New Processes and New Products in Europe and Italy

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This article investigates the differences in the mechanisms and strategies conducing to the introduction of new processes and products in Italy and Europe. Three models are proposed in order to identify the different business strategies and innovation inputs associated with new products and new processes. The empirical analysis uses innovation surveys data at the industry level for 8 European countries, with a specific focus on the Italian case. The analysis shows that while the two types of innovation have a strong complementarity, product and process innovations are the results of different innovative inputs and different strategies pursued by firms.
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1. - Introduction

Innovation is a highly differentiated phenomenon, that is associated to diverse strategies of firms and is specific to industry and country conditions. However, the limited empirical information traditionally available on technological change in firms

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has long led researchers to lump all innovative efforts together, using highly imperfect proxies such as R&D expenditures and patents. The availability of European Community Innovation Surveys (CIS) has opened up a great opportunity for detailed investigations of the variety of innovation processes. This paper proposes a family of models identifying distinct innovative strategies adopted by firms and characterising different manufacturing and service industries; the patterns for Europe and Italy will be examined. In particular, building on the Schumpeterian distinction between product and process innovation, we identify the specific mechanisms leading to these two types of innovative behaviour across industries. Such diversity of innovative efforts and outcomes has been related to the contrasting strategies of *technological* and *price competitiveness* that characterise industries and countries. In particular, the strategy of technological competitiveness appears dominant in the manufacturing and service industries with a stronger innovative activity, while sectors with lower innovative efforts mainly rely on the latter strategy, targeting innovation to cost reductions (Pianta, 2001, Crespi and Pianta, 2007).

Such a distinction is of particular relevance for examining the case of Italy, whose national innovation system — compared to those of other major European countries — has a serious weakness in the ability to carry out systematic research and development activities and in sustaining the sources of technological competitiveness (Malerba, 1993; Conte, 2005; Moncada Games Paternò Castello *et* al., 2006); in fact, the prevailing competitive model has traditionally been based on price competition and process innovation (Archibugi *et* al. 1993; Ferrari *et* al. 2007). From its post-war industrial take-off, Italy has been characterised by a technological strategy of *active imitation*, with a major role of technologies embodied in equipment and machinery, rapid technological and organizational learning, imitation of foreign products with incremental improvements, and a drive for efficiency sustained by intense process innovation (Gomellini and Pianta, 2007). While this trajectory fell short of bringing Italy in line with the technological capacities of other European countries, it allowed a substantial pace of technological diffusion and relevant gains in terms of productive efficiency, especially from the fifties to the seventies of the last century (Antonelli and Barbiellini Amidei, 2007) and, to a lesser extent, in more recent decades (De Nardis and Malgarini, 1997; De Nardis and Traù, 2005). However, such a trajectory has led to a productive and technological profile of the Italian economy marked by a strong specialisation in traditional sectors, with an increasing divergence with other major industrial countries, and with major implications in terms of potential for productivity and economic growth (see section 5 below; Crespi and Pianta, 2008*a*).

The empirical analysis is based on a new and unique dataset containing data for 8 European countries for manufacturing and service industries (2 digit level of disaggregation), drawn from three waves of the Community Innovation Survey (CIS2-3-4), covering the decade 1994-2004. A major strength of these data is that they refer to the whole economy of a large number of European countries and make it possible to investigate the dynamics and relationships between different innovative input and outputs, pointing out the differences between the sources and mechanisms of product and process innovation in different industries.

In the next section a conceptual discussion on the diversity of innovation rooted in the Schumpeterian distinction between new products and new processes is provided. In section 3 the data, the model and the methodology used are described. Section 4 provides a discussion of the main results obtained from the econometric analysis, and their economic implications are analysed in section 5. Section 6 draws the main conclusions.

2. - New Products and New Processes

Technological change opens up opportunities for a variety of innovative strategies of firms, associated to particular competitive strategies in given markets. Building on a crucial Schumpeterian insight, and on a well-established literature (Scherer, 1991; Cohen and Klepper 1994; Pianta, 2001; Edquist, Hommen and McKelvey, 2001) we argue that a clear conceptual distinction can be made between product and process innovations. Product innovations, either incremental or radical ones, developed through internal (and external) innovative activities, increase the quality and variety of goods and may open up opportunities for firms' growth in output through larger quantities and/or prices. Conversely, process innovations lead to improvements in the efficiency of production of particular goods, lowering their prices, and are associated with investment embodying new technology. While the two types of innovation are closely interlinked, and in many innovative firms they are often present together,[1] they are the results of separate innovative processes, pursuing different objectives with different means.

The importance of such a distinction has rarely been pointed out in much of the innovation literature that has developed since the 1980s. This field of economic research has addressed the sources, processes, nature and impact of technological advances in firms and industries. Major areas of study have included the nature of knowledge (tacit or codified) and competences used in innovation; the technological opportunities that are present in particular fields and industries; the property rights rules, incentives, investment decisions and organisational routines that contribute to innovative performances; the diffusion patterns of particular technologies; the importance of structural factors associated to the sectoral composition of the economy; the interaction between supply conditions, financial systems and institutional factors. Several streams of research have emerged (Fagerberg, Mowery and Nelson, 2005), shedding new light on important dimensions of the innovative process, including the role

[1] In the third EU Community Innovation Survey, for the years 1998-2000, 41% of all EU firms were successful innovators, of which 23% were both product and process innovators; 10% innovated only in products and 7% innovated only in processes. In Italy, in the same period 35% of all firms were successful innovators (38% in manufacturing industries and 24% in services), of which 16% were both product and process innovators; 8% innovated only in products and 10% innovated only in processes.

of technological regimes (Breschi, Malerba, Orsenigo, 2000) and the operation of national and sectoral innovation systems (Lundvall, 1992; Nelson, 1993, Malerba, 2004).

