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Resilience, Performance and Strategies in Firms' Reactions to the Direct and Indirect Effects of a Natural Disaster

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Abstract

This work investigates the impacts of the 2012 Emilia-Romagna earthquake and looks at the capacity of the regional economic system to adapt to the shock generated by the seismic event. We contribute to the literature by distinguishing two different effects: direct (i.e. damages to production factors of the focal firm) and indirect effects (e.g. disruptions that affected industrial and business partners). The original dataset used and the chronological sequence of the information allow us to provide insightful evidence. The analysis of the two related effects generated by the same shock provides insights on the overall capacity of a regional system to adapt. Namely, the indirect damages appear as relevant as the direct damages, especially when looking at indicators of firm performance. In addition, indirect impacts are also relevant in shaping firm strategies and thus firm resilience.

Keywords Firm resilience · Natural disasters · Firm performance · Firm strategies

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1 Introduction

An earthquake on May 20 and 29, 2012 hit one of the leading regions of the Italian economy, Emilia-Romagna, which is one of the driving forces of the Italian industrial system. The regional added value recorded in the year before the earthquake corresponded to about 9% of the national figure (Source: ISTAT data). Its dynamism is the result of an evolution that has its origins in the famous 'Emilian model' (Brusco 1982), made from interactions between the production and social system and which has developed into its current state in which companies, institutions and research are widely interconnected in a solid innovation system (e.g. Marzucchi et al. 2015). Within the region, the earthquake hit specifically the provinces of Reggio Emilia, Modena, Bologna and Ferrara, whose added value in 2011 represented 5.36% of the national aggregate and 7.01% when the industrial added value is considered in particular (Source: ISTAT data).

This paper aims to analyse the effects of the earthquake on Emilia-Romagna companies and specifically on their capacity to adapt after a shock, focusing on two types of impacts triggered by the same shock (i.e. the earthquake): on the one hand, the effect of a natural shock on the overall economic performance of firms and, on the other hand, the outcome of the companies' strategic choices. In line with the literature on resilience (Boschma 2015; Martin 2012; Martin and Sunley 2015; Modica and Reggiani 2015), we discriminate between different interpretations of the said concept and we look at two different perspectives. Namely, drawing on the first perspective (see Martin 2012), we focus on the so-called ecological resilience – that is, the capacity of firms to resist a stress – and we investigate the impact on the performance of the firms. Drawing on a second perspective, we focus on the capacity of firms to adapt to a new 'environment' (see Boschma 2015) as the result of the stress caused by a shock, and we consider the strategic reaction and choices of the companies.

While the analysis of the impact on economic performance has an intrinsic significance for the assessment of the impact on the production system affected by the earthquake, the focus on strategic choices is aimed at a short-term analysis of the introduction of practices and behaviours that can contribute to the revitalisation of the affected companies. Two recent perspectives in the field of applied economics determine the reference framework for this research. A first group of studies focuses on the effect of natural disasters on production, investment and productivity both at the micro and aggregate levels (e.g. De Mel et al. 2012; Hallegatte and Dumas 2009; Hochrainer 2009; Leiter et al. 2009; Miao and Popp 2014; Skidmore and Toya 2002). These works do not lead to clear conclusions about the expected sign of the effects of such extreme events. In fact, while a natural disaster such as an earthquake necessarily entails negative destructive effects, the need to rebuild can induce companies to increase investments and modernise plants with positive consequences on company performance.

A second perspective considers the concept of resilience, which might include the ability to keep output close to its potential (Duval et al. 2007; Reggiani et al. 2002), the ability of an entity to preserve its functions (Rose 2007) or the ability of an enterprise to adapt its structure to maintain a path of acceptable growth of production (Martin 2012) following a shock. Therefore, the focus shifts from considering only the magnitude of the disaster and its effects to encompassing the specific actions and policies that companies put in place to increase their resilience and the preparation to face possible future shocks.

In this paper, we rely on original data collected through a survey that involved a sample of about 550 companies from Emilia-Romagna. The survey allowed us to gather information on the status of the 'treatment' (having suffered damages) of the 2012 earthquake, as well as variables regarding strategic choices, economic trends and key characteristics, such as the business structure and the orientation towards innovation and human capital. Particular attention was paid to the distinction between direct and indirect damages suffered by the firm or by the productive and commercial partners of the company (e.g. suppliers and customers) and to the inclusion of 'counterfactual' companies that have not suffered any damage from the earthquake.

The results of the econometric analysis show that, in addition to the damage directly suffered by companies, the indirect effects also had a negative impact on their economic performance. The evidence confirms the difficulty of highlighting a clear effect on the investment trend. Nonetheless, this study provides evidence of the resilient characteristics of the firms in terms of their capacity to adapt to and to cope with shock. In fact, in the presence of short-term negative effects on economic performance, the earthquake also acted as an incentive for the introduction of reconstruction strategies which concerns the increase of flexibility in production, the search for new markets, the reduction of environmental impacts, increased safety and higher compliance with existing regulations. In all, we underline a negative effect of direct damages on the economic performance of firms, and we show a positive effect (mainly) coming from the indirect damages on the firms' strategies. This latter result, even if further work is needed, might be the result of the complexity and the interconnection that plays an important role in the industrial environment of Emilia-Romagna, where the presence of districts and industrial clusters is relevant.

The remainder of the paper is structured as follows. Section 2 presents a review of the relevant literature. Section 3 discusses the data used and the methodology applied. Section 4 describes the results. Finally, Section 5 presents the paper's conclusions and its main implications.

2 Review of the Literature

Until the 1990s, the economic assessment of natural disasters,[1] both at micro and macroeconomic levels, did not spark particular attention in the academic community (Okuyama 2007). Afterwards, a growing number of researchers has become interested in both the impact assessment of extreme natural events on economic systems and the degree of preparation for and of capacity for recovery from natural disasters – in line with the increasing attention on the concept of resilience (Christopherson et al. 2010; Martin 2012; Noy 2009). There are many reasons for the growing popularity of these analyses. These cannot be simply summarised by the general sense of insecurity and uncertainty that afflicts people (Christopherson et al. 2010). Rather, in addition to the sense of insecurity, these motivations can be found in the combination of several

[1] We do not confine our review to those studies concerning earthquakes, but we also focus our attention on other kinds of natural disasters. This because of two main reasons: 1. the analysis of earthquakes' economic consequences are of a relative scarce number, also because of the usual low frequency of these events; 2. the damages caused by different natural disasters produce similar, if not the same, effects on the economic systems.

factors, including the concomitance of economic and environmental crises in a context of an always greater globalisation that has produced a complex and increasingly interconnected global 'network' (Hudson 2010). The literature concerning the economic effects of disasters can be divided into two major strands. The first focuses on the effects of disasters on the main macroeconomic variables (for example, GDP). The second focuses on 'firm-level' aspects, for which assessments of the ability to respond to and to survive the scenarios created by the impacts of natural disasters on the economic-productive fabric become central.

