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THE IMPACT OF M&A ON TECHNOLOGY SOURCING STRATEGIES

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Abstract

The paper investigates the effects of Mergers and Acquisitions (M&A) on corporate research and development (R&D) strategies using Community Innovation Survey (CIS) data on the Dutch manufacturing sector. The focus of the research is whether M&A affect corporate innovation strategies, favouring in-house R&D and innovation expenses versus external technological sourcing. The results show that M&A activities have a positive and significant impact on innovation investments by firms, and particularly on R&D intensity and total expenditure on innovation. M&A affect corporate innovation strategies, favouring in-house R&D versus external technological sourcing. Firm post-merger behaviour favours the consolidation of the knowledge, competences and capabilities that have been acquired by merging with or by buying another firm, confirming that the reasons for a merger or acquisition are most often related to firms' innovative performance. Following involvement in a M&A, firms tend primarily to focus on fully integration of their resource bases in order to enable them to produce and sell innovative products that are new to the market

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1. Introduction

At the time of writing, it would seem that the peak of the 6th wave of mergers in economic history has been reached, with numbers and values matching those achieved in the second half of the 1990s. While the current and the 4th waves have been characterized by a great number of Leveraged Buy Outs (LBOs), usually arranged by private equity firms, the 5th, 1st, 2nd and 3rd waves were ‘normal’ merger waves, in the sense that most transactions concerned acquisitions by firms other than those active in private equity markets.

While it has been shown that LBOs have negative effects on both capital and R&D spending (Schenk, 2006), and take place for purely financial reasons and/or to capitalise on the target firms’ earlier acquisition errors, ‘normal’ mergers have sometimes been justified by the potentially beneficial effects of M&A on R&D and innovation activities. The results of most studies of the effects of M&A on innovation, however, are not encouraging perhaps in part because they generally focus on large, stockmarket quoted firms. But there are many thousands of smaller M&A occurring at national level, and it is possible—even likely—that the effects of these smaller transactions are quite different (Cefis et al., 2007).

In addition, deteriorating or stagnating wealth creation after a merger is not a direct indication of what is happening in terms of the technology and studies have shown that the rationale for engaging in the M&A process has evolved over the years (De Man and Duysters, 2005), with innovation being an explicit reason for the last wave of mergers. These considerations must be set against a background of an increasingly “open innovation framework” (Chesbrough, 2006) and the higher importance given to “external markets for technology” (Arora and Gambardella, 2001).

Rapid technological change and world-wide increased competition have meant that innovation has become a critical element for firms to ensure economic performance and their survival in the market (Cefis and Marsili, 2006). However, these are also the factors that have led to a much higher emphasis on exploring external environments, market opportunities and knowledge sources beyond the firm’s boundaries. Corporate level managers acknowledge that in addition to the building of in-house R&D and internal capabilities and resources, the core of the innovation process must also include identification, connection with and enhancement of external knowledge sources.

However, as “innovation greatly differs ... in terms of characteristics, sources, actors involved, boundaries of the processes and the organization of innovative activities” (Malerba, 2005; p.67), the choice of innovation strategy is rather complex. The strategic choice and the pace of innovation investment is affected by factors endogenous to the firm – fit between innovation strategy and previous investments in distinct dimensions of absorptive capacity- and by exogenous factors such as appropriability conditions, market structure, uncertainty, threat of competitive entry or impact on future value of the firm (Smit and Trigeorgis, 2007). What is clear is that firm level innovative initiatives can no longer be regarded as stand-alone decisions; rather they should be seen as links in an interrelated innovation process chain that combines in-house growth and procurement of knowledge and external resources.

Some of the recent literature highlights the complementarities versus the embedded substitutability approaches in firm level innovation choices (Cassiman and Veugelers, 2006; Catozzella and Vivarelli, 2007). Whereas in the past the relationship between in-house and external sources was generally expected to be negative, it is now recognised that there are potential synergies and gains to be derived from the use of external sources, such as through M&A. Of course, the risks are higher and changes to firm level “dynamic capabilities” (Teece et al., 1997) are required, but the pay offs in terms of innovative performance may also be higher.

These complementarities in firm level technology sourcing strategies are being emphasised by the changing rationale for M&A. Firms, and especially small and medium size enterprises (SME), are viewing M&A as mechanisms for learning and for acquiring resources, competences and capabilities from external sources of knowledge (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2007; Ahuja and Katila, 2001). Therefore, consistent in line with Cassiman et al. (2005; pag. 203), who state that “where innovation is itself the main reason of the M&A activity, the results can often be positive and sometimes extremely so”, we can expect that technology-driven M&A increase post merger in-house R&D expenditures in order to absorb the new technology, knowledge and capabilities that have been acquired through the process of merging with or acquiring a new firm.

The purpose of this study is to analyse how M&A change the technology sourcing strategies of the firms involved. The focus is on whether, following a M&A and the post merger integration process, firms are more likely to assimilate the acquired knowledge and resources and develop in-house R&D or to continue to buy the results of R&D in the market.

This paper addresses the following specific questions: i) Do M&A have an impact on R&D intensity and on the total cost of innovation? ii) What, if any, are the effects of M&A on corporate R&D? Is in-house R&D favoured over external R&D? iii) What is the capacity of these investments (internal and external) to generate new products and processes (R&D and innovation efficiencies) ?

The empirical part of the analysis uses data for the Netherlands from the Community Innovation Surveys CIS2, CIS2.5, CIS3, and CIS3.5. These data were integrated with data from the Business Register database compiled by the Central Bureau of Statistics/Statistics Netherlands (CBS), providing a comprehensive data set on innovation and M&A.

The results of this study show that M&A activity has a positive and significant impact on the innovation investments made by firms, especially R&D intensity. M&A seem to increase internal R&D, but do not have any effect on R&D outsourcing. Also M&A seem to positively affect the acquisition of new machinery, but do not have an effect on expenditure on external knowledge such as purchase of patent rights, licences and other types of knowledge from third parties.