In order to integrate these approaches with a conceptual framework capable of accounting for the specificity of different types of innovation, Pianta (2001) has identified the major distinction between a strategy of *technological competitiveness*, and a strategy of *price competitiveness*. The former is associated to a dominance of product innovation, requires substantial internal innovative efforts (research, development, design, as well as new investment), a strong inventive activity reflected in patenting, a stream of new products, with the objective of increasing market shares and opening up new markets. A strategy of *price competitiveness*, rooted in process innovation, focuses on increased efficiency achieved through innovation in cost-saving processes, introduction of new machinery, larger markets associated to a decrease in price, with a key relevance of the objective of increasing production flexibility.

Innovation is conceptualised here as a deliberate process of change based on firms' efforts (learning, managing and spending) to develop new knowledge, accumulate capital, access and absorb external sources of innovation. Innovation strategies are therefore characterised by path dependence, and are localized in nature, highly idiosyncratic with respect to firms, industries and countries. Considering knowledge-based factors, we assume a view of innovation where the sources of knowledge are present both within the innovating firm — reflected in its patenting and R&D activities —, but also emerge from the interaction and cooperation between firms and organisations where distributed and localised knowledge may be gathered and recombined, leading to new technological advances (Coombs and Metcalfe, 1998; Antonelli, 2008).

Building on this innovation literature, we want to explore in this paper the relevance of the distinction between product and process innovation strategies, associated to the search for *technological* and *price competitiveness*; for Europe as a whole and the Italian case, we will investigate the determinants of industries' innovative performances, considering the specificity of manufacturing and service sectors.

3. - Data, Models and Methodology

While there may be a complementarity between innovation in products and processes at the firm level, as shown by the evidence of European innovation surveys (Reichstein and Salter, 2006), the factors of success in either strategy are different, and industries tend to be characterised by the dominance of the search for either *technological* or *price competitiveness*. Therefore, the determinants of different innovative performances should be investigated separately, and this is made possible by the new database we have produced, where information on a large number of aspects of innovation is available at a detailed sectoral disaggregation.

3.1 *Data*

The database used for addressing the determinants of technological change is based on the Sectoral Innovation Database constructed at the University of Urbino by integrating and elaborating data from national sources of three editions of the Community Innovation Survey (CIS 2, reference period 1994-1996; CIS 3, reference period 1998-2000; CIS4, reference period 2002-2004). The Sectoral Innovation Database includes data on innovation indicators for 8 European countries - Germany, France, Italy, Norway, Netherland, Portugal, Spain, and United Kingdom. The database uses the NACE Rev.1 industry classification at the 2 digit level of aggregation, and covers 22 Manufacturing sectors and 17 Service industries.

Following previous works (Antonucci and Pianta, 2002; Crespi and Pianta, 2007; Vaona and Pianta, 2008), the indicators we use for the empirical investigation of these issues are the following.

Innovation variables: the share of firms that have introduced an innovation; the share of firms that have introduced a product innovation; the share of firms that have introduced a process innovation as dependent variables[2].

As independent variables we consider information on:

— *inputs*: the percentage of firms with R&D activities and the percentage of firms which acquired new machinery and equipments linked to innovation;

— *strategies*: the percentage of firms aiming at opening up new markets or increasing market share and the percentage of firms aiming at reducing labour costs;

— *sources of knowledge*: the percentage of firms with cooperation arrangements on innovation and the percentage of firms acquiring information from university;

— *structure of industries*: the average firm size measured as the average number of employee per firm.

The variables concerning the percentage of firms with R&D activities and the percentage of firms aiming at opening up new markets or increasing market share are assumed to describe a strategy of *technological competitiveness* and product innovation; conversely, the intensity of firms which acquired new machinery and equipments linked to innovation and the strategies aimed at reducing labour costs are assumed to account for a search for *price competitiveness* and process innovation.

While the sources of information can be relevant for either strategy[3], firm size is expected (from the "Schumpeterian hypothesis", see Vaona and Pianta, 2008) to be relevant mainly for product innovation. The use of such specific variables allows us to go beyond the traditional homogeneous view of innovations

[2] The variables on process or product innovation used in this analysis are related to the questions in the Community Innovation Survey where firms are asked to declare if they introduced product innovation independently from the fact that they introduced also process innovation or not and vice-versa. The variable on the share of innovative firms considers firms that have introduced product or/and process innovations.

[3] In particular we expect that knowledge flows from universities are relevant mainly for the development of new products.

and to dig into the details of innovative processes by analysing the role of different activities and strategies in shaping the rate and the direction of technological change. In this way our conceptual models can be properly empirically tested.

3.2 *Models*

Building on the conceptual discussion above and on previous work (Crespi and Pianta, 2007; Vaona and Pianta, 2008) in this section three models are proposed. The first is a general model in which the two major dimensions of technological activities — the strategy of technological and cost competitiveness — are both present. The remaining two specific models are aimed at testing whether these two types of innovation are associated with different strategies and activities rooted in different models of innovation.