Related to macroeconomic effects on the resilience of economies, despite the considerable number of works concerning the effects of natural disasters on economic performance, the impact on output, both in the short and long term, is not clear (Hochrainer 2009), even if this might depend on the type of natural disaster taken into consideration. For instance, Loayza et al. (2012) and Skidmore and Toya (2002) highlight the effects of natural disasters on long-term growth, differentiating the types of natural disasters (droughts, floods, etc.), finding a positive relation between climate-related events and economic growth and a negative relation when focusing on geologic events, such as earthquakes.

Many studies report a negative effect of disasters on growth, such as Benson and Clay (2004), Hallegatte and Dumas (2009), Hochrainer (2009), Okuyama (2003) and Stewart and Fitzgerald (2001). In detail, Hallegatte and Dumas (2009) suggest that some factors, such as the quality of the reconstructed and 'embodied technological change', promoting a faster turn-over of capital ('productivity effect'), may reduce the costs of a disaster, but they can never lead to a positive effect on economic growth. Hochrainer (2009) states that, on average, natural disasters have negative effects on economic growth in relation to the severity of the disaster and other vulnerability-related factors, such as the lack of financial aid or capital inflows (see also Caschili et al. 2015). Furthermore, Hochrainer (2009) underlines that direct damage (e.g. physical destruction of production factors) may be more relevant than indirect damage (e.g. the interruption of production due to causes not directly connected to the destruction of a company's productive structures). Finally, Runyan (2006), Hosono et al. (2012), De Mel et al. (2012) and Miyakawa et al. (2014) highlight the negative effects of natural disasters on business growth.[2]

Other studies, on the other hand, contrast the idea that extreme events necessarily entail negative economic effects, reporting evidence of null or even positive effects at both micro and macro levels. For example, Albala-Bertrand (1993) analyse the impact of natural disasters on GDP, deficit and inflation, finding no detrimental effects, as the rapid increase in capital inflows and both public and private transfers counteract the negative effects of natural disasters.[3]

Skidmore and Toya (2002) provide evidence of a positive correlation between the frequency of natural disasters, accumulation of human capital, total factor productivity and economic growth, hypothesising that disasters can speed up a 'quasi-

[2] Other studies reporting negative consequences for economic growth are Otero and Marti (1995), Crowards (2000), Charveriat (2000), Murlidharan and Shah (2001), Freeman et al. (2002), Mechler (2004), Hochrainer (2006), Raddatz (2007), Crespo-Cuaresma et al. (2008), Noy (2009) and Okuyama (2009).

[3] Cavallo and Noy (2009) come to similar conclusions also in the long term, as listed for large disasters, in terms of the distribution of direct damages caused by the natural disasters.

Schumpeterian' process of 'creative destruction' at least when considering climate-related events such as flooding.[4]

Leiter et al. (2009) instead assess the impact of floods on capital stock, employment and productivity, finding contrasting results regarding capital stock (depending on the percentage of intangible assets), a positive short-term effect on employment and a negative effect on productivity. Finally, Loayza et al. (2012) find contrasting results depending on the type of disaster and the economic sector, highlighting traces of positive effects on growth for some sectors. In these studies, the concept of creative destruction, borrowed from Schumpeterian theory, seems to become particularly relevant, even if, as underlined by Crespo-Cuaresma et al. (2008), in this case there is a more literal interpretation of the term, that is, substituting the old capital stock with a more technologically advanced one after destruction due to an extreme event (Andergassen et al. 2015).

The literature on firm-level aspects, on the other hand, mainly shows how companies respond and recover from a natural disaster, especially focusing on the characteristics that facilitate or prevent the ability to recover from the event and on the strategic behaviour of companies. For example, Runyan (2006) infers that the main characteristics that prevented companies from recovering from the damages caused by hurricane Katrina in 2005 were largely due to the scarce ability to prevent natural risks, a lack of access to capital for reconstruction and serious infrastructural problems in the region (even as a result of the damage caused by the hurricane). Additionally, Hosono et al. (2012) and De Mel et al. (2012) focus on the lack of access to capital as the main cause of barriers that prevent the return to pre-event conditions, limiting investments. Miyakawa et al. (2014) instead show how the 1995 earthquake in the Kobe area of Japan led to a reduction in exports. Finally, Miao and Popp (2014) show how different types of natural disasters bring greater innovation with regard to risk mitigation technologies.

It should be noted that these last considerations fit perfectly with the concept of resilience, a subject of study that is central in the regional sciences debate and that focuses on the ability to maintain output close to its potential (Duval et al. 2007), the ability of entities to preserve their functions (Rose 2007) or the ability of a company to adapt its structure to maintain a path of acceptable growth of production (Martin 2012) following a disruptive event. [5] The concept of resilience is represented in Fig. 1.

In both the above-mentioned perspectives (creative destruction and resilience), the focus shifts from the magnitude of the disaster and its effects to the specific characteristics of the enterprises, which can increase their level of resilience, improve their ability to react and prepare for future shocks. Among the characteristics that can facilitate a company's ability to react, there are, for example, investment strategies (Tol and Leek 1999; Skidmore and Toya 2002), the composition of factors and the level of technology (Crespo-Cuaresma et al. 2008), efficiency (Uchida et al. 2014) and damage prevention measures (Shughart 2006; Sobel and Leeson 2006).

An important aspect when analysing the resilient behaviour of entities such as firms is the distinction between two types of damage: (i) direct damages and (ii) indirect

[4] Crespo-Cuaresma et al. (2008) come to the same conclusion, but it is limited to high (per capita) income countries.

[5] See Modica and Reggiani (2015) for a thorough literature review.