These findings suggest that post-merger behaviour favours the consolidation of the knowledge, competences and capabilities acquired by merging with or buying another firm, confirming that M&A are more often linked to innovative performance, than other objectives. With regard to R&D and innovation cost efficiency in terms of products new to the firm, the results indicate that there are positive effects from M&A activity on firms' dynamic efficiencies. Following an M&A a firm typically will tend to focus primarily on fully integrating resource-bases in order to be able to produce and sell innovative products that are new to the market.

This paper is structured as follows. Section 2 discusses the links between M&A and innovation and/or R&D sourcing that are found in the literature. Sections 3, 4 and 5 respectively provide descriptions of the data, and the dependent and independent variables, and introduce the methodology used for the research. The results are presented in Section 6, and Section 7 offers some conclusions.

2. Theoretical background

2.1. The impact of M&A on R&D activity

Assuming rational economic behaviour, firms would be expected to undertake a merger or acquisition with the goal of either raising productivity (lowering costs) and/or creating synergies.

Alternatively, M&A might be carried out in order to build or strengthen monopoly power. Both behaviours are related to competitiveness. In this context, a merger or acquisition can have or not an effect on innovation depending on the nature of the M&A and on the innovative characteristics of the firms involved.

De Man and Duysters (2005) cluster recent studies on the effects of M&A on corporate R&D and innovation performance into two main groups: those that have studied the conditions for M&A to have a positive effect on innovation performance and those that have considered the impact of M&A on proxies of R&D activities. The conditions facilitating a positive effect from M&A on corporate innovation performance, include complementarities in resources (relatedness) (Cassiman et al., 2005), similar culture and management style (organisational fit) (Chakrabarti et al., 1994; Hagedoorn and Duysters, 2002), post-merger integration and assimilation processes (Ahuja and Katila, 2001; Epstein, 2004; Cloodt et al., 2006). In terms of the effects on R&D activity and innovation effort, studies have shown that we need to take account of economies of scale and scope (Cefis et al., 2007; Henderson and Cockburn, 1996), both of which allow firms to gain competitive advantage and to keep abreast of the competition.

Companies should strive to increase research expenditure to enable them to profit from scale economies and to expand the number of R&D projects to profit from scope economies. Minimisation of costs provides another incentive for companies to increase R&D productivity in order to increase innovation output per euro invested, and to decrease the level of R&D expenditure for a given innovation output. With the exception of Ikeda and Doi (1983), empirical studies mainly report negative effects of M&A on firms' R&D efforts (de Man and Duysters, 2005; Hitt et al, 1991; Capron, 1999).

The present study aims to assess the effects of M&A on innovation taking R&D intensity, and the costs of innovation scaled by firm-size (including intramural and extramural R&D expenses, industrial design costs, investment in the acquisition of external knowledge - licences, copyright, trademarks, software), costs of market research for innovative products, staff training, etc.) as the two proxies for innovation inputs.

The choice of innovation proxies is justified by the hypothesis, which I test later, that M&A could possibly lead to higher technology awareness, implying increased R&D efforts and thus R&D intensity and total innovation costs, followed by increased performance. This is based mainly on the fact that

M&A are employed more and more as mechanisms for learning and acquiring resources, competences and capabilities from knowledge sources beyond the firm's boundaries (Veugelers and Cassiman, 1999; Cassiman and Veugelers, 2002; Ahuja and Katila, 2001).

2.2 Effects of M&A on R&D "make or buy" strategies

If a greater emphasis on R&D efforts can be expected as a result of the M&A process, it is important to investigate the extent to which M&A affects the decomposition of R&D expenditures within the firms. Decomposing the structure of R&D expenses allows to analyse whether the proportion of internal versus external technology sourcing changes following a M&A process.

Several papers (Cassiman and Veugelers, 2006; Catozzella and Vivarelli, 2007) suggest that there are complementarities between in-house R&D and external technology sourcing, maintaining that it is these complementarities in particular that allow firms to attain higher innovative performance. Focusing solely on one technology sourcing strategy - either accumulating in-house R&D, but not exploring the opportunities available on the market, or continuously buying technology in the market, but not assimilating the new knowledge – will lead to lower innovative performance (Cassiman and Veugelers, 2006).

This view of complementarities and "supportive innovative activities" (Catozzella and Vivarelli, 2007) suggests a two way relationship between external and internal technology sourcing: that firms are able to use and assimilate external sourcing only after achieving a certain level of internal R&D and having developed absorptive capacity (Cohen and Levinthal, 1989), and simultaneously that investment in external sources of knowledge and technologies stimulates in-house innovative research (Veugelers, 1997; Lokshin et al., 2008).

This study focuses on the latter aspect. Assuming that complementarities exist among innovation activities, we would expect M&A to have two different effects on the proportion of resources devoted to internal versus external technology sourcing. The impact of these effects will vary according to the reasons for the M&A. If M&A are aimed at gaining market dominance (without any technological reasons) then they cannot be expected to have any a priori effects on either internal or external technology sourcing. Among SMEs, however, M&A are often driven by the need to obtain new knowledge, technology, and capabilities unavailable to the acquiring firm due to lack of internal competencies. In this case, we should expect the M&A to have an effect on the composition of the technological sources; the merger or acquisition should be regarded as a "buy" strategy, since it is motivated by the desire to acquire new knowledge and technology.

There are two views expressed in the literature on the possible changes to the allocation of expenditure on in-house R&D following a M&A process. The first sees internal R&D and technology driven M&A as firm level innovation strategies that are substitutes; and thus a negative relationship is hypothesised (Basant and Fikkert, 1996; Bagues, 2004). The second seizes on the potential synergies deriving from the M&A process and predicts a possible positive effect on future in-house R&D development (Bloningen and Taylor, 1997; Lokshin et al., 2008; Belderbos et al., 2006). However, Ricart and Adegbesan (2007) suggest that to some extent this depends on the (rather vaguely defined) fit between a firm's innovation strategy and its previous investments in distinct dimensions of absorptive capacity. It would also seem to depend on the wealth that has been accumulated by the acquiring firm in the past.