The general model. We start from a general model that explains the relationships between innovation and its determinants. In such a general formulation, the two innovation mechanisms associated to the strategy of technological and price competitiveness are combined. We expect from this model a general test of the relevance of key mechanisms for explaining innovation performance, and a preliminary identification of the diversity of their relevance in explaining different innovation outputs such as new products or new processes. The model is the following:

$$(1) \qquad IN_{ijt} = \alpha MA_{ijt} + \beta RD_{ijt} + \mu MK_{ijt} + \gamma LB_{ijt} + \lambda IE_{ij} + e_{ijt}$$

Where:

— *IN* represents our innovation output variables such as the percentage of firms that have introduced product or process innovations as indicator of the overall innovation activities, the percentage of firms that have introduced product innovations and the percentage of firms that have introduced process innovations;

— *MA* the percentage of firms acquiring new machinery and equipments linked to innovation;

— *RD* the percentage of firms with R&D activities;

— *MK* the percentage of firms aiming at opening up new markets or increasing market share;

— *LB* the percentage of firms aiming at reducing labour costs;

— *IE* individual fixed effect;

— *e* error term;

and with time *t*, sectors *i*, countries *j*.

The model for process innovation. In the model for the determinants of process innovations (*PC*), measured as the share of firms that have introduced a process innovation, the key determinants are a strategy for reducing labour cost and the resources available for the acquisition of new machinery and equipment. The model is the following:

$$PC_{ijt} = \alpha CO_{ijt} + \mu MA_{ijt} + \gamma LB_{ijt} + \lambda IE_{ij} + e_{ijt} \quad (2)$$

Where:

— *PC* is the percentage of firms that have introduced product innovations;

— *CO* the percentage of firms with cooperation arrangements on innovation;

— *MA* the percentage of firms acquiring new machinery and equipments linked to innovation;

— *LB* the percentage of firms aiming at reducing labour costs;

— *IE* individual fixed effect;

— *e* error term;

and with time *t*, sectors *i*, countries *j*.

The model for product innovation. In the third model proposed, we aim at identifying the determinants of product innovations (*PD*), measured as the share of firms that have introduced a product innovation. The presence of product innovation is expected to be associated in particular to a deliberate market expansion strategy and to the presence of R&D activities. Moreover, we expect that the size of firms and the propensity to acquire scientific and technological knowledge from universities play a significant role. The model is as follows:

$$(3) \quad PD_{ijt} = \alpha CO_{ijt} + \beta RD_{ijt} + \mu MK_{ijt} + \sigma UN_{ijt} + \varphi FS_{ijt} + \lambda IE_{ij} + e_{ijt}$$

Where:

— *PD* is the percentage of firms that have introduced product innovations;

— *CO* the percentage of firms with cooperation arrangements on innovation;

— *RD* the percentage of firms with R&D activities;

— *MK* the percentage of firms aiming at opening up new markets or increasing market share;

— *UN* the percentage of firms acquiring information from university;

— *FS* the average firm size measured as the average number of employee per firm;

— *IE* individual fixed effect;

— *e* error term;

and with time *t*, sectors *i*, countries *j*.

3.1 *Methodology*

The focus of this analysis is an investigation of the structural differences across sectors and countries in innovative performances through time. While in our previous studies (Crespi and Pianta, 2007; Vaona and Pianta, 2008) the use of cross-sectional analysis led us to identify broad associations among variables, rather than specific causal relationships, the possibility to test our models on a panel dataset allows us to investigate more properly the relationships we want to address. In addition, the strength of the existing literature, of the conceptual framework and the details provided by the indicators used suggest that the results of this analysis can shed new light on the factors shaping specific innovative performances.

The models are first estimated by pooling the 8 countries, 39 sectors and three CIS waves (a further investigation to be carried out will introduce a more differentiated approach). As reported in the model equations, country and industry individual effects are included in the analysis in order to account for the importance of national macroeconomic contexts and for the relevance of country and sectoral specificities. Such an approach has been followed because we have compared the Fixed Effects (FE) and the Random Effects (RE) estimators by means of the Hausman test (Hausman, 1978), finding that the FE is the most appropriate model for our model.

An additional methodological problem concerns the potential endogeneity of the variables considered. We use in the model independent and dependent variables from the same CIS surveys, and no lag is introduced at this stage; we may therefore face a problem if the explanatory variables are determined simultaneously with the dependent variable. In this case there is correlation between the error term and simultaneous covariates and our FE estimates are biased and inconsistent. To deal with this issue we chose to carry out additional separate estimates using appropriate instruments for all the variables which are suspect to be endogenous and then comparing the obtained results with those deriving from FE estimator. If the sign and the significance of the coefficients obtained with the two methods do not differ, this will lead us to conclude that the potential bias due to endogeneity does not affect the goodness and reliability of our results.

In panel data models, a general approach to deal with the failure of the strict exogeneity assumption is to remove the unobserved individual effects by means of data transformation and then use appropriate instruments for the endogenous regressors. As usual, FE is an effective transformation to remove individual effects. However, FE would then make necessary to have strictly exogenous instruments for the endogenous covariates. On the contrary, the use of a first difference (FD) transformation allows to remove the unobserved individual effects and employ two-period-back lagged levels (or differences) of the endogenous covariates as valid instruments. Using such an approach, in the next section the estimations of the three models presented above will be followed by a test adopting appropriate instrumental variables for all the covariates following a GMM procedure, in order to assess the validity of results.