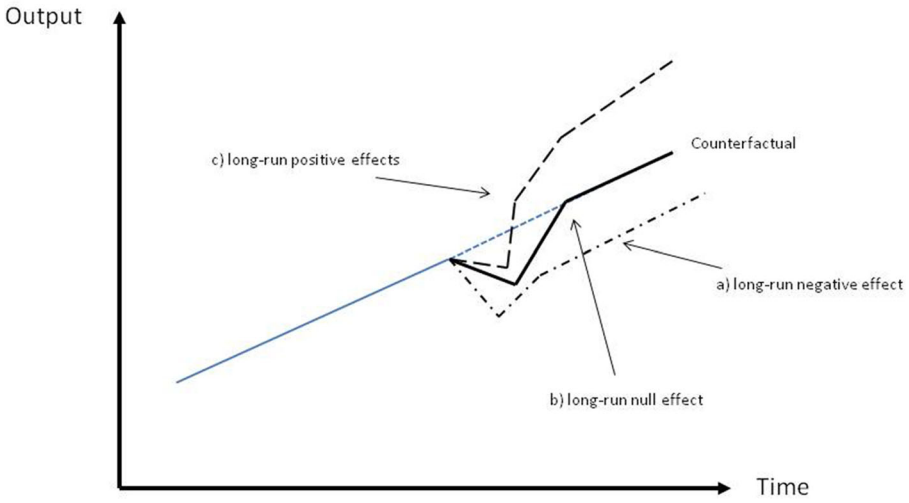

Fig. 1 Different scenarios of development after a shock: The resilience of companies

damages. As for direct damages, as reported by Leiter et al. (2009), these refer exclusively to the physical destruction of production factors such as labour (Anbarci et al. 2005; Kahn 2005; Halliday 2006) and capital (Albala-Bertrand 1993). This issue needs a different approach in the case of indirect damages caused by a natural disaster. In fact, an extreme event can lead to the interruption of production for reasons that are not connected to the direct destruction of the productive structures of a company. Even companies that experience no direct physical damages can see their production capacity reduced if the natural catastrophe has damaged strategic infrastructure (Rose and Liao 2005) or has made cuts to the production of possible customers and suppliers. Along these lines, Cardinale (2019) argues that the 'systemic interest', namely the interest of stakeholders to preserve the socio-economic system in which they are embedded, is an important aspect to consider in relation to both vulnerability and resilience. In fact, direct and indirect damages might be amplified because of the degree of connectivity of the involved firms, and even the reaction of the system in the aftermath of the shock turns to be highly affected by this important aspect.

The period following the shock that caused damage can therefore follow different developmental trajectories, which are summarised in Fig. 1 above. Following Hochrainer (2009) and Leiter et al. (2009), (a) if the factors of production are not replaced or the interruption of production causes a non-recoverable loss (e.g. due to final demand shocks), then the level of production is steadily reduced compared to the situation in which no shock occurred; (b) the production factors are replaced and the customer/supplier chain is re-established in a short time, after an initial negative production trend, and the pre-shock situation is returned with no significant changes in long-term trend production; and (c) once the production factors have been replaced, the distribution chain has been re-established and the initial period of 'turbulence' has been overcome, the production level grows at a higher rate than the period before the disaster. This may be due to different causes such as the updating of technologies and factor composition (Crespo-Cuaresma et al. 2008; Okuyama 2003; Skidmore and Toya 2002), the positive effect on employment (Skidmore and Toya 2002; Ewing et al. 2003,

2007) or product innovations and penetration into new markets. In this framework, the analysis of indirect damage appears to be more complex because it must consider all the commercial, productive and technological relationships between the different companies affected by a natural disaster. For this reason, different methods of analysis have been proposed to analyse how indirect damages spread among companies: the computable general equilibrium model (Rose and Liao 2005), input-output (Wu et al. 2012; Okuyama 2014; Dekle et al. 2015) and structural decomposition (Okuyama 2014). All these works indicate that the effects of indirect damage on production levels often depend on the specific characteristics of the companies. For example, Rose and Liao (2005) affirm that the effects of an interruption of water service following a natural disaster depend on the severity of the lack of water, the industrial sector and the adoption of prevention and resilience measures. Wu et al. (2012) focus their attention on financial constraints on reconstruction, investment instability and limited reconstruction capacity. Okuyama (2014) indicates the variation in final demand as the main lever for changing the behaviour of companies following a natural disaster. Finally, Dekle et al. (2015) show that geographic proximity to a natural disaster does not seem to affect much the effects on industrial production, but what is most important is the sectoral similarities between regions.

In summary, one can think about the following evolution of events. First, a natural disaster occurs (for example, an earthquake). This event causes direct damage to the physical capital of companies and public infrastructure with possible interruption of production. As a result of the direct damage, indirect damage occurs due to detrimental impacts on public infrastructure (e.g. electricity or transport networks) or in the form of the interrupted production of business partners (e.g. suppliers). Reconstruction and a return to operations depend on the behaviour and strategic choices of companies, which can therefore be interpreted as potential determinants of resilience (Andreoni and Scazzieri 2013; Cardinale and Scazzieri 2019). In what follows, we seek to advance our understanding of the direct and indirect effects of a natural disaster, an earthquake in this case. To do so we apply the analysis as described in the next section.

3 Data and Methods

The analysis is based on data collected specifically for this project. These data, completely original in the panorama of statistical information available for the quantitative analysis of the effects of a seismic event on companies, are particularly useful for our analysis for the following reasons.

First, sampling was carried out in such a way as to include companies from Emilia-Romagna located in areas affected by the earthquake and in areas not affected by the event. The identification of the areas affected by the earthquake was based on a list of municipalities included in the 'crater'. This list was determined on the basis of Legislative Decree 74/2012, which recognised as 'earthquake victims' 33 municipalities in the provinces of Reggio Emilia, Modena, Ferrara and Bologna. In this way, it was possible to work on a set of firms potentially affected by the earthquake and on a counterfactual set comprised of similar companies located outside the earthquake zone. It should be remembered that the identification of the firms to be included in the representative sample (254 observations inside the crater and 300 observations outside

the crater) was carried out by stratifying the reference population – manufacturing companies with more than 10 employees under the legal forms SPA, SRL, SAPA and SNC[6] – by province (NUTS3 geographical statistical unit), production sector and size of class (from 10 to 19, from 20 to 49 and equal or more than 50 employees). The main reason for the categorisation of firm size used in this work lies in the structure of the industrial system of the Emilia-Romagna region, which is in line with that of Italy, being mainly composed of micro and small firms. Because of that, the strata used for selecting a representative sample (size, sector, province) out of the population, when crossed, often provided empty cells for medium and large firms: hence, the decision to categorise the firms according to their size in the way mentioned above. The small firms, largely widespread in the surveyed territory, were subdivided into two categories, while the medium and large firms, very sparse in the territory, were grouped into one category.

The survey was conducted by a specialised company through the CATI (Computer-Assisted Telephone Interviewing) methodology and provided information on the structural characteristics of the firms as well as on the specific themes of analysis of the paper, in particular on direct and indirect earthquake damages suffered by the firms (see the Appendix for the questionnaire).

