mandojana 2013). Additionally, firms located in spatial proximity to similar firms may benefit from relevant knowledge and co-location synergies (transport, access to service providers, repair and maintenance facilities) generated by competing and cooperating firms (Van den Heuvel et al. 2014). Thus Martin, Mayer, and Mayneris (2013) argue that the presence of agglomeration economies, as well, play a key role in promoting firm performances during destabilising disturbances.

Through the empirical analysis carried out in this paper, we supplement this literature by providing econometric evidence from a sample of 1477 firms observed over the period 2005–2012. Our dataset combines data from Bureau Van Dijk (2015) – including detailed information about financial accounting data on Italian private and public firms – and PATSAT (2015) database of the European Patent Office (EPO). All the firms included in the database belong to the Italian manufacturing of motor vehicles, trailers and semi-trailer sector according to NACE[2] Rev.2 classification.

To the best of our knowledge, not many empirical studies have explored the complex mix of firm characteristics triggering companies' ability to exhibit good performances over the crisis in a mature sector such as the automotive industry. The automobile industry is, indeed, among the Italian sectors that have been hit the most by the financial crisis that started in 2008. ANFIA (Associazione Nazionale Fra Industrie Automobilistiche) in 2012 registered that demand for cars fell by 9.2% from 2007. Furthermore, the automotive sector has always been particularly sensitive to exogenous shocks. The automotive industry represents, therefore, particularly fertile ground to reflect upon the determinants of varying firms' capabilities to face destabilising disturbances. The empirical tests consist an estimation of a multinomial logit model in which our categorical distributed dependent variable is calculated by comparing the evolution of firms' sales before and during the 2008–2009 financial crisis. Our evidence highlight that the firms that invested in intangible assets and innovation in the pre-crisis period are more likely to grow during a recessionary shock. Additionally, our results uncover a negligible role of agglomeration economy on firm performance during an unexpected economic downturn.

The paper is structured as follows. Section 2 analyses the main peculiarities of the Italian automotive sector. In Section 3, we provide a synopsis of key findings in literature on firm growth during recessions and we develop a set of testable hypotheses.

Section4introduces the data, the construction of dependent variable and the set of explanatory variables that we include in our modelling exercise. In Section 5, we present our findings and provide a discussion on the estimates. Section 6 concludes the paper with policy recommendations and ideas on a green recovery post-pandemic in a mature industry.

## 2. Italian automotive sector

Globally, the automotive industry is undergoing several changes in the form of digital transformation, electrification, and the development of self-driving vehicles. To add to this, there are challenges that the COVID-19 crisis poses, like plant-closures or short-time work, disrupted supply chain and a steep drop in demand. Shortage of parts coming from China forced several car-makers to shut assembly lines (Baldwin and Weder Di Mauro 2020). This is a *déjà vu* for automotive sector around the world which suffered heavy losses in the aftermath of the 2008 financial crisis. In the U.S., auto giants GM and Chrysler went through bankruptcies they were able to escape from only with the help of bailout funds from the U.S. federal government (Katz, MacDuffie, and Pil 2013). In Europe too financial bailouts were provided and focus shifted from domestic manufacturing to outsourcing. Manufacturers quickly shifted to emerging markets like Brazil, China and India.

During the financial crisis of 2008, globally, the automotive sector was one of the hardest hit along with the banking and finance industry (Oh 2014). This was because the industry was in a dire state to begin with. Second, the high cost and longevity of vehicles made buyers postpone decisions to purchase new vehicles (Cattaneo, Gereffi, and Staritz 2010). The drop in demand for cars, and therefore manufacturing, took a turn for the worse in Italy – a country that was already performing badly on several economic indicators even before the crisis (Figure 1).

**Figure 1.** **[Q16]**Macroeconomic indicators, Italy. Source: World Bank Statistics.


At the beginning of 2009, the biggest Italian car conglomerate – Fiat, announced a 19% drop in revenue in the last three months of 2008. ANFIA (Associazione Nazionale Fra Industrie Automobilistiche) declared that car demand fell by 9.2% from 2007 to 2012. This was particularly consequential since the automotive industry is one of the most important sectors of the Italian economy.

Despite the difficulties that the automotive sector has encountered cyclically, it still represents Italy's largest manufacturing industry employing 274,000 workers (7% of the employees in the Italian manufacturing sector) and contributing 6.2% to the national Gross Domestic Product (GDP) (ANFIA, Department of Studies and Statistics). From a geographical point of view, the Italian automotive industry originated in Turin, and nowadays, it is spread all over the country: in the South (around Pomigliano d'Arco, Melfi and Termini Imerese), in the Centre (around Cassino and Chieti sites) where Fiat plants are located and in other districts of Northern Italy like Milan, Brescia, Bologna, and Modena.

Since the crisis that Fiat underwent in the early 2000s[3], the Italian car production system experienced a progressive vertical disintegration by increasingly externalising the more complex and innovative activities to specialised suppliers (Patrucco 2011). Thus, even if few Original Equipment Manufacturers (OEMs, i.e. in this context car-makers) still dominate the industry, an increasing number of suppliers provide the more specialised components and processes. Therefore, the rapid growth in terms of the global supply chain and overall outsourcing of manufacturing industries makes this sector particularly vulnerable to global shocks.

Researchers have found that industries such as automotive are prone to disruptions due to a high reliance on their supplier networks and customer's demand for personalised features. For this industry, the main supply chain risks arise in transportation,

forecasting, operations, and economic risk (Srivastava and Rogers 2021). Cars, in fact, are durable goods that yield utility over time rather than being completely consumed in one-time use. Moreover, Italy is already a mature market where the consumers' propensity to buy vehicles is lower than in other countries. To crown it all, the sector is shaped by cyclically sensitive external factors like consumer tastes and purchasing power, labour markets regulations and public policy (incentives and taxation).

In this context, the Italian automotive industry represents a particularly fertile field to reflect upon the causes of varying firms' capabilities to face severe recessionary shocks. In an evolutionary framework Breschi and Malerba (1997), Malerba (2002) agreed on the idea that sectors provide a key level of analysis to understand firms' performance. Consequently, we employ the automotive industry as a case study because it represents an interesting example of a mature, concentrated but also innovative industry (Faria and Andersen 2017).

## 3. Literature review and hypotheses

The complexity and idiosyncrasy of the process of firm growth is reflected by the ambiguous and rather controversial results that emerged in the related literature. Researchers found few empirical regularities that are related to the type of industry, technological regime, or region in which the firm is embedded. In this context, when economies are tested by recessionary shocks, the variance of firms' behaviours increases markedly. Despite the unevenness of the processes driving firm growth, the literature identified some factors that distinguish firms able to grow during the crises from the ones that experience decline. Some scholars refer to the firm's ability to cope with disturbances as resilience capacity (Lengnick-Hall and Beck 2005). According to the capability-based (Dosi et al. 2000) and the resource-based theory of the firm (Barney 2001; Penrose 1959), resilience is defined as the unique blend of cognitive, behavioural, and contextual properties that increase firm's ability to respond to sudden shocks.

More recently, the learning theory has gained traction in this literature. In particular, evolutionary scholars identify the processes of learning by individual firms and the mechanisms of market selection among the main determinants of the industry's dynamics during negative shocks. Following this line of inquiry, Geroski and Gregg (1995) argue that the pattern of firm growth and its survival relies on firms' capacity to learn. In this theoretical framework, the processes of learning concern the development of product and process innovations. Market selection, instead, is the result of the interactions among the firms on the market in which the more competitive ones gain market share at the expense of the less competitive firms that shrink their weight up to their death.

There are at least two ways through which innovation may influence firms' performances during destabilising disturbances. First of all, firms by introducing innovation, acquire temporary competitive advantage with respect to their rivals. Secondly, the process of doing innovation – by involving firms' ability to translate endogenously generated knowledge into new goods and services – permanently transforms a firm by building up its internal capabilities and by making it more perceptive and adaptable to any kind of exogenous shock. Firms that are able to produce innovative products and processes can increase their market power and gain competitive advantage (Aghion, Akcigit, and Howitt 2014; Sabahi and Parast 2020). Mansfield (1962) provides some evidence in this direction by highlighting that successful innovators grew faster than other comparable firms. Klepper (2002), by analysing the evolution of U.S. automobiles industry, demonstrates that the current leading auto manufacturers (General Motors, Ford and Chrysler) are the ones that acquired more competences and technological knowledge in the past.