4. - Results

The results of the general model, tested on the whole of European economies, including manufacturing and service industries, are shown in Table 1. Column 1 presents the findings on the determinants of the share of innovative firms, the most general indicator of overall innovative performances, where both strategies of *technological* and *price competitiveness* play a role. Proxies for the sources of *technological competitiveness* include the input indicator of the share of firms with R&D activities and the strategy indicator of the share of firms aiming their innovative efforts at new markets; both variables have a positive and highly significant coefficient. Proxies for the sources of price competitiveness include, as the input indicator, the share of firms acquiring new machinery, which also shows a positive and strongly significant coefficient, while the strategy variable — the relevance of the pursuit of lower labour costs — does not emerge as significant.

By looking at the results for Italy (Column 2), the two variables associated to the strategy of *technological competitiveness* are less relevant (in terms of magnitude and significance of coefficients) in explaining the general innovative performance of industries. On the other hand, the acquisition of new machinery linked to innovation plays a positive and significant role, and also the firms' objective of reducing labour costs becomes a significant factor shaping innovative activities in Italy. A first result of this comparison is that in Italy the sources of innovation associated to a strategy of *price competitiveness* are stronger and more relevant than in the whole of Europe, while the opposite is true for the factors contributing to technological advantages.

Columns 3 and 4 replace the dependent variable with the more specific indicators of innovation in processes and products. Here the distinct operation of the two mechanisms supporting technological change in firms clearly emerges.

The determinants of the share of firms introducing new processes is found in Column 3; the acquisition of new machinery and the search for lower labour costs are both positive and significant, confirming the role played by key aspects of a cost competitiveness strategy. The presence of R&D activities has a lower relevance than in the previous regression, while the pursuit of new markets is irrelevant for explaining the importance of process innovators in European industries.

In column 4 the results for the determinants of the share of firms introducing new products are shown; the presence of R&D and a market oriented strategy have stronger coefficients than in the previous models; the acquisition of new machinery retains its significance, but with a much reduced coefficient, while the search for lower labour costs again lacks relevance.

In all models the fixed effects (controlling for both industries' and countries' individual effects) were included and the R-square shows the equations' ability to explain a major share of total variance. The relevance of fixed effects confirms the importance of national and sectoral specificities in shaping innovative activities as emphasized by previous literature on national and sectoral systems of innovation. The diversity across industries and across countries shows that systems of innovation have a strong influence on the intensity and types of innovation confirming the importance of the patterns of national specialisation in innovation emerged in previous studies (Crespi and Pianta, 2008*b*).

Once the need for a differentiated investigation of the determinants of process and product innovation has been made clear by the previous results, the specific models for explaining the importance of process and product innovators in European industries have been estimated; the results are in Tables 2 and 3.

TABLE 1

THE DETERMINANTS OF INNOVATION IN EUROPEAN MANUFACTURING AND SERVICE INDUSTRIES

Dependent variable: share of firms introducing an innovation on the total number of firms; share of firms introducing product innovation on the total number of firms; share of firms introducing process innovation on the total number of firms
Countries: DE, ES, FR, IT, NL, PT, NO, UK
Method: Fixed Effects estimator

	Share of innovative firms All countries 1	Share of innovative firms Italy 2	Share of process innovation firms All countries 3	Share of product innovation firms All countries 4
Share of firms with R&D activities	0.33***	0.22**	0.21***	0.43***
	(8.41)	(1.99)	(4.66)	(9.56)
Share of firms aiming at opening new markets	0.25***	0.12*	0.01	0.36***
	(5.84)	(1.94)	(0.13)	(7.05)
Share of firms acquiring new machinery	0.46***	0.64***	0.43***	0.13***
	(11.28)	(7.71)	(9.37)	(2.67)
Share of firms aiming at reducing labour costs	-0.04	0.32***	0.24***	-0.06
	(-0.93)	(3.66)	(4.32)	(-1.05)
Constant	15.73***	7.20***	8.28***	9.69***
	(11.85)	(4.02)	(5.19)	(5.93)
Fixed Effects	Yes	Yes	Yes	Yes
R-sq	0.64	0.86	0.55	0.60
Number of observations	647	99	591	592

* significant at the 90% level; **significant at 95%; ***significant at 99%; t-scores in parentheses.

Table 2

THE DETERMINANTS OF PROCESS INNOVATION IN EUROPEAN MANUFACTURING AND SERVICE INDUSTRIES
Dependent variable: share of firms introducing process innovation on the total number of firms
Countries: DE, ES, FR, IT, NL, PT, NO, UK
Method: Fixed Effects estimator

	All countries All sectors 1	Italy All sectors 2	All countries Manufacturing sectors 3	All countries Services sectors 4
Share of firms with cooperation arrangements on innovation	0.28***	-0.04	0.19***	0.39***
	(4.24)	(-0.20)	(2.56)	(2.99)
Share of firms acquiring new machinery	0.45***	0.72***	0.60***	0.17*
	(9.69)	(11.07)	(11.05)	(1.91)
Share of firms aiming at reducing labour costs	0.23***	0.45***	0.22***	0.19*
	(9.03)	(10.89)	(8.75)	(1.82)
Constant	10.35***	1.77	6.29***	18.24***
	(7.05)	(0.92)	(3.67)	(6.70)
Fixed Effects	Yes	Yes	Yes	Yes
R-sq	0.52	0.82	0.60	0.30
Number of observations	592	99	421	171

* significant at the 90% level; **significant at 95%; ***significant at 99%; t-scores in parentheses.

In the investigation of *process innovators*, the two previous variables on inputs (acquisition of new machinery) and strategy (aim of reducing labour costs) are retained, and information on the learning processes is included, considering the share of firms with cooperation arrangements on innovation with other firms or institutions; this represents a major "horizontal" source of knowledge in the diffusion and implementation of new technologies (Crespi and Pianta, 2007).

