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Economic Crisis, Innovation Strategies and Firm Performance. Evidence from Italian Firm-level Data

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Abstract

Several empirical works have shown the robust and positive relation between growth and innovation at macroeconomic level and between firm economic performance and innovation at microeconomic level. However, the economists have had less opportunities to study such linkages during severe global downturns of the economic cycle. Moreover, the present disruptive economic downturn has forced the firms to implement survival strategies. One of such strategic behaviour regards the way of intervention on product and process areas through innovative actions.

Focusing the attention on the micro level, the present work provides an empirical analysis on the basis of more than 500 Italian manufacturing firms located in Emilia-Romagna region, with the aim of disentangling the relations between pre-crisis innovation strategies and firm economic performance during the crisis as well as the linkages between the innovative actions taken to react to the recession's challenges and the economic performance in the recession.

The results suggest the existence of strong relationships between past innovative activities and the capacity to react to the challenges brought by the crisis through innovative actions along product, process and organization/HRM dimensions, although the role of complementarities among past innovative activities does not emerge robustly. When the dependent variables are performance indicators the impact of pre-crisis innovation strategies emerges as robust for technological and organizational spheres, while intense innovative activities before the crisis on spheres like ICT, training and environment are detrimental for performances in the crisis. It seems that when the crisis hits those firms in a process of quite radical transformation and change, then the negative economic consequences of the recession are worse than in the case of firms on a more stable, less dynamic path.

Keywords: innovation strategies, economic crisis, firm performance.

JEL classification: L1, L23, L6, O33

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1. Introduction

A consistent amount of empirical works has shown the existence of a significant positive relationship between growth and innovation, both at the macroeconomic level and at the microeconomic one, that is between firms' economic performance and their innovativeness. As for the former, be enough to mention, for example, the works by Griliches (1995), Brynjolfsson and Yang (1996) Lipsey, Carlaw, Bekar (2005), Pianta and Vaona (2007) and Bartel, Ichniowski and Shaw (2005), as for the latter, those by Black and Lynch (2001), Caroli and Van Reenen (2001), Hall, Lotti and Mairesse (2009) and Antonioli, Mazzanti, Pini (2010), among the others. In these studies, the fact that innovation - not only technological, but also organizational - 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. Still, the same result is generally obtained, and theoretically discussed, on the background of "normal" macroeconomic conditions, that is in the absence of those severe global downturns which cyclically interrupt long-term, growth trends (e.g. Reinhart, Rogoff, 2008).

The severity and pervasiveness of the economic recession brought about by the sub-prime financial crisis burst in 2007 urged a re-analysis of the link between innovation and economic performance in times of economic crises (Bianchi, Pini, 2009). For the Italian case the situation is even more peculiar than that of other developed countries: the economic crisis has hit a stagnant economy, which had shown a rate of growth of the GDP near zero since the 2001 till the 2008, with a brief positive interval in 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 insufficient competitiveness of the Italian economic system, to the dimensional problem of the Italian firms, passing through a shortage in infrastructures or through an excessive rigidity of the labour market. If we do not take a dogmatic position we can say it is likely the diverse determinants of the decline co-exist, summing up each other negative effects on the economic growth, leading to the widening of the gap between the growth of our economy and that of other developed countries. Indeed, the experimented recession was detrimental for any economy, however it has also opened a period of deep turmoil, not yet closed, creating new business opportunities. 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 in the medium run and to grow. Thus, given the economic crisis and the Italian economy situation it becomes of extreme interest to verify for a sample of Italian firms their reaction to the crisis and their economic performance, with a special

focus on the determinants both of the strategic reaction in the field of innovative activities and of the economic performance.

A sample of 555 manufacturing firms located in the Emilia-Romagna region were surveyed in order to collect information concerning innovative strategies and economic performances, coupled with several other information about firm level industrial and labour relations and working conditions (Antonioli, Bianchi, Mazzanti, Montresor, Pini, 2010). The regional level choice is motivated by the regional nature of the so innovation strategies of the firm, also spurred by regional subsidies rather than national ones, and because Emilia-Romagna is one of the two most innovative regions (with Lombardia) in Italy (Regional Innovation Scoreboard, 2009).

The paper is organized as follows. The second section provides a brief overview of the background literature, which is useful in defining the research questions of this work. The third section reports the data and the methodology used in the empirical part. The fourth section is left to a brief description of firms reactions to the crisis and their performance. The following section provides a discussion of the econometric results, while the last section is left to conclusions and remarks.

2. Firms, innovation strategies and the economic crisis

The link between innovation and firm performance has been extensively investigated in economic literature. However, the empirical analysis has often been directed to verify the effect exerted by (or the linkage between) a single innovative activity on the economic performance, while the innovative strategy of a firm should be considered in its all multifaceted aspects.

On the basis of recent empirical contributions we can distinguish between several types of innovative areas: technology, ICT, organisation, training, environment and strategies of internationalisation. As far as the first area (technology) is concerned we cannot neglect the strong relation between technological progress and growth analysed by more than a century of economic theory and tested at empirical level (Aghion, Howitt, 1998; Griliches, 1995; Pianta, Vaona 2007; Hall, Lotti, Mairesse, 2009). Technological progress means several things but it has been mainly conceived as innovation in product and process till the 90s, when the sharp and rapid diffusion of ICT “stole the show” to the product and process innovations as main engine economic growth (Brynjolfsson, Yang, 1996; Bartel, Ichniowski, Shaw, 2005; Morrison, 1997). Both innovations in product and process and new ICT lead to productivity growth, especially when the phenomenon of “productivity paradox” is avoided thanks to the joint introduction of organisational practices that fit the organisational environment of the firms and the workforce to better exploit the potential of the

new technologies (Hughes, Scott Morton, 2005). Thus, the organisational dimension and the management practices (Bloom, Van Reenen, 2007) are crucial as they represent an innovation area which deserves investments in order to directly generate better performances for the organisation and it is also a ground that may sustain complementary innovation activities and investments in other areas of innovation (Huselid, 1995; Huselid, Becker, 1996; Black, Lynch, 2001; Zwick, 2004; Janod, Saint-Martin, 2004; Antonioli, Mazzanti, Tortia, Pini, 2004; Pini, Santangelo, 2005, 2010; Mazzanti, Pini, Tortia, 2006; Antonioli, 2009; Antonioli, Mazzanti, Montresor, Pini, 2010). An autonomous role in determining the economic growth, at macro level, and the productivity performance of the firm, at micro level, can be assigned to the training activities adopted within the firm, even if the training strategies might be included in the organisational area. In line with the implications of the human capital theory several contributions have stressed the importance of a better trained workforce in determining labour productivity (see among others Conti, 2005; Zwick, 2005; Guidetti, Mazzanti 2007, Wheeler, 2007; Andersson, Grasjo, Karlsson, 2007). In addition, it is worth stressing the very complementary nature of the training strategies to the other innovative activities, because they provides skills and competences that enable the workers to fully exploit the innovation implemented or to be implemented.

The environmental dimension of the innovation activity is strongly linked to the other innovative dimensions, although the firms have to face the nature of impure public good of the environmental innovation, because the rents generated by such kind of innovations are only partially appropriable to the firm (Mancinelli, Mazzanti, 2004; Mazzanti, Zoboli, 2009). However, intense innovative strategies on the environmental side, when integrated with other innovative spheres, may increase the firm competitiveness, in addition to the creation of positive social externalities. A sustainable growth characterised by the de-linking between the dynamic of indicators of environmental impact and economic growth (Mazzanti, Montini, 2010) is no longer a negligible issue, thus the environmental innovation strategies have to be included in a comprehensive analysis of the innovative activities at the firm level.

Last but not least, the internationalisation strategies are here considered as an integrated and complementary element of the innovative strategy of a firm. The link between innovation and internationalisation is sound and it has been theoretically stressed and empirically proved (e.g . Castellani, Zanfei, 2006; Frenz, Ietto-Gillies, 2009; Crespi *et al.*, 2008; Keller, 2004). It is consolidated a sort of “consensus-view” on the bi-directional causal relation between innovation and internationalisation. On the one hand, those firms included in global value chains may acquire innovative capabilities coming from abroad as well as they can benefit from innovative spillovers generated at local level by multinational firms. On the other hand, the most innovative firms are those more able to penetrate international markets in order to exploit investment opportunities in foreign countries. The couple of strategic activities given by

internationalisation and innovation may induce virtuous cumulative effects for the firm (see as an example the recent contribution by Filippetti *et al*, 2009), which also include the firm's economic performance.

The above considerations formulated on the base of the international literature provide a framework of interdependencies among the innovation spheres, which induce to take into consideration the potential complementary and synergic role they may exert on the economic performance of the firm, with a not negligible role given by internationalisation strategies. For such a reason this work takes a broader perspective, when compared to that of the majority of the contributions on innovation and its effect on firm performances mentioned above, which is based on the assumption that different types of innovative activities reinforce each other's effects on firms' performance and therefore can be considered complementary to each other (Antonioli, 2009). Organisational capabilities and human capital are crucial enablers of innovation activities along the technological dimension (Coriat, Weinstein, 2002; Brynjolfsson, Yang, 1996; Leiponen, 2005). The accumulation of capabilities determines the absorptive capacity of the firms towards technological innovations with the effect of helping to set the innovative path, from a technological point of view, along which the firm moves. At the same time innovation adopted may need further new knowledge, which need to be managed, maybe requiring changes in the organisational structure of the firm (Hall, Mairesse, 2006). Changes on the side of knowledge and skill base of the firm, as well as in the management of the innovation-knowledge, may generate a wider capacity to absorb and implement environmental innovations, generating positive externalities. A corollary of such processes may be given by the capacity of the firm to penetrate new markets and to set up internationalisation strategies that are not only addressed to reduce production and labour costs.

In synthesis, the single innovative spheres discussed above may be brought back to an integrated and consistent framework that can be used to determine what kind of relationships between the several dimensions of the innovative strategies of the firm are those more useful to explain sustained competitive advantages and economic performances above the average even in period of severe economic downturn.

The importance of a coherent and consistent set of innovative strategies should last in time and the dynamic of the strategies has a crucial role. Hence, because the crisis may induce radical changes in the firm strategic decision, a first aim of the present work is to verify the consistency of the innovative strategies of the firm before and during the crisis. More specifically we aim to test 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.

