HOW DO YOUNG INNOVATIVE COMPANIES INNOVATE?

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Abstract

This paper discusses the determinants of product innovation in young innovative companies (YICs) by looking at in-house and external R&D and at the acquisition of external technology in its embodied and disembodied components. These input-output relationships are tested on a sample of 2,713 innovative Italian firms. A sample-selection approach is applied to study both the determinants of product innovation and the factors affecting the intensity of innovation.

Results show that in-house R&D is linked to the propensity to introduce product innovation both in mature firms and YICs; however, innovation intensity in the YICs is mainly dependent on embodied technical change from external sources, while in-house R&D does not play a significant role.

Keywords: R&D, Embodied technological change, Product innovation, New firms, Sample selection.

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1 Introduction

Increasing interest is being shown by both the scientific community and policy makers in the role of young innovative companies (YICs) in the new technology implementation process, which contributes to the renewal of the industrial structure and ultimately to aggregate economic growth[1]. For instance, one of the possible explanations of the transatlantic productivity gap could be found in the revealed capacity of the US economy to generate an increasing flow of young innovative firms which manage to survive and introduce new products, taking their place at the core of emerging sectors. On the contrary, young European firms reveal lower innovative capacity and most of them are doomed to early failure, the process resulting in churning rather than innovative industrial dynamics (see Bartelsman *et al*., 2004; Santarelli and Vivarelli, 2007).

There are several different sources of innovation at the firm level; together with in-house and external R&D activities, technological acquisition (TA) in its embodied (machinery and equipment) and disembodied components also has to be taken into account. This input-output framework can be seen as an extension of the "Knowledge Production Function" (KPF, initially put forward by Griliches, 1979), a feasible tool for describing the transformation process running from innovative inputs to innovative outputs.

While most previous microeconometric research has focused on the R&D-Innovation-Productivity chain (see next section), few studies have explicitly discussed the role of TA and the possible differences in the KPF across firms of different ages. By using microdata from the European Community Innovation Survey 3 (CIS 3) for the Italian manufacturing sector, the main novelty of this paper lies in the authors' investigation of whether R&D and TA lead to significant differences in determining innovative output in

[1] For instance, several EU Member States have introduced new measures to support the creation and growth of YICs, especially by improving their access to funding (see BEPA, 2008; Schneider and Veugelers, 2008).

firms of different ages. In particular, it will be tested whether the KPF of YICs exhibits some peculiarities in comparison with what emerges in the case of mature incumbent firms.

The remainder of the paper is organised as follows: a discussion of the theoretical framework on which this work is based (Section 2) is followed by a description of the data and indicators used in the empirical analysis and by discussion of the adopted econometric methodology (Section 3). Subsequently, the empirical outcomes derived from the descriptive analysis and the econometric estimates (Section 4) are discussed. Section 5 concludes the paper by briefly summarising the main findings obtained.

2 The literature

Previous economic literature has taken R&D and patents as a starting point for the analysis of innovative activities across economies, industries and firms. In particular, the relationship between innovative inputs and outputs explicitly appears as one of the components of those analyses whose main target is to measure the returns on innovation. In this stream of literature, the first contribution to discuss the innovative input-output relationship was by Griliches (1979 and 1990), through a three-equation model in which one of the equations is what he called the Knowledge Production Function (KPF), a function intended to represent the transformation process leading from innovative inputs (R&D) to innovative outputs (patents)[2]. Similarly, the KFP is also included in the models provided by Crèpon *et al*. (1998) and Lööf and Heshmati (2001).

The theoretical framework so far described has provided the background for understanding the link between innovative inputs and outputs and for the empirical assessment of this relationship. However, for the particular purpose of this paper, most of the previous empirical studies suffer from two

[2] The other two equations in Griliches' simultaneous model represent the production function (augmented by the innovation term) and the determinants of R&D investment. See also Hall (1996), Hall (2000), Mairesse and Mohnen (2002), Harhoff *et al*. (2003) and Hall *et al.* (2005).

main limitations. Firstly, the relationship between innovation inputs and innovation outputs is not their main focus but rather a secondary equation, ancillary to the authors' main purpose of investigating firms' performance in terms of productivity and/or profitability. Secondly, and more importantly, the KPF is simplified as a link between R&D and patents. Historically driven by relative availability with respect to other measures of innovation, the relationship between a firm's R&D investment and patenting activity leaves room today for a more comprehensive approach to the determinants of its innovativeness. In particular, nowadays innovation surveys provide more precise and comprehensive measures of both innovative inputs and outputs[3].

Consistently, different innovation outputs can be seen as the outcomes of several innovation inputs and not only as the consequence of formal R&D investments[4]. For instance, it is important to consider the role of technological acquisition (TA), both through 'embodied technical change'[5] acquired by means of investment in new machinery and equipment, and through the purchasing of external technology incorporated in licences, consultancies, and know-how (Freeman, 1982; Freeman *et al.*, 1982; Freeman and Soete, 1987).

[3] Patents turn out to be a very rough proxy of innovation for several reasons: 1) not all innovations are patented (firms generally prefer other ways of protecting their innovation, see Levin *et al.*, 1987); 2) patents are very rare among small innovative firms and YICs; 3) patents differ greatly in their importance; 4) firms in different sectors show very different propensities to patent (see Archibugi and Pianta, 1992; Patel and Pavitt, 1995).