The model is tested on all industries (Column 1) and separately for Italy (Column 2), for manufacturing (Column 3) and service industries (Column 4). In the first estimation, all three variables' coefficients are positive and highly significant, suggesting that the model has identified major dimensions of the mechanism leading to new processes. In Column 2, the results for Italy highlight the relevance of the variables associated to the acquisition of new machinery and strategies aiming at reducing labour costs for explaining process innovation in this country — both coefficients are substantially higher than in the pool of European countries — while the cooperation variable does not emerge as statistically significant.

The evidence provided in Column 3 for manufacturing industry alone confirms the results reported in Column 1, with changes only in the size of coefficients: new machinery has a much stronger impact, while cooperation has a lower influence. In the case of services (Column 4) the results are reversed; cooperation has the strongest influence, while machinery loses importance (and significance); the reduction of labour costs maintains the size of its coefficient but loses some significance.

Again, fixed effects have been used in all models. The R-square is stable for columns 1 and 3, lower in the case of services and higher for the test on Italy, suggesting that this country fits very well with the model of *price competitiveness*.

A major result of this test is that, while the same determinants of new processes are found both in manufacturing and services, their relative importance changes. In the former the "hardware" aspects of technological change embodied in new machinery play the major role, while in services the "software" aspects of knowledge cooperatively developed with other actors have the strongest influence in industries' ability to innovate in processes.

Moving now to the explanation of *product innovation*, Table 3 shows the results of the tests on all industries (Column 1), on Italy (Column 2), on manufacturing (Column 3) and on service industries (Column 4). Again in the specific model for understanding the determinants of the share of product innovators, the two previous variables on inputs (presence of R&D) and strategy (aim of opening up new markets) are retained. Information on the learning processes is strengthened, considering both the "horizontal" dimension of the share of firms with cooperation arrangements on innovation, and the "vertical" dimension of the acquisition of information from universities, that is typical in the cases when knowledge is more codified, science plays a greater role in generating new products, and industries are characterised by greater technological opportunities (Malerba, 2004). Finally, an additional variable is introduced to test the importance of the average firms' size of industries, as the "Schumpeterian hypothesis" posits that a larger size may be associated to stronger innovative performances and greater ability to capture new product markets (Vaona and Pianta, 2008).

In the first estimation, all four variables' coefficients are positive and significant. R&D continues to play the dominant role, market oriented strategies are as important as the presence of cooperation, while information from universities has a weaker relevance both in size and significance; finally a larger firm size significantly contributes to stronger product innovation performances.

The evidence provided in Column 2 shows that in the case of Italy the variable associated to the opening of new markets is of great relevance, while the impact of R&D activities is of a lesser magnitude with respect to the case of all European countries. All the remaining variables do not emerge as playing a significant role in shaping product innovation in Italy; the ability to introduce new products is not helped either by the structure of Italian industries, where small and medium sized firms account for a very large share, or by the limited firms' ability to link to external sources of innovative ideas (in universities) and practices (in other firms and institutions). These weaknesses help explain Italy's lower share of firms innovating in products, compared to the European average, pointed out above.

Considering manufacturing industries only, in Column 3, the picture is very similar to the one for all sectors in European countries, except for the stronger influence of the input factor (R&D) and the weaker role of cooperation, in the same way as we found for process innovators in Table 2.

When the model is tested on service industries, in Column 4, the results do change, and again parallel those found in Table 2.

The input variable (R&D) loses its significance, confirming the well known evidence on the limited relevance of formal R&D for innovation in services (Evangelista and Savona, 2003), while the "software" sources of knowledge take priority, both in the case of "horizontal" cooperation and for the "vertical" flows of learning from universities (that show a lower significance). The search for new markets has a stable, highly relevant influence, while firms' size loses significance.

Again fixed effects are always introduced and the explanatory power of all models is substantial. The combination of a differentiated analysis on product and process innovation, and on manufacturing and services has made it possible to identify crucially different mechanisms that support different types of innovation in the diverse contexts of European industries. We have shown that the sources of learning, the inputs used and the overall strategies associated to innovative efforts are clearly different when we investigate product and process innovators; while the same determinants are found for manufacturing and services, the rank of their importance changes, due to the specificities of innovation processes.

A further test of the reliability of these results has been carried out — as anticipated in the previous section — by using a first differences transformation and then employing two-period-back lagged differences of the covariates as valid instruments. The results are reported in Table 4.

On the whole, we find that most of the variables used in the models shown in Tables 1-3 retain their sign, size and significance in explaining the share of innovating firms, and the shares of product and process innovators. This implies that, in general, the potential bias due to endogeneity does not affect the goodness and reliability of our results.