The second objective is that of analysing the role of the innovative activities on the economic performances of the firm during the crisis, focusing the attention on the complementarities existing among the innovative dimensions, hypothesising a positive role of integrated innovative strategies in increasing the firm resilience to the challenges brought by the economic crisis. Once controlled for firm specific characteristics the aim is to test the influence of past innovative strategies on the economic performances of the firm at the light of the hypothesis that being an innovator leads to economic performances above the average. However, such an hypothesis should sound quite trivial for relatively stable periods of the business cycle, but it turns out to be much more interesting and stimulating once we consider the relation between innovation and performance in periods of deep recession: the positive relation hypothesised could be broken by the disruptive power of the crisis; those firms across a period of internal transformation, undergone also through innovative actions, just before the crisis could be those more heavily displaced by the impact of the recession; dynamic firms opened to international markets, accomplishing wide innovation strategies in order to remain competitive, could be hit strongly by the drop in international demand brought by the recession

3. Data and methodology

The answer to the main research questions are based on micro level data coming from a unique dataset concerning a sample of 555 Italian manufacturing firms with at least 20 employees located in Emilia-Romagna region (Tab.1).

Tab.1: Population and sample distribution (%) by sector and size

Population distribution (%)		Size					
Sector		20-49	50-99	100-249	250+	Total	Total (a.v.)
FOOD		5,65	1,94	1,16	0,64	9,39	382
TEXTILE		6,17	1,47	0,71	0,37	8,73	355
WOOD, PAPER AND OTHER INDUSTRIES		7,79	1,67	0,79	0,42	10,67	434
CHEMICAL AND RUBBER		5,01	1,87	1,11	0,42	8,41	342
NON METALLIC MINERAL PRODUCTS		3,81	1,23	1,18	0,79	7,01	285
METALLURGY		16,99	3,29	1,18	0,25	21,71	883
MACHINERY		21,44	6,37	4,06	2,24	34,10	1387
Total		66,86	17,85	10,18	5,11	100,00	
Total (a.v.)		2720	726	414	208		4068
Sample distribution (%)		Size					
Sector		20-49	50-99	100-249	250+	Total	Total (a.v.)
FOOD		2,88	3,78	1,62	0,54	8,83	49
TEXTILE		2,70	1,44	1,62	0,54	6,31	35
WOOD, PAPER AND OTHER INDUSTRIES		3,60	2,88	1,08	0,90	8,47	47
CHEMICAL AND RUBBER		3,78	3,42	1,80	1,08	10,09	56
NON METALLIC MINERAL PRODUCTS		1,62	2,16	1,62	2,16	7,57	42
METALLURGY		8,83	5,77	2,16	0,18	16,94	94
MACHINERY		14,05	15,32	7,39	5,05	41,80	232
Total		37,48	34,77	17,30	10,45	100,00	
Total (a.v.)		208	193	96	58		555

The information collected mainly refer to the pre-crisis period (2006-2008), with specific questions concerning firm economic performance and actions (innovations included) adopted by the firms to react to the crisis, concerning also the 2009. The random sample is stratified by size, province (geographic location) and sector. It is well representative of the population, showing only minor distortions.

The information provided by the questionnaire administered to firm's management concern several sets of variable.

Controls (CONT) and past performance (PERF2006-2008)

The structural variables used as controls aim at capturing some firm specific elements and also peculiar characteristics of the production context (Tab.2). Within this group 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 if 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 as well as its economic performance. Such controls are thought to be partially exogenous elements influencing the propensity to innovate in a time of crises. Coupled with such controls we also use more endogenous variables, because more strongly related to the strategic decisions of the firms, that help in explaining the propensity to adopt more or less intense innovative intervention to cope with the crisis.

The first set of variables is given by industrial relations ones. With such information we aim to verify the linkage between cooperative industrial relations and the propensity to innovate, as well as the potential relation with firm economic performance, although the linkage with the latter might be weak because passing through the boost a more participative work environment provides to the innovative activities (Antonioli, 2009; Antonioli, Mazzanti, Pini, 2010) which in turn impact on the economic performance.

The set of variables used as additional controls is the trend in past performance indicators (2006-2008). We may argue that the better is their trend the higher the probability to robustly intervene with innovation during the crisis because of a sounder financial situation and competitive position. However, it can also be said that firms in financial troubles before the crisis 'exploit' the crisis time itself to implement innovation activities with an intensity above the average in order to survive. Past performances are also valid control for the firm performance during the crisis, although the latter could have so strongly displaced the firm to cut any linkage between past performance (2006-2008) and present performance (2009).

A third set of variables capturing firm specific aspects is given by the indexes concerning the workers conditions. The higher the index the better is the workers welfare along several dimension of the working environment (workers effort, economic incentives, degree of autonomy and responsibility, injuries, etc...). If the workers welfare is high it is more likely to have satisfied employees, which in turn translates into more

productive employees (e.g. Bartel *et al*, 2004) and possibly into employees more able and prone to use and implement innovations.

Finally, we also know whether or not each firm received subsidies to support innovative programs in the past, mainly related to R&D projects with specific characteristics¹. The role of such subsidies may endure in time, leading the beneficiary firms to be more innovative and pro-active in time of crisis, as well as better equipped to cope with the challenges brought by the recession and thus showing higher economic performances.

Tab.2: Construction and descriptive statistics of control variables

Controls	Construction	Mean	Min	Max
STANDARD CONTROLS				
PAVITT SECTORS (d)	Dummies (5) identifying the sectors the firm belong to on the base of the OECD-Pavitt taxonomy	/	0	1
GEO (d)	Dummies of geographical location of the firm (5 province clusters).	/	0	1
SIZE (d)	Size dummies by employees: 20-49; 50-99; 100-249; > 249.	/	0	1
EXPORT	Percentage of turnover made on international markets	0.33	0	1
GROUP_INTERNAT (d)	Dummy: 1 firm is part of an international group; 0 otherwise	0.07	0	1
GROUP_NAT (d)	Dummy: 1 firm is part of a national group; 0 otherwise	0.23	0	1
SUPPLIER	Percentage of turnover made as supplier	0.28	0	1
SKILL_RATIO	Log of non manual/manual ratio	0.85	0	5.1
PROACTIVE	Dummy variable: 1 if the firm is active in terms of strategic innovation behaviour; 0 otherwise	0.40	0	1
DEFENSIVE	Dummy variable: 1 if the firm is defensive in terms of strategic behaviour; 0 otherwise	0.14	0	1
MIX	Dummy variable: 1 if the firm shows a mixed behaviour in terms of strategy; 0 otherwise	0.13	0	1
INDUSTRIAL RELATIONS				
UNION_INV	Union representatives involvement in decisions concerning innovative activities. Original values: 0 unions absence or not involved; 1 informed; 2 consulted; 3 bargained with. Index normalized on the interval (0,1)	0.28	0	1
UNION_INF	Index as average of union information over 7 innovative activities	0.40	0	1
UNION_CONS	Index as average of union consultation over 7 innovative activities	0.14	0	1
UNION_BARG	Index as average of union bargaining over 7 innovative activities	0.05	0	1
EMP_INV	Employees involvement in decisions concerning innovative activities. Original values: 0 not involved; 1 informed; 2 consulted. Index normalized on the	0.50	0	1

¹ The regional subsidies have been provided in the framework of the PRRIITT program:

	interval (0,1)			
EMP_INF	Index as average of employees information over 7 innovative activities	0.66	0	1
EMP_CONS	Index as average of employees consultation over 7 innovative activities	0.17	0	1
PAST PERFORMANCES				
TURN0608	Trend in turnover in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.67	0.16	1
PROF0608	Trend in profits in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.59	0	1
LABPROD0608	Trend in labour productivity in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.63	0	1
EMP0608	Trend in employment in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.62	0	1
INV_TANG0608	Trend in tangible investments in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.63	0	1
INV_INTANG0608	Trend in intangible investments in 2006-2008 measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.60	0	1
WORKING CONDITIONS				
WORK_COND_P	Trend in working conditions focused on positive aspects measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.64	0	1
WORK_COND_N	Trend in working conditions focused on negative aspects measured on a 5 points scale going from -2 to +2 rescaled on the interval (0,1)	0.56	0	1
PUBLIC SUBSIDIES TO INNOVATION				
INNO_SUB (d)	Dummy: 1 firm has been publicly funded to support an innovative program 2003-2006; 0 otherwise	0.23	0	1

Before crisis innovation activities (INNO)

The set of “core” covariates is composed by variables capturing past (2006-2008) innovation activities of the firm in several spheres (technology, organization, training, environment, ICT), as well as internationalisation strategies (tab.3). Such set of “endogenous” covariates are thought to be extremely relevant in explaining the propensity to innovate of the firms during the crisis. If a firm is along a path of high intensity innovation activity it might be smoother to implement intense activities in product and process areas during the crisis too. The converse hold for those firms less used to an intense innovative activity.

In addition, the complementary nature of the innovative actions should lead to higher economic performance, thus intense activities on several innovative dimensions should provide the firm of higher level

of resilience to the crisis. However it cannot be excluded that the most dynamic firms in terms of innovation could have been more strongly crowded out by the crisis because they were in a moment of change and they were possibly financially stressed because of huge investments in innovations.

