Innovation and human capital in the Italian food industry: a comparative analysis on micro-data*

Massimiliano D'Alessio**, Ornella Wanda Maietta***

Abstract

Objective of the paper is to verify which are the determinants of the innovation process in the Italian food industry and whether they are different according to firm property rights.

The data used are the 9th (2001-2003) wave of Capitalia surveys based on a representative sample of manufacturing firms with information on firm characteristics, employee education levels, innovation, R&D investments.

The approach is a bivariate probit analysis where the dependent variables are the presence of firm R&D and of innovations and the independent variables are firm characteristics.

The results of the analysis show that the determinants of firm R&D *intra moenia* and of firm innovations in the food industry have been the subsidies for R&D *extra moenia*, which have the highest marginal effect, and the level of employee education.

Keywords: firm innovations, R&D expenditure, food industry

JEL: O31, O32, D21

* This work has been implemented under the research project: "*Spillovers sistemici sulla competitività dell'industria italiana: una valutazione quantitativa per le politiche di settore*", PRIN 2004. We want to thank Attilio Luigi Pasetto, of Capitalia, for kindly providing us the data.

** Fondazione Metes, Rome.

*** Corresponding author, Università di Napoli Federico II and Centro per la Formazione in Economia e Politica dello Sviluppo Rurale, Portici (Naples), maietta@unina.it

1. Introduction

The impact of ownership on economic performance and particularly on efficiency has been the subject of considerable theoretical debate.

Traditionally, cooperatives are perceived as less efficient organizations due to lack of monitoring, short term horizon, common property, nontransferability and control problems (Alchian and Demsetz 1972, Furubotn, 1976, Jensen and Meckling 1979). These problems lead to both free-riding or shirking; in addition, underinvestment can result.

On the other hand, a tightening in financial constraints (Maietta and Sena, 2004) and an increasing product market competition (Maietta *et al.* 2006; Maietta and Sena, forthcoming) tend to increase the efficiency of producer cooperatives and then to be beneficial to the survival of this kind of firms. Besides, the hypothesis of cooperative undercapitalisation is rejected for the Italian food industry (Maietta and Sena, 2008).

In the literature, the persistence of cooperatives in competitive markets has rarely been linked to innovation and networking capabilities: Novkovic (2007) proposes an evolutionary model in a mixed industry where the innovation strategy of a cooperative is labour-intensive oriented and the creation of cooperative networking is the resulting survival strategy.

The aim of this paper is to assess the role of firm property rights on the introduction of innovations in the Italian food industry with respect to other determinants, customarily used in literature to explain the introduction of innovations, such as skilled employees and R&D *intra* and *extra moenia*. In fact, since the Italian food industry is characterised by small firms (Coppola *et al*., forthcoming) and by a low R&D investment (1.5% on turnover in 2005), public subsidies to stimulate university-industry interactions have been important and particularly used in the South of Italy (Istituto Guglielmo Tagliacarne, 2004)

The analysis is performed by using the information on food industry firms contained in the 9th (2001-2003) wave of the Capitalia survey.

2. The university-industry interactions

Several studies, referring to the channels through which technological transfer happens have analysed the effect of the university-industry interactions for the American case (Ulrich *et al*., 1986; Mowery *et al.*, 2001; Thursby *et al.*, 2001; Colyvas *et al*., 2002; Di Gregorio and Shane, 2003). Few studies have been carried out for Europe and Italy.

Baldini *et al.* (2006) have analysed the activities of Italian universities relating to patents, by collecting detailed information on patents deposited by Italian universities at the Italian Patent and License Office (Ufficio Italiano Brevetti e Marchi): firms represent the 23% of co-patentees of Italian universities during the examined period.