In particular, Column 1 presents the results of the regression using the share of innovative firms as dependent variable, confirming that all the coefficients associated to the variables considered in the model are positive and significant, with the only exception of the share of firms aiming at reducing labour costs. Concerning the model for process innovation, the evidence

TABLE 3

THE DETERMINANTS OF PRODUCT INNOVATION IN EUROPEAN MANUFACTURING AND SERVICE INDUSTRIES
Dependent variable: share of firms introducing product innovation on the total number of firms
Countries: DE, ES, FR, IT, NL, PT, NO, UK
Method: Fixed Effects estimator

	All countries All sectors 1	Italy All sectors 2	All countries Manufacturing sectors 3	All countries Services sectors 4
Share of firms with cooperation arrangements on innovation	0.23***	0.17	0.18***	0.68***
	(3.36)	(0.46)	(2.56)	(3.12)
Share of firms with R&D activities	0.41***	0.37**	0.55***	0.03
	(9.32)	(2.47)	(11.04)	(0.30)
Share of firms aiming at opening new markets	0.22***	0.50***	0.20***	0.26***
	(7.69)	(6.97)	(6.91)	(3.14)
Share of firms acquiring information from university	0.14*	-0.43	0.13*	0.50*
	(1.80)	(-0.89)	(1.64)	(1.99)
Average firm size	0.03***	-0.05*	0.02*	0.02*
	(3.57)	(-1.86)	(1.75)	(1.86)
Constant	9.80***	15.44***	8.77***	8.34**
	(6.87)	(4.20)	(5.63)	(2.09)
Fixed Effects	Yes	Yes	Yes	Yes
R-sq	0.63	0.59	0.68	0.53
Number of observations	554	94	428	126

* significant at the 90% level; **significant at 95%; ***significant at 99%; t-scores in parentheses.

Table 4

THE DETERMINANTS OF INNOVATION IN EUROPEAN MANUFACTURING AND SERVICE INDUSTRIES- ROBUSTNESS CHECKS
Dependent variable: share of firms introducing an innovation on the total number of firms; share of firms introducing product innovation on the total number of firms; share of firms introducing process innovation on the total number of firms
Countries: DE, ES, FR, IT, NL, PT, NO, UK
Method: GMM estimator

	Share of innovative firms 1	Share of process innovation firms 2	Share of product innovation firms 3
Share of firms with cooperation arrangements on innovation		-0.06	0.39*
		(-0.29)	(1.66)
Share of firms aiming at reducing labour costs	0.10	0.41**	
	(0.42)	(2.43)	
Share of firms with R&D activities	0.26***		0.17
	(2.68)		(1.32)
Share of firms aiming at opening new markets	0.34***		0.51***
	(2.72)		(4.22)
Share of firms acquiring new machinery	0.52***	0.34***	
	(2.77)	(1.90)	
Share of firms acquiring information from university			0.50***
			(2.96)
Average firm size			0.01
			(0.31)
Constant	3.00	6.77***	5.39*
	(1.23)	(2.42)	(1.91)
Chi-sq	78.72***	12.35***	73.46***
Number of observations	111	111	112

* significant at the 90% level; **significant at 95%; ***significant at 99%; z-scores in parentheses.

emerging from Column 2 indicates that both the acquisition of new machinery and equipment and the strategy of reducing labour costs contribute to a crucial mechanism for introducing new processes.

Finally, the results reported in Column 3 of Table 4 refer to the model for product innovation; here we find that while the coefficients related to the share of R&D performers and the average firm size lose their statistical significance, the relevance of the strategy of opening new markets and of the sources of information deriving from cooperation activities and from universities is confirmed.

We can therefore conclude that the results of the models proposed above highlight diverse trajectories of technological change, associated to different innovative strategies. Such a distinction helps us explaining in a more satisfactory and effective way the innovative performances of European manufacturing and service industries, as well as the specificity of the Italian economy. Italy's poor performance in product innovation appears to be the result of specific weaknesses in the R&D efforts, in the smaller firm size, and in the ability to access the external sources of scientific and technological knowledge required for developing new products. Conversely, its concentration in the search for new processes appears to be sustained by stronger mechanisms based on the role of new machinery in a strategy aiming at lower labour costs. Such characteristics suggest that in Italian industries a model of *price competitiveness* prevails, confirming the well established pattern discussed above; this has important implications for the country's technological and economic performance.

5. - The Implications for Performance

The two separate mechanisms we have identified for the generation of new products and new processes have important implications for the performances of industries and countries in terms of innovation, productivity and growth. In recent papers we have explored the innovation-productivity link pointing out the differences in the mechanisms supporting productivity growth in industries and countries dominated either by a strategy of *technological competitiveness* relying on new products, or by a strategy of *price competitiveness* based on process innovation (Crespi and Pianta, 2008*a,b*).

A first important evidence is the gap in comparative labour productivity performances, shown in Table 5, between industries oriented towards product or process innovation[4]. The former tend to show a much stronger growth of productivity than the latter, both in the US and in the EU. While in the US the picture is less clear when all industries are considered due to the relevance of services, in manufacturing sectors productivity in product-oriented industries increased faster than in process-based ones in the mid-1990s, and even more rapidly in the period up to 2001. For the aggregate of five EU countries, in the 1996-2001 period, the product-oriented group has grown more than twice as fast as the latter, both in all industries and in manufacturing only. Such a pattern shows that the major source for productivity gains in advanced economies is represented by the expansion of production and markets supported by product innovations, in a strategy searching for *technological competitiveness*, rather than by the restructuring and job losses associated to a model of *price competitiveness* based on process innovation in traditional sectors.

The major implication of this finding is that differences in national economic structures and innovation systems are likely to be important explanatory factors of overall productivity dynamics.

When individual country performances are analysed we observe that the US improves its performance over time and the five EU countries have a slow down in both groups of industries. France and Germany experience a solid growth in product innovation oriented sectors in the period 1996-2001, with rates that are twice as high as those realised by the Italian economy. Italy is the only country where, in both periods, the highest

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[4] Manufacturing and service sectors have been divided into these two groups considering the nature of industries, as highlighted by the innovation literature, and the empirical evidence, such as percentage of firms that have introduced product or process innovations (see CRESPI F. - PIANTA M., 2008*a* for details).