Several papers analysing the patterns of firms' growth during the 2008 recession, highlight that innovation increases their ability to face destabilising disturbances. Spescha and Woerter (2019) analysing firms' performance in Switzerland during this same downturn demonstrated that more innovative firms experienced a smaller decrease in sales than other firms. Madrid-Guijarro, Lema, and Van Auken (2013) found similar results respectively for Spanish manufacturing firms and Finnish SMEs.

The results regarding innovation however are far from unanimous. In times of resource constraints, investing in innovation can negatively affect firms' financial stability and therefore their performance (Filippetti and Archibugi 2011). The effect of innovations depends on the type of industry in which the firms is competing and also the firms' size. Following this line of inquiry, Teplykh (2018) finds that during financial crisis of 2008, there is a clear relation effect of patent on firms' economic performance. Sidorkin and Srholec (2014) find that pre-crisis innovation investments had a positive effect on firms' performance only in less developed countries in South and Eastern Europe.

These studies, however, focus on cross-sectoral variation of firm performances during destabilising shock. To the best of our knowledge, no studies have tested the role of innovation on firms' performances in a mature industry like the automotive sector. In this industry that is characterised by a rather static market with high competition, coping with recession requires firms to be flexible to adapt their activities to the evolving market conditions and find new opportunities not exploited yet.

This leads us to formulate the following hypothesis:

> **HP 1:** Firms that invested in innovation in the pre-crisis period are more likely to grow throughout the crisis than non-innovating ones.

If knowledge is a key strategic resource that allows firms to grow during destabilising shocks, it becomes imperative to consider also the role of intangible resources to fuel innovation and consequently growth (Singh et al. 2019). This leads us to conjecture that the amount of firm's investments in intangible assets before the crisis may also influence its performance throughout the crisis. The Financial Accounting Standards Board (FASB) defines intangibles as long-term resources of an entity, other than a financial asset, that are characterised by lack of physical substance. At firm level, they encompass all the stock of immaterial resources that enter the production process and are necessary for the creation or improvement of products and processes that drive long-term value creation. More specifically, what is recorded in the firms' balance sheet under the label 'intangible' includes both endogenously created assets e.g. research and development, Blueprints, brand equity and designs – and assets procured through the external market – e.g. technology patents, licenses, and copyrights (Corrado, Hulten, and Sichel 2009).

Following this line of enquiry, the evidence from Geroski et al. (1995) confirms the prominent role played by investments in intangible assets in the pre-crisis period in mitigating the risk of failure during a disturbance. The authors, following a Schumpeterian approach, argue that all forms of investments in innovation are the key drivers of firms' resilience throughout economic crises. In the contemporary context of knowledge economy, more recent studies (among others Bontempi and Mairesse 2008; Corrado, Hulten, and Sichel 2009; Dettori, Marrocu, and Paci 2012) provided evidence of the crucial role played by intangible assets in fostering firm growth. Landini, Arrighetti, and Lasagni (2020) employing Italian firm-level data uncover the key role that intangibles played in shaping firm growth during the economic downturn followed by the financial crisis of 2008–2009.

Teece et al. (1997) argue that intangibles are fundamental in shaping the path through which new capabilities are generated. Thus, firms with more abilities are more likely to create new products and technologies by recombining new and old know-how. Therefore, other things being equal, we expect that during a recessionary shock firms endowed with a greater stock of intangibles might be better prepared to orient the use of resources towards new demand patterns and, thus might be more likely to grow throughout recessionary pressure.

Therefore, Hypothesis 2 can be formulated as follows:

> **HP 2:** The amount of investment in intangible assets in the pre-crisis period positively influences firms' performance during a recessionary shock.

The literature does not provide any clear evidence about the role of spatial agglomeration on firm growth during the crisis. Martin, Sunley, and Gardiner (2016) suggest that firm agglomerates in clusters performed better during the crisis of 2008–2009. According to Cainelli, Ganau, and Modica (2019), instead during downturns firms belonging to a local cluster show a lower likelihood of failure but also lower performance compared to the other firms. This could be due to the lower market demand and subsequently increased market competition. Thus spatial agglomeration may have an ambiguous effect that depends on the kind of industry and its stage in the industry life cycle. In more general literature concerning firm growth several studies like Beaudry and Peter Swann (2009), highlight that firms that are located within agglomerations of their industry should have higher growth potentials. This could be due to the fact that firms located within a cluster have easier access to more qualified human capital, to non-traded inputs and specialised goods, to venture capitalist, to the final markets and to the regional network of firms and other institutions such as universities and public research laboratories (Audretsch and Dohse 2007). The presence of an agglomeration of firm within the same sector encourages the exchange of knowledge spillover and processes of inter-industry learning. Moreover, in the short-run, geographically clustered firms can reduce, transportation and logistics costs (Cainelli, Montresor, and Marzetti 2014; Van den Heuvel et al. 2014). Thus, other things being equal, we expect that firms that benefit from this type of spatial externalities are more likely to undertake processes of adaptation during financial shock. This leads us to propose the following hypothesis:

> HP 3: Firms that are located within clusters are more likely to grow during a disturbance.

There is a considerable debate in the literature on the effects of firm size on the likelihood to grow during business cycles. Ellinger et al. (2015) argue that innovation initiatives that take place at the highest level of conceptualisation within firms and 'best practices' for improving firm structure and culture are by no means a 'one size fits all' solution. However, some scholars (Moscarini and Postel-Vinay 2012) find that the downturn strengthens the performance of smaller firms since they are more flexible to respond to sudden shocks and have a higher growth potential than large firms. Conversely, Butler and Sullivan (2005), Classen et al. (2014), and Fort et al. (2013) claim that smaller and younger firms are more cyclically sensitive than large and mature firms. Smaller firms have limited resources and fewer clients and this may render them more vulnerable during the economic downturn. For example, in the Italian context, smaller firms that are supplying to a large conglomerate like Fiat have relative dependence on a single client. This could be due to the bigger company's push on the smaller ones to a largely technical orientation since they lie in the lower end of the supply structure (Whitford and Enrietti 2005).

Due to this peculiarity of the automotive sector, we conjecture that among the firms that make up the Italian Automotive Industry

supply chain the bigger and less specialised manufacturers have better chances of growing throughout the crisis.

```
HP 4: Larger and more diversified firms are more likely to grow during crises.
```

We reiterate that our analysis is focused on the Italian automotive industry. While it is not possible to generalise from this setting to other parts of the world as well as other industry settings, it is important to pay attention to our findings as they underscore the importance of innovation in times of crisis. Not only this, we believe that the findings pertaining to the financial crisis of 2008 are relevant as the COVID-19 pandemic has hit industries and economies in a similar way, albeit at a larger scale. Firms are likely to see entries, exits and bankruptcies that were a characteristic of the period post the 2008 financial crisis. In this light, our findings, although not generalisable, could provide a first step in the planning of a green and sustainable recovery through innovation.

## 4. Empirical strategy

### 4.1. Data

The data set combines information from PATSAT (2015) and Bureau Van Dijk (2015)[4] database called AIDA.

PATSAT (Patent Statistical Database) is a register of patent records from the European Patent Office (EPO). For the purpose of this study, it provides information about the patenting activities of the firms included in our sample. AIDA, is a service maintained by Bureau Van Dijk (2015) and contains detailed information about financial accounting data on Italian private and public firms. The edition at our disposal (2015) covers a time span of 9 years, from 2005 to 2014. We restrict our analysis to the period 2005–2012 to have a time interval with a good coverage of the variables of interest. In line with previous researches (among others Bianchini, Bottazzi, and Tamagni 2017), we excluded those businesses that entered the market after 2008 because our main concern is to compare the behaviour of the firms before and during the financial crisis.

All the firms are classified according to their sector of principal activity dis-aggregated up to 4-digits of NACE Rev. 2 classification. NACE, since 1970, is the acronym used by EUROSTAT to indicate the statistical classification of all the economic activities in the European Union. Our study focuses on the automotive industry therefore all the firms included in the database belong to the manufacturing of motor vehicles, trailers and semi-trailer sector according to the NACE Rev. 2 classification (code 29). Therefore, all the firms included in our database pertain to the Italian automotive sector.

Within the constraints imposed by the available data, our general empirical strategy is to divide the available time span into two periods. Firm characteristics are measured before the 2008 financial crisis (2005–2007) and also throughout the recessionary phase (2008–2012). We decided to consider 2008 as the beginning of the crisis by analysing the main trend (expressed in term of average sales) of the Italian automotive sector over the period 2005–2012 (see Figures 2 and 3).

