

Innovation Strategies and Economic Crisis: Evidence from Firm-level Italian Data

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1. Introduction

A consistent number of empirical works have shown the existence of a significant positive relationship between growth and innovation, especially stressing the role of innovation for economic growth, both at the macroeconomic and microeconomic levels (see Griliches, 1995; Brynjolfsson-Yang, 1996; Black-Lynch, 2004; Lipsey-Carlaw-Bekar, 2005; Pianta-Vaona, 2007; Hall-Lotti-Mairesse, 2009; Antonioli-Mazzanti-Pini, 2010, and Leoni, 2012 to cite a few). In these studies, the fact that innovation - not only technological, but also organisational¹ - is an important driver of growth and competitiveness, of both countries and firms, emerges as a general result, which holds true across different geographical contexts and industrial sectors. However, the same result is usually obtained, and theoretically discussed, on the background of “normal” macroeconomic conditions, that is, without controlling for those severe global downturns which cyclically interrupt long-term growth trends (e.g. Reinhart-Rogoff, 2008; Lucchese-Pianta, 2011).

The severity and pervasiveness of the economic recession stimulated an analysis of the relation between innovation and firm resilience to the crisis challenges. For the Italian case, the state is even more peculiar than that of other developed countries: the economic crisis hit a stagnant economy, which had shown a rate of growth of the GDP next to zero for the period 2001-2008, with a brief positive interval in the period 2006-2007. The decline in productivity growth has opened a debate on its determinants (Faini-Sapir, 2005; Brandolini-Bugamelli, 2009). Several structural factors have been called into question to explain the stagnation of the Italian economy, ranging from the

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¹ See the recent literature discussed in the survey by Leoni (2013).

insufficient competitiveness of the Italian economic system, to the small size of the Italian firms, or the shortage of infrastructures or the excessive rigidity of the labour market. Indeed, diverse determinants co-exist, leading to the widening of the gap between Italian economy and other developed countries. The capacity of the economic actors, such as the firms, to react actively to the challenges brought by the crisis deeply influences the capacity of the whole economy to recover. For such a reason, it is of extreme importance to study Italian firms reaction to the crisis, with a special focus on the field of innovative activities as a response to the crisis.

A sample of 555 manufacturing firms located in the Emilia-Romagna region were surveyed, in order to collect information mainly concerning innovative strategies, coupled with several other information about firm level industrial and labour relations and working conditions (Antonioli-Bianchi-Mazzanti-Montresor-Pini, 2011). The regional level choice is primarily motivated, because the regional nature of innovation strategies has been recognised as relevant, by the recent literature on the Regional Innovation Systems (RIS), because the role of regional subsidies to sustain innovation projects has grown for Emilia-Romagna firms in the last decade and since Emilia-Romagna is one of the two most innovative regions (with Lombardia) in Italy (Hollander-Tarantola-Loschky, 2009). Moreover, a rebalanced emphasis that explicitly includes the role of 'Regions' as drivers of development and growth is present in the re-launching of the redefined Lisbon agenda. Thus, EU growth policy is moving the attention from economic sectors and consequent sector specialisation, to a more balanced perspective that accounts for regional/sector specialisation. This implies a full recognition of regional idiosyncratic elements, such as industrial relations, local policy, institutions and networks with specific characteristics that allow to distribute the risk of the crisis among all network members² (Cainelli-Montresor-Vittucci, 2012).

The work is organised as follows. The second section provides a brief overview of the background literature, which is useful in defining the research hypotheses. The third section reports the data and the methodology used in the empirical part. The fourth section provides a discussion of the econometric results, while the last section is left to conclusions and remarks.

² The EU policy scenario is currently holding more attention and focus on regional growth, rather than country convergence, to fulfil a long-run economic development. It is, thus, based more on attention to within country heterogeneity of 'regional economic stories'. The peculiarities and idiosyncratic features of EU regions have been recognised to be a source that has to be empowered. The new 'Smart Specialisation Strategy' based policies take in fact Regions as main actors of development, in line with the consolidation and suggestions coming from 'economic geography' and geography of innovation realms (Foray-David-Hall, 2011). This new policy emphasis on spatial and regional issues for the future economic development of Europe is a pillar of strategies that aim at achieving 20-20-20 goals and future cohesion policy targets from 2014 onward (see the DG-REGIO paper by Barca-McCann, 2011). The EC DG JRC IPTS will support implementation of smart specialisation strategies that place regions at the heart of EU economic growth.

2. Research background and hypothesis

Several authors have pointed out the linkage between innovation types and fluctuations of the business cycle. Focussing attention on microeconomic behaviour, Giedeman-Isley-Simons (2006) distinguish two broad categories of theories linking innovation to the business cycle: countercyclical (Hall-Blanchard-Fischer, 1991; Aghion-Saint-Paul, 1998) and procyclical ones (Stiglitz, 1993; Barlevy, 2007). The former stream of works considers the “opportunity cost effect”³ as a main engine to become more efficient during recessions. In periods of growth, firms have less incentives to reorganise the production process and to contrast inefficiencies, because the amount of foregone profits due to reorganisation activities could be very high. However, during recessions, when the demand for goods is low, such an amount of foregone profits is lower and it is more convenient to reorganise production and labour activities. According to this position, investments in organisational changes and training, which yield benefits over a long period of time (Aghion-Saint-Paul, 1998), are likely to be more countercyclical than other types of investments, such as R&D, that are cash intensive. The procyclical position focusses on the cyclicity of R&D activities. As an example, Barlevy (2007) shows how combining growth data and R&D data the hypothesis of procyclicality of R&D is supported. The explanation lies both on the constrained financial markets during recessions, that make it more difficult for firms to secure enough funds to conduct the planned R&D activities (Stiglitz, 1993) and on the likely short-run perspective of firms and entrepreneurs (Barlevy, 2005). Entrepreneurs know that the main gains from an innovation accrue in the short run, before the competitors learn and innovate on the original idea, securing for them a new stream of short-run returns; hence, entrepreneurs will be reluctant to invest resources during recessions, especially if recessions are expected to last in time, since the short-term gains would be lower than during booms.