The identification of the firms affected by the earthquake, however, cannot be based only on its location in a municipality affected by the event. This is all the more true when one considers that some municipalities may have a territorial dimension sufficiently large to include areas with different intensities of damage derived from the event. Moreover, only requiring being located in an affected municipality could lead to an incorrect identification of the affected companies, as the actual damage of the earthquake depends ultimately on the state of maintenance, the obsolescence of the production structure and the construction technology. Therefore, a question on the real presence of earthquake damage was included in the questionnaire. This question allowed for the creation of two dummy variables. The first, *Direct Damage*, indicates if the firm has reported damages to production facilities. The second, *Indirect Damage*, indicates if the firm has suffered damages derived from the impact of the earthquake on suppliers, customers or other partners. This variable, in addition to providing a more complete picture of the impact of the earthquake, also allows one, as described below, to check for possible violations of an assumption at the basis of the econometric estimate, the stable unit treatment value assumption (SUTVA). The third characteristic that makes the dataset particularly useful for the analysis concerns the temporal setting of the collected variables. A purely cross-sectional setting in which the independent variables (e.g. the presence of damage or control variables such as the enterprise size) and the dependent variables (e.g. the economic performance of the enterprise) are recorded in the same reference period would run the risk of having endogeneity problems in the econometric estimation due to reverse causality. To overcome this problem, with the impossibility of resorting to a real panel structure in which information is collected before and after the earthquake, the questionnaire was structured to

[6] The acronyms can be translated as follows, although for some categories there are no equivalents in English: SPA = Società Per Azioni = Joint Stock Company; SRL = Società a Responsabilità Limitata = Limited Liability Company; SAPA = Società in Accomandita Per Azioni = Limited Partnership Joint Stock Company; SNC = Società in Nome Collettivo = General Partnership Company.

gather, for most of the questions used for the construction of control variables, information for the pre-earthquake period from 2010 to 2011 and information on the outcome variables (or dependent variables) for the post-earthquake period from 2012 to 2013.[7]

Starting from the structure of the dataset just described, the econometric analysis consisted of estimating models such as the following. Specifically, the first set of estimates uses as dependent variables a vector of information that captures the economic performance of the company in the period from 2012 to 2013, while the second set of estimates uses as dependent variables a vector of information that reflects the strategic objectives of the company in the period from 2012 to 2013.

$$Performance_i = \beta_0 + \beta_1\, Direct\ Damage_{i,} + \beta_2\, Indirect\ Damage_{i,} + \gamma\, \mathbf{CTRLS} + \varepsilon_i \quad (1)$$

$$Strategies_i = \beta_0 + \beta_1\, Direct\ Damage_{i,} + \beta_2\, Indirect\ Damage_{i} + \gamma\, \mathbf{CTRLS} + \varepsilon_i \quad (2)$$

Specifically, the *Performance* variables are based on a 5-point Likert scale (very negative, negative, no change, positive, very positive) and capture changes from the previous period from 2010 to 2011 related to *Turnover*, *Employment*, *Tangible Investments*, *Intangible Investments*, *Productivity* and *Profits*. The *Strategies* variables reflect the relevance of the strategic objectives. The relevance is captured with a 4-point Likert scale (from nil to high), and the objectives refer to widening of the *Product Types*, (new) *Market Penetration*, increase of production *Flexibility*, reduction of *Environmental Impact*, improvement of *Safety and Security* conditions and compliance with *Regulation*.

Given the nature of the dependent variables, Eqs. 1 and 2 are estimated via ordered probit, which accounts for the ordered nature of the variables (Cameron and Trivedi 2005).

The key explanatory variables of Eqs. 1 and 2 are *Direct Damage* and *Indirect Damage*; the parameters β_1 and β_2 thus capture the effect of the earthquake on the dependent variables. The estimations of these parameters, given the random nature of the natural event in terms of timing and affected area, are not subject to relevant endogeneity issues due to selection bias. The 'treatment' in other terms, due to the unpredictability, can be considered as exogenous to the decision of the firms to locate (prior to 2012) in a specific area. This is particularly true in the specific regional context we analyse, where the seismic risk is rather homogeneous.[8]

Even so, when Eqs. 1 and 2 are estimated, the causal effect of the 'treatment' can be unreliable in case the SUTVA does not hold; this happens when the treatment status of one unit affects the other units. This assumption may be violated in case the earthquake

[7] To further reduce the reverse-causality problem, when the questionnaire was administered, respondents were explicitly asked to refer to the post-seismic period of 2012, that is, after May 2012.

[8] See the seismic risk map produced by the Italian Department for Emergency Prevention and Management (Protezione Civile): www.protezionecivile.gov.it/resources/cms/documents/A3_class20150416_r.pdf (last accessed Nov 2020)

affected a firm *i*, and through business and operational relations, the effect on unit *i* caused disruption to another unit *j*. In brief, when this happens, firm *j* could not be considered as a 'non-treated' unit. Our econometric strategy, through the inclusion of the *Indirect Damage* dummy, controls for this possibility, in addition to providing a direct assessment of the impacts due to the indirect changes.

We also rely on a series of controls. First, we control for factors that generate internal and external economies of scale. Large companies or firms belonging to a group may have more resources to absorb the shock of the earthquake, both with respect to their capacity to react to disruptions in economic trends and performance and with respect to the need to re-adjust their strategic objectives. Hence, we include in the specification two variables: *Group* and *Employment* (*ln*). The former is a dummy variable that takes a value of 1 in case the firm is part of a group. The latter captures the (log) number of employees. The capacity and possibility of a firm's reaction may depend on other factors. Human capital can help retain a competitive edge even in the presence of structural damages to buildings and physical capital. At the same time, the human capital endowment may influence the type of strategies that the firm adopts to respond to the earthquake. Hence, we include the variable *Human Capital* among our controls; the variable captures the ratio between white-collar workers (i.e. those in upper and lower management and clerks) and blue-collar workers (i.e. manual workers). Similarly, innovativeness could affect a company's capacity for reaction and affect strategic orientations. We include a dummy variable, *Product Innovation*, which takes a value of 1 in case the firm has introduced new products. Another factor that may affect the reaction of a firm is public policy that targets the firm's capacity to innovate. We thus include a dummy variable, *Subsidy,* which reflects whether the company has received public support from the central or local government or the European Union. The availability of *Insurance* is another factor that may affect the response of the firms affected by the earthquake. We thus include a variable that captures the percentage of turnover that is spent on insurance against seismic risk. We also account more directly for the decision to adopt risk management measures by the firms, and we add, among the independent variables, the variable *Seismic Measures*, which reflects in the pre-event period the percentage of turnover that was spent on anti-seismic prevention measures aimed at improving the safety of workers and production facilities.[9]