TABLE 5

THE DYNAMICS OF PRODUCTIVITY IN PROCESS AND PRODUCT INNOVATION ORIENTED INDUSTRIES
(COMPOUND ANNUAL RATES OF GROWTH)

	All Industries		Process Industries		Product Industries		Process Industries Manufacture Only		Product Industries Manufacture Only	
	92-96	96-01	92-96	96-01	92-96	96-01	92-96	96-01	92-96	96-01
USA	1.9	3.5	2.0	3.3	1.8	3.6	1.4	0.3	6.8	7.2
EU-5	1.9	1.3	1.2	0.8	3.3	2.1	2.5	1.3	3.8	2.9
DE	2.6	1.7	1.9	0.7	3.3	3.2	3.2	1.0	2.2	2.0
FR	1.3	1.3	0.6	0.2	2.5	3.4	0.9	1.7	5.7	6.7
IT	2.4	0.7	1.8	0.3	3.6	1.5	2.3	1.8	3.1	1.0
NL	1.2	1.1	0.2	1.2	3.9	0.7	4.5	1.8	5.4	2.4
UK	2.1	1.8	1.5	1.9	3.3	1.6	1.5	0.2	2.9	2.6

Source: CRESPI F. - PIANTA M. (2008*a*).

productivity growth in manufacturing is found in process innovation industries, suggesting that labour saving restructuring in traditional industries is dominant over the ability to increase productivity through new products and new markets. In Italy, in contrast to other advanced countries, the main mechanism supporting productive efficiency appears to be rooted in a search for *price competitiveness* that, however, is associated to a much inferior ability to sustain productivity growth.

Hence, the alternative between the strategies of *technological* or *price competitiveness* appears to have important implications since it can contribute to taking European countries and industries along diverging roads, both in terms of the mechanisms supporting productivity growth, and in terms of the potential results that can be achieved. When we compare the very slow increase of Italian labour productivity to the better performances of other advanced countries, important explanatory factors can be found in the strength, within the country's economic structure, of industries whose competitiveness relies on cost-cutting new processes, and in the weakness in product innovation and in the search of a competitiveness based on technological advantages. These characteristics of the Italian economic and innovation system have progressively locked-in the country on a slower trajectory of productivity growth.

6. - Conclusions

Four major conclusions can be drawn from this analysis. First, the conceptualisation of the strategies of *technological competitiveness* relying on new products, and of *price competitiveness*, based on new processes appears as a major contribution to a better understanding of the diverse mechanisms leading to different types of innovation in European industries. A higher share of product innovators in industries is explained by a growth-oriented strategy, described by the relevance of firms pursuing new markets, carrying out R&D, using both horizontal (cooperation among peers) and vertical (links with universities) sources of knowledge (in contexts where firms' size matters). Conversely, a higher share of process innovators is associated to the prevalence of strategies aiming at lowering labour costs, introducing new machinery (usually with a labour saving bias, see Antonucci and Pianta, 2002), and using only horizontal sources of knowledge. These distinct models identify two trajectories for innovation that are largely separate from one another, although complementarities may be important.

The second outcome is that industries — in particular manufacturing and service sectors — differ in the relative importance of the factors listed above. The technological opportunities and the characteristics of sectoral innovation systems play an important role, emphasising the distinction between manufacturing and services. The specificities of innovation processes in industries with different characteristics is likely to differentiate the mix of factors supporting the two separate mechanisms for innovation.

The third conclusion of this work is that three major dimensions of innovative efforts regularly emerge as key determinants of innovation performances. They include the inputs, the sources of knowledge, and the overall strategies orienting the innovative choices of firms. Additionally, structural factors, such as firms' size, may play a role.

For innovation studies, these results have important consequences. Current research is likely to benefit from a clear distinction between the alternative directions of innovation in firms and industries, between the technology-based or cost-driven strategies associated to innovative efforts. Likewise, innovation policies can become more effective if they target explicitly the types of knowledge, learning, innovation expenditures, investments and new markets expansion that are relevant in specific industries and countries.

A fourth conclusion concerns the relevance of countries' economic structure and innovation system in shaping the prevalent model of technological change and its impact on economic performance. The two strategies of *technological* and *price competitiveness* are associated to diverging country performances in terms of labour productivity, with a superior growth path associated to the prevalence of technological advantages rooted in new products (Crespi and Pianta, 2008*b*). In this perspective, the nature of the innovation mechanism characterising a country is likely to shape its trajectory of long run economic growth. The case of Italy appears in stark contrast with the other major European countries investigated in this article; a model of *price competitiveness* relying on process innovation has appeared as the dominant pattern of Italian innovation. The acquisition of new machinery linked to innovation and firms' objective of reducing labour costs have emerged as the strongest factors behind Italy's innovative performances, typical of industries with lower technological activities. In Italy, this specific model of change and diffusion of technologies has sustained in the last decade a modest rate of productivity growth, but its potential is substantially lower than the alternative source of expansion based on new products and technological advantages, that is typical of other advanced countries. A result of this analysis that may be a cause for concern is that the Italian economy appears to be locked-in in an inferior path of technological development and productivity growth.

BIBLIOGRAPHY

ANTONELLI C., *Localized Technological Change. Towards the Economics of Complexity*, London, Routledge, 2008.