Taking the move from this point, we shift our attention to a relatively unexplored set of firm level relations, in a short term perspective, during a recession period. As firms are the actors responsible for the introduction, implementation and diffusion of innovations, they are the fundamental (micro) actors through which innovation triggers or slows down (macro) economic growth and they represent our natural unit of analysis. More emphasis ought to be granted to the microeconomic perspective through the analysis of the strategies and behaviours of micro economic agents, instead of giving too much attention to macro aggregates. In our analysis, the crisis and the

³ Other mechanisms leading to high levels of productivity are also countercyclical according to Aghion-Sain-Paul (1998): clearing up or lame duck effect; disciplinary effect and externality effect.

fluctuations of the cycle become the background over which firms operate their strategic choices, according to their specific characteristics and pre-crisis strategies.

Our main aim is to investigate whether the more innovative firms before the crisis are also those more active in the innovation fields during the crisis, using innovation as a way to exit from the crisis and to cope with challenges brought by the latter. In fact, the more innovative firms could have planned (before the crisis) investments in R&D and other innovation activities they are reluctant to cut, even if demand drops. Moreover, it can be argued that the more firms are active before the crisis, in terms of innovation activities, the better they are equipped to pursue innovation activities, also during the crisis. Although we do not directly aim to test the persistence of innovation and to answer the question whether or not ‘success breeds success’, our research hypothesis could be inscribed at the margin of a stream of literature interested in verifying such a persistence over time (Peters, 2009; Raymond-Mohnen-Palm-van der Loeff, 2010). Indeed, we aim to verify the persistence of intense innovative activities at firm level, but with a short-run perspective and on the background of an economic recession looking at innovation reaction to the crisis. We can argue that there is a dynamic correlation over time among innovation strategies; thus, the first hypothesis is accordingly:

Hp1 Innovation activities before the crisis are related to innovative strategies to react to the crisis, pointing to a dynamic correlation of innovation activities (innovation calls for innovation);

A further aspect related to the linkage between innovation strategies concerns the issue of complementary innovation activities. Several works have investigated the effect of a joint adoption of managerial and organisational practices on outcome variables, ranging from innovation (e.g. Hujer-Radic, 2003; Bondarouk-Looise, 2005; Pini-Santangelo, 2010; Lynch, 2012) to firm’s economic performance (e.g. Caroli-Van Reenen, 2001; Janod-Saint-Martin, 2004). As for the organisation sphere, the same may hold for other innovation spheres, for which the issue of complementary activities is less explored: technology, information and communications technologies (ICT), environment and strategies of internationalisation. Complementary activities and practices within each of such innovation *spheres* are likely to exist. Whether or not such complementary nature emerges, when we consider the reaction to the crisis as the output variable, is an unexplored issue, as far as our knowledge is concerned; hence, the following hypothesis is put forward:

Hp2a Jointly adopting several innovation practices in each innovation *sphere* increases the capacity to react to the crisis through innovative actions (complementarities *within* innovation spheres)

The complementary nature of innovation activities is not limited to the boundaries of each innovation sphere (*within* sphere), rather, it is likely to hold also *between* innovation *spheres*. Even in this case, the literature mainly focusses on the impact of innovation complementarities on firm economic performance. The prevalent message stemming from the empirical contributions (see among others Aral-Weill, 2005; Laursen-Foss, 2003) is that a consistent innovation strategy, whose building blocks are complementary technological and organisational activities, leads to productivity gains. The ‘productivity paradox’ described by Brynjolfsson-Hitt (2000) is an illuminating example of what may happen when firms adopt innovations (ICT, in that case) without introducing complementary organisational changes that allow for the full exploitation of the ICT, formerly introduced. Following Pini-Santangelo (2005), who clearly recognises in labour, organisational practices and innovative activity of mutually feeding phenomena, as organisational practices provides “the flexibility which allows firms to promptly respond to the drastic pace of technological change [*and*] similarly, innovative activity feeds labour organisational practices by requiring greater organisational flexibility” (Pini-Santangelo, 2005, p.254), we can argue that innovating in *more than* one sphere does provide the firms with the necessary capabilities, skill base and flexibility needed to cope with the crisis, through an intense and diversified innovation reaction. Accordingly, the following hypothesis is proposed:

Hp2b Jointly innovating on different innovation *spheres* increases the capacity to react to the crisis through innovative actions (complementarities *between* innovation spheres)

A third set of firm level relations deals with the role of industrial relations on the capacity of firms to innovate as a reaction to the crisis. As put forward by several authors, both from theoretical (Metcalf, 2003; Menezes-Filho-Van Reenen, 2003) and empirical (Boheim-Booth, 2004; Blundell-Griffith-Van Reenen, 1999; Della Torre, 2009) points of view, the impact of union presence and activity on firm innovations is not univocal. The linkage between industrial relations and innovation has to be tested case by case, and in recent papers (Antonioli, 2009; Antonioli-Mazzanti-Pini, 2010) we provided evidence of an overall positive link between good quality (participative) industrial relations and innovation activities, especially on the organisational sphere.⁴ Participative industrial

⁴ It is worth stressing the positive role that cooperative industrial relations also have for workers’ well-being in Emilia-Romagna manufacturing firms, as pointed out by Antonioli-Mazzanti-Pini (2009; 2011).

relations contribute to a win-win strategic behaviour between management and unions, so that common goals and gains are pursued within a non-adversarial climate, favouring innovation activity. On the basis of the above consideration, we may argue that a 'good climate' between management and unions is crucial in times of economic crisis for containing costs and improving efficiency, mainly through changes in production process and labour organisation, which need to be shared by a large number of employees.

However, the traditional model of *indirect participation* has been challenged in recent years by the introduction of new human resource management practices, which delegate more responsibility and autonomy to the employees (Santangelo-Pini, 2011). A model of direct participation, without the mediating role of unions, has grown side by side with the indirect participation model, questioning the relevance of union representatives at firm levels and lowering their appeal: management practices addressed to increase employees direct participation may increase job satisfaction and job empowerment as well, reducing the scope for firm-level unions representatives, since the latter could become redundant, according to the employees (Antonioli-Pini, 2005; Machin-Wood 2005; Pini, 2005). Thus, it might be the case that a more direct participation model substitutes for the indirect one, making the relation between management and employees more relevant in sustaining innovation activities during the crisis than the relation between firm-level union representatives and management. This leads to the following two hypotheses:

Hp3a A good quality industrial relation climate before the crisis is positively related to the adoption of innovation strategies to overcome the crisis' challenges, since a high level of participation is functional to adopt innovation activities that are shared by a large amount of workers ('smoothly' implementable);

Hp3b A direct participation model overshadows the role of the traditional indirect participation, emerging as the leading industrial relations driver of an intense innovation activity to tackle the challenges brought by economic downturns.