Tab.3: Construction and descriptive statistics of innovation variable (period 2006-2008)

Innovations (2006-2008)	Construction	Mean	Min	Max
TECHNOLOGICAL INNOVATION				
INNO_TECH..	Composite index of innovation intensity in the technological sphere. Values on the interval (0,1)	0.22	0	0.60
OUTPUT_TECH	Index including innovation aspects belonging to the dimension of technological output	0.12	0	0.82
INPUT_TECH	Index including innovation aspects belonging to the dimension of technological input	0.32	0	0.65
ORGANISATIONAL INNOVATION				
INNO_ORG...	Composite index of innovation intensity in the organizational sphere. Values on the interval (0,1)	0.26	0	0.75
OUTSOURCING	Index of outsourcing activities	0.11	0	0.8
ORG_COLL	Index of collaboration activities to carry out organisational innovations	0.20	0	1
PROD_PRACTICES	Index as the average number of production organisation practices	0.48	0	1
LAB_PRACTICES	Index as the average number of labour organisation practices	0.25	0	1
TRAINING				
TRAINING...	Composite index of intensity in training policies. Values on the interval (0,1)	0.50	0	1
TRAIN_TYPE	Index of training typologies	0.42	0	1
COV_INDET	Percentage of permanent workers involved in training programs	0.38	0	1
COV_DET	Percentage of fixed-term workers involved in training programs	0.21	0	1
TRAIN_COMP	Index of training competencies covered by training programs	0.44	0	1
ENVIRONMENTAL INNOVATION				
INNO_ENV...	Composite index of innovation intensity in the environmental sphere. Values on the interval (0,1)	0.13	0	0.89
ENV_BEN	Index of benefits due to environmental innovations	0.13	0	1
ENV_MOT	Index of motivations that induced environmental innovations	0.09	0	1
ENV_PROC	Index of environmental innovation procedures	0.06	0	1
ICT				
ICT...	Composite index of innovation intensity in information and communication technologies sphere. Values on the interval (0,1)	0.59	0	1
INSTR_ICT	Index of ICT instruments implemented	0.83	0	1
SYS_ICT	Index of ICT management systems implemented	0.29	0	1
ACT_ICT	Index of activities supported by ICT	0.69	0	1

ROLE ICT	Index of types of role covered by ICT	0.55	0	1
INTERNATIONALISATION				
INTERNAT...	Composite index of internationalization activities. Values on the interval (0,1)	0.08	0	0.59
IDE (d)	Dummy variable: 1 if foreign direct investments are done; 0 otherwise	0.16	0	1
IDE_TYPE	Index of IDE typology	0.04	0	0.80
IMPORT	Dummy variable: 1 if the firm import intermediate goods from abroad; 0 otherwise	0.40	0	1
IMPORT_TYPE	Typology of firms providing intermediate goods	0.12	0	1
INT_PART	Index capturing different typologies of international participation	0.02	0	0.83

Dependent variables: innovative action to react to the crisis and performances in 2009

Two kinds of dependent variables are used in this work. The first kind is given by innovative actions taken in order to react to the challenges brought by the crisis. More specifically it has been asked to the management whether or not and with which degree of intensity innovative interventions on product, process and organization/HRM factors have been adopted to cope with the crisis (tab.4).

Tab.4: Innovative actions to react to the crisis

Innovations	Construction	Mean	Min	Max
Degree of the intervention intensity (Null=0; Very feeble=1; Feeble=2; Strong=3; Very strong=4)				
ACTION_PROC	Index as sample average of the answers on five dimensions of process innovation: designing of product and service; efficiency/productivity/costs; flexibility in product variety; productive capacity; quality of productive process. Values normalised on the interval (0-1)	0.66	0	1
ACTION_PROD	Index as sample average of the answers on five dimensions of product innovation: new products and services; quality of product and service; access to new markets; marketing activities; logistics and distribution activities. Values normalised on the interval (0-1)	0.62	0	1
ACTION_ORG_HRM	Index as sample average of the answers on five dimensions of competitive factors: increased employees competencies; increased employees responsibility and satisfaction; increased security and decreased injuries; environmental impact reduction; adjustment to standard laws. Values normalised on the interval (0-1)	0.62	0	1
ACTION_INDEX	Overall average of the preceding indexes Values normalised on the interval (0-1)	0.63	0	1

Each index is the expression of the average of the intensity degree of the intervention over several dimensions for three typologies of intervention: process, product and organization/HRM factors, mainly concerning organizational and human resources management aspects. As it is shown in table 4 the average degree of intervention intensity is quite high and close to a strong degree for all the three typologies of innovative action. As a whole the firm privilege an intervention on the process dimension rather than on the other two.

As far as the other set of dependent variables is considered we face different indicators of economic performance of the firm, ranging from labour productivity to the employment, passing through profits and turnover and investments (tab.5). For each indicator it has been asked to the management what was the perceived trend in the first two quarters of 2009, the period of deepest crisis, just before the faint signals of economic recovery registered in the last part of the 2009. The trend ranges from very negative (-2) to very positive (+2) and it is possible to verify how the average trend for each indicator is closer to the lower bound of the range rather than to the upper one, because of the severe slowdown.

Tab.5: Performances in 2009

Performances	Construction	Min	Max	Mean
LABPROD2009	Average of the trend of Labour productivity. Original index range (-2-2) normalised in the interval (0-1)	0.43	0	1
TURN2009	Average of the trend of Turnover. Original index range (-2-2) normalised in the interval (0-1)	0.37	0	1
PROF2009	Average of the trend of Profits. Original index range (-2-2) normalised in the interval (0-1)	0.36	0	1
EMP2009	Average of the trend of Employment. Original index range (-2-2) normalised in the interval (0-1)	0.43	0	1

Setting the reduced form models

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 two reduced form models as follows in order to answer our research questions:

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

$$2) \text{ PERF}_{i,2009} = \beta_0 + \beta_{1i,2006-2008}(\text{CONT}) + \beta_{2i,2006-2008}(\text{PERF}) + \beta_{3i,2006-2008}(\text{INNO}) + \beta_{4i,2006-2008}(\text{INTERACTION}) + \varepsilon_{i,t}$$

where i identifies the single firm and 2009 and 2006-2008 stands for the period considered. Because the variables on the left hand side are measured on a different period with respect to those on the right hand side it is possible to exploit such diachronic nature in order to partially mitigate the

endogeneity problem given by the potential simultaneous determination of dependent and independent variables (Michie, Sheean, 2003), while the richness of the data reduces to some extent the likelihood of relevant variables being omitted. The specifications reported in section 5 below go from the basic one with controls (specification 1) to more exhaustive ones capturing the effect of interaction² terms between innovation indexes (specification 4) and between innovation indexes and industrial relations variables (specification 5). The last two specifications are used in order to verify the existence of potential synergies and complementarities between the interacted variables. Intermediate types of specifications, but extremely relevant ones, include composite innovation indexes (specification 2) and disaggregated innovation indexes (specification 3). With the former we can disentangle the role of innovative strategies carried out at the level of innovation spheres as a whole; with the latter we may single out the impact of specific innovative activities undergone within each innovation sphere.

4. The firms before and during the crisis

One question has been explicitly addressed to the respondents in order to check the firm situation before the economic crisis. It markedly assesses the “health status” of the firm in terms of its competitiveness and its capacity of generating profits and sustaining innovation activities. It also captures the relative stability of the firm or its crisis even in years characterized by a good performance of the Italian economic system, in comparison to the preceding years of the same decade that were marked by a substantial stagnation.

The great majority of the firms was in a situation of good capacity to compete and it also was engaged in a recent innovative effort (tab.6). Such a result is in line with an interpretation concerning the dynamic of the Italian production system as a whole (Bugamelli, Cristadoro, Zevi, 2009), which is seen in a moment of “structural changing” in the last decade. Such evolution implies a strong effort to be devoted to innovative activities, which bring economic benefits in the medium-long run. The “changing momentum” has been abruptly interrupted by the global economic crisis that could have crowded out in a stronger way just those firms more engaged in the transformation process, that is to say those firms more engaged in the innovative effort. The innovating firms could also have been hit by the crisis in a moment of financial stress given by the monetary effort to sustain the innovation process, put it another way they have been hit when they were more vulnerable.

² The interacted variables have been centered around their mean, before producing the interaction terms, in order to reduce problems of multicollinearity in the specifications.

Tab.6: Firm's pre-crisis condition (%proportion of answers with respect to the total number of firms)

Answer	Firm's condition when the international economic crisis hit	%
1-	The firm was competitive on the market and it was realizing high levels of profits	72,89
2-	The firm was engaged in an innovative effort and it was close to enjoy the first benefits deriving from the investments in innovation	70,02
3-	The firm was substantially stable	53,14
4-	The firm was in a difficult situation because of the competitive pressure coming from other firms. especially those firms located in emerging countries (China. India. Brasil. etc..)	19,39
5-	The firm was suffering from structural high costs of production. labour and financial capital and it was losing competitiveness with respect to its competitors	22,44

Note: more than one answer allowed

The second questions of the structured questionnaire was addressed to capture the respondents preferences in terms of policies (international, national and local) to be implemented in order to cope with the crisis (tab.7). The net preference goes to a policy aimed to reduce labour costs and taxes (82%). Although such need seems to be shared by many social and political actors it cannot be neglect the cost-saving defensive character of such a policy, which probably adds to other defensive strategies implemented by the firm. It is also well recognised the crucial role the national government can play in sustaining the demand (50%), but also in supporting those “enablers” of economic recovery (schooling system, professional training programmes, development of firm level innovations) and long run growth (41%). Finally, it is perceived as important a policy oriented to reduce the effect of the credit crunch for the small firms, which are struck in a harder way by this problem with respect to bigger companies that likely have the financial capacity to sustain their business and, possibly, their innovative strategies.

Tab.7: Policies to cope with the crisis (%proportion of answers with respect to the total number of firms)

Answer	Policies	%
1 –	Firms should be helped through a reduction in labour costs and taxes	82,41
2 –	National government should favour the growth of internal aggregate demand sustaining the earnings	50,45
3 –	The European monetary authority should induce a more favourable Exchange rate of the euro (competitive devaluation of the euro)	24,42
4 –	The European Union should introduce measures of protectionism. safeguarding the National productions of the single members states	17,95
5 –	There is a need of policies that shift the real economy at the centre of economic choices sustaining the production system. empowering the schooling system and the professional training and sustaining the development of firm level innovations	40,93
6 –	It is necessary a new world governance of economic systems based on shared policies that favour social inclusion and a fairer wealth distribution	10,77
7 –	Strongly favour the areas of free commercial trade ruled by bilateral or multilateral agreements between countries	5,39
8 –	Actions of industrial and trade policies pursued both by Italian government and the EU with the aim of supporting policies sustaining the export of the small and medium Italian firms towards emerging markets and/or their entrance in such markets	13,11
9 –	Policies contrasting the credit crunch, especially addressed to favour credit accessibility for small and medium firms	39,68
10 –	Industrial policies sustaining innovation and research designed by the Emilia-Romagna Region	12,57

On the side of reactions to the crisis through innovative activities, which represent the first set of dependent variables in our econometric exercise, we find that on average the firms' interventions are mainly along the process dimension rather than the product one or the dimension concerning other competitive factors (tab.8). Looking at the results by firm size it is clear the capacity of large firms to intervene with higher intensity along the three dimensions of innovative activities with respect to the small firms. This finding may be linked to the capacity of larger firms to self-finance (to some extent) their activities, capacity that small firms are less likely to have.