ANTONELLI C. - BARBIELLINI AMIDEI F., «Innovazione tecnologica e mutamento strutturale dell'industria italiana nel secondo dopoguerra», in ANTONELLI C. - BARBIELLINI AMIDEI F. - GIANNETTI R. - GOMELLINI M. - PASTORELLI S. - PIANTA M., *Innovazione tecnologica e sviluppo industriale nel secondo dopoguerra*, Bari, Laterza, 2007, pages 3-358.

ANTONUCCI T. - PIANTA M., «The Employment Effects of Product and Process Innovations in Europe», *International Review of Applied Economics*, no. 16 (3), 2002, pages 295-308.

ARCHIBUGI D. - EVANGELISTA R. - PIANTA M., «Forze e debolezze del sistema innovativo italiano», *Economia e Politica Industriale*, no. 79 (3), 1993, pages 137-166.

BRESCHI S. - MALERBA F. - ORSENIGO L., «Technological Regimes and Schumpeterian Patterns of Innovation», *Economic Journal*, no. 110, 2000, pages 388-410.

COHEN W.M. - KLEPPER S., «Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D», *Review of Economics and Statistics*, no. 788 (2), 1994, pages 232-243.

CONTE A., «La relazione tra input ed output innovativi nell'industria italiana», *Rivista di Politica Economica*, no. 7 (4), 2005, pages 129-159.

COOMBS R. - METCALFE J.S., «Distributed Capabilities and the Governance of the Firm», Manchester, *CRIC, Discussion Paper*, n. 16, 1998.

CRESPI F. - PIANTA M., «Innovation and Demand in European Industries», *Economia Politica - Journal of Institutional and Analytical Economics*, no. 24 (1), 2007, pages 79-112.

— — - — —, «Demand and Innovation in Productivity Growth», *International Review of Applied Economics*, no. 22 (6), 2008*a*, pages 655-672.

— — - — —, «Diversity in Innovation and Productivity in Europe», *Journal of Evolutionary Economics*, no. 18 (3-4), 2008*b*, pages 529-545.

DE NARDIS S. - MALGARINI M., «Le politiche di prezzo all'esportazione delle imprese manifatturiere», Roma, *ICE, Quaderni di Ricerca*, n. 2, 1997.

DE NARDIS S. - TRAÙ F., *Il modello che non c'era. L'Italia e la divisione internazionale del lavoro industriale*, Soveria Mannelli, Rubbettino, 2005.

EDQUIST C. - HOMMEN L. - MCKELVEY M., *Innovation and Employment: Product versus Process Innovation*, Cheltenham, Elgar, 2001.

EUROPEAN COMMISSION - EUROSTAT, *Innovation in Europe. Results for the EU, Iceland and Norway. Data 1998-2001*, Luxembourg, European Commission, 2004.

EVANGELISTA R. - SAVONA M., «Innovation, Employment and Skills in Services. Firm and Sectoral Evidence», *Structural Change and Economic Dynamics*, no. 14 (4), 2003, pages 449-474.

FAGEBERG J. - MOWERY D. - NELSON R.R. (eds.), *The Oxford Handbook of Innovation*, Oxford, Oxford University Press, 2005 (ital. edn. *Innovazione. Imprese, industrie, economie*, Roma, Carocci, 2007).

FERRARI S. - GUERRIERI P. - MALERBA F. - MARIOTTI S. - PALMA D.(eds.), *L'Italia nella competizione tecnologica internazionale. Quinto Rapporto*, Milano, Franco Angeli, 2007.

GOMELLINI M. - PIANTA M., «Commercio con l'estero e tecnologia in Italia negli anni Cinquanta e Sessanta», in ANTONELLI C. - BARBIELLINI AMIDEI F. - GIANNETTI R. - GOMELLINI M. - PASTORELLI S. - PIANTA M., *Innovazione tecnologica e sviluppo industriale nel secondo dopoguerra*, Bari, Laterza, 2007, pages 359-594.

HAUSMAN J.A., «Specification Tests in Econometrics», *Econometrica*, no. 46 (6), 1978, pages 1251-1271.

LUNDVALL B.A., *National Systems of Innovation*, London, Pinter Publishers, 1992.

MALERBA F., «The National System of Innovation: Italy», in NELSON R.R., *National Innovation Systems: A Comparative Analysis*, New York, Oxford University Press, 1993, pages 230-259.

— —, (ed.), *Sectoral Systems of Innovation*, Cambridge, Cambridge University Press, 2004.

MONCADA PATERNÒ-CASTELLO P. - CIUPAGEA C. - PICCALUGA A., «L'innovazione industriale in Italia: persiste il modello "senza ricerca?"», *L'industria*, no. 27 (3), 2006, pages 533-551.

NELSON R.R. (ed.), *National Innovation Systems*, New York, Oxford University Press, 1993.

PIANTA M., «Innovation, Demand and Employment», in PETIT P. - SOETE L. (eds.), *Technology and the Future of European Employment*, Cheltenham, Elgar, 2001, pages 142-165.

REICHSTEIN T. - SALTER A., «Investigating the Sources of Process Innovation among UK Manufacturing Firms», *Industrial and Corporate Change*, no. 15 (4), 2006, pages 653-682.

SCHERER F.M., «Changing Perspectives on the Firm Size Problem», in ACS Z.J. - AUDRETSCH D.B. (eds.), *Innovation and Technological Change: An International Comparison*, Ann Arbor, University of Michigan Press, 1991, pages 24-38.

VAONA A. - PIANTA M., «Firm Size, Innovation and Growth in European Manufacturing», *Small Business Economics*, no. 30 (3), 2008, pages 283-299.