Finally, there could be systemic factors that may influence the impact of the earthquake. The first one is the sector in which the firm is operating. First, there may be sectoral dynamics that can affect the firm's capacity to react, such as, for example, the exposure of the sector to the pressures exerted by the financial crisis, which was still affecting the Emilia Romagna economy in 2012, the year of the seismic event. On the other hand, sectoral specificities related to technology, market dynamics and industrial dynamics may exert an influence on the types of strategies that firms put in place to respond to the shock. For these reasons, we include nine dummies that capture the following sectors: the manufacture of chemicals, chemical products and plastics; the

[9] In an ancillary unreported regression (whose results are available upon request), we tested the effect of direct and indirect damages on the adoption of risk management measures in the immediate aftermath of the earthquake (the period from 2012 to 2013). Results show that in addition to direct damages a main driver is the previous adoption in the period from 2010 to 2011 of similar measures. Risk management thus appears persistent behaviour of the companies.

manufacture of food products; metallurgy; the manufacture of non-metallic mineral products; the manufacture of paper and paper products; the manufacture of textiles, apparel and footwear; the manufacture of wood products and furniture and other industries. Another important characteristic we account for is geographic location. Even if we define the 'treatment' status, based on the presence of direct and indirect damages, controlling for the NUTS-3 province is particularly important. The local agglomeration forces of particular territories of the region are quite relevant, such as, for example, the well-known industrial districts (Brusco 1982). These forces could have influenced the effect of the earthquake, particularly regarding the indirect effects, which relates to linkages with suppliers and clients, and could have influenced the strategic responses put in place by local firms. For these reasons, we include in the analysis nine dummies that capture the NUTS-3 location of the firms in the provinces of Piacenza, Parma, Modena, Bologna, Ferrara, Ravenna, Forlì-Cesena, Reggio Emilia and Rimini.

4 Results

Table 1 provides a snapshot of the variables employed in the analysis with a set of descriptive statistics. The correlation among the variables is reported in Table 2. The coefficients rule out severe collinearity issues.

4.1 The Direct and Indirect Effects of the Earthquake on Firms' Economic Performance

Table 3 reports the evidence on the direct and indirect effects of the seismic event on the economic performance of the firms. Results emerge from estimates performed on about 415 firms with non-missing values in the employed variables.[10] One-hundred-two firms were directly affected by the earthquake, while 78 firms reported indirect damages (77 in the estimation of the effect on physical capital investments). The econometric analysis is based on a relatively larger counterfactual group, which consists of about 257 companies that did not suffer direct or indirect damages associated with the earthquake and thus are able to provide information on what would have happened in the absence of the seismic shock on the economic performance of the companies.

The coefficients of *Direct Damages* and *Indirect Damages* are generally negative and significant when looking at the impact on economic performance. The impact of the seismic event seems to dominate most of the other firms' characteristics in terms of capacity to influence economic performance. The effect of the earthquake, both in terms of disruptions caused to the physical productive structures and those related to relations with other economic actors, is generally detrimental to firms' economic performance. It is worth mentioning that the magnitude of the impact of the two types of damage (when both significantly affecting the economic performance) does not appear to be too dissimilar. Thus, we can infer that the earthquake, in a territory like

[10] The number of used observations in our specifications is not 554 for two main reasons: (1) the calculation of the human capital variable as the ratio of white-collar workers to blue-collar workings and (2) the presence of missing values in the variables used in our specifications.

Table 1 Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Independent variables (x)					
Direct Damages	417	0.25	0.43	0	1
Indirect Damages	417	0.19	0.39	0	1
Group	417	0.08	0.27	0	1
Employment (ln)	417	2.96	0.81	0	7.07
Human capital	417	0.89	2.36	0	32.33
Subsidy	417	0.05	0.21	0	1
Insurance	417	3.41	8.80	0	60
Product Innovation	417	0.02	0.15	0	1
Seismic Measures	417	2.01	9.80	0	90
Dependent variables: Performance (y)					
Turnover	417	2.11	0.86	0	4
Employment	417	2.20	0.72	0	4
Tangible Investments	412	2.08	0.70	0	4
Intangible Investments	413	2.07	0.68	0	4
Productivity	415	2.14	0.74	0	4
Profits	415	2.08	0.76	0	4
Dependent variables: Strategies (y)					
Product Types	416	2.10	0.90	0	3
Market Penetration	415	2.07	0.87	0	3
Flexibility	416	2.05	0.74	0	3
Environmental Impact	414	2.05	0.74	0	3
Safety and Security	415	2.17	0.70	0	3
Regulation	414	2.17	0.70	0	3

Emilia-Romagna where economic activities are extremely interconnected and integrated – or even occur within districts and clusters – damages experienced by clients,

Table 2 Correlation matrix among the controls (Controls)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Direct Damages	1.0000								
(2) Indirect Damages	0.0148	1.0000							
(3) Group	−0.0077	−0.0525	1.0000						
(4) Employment (ln)	−0.0138	0.0727	0.3806	1.0000					
(5) Human capital	0.0032	−0.0432	0.0042	−0.0033	1.0000				
(6) Subsidy	−0.0182	0.1622	0.0185	0.1061	−0.010	1.0000			
(7) Insurance	0.0155	0.1975	0.0191	0.0419	−0.036	0.0240	1.0000		
(8) Product Innov.	−0.0084	0.0564	0.1364	0.1882	−0.029	0.0465	0.2438	1.0000	
(9) Seismic measures	0.0828	0.0830	−0.034	−0.0217	−0.025	0.0728	0.5636	0.0539	1.0000