**Figure 2.** Partitioning of the sample time period. Source: Authors' visualisation.

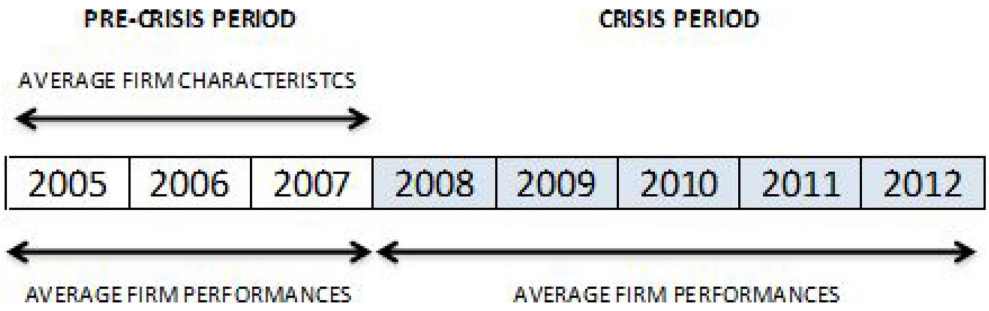
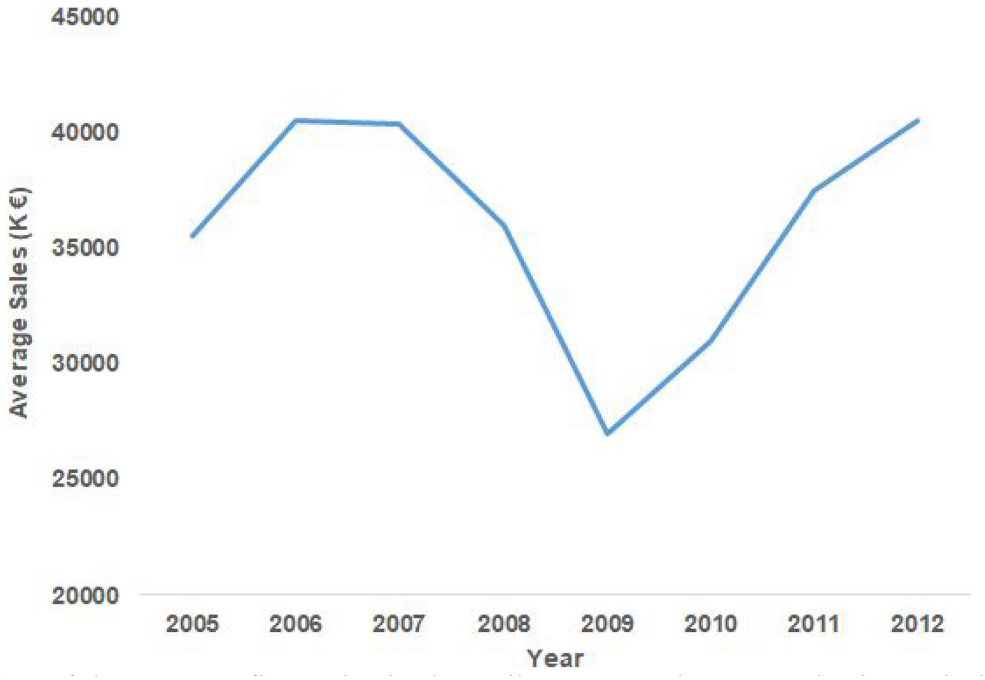



**Figure 3.** Evolution of the average firm sales in the Italian automotive sector in the period 2005-2012. Source: Authors' calculation. Note: We included years 2011 and 2012 as a part of the crisis period because in Italy the Great Recession started in 2008 and lasted until and including 2012.




## 4.2. Variables used in estimations

### 4.2.1. Dependent variable

As explained before, the econometric analysis aims to explore the factors affecting firm probability to grow throughout the financial crisis of 2008. Thus, our dependent variable aims to analyse the different performances, measured in terms of firm growth, displayed by the firms included in our sample, before and throughout the financial downturn started in 2008. A variety of proxies of firm growth have been employed in the literature. Employment and total sales, however, are among the most widely used (Delmar 1997). Due to the characteristics of our database, we decided to adopt, as a measure of firm growth, the annual sales growth rate calculated for each firm *i* at time *t* as follows:

$$Gsales_{it} = \frac{sales_{it} - sales_{i(t-1)}}{sales_{i(t-1)}}$$

We adjusted the value of sales by using the sectoral deflator index furnished by OECD statistics.[5]

To assess the factors able to increase firms' ability to mediate the effect of the recession, we then compute a categorical distributed dependent variable $Firmperformance_i$ by analysing and comparing the evolution of firm's sales ($Gsales_{(i,t)}$) during the period 2005–2007 and the crisis period 2008–2012. Following this line of inquiry, our dependent variable is a discrete indicator that assumes the following values:

$$y_i = \begin{cases} 0 & \text{if } \bar{g}_{i,2005-2007} \leq 0 \ \square \ \bar{g}_{i,2008-2012} \leq 0 \\ 1 & \text{if } \bar{g}_{i,2005-2007} > 0 \ \square \ \bar{g}_{i,2008-2012} \leq 0 \\ 2 & \text{if } \bar{g}_{i,2005-2007} \leq 0 \ \square \ \bar{g}_{i,2008-2012} > 0 \\ 3 & \text{if } \bar{g}_{i,2005-2007} > 0 \ \square \ \bar{g}_{i,2008-2012} > 0 \end{cases}$$

This variable divides the firms of our samples into four different categories according to their average performance in terms of sales growth rate, before and during the recessionary shock.

In particular, the first class ($Firmperformance_i = 0$) – the one of the Worst Performers (WP) – comprehends all the firms that exhibit on average, both in the pre-crisis and in the crisis period, a negative growth rate.

The second category ($Firmperformance_i$ = 1), defined as Deteriorated Performers (DP), includes the firms whose growth rate is on average positive (greater than zero) in the pre – crisis period, while is negative throughout the recession. Symmetrically, all the firms whose performances were negative in the pre-crisis period but improved to become positive during the financial downturn are considered by the third status: Ameliorated Performers (AP) ($Firmperformance_i$ = 2). Finally, the last category ($Firmperformance_i$ = 3) – Best Performer (BP) – contains all the firms that registered positive growth rates both before and during the recessionary shock.

#### 4.2.2. Independent variables

In the literature review, we highlight that the processes of learning influences firms' ability to cope with recessionary pressures and, that it mainly concerns the development of innovative products and processes role. Innovation is usually measured at the firm level through the expenditure in R&D or through the patenting activities. However, there exist certain limits of patent statistics. As Scherer (1983) argues, the propensity to patent an invention varies with market structure, sector and firm size and not all the inventions are patent-able. Nonetheless, according to Acs and Audretsch (1989), patents are a more than adequate measure of the output side of the innovative process. In our sample, few firms applied for patent to EPO before 2008 while many others did not. To control for such heterogeneity, we include a dummy variable (***Patent***) that captures whether a firm applied for a patent grant prior to 2008.[6] It takes the value of 1 if the firm has at least one patent application before the crisis, and 0 otherwise. In order to get information about the firms of our sample that applied for patents before the crisis, we use the data furnished by Lotti and Marin (2013). This dataset combines information about Italian firms and patent applications to the EPO.[7] As we conjecture in our first hypothesis, we expect that firms that innovated in pre-crisis period will be more likely to grow during unforeseen shocks.

To test our second hypothesis, we include in our econometric analyses a measure of the amount of investments in intangible assets made during pre-crisis period: the average value of ***Intangibles*** reported by the firms' balance sheet for the years 2005–2007, normalised by each firm's total asset size.

Previous literature has found that several smaller firms tend to find the process of patenting too expensive or too slow and therefore they implement alternative measures such as secrecy or copyright to protect their innovations (Archibugi 1992; Arundel and Kabla 1998). Therefore, we include both – the number of patents and the amount of investments in intangible – as a measure of firm learning abilities.

To control for the presence of localised agglomeration economies, we include the number of firms located in the same province (***Agglomeration economies***). The positive role of geographical proximity on firm performance during crisis is well document by the recent literature (González-Bravo, López, and Valdaliso 2018). Following this line of inquiry, we conjecture that firms belonging to cluster associations can 'shelter' from negative business cycle and are more likely to grow during the shock. On the other hand, researchers have also found that clustering or agglomeration effects on firm resilience or growth are not stronger during crises (Behrens, Boualam, and Marti, 2020, Martin, Mayer, and Mayneris, 2013).