Finally, the last set of firm level relations concerns firm economic performance and innovation activity. This issue has attracted the attention of several scholars, interested in evaluating the impact of innovation on firm performance (see among others Cappelli-Neumark, 2001; Zwick, 2004, 2005; Arvanitis, 2005; Black-Lynch, 2001; Janod-Saint Martin, 2004). However, for the aim of the present work it is appropriate to reverse the question: are the best performers before the crisis also those that intervene more intensively on innovation activities during the crisis? The reversed

question is of relevance in the light of the credit crunch ‘imposed’ by the financial crisis to economic agents. Because certain types of innovation, especially activities linked to product innovation, which usually rely on R&D investments, are cash intensive, we expect a positive link between performance and intensity in reaction to the crisis through innovation strategies. The ‘accumulation effect’, driven by a successful past that results in high levels of economic performance before the crisis, may influence the capacity to innovate during the crisis. This dynamic relation also results in a process of self-selection of the high performers as the group of most reactive firms.⁵ The fourth hypothesis can be formulated as:

Hp4 The economic performance in the pre-crisis period is positively linked to the reaction to the recession through innovative action.

3. Empirical framework

In order to test our research hypotheses, we base the analysis on micro-level data coming from a unique dataset concerning a sample⁶ of 555 Italian manufacturing firms with at least 20 employees located in Emilia-Romagna region (tab. 1), NUTS 2 level of analysis, which counts the 4th regional GDP in Italy⁷ and creates the 3rd regional industrial value added, counting around the 7% of the Italian population⁸. Moreover, the region is one of the two most innovative regions in Italy, with Lombardia, as stated by the Regional Innovation Scoreboard (Hollander-Tarantola-Loschky, 2009), which classifies Emilia-Romagna as a medium-high innovator region. In addition, the presence of industrial districts, mainly composed of small- and medium sized enterprises strictly intertwined, well marked entrepreneurship spirits, conjugated to a deep-rooted unionism and to common social and cultural values, constitute the elements of what has been called the “Emilian model” (Amin, 1999; Brusco, 1982). Such elements sum up to identify a Regional Innovation System (RIS), although with some peculiarities (Miceli, 2010) that lead Evangelista, Iammarino, Mastrostefano and Silvani (2002) to define it as an informal learning system.⁹

⁵ In a sense, the process underlying the firm decision to implement innovation activities with a high intensity, in order to react to the crisis mirrors the Melitz (2003) model on productivity and trade: in that model, the more productive firms are those that ‘self-select’ as exporters, when exposed to trade, while the least productive firms are eventually forced to exit.

⁶ The random sample is stratified by size, province (geographic location) and sector. It is well representative of the population, showing only minor distortions (tab. 1).

⁷ Italian territory is subdivided into 20 regions.

⁸ Data come from ISTAT (Italian National Institute of Statistics)

⁹ See also, Marzucchi-Antonioli-Montresor (2012), on the relationships the Emilia-Romagna manufacturing firms develop with research organisations and universities located both within and outside the regional borders.

Table 1 here

The original set of information we use was collected through phone interviews with the firm managements in 2009, and was based on a structured questionnaire, subdivided into several sections: the firm in the crisis, organisational innovation, training, technological innovation, environmental innovations, ICT, internationalisation, firm performances and firms descriptive characteristics. Almost the totality of the data refers to the pre-crisis period (2006-2008), unless those concerning firm economic actions (innovations) adopted to react to the crisis, which refer to the 2009. Finally, as expressed by a version of the Cochran test (tab. 1) for sample distortion, we have acceptable results.

The survey data have been merged with balance sheet data coming from the Bureau Van Dijk-AIDA database. The time span covered by such data refers to the period 2006-2008. The choice of the period was made in order to homogenize the time of the accounting variables with the survey ones (see section 3.1). The firms covered by balance-sheet data for all of the three years, are significantly less than the 555 surveyed firms (tab. 2) and appropriate methods were used to solve the missing data problems in the empirical analysis. The chosen accounting variables, labour productivity (VA/EMP), profitability (PROFIT/EMP) and cash flow (CASHFLOW/EMP) per capita, aim to provide a picture of the overall performance for the period 2006-2008 that can, potentially, affect the capacity to react to the crisis with innovative activities.

Table 2 here

3.1 Empirical model and variables

Provided that we have at our disposal a wide range of information and given the considerations reported in the second section, it is possible to set up the reduced form model as follows in order to test our research hypothesis:

$$(1) \text{ ACTION_INNO}_{i,2009} = \alpha_0 + \alpha_{1i,2006-2008}(\text{FIRM_SPEC}) + \alpha_{2i,2006-2008}(\text{INNO}) + \alpha_{3i,2006-2008}(\text{INDREL}) + \alpha_{4i,2006-2008}(\text{PERF}) + e_{i,t}$$

where i identifies the single firm, and 2009 and 2006-2008 represent the periods considered, FIRM_SPEC identifies the vector of firm-specific characteristics, INNO is the vector of innovation variable, INDREL encloses the industrial relations aspects and PERF is a vector of performance variables. A full description of all the covariates is provided below.

The convenient specifications to test the single hypotheses are reported in Section 4 where the results are discussed. The main econometric issues are tackled in the following way.