Table 3 Effects of the earthquake on the firms Performance

	(1) Turnover	(2) Employment	(3) Tangible Investments	(4) Intangible Investments	(5) Productivity	(6) Profits
Direct Damages	−0.374***	−0.388***	−0.0908	−0.102	−0.271*	−0.328**
	(0.135)	(0.144)	(0.145)	(0.140)	(0.143)	(0.146)
Indirect Damages	−0.497***	−0.464***	−0.404***	−0.438***	−0.435***	−0.352**
	(0.144)	(0.145)	(0.150)	(0.138)	(0.137)	(0.144)
Group	−0.0137	0.0114	0.0584	0.0739	−0.312	0.0738
	(0.213)	(0.265)	(0.266)	(0.243)	(0.220)	(0.223)
Employment (ln)	0.0190	0.0497	−0.00424	0.0680	0.0790	0.0824
	(0.0762)	(0.0747)	(0.0747)	(0.0756)	(0.0736)	(0.0741)
Human capital	0.0532**	0.0216	0.0448***	0.0474***	0.0300	0.0366**
	(0.0257)	(0.0275)	(0.0147)	(0.0162)	(0.0200)	(0.0151)
Subsidy	0.356	0.366	−0.0292	−0.246	0.133	−0.221
	(0.345)	(0.330)	(0.299)	(0.324)	(0.286)	(0.256)
Insurance	0.00623	−0.000901	−0.00467	−0.00787	0.0111	0.00264
	(0.00824)	(0.00631)	(0.00756)	(0.00722)	(0.00862)	(0.00698)
Product Innovation	0.0780	0.184	1.027***	0.567*	0.127	0.756**
	(0.441)	(0.381)	(0.335)	(0.310)	(0.368)	(0.383)
Seismic measures	0.00426	0.00481	0.00206	0.00219	−0.00336	0.000795
	(0.00563)	(0.00571)	(0.00647)	(0.00623)	(0.00678)	(0.00631)
Sector Dummy	YES	YES	YES	YES	YES	YES
Province Dummy	YES	YES	YES	YES	YES	YES
R^2	0.0515	0.0531	0.0502	0.0437	0.0523	0.0490
Chi^2	61.41	60.31	52.42	43.77	56.99	63.85
N	417	417	412	413	415	415

*, **, *** significance at 10%, 5% e 1%. Robust S.E. in parenthesis

suppliers and business partners can be as severe as those suffered by the same focal firms. This result, as we discuss in the conclusion, deserves particular attention both for its implications for policy making and for its implications regarding the optimal design of insurance schemes.

Another key aspect to consider is the lack of a significant effect of *Direct Damages* on the firms' investments. This result only appears counterintuitive. As emerged in the literature review (Section 2), it is almost impossible to have a prior clue on the sign of the effect of a natural disaster on the firms' investment outlook. On the one hand, the effect could be positive, due to the necessity to restore or rebuild the production facilities. On the other hand, it is not possible to exclude a negative effect. In fact, in the aftermath of a seismic event, there could be a reduction of the expected return on investment due to the higher perceived risk (e.g. Skidmore and Toya 2002; Crespo-Cuaresma et al. 2008). Our evidence suggests that these two forces counterbalance each other, resulting in an effect that is not different from zero.

Another issue to consider is the effect of insurance and seismic prevention measures which, according to the evidence emerging from our estimates, is not statistically different from zero. These results appear counterintuitive, but in the case of insurance coverage, it is worth mentioning that the variables we use on the left-end side of the econometric model capture economic trends and performance in the immediate aftermath of the earthquake, when reimbursements from the insurance companies were not entirely liquidated or possibly not yet factored in when defining the strategic choices of the firms regarding reconstruction after the earthquake. Finally, other relevant control variables such as human capital and product innovation show positive significant results in line with the literature (see e.g. Huo et al. 2016).

4.2 The Direct and Indirect Effects of the Earthquake on Firms' Strategic Behaviour and Objectives

The second part of our analysis focuses on the impact of the earthquake on the strategic choices that companies have adopted as a reaction to the seismic event. In particular, the number of firms in our sample which suffered direct damages due to the earthquake is 92, while the number of firms hit by indirect damages is 102 (101 in Column 6). Additionally, in this case, the estimations are carried out over a relatively large counterfactual group of around 257 firms (256 in Column 4).

The effects of the earthquake damages on the firms' strategic choices emerge from the evidence provided in Table 4. At the outset, the presence of significant effects on strategic choices seems to suggest that the seismic event worked as a break to organisational inertia and facilitated the adoption of new and resilient behaviours. These seem to be induced mainly by indirect disruptions, which affected the firm's network of partners. Once again, this represents an interesting feature of the way in which the earthquake effects propagate in a territory characterised by high connectivity. More precisely, *Indirect Damages* induced firms to find new markets and to increase their flexibility of production. This is quite consistent with our expectations, given that this type of damage reflects disruptions to the business partners of the surveyed firms. Our results seem to suggest that the reduction of demand, due to damages that hit clients, induced surveyed firms to find new markets where they could sell their products. Similarly, damages suffered by firms along the value chain (either suppliers or customers) appear to dictate the need to introduce new and more flexible production processes to re-internalise some of the production phases or readjust specific production processes to enter new relations with suppliers and customers that replace previous ones.

Another set of relevant effects pertains to the strategic choices that are related to reduced environmental impacts or compliance with regulations. From Table 4, we can observe that *Indirect Damages* induced firms to pursue objectives related to the reduction of environmental impacts. A possible explanation for this effect is the following. The reconfiguration of the production network induced by the earthquake disruptions may have led the firms to search for greener suppliers and to connect with more environmentally aware clients. In turn, it seems that the indirect disruptions stimulated a reinforced green orientation that could lead to exploiting business-

Table 4 Effects of the earthquake on the firms Strategies

	(1) Product Types	(2) Market Penetration	(3) Flexibility	(4) Environmental Impact	(5) Regulation	(6) Safety and Security
Direct Damages	−0.120	−0.0549	−0.00130	0.114	0.222	0.324**
	(0.132)	(0.135)	(0.144)	(0.144)	(0.142)	(0.141)
Indirect Damages	0.353**	0.407**	0.499***	0.326**	0.371**	0.250
	(0.165)	(0.159)	(0.153)	(0.165)	(0.163)	(0.162)
Group	−0.0832	0.228	0.507**	0.0532	0.330	0.402
	(0.245)	(0.238)	(0.253)	(0.289)	(0.240)	(0.245)
Employment (ln)	0.0459	0.180**	0.0913	0.113	0.175**	0.157**
	(0.0745)	(0.0781)	(0.0755)	(0.0765)	(0.0720)	(0.0695)
Human capital	0.0379*	0.0514**	0.0588***	0.00964	0.000155	0.000373
	(0.0217)	(0.0232)	(0.0226)	(0.0151)	(0.0179)	(0.0177)
Subsidy	0.0245	−0.166	0.0701	0.391	0.180	0.0130
	(0.274)	(0.294)	(0.294)	(0.309)	(0.304)	(0.298)
Insurance	−0.000314	−0.00551	−0.0102	−0.0159**	−0.0139*	−0.0155**
	(0.00939)	(0.00990)	(0.00761)	(0.00755)	(0.00797)	(0.00740)
Product Innovation	0.623*	0.714*	0.726*	0.0852	0.218	0.238
	(0.343)	(0.424)	(0.401)	(0.415)	(0.491)	(0.447)
Seismic measures	−0.00819	−0.00749	0.00495	0.0188**	0.0138*	0.0153*
	(0.0102)	(0.0119)	(0.00867)	(0.00799)	(0.00804)	(0.00802)
Sector Dummy	YES	YES	YES	YES	YES	YES
Province Dummy	YES	YES	YES	YES	YES	YES
R^2	0.0287	0.0436	0.0616	0.0500	0.0641	0.0669
Chi^2	33.36	50.31	59.45	49.63	66.62	82.01
N	416	415	416	414	414	415

*, **, *** significance at 10%, 5% e 1%. Robust S.E. in parenthesis

environmental win-win strategies (e.g. Ambec and Lanoie 2008; Antonietti and Marzucchi 2014; Leoncini et al. 2019).