In order to uncover the peculiarities of the firms that achieve a certain level of performance subsequent to the recessionary shock, we include dummies for the NACE (2008) code classification. This can help us identify the placement of the firms in our sample in the automotive sector supply chain. According to EUROSTAT, the NACE code ***29.10*** corresponds to OEM (Manufacture of motor vehicles) while ***29.20*** corresponds to the firms that produce bodies (coachwork) for motor vehicles, manufacture of trailers and semi-trailers. Furthermore, the businesses that manufacture parts and accessories for motor vehicles are classified with code ***29.30.*** We expect that the businesses classified under 29.10 and 29.30 could display better performances during the crisis. For the latter, this could be because they provide the more complex, innovative and specialised components and processes in the automotive supply chain.

In addition, we consider in our estimations a battery of other variables that are usually employed in the firm growth literature: firm age (***Age***), the amount of debts (***Debts***) the company bears and, the size of the firm (***Size***) – measured in terms of log of personnel cost. In order to take into account firm efficiency, we add the variable return on assets (***ROA***) that measures how efficiently a company can manage its assets to produce profits during a period. Finally, to account for any regional level unobserved characteristics, we include dummies for ***regions*** in all the regressions.

In this study, following Durnev and Han Kim (2005), we measure all our firm level independent variables before the financial crisis to avoid possible confounding effects associated with the crisis. Thus, due to our database's intrinsic characteristics, we compute the entire explanatory variable as an average between the values registered before the recessionary period in the time span 2005–2007. On this basis, we use these variables to predict the firm probability to grow throughout the economic downturn.

### 4.3. Descriptive statistics

Table 1 provides the descriptive statistics for the explanatory variables measured in the pre-crisis period, while Table 2 presents

the correlations between these variables. The descriptive statistics reported by Table 1 confirm, as stipulated previously, that both the variables Intangibles and *Patent* present a highly skewed distribution. Furthermore, Table 2 highlights that our sample shows a high degree of heterogeneity in terms of firm size, age, debt and ROA.

**Table 1.** Descriptive statistics of the explanatory variables.

| | Observations | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| Patent | 1389 | 0.12 | 0.33 | 0 | 1 |
| Intangibles (log) | 1076 | 0.20 | 0.29 | −0.044 | 2.10 |
| Agg. economies | 1389 | 60.80 | 70.48 | 1 | 219 |
| Size | 1390 | 6.10 | 2.01 | 0 | 13.84 |
| Age | 1476 | 20.35 | 14.87 | 2 | 111 |
| Debts | 1094 | 351.10 | 7797.64 | 0.001 | 254,878.1 |
| ROA | 1398 | 3.87 | 14.45 | −248.51 | 51.27 |

**Table 2.** Correlation matrix.

| | Firm perf. | Patent | Intangibles | Agg. econ. | Size | Age | Debts | ROA |
|---|---|---|---|---|---|---|---|---|
| Firm perf. | 1.0 | | | | | | | |
| Patent | 0.1432* | 1.0 | | | | | | |
| Intangibles | 0.0412* | −0.0081 | 1.0 | | | | | |
| Agg. econ. | 0.0710* | 0.0971* | 0.0223 | 1.0 | | | | |
| Size | 0.0615* | 0.4005* | −0.0548* | 0.1386* | 1.0 | | | |
| Age | −0.0264* | 0.0203* | −0.1101* | −0.0662* | 0.0316* | 1.0 | | |
| Debts | −0.0609* | −0.0121 | 0.1854* | −0.0073 | −0.0103 | 0.0437* | 1.0 | |
| ROA | 0.1587* | 0.0401* | −0.0353 | 0.0210 | 0.0632* | 0.0275 | 0.0008 | 1.0 |

*5% significance level.

Before moving to the econometric estimation, it is interesting to analyses the distribution of the explanatory variables across the four distinct values assumed by our dependent variable. The descriptive statistics reported in Table 3 reveal that firms' ability to grow ($Firmperformance_i$) during a recessionary shock is very uneven across the firms included in our sample.[8] At first glance, this table also reveals that the category of firms ($Firmperformance_i = 3$) – containing all the firms that registered a positive growth rate both before and during the crisis – is the one that present the highest amount of intangibles assets and patent applications. Nonetheless, these descriptive statistics do not provide any clear indication of the relationship between our categorical dependent variable and the set of the hypothesised determinants.

**Table 3.** Descriptive statistics across status.

| Performer → | Worst | | Deteriorated | | Ameliorated | | Best | |
|---|---|---|---|---|---|---|---|---|
| Nr. of firms → | 168 | | 440 | | 280 | | 501 | |
| % of the sample → | 12.1% [1] | | 31.68% | | 20.16% | | 36.07% | |
| Variable ↓ | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Patent | 0.071 | 0.25 | 0.095 | 0.29 | 0.103 | 0.305 | 0.20 | 0.40 |
| Intangibles | 0.18 | 0.28 | 0.20 | 0.28 | 0.20 | 0.31 | 0.22 | 0.30 |
| Agg. economies | 63.07 | 75.16 | 49.50 | 62.40 | 69.54 | 73.16 | 66.78 | 73.34 |
| Size | 5.75 | 1.98 | 6.18 | 1.87 | 5.98 | 2.21 | 6.28 | 2.07 |
| Age | 21.38 | 14.5 | 20.43 | 15.74 | 20.36 | 13.54 | 19.96 | 14.46 |
| Debts | 2326.86 | 22600.91 | 132.8 | 1142.25 | 52.62 | 190.69 | 75.95 | 446.15 |
| ROA | 0.018 | 12.16 | 4.89 | 9.63 | 3.85 | 13.86 | 6.83 | 9.23 |

We have 1477 firms in our sample period. However, *Firm Performance* data can be calculated for 1389 firms only (based on the methodology presented in Section 4.2).

Therefore, we are going to test what are the firms' characteristics that shape the probability of a firm to grow during a recessionary shock in the econometric exercise that follows.

### 4.4. Estimation technique

In order to investigate the set of characteristics that influence the probability for a firm to grow throughout the crisis of 2008, we estimate a multinomial logit model. In particular, our econometric estimation aims at analysing how, ceteris paribus, changes in a firm to belong to $k = 0, 1, 2, 3$ (Wooldridge 2010). $k$ is the set of values that our categorical dependent variable *Firmperformance* assumes following the criteria mentioned in Section 4.2. In this specification, the probability of choosing each alternative sum up to one, i.e. $\sum_{k=0}^{3} p_{i,k} = 1$.

$$\Pr\left(Firmperformance_i = k\right) = \frac{\exp^{(XF_i'+\beta_F^k+XC_i'\beta_c^k)}}{1+\sum_{j=0}^{3}\exp^{(XF_i'+\beta_F^k+XC_i'\beta_c^k)}}$$

$$\Pr\left(Firmperformance_i = k\right) = \frac{\exp\left(XF_i'\beta_F^k + XC_i'\beta_c^k\right)}{1+\sum_{j=0}^{3}\exp\left(XF_i'\beta_F^j + XC_i'\beta_c^k\right)}$$

for $k = 0,\ 1,\ 2,\ 3$

In addition, $XF_i$ is a vector of explanatory variables that includes both our key hypothesised determinants and all the independent variables that are usually associated with firm growth during recessions. $XC_i$, is the vector of control variables. Finally, the vectors of parameters to be estimated through the econometric analysis are: $\beta_F$ and $\beta_C$.

This estimation method is a natural choice since, by construction, our discrete dependent variable $Firmperformance_i$ is un-ordered and the independence from irrelevant alternatives assumption holds.[9]

It is important to mention that in the firm growth literature, most studies (among others: Coad and Hölzl 2009) use quantile regression techniques. These methods, however, have some drawbacks. Bianchini, Bottazzi, and Tamagni (2017) argue that these strategies may constrain the analysis into specific notion of firm growth, based on the auto-correlation structure of the growth rates, which is inadequate to capture firm behaviour in some specific context. Starting from these considerations, maximum likelihood estimations have been increasingly used by recent researches (among others: Bianchini, Bottazzi, and Tamagni 2017; Landini, Arrighetti, and Lasagni 2020) to track and analyse the behaviour of the firms throughout the financial downturn started in 2008 and to compare the pre-and post-crisis firms' performances.