Technological transfer from universities to firms is realised not only through patents and research collaborations: the results of D'Este and Patel's study (2007), based on a large scale survey of UK academic researchers, show that university scholars interact with industry using a wide variety of channels, and engage more frequently in the majority of the channels examined, such as *consultancy & contract research, joint research, or training,* as compared to patenting or spin-out activities. The variety and frequency of interactions is explained more by individual characteristics of researchers than by the characteristics of their departments or universities.

Iorio (2006) confirms that patenting is not the most frequent mechanism of interaction between university and industry in Italy. The impact of the research collaboration with industry in the Universities of Bologna, Ferrara and Trieste is judged as favourable in the interviews carried out on academic scholars, both on the quantity and quality of publications. However, the increase in time devoted to industrial research reduces the time devoted to academic research and the publications stemming from industrial research are delayed, particularly when the research in collaboration stems from a patent respect to a joint publication.

Bonaccorsi *et al.* (2006) measure the efficiency of Italian universities also by taking into account industrial transfers. They find out that scale and scope economies are not important factors in explaining research and education productivity for Italian universities. About the trade-off between academic publications and industry oriented research, their results imply that, initially, collaboration with industry may improve productivity, but above a certain threshold, it may be too demanding and deteriorate the publication quality. The rivalry effects have a local characterization with evidence of an inverted U-shaped relation between the share of university budget stemming from industrial transfers and the university efficiency variation.

Ramaciotti (2006) observes that the collaboration between university and industry is crucial for the economic development of local systems and the notion itself of technological transfer from university to industry is obsolete because it is based on the existence of two separated organisations which exchange an appropriable good: the applied research. This notion is linked to a particular historical phase, the fordist one, where firms were big organisations aimed at the physical production of a good; their plants were given and their advantages were static scale economies of mass reproduction of a standardised product. In this model, research was an activity antecedent to production, whose results required changes in the production processes in order to be applied. Industrial innovation was, then, a shock to be realised in discontinuous terms. On the contrary, universities themselves can be incubators of new firms, allowing the birth of firms stemming from research, the so-called spin-off effect, attracting investments of firms which are outside the university area and transmitting technology to already existing firms (belonging to high-tech clusters).

Quadrio Curzio and Fortis (2002) analyse the elements which explain the success of relatively small high-tech firm systems all over the world. Their results show that the collaboration between university and industry is crucial for the development of local systems. In this ambit, the presence of human capital specialised in particular technical and scientific skills, both similar or complementary, is fundamental (Ramaciotti, 2006).

3. The empirical evidence on innovation determinants

The empirical literature on innovation determinants is very broad[1]: this section will review only the studies which verify the role of universities and public research labs on innovations or which are referred to the Italian manufacturing industry.

De Jong and Vermeulen (2007), by referring to the Netherlands, investigate the determinants of product innovations for small and medium firms (with less than 100 employee), of different sectors in order to disentangle the effect of intersectoral aggregation on the parameter estimates. The use of external networks, to extend a firm's knowledge base (consisting of relations with universities, suppliers and

[1] A review of empirical investigations on product innovations in small and medium firms is in de Jong and Vermeulen (2007).

knowledge institutes) is significant for the whole sample in the logit regression but not for the manufacturing industry, for which the determinants are the presence of documented innovation plans, of market researches and of inter-firm cooperation.

Basile (2001) identifies the innovation determinant factor in the Italian manufacturing industry by applying a probit regression to the data of the 6th wave of Capitalia survey, referred to the period 1992-94. The most significant factors explaining the probability of selling a new product for the whole sample are: the technological agreements with external firms, the firm size and age, R&D intensity, the share of investments devote to the introduction of new machineries and plant, the presence of skill level workers and the firm localization in the Centre-North of Italy. For the traditional sectors, the most significant factors are: the firm age, the technological agreements with external firms and the share of investments devote to the introduction of new machineries and plants.