The result regarding increased compliance with *Regulation* can be seen as motivated by a similar argument. The need to reorient production activities in the aftermath of the event seems to have induced a 'qualitative' change in the firm's operations, which besides being oriented towards environmental sustainability, aims to respond more closely to existing standards and regulations. It should be noted that this similar result may also be due to the partial overlap of the two objectives – due to the presence of environmental regulations – which is reflected in a correlation coefficient between the two dependent variables of around 0.6.

Only one strategic orientation is induced by *Direct Damages*: *Safety and Security.* The reconstruction of production facilities seems to be oriented towards a strategy of improving health and safety conditions. This evidence seems a natural consequence of the reconstruction of the damaged production facilities and suggests that affected firms have implemented changes to reduce future seismic risks.

Among the determinants of the strategic changes, there are some of the firms' characteristics that deserve mention. First, *Human Capital* and *Product Innovation* appear crucial drivers of the firms' decisions to widen: their capacity to develop new products, their flexibility and new market penetration. The adoption of *Seismic Measures* is positively correlated with the adoption of environmental strategies, regulation compliance and health and safety. An opposite effect is produced by *Insurance*, which in three models seems to negatively affect the firms' decisions to implement strategic changes. It seems that firms that can benefit from insurance coverage are not induced to introduce changes, possibly in light of the crowding out of resources used to pay for the premiums or because of the risk aversion of management, which can be translated into a sort of resistance to implement strategic changes.

In the empirical strategy, we use two dummy variables for direct and indirect damages without discriminating the level of these damages. In fact, it is possible to recognise that the size of damages varies across companies. Thus, in the analysis provided in Tables 3 and 4, small and large damages are considered the same. To test whether the effects are stable when considering different damage intensities, we resorted to another piece of information that was collected during the survey that points to the period during which the production facility was shut as a result of the damages. In the questionnaire, we referred to direct damages only because it was impossible to collect information on plant closures for all the business partners (as would be required to capture the intensity of indirect damages). Therefore, we distinguish between damages that led to a stop in production and minor (or limited) damages that allowed

Table 5 Effects of the earthquake on the firms Performance (robustness checks)

	(1) Turnover	(2) Employment	(3) Tangible Investments	(4) Intangible Investments	(5) Productivity	(6) Profits
Direct Damages (with no stop of production)	−0.229	−0.247	0.170	0.199	−0.117	−0.171
	(0.203)	(0.209)	(0.202)	(0.195)	(0.211)	(0.207)
Direct Damages (with stop of production)	−0.458***	−0.471***	−0.237	−0.271	−0.360**	−0.418**
	(0.159)	(0.176)	(0.178)	(0.173)	(0.172)	(0.179)
Indirect Damages	−0.484***	−0.452***	−0.383**	−0.414***	−0.422***	−0.339**
	(0.144)	(0.146)	(0.152)	(0.140)	(0.139)	(0.145)
Controls	YES	YES	YES	YES	YES	YES
Sector Dummy	YES	YES	YES	YES	YES	YES
Province Dummy	YES	YES	YES	YES	YES	YES
R^2	0.0525	0.0541	0.0535	0.0482	0.0535	0.0502
Chi^2	61.47	60.12	52.35	44.17	57.60	63.32
N	417	417	412	413	415	415

*, **, *** significance at 10%, 5% e 1%. Robust S.E. in parenthesis

Table 6 Effects of the earthquake on the firms Strategies (robustness checks)

	(1) Product Types	(2) Market Penetration	(3) Flexibility	(4) Environmental Impact	(5) Regulation	(6) Safety and Security
Direct Damages (with no stop of production)	−0.240	0.0340	0.0373	0.00633	0.282	0.404*
	(0.209)	(0.191)	(0.200)	(0.202)	(0.223)	(0.220)
Direct Damages (with stop of production)	−0.0504	−0.106	−0.0234	0.176	0.188	0.278*
	(0.150)	(0.166)	(0.178)	(0.177)	(0.169)	(0.165)
Indirect Damages	0.343**	0.415***	0.503***	0.317*	0.376**	0.257
	(0.165)	(0.159)	(0.153)	(0.165)	(0.163)	(0.162)
Controls	YES	YES	YES	YES	YES	YES
Sector Dummy	YES	YES	YES	YES	YES	YES
Province Dummy	YES	YES	YES	YES	YES	YES
R^2	0.0294	0.0439	0.0617	0.0506	0.0642	0.0672
Chi^2	33.49	51.84	59.09	51.23	68.05	87.46
N	416	415	416	414	414	415

*, **, *** significance at 10%, 5% e 1%. Robust S.E. in parenthesis

production to continue. We re-estimated our models with three dummies (*no damages* as a reference category; *direct damages with no stop* of production activities and *direct damages with stop* of production activities). The results are reported in Tables 5 and 6. We decided to resort to this aggregate specification and to avoid a finer grained operationalisation of the damage intensity because, while the decision of closing or not a production facility is closer to the actual relevance of the damages, and in particular, their implications in terms of the safety of the operations, the decision on the duration of the closure may be more closely determined by the expectations regarding the economic performance of the firm. This would make our analysis subject to endogeneity problems (due to reverse causality). It is interesting to note that the results are consistent with those presented in Tables 3 and 4. Moreover, we can see that it is the closure of the production facilities that in most cases drives the effects of *Direct Damages* on the firms' performance.

5 Conclusions

The objectives of the analysis of the present work have been twofold. On the one hand, we aimed at testing the impact of the May 2012 Emilia-Romagna earthquake on the economic performance of the regional firms; on the other hand, we sought to analyse the potential reactions induced by the earthquake on the firms' strategies. The investigation was conducted with a unique and ad-hoc

dataset on a sample of Emilia-Romagna manufacturing firms. The evidence concerns both the seismic event's direct effects (e.g. damages on productive structures) and its indirect effects (e.g. repercussions on suppliers).