As far as the endogeneity problem due to simultaneity is concerned, it is possible to mitigate such a problem by exploiting the diachronic nature of the variables involved in the regressions, since the variables on the left-hand side are measured on a different period, with respect to those on the right-hand side (Michie-Sheean, 2003). We are aware of the fact that testing our hypothesis amounts to testing dynamic correlations in a multivariate framework, rather than causal relationships. As for the unobserved heterogeneity issue, we contend that the high number of firm structural variables coupled with relevant covariates capturing managerial attitudes allow to deal with large part of firm specific heterogeneity (Huselid-Becker, 1996), often attributable to the different managerial attitudes.¹⁰

Firm specific characteristics (FIRM_SPEC)

The structural variables used as controls aim at capturing some firm specific elements and also peculiar characteristics of the production context (FIRM_SPEC). Within this group (tab. 3) we have the usual sector dummies, size dummies and also the geographical location of the “registered office” of the firm, the “openness” to international markets provided by a variable capturing the percentage of turnover made on international markets and the belonging to a national or international group. It is also known whether or not a firm is a supplier, and the percentage of turnover made as a supplier. The workforce structure, in terms of manual and non-manual workers, is another element potentially influencing both the absorptive capacity of the firm and its innovative propensity and, as such, is included among the controls. Such controls are thought to be partially exogenous elements influencing the propensity to innovate. Coupled with such controls, we also use other firm specific variables, strongly related to the strategic decisions of the firms, that help in explaining the propensity to adopt more or less intense innovative intervention. Indeed, we classify the firms in terms of their pre-crisis behaviour and of their propensity to prefer ‘active’ policies to be implemented by policy makers to overcome the criticalities brought by the recession.¹¹

Another set of less usual controls, which captures firm specific aspects, is given by the indexes concerning workers conditions. The higher the index, the better is worker welfare, along several dimensions of the working environment (worker effort, economic incentives, degree of autonomy and responsibility, injuries, etc.). If worker welfare is high, it is more likely to observe satisfied

¹⁰ In synthesis, although we acknowledge the potential presence of endogeneity, we do not directly address the issue here. It certainly remains as an issue to cope with in future developments of the analysis, related to the linkage between innovation and firms’ economic performances.

¹¹ Information on this kind of propensity is given by specific questions in the questionnaire. They are available from the authors upon request.

employees, which might translate into more productive and innovation-oriented employees (e.g. Bartel-Ichniowski-Shaw, 2005).

Finally, we also know whether or not each firm received subsidies to support innovative programmes in the past (2004-2006), mainly related to R&D projects with specific characteristics.¹² The role of such subsidies may endure in time, leading the beneficiary firms to be more innovative, and better equipped to cope with the challenges brought by the recession.

Table 3 here

Pre-crisis techno-economic profile of the sampled firms

The set of “core” covariates is composed of variables capturing past (2006-2008) (a) innovation activities (INNO) of the firm in several spheres (technology, organisation, training, environment, ICT), as well as internationalisation strategies, (b) industrial relations quality (INDREL) as perceived by the respondents and (c) economic performance (PERF) (tab. 4). Each subset of variables allows us to test the hypotheses listed in Section 2.

The first subset (INNO) of covariates is assumed to have relevant linkages with the innovative activity in the crisis and it allows us to test Hp1, Hp2a and Hp2b. Specific and composite innovation indexes, as well as the interactions among the latter, are included in a first set of specifications, as fully described in Section 4. In so doing, we are able to depict whether the Emilia-Romagna industrial system copes with the crisis, widening the distance between leading innovators and the other firms and, possibly, moving toward an even more pronounced regional specialisation.

With the second subset of core covariates (INDREL), we aim to test the expected positive linkage between cooperative industrial relations and the propensity to innovate, as has been demonstrated in our previous works (Antonioli, 2009; Antonioli-Mazzanti-Pini, 2010). In so doing, we are also able to test whether or not the indirect participation model is capable of providing firms with the capacity to react more intensely to the crisis, or if it is the direct participation model to be more closely related to such a capacity (Hp3a and Hp3b).

Finally, with the last subset of covariates, given by performance indicators (PERF) for the period 2006-2008, which are constructed on the basis of balance sheet variables, we want to verify the relation between the pre-crisis economic performance and the capacity to robustly intervene with innovation during the crisis (Hp4).

¹² The regional subsidies have been provided in the framework of the PRRITT program: Regional Program For Industrial Research, Innovation and Technology Transfer. For recent results on the impact of PRRITT, see Antonioli-Marzucchi-Montresor (2013).

Table 4 here

Because of the number and nature of our covariates we, firstly, check for high levels of bivariate correlation, in order to exclude potential problems due to multicollinearity. The main relevant covariates do not show very high levels of correlations (tab. 5). However, the risk of multivariate collinearity cannot be excluded and a check for it is conducted in the econometric analysis, through the use of the Variance Inflation Factor (VIF) indicator.

Table 5 here

The dependent variables: innovative action to react to the crisis in 2009

Our dependent variables are given by innovative reactions to the challenges brought by the crisis (ACTION_INNO). Less than 1% of the interviewed firms declare a null reaction to the crisis¹³. In more detail, we asked the management whether or not, and with which degree of intensity, innovative interventions on product, process and organisation/HRM factors have been adopted to cope with the crisis (tab. 6). An average of the intensity of reaction of all the three dimensions is given by the ACTION_TOT index, which is an arithmetic average of the values of the three specific indexes of reaction.

Table 6 here

Each index of reaction is the expression of the average intensity degree of the intervention. As shown in table 6, the average degree of intervention intensity is quite high and close to a ‘strong’ degree for all the three typologies of action. As a whole, the firms are slightly more privileged with an intervention on the process dimension, rather than on product and organisation. This result is, somehow, expected if we consider, according to the countercyclical linkage between recessions and innovation, the bad times of the business cycle as windows of process/organisational changes implemented by the firms, which they are reluctant to undertake in periods of growth, because of the higher opportunity costs. Overall, we may say that firms of our sample are not inactive in front

¹³ The answers could be affected by a potential bias of cognitive nature. In brief, if a manager has a self-image of being active and an innovator, it is likely he/she behaves as an active and innovating manager, in order to avoid dissonance between his/her self-image and his/her behaviours. The same manager when asked about the innovation activity within the firm could tend to over-estimate it, in order to remain consistent with the image he/she has of him/herself, even if the level of innovation activity is low. In synthesis, we could have what is called a problem of cognitive dissonance here: if real events (low innovation activity) do not prove deeply-held manager beliefs (being an innovating manager) this generate a psychological discomfort so that he/she will respond through distortion and denial (when asked, he/she still confirms a high level of innovation activity within the firm). Unfortunately, because of data shortcomings, we are not able to control for the actual presence of such a problem of cognitive dissonance, for which we refer to Akerlof-Dickens (1982); Hosseini (1997); Oxoby (2004) and Smith (2009).

of the crisis, rather, they are active in reacting to it by implementing different strategies, ranging from the expected cost saving/efficiency gaining strategies (ACTION_PROC),¹⁴ to the less likely strategies aimed at increasing profits, due to higher level of competitiveness secured by further product innovations (ACTION_PROD)¹⁵ and by the construction of a more skilled/satisfied workforce (ACTION_ORG_HRM).¹⁶

4. Results

Our discussion of the results develops in order to test each hypothesis at a time on the basis of the general framework defined in equation (1).