The results by sectors *a là* OECD-Pavitt shows that the Science Based (SB) firms are those more active in reacting to the crisis through innovation. The results seems to imply that the firms more used to innovate, such as the SB ones, consider the innovative activities as a strategic element to cope with the crisis, likely besides and behind cost-saving strategies, which are rational strategies in front of a sudden drop in the demand, but that do not guarantee the capacity to survive once the deepest point of the crisis has passed. Accordingly, it is not a surprise that Labour Intensive (LI) firms are those less inclined to use innovation as an instrument to cope with the crisis: innovative activities are less relevant as part of the firm competitive strategies for this sector with respect to the other considered, especially with respect to the SB one.

Tab. 8: Indices of action intensity on process, product and other competitive factors in order to cope with the crisis. Interval (0-1)

Size	Intensity of actions on the process	Intensity of actions on the product	Intensity of actions on organization/HRM factors
20-49	0.61	0,56	0,58
50-99	0.67	0,63	0,65
100-249	0.64	0,68	0,65
>249	0.69	0,68	0,65
Sector	Intensity of actions on the process	Intensity of actions on the product	Intensity of actions on organization/HRM factors
Labour Intensive (LI)	0.62	0.57	0.60
Resource Intensive (RI)	0.65	0.63	0.64
Science Based (SB)	0.68	0.68	0.62
Scale Intensive (SI)	0.64	0.60	0.62
Specialised Suppliers (SS)	0.66	0.65	0.63
Total	0.65	0.62	0.62

To conclude this brief overview of the firms behavior in front of the crisis and their perception of the consequences and needs derived by the crisis we show the perceived economic performance in 2009, comparing it with that of the preceding years (tab.9): the higher the performance index the better the performance of the firm. It is straightforward and trivial, to some extent, highlighting the drop in the performance in 2009 with respect to the preceding years, but it is interesting to show the relative performance of the different sectors and size. As a whole the smallest firm in our sample (20-49 employees) are those declaring to suffer less with compared to the other size classes, and at

the same time the best performing sector in 2009 is the Science Based, whose firms are the most innovative during the 2009. Innovative activities and better performance for the Science Based firms in 2009, in relative terms, go together. On the other hand, it is clear the economic suffering of Specialised Suppliers, Scale Intensive and Labour Intensive firms, whose management declares for the 2009 an overall performance which is more or less a halve of that perceived for 2006 and 2007, the only biennium of relative growth for the Italian economy after 2001.

Tab. 9: Overall economic performance indicator (productivity, turnover, profits). Interval (0-1)

Size	Perf 2009	Perf 2006	Perf 2007	Perf 2008
20-49	0.40	0.63	0.63	0.58
50-99	0.37	0.64	0.65	0.61
100-249	0.38	0.67	0.67	0.63
>249	0.39	0.65	0.66	0.63
Sector	Perf 2009	Perf 2006	Perf 2007	Perf 2008
Labour Intensive (LI)	0.34	0.63	0.64	0.58
Resource Intensive (RI)	0.45	0.63	0.62	0.58
Science Based (SB)	0.50	0.63	0.62	0.60
Scale Intensive (SI)	0.37	0.63	0.64	0.59
Specialised Suppliers (SS)	0.37	0.66	0.67	0.64
Total	0.39	0.64	0.64	0.60

5. Innovation and performance: results of the econometric exercise

5.1 Actions for innovations

Starting the discussion from our first line of econometric analysis as expressed in equation 1, which has as dependent the indexes of firm strategic reaction to the crisis through the implementation of innovative activities in process (column 1), product (column 2) and organization/HRM dimensions (column 3), with also an overall index (column 4) synthesizing the intensity in reaction for all the three dimensions, we may stress the subsequent principal points (tabb.10-14).

The controls have the following behavior across the diverse specifications (from 1 to 5).

About the firm size the most active seems to be the small-medium firms (50-99 employees), especially on process and organization/HRM practices. The smallest firms (20-49 employees) and the medium large (100-249 employees) show some criticalities once industrial and employment relationships are considered as interacted with innovation. By sectors *a là* OECD/Pavitt we can see that Science Based (SB) firms are those better equipped to react to the crisis through the instrument of innovation activities. Since SB firms are those more likely to be involved in innovative or

research activities in daily routines they are probably called even in recession times to endure along an innovative path that allow them to remain on the market and to be competitive. The geographical location seems to play a role as well. The provinces (Forlì-Cesena, Ravenna, Rimini and Piacenza), that have not been hit so hard as those representing the core of the manufacturing system of the region (Reggio Emilia, Modena, Bologna and Parma) are also those that are capable of reacting with more intense innovative activities. If a firm is part of a group or if it does a large amount of turnover as a supplier the innovation activities in product are hampered, while the opposite holds when the export increases, which seems to positively influences also the innovative activities on process dimension. The ratio between non-manual and manual workers is significant with a negative sign when the dependent is the process dimension. Having a relative larger amount of manual workers with respect to the non-manuals increases the intensity in interventions for the process activities³.

It is interesting to show that the index qualifying the firm as proactive and dynamic in innovative strategies according to the respondent perception about the firm strategic position before the crisis and the need of specific policies to overcome the crisis is strongly related to innovative activities as reactions to the crisis, while the index identifying firms having a defensive behaviour is negatively associated with innovation during the crisis.

In terms of past performances the evidence supports the idea of a positive relation between past labour productivity and innovative activities on process dimension, while high levels of turnover in the past are negatively associated to action in organization and HRM dimension. At the same time an effort on intangible investments before the crisis is negatively associated mainly to the reaction through product innovation. A strong financial effort in the past could have hampered the capacity of the firm to sustain innovation activities in the period of deepest recession.

The variables capturing the participative nature of industrial and employment relationships are positively associated to the innovative actions implemented to react to the crisis. It is worth stressing the fact that the significance level persists across different specifications, witnessing a substantial robustness of the link between involvement of union representatives and employees and innovative strategic reaction. More specifically we notice that for union representatives the two modalities of interaction used by the management that are linked to the innovative capacity in the crisis are information and bargaining, with less room for an intermediate instrument such as consultation. About employees is the information process, rather than consultation, to be more closely related to innovative activities.

³ Innovation subsidies received in the past do not have any impact on innovative actions to cope with the crisis.

Finally, good quality working conditions are related to the innovation activities as well, across all the three dimensions and even to the overall index of intervention. The workers well being is crucial for the innovative activities of the firm, because the implementation of each single innovation passes through the human resource or it has consequences on the work environment. Good quality working conditions are likely to make the workers more prone to adopt, implement and utilize the innovations introduced.

As a whole we can synthesis the results for the group of controls as follows. The presence of participative industrial and employment relationships coupled with good quality working conditions, a pro-active/innovative behaviour of the firm before the crisis and some specificities related to the size, sectors and geographical location represent the mix of firm characteristics that are overall more likely to positive influence the innovative activities in order to react to the recession's challenges.

Once we have controlled for a wide range of firm specificities, the attention turns on the core group of covariates, that is on those variables capturing the innovative effort of the firm in the period 2006-2008 on several dimensions of the innovation field.

As far as the composite indexes are concerned (tab.11, specification 2) it is possible to highlight their impact, in order of number of linkages and their robustness: 1. organizational and technological innovations; 2. ICT and training; 3. environmental innovation. The internationalization strategies does not impact on innovative activities in the crisis. The past innovative activities on organisational and technological innovation spheres provide the firm of the necessary capabilities to cope with the crisis through the implementation of intense reaction on process, product and organizational/HRM dimensions. The other innovation spheres are less capable of giving the firm the capacity to react through intense activities on all the three dimensions, but they give the firm the capacity to intensely react at least on one dimension: ICT and training impact positively on product and organizational/HRM dimensions, with the latter that is positively influenced, although in a weak way, by environmental innovation as well.

When the composite innovation indexes are disaggregated in their sub-components (tab.12, specification 3) the following results emerge. The diffusion of production and labour organizational practices drive the sign of the composite innovation index of the organizational sphere. As expected, both the two aspects are mainly related to organization/HRM dependent, with production practices also linked to the process dimension. For the technological sphere the aspects that can be defined as input activities are those strongly related to the dependents, likely because they are those elements that influence the capabilities of the firm to pursue further innovation.

Within the sphere of training, it is its diffusion among permanent workers that seems to impact on the dependent variables: also in this case the results can be interpreted at the light of the capabilities created by training activities, which involve mainly permanent workers, because of the costs and benefits shared by employees and firms during the entire working life cycle of the trained employee when specific training programs are implemented. A strong skill base allows the firm to increment its capacity to absorb and generate innovation and in turn innovation calls for new skills and competences in a virtuous circle.

About ICT and environmental innovation, we see that the activities conducted through ICT and the motivation behind the introduction of environmental innovation are weakly related to process and organization/HRM actions.

The last two specifications are constructed including interaction terms between innovation composite indexes (tab.13, specification 4) and between innovation composite indexes and industrial relations indexes (tab.14 specification 5). The interaction terms provide a “flavor” of complementarities existence between innovation and between innovation and industrial relations.

The first interesting results of specification 4 comes from the negative and significant sign associated to the interaction between organizational and technological innovation. It may be hypothesised that those firms involved in a large effort in terms of innovation activities before the crisis are less capable/willing to implement innovation action to react to the crisis: financial constraints and resources just exploited might induce the firms that extensively innovated in organizational and technological sphere to proceed with quite slow pace in reaction to the recession’s challenges through further innovation.

The role of training re-emerges quite strongly in the interactions. The training index interacted with technological and environmental innovations positively impacts on the dependent variables. It is clear the need of new skills and competences construction jointly with the introduction of innovations in order to create a favorable environment to innovative activities.

A last interesting result concerns the interactions the technological dimension has with ICT and environmental innovation, because ICT and technology seems to be complementary on the organization/HRM activities, while environmental innovation and technology seems to be substitute on the product activities.

Finally, in specification 5 we see that interactions between industrial and employment relations variables, on the one hand, and innovation on the other hand, produce covariates with a weak explicative power when innovative interventions to cope with the crisis are the dependents variables. The few and weak significant terms provide a fragmented framework from which only the positive coefficients associated to the interaction between employees involvement and

internationalization strategies assumes a certain relevance. It might be hypothesised that only where employees are involved with a certain intensity they are capable of exploiting positive externalities in terms of innovation and knowledge coming from the international nature of the firm and constructing, in so doing, a good skill base that spur further innovation.