[4] This broader perspective is also endorsed in methodological advice as to the collection of data regarding innovation; in particular, this is well represented by the shift from the R&D-focused Frascati Manual ("Guidelines for the collection of R&D data", first published in 1963) to the Oslo Manual in the 1990s (OECD, 1997).

[5] The embodied nature of technological progress and the effects related to its spread in the economy were originally discussed by Salter (1960) and Solow (1960); in particular, vintage capital models describe an endogenous process of innovation in which the replacement of old equipment is the main way through which firms update their own technologies (see also Jorgenson, 1966; Hulten, 1992; Greenwood *et al.* 1997; Hercowitz, 1998).

This paper represents an attempt to open up this broader perspective. Once it has been recognized that innovative inputs are not confined to formal R&D and that innovative outputs can be measured by other (more satisfactory) indicators than patents[6], we pave the way for a deeper analysis of firms' peculiarities in the KPF. In this framework, firms adapt their innovative strategy to their own particular economic environment by choosing the most effective combination of innovative inputs and outputs. In doing so, they distribute economic resources between formal in-house and external R&D, technological change embodied in machinery and equipment and the purchasing of external know-how and licenses.

In particular, we wonder whether YICs differ from mature incumbents in their input-output innovative relationships. Are YICs more R&D-based and conducive to a science-based reorientation of the current industrial structure?[7] Or - on the contrary - are YICs weaker than innovative incumbents and so less R&D-based and basically dependent on external knowledge provided by larger mature firms and research institutions?

The hypothesis of small and newly established firms being more science-based and technologically advanced is consistent with the entrepreneurial process of 'creative destruction' (Schumpeter, 1934; the so-called Schumpeter Mark I), while the process of 'creative accumulation' calls for large and established firms to take a leading role in the innovative process (Schumpeter, 1942;

[6] See Nelson and Winter (1982) and Dosi (1988) for an extended and more articulated view of the innovative process across firms.

[7] This seems to be the view implicitly accepted in the literature on the so-called "New Technology Based Firms" (NTBFs, see Storey and Tether, 1998; Colombo and Grilli, 2005), where only YICs in the high-tech sectors are analyzed; in contrast, in this paper YICs across all sectors are studied. While in this study we compare YICs with mature innovative incumbents, a related stream of literature investigates the role of innovation in facilitating the entry and post-entry performance of newborn firms (see Audretsch and Vivarelli, 1996; Arrighetti and Vivarelli, 1999; Cefis and Marsili, 2006). Finally, in this paper only innovative firms are studied, while another related field of studies investigates the different propensity to innovate according to a firm's age (see Hansen, 1992; Huergo and Jaumandreu, 2004).

Schumpeter Mark II). Adopting evolutionary terminology, the former context can be seen as an ‘entrepreneurial regime’, where new firms and the industrial dynamics are the basic factors of change, while the latter can be considered a ‘routinized regime’, where larger and older incumbents are the engines of change and lead the innovative process (see Winter, 1984; Malerba and Orsenigo, 1996; Breschi *et al.*, 2000).

Indeed, when focusing on all the industrial sectors and not only the emerging or the high-tech ones, several arguments sustain the view that larger mature firms might turn out to be more R&D based than their younger counterparts. Firstly, mature larger incumbents are not affected by liquidity constraints since they have both easier access to external finance and more internal funds to support R&D activities which are both costly and uncertain. Secondly, larger incumbent firms possess a higher degree of market power and so enjoy a higher degree of “appropriability” (Gilbert and Newbery, 1982). Empirically, Cohen and Klepper (1996) provide stylised facts supporting the view that the likelihood of a firm carrying out R&D increases with size, while Mairesse and Mohnen (2002) highlight the scale economies and the differences in the organisation of work that make larger established incumbents more inclined to carry out R&D activities. Thirdly, learning economies (see Arrow, 1962; Malerba, 1992) are often crucial in innovative dynamics and older (experienced) firms are obviously at an advantage from this perspective.

However, not all innovative firms are large established corporations. Indeed, economic literature supports the hypothesis that small and young firms face a different technological and economic environment from large mature firms with respect to innovative activities (see Acs and Audretsch, 1988 and 1990; Acs *et al.*, 1994). In particular, as discussed above, R&D does not represent the sole input through which firms can produce some innovative outcomes. While the financial and competitive reasons discussed above can hamper an R&D-based innovative strategy for YICs, it seems much easier for them to rely on the market and choose "to buy" instead of "to make" technology (Acs and Audretsch, 1990). One of the hypotheses to be tested in this paper is therefore whether an innovation outcome in YICs relies more on external sources of knowledge than on formal in-house R&D. This hypothesis appears even more plausible in a middle-technology economy, such as that of Italy, where middle-tech and traditional sectors represent the core of the industrial structure (for evidence on the crucial role of embodied technical change and other external sources of knowledge in spurring innovation in the medium and low-tech sectors, see Santarelli and Sterlacchini, 1994 and Santamaría *et al.*, 2009).

In other words – in the specific Italian 'national innovation system' (see Freeman, 1987, Lundvall, 1992 and Nelson, 1993, for an introduction to the concept; Malerba, 1993, for an application to the Italian case) - NTBFs may be an exception, while for YICs the main way to acquire knowledge might be through embodied technical change and technological acquisition (for previous evidence on the role of embodied technological change in fostering innovation in Italian manufacturing firms, see Santarelli and Sterlacchini, 1990, and Conte and Vivarelli, 2005).