Since firm specific characteristics are included in all the specifications, it is convenient to discuss their evidence here. Only the significant firm specific characteristics are discussed, but their results are not reported in tables 7, 8 and 9 for space constraint. A first general evidence is that the significant controls maintain their level of significance across the diverse specifications. It is also worth reminding that the set of firm specific characteristics we use largely outperform the standard controls used in the empirical literature, allowing us to capture much more firm heterogeneity, with respect to other empirical works.

Starting with the discussion of the results, they show that being a small- or medium sized firm (50-99 employees) might help coping with the crisis through the implementation of innovation actions, especially those actions related to human resource management and organisation (ACTION_ORG_HRM). The flexibility granted by the small size might be at the basis of a quick reaction, in the way that labour is managed and the firm is organised, to the challenges brought by the crisis. Firms belonging to an industrial group show a less innovative behaviour in the crisis, especially on the side of product innovation (ACTION_PROD). A tentative explanation is that groups might internally redirect their innovation efforts in order to address them towards markets where such efforts are potentially more valuable. Moreover, an additional strategic behaviour for groups could be that of delocalising the production process instead of reacting through innovation. In synthesis, the different options the groups have at their disposal to cope with the crisis challenges possibly reduce the probability of innovation intervention.

A negative coefficient is also associated with the suppliers. In this case, we may argue that suppliers are likely to be the link of the production chain that suffers more from the cash constraint, deriving both from the financial sector and from the deferred payments of their clients, represented

¹⁴ Absence of any action in the process dimension for 13 firms.

¹⁵ Absence of any action in the product dimension for 16 firms.

¹⁶ Absence of any action in the HRM/ORG dimension for 7 firms.

by other - frequently larger – firms (Cainelli-Montresor-Vittucci, 2012). Another general result concerns the positive significant coefficients usually associated to the firms ‘proactive behaviour’ (PROACTIVE). The latter means that a firm is dynamic in the pre-crisis and that it has a vision of what the policy makers should do in coping with the crisis that involves stimulus to the aggregate demand and to the development of human capital. Those firms sharing such characteristics seem to have a higher capacity to innovate during the crisis. Finally, another ‘pillar’ among the firm characteristics is given by the importance of providing the employees with a good quality working environment (WORK_COND_P). This index, that includes positive elements of the working environment, is positively related to the innovation reaction of the firms: especially with product and process elements.

4.1 Innovation before and during the crisis: does innovation call for innovation?

The first specification we use to test Hp1 and Hp2a,b shows the results as reported in table 7 and assumes the following forms:

$$(2a) \text{ ACTION_INNO}_{i,2009} = \alpha_0 + \alpha_{1i,2006-2008}(\text{FIRM_SPEC}) + \alpha_{2i,2006-2008}(\text{SPECIFIC_INNO_INDEXES}) + e_{i,t}$$

$$(2b) \text{ ACTION_INNO}_{i,2009} = \alpha_0 + \alpha_{1i,2006-2008}(\text{FIRM_SPEC}) + \alpha_{2i,2006-2008}(\text{COMPOSITE_INNO_INDEXES}) + e_{i,t}$$

$$(2c) \text{ ACTION_INNO}_{i,2009} = \alpha_0 + \alpha_{1i,2006-2008}(\text{FIRM_SPEC}) + \alpha_{2i,2006-2008}(\text{INNO_INTERACTIONS})^{17} + e_{i,t}$$

where the dependent is in turn, for each specification, an overall measure of reaction to the crisis (ACTION_TOT), a reaction on process innovation (ACTION_PROC), a reaction on product innovation (ACTION_PROD) and a reaction on human resources and organisational aspects (ACTION_ORG_HRM). The FIRM_SPEC vector encloses the firm specific characteristics, the SPECIFIC_INNO_INDEXES vector is given by the innovation indexes capturing specific elements of the innovation activity within each innovation sphere, the COMPOSITE_INNO_INDEXES vector encloses indexes for each innovation sphere, which are constructed on the basis of the specific innovation elements, and finally, the vector INNO_INTERACTIONS is given by the multiplicative interaction between couples of composite innovation indexes.

Looking now more closely to each specification, we notice the relevant correlation of several ‘before-crisis’ innovative practices with the intensity of reaction (Hp1). Two pillars of the organisational sphere, changes in both labour and production organisation (LAB_PRACTICES and

¹⁷ The composite indexes we chose to interact were centred around their mean in order to construct multiplicative interacting variables (INNOxINNO) that are not correlated to each other, so that we can include them in the same specification avoiding multicollinearity problems.

PROD_PRACTICES), are positively linked to the overall reaction intensity and to the ACTION_ORG_HRM. A mixed evidence is instead associated to the training sphere. On the one hand, we have a positive and significant coefficient for permanent employees covered by training programmes (COV_PERM), pointing to the importance of new skills and competences to sustain innovative organisational/HRM activities during the crisis. On the other hand, we find a negative sign associated to the variable capturing the wideness of competencies covered by training programmes. The result is quite puzzling, but it might be due to a sort of threshold effect: widening too much the competencies in the pre-crisis turns out to be an obstacle to further innovation actions in the recession phase.¹⁸

For the technological sphere, INPUT_TECH is positively linked both with the overall reaction and with product and process reaction. Finally, also the activities covered by ICT (ACT_ICT) are positively related to process innovation in the crisis. This list of relations outlines the importance of past innovation for the firm capacity to implement innovation activities during the crisis as a way to answer to the challenges brought by the crisis itself, confirming the validity of Hp1 for the covariates belonging to several innovation spheres.