Parisi *et al*. (2006) extract a panel data front the 6th and 7th waves of Capitalia surveys and apply simple and random logit regressions where the dependent variables are the introduction of process and product innovations while the independent variables are size, measured by the logarithm of the stock of physical capital, the intensity of R&D on physical capital, the intensity in physical capital investment and the interaction between the latter and the R&D intensity. They found out that R&D spending is positively associated with the probability of introducing a new product, but not with the probability of introducing a new process. The latter is strongly associated with spending on new fixed capital, which is enhanced by R&D spending, suggesting an important role for embodied technological progress.

Piga and Vivarelli (2004), by applying a probit regression with sample selection to the data of the 7th wave of Capitalia, find out that the determinants of firm external relationships with universities and public research labs are the public property of firms, the presence of public subsidies for the promotion of innovation and the proportion of firm inputs acquired via outsourcing agreements. A lower propensity results for firms located in Central Italy.

Medda *et al*. (2005) use the data of the 7th wave of Capitalia survey in order to investigate the determinants of firm external relationships with universities and public research labs by applying a probit regression with sample selection. It appears that small firms (< 50 employees) and those companies acquiring a large proportion of their inputs via outsourcing agreements, are more likely to establish such alliances while the share of exports on sales firms is a significant variable with a negative effect. The variables statistically significant which influence the presence of internal R&D are: the size, the workers' human capital, the exports and the competition degree, while significant variables with a negative effect are: the proportion of inputs acquired via outsourcing agreements and the share of total sales acquired by the three main clients, which seem to indicate a firm technological dependence, through inputs or outputs.

4. Methodology

4.1. The bivariate probit regression

We adopt a bivariate probit regression (Greene, 2004) were the dependent variables refer to the presence of firm R&D *intra moenia* and of firm innovations while the covariates are variables which influences the probabilities of observing both the events.

More precisely, y_1^* and y_2^* are latent variables, such that:

y_1*= presence of firm R&D *intra moenia*;

y_2*= presence of firm innovation;

x = vector of firm structure variables which influences the probability of firm R&D *intra moenia*;

z = variable vector which influences the probability of firm innovations;

$$y_1^* = \boldsymbol{\beta}'\mathbf{x} + u, \quad F_{R\&D} = 1, \quad \text{if} \quad y_1^* > 0, \quad 0 \text{ otherwise},$$

$$y_2^* = \boldsymbol{\delta}'\mathbf{z} + v \qquad F_{INN} = 1, \quad \text{if} \quad y_2^* > 0, \quad 0 \text{ otherwise},$$

$$E(u \mid \mathbf{x}, \mathbf{z}) = E(v \mid \mathbf{x}, \mathbf{z}) = 0,$$

$$Var(u \mid \mathbf{x}, \mathbf{z}) = Var(v \mid \mathbf{x}, \mathbf{z}) = 1,$$

$$Cov(u, v \mid \mathbf{x}, \mathbf{z}) = \rho$$

4.2. The data

Our data are sourced from the manufacturing firm survey, conducted by (former Mediocredito Centrale) Capitalia, for the periods 2001-2003 (9^{th}). The Survey collects information on a representative sample of manufacturing firms operating in Italy with more than ten employees and all firms with more than 500 employees. Using ATECO classification, we extracted a sample of respectively 484 firms for the food industry in the period under examination. Capitalia Surveys collect information on the introduction of innovations and on firm characteristics, such as its property rights and its interaction with universities, public and private research labs. Table 1 reports the descriptive statistics for the sample examined.