In line with the findings of Cassiman and Veugelers (2006) this study adopts the complementarities approach to studying firms' "make or buy" investment decisions. Hence, given the complementarities among innovation activities, we should expect firms that have used M&A in the past as a way of acquiring external resources, to increase in-house R&D efforts in order to fully exploit the new technology, knowledge and capabilities acquired from exploring the "markets for technology"(Arora and Gambardella, 1994; Rosenberg, 1990). This strategy is based on a higher technology awareness: the externally acquired knowledge and technologies must be integrated and assimilated to enhance the firm's capabilities to develop R&D and innovative activities internally.

3. The data

The data set used for this study come from the Dutch CIS and ABR, which provide respectively firm level information on innovation behaviour and technological change and firm specific demographic characteristics. Both data sources were made available by the Central Bureau of Statistics (CBS) Netherlands.

The CIS database gathers information on the extent and characteristics of firms’ innovation activity, technological performance and organizational change. In the Netherlands, the CIS is conducted on a two-yearly basis. Each wave covers the three year period prior to the survey. To date, firm level data from five CIS waves are available at the CBS, covering the period 1994-2004.

In analysing the effects of M&A on firms R&D and innovation expenses structure, we allow for a post-acquisition integration period of three to five years following firms M&A involvement, which limited the time frame of the analysis to 1994-2002, covering the first four CIS waves (CIS 2, CIS 2.5, CIS 3 and CIS 3.5), but excluding CIS 4 because the previous wave, i.e. CIS 3.5, did not include a variable for firms’ M&A activity.

The CIS target population includes a stratified sample[1] of private sector firms with at least 10 employees, drawn from those present in the ABR. CIS2.5 and CIS3, which were financed by the Ministry of Economic Affairs, include firms with 1-10 employees. In order to have comparable sample, for those waves I excluded firms with less than 10 employees.

The second data source, ABR, supplies firm demographic information - firm age, size, industrial sector and nature of involvement in M&A activity. A schematic overview of the design of our panel is provided in Figure 1. ABR includes the industrial sector (at the 5 digit level), size (measured by number of employees), and date of entry in and exit from the register. The integration of these data led to an unbalanced panel of 4,604 firm-level observations, from 1994 to 2002, which correspond to 2,913 manufacturing firms.

4. The variables

Firms are favouring M&A as channels of access to technology and incentives for innovative activities. However, assessing M&A processes in terms of firms’ ex-post capabilities to manage innovation (firms’ dynamic efficiencies) is controversial. One aspect that is important is the way in which M&A affect the composition of R&D and the costs related to innovation. This study considers the impact of M&A on firms’ technology sourcing strategies, distinguishing between: i) R&D

[1] Firm size, industrial sectors and regions are used as stratifying variables

expenditure on in-house R&D, and external R&D; ii) innovation expenses related to external knowledge acquisition (patents and licences), acquisition of new machinery and software, market research and training R&D personnel related expenses; and iii) capacity of these investments to generate new products and processes (R&D and innovation efficiencies).

4.1 The selection model

We can reasonably assume that firms decide to invest in innovative activities only if the foreseeable pay offs from doing so are significant and the risks associated with them are below a certain threshold. We can observe firm behaviour (i.e. level of R&D expenditure, or, more generally, innovation investments) only for firms that have decided to invest in innovative activities over a certain threshold. Given this, I need to account for selectivity bias in the sample.[2] I introduced a selection model to explain the firm's decision to invest in innovative activities, which depends on firm-specific variables such as: financial and marketing constraints, and organizational, strategic and regulatory constraints perceived by companies as impeding their innovative activities. These are endogenous and exogenous factors to identify and capture the reasons affecting firms' engaging or not in innovative activities, and their innovative performance. The first proxy - financial constraints – is a dummy variable measuring the lack of financial resources required for engagement in innovative activities that takes the value 1 if the company replies positively to the question: "Has your company been faced with financial constraints due to which innovation projects have not started?" The remaining proxies have a similar structure (1/0 dummies). The marketing constraints proxy captures whether firms have been reluctant to engage in innovative activities due to uncertain market development of new products. The internal organisational constraints dummy tests whether lack of innovation activity is due to inflexible firm organisational structures. Strategic constraints proxy tests whether the absence of innovative activities is due to uncertainty of outputs and future profits from innovation based on a lack of managerial, organisational or technological capabilities in the firm. Finally, the regulatory constraint variable includes exogenous legislation (personnel, tax or environment related) that might affect innovative performance at firm level.

[2] See Section 5 for a more detailed explanations of the two-stage Heckman model used to model R&D and innovation expenses.

As explanatory variables for the probability of investing in innovation, I included firm characteristics such as size, age and technological regime (Pavitt categories), which have been proven to be relevant in shaping the innovative behaviour of firms (see among others Pavitt, 1984; Dosi, 1988; Breschi et al., 2002; Marsili and Verspagen, 2002; Cefis, 2003)

4.2. The technology sources model

4.2.1 Dependent Variables

Firm-level innovation activities require a broad spectrum of investments, ranging from internal and/or external R&D expenditure to investments in new machinery, patents and licences, training and launching of a new product in the market. These investments can be categorised as: a) R&D related expenditure; and b) innovation expenses.

The CIS-ABR panel allows me to analyse these technology sourcing indicators and their composition. I can also analyse the extent to which firms are able to derive dynamic efficiencies from the innovation process, by constructing R&D and innovation efficiency proxies.

Decomposition of R&D Expenditure

The distinction between internal and external R&D spending is very important in a post-acquisition technology sourcing study. Cassiman and Veugelers (2006) emphasise the complementarities between internal and external R&D, indicating that firms need both in order to attain the highest innovative performance. However, Cohen and Levinthal (1989) claim that firms need first to conduct internal R&D in order to be able to successfully integrate technology and knowledge bases produced outside the firm. Firms need to develop absorptive capacity internally before they can use externally sourced knowledge and technologies.

In this study of firms' technology sourcing strategies I examine the changes induced by the M&A process on the structure of R&D expenditure. In terms of R&D expenses (as well as the total costs related to innovation) M&A may motivate firms to i) make use of recently acquired knowledge bases and technological capacities and capitalise on internal technology assets through in-house R&D; ii) maintain a high level of external R&D spending on knowledge base and technological know-how from third parties or subcontractors; iii) combine internal and external R&D, taking maximum advantage of in-house technological investments and absorptive capacity.