Tab. 10: Results for the controls (Equation 1)

	Specification 1			
	1	2	3	4
	ACTION_PROC	ACTION_PROD	ACTION_ORG_HRM	ACTION_INDEX
SIZE 20-49		-0.0579**		-0.0249
SIZE 50-99	0.0324*	-0.0235	0.0391**	0.0121
SIZE 100-249	-0.0162		0.0209	
LABOUR INTENSIVE		-0.0333		-0.0193
RESOURCE INTENSIVE		-1	0.0182	
SCIENCE BASED	0.0570**	0.0595**	0.0192	0.0408**
SCALE INTENSIVE		-0.0283		-0.0154
BOREMOPR		-4	0.0258	
FCRARN	0.0254	0.0421**	0.0422	0.0249*
FE	0.045			
PC	0.0578**			
GROUP		ACTION_PROD	0.0269	-0.0157
EXPORT	0.0632**	ACTION_ORG_HRM		0.0428*
SUPPLIER	-0.0282	ACTION_INDEX		-0.0261*
SKILL_RATIO	-0.0269		0.0149	
INNOVATION	0.0203			
DEFENSIVE	-0.0432	-0.0427	-0.0276	-0.0358*
PROACTIVE	0.0667***	0.0576***	0.0376**	0.0546***
MIX	0.019	0.0304		0.017
LABPROD0608	0.133**	-0.0249		
EMP0608		0.0514	0.0497	0.052
TURN0608	-0.077	-0.0767	-0.0954	-0.0858
SIZE 50-99				
PROF0608	-0.0628	0.0324*	0.0444	
INV_TANG0608		0.153**	0.134*	0.108*
INV_INTANG0608	-0.0544	-0.0235	-0.103	-0.110*
UNION_INF	0.024	0.0585***	0.0387**	0.0395***
UNION_BARG	0.0741***	0.0997***	0.0702***	0.0814***
EMP_INF	0.0381*	0.0335	0.0661***	0.0519**
SIZE 100-249			0.0778**	0.0325
EMP_CONS		-0.0162	0.160**	0.186***
WORK_COND_P	0.181***	0.202***		0.036
WORK_COND_N	0.0643	0.0823	-0.0393	0.438***
Constant	0.453***	0.425***	0.372***	
Observations	547	547	547	547
Adjusted R2	0.117	0.17	0.081	0.174
F	4.812	6.834	3.661	6.576

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure.

RESOURCE INTENSIVE

0.0182

SCIENCE BASED

0.0570**
0.0595**
0.0192
0.0408**

SCALE INTENSIVE

-0.028
19
-0.0154

BOREMOPR

Tab.11: Results for controls and composite indexes of innovation strategies (Equation 1)

	Specification 2			
	1	2	3	4
	ACTION PROC	ACTION PROD	ACTION ORG HRM	ACTION INDEX
SIZE 20-49	0.0339		0.0403	0.0216
SIZE 50-99	0.0516***	0.0159	0.0584**	0.0398*
SIZE 100-249		0.0363	0.033	0.0193
RESOURCE INTENSIVE	0.0181	0.0282	0.0246	0.0244
SCIENCE BASED	0.0462*	0.0466		0.0312
SCALE INTENSIVE		-0.0295	-0.0214	-0.021
BOREMOPR		-0.0316*	0.0293	
FCRARN	0.0196		0.0369	0.0202
FE	0.0402			
PC	0.0640***	-0.0477		
GROUP		-0.0529***	0.0195	-0.0159
EXPORT	0.0502	0.0520*		0.0292
SUPPLIER	-0.0285	-0.0548***	-0.0187	-0.0329**
SKILL_RATIO	-0.0404**			-0.0148
INNO_SUB			-0.0216	
DEFENSIVE	-0.0454*	-0.0429	-0.0232	-0.0381*
PROACTIVE	0.0579***	0.0418**	0.0313**	0.0431***
LABPROD0608	0.133**			0.0393
TURN0608	-0.0801	-0.05	-0.0848	-0.0747*
PROF0608	-0.0617		0.0492	
INV_TANG0608	-0.0605	0.101	0.102	0.0492
INV_INTANG0608	-0.0473	-0.142**	-0.0971	-0.0962*
UNION_INF	0.0199	0.0578***	0.0317*	0.0357**
UNION_BARG	0.0530**	0.0782***	0.0418*	0.0580***
EMP_INF	0.0226	0.0277	0.0395	0.0301**
EMP_CONS	-0.026		0.0327	
WORK_COND_P	0.140**	0.153**	0.0973	0.134**
WORK_COND_N	0.0577	0.061		0.0299
INNO_ORG	0.133**	0.112*	0.275***	0.169***
TRAINING			0.0983***	0.0266
INNO_TECH	0.243***	0.400***		0.228***
INNO_ENV		-0.0489	0.0490*	
ICT	0.0848	0.134**		0.0745*
INTERNAT		-0.0576		
Constant	0.402***	0.326***	0.337***	0.365***
Observations	547	547	547	547
Adjusted R2	0.152	0.227	0.147	0.243
F	5.202	7.97	5.062	8.072

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure.

Tab.12: Results for controls and disaggregated innovation indexes (Equation 1)

	1	Specification 3 2	3	4
	ACTION_PROC	ACTION_PROD	ACTION_ORG_HRM	ACTION_INDEX
SIZE 20-49	0.0237		0.0232	0.02
SIZE 50-99	0.0398*	0.0138	0.0388	0.0345*
SIZE 100-249		0.0434**	0.0313	0.0245
RESOURCE INTENSIVE	0.02	0.0295	0.0319	0.0275
SCIENCE BASED	0.0377	0.0458		0.0308
SCALE INTENSIVE		-0.0236	-0.0243	-0.0206
BOREMOPR		-0.0343*	0.0256	
FCRARN	0.0178		0.0288	0.0187
FE	0.0424			
PC	0.0744***	-0.0366		0.015
GROUP	-0.0172	-0.0556***		-0.0212
EXPORT	0.0550*	0.0514*		0.0317
SUPPLIER	-0.0263	-0.0527**	-0.0224	-0.0350**
SKILL_RATIO	-0.0361*			-0.0135
INNO_SUB	0.0229			
DEFENSIVE	-0.0454*	-0.0472*	-0.0246	-0.0391**
PROACTIVE	0.0604***	0.0423**	0.0289*	0.0461***
LABPROD0608	0.137**			0.0364
TURN0608	-0.089	-0.0417	-0.105*	-0.0772*
PROF0608	-0.0578		0.0671	
INV_TANG0608	-0.0704	0.103	0.0765	0.0412
INV_INTANG0608	-0.0478	-0.161**	-0.0832	-0.0977*
UNION_INF	0.0269	0.0603***	0.0334*	0.0363**
UNION_BARG	0.0515**	0.0758**	0.0361*	0.0492***
EMP_INF			0.0409*	0.0311**
EMP_CONS	-0.0454*	-0.0323	0.0225	
WORK_COND_P	0.145**	0.166**	0.1	0.138***
WORK_COND_N	0.0555	0.0656		0.0434
OUTSOURCING		0.0611	-0.0394	
PROD_PRACTICES	0.0562**	0.0219	0.0693***	0.0487**
LAB_PRACTICES	0.0699	0.0818	0.177***	0.104***
TRAIN_TYPE			0.0411	0.0208
COV_INDET	0.0369**		0.0517***	0.0254*
COV_DET			0.0208	
TRAIN_COMP	-0.0625**	-0.0305	-0.0265	-0.0383
INPUT_TECH	0.201***	0.337***	0.0927*	0.205***
OUTPUT_TECH	0.0483	0.0484	-0.0593	
ENV_BEN	-0.037			
ENV_PROC	0.0679		-0.0543	
ENV_MOT		-0.0582	0.0781*	
INSTR_ICT	0.0508		0.036	0.0426
SYS_ICT		0.0291	-0.0393	
ACT_ICT	0.0537*	0.0523		0.0361
ROLE_ICT		0.0262		
IDE	0.0392	0.0315	-0.0517	
IMPORT			0.0208	
INT_PART	-0.11	-0.0765		
IDE_TYPE	-0.154	-0.115	0.131	
IMPORT_TYPE		-0.0488		
Constant	0.385***	0.344***	0.338***	0.338***
Observations	547	547	547	547
Adjusted R2	0.163	0.231	0.176	0.262
F	4.444	6.263	4.667	7.595

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure.

Tab.13: Results for controls and interactions among innovative strategies (Equation 1)