¹⁸ Such a result holds for specific types of competencies and innovative reactions. A check on the specific types of competencies shows that ‘technical competencies’ and ‘organisational/relational competencies’ are the two elements out of four (see tab. 4) to drive the sign and the level of significance. On ACT_PROD the ‘technical competencies’ and on ACT_PROC the ‘organisational/relational competencies’ show negative and significant coefficients. Results are not reported for space constraint, but they are available upon request.

Table 7 here

We now question whether or not some forms of synergy exist among pre-crisis innovations that exert an effect on the capacity to implement innovation activities during the crisis (tab. 7): Hp2a and Hp2b. With Hp2a we aim to test the existence of *within* innovation sphere complementarities. For both INNO_ORG and INNO_TECH we may claim that the nature of innovation activities within each of the two spheres is synergic: indeed such composite indexes are significant and have relatively larger coefficients with respect to their specific elements, which also emerged as significant.

For the ICT sphere, the presence of potential complementarities seems to emerge more robustly, since the composite index has a positive and significant coefficient for ACTION_TOT and ACTION_PROD, while the specific indexes are not related to such dependents. In this case, a complex strategy of joint introduction of different types of ICT, accounting for several managerial activities and objectives (Electronic Data Interchange, Enterprise Resource Planning, etc.), seems to create a background over which a more intensive reaction to the crisis is feasible.

Also noteworthy is the (weak) relation of the environmental innovation (INNO_ENV) composite index with ACTION_ORG_HRM. This result may be interpreted as the capacity to integrate environmental innovation with other organisational factors, mainly involving the management of human resources and organisational aspects. Whether such an integration is capable of bringing the firms out of the crisis along a sustainable path is a matter of interest for future works.

The last set of results is provided in order to verify the Hp2b, which is only marginally supported by our evidence. A quite robust evidence supporting this type of complementarities emerges only for training and environmental innovation (TRAINxENV), for the overall reaction and both for process and organisational/HRM aspects. We may argue that the small fraction of firms engaged in environmental related innovation activities is dynamic and possibly more flexible than the counterpart not involved in green strategies. Such dynamism is supported by investment in workers' human capital and it persists over time, even in a period of deep recession, leading these firms to react more intensively to the crisis challenges. Also, the interaction between technological innovation and ICT (INNO_TECHxICT) is robustly related to the reaction intensity in organisational/HRM aspects. Firms involved in complementary technological and ICT innovations before the crisis seem to be aware of the need for the introduction of further complementary organisational and human resource practices to complement the technological/ICT ones, also in time of crisis.

The two interacted terms slightly and negatively significant INNO_TECHxINNO_ENV and INNO_ORGxINNO_TECH seem to point to a sort of trade off between high levels of innovation intensity just before the crisis on different innovation spheres and the capacity to innovate during

the crisis for product innovation and for the overall index of reaction.¹⁹ Although the evidence is very weak, a tentative explanation might be that the intense innovative effort in such specific innovation spheres makes firms equipped only to tackle the crisis challenges in virtue of the innovation activity made before the crisis. Another possible explanation may lie on the fact that most dynamic firms, in terms of these specific couples of innovations, could have been more strongly displaced by the crisis, because they were in a moment of change and they were possibly financially stressed.

In synthesis, the evidence points out how the innovation persistence, before and during the crisis, can be attributable to a tradition of incremental innovation and accumulation of competences, over time (see Antonioli-Bianchi-Mazzanti-Montresor-Pini, 2011 for a detailed description of Emilia-Romagna manufacturing firm innovation strategies): the more innovative firms had been in the past, the more innovative during the crisis they tend to be. It is likely that such ‘path dependency’ builds on the basis of existing competencies and capabilities that had been widened and developed through organisational changes and technological innovation before the recession. The role of synergic innovation activities is also confirmed, especially *within* the innovation sphere, while the complementary nature of innovation activities belonging to different spheres (*between* innovation spheres complementarities), that usually emerges with reference to economic performance, is less evident.

4.2 The industrial relations climate: how do firm-level employment relationships influence the reaction to the crisis?

In order to test the Hp3a Hp3b hypotheses we set up the following specifications:

$$(3a) \text{ ACTION_INNO}_{i,2009} = b_0 + b_{1i,2006-2008}(\text{FIRM_SPEC}) + b_{2i,2006-2008}(\text{COMPOSITE_INNO_INDEXES}) + b_{3i,2006-2008}(\text{INDREL_COMPOSITE_INDEXES}) + u_{i,t}$$

$$(3b1) \text{ ACTION_INNO}_{i,2009} = b_0 + b_{1i,2006-2008}(\text{FIRM_SPEC}) + b_{2i,2006-2008}(\text{COMPOSITE_INNO_INDEXES}) + b_{3i,2006-2008}(\text{INDREL_SPECIFIC_INDEXES}) + u_{i,t}$$

$$(3b2) \text{ ACTION_INNO}_{i,2009} = b_0 + b_{1i,2006-2008}(\text{FIRM_SPEC}) + b_{2i,2006-2008}(\text{COMPOSITE_INNO_INDEXES}) + b_{3i,2006-2008}(\text{INDREL_SPECIFIC_INDEXES_BY_INNOVATION}) + u_{i,t}$$

where ACTION_INNO and FIRM_SPEC vectors are defined as before (see specifications 2a, b, and c), the COMPOSITE_INNO_INDEXES vector is the same as in specification 2b,

¹⁹It is worth stressing the low level of significance of the coefficients (10%), especially in a cross section environment.

INDREL_COMPOSITE_INDEXES is made of two main industrial relations variables, one (UNION_INV) capturing the cooperative nature of the relation between unions and management (indirect participation), and the other (EMP_INV) capturing the same participative relations between employees and management (direct participation). The INDREL_SPECIFIC_INDEXES encloses more specific participative variables as described in table 4. Finally, the INDREL_SPECIFIC_INDEXES_BY_INNOVATION is a further refined set of variables that captures the degree of unions and employees ‘participation’ in the decisions concerning each innovation sphere.