In order to test these hypotheses, I use, as proxies for the firm's R&D engagement, firm total R&D expenses and the division between internal and external R&D spending. Total R&D expenses includes all creative, systematic research directed towards innovation. It consists of investments and research related expenses in R&D projects, and the costs of hiring R&D personnel. The division between external/internal R&D refers to whether these activities are performed within the firm, or by employing subcontractors or third parties (including specialists on temporary contracts to work on a specific innovation). These proxies are considered in relative terms to measure R&D intensity, calculated as ratios of R&D expenditures over total number of employees.

Decomposition of Innovation Expenses

R&D is only part of the innovation process; we also need to examine innovation investments which include all firm expenditure made to develop technologically new, or substantially improved, products, processes or services. Arrow (1962) stresses the distinction between R&D and innovation engagement, in his phrase the economic dilemma of R&D financing. Firms experience various gaps in financing for R&D activities especially due to the sunk cost nature of R&D expenses. This was confirmed by Hall (1999), which emphasises that this gap can be explained by the reluctance to allocate money to research or knowledge and a far higher prevalence of financing physical assets (such as machinery).

The variable *Innovation Expense*s includes purchase of innovative machinery, computer hardware and software purchased specifically for realising an innovation, patents and licences, market research and training of R&D personnel. I decompose it considering distinctly two proxies for innovation engagement: a) purchase of patent rights, licences or other types of knowledge from third parties, labelled "external innovation expenses"; b) acquisition of hardware/software and new machinery; plus the costs of market research aimed directly at the market introduction of new products or services and R&D personnel training, labelled "in-house innovation expenses". These proxies are also considered in relative terms, as innovation intensity, calculated as the ratio of innovation expenditure on total number of employees.

R&D and Innovation Efficiencies

We also need to analyse the impact of M&A processes on a firm's capacity to create dynamic efficiencies. Dynamic efficiencies are aimed at generating higher levels of innovation. They are estimated as the ratio between a firm's innovative outputs and inputs (from responses to the previous CIS). I consider innovative output only in terms of total firm sales due to new or significantly improved products, but allowing for two levels of novelty: products that are new or technologically improved for the firm; and products that are new or improved for the market. As proxies for innovative inputs I use total R&D expenses and total costs of innovation. Thus, four efficiency variables are constructed:

1) R&D efficiency in terms of products new to the market, as the ratio between total sales due to products new to the market at time *t* and total R&D expenses at time *t-1*, where *t* represents a specific CIS wave and *t-1* the previous wave, thus allowing a lag of 2 years;

2) innovation cost efficiency in terms of products new to the market, as the ratio between total sales of products new to the market at time *t* and the total cost of innovation at *t-1*;

3) R&D efficiency in terms of products new to the firm, as the ratio between total sales of products new to the firm at time *t* and total R&D expenses at time *t-1*;

4) innovation cost efficiency in terms of products new to the firm, as the ratio between total sales of products new to the firm at time *t* and the total cost of innovation at time *t-1*.

4.2.2 Independent Variables

Proxy for M&A

The main interest in this study is to analyse the extent to which an M&A event influences the firm's technology sourcing strategy. The impact of a merger or acquisition on a firm's innovation-related sourcing strategies cannot be predicted easily, as it often depends on several technology and market related dimensions of the companies involved.

Cassiman et al. (2005) and Cassiman and Colombo (2006) report positive and negative effects of M&A on innovation. The negative effects refer to decreases in R&D output and productivity following a merger, with merging companies rarely able to appropriate the scale and scope economies in R&D.

However, there is also evidence of positive effects of M&A on firm R&D and innovative capacities: the combination of knowledge bases, resources and technologies allows the firm to develop new knowledge, competences and capabilities that enable it to become a successful innovator.

Using a case-study approach, Cassiman and Colombo (2006) find evidence that efficient management of the post-M&A integration process can lead to improved innovative performance despite a short-term weakening of R&D efforts and financing. This is also confirmed by Haspeslagh and Jemison (1991) and Jansen (2002), who stress the importance of a very well-planned post merger integration period to allow an efficient transfer of strategic capabilities from the target to the acquiring firm.

As a proxy for M&A, I have chosen an indicator that shows whether or not the company has acquired another firm in the previous three years. I use the lagged value of this indicator in order to allow for a sufficiently long post-merger integration period. Accordingly, I allow for a 3-5 year time span following M&A activity in order to analyse the effects of a M&A in the previous CIS wave on firm innovation and R&D expenses, and the effectiveness of R&D and innovation input usage, as reported in the current CIS wave.

Accounting for technological regimes and firm demographic characteristics

In order to capture technology-specific conditions, in our model I include proxies to classify firms according to Pavitt's (1984) taxonomy. Four dummy variables have been constructed, classifying the sample into: science-based firms, specialized suppliers, scale intensive, and supplier dominated firms. The last category acts as reference category for the estimates. The Pavitt dummies are meant to capture and control for technological opportunity conditions (easier to innovate in certain fields than in others; possibly industry-targeted innovation policies), appropriability conditions and organisational characteristics of the technology (Mairesse and Mohnen, 2002). Teece (1986) stresses the importance of technological regime in selecting for internal *versus* external innovative strategies.

Also important in an analysis of firm knowledge and technology sourcing strategies are firm size and age. Gopalakrishnan and Bierly (2006) found evidence that both age and size influence the relationship between firms' knowledge sourcing strategies and innovative behaviour. Large firms are more likely to benefit from in-house R&D and from external technology sourcing, due to their higher absorptive capacity (Cockburn and Henderson, 1998). Small firms may prove more innovation efficient due to their lower levels of bureaucracy and increased adaptability (Acs and Audretsch, 1987). In terms of age, younger firms seem more likely than older firms to develop and maintain connections to sources outside the firm and to more easily appropriate the benefits related to external sourcing. However, both relationships are likely to show a non-linear trend. To account for this non-linearity, I introduce squared terms for the age and size proxies in our models.

Firm size is measured using the natural logarithm of the number of employees as reported in the ABR files and age is calculated on the ABR dataset, as difference in months between the date of the CIS wave (December of the last year of the wave) and date of entry in the register (always expressed in logarithmic terms).