Table 1 - *Descriptive statistics for the food industry firms in the sample*

Variable	**Italy**	**South**
N. firms	484	154
Firms with product innovations	275	96
Firms with process innovations	166	50
Firms with other innovations	100	33
Turnover average (ml €)	31622	19589
Investment rating (th €)	963	747
R&D/turnover (%)	0.24	0.21
No. emplyoees	87	56
Skilled employees (%)	1.6	1.8
Firms with intra moenia R&D	126	36
Firms with R&D from universities and public research labs	35	35
Firm with R&D from other firms	44	44
Firms with non standard jobs (%)	67	58
Firms that receive subsidies	245	95
Cooperatives	81	27

4.3. The empirical specification

The specification adopted for the index functions of the bivariate probit regression are the following:

$F_{R\&D} = \beta_0 + \beta_1$ Skilled employees + β_2 Non standard jobs + β_3 Subsidies for extra moenia R&D+β_4 Cooperative + firm relative prices + North and South dummies

$F_{INN} = \delta_0 + \delta_1$ Imm + δ_2 District + δ_3 Province social capital +δ_4 R&S *extra-moenia*+δ_5 Cooperative +δ_6 Product quality improvement + δ_7 Environment friendly technology + North and South dummies + dummies for size classes and subsectors

where:
Non standard jobs, Subsidies for *extra moenia* R&D, Cooperative, R&S *extra-moenia*, Product quality improvement, Environment friendly technology are dummy variables;

Skilled employees = share of graduate employees;

Firm relative price proxies, calculated from the firm balance sheets, are averaged over the three years:
user cost of capital
Materials/turnover
Imm = immaterial capital on total capital

Size classes dummies are defined according to AGRA classification (2004):
Size class 3 = 5 - 25 ml € turnover
Size class 4 = 25 - 50 ml € turnover
Size class 5 = ≥ 50 ml € turnover

Province social capital is sourced from Sessa (1998) and is referred to the province where the firm is located.

5. Econometric results

This section illustrates the results from the econometric analysis on firm innovative behaviour. Our sample reduces respectively to 345 observations, due to missing values.

Tables 2 and 3 contain the estimates of the coefficients (with their p-values) of the two univariate probit regressions. In general, the regression fit is good as the covariates used are significant as it is possible to judge from the value of the Wald test performed on the joint significance of all the variables [Wald χ^2 (30) = 90.42, Prob > χ^2 = 0.0000]. Besides, the value of ρ is high (0.62998) and significant [LR test of ρ =0: χ^2 (1) = 12.357, Prob χ^2 = 0.0004].

Table 2 - *R&D intra moenia determinants*

Variable	**Coef.**	**z**	**P>|z|**
Skilled employees	0.12	**3.41**	0.001
Non standard jobs	0.58	**3.24**	0.001
Subsidies for *extra moenia* R&D	2.79	**3.42**	0.001
User cost of capital	-0.24	-2.52	0.012
Immaterial capital on total	0.44	1.26	0.208
Materials/turnover	-1.77	**-3.13**	0.002
User cost of capital*Coop	0.18	0.93	0.351
Immaterial capital on total*Coop	-0.48	-0.58	0.565
Materials/turnover* Coop	-2.63	-1.06	0.29
Coop	2.46	1.15	0.248
North	0.29	1.04	0.297
South	-0.04	-0.13	0.896
Constant	-0.20	-0.39	0.699

Table 3 - *Innovation determinants*

Variable	**Coef.**	**z**	**P>|z|**
Immaterial capital on total	-0.65	**-1.86**	0.063
R&D extra moenia	0.67	**1.63**	0.104
District	0.07	0.33	0.739
Social capital	0.01	1.50	0.133
Coop	-0.12	-0.46	0.644
Product quality imprment	0.11	1.27	0.205
Envir. friendly technology	0.31	**2.62**	0.009
Size class 5 - 25 ml € turnover	0.35	1.52	0.128
Size class 25 - 50 ml € turnover	0.50	1.41	0.159
Size class ≥ 50 ml € turnover	0.25	0.76	0.449
North	-0.09	-0.29	0.775
South	0.23	0.68	0.499
Meat dummy	-0.99	**-3.28**	0.001
Fruit&vegetable dummy	-1.15	**-3.64**	0.000
Dairy dummy	-0.83	**-2.70**	0.007
Rice dummy	-1.32	**-3.36**	0.001
Constant	0.53	1.03	0.304

Table 4 contains the estimates of the marginal effects (with their p-values) for the bivariate probit model regression related to the 2001-2003 period.