3 Dataset, indicators and methodology

The empirical analysis was carried out using microdata drawn from the third Italian CIS, conducted over a three-year period (1998-2000) by the Italian National Institute of Statistics (ISTAT). This survey is representative at both the sector and the firm size level of the entire population of Italian firms with more than 10 employees. The CIS 3 dataset adopts a weighting procedure that relates the sample of firms interviewed to the entire population[8] (ISTAT, 2004).

[8] Firm selection was carried out through a "one step stratified sample design". The sample in each stratum was selected with equal probability and without reimmission. The stratification of the sample was based on the following three variables: firm size, sector, regional location. Technically, in the generic stratum h, the random selection of n_{h} sample observations among the N_{h} belonging to the entire population was realized through the following procedure:

- a random number in the 0-1 interval was attributed to each N_h population unit;
- N_h population units were sorted by increasing values of the random number;
- units in the first n_h positions in the order previously mentioned were selected.

The dataset comprises a set of general information (main industry of affiliation, group belonging, turnover, employment, exports) and a (much larger) set of innovation variables measuring the firms' innovativeness, economic and non-economic measures of the effects of innovation, subjective evaluations of factors hampering or fostering innovation, participation in cooperative innovation activities and access to public funding. The response rate was 53%, determining a full sample size of 15,512 firms, 9,034 of which (58.24%) in the manufacturing sector, our focus of attention. The manufacturing sample was then cleaned of outliers and firms involved in mergers or acquisitions during the previous three years, which would have biased our results[9]. We thus ended up with 7,965 innovating and not-innovating firms.

The sub-sample of innovators was then selected following the standard practice of identifying innovators as those firms declaring that in the previous three years they had introduced product or process innovations, or had started innovative projects (then dropped or still-to-complete at December 31st, 2000). The same definition was implemented by ISTAT as a filter to save non-innovators having to plough through all the questions not relevant to them (with the risk of non-innovating firms not responding to the rest of the questionnaire). Thus, firms identified as non-innovators were allowed to skip a large number of 'innovation questions', leaving us with very little information about their propensity to innovate or to invest in innovative inputs. This means that the CIS database provides information relevant to this study

Estimates obtained from the selected sample are very close to the actual values in the national population. The weighting procedure follows Eurostat and Oslo Manual (OECD, 1997) recommendations: weights indicate the inverse of the probability that the observation is sampled. Therefore, sampling weights ensure that each group of firms is properly represented and correct for sample selection. Moreover, sampling weights help in reducing heteroscedasticity commonly arising when the analysis focuses on survey data.

[9] In fact, mergers and acquisitions may break the link between innovative inputs and outputs (a link that must be studied within the context of a single firm).

only for innovative firms; therefore only these firms were considered in the following analysis[10], ending up with 3,045 firms. This sample was further reduced to 2,713 firms by keeping only firms the age of which is available and investing in at least one of the four innovative inputs we focus on. Finally, YICs were identified as young firms with less than eight years of activity (293 out of 2,713)[11].

3.1. Innovative outputs

Innovative outputs can be distinguished with respect to their position in the innovation process. For instance, while patents are better defined as the outcome of the inventive process, product innovation properly represents the result of the market-oriented innovative process. However, even though product innovation is driven by demand considerations, it represents a pre-market result. In contrast, the share of sales deriving from innovative products (Mairesse and Mohnen, 2002) represents an *ex-post* result in which the market has positively welcomed the new products introduced by the firm (Barlet *et al.,* 2000).

Taking these considerations and the interpretative background discussed in Section 2 into account, this paper uses two available output indicators for the empirical analysis: namely, the introduction of product innovation (PROD), and the share of turnover (sales) derived from innovative products

[10] Given that our aim is that of analyzing the nature of the relationships within the innovative process (and not, for example, the effect of different inputs in determining the probability of innovating), this data limitation does not raise a problem of selection bias. Since we are interested in the internal mechanisms of the innovative process, we have to focus on a randomly selected sample of innovative firms (that is, randomness must hold *within* the innovative sub-sample, not in comparison with the non-innovative one where such mechanisms are obviously absent). For a study based on a comparison *between* innovative and non-innovative Italian firms, see Parisi *et al.* 2006.

[11] As far as the age of the firms in the 'young firms' sub-sample is concerned, the threshold of 8 years was chosen to take into account the trade-off between a lower age and the representativeness of the sub-sample of YICs (here almost 10% of the entire sample). However, estimates in Section 3.4 were replicated using a larger sample of young firms no more than 10 years old. The results, available from the authors upon request, do not change substantially.

(TURNIN)[12]. It is worth noting that this sales-weighted measure of innovation is the only continuous output indicator provided by the CIS and it indicates the intensity of innovation (Lööf and Heshmati, 2002; Mairesse and Mohnen, 2002).

3.2. Innovative inputs

Bearing in mind the theoretical discussion presented in Section 2, four innovative inputs are used in this paper: in-house and external expenditures in formal Research and Development (intra muros R&D = IR); Research and Development outsourced to other firms or research institutes (extra muros R&D = ER); expenditures in embodied technological change (innovative investment in equipment and machinery = MAC); and expenditures in technology acquisition (disembodied technology such as know-how, projects and consultancies, licenses and software = TA).