We acknowledge that the estimation techniques used in this paper establish the correlation between variables. We do not claim to establish a causal relationship. We reiterate that the dependent, as well as independent variables, are averaged for the period pre-crisis and during crisis. Therefore, any potential concerns about endogeneity are addressed.

## 5. Analysis and findings

In Table 4, we report the results of the multinomial logistic regression. As far as the variable ***Patent*** is concerned, the empirical evidence shows that it positively influences the probability for a firm to belong to the category BP and therefore to grow during a

recessionary shock. The relative log odds of being in VP category vs. WP category will increase by 1.552 if *Patent* is equal to 1. In other words, 1.552 represents the relative likelihood ratio for a one-unit increase in Patent score for BP relative to WP given that the other variables in the model are held constant. If a firm were to make a patent, the relative likelihood for BP relative to WP would be expected to increase by a factor of $e^{1.552} = 4.7$, given the other variables in the model are held constant. This evidence corroborates our first hypothesis that innovation plays a key role in shaping firm performances during unexpected shocks.

**Table 4.** Results of the multinomial logit estimation.

| Variables ↓ | Excluded category – Worst Performers | | |
|---|---|---|---|
| Categories (Performers) →~~Variables ↓~~ | Deteriorated (1) | Ameliorated (2) | Best (3) |
| Patent | 0.914 (0.603) | 0.865 (0.624) | 1.552*** (0.584) |
| Intangibles | 1.175* (0.627) | 0.0953 (0.716) | 1.052* (0.629) |
| Agg. economies | −0.00302 (0.00357) | 0.00261 (0.00368) | −0.00431 (0.00347) |
| Size | 0.101 (0.0803) | −0.0202 (0.0878) | 0.0231 (0.0794) |
| Size × Intangibles | 5.68e-06 (1.34e-05) | 8.82e-06 (6.46e-06) | 1.27e-05** (5.69e-06) |
| Age | 0.00341 (0.0105) | 0.000160 (0.0101) | −0.00491 (0.00957) |
| Age × Intangibles | −7.84e−06 (5.53e-06) | −8.51e−06*** (2.54e-06) | −7.21e−06**~~statistics of the explanatory~~ (2.50e-06) |
| Debts | −0.000427 (0.000603) | −0.000121 (0.000540) | −0.000224 (0.000478) |
| ROA | 0.0468** (0.0197) | 0.0192 (0.0222) | 0.0507*** (0.0196) |
| ROA x Intangibles | 0.106* (0.0626) | 0.239*** (0.0740) | 0.141** (0.0642) |
| Vehicle Manufacturers *(NACE code 29.10)* | 0.709 (0.651) | 1.572** (0.674) | 1.105* (0.639) |
| Parts and Accessories manufacturers *(NACE Code 29.30)* | −0.585 (0.365) | 0.528 (0.388) | 0.438 (0.357) |
| Constant | 0.233 (0.941) | 0.228 (0.980) | 0.0649 (0.919) |
| Regional dummies | YES | YES | YES |
| Observations | 708 | 708 | 708 |
| Pseudo $R^2$ | 0.10 | 0.10 | 0.10 |

Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Our evidence highlights that the variable ***Intangibles*** plays a significant role in influencing firms' probability to be in the groups of businesses that exhibit good performance during the financial crisis of 2008. The relative log odds of being in DP category vs. WP category will increase by 1.175 and the relative log odds of being in BP category vs. WP category will increase by 1.052 if Intangibles increase by 1%. While the latter result is in line with our expectation, the former result (DP vs. WP category) is contrary to extant literature as well as our hypothesis. In order to shed the light on this confounding results, we interact ROA with Intangibles. Our results in Table 4 show that the amount of investments in intangibles assets, when interacted with the variable ROA, positively affect the probability to belong to the category of AP (*Firmperformance* = 2) and BP (*Firmperformance* = 3), relative to WP category.

Thus, when ***Intangibles*** interacted with an indicator of firm efficiency (in this case ***ROA***), it positively influences the probability for a business to grow, no matter the performance in terms of sales registered before the crisis. This last empirical evidence suggests that when faced with an economic recession, intangible assets increase the probability of a firm to grow, especially when they are combined with an efficient allocation of the resources inside the company. In this context, even the firms that saw a decrease in sales, but were not myopic, and invested in intangibles before the financial downturn, are more likely to grow during the crisis. Following this line of inquiry, we argue that intangibles play a key role in influencing firm growth by shaping the path through which new capabilities are generated. They can, indeed, ameliorate firm's ability to orient the use of resources towards new demand pattern even during recessionary shocks. Therefore, our results exhibit that the second hypothesis is validated by the estimates presented in the case of variables viz. Intangibles and interaction of Intangibles and ROA.

In the empirical testing, we include the variable ***Agglomeration economies*** which was the number of firms (belonging to the automotive sector) located in the same province, to evaluate if the clustering of firms in a specific industry has an impact on the firm probability to grow throughout exogenous shocks. In contrast to previous literature and contrary to our third hypothesis, our results suggest that agglomeration economies do not have any effect on the firm probability to grow through the recessionary phase. Our results seem to fall in line with the findings of Behrens, Boualam, and Martin (2020) (for Canadian textile firms) and Martin, Mayer, and Mayneris (2013) (for French exporters) who find that clustering or agglomeration effects on firm resilience or growth are not stronger during crises like the 2008–2009 crisis or the surge in Chinese exports. Our results also corroborate the findings of the researchers who find no difference between firms that are inside or outside a cluster.

Further, our results suggest that the variables usually associated with firm growth such as size, age and debts do not have any effect on the firm probability to grow during the financial crisis. However, the variable ***Age***, when interacted with the variable ***Intangibles***, shows a negative and significant coefficient for both the category AP and BP. Thus, following Coad, Segarra, and Teruel (2016), we can hypothesise that younger businesses are more likely to undertake riskier and more radical innovative processes, that in some cases, yield higher returns. This is in line with the Schumpeterian theory, according to which the level of novelty and imitation of innovations tends to change over the firm life cycle.

As far as the variable *Size* is concerned our evidence shows that it influences firm probability to be in BP category only when it interacted with the variable that measures the amount of investments in intangible in the pre-crisis period. Thus we can conjecture that bigger firms have more resources to invest in intangible assets and therefore are more likely to grow both before and during recessionary shock.

The relevance of the firm's degree of efficiency in affecting the firm's probability to grow is confirmed by the fact that the variable ***ROA*** exhibits a positive and significant coefficient in DP and BP categories. However, as mentioned earlier, our results on ROA should be read in conjunction with Intangibles to gain a better understanding the role of efficiency in shaping firm growth during the recessionary shocks.

As mentioned before, to uncover the peculiarities of firms based on their position in the automotive supply chain, we also include dummies pertaining to NACE categories 29.10 (Manufacture of motor vehicles), 29.20 (Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers) and 29.30 (Manufacture of other parts and accessories for motor vehicles). We find that when compared to bodies/coachwork manufacturers (NACE code 29.20), the vehicle manufacturers (NACE code 29.10) have a higher likelihood to be in the AP and BP category vs. the WP category. Thus, we observe that the firms that are placed on a wider range of processes (complete vehicle manufacturing as opposed to only chassis manufacturing) are better prepared to face an unexpected economic downturn and therefore are more likely to grow throughout recessionary phases. In case of firms that fall in the category NACE 29.30 (parts and accessories manufacturers), we do not find any effect on firm performance. The aforesaid results in addition to our results on ***Size*** corroborate our fourth hypothesis in which we argue that larger and more diversified firms are better able to withstand unexpected economic downturns. It is also possible that the smaller firms, like the parts and accessories manufacturers (NACE 29.30) could have a higher reliance on a single client and therefore do not directly exhibit any better performance.

In conclusion, it is worth highlighting the main differences between the firms pertaining to the category DP and BPs. These firms, indeed, had both good performances in term of sales before the Great Recession. From Table 4, we can observe that *Patent* and *ROA* × *Intagibles* variables are not significant in explaining DP firm growth during the crisis. The same variables are instead positive and very significant in explaining BPs' growth path during the negative downturn. These findings corroborate the idea that innovation has a crucial role in firm performances during negative business cycles.