5. Methodology

The focus on structural differences in firm R&D and innovation expenses and cost-efficiencies implies the need for separate regression models to be estimated for each R&D and innovation proxy described above. The panel structure of our dataset allows us to model the changes observed in these proxies over time (1994-2002) and in particular circumstances (following an M&A event).

Based on a number of influencing factors, firms make decisions about whether to invest money in R&D activities or development of innovative products, processes and technologies. The R&D and innovation investment behaviour of firms raises some methodological concerns. The main one is selectivity The main issue is that of selectivity, analogous to the one that raises when estimating a labour supply function, where income data is only available for those active in the labour market (Love and Roper, 2002; Griffith et al., 2006)). Likewise, we can only observe R&D expenditure and innovation costs for those firms that spend more than a certain amount on these activities (Crepon et al,. 1998; Benavente, 2006).

Gonzalez and Pazo (2003) show that firms perform R&D and innovation activities only when their optimal level of R&D expenditure surpasses a certain threshold, beneath which firms would be indifferent about performing R&D or not. That is, if:

$\pi_i(p_i^*, x_i^*) > \pi_i(p_i^{**}, 0)$, where:

p_i^* = the optimal price;

x_i^* =the optimal R&D expenditures;

p_i^{**} =the price the firm will set if it decides not to invest in R&D.

Thus, although the amount of money invested in innovation and R&D may appear to be zero for many companies, this should be interpreted as their decision not to get involved in these activities, because they consider it too risky, or too difficult given their internal organisational structure and internal competences and capabilities at that moment, or because the funds at their disposal are insufficient for involvement in innovation activities.

To account for this, I estimate a two-stage Heckman model. The framework of a sample selection model allows for: (1) a Probit model for the firm's decision to invest or not in innovation activities, estimating the sample selection term[3] λ; and (2) a model for the amount of funds the firm allocates to R&D and innovation, either internal or external, corrected for selectivity bias.

The selection model can be written as:

$$z_i^* = W'_i \alpha + e_i$$

$$z_i = 0 \text{ if } z_i^* \leq 0$$

$$z_i = 1 \text{ if } z_i^* > 0,$$

where z_i = the firm's choice to invest in innovation activities, and W_i is the set of the variables that explain the firm's choice.

The second model is an OLS regression estimating the expected value of y conditional on $z=1$ and other explanatory variables denoted by X.

The specification of the OLS model is of the form:

$$y_i^* = X'_i \beta + u_i$$

$y_i = y_i^*$ if $z_i = 1$, y_i not observed if z_i =0.

[3] λ expresses the effect of the unmeasured firms' characteristics on firms' innovation investment decision. In the Heckman 2-stage model, the value of this factor is added as an additional proxy in the 2nd stage - the OLS regression.

where y_i^* = the amount allocated by the firm to internal/external R&D and other innovation activities (either as global costs, or as disaggregated elements).

The Heckman 2-stage estimator requires "exclusion restrictions" (Heckman,1979): i.e. variables that are likely to affect the probability of investing in innovation, but are unrelated (orthogonally) to the actual amount spent internally or externally by the firm on innovation-related activities. The selection function, therefore, includes a set of explanatory variables *W*, which include some *X* factors, but must also include additional factors that do not appear in *X*. In our selection model, the dependent variable is a dummy, indicating whether a firm has invested in innovation or not. This proxy is calculated taking account of the firm's total innovation costs (including R&D expenses). If innovation costs are above zero, the firm is regarded to be a firm that has decided to invest in innovation, without differentiation of whether the investment is for internal or external innovative activity. If the total cost of innovation is zero, or the question in the CIS questionnaire has no response (due to non-innovative status, acknowledged in the response to the first CIS question), the firm is categorised as one that has decided not to invest in innovation. The independent variables are size, age, technological class, and a number of proxies that capture problems experienced by the firm, in the process of considering innovation activity, related to financial risk, market uncertainties, strategic/internal organizational problems or regulation issues that in any way impeded or affected the innovative process and their decision ultimately to invest/not invest in innovation.

Thus, the selection model is estimated by:

$$\begin{aligned} P(invest)_{it} = probit(&\beta_1 fin\_risk_{it} + \beta_2 mkt\_risk_{it} + \beta_3 int\_org_{it} + \beta_4 regulations_{it} + \\ &+\beta_5 strategic\_risk_{it} + \beta_6 age_{it} + \beta_7 size_{it} + \beta_8 scien-based_{it} + \\ &+\beta_9 special-sup_{it} + \beta_{10} scale-int_{it} + \nu_i\ ) \end{aligned}$$

The second stage of the Heckman model, the OLS regression, captures the effects of previous M&A involvement on firm R&D and innovation expenditure, controlling for the firm's demographic and technological specificities, and any selection bias. The following model was estimated using a pooled OLS estimator:

$$\begin{aligned} ln(tech\_source)_{it} = &\alpha + \beta_1 (M\ \&\ A)_{it-1} + \beta_2 age_{it} + +\beta_3 size_{it} + \beta_4 scien-based_i + \\ &+\beta_5 special-sup_i + \beta_6 scale-int_i + \beta_7 \lambda_i + \varepsilon_i \end{aligned}$$

where λ is the Mills ratio capturing the sample selection bias estimated in the first stage using the Probit model.

Sensitivity analysis

The Heckman two-stage models have been estimated pooling together the data across CIS waves (*t*). As a sensitivity analysis to evaluate whether the results are robust to changes in the model, Random Effects models (RE) were estimated on the baseline specification used for the Heckman two-stage models. The RE allow to exploit the panel structure of the data and time dummies are added as regressors. A time dummy for each CIS wave is included: d1998, d2000 and d2002 indicating the last year of each CIS wave. d2000 was chosen as the reference year and, therefore, dropped from the regression. RE estimators were applied to the empirical models specified in Tables 5, 6, and 9; the results tables are included in the Appendix.