3.3. Control variables

CIS 3 provides further information on firms beyond their innovative activity. Econometric estimates in this paper adopt some of these indicators as further controls and explanatory variables. Attention is paid to the following control variables:

1. Firm's export propensity (EXPint): global competition can spur innovation and capabilities, while technologically inactive firms are doomed to exclusion from the international arena (e.g. Archibugi and Iammarino, 1999; Narula and Zanfei, 2003).

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[12] It is worth emphasizing the link adopted in the questionnaire design; this link goes from product innovation to the sales ratio indicator since only firms that have introduced product innovation can record a positive percentage of their sales as being derived from product innovation. This raises an issue of sample selection that will be discussed in the next methodological Section 3.4.

2. Firm's belonging to an industrial group (IG): Mairesse and Mohnen (2002) underline the expected innovative benefits due to easier access to (internal) finance and to the effect of intra-group knowledge links for firms that are members of industrial groups.

3. Firm's access to policy support (SUPPORT): a government subsidy or a fiscal incentive should increase a firm's innovative performance, although the empirical evidence on this is quite controversial[13].

4. Firms participating in a cooperation agreement (COOP): as regards the important role of cooperation agreements in affecting the innovative output of firms see Cassiman and Veugelers (2002), Piga and Vivarelli (2003 and 2004), Fritsch and Franke (2004), Parker (2008).

5. Appropriability: the availability and use of different instruments for achieving a larger degree of appropriability of the innovation rent, such as patents (PATENT), trademarks, secrecy, etc. (PROT) (see Levin *et al*., 1987) should positively affect the innovative performance.

6. While the recognized obstacles to innovation (such as financial constraints or organizational hindrances) (HURDLE) should obviously damage innovative performance, the occurrence of

[13] In fact, while public funding should stimulate (in absolute terms) both the input and the output side of innovation, a crowding out effect seems to operate, displacing (totally or partly) privately funded innovation activities. Using a dataset of firms which benefited from the Small Business Innovation Research Program, Wallsten (2000) even comes to the conclusion that R&D grants completely crowd out firm-financed R&D spending, dollar for dollar. The view of Gonzáles *et al.* (2005) is much more optimistic: they found no evidence of crowding out. Using an unbalanced panel of more than 2000 Spanish manufacturing firms, the authors show that government intervention stimulates R&D activities. Midway between such extreme results, the majority of existing empirical literature on the subject shows that public support fosters innovation, crowding out effects operating only partially (see Busom, 2000).

other forms of innovation (such as organizational change, see Bresnahan *et al* 2002; Hitt and Brynjolfsson, 2002; Piva *et al*, 2005) (OTHERIN) should be complementary to the four innovative inputs described in the previous section.

Finally Pavitt's sectoral dummies (Pavitt, 1984) were added to the econometric specification in order to control for the different sectoral technological opportunity and appropriability conditions.

Table 1 describes the variables used in the empirical analysis, while Table 2 reports the corresponding descriptive statistics, distinguishing all firms, mature firms and YICs and – within each of these three categories – innovative firms from the subsets characterised by having introduced a product innovation[14].

< INSERT TABLES 1 AND 2 >

Table 3 reports the sectoral compositions of the two subsamples of mature firms and YICs: as can be seen, with regard to most sectors and the four Pavitt (1984) categories, no significant differences emerge; however - to be on the safe side - all the regressions were controlled for Pavitt's sectoral dummies. Differently, as far as the size of the firms is concerned, YICs turn out to be relatively smaller (112 employees on average) than their older counterparts (183 employees). This means that the subsample of YICs – in contrast with the mature firms - may be affected by those advantages and disadvantages discussed at the end of Section 2 with reference to small innovative firms (Schumpeter Mark I type).

< INSERT TABLE 3 >

[14] In the Appendix, Table A1 reports the correlation matrix for the entire sample; as can be seen, all the correlation coefficients are less than 0.371, showing that data are not affected by serious collinearity problems. Finally, Table A2 reports the CIS questions on the basis of which the variables were constructed.

3.4. Econometric issues

Equation (1) describes the general specification adopted for the aggregate empirical test of the innovative input-output relationship:

$$TURNIN_i = C + \beta_1 IRint_i + \beta_2 ERint_i + \beta_3 MACint_i + \beta_4 TAint_i + \sum \beta_J X_{ji} + \sum \gamma_k PAVITT_{ki} + \varepsilon \qquad \textbf{(1)}$$

where C is the constant, i is the firm-index, TURNIN represents the innovative output in terms of the percentage of sales due to innovative products, IR, ER, MAC and TA indicate the innovative inputs we are interested in, X is the vector of the (max j=8) control variables and PAVITT are the sectoral dummies (Science-based, Scale intensive and Specialised suppliers, with the Suppliers-dominated as the default category; k=3). Consistently with the dependent variable, the four innovative inputs were normalized by sales; this makes the inputs homogeneous to the output and also controls for the scale effect due to the different sizes of the investigated firms.

As a consequence of the questionnaire's design, the adopted sales-weighted measure of a firm's innovativeness (TURNIN) assumes a positive value only for firms that have introduced product innovation (PROD). This raises an obvious problem of sample selection that has to be dealt with. In particular equation (1) was tested jointly with a selection probit equation (2) of the type:

$$P(PROD_i=1) = C + \beta_1 IRint_i + \beta_2 ERint_i + \beta_3 MACint_i + \beta_4 TAint_i + \sum \beta_J Z_{ji} + \sum \gamma_k PAVITT_{ki} + \varepsilon_i \qquad \textbf{(2)}$$

where Z is an extended vector of controls in equation (1), with $X \in Z$[15].