### 5.1. Robustness checks

The estimates presented in Table 4 highlight that the firms that innovate and invest comparatively more in intangibles in the pre-crisis period have more probability to grow throughout exogenous shock. In order to test the robustness of these results, we estimate the probability for a firm to grow through an economic downturn by using an alternative measure of firm size: the yearly

variation in the number of employees. This is calculated as:

$$Gemployees_{i,t} = employees_{i,t} - employees_{i,(t-1)}$$

$$Gemployees_{it} = employees_{it} - employees_{i(t-1)}$$

where $employees_{i,t}$ is the logarithm of firm size at time $t$ and $employees_{i,(t-1)}$ is its lagged value. In the Bureau Van Dijk (2015) database, however, this variable is characterised by many missing observations leading to a reduction in our sample size. To avoid problem of small sample bias, we estimate a simple binary choice model through which we aim to predict the probability for a firm to grow during the recessionary shock started in 2008. In this context, our dependent variable ($Gemployees_{i,t}$) takes the values of one for the group of companies that increased the number of workers during the financial crisis of 2008; and zero otherwise. The evidence presented in Table 5 corroborates the hypothesis concerning the anti-cyclical effect of innovation (Hypothesis 1). The coefficient of the variable ***Patent*** is positive and significant. Thus, our results suggest that the firms that innovated, and consequently, patented in the pre-crisis period are more likely to grow during the recessionary phase.

**Table 5.** Results of the logit estimation.

| Variables | *Gemployees* |
|---|---|
| Intangibles | 0.166 (0.362) |
| Patent | 0.621** (0.238) |
| Size | −0.111* (0.0501) |
| Age | −0.00857 (0.00554) |
| Debts | −0.000134 (0.000262) |
| ROA | 0.0289* (0.0114) |
| ROA × Intangibles | 0.0447** (0.0303) |
| Age × Intangibles | 0.00000209 (0.00000196) |
| Size × Intangibles | −0.00000309 (0.00000315) |
| Agglomeration economies | −0.365 (0.582) |
| 29.1.0.nace *(vehicles)* | −0.0407 (0.272) |
| 29.2.0.nace *(vehicles and trailers)* | −154 (1.136) |
| 29.3.1.nace *(electrical components)* | 1.036* (0.539) |
| CONSTANT | −0.314 (0.578) |
| Regional dummies | YES |
| Observations | 900 |
| Pseudo R2 | 0.251 |

Robust standard errors in parentheses.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

As far as the variable ***Intangibles*** assets are concerned, our empirical findings show that they positively influence the probability to grow during the crisis only when interacted with the variable concerning the degree of firm efficiency ***ROA***. This evidence confirms the importance of intangible assets in shaping firms' adaptability to recessionary pressures. With respect to the firms' placement in the automotive supply chain, we do not find any effect on firm performance. This might be due to the reduction in the number of observations due to the missing values of the number of employees.

The results (Table 5) of this additional empirical testing are overall in line with those of our main estimations (Table 4),

suggesting that our findings are robust to different estimation techniques.

## 6. Conclusion

The COVID – 19 pandemic and ensuing economic crisis are likely to impact businesses through entries, exits, and bankruptcies (International Monetary Fund, IMF). If we turn to history, the most recent economic shock that affected small and large businesses alike, in almost all sectors of the economy, was the financial crisis of 2008–2009. While one can argue that the 2008 financial crisis and the current COVID-19 related economic downturn are not exactly same in nature and effect, there are certain similarities between the two crises that cannot be overlooked. First of all, the financial and medical systems share many elements such as opacity and interconnectedness (Spatt 2020). Secondly, the two crises are similar in terms of uncertainty, collapsing financial markets as well as industry and stock-market reactions. Therefore, we argue that there could be learnings from the economic downturn that the 2008 financial crisis triggered which could be important to plan a post-pandemic revitalisation.

In this paper, we have explored the factors affecting firms' probability to grow throughout an economic downturn. This paper offers an original contribution by focusing on the role played by innovation and intangible assets in shaping the degree of firms' ability to face external shocks. We focus on the Italian automotive industry because it is among the sectors that had been hit the most by the 2008–2009 crisis and therefore it constitutes a particularly interesting case to reflect upon the determinants of varying firms' capabilities to face severe recessionary downturns.

The descriptive statistics revealed that the capacity to react to the crisis and to grow was uneven across the companies of the Italian automotive sector. We conjectured that fundamental reasons had to be found in the amount of investments in intangible assets and in the patenting activities realised in the pre-crisis period. We set out a multinomial logistic estimation to explore the companies' characteristics that affected firm probability to grow during the crisis.

The results suggest that innovators are more likely to exhibit good performances even during a recessionary shock. This is arguably due, according to Geroski and Walters (1995), Geroski and Gregg (1995), and Geroski et al. (1995), to the fact that the process of doing innovation, by involving firm's ability to translate endogenously generated knowledge into new goods and services, permanently transforms a firm, building up its internal capabilities and improving its degree of adaptability. Coping with recessions always requires increasing firms' ability to be flexible to adapt their activities to the changing market conditions and to find new opportunities not exploited yet.

Our evidence further confirmed the counter-cyclical effect of innovation by indicating that intangible assets play a fundamental role in shaping firm probability to grow during a crisis. We also highlight that intangibles assets, when interacted with an indicator of firm efficiency, played a fundamental role in shaping firms probability to grow during the crisis even for the group of companies that were witnessing a decrease in sales before the recession.

The collapse in demand registered in the automotive sector during the financial crisis of 2008 was translated into an increasing competition among the firms operating in this market. Thus, relatively inefficient firms were less likely to grow while more efficient ones took advantage of the changed market condition. Companies that were not myopic and invested in learning abilities before the crisis, indeed, were more prepared to face increased competition in the new market scenario.

We also find that, contrary to the previous literature, agglomeration economies do not have any impact on the firm probability to grow throughout destabilising shock. This could be due to the fact that various empirical investigations have shown that industrial clusters have ambiguous effect on firm growth (Klepper 2002). According to Audretsch and Dohse (2007), firms benefit from being located in industrial clusters only under specific circumstances. In particular, they suggest an industry-specific perspective. Knowledge spillovers from co-localised firms matter more for companies operating in the emerging sector as well as for those pertaining to knowledge intensive industries. At a more mature stage, spatial agglomeration might even hinder the process of firm growth by triggering an intensified competition among co-localised firm. This might be especially true at times of reduced demand and greater uncertainty.

Concerning the automotive supply – chain our evidence uncovers that larger firms that have wider access to market (vehicle manufacturers) are more likely to maintain satisfactory performance during the shock. This might be because firms diversified in more types of corporate activities i.e. products, markets and technologies, may be less likely to experience a decline in sales due to idiosyncratic shock.

The study has, of course, limitations. First of all, the results are limited to only one mature industry pertaining to a single country: Italy. Further research might shed light on comparative effect of innovation strategies on firm growth throughout recessions by using micro-data from different sectors. Moreover, further researches could build up on our framework and findings to understand the determinants of innovation behaviour in European firms both during recessions and recovery phases.

Our results, obtained using data pertaining to the 2008–2009 crisis, can have broader implications for the study of firm resilience and can prove vital in coping with the aftermath of the COVID-19 pandemic. With reference to the financial crisis triggered in

2008, the data show that the current COVID-19 related economic crisis, widened the differences in performances across firms. In this context, finding solutions to avoid business to exit the market during downturns, has become a key European policy challenge. Businesses that close have a negative impact on the overall employment figures. This is especially true for automotive industry that employs a considerable amount of workers in the manufacturing sector.

Our evidence indicates that firm resilience can be boosted by continuously investing in innovation. The results that we have obtained using data pertaining to the crisis that unfolded in 2008–2009 could serve as a first step to plan a green recovery more conducive for a circular economy. This could be channelled through several innovation techniques lying in use of alternate raw material, cleaner methods in manufacturing and investment in intangible assets (Jabbour et al. 2019). Our results highlight that innovative firms fare better in times of crisis and, therefore, underline the need for policies and initiatives that promote investments in innovation for a green revitalisation post-pandemic.

## Notes

1 The European Statistical Office (EUROSTAT) registered that between April 2008 and April 2009 industrial production in the EU-28 dropped by more than 22 percentage points and EU unemployment rate soared by more than 2 percentage points.

2 The Statistical Classification of Economic Activities in the European Community, commonly referred to as NACE (for the French term "nomenclature statistique des activités économiques dans la Communauté européenne" (NACE, 2008)), is the industry standard classification system used in the European Union.

3 The city of Turin in Italy is built around, and in part, *by* Fiat and the auto industry. Therefore, in 2002, when the company faltered under an enormous debt load and rapidly falling market share, mass layoffs and the closure of 18 plants worldwide were announced (Whitford and Enrietti, 2005).