From table 4, subsidies for R&D *extra moenia* have the highest impact on firm R&D and innovation; non standard jobs and skilled employees are also significant. Among the proxies of relative prices, the variable materials on turnover has a negative

impact on firm R&D and innovations; after including the relative prices, the coop dummy is positive and significant (6%).

We do not observe a statistically significant difference between firms belonging to different size classes, geographic areas and sub-sectors as all size, geographical, territorial and sub-sector dummies are not significant.

Table 4 - *Marginal effects of R&D intra moenia and innovation determinants*

Variable	**dy/dx**	**z**	**P>|z|**
Skilled employees	**0.04**	**3.42**	0.001
Non standard jobs	**0.17**	**3.42**	0.001
Subsidies for extra moenia R&D	**0.67**	**17.01**	0.000
User cost of capital	-0.08	-2.49	0.013
Immaterial capital on total	0.13	1.22	0.224
Materials/turnover	**-0.56**	**-3.14**	0.002
User cost of capital *Coop	0.06	0.92	0.357
Immaterial capital on total *Coop	-0.15	-0.58	0.565
Materials/turnover * Coop	-0.83	-1.06	0.290
Coop	**0.68**	**2.77**	0.006
North	0.09	1.04	0.299
South	-0.01	-0.12	0.908
R&D *extra moenia*	0.00	0.74	0.462
District	0.00	0.32	0.748
Social capital	0.00	0.71	0.475
Product quality improvment	0.00	0.68	0.498
Envir. friendly technology	0.00	0.84	0.402
Size class and sector dummies	not significant		

Log likelihood = -284.026

6. Concluding remarks

The aim of this work is to assess the determinants of the introduction of innovations in the Italian food industry. The analysis was carried out by applying a bivariate probit regression model to the data of food firms sourced from the 9th (2001-2003) wave of the Capitalia Survey.

The results of the analysis show that the determinants of firm R&D *intra moenia* and innovations in the food industry have been the subsidies for R&D *extra moenia*, which have the highest marginal effect, non standard jobs and skilled employees. Among the proxies of relative prices, the variable materials on turnover has a negative impact on firm R&D and innovations; finally, after including the relative prices and their interactions with the coop dummy, the latter turns out to be positive and significant (6%).

References

AGRA (2004), Industria alimentare in Italia, Roma.

Alchian A.A., Demsetz H. (1972), Production, Information Costs, and Economic Organization, *American Economic Review*, 62: 5, 777-795.

Baldini N., Grimaldi R., Sombrero M. (2006), Institutional changes and the commercialization of academic knowledge: a study of Italian universities' patenting activities between 1965 and 2002, *Research Policy*, 35, 518-532.

Basile R. (1998), Innovazione tecnologica e strategie organizative delle imprese nell'industria manifatturiera italiana, *Economia e politica industriale*, n. 100, 119-152.

Bonaccorsi A., Daraio C., Simar L. (2006), Exploring size and agglomeration effects on public research productivity, *Scientometrics*, Vol. 63, No. 1, 87–120.

Bratti M., Matteucci N. (2005), Is there Skill-Biased Technological Change in Italian Manufacturing? Evidence from Firm-Level Data, *Brussels Economic Review*, 48, 1, 715-744.

Colyvas J. et al. (2002), How do universities inventions get into practice?, *Management Science*, 48, 1, 61-72.

Coppola, A., Maietta, O.W., Pascucci, S. (forthcoming), Corporate governance e performance: un'analisi comparata delle imprese del sistema agro-alimentare italiano, in (eds.) Cella G., Zago A., *Spillover sistemici, efficienza e competitività dell'economia italiana: una valutazione quantitativa per le politiche di settore*, Bologna, Il Mulino.

