Resilience as a response to natural disasters: an empirical analysis of firms' reactions to the 2012 Emilia Romagna (Italy) earthquake

Davide Antonioli[*] Alberto Marzucchi[†] Marco Modica[‡]

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Until the '90s, the economic evaluation of natural disasters, both at micro and macro level, did not received particular attention, in the academic community (Okuyama, 2007). However, in recent years, an increasing number of analyses have been implemented to assess the economic impact of extreme natural events. Two aspects have received attention: the degree of preparation and the ability to recover (the so-called resilience) from the impact of the entity that has suffered the shock (e.g. firms, households regions, and so on). On these regards, firm-level literature primarily focus on two aspects: i) the firm characteristics that might foster or prevent the ability to recover from the disaster and ii) the strategic behaviours of firms. For instance, Runyan (2006) shows that the main aspects that have limited firms to recover from the damage caused by Katrina in 2005 were mainly due to: the poor capacity of preventing natural hazards, the lack of access to capital for reconstruction and the severe infrastructure problems of the region (also as a result of the hurricane). Hosono et al., (2012) and De Mel et al., (2012) provide evidence that the main barriers that reduce the capacity of firms to return to the pre-event conditions is due to the limited amount of investments and a related lack of access to capital. Miao and Popp (2014) show how different types of natural disasters contribute to a greater innovation on the risk mitigation technologies.

The framework of this study lies in two recent strands of contributions in applied economics. The first focuses on the effect of natural disasters on production, investments and productivity at both micro and aggregate level (e.g. De Mel et al., 2012; Hallegatte and Dumas, 2009; Hochrainer, 2009; Leiter et al., 2012; Miao and Popp, 2014; Skidmore and Toya, 2002). Extant literature does not always lead to clear conclusions on the expected sign of the effect of such events. In fact, while an extreme event, such as an earthquake, necessarily entails adverse destructive effects, the need of reconstruction can induce firms to increase investments and renew plants, leading to subsequent positive effects on firm performance. The

[*] Department of Management and Business Administration – DEA, University "G. d'Annunzio" of Chieti-Pescara (IT). Email: davide.antonioli@unich.it
[†] SPRU, Science Policy Research Unit, University of Sussex (UK). Email: a.marzucchi@sussex.ac.uk
[‡] IRCReS – CNR, Research Institute on Sustainable Economic Growth (IT). Email: marco.modica@ircres.cnr.it

second set of works considers the concept of resilience, namely the ability of a firms to maintain the output close to potential (Duval et al., 2007) or to preserve its functions (Rose, 2007), or to adapt its structure in order to maintain an acceptable production growth path (Martin, 2012) as a result of a shock (see Modica and Reggiani, 2015 for a review). Therefore, the focus shifts from the magnitude of the disaster to the effects on the recovery capacity and on the specific reactions that firms implement.

We contend that two kind of impacts should be analyzed when looking at the economic impact of natural disasters: i) the impact of a disaster on the economic performance and, ii) the effect on the strategic choices of firms. The impact on the economic performance has an inherent importance for the assessment of the damages produced by the earthquake on the productive system *per se*, but also represent the outcome of firms' resilience. The focus on strategic choices is aimed at analyzing the introduction of practices and behaviours that have been implemented as a response to the natural disaster and thus represent the mechanisms that favour the resilience of firms.

Our empirical analysis focuses on the 2012 Northern Italy earthquake. This event hit one of the driving areas of the Italian economy: the Emilia-Romagna Region, which accounts for around the 9% of national GDP (Source: Italian National Institute of Statistics, ISTAT) and is the only medium-high innovating Italian region, together with Lombardy. The dynamism of this region is the result of an evolution that has its origins in the famous 'Emilian Model' (Brusco, 1982), made of interactions between the productive and the social system. Nowadays the Emilia-Romagna region is characterized by a solid innovation system, where companies, institutions and research centres are widely interconnected (e.g. Marzucchi et al., 2015). Within the region, the earthquake affected in particular the provinces of Reggio Emilia, Modena, Bologna and Ferrara, whose value added in 2011 represented 5.36% of the national total, the 7.1% if considering the industrial added value only (Source: ISTAT).

Our analysis is based on a unique dataset stemming from a firm-level survey conducted in the aftermath of the earthquake. The survey was aimed at collecting information on the "treatment" status (i.e. presence of damages created by the earthquake), as well as variables concerning strategic decisions, economic performance, innovation, human capital and structural characteristics of the firms. Particular attention was paid to the distinction between direct and indirect damages. The former are defined as the damages suffered directly by the firm (e.g. partial or total destruction of the production facilities), the latter are defined as disruptions caused by damages suffered by the firm's partners (e.g., suppliers and customers). The survey intended to collect information on companies that were hit by the earthquake and similar firms

that were not affected by the event. In particular the following sampling strategy was adopted. First, sampling was carried out so as to include firms located in areas affected by the earthquake and in areas not affected by the event in the same region. The identification of the areas affected by the earthquake occurred on the basis of the official (Italian law N. 74/2012) list of municipalities that lie in the epicentral area. A total of 33 municipalities in the provinces of Reggio Emilia, Modena, Ferrara and Bologna have been recognized. In this way we had the opportunity to work on a set of firms potentially affected by the earthquake and counterfactual firms located outside the area of the earthquake. The identification of the firms included in the representative sample (254 observations in the epicentral area and 300 observations outside that area) was made by layering the reference population – manufacturing firms with more than 10 employees - by province, industry sector and size class (from 10 to 19, 20 to 49 and over 50 employees). The overall sample is thus made of "treated firms" and similar (on the basis of sector and size) "non treated" companies.

Exploiting the exogeneity of the treatment, and employing a suitable set of controls to minimize the potential omitted variable bias, our econometric analysis is based on a set of ordered probit models which accommodate the nature of our dependent variables. The results show that both direct and indirect damages have had a negative impact on the economic performance of firms. This evidence points out once again the difficulty in isolating the direct effects of the disaster on the investment trends of firms. In fact, the need for reconstruction has a positive effect on investment of firms but this appears to be offset by a reduction of the expected return as a result of the increased perception of risk. Moreover, even in presence of short-term negative effects on economic performance, the earthquake has also stimulated reconstruction strategies aimed at increasing production flexibility, new markets penetration, the reduction of the environmental impact, the increase of the labour safety conditions and increased compliance with the existing regulations.

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