[15] X and Z were differentiated, taking into account the statistical significance of the different controls in the two equations, the occurrence of convergence in all the three models and the need for a homogeneous comparison between them. However, results are robust to different specifications of the sample selection model (available upon request).

Both the high values of the correlation coefficients (ρ) between the selection and the main equation and the statistical significances of the Mills ratios in the three models (all firms, mature firms, YICs) (see Table 4) confirm the validity of the choice of a Heckman-Type (see Heckman, 1979) specification.

Besides these statistical reasons, the advantage of running a Heckman-Type model is the possibility to separately assess the impact of the different regressors on: (1) the probability to engage in product innovation (PROD); (2) the intensity of innovation (TURNIN). As we will discuss in the next Section, this is important from an interpretative point of view. The possible alternative TOBIT methodology (the results of which are reported in Table A3 for completeness) looses this degree of freedom, arbitrarily assuming "*ex-ante*" that the same model can explain both the decision to engage in product innovation and the intensity of such an innovative behaviour.

< INSERT TABLE 4 >

4 Empirical results

Table 4 reports the econometric results of the sample selection model applied to the entire sample and separately to the two sub-samples of the mature incumbents and the YICs. As can be seen, in-house R&D is important in increasing the likelihood of product innovation for the entire sample, although this link is less significant for the YICs. More importantly and in contrast with the mature firms, innovation intensity (TURNIN) is not related to internal R&D (IR) as far as the YICs are concerned. Far from being NTBFs, Italian YICs do not turn out to be R&D based, but rather dependent on external sources of knowledge.

The above result becomes obvious if we turn our attention to the other three innovative inputs. Neither external research (ER) nor technological acquisition (TA) seem to play a significant role in spurring product innovation in Italian manufacturing firms. However, in contrast with what happens for well-established incumbents, their impact is positive, although not significant, with regard to the YICs. Although statistically very weak, this outcome may suggest a possible role of ER and TA in facilitating innovation in the young firms.

Much more statistically robust is the outcome concerning the "embodied technical change" variable MAC. While rendering product innovation less likely[16], MAC is positively and significantly linked to the innovation intensity in all the three models.

However, the coefficient is more than double the size in the case of the YICs. This means that Italian YICs are particularly dependent on the embodied technical change incorporated in machinery and equipment purchased from external sources. Together with what was found in relation to the non-significant impact of IR, this means that the investigated YICs lack endogenous technological capabilities, while they are massively dependent on technologies coming from other firms through input-output relationships. On the whole, these results highlight a potential weakness of Italian YICs, which seem to lack an endogenous capacity to sustain their own innovative activities.

Briefly looking at the control variables (see Section 3.3), not surprisingly we notice that exporting and science-based YICs are more likely to perform better in terms of innovative intensity. Instead, and in contrast with the mature firms, YICs do not seem to be established enough to be responsive to variables such as HURDLE, OTHERIN and PROT. This can be seen as a sign that these firms are still too young

[16] This result is consistent with previous studies (see Conte and Vivarelli, 2005) and is not surprising; indeed, it can be seen as a direct consequence of the sample selection procedure. In fact, MAC is strictly related to process innovation, which is the innovative category excluded in the selected sample. The 615 excluded firms are those only engaged in process innovation, while the 2,098 firms included are those exhibiting either product innovation only or product and process innovation jointly.

and inexperienced to set up a proper appropriability regime and to develop complementary innovative strategies.

The results from the alternative TOBIT methodology – pooling together those firms not engaged in product innovation with those involved into it – are reported in Table A3 in the Appendix. As mentioned at the end of the previous section, this approach does not allow to disentangle the impact on the probability to introduce a product innovation from the impact on the intensity of innovation. For instance, we miss the possibility to single out the peculiar role of MAC within the mature firms, rendering product innovation less likely but increasing innovation intensity[17]. However, the main outcome showing that Italian YICs are mainly dependent on embodied technical change, with in-house R&D not playing a significant role, is fully confirmed by the TOBIT estimates.

5 Concluding remarks

This paper has discussed the determinants of innovative output in YICs and mature firms, by looking both at firms' internal and external R&D activities and at the acquisition of external technology in its embodied and disembodied components. These input-output relationships have been tested through a sample selection procedure which takes into account the fact that our measure of innovative performance only refers to product innovation.

Looking at the aggregate results, it turns out that in-house R&D is closely linked to innovative performance, while external R&D does not seem to play a relevant role in Italian manufacturing. However, once the YICs are distinguished from the established firms, in the former internal R&D expenditures no longer play a role in increasing innovation intensity, although they do increase the

[17] Not surprisingly, the two significant and opposite effects singled out in the first two models of Table 3 average down into a not significant impact in the first two columns of Table A3.

probability of engaging in product innovation. The crucial innovative input for YICs turns out to be the external acquisition of technology in its embodied component (MAC). This input is also positive and significant with regard to the mature firms, but it more than doubles in the case of the YICs.

These results suggest that in a intermediate-technology context such as Italian manufacturing where middle-tech and traditional sectors represent the core of the industrial structure, on average YICs cannot be considered as NTBFs. Rather, they appear to be entrepreneurial entities which need to acquire external knowledge in order to foster their own innovation activity and are therefore crucially dependent on the external environment.