D'Este P., Patel P. (2007), University-industry linkages in the UK: what are the factors underlying the variety of interactions with industry?, *Research Policy*, 36, 1295-1313.

de Jong J. P.J., Vermeulen P. A.M. (2006), Determinants of product innovation in small firms: a comparison across industries, *International Small Business Journal*, 24(6), 587 – 609.

Di Gregorio D., Shane S. (2003), Why do some Universities generate more start-ups than others?, *Research Policy* , 32, 209-227.

Furubotn E. G. (1976), The Long-Run Analysis of the Labor-Managed Firm: An Alternative Explanation, *American Economic Review*, 66, 1: 104–123.

Greene W.H. (2004), *Econometric Analysis*, Prentice Hall.

Iorio R. (2006), Ricerca industriale di scienziati accademici: un'opportunità o un rischio per la "*open science*"? UN'analisi alla luce degli esiti di un questionario in tre università italiane, in Ramaciotti, op. cit.

Istituto Guglielmo Tagliacarne (2004), *L'innovazione nelle imprese del Mezzogiorno*,

Jensen M. C., Meckling W. H. (1979), Rights and Production Functions: An Application to Labor-Managed Firms and Codetermination, *Journal of Business*, 52, 4: 469–506.

Maietta O.W., Sena V. (2004), Profit sharing, technical efficiency change and finance constraints, *Advances in the Economic Analysis of Participatory and Labor-Managed Firms*, 8, 149-167.

Maietta O.W., Sena V. (2008), Is competition really bad news for cooperatives? Some empirical evidence for Italian cooperatives, *Journal of Productivity Analysis*, vol. 29, n. 3, 221-233.

Maietta O.W., Sena V. (forthcoming), Shadow Price of Capital and the Furubotn-Pejovich Effect: Some Empirical Evidence for Italian Wine Cooperatives, in *Applied Stochastic Models in Business and Industry*.

Medda G, Piga C. (2004), R&S e spillover industriali: un'analisi sulle imprese italiane, *CRENOS Working Papers* No.04/06.

Medda G, Piga C.A., Siegel D.S. (2005), University R&D and firm productivity: evidence from Italy, *Journal of Technology Transfer*, 30, 1/2, 199-205.

Mowery D.C., Nelson R.R., Sampat B.R., Ziedonis A.A. (2001), The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980, *Research Policy*, 30, 99-119.

Nelson R.R. (1996), *The Source of Economic Growth*, Cambridge, Massachusetts: Harvard University Press.

Nelson R.R., Winter S.G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Massachusetts, Harvard University Press.

Nelson R.R., Winter S.G., Schuette L.H. (1976), Technological change in an evolutionary model', *Quarterly Journal of Economics*, 90, 90–118.

Novkovic S. (2007), R&D, innovation and networking: strategies for cooperative survival, *Advances in the Economic Analysis of Participatory and Labor-Managed Firms*,10, 205-232.

Parisi M.L., Schiantarelli F., Sembenelli A. (2006), Productivity, Innovation creation and Absorption, and R&D: Micro Evidence for Italy, *European Economic Review*, 50, 8, 2037-2061.

Piga C. A., Vivarelli M. (2004), Internal and external R&D: a sample selection approach, *Oxford Bulletin of Economics and Statistics*, 66, 4, 457-482.

Quadrio Curzio A., Fortis M. (a cura di) (2002), *Complessità e distretti industriali*, Il Mulino, Bologna.

Sessa C. (1998), I beni relazionali nelle province italiane: una metodologia di misurazione, *Economia e Lavoro*, 32, 2, 27-48.

Thursby J., Jensen R., Thursby M.C. (2001), Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities, *Journal of Technology Transfer* , 26 (2001), 59-72.

Ulrich A., Furtan H., Schmitz A. (1986), Public and private returns to joint venture research: an example from agriculture, *The Quarterly Journal of Economics*, 51, 1, 103-130.