Another part of the sensitivity analysis tests whether the results obtained with the Heckaman 2-stage models are robust to a different hypothesis on the firm's behaviour. The new assumption is that the firm's decision to invest in innovation (either internal or external) is made *simultaneously* with the decision about of the amount to be invested in both type of investment. Given this assumption, I estimate Bivariate Tobit regression models for: (1) internal R&D expenditure *vs* external R&D expenditure; (2) internal innovation expenses (in particular for acquiring innovative equipment) *vs* external innovation expenses (e.g. for patents and licences). The Tobit regressions take into account the censured nature of R&D and innovation expenses data.

6. Results

6.1 The Univariate Analysis

Univariate analyses were conducted on the individual CIS waves considered and on the complete CIS-ABR panel. Tables 1 and 3 present descriptive statistics for the individual CIS waves, while Tables 2 and 4 focus on the mean differences between the two groups of firms: those previously involved in M&A activities and those not engaged in these kind of activities.

Table 1 provides a general overview of the sample, categorising firms as M&A active or M&A non-active. The average mean values of firm demographic characteristics (age and size) are calculated for the complete panel. Values of firm size proxies (number of employees and total sales) as well as firm age (in months) are presented for both categories of firms, to reflect their potential importance in an investigation of post-M&A technology sourcing strategies at firm-level. The mean values for firm size (regardless of whether I use total sales or number of employees as the proxy) are clearly larger for firms previously involved in M&A. Thus, in the multivariate analysis I control for size and age by inserting these proxies in the model and by considering all dependent variables in relative terms, namely scaled by firm size.

-------- Insert Table 1 around here -----------

Tables 2 and 3 present the descriptive statistics for the dependent proxies used to model the decomposition of total R&D expenditure and total innovation expenses. Table 2 displays firm-level technology sourcing variables across CIS waves while Table 3 gives the averaged image of these proxies across the complete CIS-ABR panel, both Tables providing the distinction between M&A active and non-active firms

Table 2 shows that the mean of the variables of interest is fairly stable across CIS waves. The only proxies showing a different trend are firm total innovation expenses and expenditure on acquisition of machinery. The former figure includes the latter item, suggesting that the cause of the sudden decrease in total innovation expenses at firm level can be explained by the decrease in expenditure on machinery acquisition, which can be considered our most pro-cycle variables. Indeed, we see that expenses involved in the acquisition of machinery were at their lowest in the last CIS wave considered (CIS 3.5) in our analysis, covering the time period 2000-2002. During these three years, the Dutch economy was experiencing a recession, which was at its lowest in 2002 (CPB's Economic Outlook, Report 2003/1).

-------- Insert Table 2 around here -----------

Table 3 presents the descriptive statistics for the same R&D and innovation technology sourcing proxies, averaged along our CIS-ABR panel. It presents the means for firm R&D expenses and total innovation costs, as well as their decomposition proxies, distinguishing between M&A and non M&A active firms. Generally, M&A active firms show higher means than their non-active counterparts and the difference is significant. This suggests that M&A active firms invest and spend more on R&D and innovation related activities than M&A non active firms. It shows that the difference between the two groups is significant for the total R&D expenses proxy and for the in-house R&D proxy, while not significant for the external R&D proxy (R&D performed by third parties). It seems that there are no differences between M&A and non-M&A firms when they decide to outsource their R&D activities.

The difference between means is not significant for the proxies denoting total expenditure due to acquisition of machinery and firm market and personnel innovation related expenses (including marketing activities aimed directly at the introduction of new products or services to the market and training costs for R&D personnel).

It should be noted that the higher mean values, in terms of R&D intensities or innovation expenses scaled by size, registered by firms involved in M&A, as shown in Table 3, are not the result of an accounting artefact arising from the fact that firms have been merged or acquired. The statistics are calculated for firms that have been M&A active for 3-5 years before the year of the statistics, thus allowing a post-merger integration period that should eliminate or at least considerably reduce any accounting distortion.

-------- Insert Table 3 around here -----------

The panel-level descriptive statistics allow to identify whether most of the variation in the sample is between firms or across firms over time. The results suggest that most of the total variation is accounted for by the between firms variation, which is one of the justifications for the choice of model estimation technique for the multivariate analysis.

6.2. The Multivariate Analysis

As a first step, we look at the effects of M&A on total R&D expenses and on the decomposition between R&D performed in-house and external R&D (see Tables 4-6). The results of the selection equation are presented in Table 4. Strategy constraints, namely uncertainty of outputs and future profits deriving from innovation due particularly to lack of managerial, organisational and technological capabilities in the firm, is the only proxy that has a significant effect on the firm's investment decision, when controlling for other factors. It seems that what really matters in the firm's decision to invest in innovative activities is the certainty that it has the managerial, organisational and technological resources needed for innovation. Other constraints play a less important role.

-------- Insert Table 4 around here -----------

Considering the decomposition of R&D expenditure (Table 5), M&A seem to positively affect total R&D expenses scaled by the number of employees, that is R&D intensity. In particular, the amount of R&D performed by the firm's own personnel increases after a merger or acquisition. This result does not derive solely from the post-M&A integration process or the accounting distortions that can occur following a M&A because I allowed for a 3-5 year lag (from the time of the M&A to the time that the data on R&D and innovation expenses were collected) for these events. Thus, M&A seem to foster innovation through the direct channel of the R&D resources invested inside the firm.

-------- Insert Table 5 around here -----------

If we consider a more comprehensive proxy than R&D expenses, i.e. the variable that measures all the costs involved in innovation (total innovation expenses), the previous results are confirmed. Table 6 presents the coefficient estimates of the regressions run on total innovation expenses (from which R&D expenses have been subtracted) and on some of its components divided into expenses for developing innovations internally or externally. The investments made by the firm to enhance innovation activities within the firm include the costs of acquiring innovative machinery, computer hardware and software specifically purchased for realising innovations, market research for launching new products, training of internal personnel in the use of innovative machinery or applying a new production process. The innovation investments external to the firm include financing the development of innovations by third parties, acquisition of external knowledge such as patents, licences, copy-right, etc., and market research for launching new products conducted by third parties.