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Table 1: The variables

Innovative input variables	
IRint	Internal R&D expenditure in 2000, normalized by total turnover
ERint	External R&D expenditure in 2000, normalized by total turnover
MACint	Investments in innovative machinery and equipment in 2000, normalized by total turnover
TAint	Technological acquisitions in 2000, normalized by total turnover
Innovative output variables	
TURNIN	Share of firm's total sales due to sale of new products
PROD	Product innovation: dummy = 1 if TURNIN > 0
Firm's general characteristics	
EXPint	Export intensity ((turnover from export) / turnover)
IG	Dummy = 1 if belonging to an industrial group
Innovative-relevant information	
SUPPORT	Dummy = 1 if the firm has received public support for innovation
COOP	Dummy = 1 if the firm takes part in cooperative innovative activities
PATENT	Dummy = 1 if the firm uses patents
PROT	Dummy = 1 if the firm adopts other instruments of protection than patents
HURDLE	Dummy = 1 if the firm has faced some kind of obstacle to innovation
OTHERIN	Dummy = 1 if the firm has realized managerial, strategic or organizational innovation
Pavitt sectoral dummies	
SB	Dummy = 1 if science-based firm
SI	Dummy = 1 if scale intensive firm
SS	Dummy = 1 if specialized supplier firm
SD	Dummy = 1 if supplier-dominated firm

Table 2: Descriptive statistics

	ALL FIRMS				MATURE FIRMS				YOUNG FIRMS (YICs)			
	2,713 OBS		2,098 OBS		2,420 OBS		1,870 OBS		293 OBS		228 OBS	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Innovative input variables												
IRint	0.013	0.026	0.015	0.028	0.013	0.025	0.015	0.027	0.014	0.032	0.017	0.036
ERint	0.002	0.009	0.002	0.010	0.002	0.008	0.002	0.009	0.002	0.011	0.003	0.013
MACint	0.035	0.078	0.028	0.067	0.034	0.076	0.027	0.063	0.042	0.091	0.038	0.093
TAint	0.002	0.018	0.002	0.015	0.002	0.017	0.002	0.013	0.004	0.023	0.004	0.025
Innovative output variables												
TURNIN	0.30	0.29	0.39	0.28	0.30	0.29	0.39	0.27	0.34	0.32	0.44	0.30
PROD (*dummy*)	0.773	0.419	1	0	0.773	0.419	1	0	0.778	0.416	1	0
Firm's general characteristics												
EXPint	0.254	0.285	0.278	0.290	0.259	0.286	0.283	0.290	0.215	0.279	0.235	0.286
IG (*dummy*)	0.291	0.454	0.318	0.466	0.290	0.454	0.318	0.466	0.300	0.459	0.316	0.466
Innovative-relevant information												
SUPPORT (*dummy*)	0.533	0.499	0.539	0.499	0.533	0.499	0.536	0.499	0.536	0.499	0.566	0.497
COOP (*dummy*)	0.161	0.368	0.192	0.394	0.162	0.369	0.193	0.395	0.150	0.358	0.180	0.385
PATENT (*dummy*)	0.348	0.476	0.413	0.492	0.354	0.478	0.420	0.494	0.293	0.456	0.360	0.481
PROT (*dummy*)	0.679	0.467	0.756	0.430	0.683	0.465	0.758	0.428	0.642	0.480	0.737	0.441
HURDLE (*dummy*)	0.402	0.490	0.424	0.494	0.397	0.489	0.418	0.493	0.440	0.497	0.474	0.500
OTHERIN (*dummy*)	0.841	0.365	0.886	0.318	0.838	0.369	0.884	0.320	0.874	0.333	0.899	0.302
Pavitt sectoral dummies												
SB (*dummy*)	0.116	0.320	0.134	0.341	0.113	0.316	0.130	0.337	0.140	0.347	0.167	0.373
SI (*dummy*)	0.284	0.451	0.250	0.433	0.282	0.450	0.248	0.432	0.300	0.459	0.267	0.444
SS (*dummy*)	0.280	0.449	0.314	0.464	0.282	0.450	0.318	0.466	0.266	0.443	0.285	0.452
SD (*dummy*)	0.320	0.466	0.301	0.459	0.323	0.468	0.304	0.460	0.293	0.456	0.281	0.450

Table 3: Sectoral composition and average employment of the firms belonging to the two subsamples: YICs and Mature firms.