The evidence points out that both direct and indirect damages caused by the earthquake had a negative impact on the Emilia-Romagna firms' performance. The indirect damages had negative impacts on all the performance dimensions considered: turnover, employment, tangible and intangible investments, productivity and profit. The empirical evidence also highlights the difficulty in singling out the effect of direct damages on investment trends. On the one hand, the necessity for reconstruction calls for new investments, which would imply a positive effect from the direct disruptions on the production facilities. On the other hand, this positive effect appears to be counterbalanced by the reduction of expected investment returns given the increased risk perception. Although we are in front of short-term negative effects on economic performance, it seems clear that the earthquake triggered the introduction of new strategies, which can be seen as resilient reactions by the affected companies. The latter concern increased not only production flexibility and the search for new markets but also more qualitative changes such as the reduction of environmental impacts, increased safety and security conditions and better compliance with existing regulations.

A main implication emerges from the present work. The relevance of the indirect damages, in addition to the direct ones, calls for a close reflection on political choices and on risk insurance policies. The negative effects of the earthquake do not materialise only in the destruction of the productive structures owned by each firm. The interruption or reduction of business and production relations, caused by damages suffered by suppliers and clients, appears as relevant as the direct negative effects are. Such relations, in productive contexts characterised by strong integrations among firms along the supply chain, as in the regional context analysed, are the source of the competitive advantages generated by the district-based model of industrial development. These aspects should be taken into account in the identification of the beneficiaries of reconstruction policies, which can take the form of direct actions or reductions of fiscal pressure. In the same manner, private insurance policies should also take into consideration, among the covered risks, those risks arising from the interruption of production and of technological relations with partner firms.

Within the boundaries given by data shortcomings, the present work provided the basis for a detailed analysis of the effects of the 2012 earthquake on the Emilian productive system. Future research could go in the direction of a further exploration of such effects. In a long-term perspective, it would be of interest to analyse the impact of the strategic changes induced by the earthquake on the firms' economic performance.

Appendix

Questionnaire excerpt

Questionnaire to the firms

Effects of the earthquake of May 2012 and post-earthquake recovery strategies of the Emilian manufacturing system

Cover letter

The National Research Council (CNR) is carrying out a research on the economic consequences of natural disasters in Italy, three of its institutes (CERIS, IDPA, IRPI) work on it in collaboration with INGV and SEEDS, a research center that includes two Emilian universities. In this context, an investigation is being carried out on the consequences of the 2012 earthquake for the Emilian manufacturing system. The aim is to achieve a more complete assessment of the costs and economic consequences, direct and indirect, and to obtain an understanding of the strategies that the Emilian manufacturing companies have implemented in response to the earthquake, also in comparison with the strategies of Emilian companies not directly interested in the seismic event. For this purpose, a sample of companies located both inside and outside the so-called 'crater' (municipalities identified by Legislative Decree 74/2012) was identified. Your company is part of this sample.

We believe that it is of great interest to you to contribute to a survey that will highlight the trends and resilience of the Emilia production system in the face of the difficulties generated by the earthquake. We believe that the survey will help political actors in supporting policies for the Emilian production system in the coming years.

[…]

This survey has been entrusted to the data collection company SWG, which will contact you for this purpose. The company has proven experience and high professionalism in the sector
[…]

Index

***Information on the company*……..**

[…]

……..***and on the respondent(s)***

[…]

1.Company characteristics

1.1 Is the company part of a group? (GROUP)

□ No

□ Yes [...]

[…]

1.4 Indicate the number of employees and the relative percentage compositions (EMPLOYMENT, HUMAN CAPITAL)

	Emp. 2010-2011	**Emp. 2012-2013**
Total number of employees of the company		
% employees by qualification out of total employees		
Executives and middle managers		
White-collar workers (clerks)		
Specialized and / or qualified manual workers		
Non specialised manual workers		
Total	100.00	100.00
% Graduates		

[…]

1.5 What was the economic performance of the company in the period 2012-2013 for the following indicators compared to 2010-2011? (indicate if very negative, negative, neither negative nor positive, positive, very positive) (PERFORMANCE INDICATORS)

Indicators	**2012-2013**				
	very negative	***negative***	***neither negative nor positive***	***positive***	***very positive***
1. Turnover					
2. Employment					
3. Tangible investments					
4. Intangible investments					
5. Productivity					
6. Profit					

2.1 Has the company received public support for investment in buildings and plants (eg subsidies for the purchase of machinery, tax breaks, credit facilities)? (SUBSIDY)

Year	2010-2011		2012-2013	
Type of public support	**Yes**	**No**	**Yes**	**No**
1.Provincial level				
2. Regional level				
3. National level				
4. European level				

[…]

2.4 What was the result of the innovative activities in the 2010-2011 and 2012-2013? (PRODUCT INNOVATION)

	2010-2011		2012-2013	
	Yes	No	Yes	No
Product innovation – new to the market				
Product innovation – new to the firm				
Process innovation				

[…]

2.6 What were the strategic objectives of the company in the periods 2010-2011, 2012-2013? Indicate the importance: 3 High importance; 2 medium importance; 1 lowimportance; 0 no importance / No objective of this type) (PRODUCT TYPES, MRKET PENETRATION, FLEXIBILITY, ENVIRONMENTAL IMPACT, SAFETY AND SECURITY, REGULATION)

	2010-2011	2012-2013
Expansion of the range of products and services		
Penetration of new markets / expansion of market share		
Greater flexibility in production		
Lower environmental impact		
Improvement of health and safety conditions		
Response to regulations		

/…/

3.Composition of supplier and customers and internationalisation

[…]

4. Evaluation of the consequences of the earthquake and of the perception of seismic risk

[…]

4.2 How much of the turnover was allocated to measures to reduce the seismic risk? (INSURANCE, SEISMIC MEASURES)

		2010-2011	2012-2013
1.	Insurance		
2.	Seismic measures		
3.	Other natural events		

4.3 Have you suffered direct and indirect effects from the 2012 earthquake? (By indirect effects we mean the effects not directly related to the company's production plants, but resulting from the impact of the earthquake on suppliers, customers or other partners) (DIRECT DEMAGE, INDIRECT DEMAGE)

□ No **(if NO end of the questionnaire)**

□ Direct effects

□ Indirect effects

4.4 Following the 2012 earthquake, how many months were the plants down?

Closed months	
Less than 1	
Between 1 and 3 months	
More than 3 months	

[…]

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