4 Bureau van Dijk (BVD) is a major publisher of business information, and specializes in private company data combined with software for searching and analysing firms. It is a Moody's Analytics company.

5 The OECD furnishes data on the price index implicit deflator byNACErev.2 code 29.

6 We use a dummy variable for the variable Patent because only few firms of our sample applied for patent before the 2008 financial crisis. The distribution of the number of patent produced from the automotive companies of our sample is skewed to the right. Few companies produce a lot of patents while many others produce one or zero patents. Following Afifi et al.(2007), we also code our *Patent* variable as a binary variable. According to the authors this can be a good method for improving regression analysis for skewed continuous or counted responses.

7 In particular, this dataset Lotti and Marin(2013) matched Italian firms from AIDA database (Bureau van Dijk) to applicants at the European Patent Office (EPO) in PATSTAT for the period 1978–2008.

8 The firms that entered the business after 2008 are not considered in our sample. Moreover, the firms that exit the market after the 2008 crisis, are included in the category Worst Performers or Deteriorated Performers depending on their sales performance before the crisis.

9 see robustness checks.

## Disclosure statement

No potential conflict of interest was reported by the author(s **[Q3]**).

## ORCID

*Silvia Rocchetta* http://orcid.org/0000-0002-8371-4425

## References

**Acs, Zoltan J., and David B. Audretsch**. 1989. "Patents Innovative Activity." *Eastern Economic Journal* 15 (4): 373–376.

**Afifi, Abdelmonem A., Jenny B. Kotlerman, Susan L. Ettner, and Marie Cowan**. 2007. "Methods for Improving Regression Analysis for Skewed Continuous or Counted Responses." *Annual Review of Public Health*, 28: 95–111.

**Aghion, Philippe, Ufuk Akcigit, and Peter Howitt**. 2014. "What do we Learn from Schumpeterian Growth Theory?" *Handbook of Economic Growth*. Vol. 2, 515–563. Elsevier.

**Aguilera-Caracuel, Javier, and Natalia Ortiz-de Mandojana**. 2013. "Green Innovation and Financial Performance: An Institutional Approach." *Organization & Environment*, 26(4): 365–385.

**ANFIA (Department of Studies and Statistics)**. 2020. "Report on the Italian Auto-Motive Industry."

**Archibugi, Daniele.** 1992. "Patenting as an Indicator of Technological Innovation: A Review." *Science and Public Policy*, 19(6):

357–368.

**Arundel, Anthony, and Isabelle Kabla**. 1998. "What Percentage of Innovations are Patented? Empirical Estimates for European Firms." *Research Policy*, 27(2): 127–141.

**Audretsch, David B., and Dirk Dohse**. 2007. "Location: A Neglected Determinant of Firm Growth." *Review of World Economics*, 143(1): 79–107.

**Baldwin, Richard, and B. Weder Di Mauro**. 2020. "Economics in the Time of COVID-19: A New EBook." *VOX CEPR Policy Portal*, 2–3.**[Q4]**

**Barbier, Edward B.** 2020. "Greening the Post-Pandemic Recovery in the G20." *Environmental and Resource Economics*, 76(4): 685–703.

**Barney, Jay B.** 2001. "Is the Resource-Based "View" a Useful Perspective for Strategic Management Research? Yes." *Academy of Management Review*, 26(1): 41–56.

**Beaudry, Catherine, and G. M. Peter Swann**. 2009. "Firm Growth in Industrial Clusters of the United Kingdom." *Small Business Economics*, 32(4): 409–424.

**Behrens, Kristian, Brahim Boualam, and Julien Martin**. 2020. "Are Clusters Resilient? Evidence from Canadian Textile Industries." *Journal of Economic Geography*, 20(1): 1–36.

**Bianchini, Stefano, Giulio Bottazzi, and Federico Tamagni**. 2017. "What Does (not) Characterize Persistent Corporate High-Growth?" *Small Business Economics*, 48(3): 633–656.

**Bontempi, Maria Elena, and Jacques Mairesse**. 2008. "Intangible Capital and Productivity: An Exploration on a Panel of Italian Manufacturing Firms." *National Bureau of Economic Research*.**[Q5]**

**Breschi, Stefano, and Franco Malerba**. 1997. "Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries." *Systems of Innovation: Technologies, Institutions and Organizations*, 1: 130–156.

**Bureau Van Dijk**. 2015. "AIDA."

**Butler, John E., and Jeremiah J. Sullivan**. 2005. "Crisis Response Tactics: Us Smes' Responses to the Asian Financial Crisis." *Journal of Business and Entrepreneurship*, 17(2): 56.**[Q6]**

**Cainelli, Giulio, Roberto Ganau, and Marco Modica**. 2019. "Industrial Relatedness and Regional Resilience in the European Union." *Papers in Regional Science*, 98(2): 755–778.

**Cainelli, Giulio, Sandro Montresor, and Giuseppe Vittucci Marzetti**. 2014. "Spatial Agglomeration and Firm Exit: A Spatial Dynamic Analysis for Italian Provinces." *Small Business Economics*, 43(1): 213–228.

**Cattaneo, Olivier, Gary Gereffi, and Cornelia Staritz**. 2010. *Global Value Chains in a Postcrisis World: A Development Perspective*. World Bank Publications.**[Q7]**

**Choi, Seok-Beom, Hokey Min, Hye-Young Joo, and Han-Byul Choi**. 2017. "Assessing the Impact of Green Supply Chain Practices on Firm Performance in the Korean Manufacturing Industry." *International Journal of Logistics Research and Applications*, 20(2): 129–145.

**Cimoli, Mario, and Giovanni Dosi**. 1995. "Technological Paradigms, Patterns of Learning and Development: An Introductory Roadmap." *Journal of Evolutionary Economics*, 5(3): 243– 268.

**Classen, Nicolas, Martin Carree, Anita Van Gils, and Bettina Peters**. 2014. "Innovation in Family and Non-Family SMEs: An Exploratory Analysis." *Small Business Economics*, 42(3): 595–609.

**Coad, Alex.** 2009. *The Growth of Firms: A Survey of Theories and Empirical Evidence*. Edward Elgar Publishing.**[Q8]**

**Coad, Alex, and Werner Hölzl**. 2009. "On the Autocorrelation of Growth Rates." *Journal of Industry, Competition and Trade*, 9(2): 139–166.

**Coad, Alex, Agustí Segarra, and Mercedes Teruel**. 2016. "Innovation and Firm Growth: Does Firm Age Play a Role?" *Research Policy*, 45(2): 387–400.

**Corrado, Carol, Charles Hulten, and Daniel Sichel**. 2009. "Intangible Capital and US Economic Growth." *Review of Income and Wealth*, 55(3): 661–685.

**Delmar, F.** 1997. "Measuring Growth." *Entrepreneurship and SME Research: On its Way to the Next Millennium*, 199–216.**[Q9]**

**Dettori, Barbara, Emanuela Marrocu, and Raffaele Paci**. 2012. "Total Factor Productivity, Intangible Assets and Spatial Dependence in the European Regions." *Regional Studies*, 46(10): 1401–1416.

**Dosi, Giovanni, Richard R. Nelson, Sidney G. Winter, et al.** 2000. *The Nature and Dynamics of Organizational Capabilities*. Oxford

University Press.**[Q10]**

**Durnev, Art, and E. Han Kim**. 2005. "To Steal or not to Steal: Firm Attributes, Legal Environment, and Valuation." *The Journal of Finance*, 60(3): 1461–1493.

**Ellinger, Alexander E., Haozhe Chen, Yu Tian, and Craig Armstrong**. 2015. "Learning Orientation, Integration, and Supply Chain Risk Management in Chinese Manufacturing Firms." *International Journal of Logistics Research and Applications*, 18(6): 476–493.

**Fareed, Fozan, and Bastiaan Overvest**. 2021. "Business Dynamics During The COVID Pandemic."

**Faria, Lourenço Galvão Diniz, and Maj Munch Andersen**. 2017. "Sectoral Patterns Versus Firm-Level Heterogeneity-The Dynamics of eco-Innovation Strategies in the Automotive Sector." *Technological Forecasting and Social Change*, 117: 266–281.

**Filippetti, Andrea, and Daniele Archibugi**. 2011. "Innovation in Times of Crisis: National Systems of Innovation, Structure, and Demand." *Research Policy*, 40(2): 179–192.