INDUSTRY	YOUNG			MATURE		
	N. of firms	%	Av. Emp	N. of firms	%	Av. Emp
Manufacture of food products and beverage	14	4.8	136	152	6.3	210
Manufacture of textiles	13	4.4	107	110	4.5	205
Manufacture of wearing apparel; dressing and dyeing of fur	6	2.0	47	43	1.8	131
Manufacture of leather and related products	7	2.4	73	58	2.4	83
Manufacture of wood and of products of wood and cork, exc. furniture	9	3.1	26	80	3.3	55
Manufacture of paper and paper products	8	2.7	65	72	3.0	89
Printing and reproduction of recorded media	10	3.4	34	124	5.1	97
Manufacture of coke and refined petroleum products	5	1.7	139	18	0.7	52
Manufacture of chemicals and chemical products	27	9.2	191	200	8.3	189
Manufacture of rubber and plastics products	15	5.1	62	151	6.2	128
Manufacture of other non-metallic mineral products	17	5.8	37	152	6.3	173
Manufacture of basic metals	18	6.1	133	94	3.9	335
Manufacture of fabricated metal products	26	8.9	79	194	8.0	115
Manufacture of machinery and mechanichal equipment	37	12.6	197	292	12.1	252
Manufacture of office machinery and computers	7	2.4	26	33	1.4	82
Manufacture of electrical equipment	13	4.4	96	154	6.4	174
Manufacture of radio, television and communication equipment	9	3.1	277	97	4.0	222
Manufacture of medical, precision and optical instruments	23	7.8	118	126	5.2	75
Manufacture of motor vehicles, trailers and semi-trailers	11	3.8	77	84	3.5	460
Manufacture of other transport equipment	8	2.7	73	49	2.0	646
Other manufacturing	8	2.7	53	124	5.1	91
Waste collection, treatment and disposal activities; materials recovery	2	0.7	15	13	0.5	17
PAVITT TAXONOMY						
Science Based	41	14	165.29	273	11.28	296.52
Scale Intensive	88	30.03	95.02	683	28.22	192.74
Specialized Suppliers	78	26.62	131.13	683	28.22	179.43
Suppliers Dominated	86	29.35	87.30	781	32.27	136.77
SAMPLE	293	100	112.20	2,420	100	182.63

Table 4: The sample selection estimates

	ALL FIRMS		MATURE FIRMS		YICs	
	PROD	TURNIN	PROD	TURNIN	PROD	TURNIN
Constant	-0.19** (-2.13)	0.16*** (3.01)	-0.16* (-1.79)	0.2*** (3.60)	-0.25 (-0.83)	0.12 (0.85)
IRint	15.17*** (7.20)	1.29*** (4.62)	15.23*** (6.91)	1.28*** (4.29)	14.42* (1.90)	0.80 (1.16)
ERint	7.75 (1.24)	0.26 (0.37)	8.47 (1.25)	-0.01 (-0.02)	2.59 (0.14)	1.36 (0.79)
MACint	-1.11*** (-3.23)	0.32*** (3.07)	-1.38*** (-3.61)	0.27** (2.32)	0.19 (0.20)	0.68*** (3.03)
TAint	-0.32 (-0.20)	-0.35 (-0.87)	-0.25 (-0.15)	-0.69 (-1.47)	-0.90 (-0.21)	0.37 (0.43)
EXPint	0.10 (0.89)	0.03 (1.29)	0.11 (0.93)	0.015 (0.65)	0.04 (0.11)	0.17** (2.14)
IG	0.01 (0.19)		0.02 (0.24)		-0.11 (-0.48)	
SUPPORT	-0.09 (-1.43)		-0.13** (-2.00)		0.38* (1.88)	
COOP	0.37*** (3.55)	0.03* (1.86)	0.38*** (3.39)	0.03* (1.65)	0.53 (1.44)	0.01 (0.25)
PATENT	0.48*** (6.21)		0.47*** (5.85)		0.66** (2.20)	
PROT	0.46*** (6.95)	0.05** (2.41)	0.43*** (6.12)	0.05** (2.11)	0.72*** (3.50)	0.06 (0.75)
HURDLE	-0.01 (-0.09)	-0.02 (-1.60)	-0.022 (-0.34)	-0.03** (-2.11)	0.08 (0.39)	0.02 (0.57)
OTHERIN	0.42*** (5.47)	0.07*** (2.97)	0.45*** (5.54)	0.06** (2.52)	0.15 (0.58)	0.05 (0.76)
SB	0.18 (1.46)	0.08*** (3.67)	0.13 (1.03)	0.06*** (2.63)	0.56 (1.38)	0.20*** (2.81)
SI	-0.08 (-1.20)	-0.00 (-0.06)	-0.08 (-1.13)	0.00 (0.05)	-0.26 (-1.15)	-0.01 (-0.11)
SS	0.35*** (4.41)	0.07*** (4.05)	0.37*** (4.30)	0.07*** (3.53)	0.20 (0.80)	0.07 (1.18)
ρ	0.62		0.48		0.85	
Mills λ	0.18*** (2.98)		0.14** (2.19)		0.27* (1.75)	
N. of firms	2,713	2,098	2,420	1,870	293	228

Notes:
- *z*-statistics in parentheses: * Significant at 10%; ** 5%; *** 1% .

APPENDIX

Table A1: Correlation matrix (overall sample: 2,713 firms).

	PROD	IRint	ERint	MACint	TAint	EXPint	OTHERIN	IG	SUPPORT	COOP	PATENT	PROT	HURDLE
PROD	1.000												
IRint	0.186	1.000											
ERint	0.093	0.245	1.000										
MACint	-0.159	-0.069	-0.046	1.000									
TAint	-0.007	0.026	0.044	0.034	1.000								
EXPint	0.160	0.050	0.041	-0.167	-0.037	1.000							
OTHERIN	0.223	0.062	0.049	-0.093	0.027	0.163	1.000						
IG	0.110	0.024	0.057	-0.115	-0.008	0.243	0.109	1.000					
SUPPORT	0.021	0.178	0.061	0.060	0.003	0.055	0.031	0.000	1.000				
COOP	0.156	0.173	0.168	-0.074	0.014	0.159	0.105	0.249	0.118	1.000			
PATENT	0.253	0.096	0.102	-0.141	0.020	0.304	0.171	0.241	0.055	0.196	1.000		
PROT	0.306	0.150	0.099	-0.134	-0.003	0.240	0.311	0.185	0.059	0.186	0.370	1.000	
HURDLE	0.083	0.100	0.091	-0.018	0.036	0.048	0.139	0.000	0.002	0.093	0.116	0.152	1.000
SB	0.108	0.234	0.220	-0.054	0.001	0.048	0.059	0.050	0.019	0.127	0.135	0.140	0.051
SI	-0.139	-0.077	-0.090	0.107	0.017	-0.149	-0.073	-0.015	0.008	-0.031	-0.121	-0.126	-0.058
SS	0.138	0.065	0.037	-0.094	-0.024	0.154	0.010	0.041	0.031	0.077	0.114	0.059	0.042
SD	-0.073	-0.149	-0.100	0.024	0.006	-0.038	0.020	-0.059	-0.051	-0.130	-0.086	-0.031	-0.020