M&A performed 3-5 years earlier have a positive and significant effect on a firm’s total innovation expenses (excluding R&D expenses). The estimates show that M&A play a significant role in increasing expenditure on innovation inside the firm, including acquisition of new types of machinery or software, marketing activities for launching new products, and training of R&D personnel. Consistent with the R&D results, Table 6 shows that M&A do not significantly affect spending on outsourcing of innovation activities and acquisition of external knowledge. M&A seem not to enhance the purchase of rights to use patents, licences or other types of knowledge from third parties. It could be argued that it is the merger or acquisition that is the means of accessing external knowledge and, therefore, that the firm’s post-merger behaviour favours consolidation of the knowledge that has been acquired by merging with or buying another firm. As a consequence, we should see an increase in expenditure to enhance the consolidation of the knowledge and, more generally, of the competences and capabilities that the firm acquires through the M&A process. This interpretation, sustained by this empirical analysis, would support the argument that M&A are more often performed for reasons linked to innovative performance, than other reasons.

-------- Insert Table 6 around here -----------

These results are confirmed if we assume that the firm's decision to invest in internally or externally driven innovation is made simultaneously with the decision about how much will be invested. The estimates of the Bivariate Tobit models are presented in Tables 7 and 8. Table 7 shows the results of the regression when considering the simultaneous choice between expenditure on internal R&D and external R&D. The results confirm the previous findings that following a M&A process firms seem to invest more in in-house R&D than in outsourcing of R&D to third parties. The results in Table 8 also show that M&A seem to favour firm investment in internal innovation expenditure (in particular the costs of acquiring innovative machinery) rather than exploring market opportunities (investing in patents and licences).[4]

-------- Insert Tables 7 - 8 around here -----------

Table 9 completes the investigation of M&A effects on corporate strategies for R&D investment by considering efficiency: the firm's capacity to transform R&D and innovation investments into valuable innovative outputs, namely products new to the firm and new to the market. Here we are assessing both changes in the firm's technology sourcing strategies as well as the extent to which these changes have proven beneficial in terms of dynamic efficiencies.

For R&D and innovation cost efficiencies related to products new to the firm, the estimates indicate a negative effect of a M&A involvement on the firm's capacity to derive dynamic efficiencies. However, for the second group of efficiency proxies, namely R&D and innovation cost efficiencies in terms of products that are new or significantly improved for the market, the estimates indicate a positive effect of M&A involvement.

This would suggest that besides contributing to an increase in firm in-house R&D potential and absorptive capacity of external R&D, M&A also enable firms to derive valuable gains in terms of firm-level innovativeness. The results seem to point to the fact that firms involved in M&A processes are more efficient in terms of being able to introduce products and services that are new to the market. These results show that M&A play an important role in increasing the radical innovativeness of the firms, and support the argument according that following a M&A process firms combine their knowledge bases, competences and technologies, enhancing the ability to produce products new to the

[4] Additional results showing the distinction among acquisition of new machinery and the purchase of licences or copy rights are available on request.

market, i.e. products that do not merely imitate existing products (products new to the firm but not to the market, columns 1 and 3 in Table 9).

-------- Insert Table 9 around here -----------

Finally, the Appendix reports the results of the sensitivity analysis. In order to check whether the results obtained are robust to changes in the model, we estimated all the models in Tables 5, 6, and 9 using a RE estimator and exploiting the panel structure of the data (including year dummies). The results for the main variable of interest, *M&A (t-1)*, do not change qualitatively: the sign and the significance of the coefficients is consistently the same and the magnitude does not change significantly. In considering the effects of M&A on R&D and innovation expenses (Tables 5a and 6a), the proxies for technological regimes or Pavitt categories, become positive and significant at 1%, while in the Heckman models they were generally less significant. On the other hand, in the efficiency models (Table 9a), Pavitt proxies are all non-significant. The time dummies in general are very significant in all models suggesting that the time dimension of the panel is important.

7. Conclusion

The results reported in this paper suggest that M&A activity has a positive and significant impact on firms' innovation investments. In particular, M&A seem to foster innovation through the direct channel of R&D resources invested inside the firm. Firms that have experienced a M&A do not seem to invest more than before in external R&D, but they do invest more in in-house R&D.

Similarly, M&A that took place 3-5 years earlier have a positive and significant effect on a firm's total innovation expenditure. The estimates show that M&A have a significant role in increasing expenditure on the acquisition of new types of machinery or software, marketing activities, and the training of R&D personnel. M&A do not significantly affect expenditure on external knowledge, such as purchase patent rights, licences or other types of external knowledge.

It could be argued that M&A are a means of acquiring external knowledge and, therefore, that post-merger behaviour favours the consolidation of the knowledge that has been acquired by merging with or by buying another firm. As a consequence, there is an increase in expenditure on the consolidation of new knowledge and integration of the competences and capabilities the firm has acquired through the M&A process. This interpretation, confirmed by the empirical analysis, would support the argument that M&A are generally linked to improving innovation performance.

Concerning R&D and innovation cost efficiencies in terms of sales of new products, the estimates indicate positive effects from M&A involvement on firms' capacity to derive dynamic efficiencies. This seems to suggest that as well as contributing to an increase in in-house R&D, M&A stimulate firms to achieve gains in firm-level innovativeness. Following M&A involvement, firms tend primarily to focus on fully integrating their resource bases in order to be able to produce and sell innovative products that are new to the market. The development of new products based on researching market needs and producing market novelties, seem to be the main focus of firms seem to be the main focus of firms that through a M&A process have acquired the necessary technological and organizational capabilities once the post-merger integration process has completely succeeded.