	1	Specification 4 2	3	4
	ACTION_PROC	ACTION_PROD	ACTION_ORG_HRM	ACTION_INDEX
SIZE 20-49	0.0313		0.0371	0.0232
SIZE 50-99	0.0508**		0.0588**	0.0403**
SIZE 100-249		0.03	0.0312	0.0201
LABOUR INTENSIVE		-0.027		
RESOURCE INTENSIVE	0.017		0.0285	0.0227
SCIENCE BASED	0.0508**	0.0366		0.0369*
SCALE INTENSIVE		-0.0472*	-0.0141	-0.0192
BOREMOPR		-0.0343*	0.0293	
FCRARN	0.0183		0.0385	0.0205
FE	0.0406			
PC	0.0667***	-0.052		
GROUP	-0.0138	-0.0493**	0.0176	-0.0148
EXPORT	0.0449	0.0355		0.0244
SUPPLIER	-0.0294	-0.0554***	-0.0173	-0.0346**
SKILL_RATIO	-0.0413**	-0.0135	0.0145	-0.0131
INNO_SUB			-0.0282	-0.0112
DEFENSIVE	-0.0497*	-0.0446	-0.0331	-0.0437**
PROACTIVE	0.0638***	0.0438**	0.0359**	0.0492***
LABPROD0608	0.127**			0.033
TURN0608	-0.0988*	-0.0606	-0.0659	-0.0837**
PROF0608	-0.0552			
INV_TANG0608	-0.0569	0.109	0.127*	0.0478
INV_INTANG0608	-0.067	-0.154**	-0.122*	-0.112**
UNION_INF	0.0257	0.0655***	0.0356**	0.0424***
UNION_BARG	0.0435*	0.0811***	0.0321	0.0522***
EMP_INF	0.0448**	0.03	0.0491*	0.0357**
EMP_CONS			0.0314	
WORK_COND_P	0.142**	0.153**	0.0901	0.142***
WORK_COND_N	0.0448	0.0624		
INNO_ORG (centered)	0.145**	0.11	0.300***	0.185***
TRAINING (centered)			0.0980***	0.0331
INNO_TECH (centered)	0.229***	0.420***		0.232***
INNO_ENV (centered)		-0.0451		-0.0181
ICT (centered)	0.0942*	0.130**		0.0813**
INNO_ORG*TRAINING		0.204		
INNO_ORG*INNO_TECH	-1.243**	-0.951	-1.173**	-1.081**
INNO_ORG*INNO_ENV		0.22		
INNO_ORG*ICT			-0.305	
INNO_ORG*INTERNAT		-0.506		
TRAINING*INNO_TECH	0.565**	0.590*	0.274	0.523**
TRAINING*INNO_ENV	0.122		0.238**	0.171**
TRAINING*ICT	0.205		-0.299	
TRAINING*INTERNAT	-0.397	-0.504		-0.343
INNO_TECH*INNO_ENV		-0.654**	0.245	-0.131
INNO_TECH*ICT			1.296***	0.271
INNO_TECH*INTERNAT		0.451		
INNO_ENV*ICT	-0.173	0.224		
INNO_ENV*INTERNAT	0.278	0.265		0.214
ICT*INTERNAT	0.692			0.322
Constant	0.549***	0.556***	0.461***	0.539***
Observations	547	547	547	547
Adjusted R2	0.161	0.233	0.167	0.252
F	4.504	6.395	5.337	7.086

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure.

Tab.14: Results for controls and interaction between innovation and industrial relations variables (Equation 1)

	1	Specification 5 2	3	4
	ACTION_PROC	ACTION_PROD	ACTION_ORG_HRM	ACTION_INDEX
SIZE 20-49	0.0281	-0.018	0.0355	
SIZE 50-99	0.0483**		0.0562**	0.0216*
SIZE 100-249		0.0274	0.0315	
RESOURCE INTENSIVE	0.0264	0.0356	0.0348*	0.0314*
SCIENCE BASED	0.0532**	0.0368		0.0269
SCALE INTENSIVE		-0.0267	-0.0236	-0.0219
BOREMOPR		-0.0326*	0.0344	
FCRARN	0.0214		0.0361	0.0175
FE	0.0427			
PC	0.0622***	-0.0559*		
GROUP	-0.0142	-0.0524**	0.0159	-0.0196
EXPORT	0.0534	0.0499		0.0299
SUPPLIER	-0.0307	-0.0494**	-0.0251	-0.0336**
SKILL_RATIO	-0.0360*			-0.0131
INNO_SUB			-0.0223	
DEFENSIVE	-0.0468*	-0.0395	-0.0257	-0.0395**
PROACTIVE	0.0574***	0.0518**	0.0299*	0.0438***
MIX		0.0215		
LABPROD0608	0.131**			0.0361
TURN0608	-0.0853	-0.0392	-0.0923*	-0.0725*
PROF0608	-0.0592		0.0466	
INV_TANG0608	-0.0569	0.0984	0.0868	0.0465
INV_INTANG0608	-0.0495	-0.143**	-0.0813	-0.0957*
WORK_COND_P	0.136*	0.165**	0.0894	0.138**
WORK_COND_N	0.0467			
UNION_INV (centered)	0.0326	0.042		0.0238
EMP_INF (centered)	0.0234	0.0446**	0.0533**	0.0405***
EMP_CONS (centered)	-0.0276		0.0336	
INNO_ORG (centered)	0.156**	0.101	0.286***	0.179***
TRAINING (centered)		-0.0253	0.0967***	0.0193
INNO_TECH (centered)	0.205***	0.374***		0.209***
INNO_ENV (centered)		-0.0426	0.0488*	
ICT (centered)	0.0954*	0.148***		0.0844**
INTERNAT (centered)			0.0698	
UNION_INV*INNO_ORG	-0.307	-0.172		-0.12
UNION_INV*TRAINING	-0.103	0.0954		
UNION_INV*INNO_TECH	0.21	-0.309	0.365	
UNION_INV*INNO_ENV				0.057
UNION_INV*ICT	0.239			
UNION_INV*INTERNAT			-0.378	
EMP_INVa*INNO_ORG			0.303	0.129
EMP_INV*TRAINING	-0.0832	-0.104		-0.073
EMP_INV*INNO_TECH		0.261	-0.247	
EMP_INV*INNO_ENV	0.0623		0.160**	0.0767
EMP_INV*ICT		0.114	-0.102	
EMP_INV*INTERNAT	0.184	0.452**	0.15	0.279*
Constant	0.574***	0.584***	0.522***	0.586***
Observations	547	547	547	547
Adjusted R2	0.147	0.217	0.148	0.238
F	4.132	6.936	4.229	7.407

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure; a) the variable EMP_INV is a synthetic index for the employees involvement, which include in its construction both EMP_INF and EMP_CONS variables

5.2 Performances in the crisis

The same series of specifications have been applied for the set of four performance indicators, labour productivity, turnover, profit, employment as represented in equation 2 in the preceding section (tabb.15-19).

The usual controls, size, sector and geographical location within the Emilia-Romagna region seem to capture relevant aspects influencing the economic performance of the firm (see tab.15, specification1, for a glance to the controls only), as emerge in all the five specifications. The small size is positively related to indicators of profitability and to the trend of employment. The Science Based and the Resource Bases firms are positively related to all the indicators of economic performance. In terms of geographical location of the firm we have, as expected, a negative and significant sign associated to the cluster of provinces that have been hit harder by the economic crisis. Being part of a group generates a positive impact on labour productivity and the skill ratio, which is proxied by the ratio of non-manual over manual workers, positively impact on the turnover of the firm. Innovation subsidies received in the past have a null impact, as in the case of innovative reaction to the crisis, or a weak negative one on the profits. As stressed before there are some firm's specificities that influence the capacity to have good economic performances. In particular, the production sector and the dimension of the firm seem to be of crucial relevance.

The past performances of each indicator matter in determining the present trend. The same hold for the past investments in intangibles. Having a good performance before the crisis and sound investments in intangible activities help the firm to better cope to the recession.

Turning our focus on the industrial relations aspects it emerges how union involvement is detrimental for the economic performance of the firm. The opposite holds for the linkage between employees consultation and the turnover of the firm. The negative sign associated to union involvement may be interpreted as the consequence the crisis have had on the highly unionized machinery sector. Traditional productions have been strongly "bitten" by the fall in the demand, especially the international one, given the high export propensity of the Emilia-Romagna firms. At the same time the machinery sector as well as the non metallic mineral products are sectors where the cooperative and participative aspects of industrial relations were and are diffused and have been evolved for decades in a region characterized by dialogue between institutional actors and the production system. Thus, we could say that union involvement is not detrimental per-se, although unions can act as rent seekers, but that competitive firms, opened to international markets, with good quality industrial relations have been hit harder than others by the crisis.

The last set of control variables includes the indexes of working conditions. The positive aspects of workers welfare positively impact on the economic performances of the firm even in the recession, showing the importance of the working environment not only for the workers but also for the firm. The workers well being emerges as a sort of mediating element through which the firms should pass in order to have not only a higher capacity to innovate but also better economic performances.

Looking now more specifically to the specifications where innovation variables have been included, we have in specification 2 (tab.16) the positive impact of organizational and technological innovations on the labour productivity, while past training programs and environmental innovations are negatively linked to economic profit, turnover and employment and ICT are negatively related to labour productivity. The negative signs of some the innovation indexes may be interpreted at the light of the asymmetric way in which the economic crisis have hit: those firms more exposed on international markets and the firms belonging to specific sectors have been harder bitten on average with respect to other types of firm, smaller and more related to local markets. As an example, it is likely the case that firms interested by international competition as the machinery ones in the central Emilia-Romagna are those firms more active in innovation activities such as ICT and environmental innovation before the crisis and, thus, generating a negative linkage between past innovation activities and performance during the crisis. Linkage that would have been positive in the absence of the international recession, that interrupts a path of changes undergone by the firms, displacing them in a deep way.

In specification 3 (tab.17) it is possible to single out the specific aspect of innovative activities that positively or negatively impact on the dependents and that drive the signs of the composite indexes. Changes in labour organizational practices positively influence all the dimensions of economic performance considered, while the technological output, that drives the sign of the technological composite index, mainly impact on labour productivity and profits. As far as training is concerned, we can see that the extension of training, captured by the percentage of employees covered by training programs, is positively related to the economic performance. In particular, as increases the permanent workers involved in training programs the turnover of the firm increases, and as increases the percentage of short-term workers involved in training programs the occupational performance of the firm increases. In the latter case the specific human capital acquired by non permanent workers would make it costly for the firm to dismiss such workers, inducing to retain them even in a period of recession.

The environmental aspects driving the negative sign of the composite index and those of the ICT sphere seem to confirm the above interpretation. When firms are moved by reasons laying within

the boundaries of corporate social responsibility as the introduction of green innovation to reduce emission, improve recycling and reduce the impact on soil, water and air or when firms introduce complex systems of ICT to manage several aspects of the production process, then their performance is less good during the recession. As said we may hypothesize that the firms more active before the crisis are those more heavily crowded out by the challenges brought by the recession as the credit crunch, because more financially vulnerable given the investments in green innovations or ICT. However the latter hypothesis seems to hold only if ICT and environmental innovations are not jointly considered. In fact, in specification 4 (tab.18), when potential synergies among innovations are captured through the utilization of interacted terms, we notice that just only the joint introduction of ICT and green innovations positively impact on the economic performance. Hence, we may further refine our interpretation at the light of the existence of complementarities between ICT and environmental innovations. When high intensity levels of innovations on both ICT and green spheres are implemented by the firm, then the economic performance is better than average. However, it should be considered that the disruptive power of the economic recession cancel out the complementarities effects that we found in other works on Emilia-Romagna local production systems (Antonioli, 2009; Antonioli, Mazzanti, Pini 2009) in period of relatively stable, although weak, growth for the Italian economy.