We, thus, capture both the correlation of cooperative industrial relations with the reaction to the crisis and the potential substitution effect between indirect and direct participation.

It is worth stressing that the analysis is conducted for the firms with union representatives,²⁰ a sample of 402 firms.²¹

As we can see in table 8, the main composite indexes of both direct and indirect participation, which capture less adversarial employment relationships, are not significant. This means that a general involvement of unions and employees is not related to a high level of innovation reaction to the crisis. This first evidence would leave us to consider a participative industrial relations climate substantially neutral. However, if we refine our analysis by looking at the specific degree of involvement, we find that having implemented a process of bargaining with unions (on changes over the innovation spheres) before the crisis is correlated with a high reaction capacity. The link is more robust for the overall reaction to the crisis and less for the other specific strategies, but if we couple this evidence with the quite robust and positive linkage of employees involvement, although through simple information, with product innovation we can argue that H_{p3a} is not rejected. The interpretation behind this evidence could be that the mediating role of the unions is important, in order to smooth the adoption of innovation activities that may have a possible negative outcome for the employees (e.g., process changes in order to reduce the labour costs).

²⁰ In such a way, we are not forced to arbitrarily impute a value in the industrial relations variables concerning the unions/management relationships for those firms with no union representatives.

²¹ Because the employees involvement may be present, also where union representative are not present, and possibly be even wider where unions are absent, we also run regressions for the 153 firms without unions, in order to verify the influence of employees involvement. The results tell us that employees’ involvement does not have any significant impact on the innovative reaction in the crisis. The results are not reported due to space constraint but they are available from the authors upon request.

Table 8 here

Notwithstanding the challenges brought by the diffusion of managerial practices addressed to increase the employees involvement without the mediating role of the unions, it appears quite clear how a participative industrial relation climate favours firms addressing innovation strategies.

Looking at the specific indexes of unions and employees involvement on each innovation sphere, we notice that the higher the employees involvement on environmental related innovation, the higher is the reaction capacity of the firm, while the union representatives involvement on two single innovation spheres, environmental innovation and internationalisation, shows some negative relations with the capacity to innovate in the crisis. The same is also true for the employees' involvement on internationalisation strategy when the dependent is innovation in product related activities. It seems possible to infer that, for the share of firms undertaking environmental innovation, the employees' involvement represents an element that improves firm capacity to react to the crisis through further innovation. Hypothesis Hp3b finds weak partial support. We are looking, although through a static picture provided by our data, to a likely process of 'relevance transfer', from indirect to direct participation of the employees in the decisions related to environmental innovation activities.

In synthesis, we may argue that the strategic reaction through intense innovative actions is also supported by a pre-crisis participative industrial relations climate, when participation has to be intended as indirect participation. The role of unions acquires importance in a phase of deep production contraction. We argue that the strategic choices adopted to deal with the crisis need more consensus and cohesion between social parties, in a period of economic downturn than in a stable or growing economic environment and non-adversarial relationships between management and unions may provide such a consensus, more than employees' direct participation. However, the latter emerges as important especially for firms involved in environmental innovations, pointing to a process of substitution between indirect and direct participation, that might have been delayed but not stopped by the economic crisis. This has revived the role of unions as institutions to deal with, faced with grievances and conflicts, more frequent during an economic downturn than in a stable phase of the economic cycle.

4.3 Does past economic performance act as a base upon which to rely in order to innovate during the crisis?

Because both innovation and industrial relations add knowledge to our investigation of innovation reaction, we keep them in this last set of specifications, to which we add past economic performances.²²

$$(4) \text{ ACTION_INNO}_{i,2009} = c_0 + c_{1i,2006-2008}(\text{FIRM_SPEC}) + c_{2i,2006-2008}(\text{COMPOSITE_INNO_INDEXES}) + c_{3i,2006-2008}(\text{INDREL_SPECIFIC_INDEXES}) + c_{4i,2006-2008}(\text{ECONOMIC_PERF}) + v_{i,t}$$

where the vectors FIRM_SPEC, COMPOSITE_INNO_INDEXES and INDREL_SPECIFIC_INDEXES are as in the previous sections and the vector ECONOMIC_PERF is given by three account indicators that are expressed in rate of growth for the period 2006-2008: value added per employee, cash flow per employee and profit per employee.

In order to overcome²³ missing values flaws, we implement the Multiple Imputation (MI) procedure.²⁴ The MI procedure is reasonable if we assume that the missingness pattern is at least a Missing At Random (MAR) pattern, that is to say, the “probability that data are missing does not depend on unobserved data, but may depend on observed data” (Stata Manual, 2009, p.6). In our case, we are able to control for the variables likely to induce the missingness pattern, such as the firm dimension: the smaller the firm, the higher the probability of having missing values in the account data. Hence, we are confident in defining the missingness pattern of account data as a MAR.

We notice, in table 9, that there is no relationship between pre-crisis growth of performance indicators and firm capacity to react in an intense way, hence, Hp4 is not supported by our evidence. The absence of any significant relation is a signal of the potential disrupting effect of the recession on the ‘traditional’ linkage between innovation and economic performance, as pointed out by many scholars, notwithstanding the causal nexus and the causality direction (see among others the recent contributions by Coad - Rao, 2010 and Hall, 2011, for an assessment of the linkage

²² Here, we return to the 555 firms, although industrial relations variables are used. Since we are no longer interested in the relation between industrial relations and innovative reaction (we analysed such a relation in the preceding section), but we do not want to lose relevant information, we decided to fill in the missing values in the industrial relations variables with zeroes (0s).

²³ With missing values, originally in the account dataset and those generated by the processing of the data, the remaining observations are 233. The analysis run on this limited subset of observations provides similar results with respect to those presented in table 9. Evidence is available from the authors upon request.