Table A2: The questionnaire

Innovative input variables	
Did your enterprise engage in the following innovation activities in 2000?:	
IR: Intramural research & experimental development (R&D)	All creative work undertaken within your enterprise on a systematic basis in order to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications, such as new and improved products (goods/ services) and processes (including software research)
ER: Acquisition of R&D (extramural R&D)	Same activities as above, but performed by other companies (including other enterprises within the group) or other public or private research organisations
MAC: Acquisition of machinery and equipment	Advanced machinery, computer hardware specifically purchased to implement new or significantly improved products (goods/services) and/or processes
TA: Acquisition of other external knowledge	Purchase of rights to use patents and non-patented inventions, licenses, know-how, trademarks, software and other types of knowledge from others for use in your enterprise's innovations
Innovative output variable: TURNIN	
- Estimate how your turnover in 2000 was distributed between: - New or significantly improved products (goods or services) introduced during the period 1998-2000 - Unchanged or only marginally modified products (goods or services) during the period 1998–2000	
Firm's general characteristics	
IG	▪ Is your enterprise part of an enterprise group?
Innovative-relevant information	
SUPPORT	▪ Did your enterprise receive any public financial support for innovation activities during the period 1998-2000? (from: local or regional authorities; central government; the European Union) ▪ Has your enterprise received funding from the EU's 4th (1994-98) or 5th (1998-2002) Framework Programmes for RTD?
COOP	▪ Did your enterprise have any co-operation arrangements on innovation activities with other enterprises or institutions during 1998-2000?
PATENT	▪ Did your enterprise, or enterprise group, have any valid patents at the end of 2000 protecting inventions or innovations developed by your enterprise?
PROT	▪ During the period 1998-2000, did your enterprise, or enterprise group, make use of any of these other methods to protect inventions or innovations developed in your enterprise? (such as registration of design patterns; trademarks; copyright; secrecy; complexity of design; lead-time advantage on competitors)
OTHERIN	▪ Did your enterprise during the period 1998-2000 undertake any of the following activities?: -Strategy (Implementation of new or significantly changed corporate Strategies) -Management (Implementation of advanced management techniques within your enterprise) -Organisation (Implementation of new or significantly changed organizational structures) -Marketing (Changing significantly your enterprise's marketing concepts/strategies) -Aesthetic change (Significant changes in the aesthetic appearance or design or other subjective changes in at least one of your products)
HURDLE	▪ If your enterprise experienced any hampering factors during the period 1998-2000? Economics factors (excessive perceived economic risks; innovation costs too high; lack of appropriate sources of finance); internal factors (organisational rigidities within the enterprise; lack of qualified personnel; lack of information on technology; lack of information on markets); other factors (insufficient flexibility of regulations or standards; lack of customer responsiveness to new goods or services)

Table A3: The TOBIT estimates

	ALL FIRMS	MATURE FIRMS	YICs
Dependent variable: TURNIN			
Constant	0.01 (0.61)	0.02 (0.87)	-0.01 (-0.15)
IRint	1.94*** (7.12)	2.07*** (6.99)	1.07 (1.48)
ERint	0.37 (0.47)	0.11 (0.12)	0.97 (0.50)
MACint	0.01 (0.06)	-0.11 (-1.12)	0.63** (2.58)
TAint	-0.34 (-0.84)	-0.46 (-1.00)	0.26 (0.27)
EXPINT	0.05* (1.78)	0.04 (1.54)	0.09 (1.13)
IG	-0.03* (-1.76)	-0.03* (-1.82)	-0.02 (-0.37)
SUPPORT	-0.03** (-2.44)	-0.04*** (-2.74)	0.02 (0.38)
COOP	0.06*** (3.11)	0.06*** (3.14)	0.04 (0.64)
PATENT	0.03** (2.11)	0.03* (1.78)	0.09* (1.72)
PROT	0.11*** (6.74)	0.11*** (6.41)	0.11** (2.17)
HURDLE	-0.02 (-1.29)	-0.03* (-1.72)	0.03 (0.67)
OTHERINN	0.13*** (6.03)	0.13*** (5.96)	0.08 (1.15)
SB	0.09*** (3.60)	0.07*** (2.66)	0.19*** (2.64)
SI	-0.01 (-0.71)	-0.01 (-0.65)	-0.03 (-0.44)
SS	0.09*** (5.24)	0.09*** (4.94)	0.08 (1.32)
N. of firms	2,713	2,420	293
Censored	615	550	65
Uncensored	2,098	1,870	228

Notes
t- statistics in parentheses: * Significant at 10%; ** 5%; *** 1%