Finally, the last specification (tab.19) puts in evidence that synergies between participative industrial relations and innovations are not likely to exert their effect on economic performance in the crisis. Only when training and union involvement are jointly high we have a positive and significant impact on profits and occupation; in few other cases employees involvement interacted with innovation in ICT, environmental aspects and with internationalization strategies have a weak positive impact on profits and employment. Overall we cannot say the synergies between industrial relations and innovation strongly influence firm's economic performance, although it should not be neglected the fact that union involvement in some cases of interaction changes sign turning from negative to positive.

Tab.15: Results for the controls (Equation 2)

	1	Specification 1 2	3	4
	LABPROD2009	PROF2009	TURN2009	EMP2009
SIZE 20-49	0.0253	0.0402*	0.0585***	0.0840***
SIZE 50-99				0.0381*
SIZE 100-249	-0.0194	0.0266		
LABOUR INTENSIVE	-0.0194		-0.0238	-0.0201
RESOURCE INTENSIVE	0.0751***	0.0877***	0.118***	0.0607***
SCIENCE BASED	0.140***	0.135***	0.177***	0.113***
SCALE INTENSIVE		0.0251	0.0311	-0.0271
BOREMOPR	-0.0362*	-0.0640***		
FCRARN			0.0347	
FE		-0.0313		-0.0294
PC	0.0673	0.0736	0.122***	0.104***
GROUP	0.0398*		0.023	0.0308*
EXPORT	0.0266	0.0317		
SUPPLIER		-0.0324		-0.0166
SKILL_RATIO	0.0196		0.0364	0.0282
INNO_SUB		-0.0367	-0.0214	
PROACTIVE	0.0132		0.0154	
MIX	0.0312			-0.0346
INV_TANG0608		0.0852		0.0601
INV_INTANG0608	0.114*	0.0738	0.140**	
LABPROD0608	0.214***			
PROF0608		0.178***		
TURN0608			0.149**	
EMP0608				0.280***
UNION_INV	-0.0768**	-0.0734**	-0.0949***	-0.0434
EMP_INF		-0.0383		
EMP_CONS	0.0397*	-0.0428	0.0539*	0.0295
WORK_COND_P	0.131*	0.114	0.129	
WORK_COND_N		0.0638	0.119	0.102*
Constant	0.112*	0.0974	-0.0514	0.0903
Observations	547	547	547	547
Adjusted R2	0.116	0.118	0.141	0.166
F	6.257	5.371	6.626	7.414

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure

Tab.16: Results for controls and composite indexes of innovation strategies (Equation 2)

	1	Specification 2 2	3	4
	LABPROD2009	PROF2009	TURN2009	EMP2009
SIZE 20-49	0.0284	0.0385*	0.0771**	0.0766***
SIZE 50-99			0.0234	0.0352*
SIZE 100-249	-0.0188	0.0344	0.0233	
LABOUR INTENSIVE	-0.0194		-0.0188	-0.0221
RESOURCE INTENSIVE	0.0767***	0.101***	0.131***	0.0642***
SCIENCE BASED	0.118***	0.126***	0.182***	0.110***
SCALE INTENSIVE		0.0334	0.0416	-0.0243
BOREMOPR	-0.0294	-0.0580***		
FCRARN			0.0373	
FE				-0.0337
PC	0.0672	0.0773	0.129***	0.110***
GROUP	0.0363*		0.0233	0.0288
EXPORT		0.0258		
SUPPLIER		-0.0247		
SKILL_RATIO	0.0236	0.0196	0.0378*	0.0329
INNO_SUB	-0.0158	-0.0382*	-0.0236	
PROACTIVE	0.0143		0.0177	
MIX	0.0243			-0.0398
INV_TANG0608	-0.0832	0.0917		0.0564
INV_INTANG0608	0.149*	0.0568	0.150**	
LABPROD0608	0.226***			
PROF0608		0.192***		
TURN0608			0.160**	
EMP0608				0.282***
UNION_INV	-0.0823**	-0.0805**	-0.0885**	-0.0443
EMP_INF				
EMP_CONS	0.025		0.0579**	0.0304
WORK_COND_P	0.116	0.133*	0.142*	
WORK_COND_N			0.0999	0.0984*
INNO_ORG	0.183**	0.0784	0.0858	0.0761
TRAINING	-0.0288	-0.0649*	-0.0638*	-0.0547*
INNO_TECH	0.239***	0.1		
INNO_ENV		-0.105***	-0.0687*	
ICT	-0.118*			
INTERNAT			0.0937	
Constant	0.140**	0.0655	-0.0808	0.0965*
Observations	547	547	547	547
Adjusted R2	0.134	0.136	0.146	0.17
F	6.378	6.075	5.317	7.253

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure

Tab.17: Results for controls and disaggregated innovation indexes (Equation 2)

	1	Specification 3 2	3	4
	LABPROD2009	PROF2009	TURN2009	EMP2009
SIZE 20-49			0.0556**	0.0760***
SIZE 50-99	-0.023	-0.0359*		0.0279
SIZE 100-249	-0.0395*			
LABOUR INTENSIVE			-0.0259	-0.0264
RESOURCE INTENSIVE	0.0859***	0.0905***	0.121***	0.0632***
SCIENCE BASED	0.120***	0.103***	0.161***	0.102***
SCALE INTENSIVE			0.0262	-0.0346
BOREMOPR	-0.0293	-0.0544**		
FCRARN			0.0314	
FE		-0.0337		-0.0355
PC	0.0555	0.0617	0.111**	0.102***
GROUP	0.025			0.0181
EXPORT	0.0307	0.0277		
SUPPLIER		-0.0367		-0.0176
SKILL_RATIO	0.0252	0.0203	0.0405*	0.03
INNO_SUB				0.0148
PROACTIVE	0.0167		0.0209	
MIX	0.0309			-0.0355
INV_TANG0608	-0.124			0.0645
INV_INTANG0608	0.184**	0.146**	0.176***	
LABPROD0608	0.237***			
PROF0608		0.199***		
TURN0608			0.142**	
EMP0608				0.273***
UNION_INV	-0.0810**	-0.0781**	-0.0879**	-0.0437
EMP_INF		-0.0294		
EMP_CONS	0.0245	-0.0373	0.0574**	0.0292
WORK_COND_P	0.109	0.126*	0.147*	
WORK_COND_N		0.0621	0.112	0.110*
OUTSOURCING	0.0951			
ORG_COLL	0.0403	0.0388		
PROD_PRACTICES	0.0327			0.0213
LAB_PRACTICES	0.109*	0.102*	0.131**	0.0864*
COV_INDET	0.0321	0.0361*		
COV_DET			0.0453	0.0403*
TRAIN_COMP	-0.0797**	-0.100***	-0.117***	-0.0861***
INPUT_TECH	0.0725			
OUTPUT_TECH	0.235***	0.178**	0.116	
ENV_BEN	-0.107**	-0.0781*	-0.0692**	-0.0485
ENV_PROC		-0.0708		-0.0562
ENV_MOT	0.101			0.0791
INSTR_ICT			0.0648	0.0491
SYS_ICT	-0.0496	-0.0562*	-0.0839**	-0.0461
ACT_ICT	-0.0563			
IDE	-0.0311	-0.100**	-0.0661	-0.0854**
IMPORT	-0.0236	-0.0473		0.0185
INT_PART		0.176	0.168	0.17
IDE_TYPE		0.168	0.157	0.178
IMPORT_TYPE	0.0768	0.15	0.0684	
Constant	0.134**	0.105	-0.111	0.0634
Observations	547	547	547	547
Adjusted R2	0.143	0.159	0.172	0.182
F	5.058	5.321	5.891	5.201

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure

Tab.18: Results for controls and interactions among innovative strategies (Equation 2)

	1	Specification 4 2	3	4
	LABPROD2009	PROF2009	TURN2009	EMP2009
SIZE 20-49	0.0273	0.0384*	0.0812**	0.0765***
SIZE 50-99			0.0242	0.0307
SIZE 100-249	-0.0192	0.0346	0.0242	
LABOUR INTENSIVE	-0.0157		-0.0196	-0.0199
RESOURCE INTENSIVE	0.0742***	0.0910***	0.125***	0.0671***
SCIENCE BASED	0.120***	0.117***	0.182***	0.123***
SCALE INTENSIVE		0.0323	0.0366	-0.0244
BOREMOPR	-0.0304	-0.0567***		
FCRARN			0.0382	
FE				-0.0252
PC	0.067	0.0744	0.126**	0.109***
GROUP	0.0423**	0.0195	0.03	0.0335*
SUPPLIER		-0.0324		
SKILL_RATIO	0.0238	0.02	0.0348	0.033
INNO_SUB	-0.0173	-0.0384*	-0.0263	
DEFENSIVE				-0.0159
PROACTIVE	0.0134		0.0179	
MIX	0.0246			-0.0413*
INV_TANG0608	-0.0826	0.118*		0.0542
INV_INTANG0608	0.134*		0.144**	
LABPROD0608	0.222***			
PROF0608		0.200***		
TURN0608			0.157**	
EMP0608				0.263***
UNION_INV	-0.0769**	-0.0775**	-0.0796**	-0.0345
EMP_CONS	0.025		0.0547*	0.0254
WORK_COND_P	0.125*	0.132*	0.148*	
WORK_COND_N			0.0959	0.0797
INNO_ORG (centered)	0.197***	0.0805	0.0988	0.0965
TRAINING (centered)	-0.026	-0.0741*	-0.0667*	-0.0507
INNO_TECH (centered)	0.232***	0.115		
INNO_ENV (centered)	-0.0346	-0.109***	-0.0763*	-0.0387
ICT (centered)	-0.121*			
INTERNAT (centered)			0.147	
INNO_ORG*TRAINING		0.324	0.208	0.281
INNO_ORG*INNO_TECH				-0.559
INNO_ORG*INNO_ENV		-0.415		
INNO_ORG*ICT			-0.33	-0.431
INNO_ORG*INTERNAT	-0.873	-0.494	-0.651	
TRAINING*INNO_TECH			0.354	0.553*
TRAINING*ICT		-0.228		-0.26
TRAINING*INTERNAT		-0.501	-0.65	
INNO_TECH*INNO_ENV	-0.261	-0.504	-0.629*	-0.192
INNO_TECH*ICT	-0.436			
INNO_TECH*INTERNAT	0.959	1.177	0.746	
INNO_ENV*ICT	0.660***	0.658***	0.579**	0.496**
INNO_ENV*INTERNAT		0.349		
ICT*INTERNAT				-0.406
Constant	0.159***	0.0815	-0.087	0.113*
Observations	547	547	547	547
Adjusted R2	0.145	0.145	0.155	0.179
F	5.92	4.642	4.197	6.028