²⁴ The procedure creates multiple datasets on the basis of the original one. We decided to generate 20 of them, in order to reduce the sampling error. The original missing values are replaced by ‘plausible’ values. All the covariates used in the regression model (the completed model), as well as the outcome variables of such model, are also used as predictors in the imputation model, in order to avoid misspecification in the imputation model. The analysis of the completed-data model is then performed over the 20 datasets and the results are combined in a single result (see the Stata Manual, 2009, for further information).

between innovation and economic performance). Here, we find a different evidence; it is as different as the innovative reaction to the crisis, with respect to the business-as-usual innovation activity during stable periods of the economic cycle. This evidence means that the reaction of high performers is not dissimilar to the reaction of poor performers, before the crisis. The disruptive nature of the crisis breaks the positive linkage between economic performance and innovation.

Table 9 here

The specific evidence reported in tables 7-9 is synthesised in table 10, in order to provide a meaningful set of results that can be easily referred to the hypotheses.

Overall, it is clear how the first set of hypotheses, related to the linkages among innovations before and during the crisis, is largely supported by our evidence. The same holds, although with a lesser degree of robustness, for the relationships between participative industrial relations and innovation reactions, while there is no evidence of a nexus between economic performance in the pre-crisis, and innovation during the recession.

Table 10 here

5. Conclusions

The present work shows the reaction of Emilia-Romagna manufacturing firms faced with the economic downturn, by means of econometric analysis, based on data from a structured survey carried out in 2009.

The econometric exercise provides evidence for the main research hypotheses concerning the linkages between pre-crisis innovative strategies, economic performances and industrial relations and the capacity to react to the crisis through further innovation activities. In a sense, we are investigating whether the Emilia-Romagna manufacturing firms have the resistance to survive the economic crisis and to resurge in the medium run as one of the leading industrial manufacturing system. On the basis of our evidence we can provide some tentative considerations.

The reduced-form model, with innovative activities in the recession as dependent variables, clearly shows how some firm specificities are important in sustaining innovation as an instrument to react to a downturn. Because it is not straightforward to think about innovation as a means to overcome the recession criticalities, we consider the characteristics that positively impact on the innovative strategies in the crisis as extremely relevant. Indeed, it seems that the crisis has to be considered, to some extent, more as a period of change (Mensch, 1979) rather than inertia for

Emilia-Romagna manufacturing firms, given the declared intensity of innovation. Furthermore, a sustained innovative activity may contribute in a crucial way to the survival and to the competitive capacity of the firms at the end of the slowdown: the higher the innovation intensity in the crisis, the shorter will, probably, be the shadow cast by the crisis upon the future. The capacity of firms to maintain a certain coherence between innovation strategies, before and during the crisis, is a point of strength of the Emilia-Romagna manufacturing firms: the recession phase does not interrupt the innovation path.

Globally, the analysis of the dynamic relations between pre-crisis and during-crisis innovation activities clarifies the complex nature of the innovation strategies. Complementarities among innovation activities *within* each innovation sphere clearly emerge, while the crisis nature and strength seem to weaken the complementary link *between* innovation spheres.

A further important element for the implementation of all the innovation strategies in the crisis is the connotation of the industrial relations climate: the more participative the relations are, the better this will be for the innovation intensity during the crisis. The analysis on industrial relations aspects points out the importance of indirect participation of the employees through union representatives, but also the relevance of direct employees' participation. The dialogue between management and unions turns out to be important in times of crisis, as 'driver' of a superior capacity to react to the crisis through innovation. Although the social dialogue and the industrial relations system have been undermined in the last decade, for several reasons - ranging from critical government orientation towards the social dialogue, to the lack of capacity of the unions to provide a unified front and, at firm level, to the diminished quality of the union representatives, which hampers the capacity of the union to resolve, in an efficient and efficacious manner, the manifested grievances - the firm level industrial relations climate, oriented to cooperation, rather than to conflict, is a point of strength of the Emilia-Romagna production model.

The same does not hold for the pre-crisis economic performance effect. The substantial lack of significance of economic performance indicators coupled with the results of past innovation strategies tell us that it is not the economic trend of a firm which supports innovation activities in the crisis, rather it is its innovation dynamism before the recession: in a sense, innovation calls for innovation. Hence, the lack of economic performance lock-in emphasises the role of various innovative drivers and encourages firms to adopt innovations to tackle downturn periods.

Our main results translate into clear recommendations to policy makers and social actors. The first one concerns the strategic choice to innovate. This should be a priority in positive phases of the economic cycle, because it helps in sustaining the firm competitiveness, and also because it creates the capacity to cope with the crisis challenges, in a way that can lead to a smoother exit from the

economic downturns. Thus, on the one hand, the firm management is called upon to be dynamic on the innovation side and, on the other hand, regional policy makers should be aware of the importance of policy programmes aimed at sustaining not only firm innovation activities, but also those elements that help to connote a regional innovation system. One of these elements is the social dialogue among the economic actors. Indeed, the main second insight concerns the importance of fostering social dialogue. The latter turns out to be a powerful instrument to accommodate different innovation strategies.

The evidence suggests that designing a consistent and coherent innovation strategy could help firms in constructing their capacity to react to the downturns through innovation. This can be thought to be an exit strategy, potentially capable of creating post-crisis competitive advantages.

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Summary: Innovation Strategies and Economic Crisis: Evidence from Firm-level Italian Data
(J.E.L. L1, L23, L6, J53, O3)

The disruptive economic downturn of the period 2008-2009, forced industrial firms to implement strategies, in order to survive and to generate new competitiveness sources. One of such strategic behaviours regards the way of intervention on several innovation areas through different strategies. Disentangling the effect of pre-crisis adopted innovations, industrial relations quality and economic performance on such strategies may be of extreme relevance to analyse the nexus between the reactions to the challenges brought by the crisis and the capacity of the firms to proactively tackle economic downturns.

The present work provides an empirical analysis on the basis of more than 500 Italian manufacturing firms located in Emilia-Romagna region. The results suggest the existence of strong relationships between pre-crisis innovative activities and the capacity to react to the challenges brought by the crisis. This happens through innovative strategies, whose contents are mainly product (technological competitiveness), process and organisation/HRM innovative dimensions (cost competitiveness/efficiency gaining). Complementary innovative activities emerge as a key factor. Industrial relations quality is also related to the strategic reaction to the crisis: more participative industrial relations support the adoption of diversified types of innovation strategies. There is, instead, no evidence of a relation between past economic performance and innovation actions in the crisis.