**Financial Accounting Standards Board (FASB)**. 2019. "For the Investor: By Gary Buesser."

**Foroni, Claudia, Massimiliano Marcellino, and Dalibor Stevanovic**. 2020. "Forecasting the Covid-19 Recession and Recovery: Lessons from the Financial Crisis." *International Journal of Forecasting*.**[Q11]**

**Fort, Teresa C., John Haltiwanger, Ron S. Jarmin, and Javier Miranda**. 2013. "How Firms Respond to Business Cycles: The Role of Firm age and Firm Size." *IMF Economic Review*, 61(3): 520–559.

**Geroski, Paul, et al.** 1995. "*Innovation and Competitive Advantage*." OECD Publishing.**[Q12]**

**Geroski, Paul, and Paul Gregg**. 1995. "Recessionary Benefits: The Firms that Go Under are Often the Weaker Ones." *New Economy*, 2(3): 197–201.

**Geroski, Paul A., and Paul Gregg**. 1996. "What Makes Firms Vulnerable to Recessionary Pressures?" *European Economic Review*, 40(3-5): 551–557.

**Geroski, Paul A., and Chris F. Walters**. 1995. "Innovative Activity Over the Business Cycle." *The Economic Journal*, 105(431): 916–928.

**González-Bravo, Isabel, Santiago M. López, and Jesús M. Valdaliso**. 2018. "Coping with Economic Crisis: Cluster Associations and Firm Performance in the Basque Country." *Agglomeration and Firm Performance*. 245–262. Springer.

**Gupta, Himanshu, and Mukesh Kumar Barua**. 2018. "A Novel Hybrid Multi-Criteria Method for Supplier Selection among SMEs on the Basis of Innovation Ability." *International Journal of Logistics Research and Applications*, 21(3): 201–223.

**International Monetary Fund (IMF)**. 2020. "World Economic Outlook, April 2020: The Great Lockdown."

**Jabbour, Charbel Jose Chiappetta, Joseph Sarkis, Ana Beatriz Lopes de Sousa Jabbour, Douglas William Scott Renwick, Sanjay Kumar Singh, Oksana Grebinevych, Isak Kruglianskas, and Moacir Godinho Filho**. 2019. "Who is in Charge? A Review and a Research Agenda on the 'Human Side' of the Circular Economy." *Journal of Cleaner Production*, 222: 793–801.

**Katz, Harry C., John Paul MacDuffie, and Frits K. Pil**. 2013. "Crisis and Recovery in the US Auto Industry: Tumultuous Times for a Collective Bargaining Pacesetter." **Howard Stanger; Paul Clark, & Ann Frost** (eds.), *Collective Bargaining Under Duress: Case Studies of Major North American Industries*, Champaign, IL: Labor and Employment Research Association, 45–80.

**Klepper, Steven.** 2002. "The Evolution of the US Automobile Industry and Detroit as its Capital." 22–23, Citeseer.**[Q13]**

**Landini, Fabio, Alessandro Arrighetti, and Andrea Lasagni**. 2020. "Economic Crisis and Firm Exit: Do Intangibles Matter?" *Industry and Innovation*, 27(5): 445–479.

**Lee, Voon-Hsien, Keng-Boon Ooi, Alain Yee-Loong Chong, and Christopher Seow**. 2014. "Creating Technological Innovation via Green Supply Chain Management: An Empirical Analysis." *Expert Systems with Applications*, 41(16): 6983–6994.

**Lengnick-Hall, Cynthia A., and Tammy E. Beck**. 2005. "Adaptive Fit Versus Robust Transformation: How Organizations Respond to Environmental Change." *Journal of Management*, 31(5): 738–757.

**Lotti, Francesca, and Giovanni Marin**. 2013. "Matching of PATSTAT applications to AIDA firms: Discussion of the methodology and results." *Bank of Italy Occasional Paper*, (166).

**Madrid-Guijarro, Antonia, Domingo García-Pérez-de Lema, and Howard Van Auken**. 2013. "An Investigation of Spanish SME Innovation During Different Economic Conditions." *Journal of Small Business Management*, 51(4): 578–601.

**Malerba, Franco.** 2002. "Sectoral Systems of Innovation and Production." *Research Policy*, 31(2): 247–264.

**Mansfield, Edwin.** 1962. "Entry, Gibrat's law, Innovation, and the Growth of Firms." *The American Economic Review*, 52(5): 1023–1051.

**Martin, Phillipe, Thierry Mayer, and Florian Mayneris**. 2013. "Are Clusters More Resilient in Crises? Evidence from French

Exporters in 2008-2009."

**Martin, R.L., P. Sunley, and B. Gardiner**. 2016. "How Regions React to Recession: Resistance, Recoverability and Resilience." *Regional Studies*, 50: 561–585.

**Moscarini, Giuseppe, and Fabien Postel-Vinay**. 2012. "The Contribution of Large and Small Employers to Job Creation in Times of High and Low Unemployment." *American Economic Review*, 102(6): 2509–2539.

**NACE**. 2008. "NACE Rev. 2 – Statistical Classification of Economic Activities in the European Community." 68.

**Nelson, Richard R., and Sidney G. Winter**. 1977. "In Search of a Useful Theory of Innovation." In *Innovation, Economic Change and Technology Policies*, 215–245. Springer.

**Nelson, Richard R., and Sidney G. Winter**. 1982. "The Schumpeterian Tradeoff Revisited." *The American Economic Review*, 72(1): 114–132.

**Oh, Seung-Youn.** 2014. "Shifting Gears: Industrial Policy and Automotive Industry After the 2008 Financial Crisis." *Business and Politics*, 16(4): 641.

**Patrucco, Pier Paolo.** 2011. "Changing Network Structure in the Organization of Knowledge: The Innovation Platform in the Evidence of the Automobile System in Turin." *Economics of Innovation and New Technology*, 20(5): 477–493.

**PATSAT**. 2015. "Patent Statistical Database Published by the European Patent Office (EPO)."

**Pavitt, Keith.** 1984. "Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory." *Research Policy*, 13(6): 343–373.

**Penrose, E.** 1959. "The Theory of the Growth of the Firm '(Oxford: Basil Blackwell)."

**Sabahi, Sima, and Mahour M. Parast**. 2020. "Firm Innovation and Supply Chain Resilience: A Dynamic Capability Perspective." *International Journal of Logistics Research and Applications*, 23(3): 254–269.

**Scherer, Frederic M.** 1983. "The Propensity to Patent." *international Journal of Industrial Organization*, 1(1): 107–128.

**Sidorkin, Oleg, and Martin Srholec**. 2014. "Surviving the Times of Crisis: Does Innovation Make a Difference?" *International Journal of Technological Learning, Innovation and Development*, 7(2): 124–146.

**Singh, Sanjay Kumar, Shivam Gupta, Donatella Busso, and Shampy Kamboj**. 2019. "Top Management Knowledge Value, Knowledge Sharing Practices, Open Innovation and Organizational Performance." *Journal of Business Research*.**[Q14]**

**Spatt, Chester S.** 2020. "A Tale of Two Crises: The 2008 Mortgage Meltdown and the 2020 COVID-19 Crisis." *The Review of Asset Pricing Studies*, 10(4): 759–790.

**Spescha, Andrin, and Martin Woerter**. 2019. "Innovation and Firm Growth Over the Business Cycle." *Industry and Innovation*, 26(3): 321–347.

**Srivastava, Mohit, and Helen Rogers**. 2021. "Managing Global Supply Chain Risks: Effects of the Industry Sector." *International Journal of Logistics Research and Applications*, 1–24.

**Teece, David J., Gary Pisano, and Amy Shuen**. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal*, 18(7): 509–533.

**Teplykh, Grigorii V.** 2018. "Innovations and Productivity: The Shift During the 2008 Crisis." *Industry and Innovation*, 25(1): 53–83.

**Van den Heuvel, Frank P., Peter W. De Langen, Karel H. van Donselaar, and Jan C. Fransoo**. 2014. "Proximity Matters: Synergies Through Co-Location of Logistics Establishments." *International Journal of Logistics Research and Applications*, 17(5): 377– 395.

**Whitford, Josh, and Aldo Enrietti**. 2005. "Surviving the Fall of a King: The Regional Institutional Implications of Crisis at Fiat Auto." *International Journal of Urban and Regional Research*, 29(4): 771–795.

**Wooldridge, Jeffrey M.** 2010. *Econometric Analysis of Cross Section and Panel Data*. MIT press.**[Q15]**

## Attachment Files

**1 GDP_IVA_Italy300.png** *:*