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure

Tab.19: Results for controls and interaction between innovation and industrial relations variables (Equation 1)

	1	Specification 5 2	3	4
	LABPROD2009	PROF2009	TURN2009	EMP2009
SIZE 20-49	0.0325	0.0391*	0.0540**	0.0754***
SIZE 50-99				0.0304
SIZE 100-249	-0.0213	0.0335		
LABOUR INTENSIVE				-0.0205
RESOURCE INTENSIVE	0.0838***	0.109***	0.139***	0.0682***
SCIENCE BASED	0.115***	0.129***	0.187***	0.110***
SCALE INTENSIVE		0.0349	0.0520**	-0.0201
BOREMOPR	-0.0295	-0.0532**		
FCRARN			0.0383	
FE				-0.0238
PC	0.0623	0.0839*	0.129***	0.110***
GROUP	0.0350*		0.0231	0.0324*
EXPORT	0.0229	0.0389		
SUPPLIER		-0.028		
SKILL_RATIO	0.0232	0.0184	0.0455**	0.0351*
INNO_SUB		-0.0443*	-0.0241	
DEFENSIVE		-0.0178		
PROACTIVE	0.0144		0.0191	
MIX	0.0229			-0.0353
INV_TANG0608	-0.0802	0.0756		0.0528
INV_INTANG0608	0.144*	0.0748	0.145**	
LABPROD0608	0.226***			
PROF0608		0.173***		
TURN0608			0.170**	
EMP0608				0.288***
WORK_COND_P	0.130*	0.127*	0.151*	
WORK_COND_N		0.0465	0.0975	0.0889
UNION_INV (centered)	-0.0811**	-0.0714**	-0.0858**	-0.0486
EMP_INF (centered)				0.0217
EMP_CONS (centered)	0.0256		0.0595**	0.0503
INNO_ORG (centered)	0.166**	0.120*	0.0839	0.0778
TRAINING (centered)		-0.052	-0.0608	-0.044
INNO_TECH (centered)	0.229**			
INNO_ENV (centered)		-0.101***	-0.0738**	-0.0263
ICT (centered)	-0.122**			
INTERNAT (centered)			0.0827	
UNION_INV*INNO_ORG	-0.195	-0.461*	-0.448*	-0.446*
UNION_INV*TRAINING	0.194	0.245*	0.162	0.222*
UNION_INV*INNO_TECH		0.381		0.265
UNION_INV*INNO_ENV	0.098	-0.0781		
UNION_INV*ICT	-0.175	-0.248	0.165	
UNION_INV*INTERNAT				-0.277
EMP_INVa*INNO_ORG		0.274		
EMP_INV*TRAINING	0.0779	0.081		0.115
EMP_INV*INNO_TECH	-0.195	-0.363		
EMP_INV*INNO_ENV	-0.0694	0.187*		
EMP_INV*ICT	0.236	0.254*	0.169	
EMP_INV*INTERNAT			0.245	0.418**
Constant	0.111*	0.0228	-0.11	0.0812
Observations	547	547	547	547
Adjusted R2	0.133	0.147	0.151	0.181
F	5.547	4.936	5.277	5.922

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; a stepwise procedure has been applied in order to end up with parsimonious specifications starting from more general ones (probability threshold to keep the variable is 0.5); empty cells mean the variables have been dropped according to the stepwise procedure; a) the variable EMP_INV is a synthetic index for the employees involvement, which include in its construction both EMP_INF and EMP_CONS variables

6. Conclusions

The present work has shown the reaction of Emilia-Romagna manufacturing firms in front of the economic downturn experimented in 2009 through the data analysis provided by a structured survey carried out in 2009.

The descriptive analysis of information related to the pre-crisis firms conditions, to the policies the firms perceive have to be applied in order to cope with the crisis by local, national and international institutions, to the innovative activities implemented to answer to the recession and to the economic performance during the recession, provide a framework that tells us what follows.

Many firms were involved in an innovative effort in the moment the economic crisis burst. This may have made the firms financially vulnerable in front of the credit crunch that accompanied the drop in demand, crowding out the more innovative firms in a stronger way with respect to those not engaged in innovative effort before the recession. The manufacturing firms are aware of the importance of economic policies oriented to sustain the demand and the innovation, although they perceive the labour cost as the first issue to be addressed in the short run. The reaction to the crisis through innovations and the resilience in terms of economic performance seems to be sector based.

As a whole we are in front of a manufacturing sector showing a persistent innovation dynamic before the crisis, good economic performances and a capacity to recognize the importance of policies that are innovation oriented to exit from the slowdown with competitive advantages to be exploited on international markets.

The econometric exercise has provided answers to the main research questions concerning the linkages between pre-crisis innovative strategies and the capacity to react to the crisis through innovative activities, on the one hand, and the economic performance of the firm during the crisis on the other hand.

The reduced form model with innovative activities in the crisis as dependent variables has shown clearly how some firm specificities are important in sustaining innovation as an instrument to react to the crisis. Because it is not straightforward to think about an innovative strategy as a mean to overcome the recession criticalities, we consider the characteristics that positively impact on the innovative intensity in the crisis as extremely relevant. As a matter of fact, a sustained innovative activity may contribute in a crucial way to the survival and to the competitive capacity of the firm at the end of the slowdown. Good quality industrial relations, workers well being, a proactive/innovative behavior of the firm before the crisis, a small-medium size, belonging to the Science Based sector, and the geographical position of the firm, far from the core manufacturing provinces in the heart of the region, are all elements that spur innovative strategy as a way to

overcome the crisis, putting the root for the creation of competitive advantages at the end of the recession. This strategic orientation is also consistent with past innovation intensity. In particular the spheres of technology and organisation innovation show robust and positive linkages with innovative actions to cope with the crisis in all the three dimensions considered: process, product and organizational/HRM. Also training programs and ICT innovation carried out in the past are linked to innovative intensity in product and organizational/HRM dimensions. The presence of complementarities between innovation in the past that exert their influence on the capacity to innovate to react to the crisis is, however, not strongly supported by the evidence. Doing intensively innovation on the two spheres of organisation and technology negatively impact on innovative reactions to the recession's challenges. The result may be interpreted as the weaker capacity of those firms that heavily innovated in the past to carry out innovative activities in the crisis, likely because of the financial effort recently beard and because the changes introduce have not been yet completely closed or 'routinised' in the production process. An interesting point in terms of complementarities and synergies concerns the role of training which re-emerges when interacted with other innovative activities, witnessing the relevance of a strong skill base to undergone innovation strategies with intensity also during the crisis.

The second line of analysis, synthesized by the reduced form model with economic performance as dependent variables provides interesting results, with quite clear differences with respect to the results of the preceding analysis. In this analysis as in the preceding one some firm specific aspects influence the dynamic of economic performances (labour productivity, profits, turnover and employment) of the firm during the deepest period of economic crisis. In particular, small size and specific sectors are positively related to performance indicators, while geographical position is important but the signs reflect the impact of the crisis on specific local areas of the Emilia-Romagna region. Then, as expected the past performance matter: there is a sort of auto-correlation in the performance indicators, even if they are perceived ones and they do not come from balance sheets. Union involvement is negatively associated to the performance, but it is possible to hypothesise that the recession has hit highly competitive and unionized firms with participative industrial relations rather than participative industrial relations have induced worse than average economic performances. Moreover, it is likely the case that the effect of good quality industrial relations impact on firm's performances through the positive effect they have on innovation activities (Antonioli, 2009), rather than having a direct impact on economic performances. The employees involvement, on the contrary, is positively related to some indicators of performance, witnessing the important role that direct participation can play in determining firms resilience to the crisis. The importance of the human resources emerges even by the positive impact of working conditions on

the economic performance. The commitment to the firm, which also passes through workers well being, may constitute a point of strength for the firm during economic downturn.

Once we take into account past innovation strategy as explicative factors for the economic performance in the crisis the results are less clear cut than in the first line of analysis. On the one hand technological and organizational innovations positively impact on firm performance (labour productivity), but on the other hand training, environmental innovations and ICT have a negative impact on other performance indicators. The signs are driven by specific innovative elements that are included in each innovation sphere, thus it should not be correct to say that ICT, environmental innovations or training programs negatively impact on economic performances, rather it is better saying that some elements of those innovation spheres are negatively related to the performance of the firm in the crisis. Moreover, it can be hypothesized that the more dynamic and competitive firms before the crisis, opened to international competition and for such reason active on several innovation spheres are those more largely displaced by the drop in international demand with respect to the firms linked to local markets, which had a less intense innovative activity. More dynamic firms before the crisis could show worse economic performance during the crisis, but they potentially have the capacity to survive and to better compete in the medium-long run. The resilience of the firm to the recession is not even related to the existence of complementarities between innovation strategies. The disruptive power of the recession seems to have shadowed the potential role of innovation synergies on the economic performance of the firm. The same irrelevance of complementarities emerges between industrial relations and innovation strategies, although industrial relations when interacted with innovation activities turn their sign from negative to positive in some cases.

Before concluding we notice that what is relevant of the past innovative strategy of the firm and of the firm's specificities in spurring innovative reaction to the crisis is not necessarily what is relevant to obtaining good economic performances in the crisis.

The results here discussed represent a first attempt to evaluate the importance of the before crisis innovative strategy of the firm in determining the capacity to survive and react to the crisis itself. The evidence suggests that designing a consistent and coherent innovation strategy that could help the firm both to maintain above the average economic performance during periods of slowdown and to construct its capacity to react to the crisis through innovation, using it as an exit strategy capable of creating post-crisis competitive advantages, results to be very complex and challenging. The importance of the issue calls for further research and refinement of the present one, such as: econometric exercises to test the relevance of pre-crisis balance sheet data on firm performance as determinants of both innovative activities and higher performances in 2009; collecting future

balance sheets data in order to verify the linkage between innovative activities during the crisis and the capacity to exit from the crisis maintaining good economic performances and competitive advantages.

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