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Figure 1: CIS manufacturing – Data File Structure

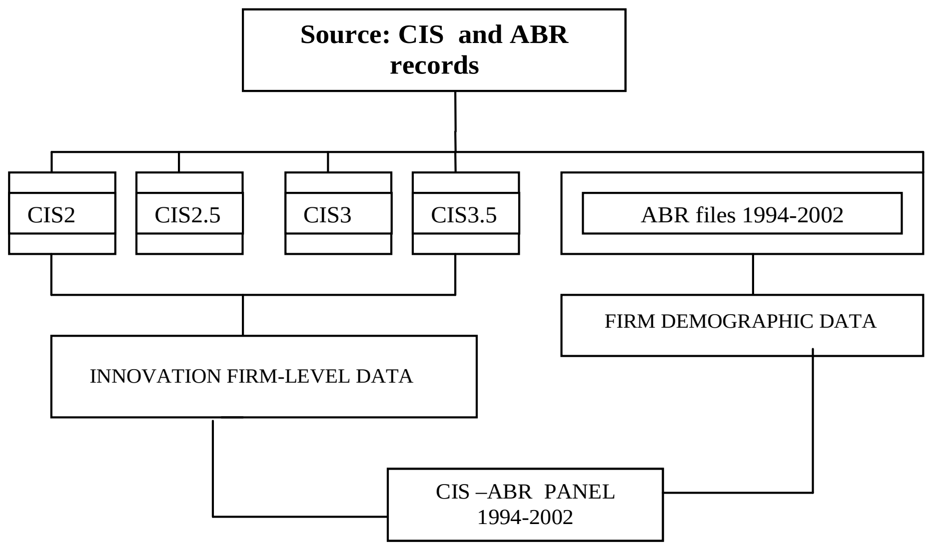

Table 1: General overview of manufacturing firms split by involvement in M&A transactions

		M&A ACTIVE FIRMS		M&A NON ACTIVE FIRMS	
Variable		Mean	Std.dev.	Mean	Std.dev.
Firms number of employees	Overall	464.01	1957.3	165.7	494.6
	Between		2027.7		510.9
	Within		165.7		156.7
Firms total sales (thousand of euro)	Overall	173354.7	497458.4	71166.5	356233.5
	Between		477190.2		313117.7
	Within		25148.2		146993.6
Firms age (expressed in months)	Overall	385.3	298.5	370.4	271.5
	Between		300.2		267.4
	Within		6.23		17.13

Table 2: Descriptive statistics on the dependent variables across CIS waves

Variable	CIS wave	Mean	Median	Skewness	Kurtosis	25th percentile	75th percentile
Total R&D expenses (thousand euros per employee)	CIS 2.5	2.47	0	14.8	292.7	0	0
	CIS 3	2.89	0	16.9	430.8	0	0
	CIS 3.5	3.13	0	35.3	1457.5	0	2.2
Total R&D expenses with own personnel (thousand euros per employee)	CIS 2.5	2.18	0	15.5	319.5	0	0
	CIS 3	3.53	0	12.4	266.8	0	2.33
	CIS 3.5	2.56	0	21.8	625.1	0	2.004
Total R&D expenses performed by third parties (thousand euros per employee)	CIS 2.5	1.25	0	15.7	283.02	0	0
	CIS 3	1.52	0	14.4	262.01	0	0
	CIS 3.5	1.47	0	49.6	2588.8	0	0
Total expenses for innovation (thousand euros per employee)	CIS 2.5	10.19	1.49	56.9	3460.8	0	6.89
	CIS 3	7.16	0	27.13	1078.1	0	5.47
	CIS 3.5	4.14	0	34.06	1480.5	0	3.44
Expenditures in other external knowledge (purchase of licenses) (thousand euros per employee)	CIS 2.5	1.09	0	19.15	508.3	0	0
	CIS 3	1.1	0	22.77	656.8	0	0
	CIS 3.5	1.05	0	14.06	269.9	0	0
Expenditures in acquisition of machinery (thousand euros per employee)	CIS 2.5	5.53	0	63.7	4133.7	0	1.49
	CIS 3	3.36	0	22.25	748.05	0	1.009
	CIS 3.5	1.85	0	10.47	149.3	0	1.04
Other innovation expenditures (technical preparation of production process, training of personnel, marketing activities) (thousand euros per employee)	CIS 2.5	1.8	0	14.6	321.6	0	1.4
	CIS 3	1.64	0	51.8	2874.3	0	0
	CIS 3.5	1.2	0	19.17	459.8	0	1.014

Table 3: Descriptive statistics grouped by M&A active and NON-active firms

		M&A ACTIVE FIRMS		M&A NON ACTIVE FIRMS		
Variable		Mean	Std.dev.	Mean	Std.dev.	MEAN DIFFERENCE TEST
Total R&D expenses (thousand euros per employee)	Overall	5.7	16.2	4.34	17.8	-1,44**
	Between		16.1		11.8	
	Within		4.3		11.7	
Total R&D expenses with own personnel (thousand euros per employee)	Overall	5.05	13.2	3.68	10.9	-2,36***
	Between		13.08		8.5	
	Within		3.56		6.3	
Total R&D expenses performed by third parties (thousand euros per employee)	Overall	1.74	3.47	1.72	8.7	0.05
	Between		3.5		6.5	
	Within		0.74		4.4	
Total expenses for innovation (thousand euros per employee)	Overall	9.62	19.5	7.69	28.26	-1,35**
	Between		19.4		27.53	
	Within		2.4		13.44	
Expenditures in other external knowledge (purchase of licenses) (thousand euros per employee)	Overall	1.13	0.77	1.07	0.45	-2.14***
	Between		0.8		0.42	
	Within		0.11		0.23	
Expenditures in acquisition of machinery (thousand euros per employee)	Overall	2.81	5.77	3.26	12.7	0.7
	Between		5.75		13.5	
	Within		1.6		5.23	
Other innovation expenditures (technical preparation of production process, training of personnel, marketing activities) (thousand euros per employee)	Overall	1.58	1.8	1.55	10.3	-0,06
	Between		1.6		12.6	
	Within		0.56		0.95	

Note: statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 4: The selection equation.
The first stage of Heckman procedure (Probit model)

SELECTION EQUATION	Firms decision to invest in innovative activities
Financial constraints	0.056
	(0,074)
Marketing constraints	-0,08
	(0,07)
Organizational constraints	0.07
	(0,073)
Regulatory constraints	-0,15
	(0,13)
Strategy constraints	0,67****
	(0,07)
Size	0,47***
	(0,14)
Age	0,204***
	(0,17)
Science-based firms	0,74***
	(0,05)
Specialized suppliers	0,28***
	(0,048)
Scale-intensive firms	0,67***
	((0,05)
LRχ^2(10)	2077.29***
Pseudo R^2	0.238
Log-likelihood	-3332.633
Number of observations	10028

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 5: The effects of M&As on firms R&D expenses. Heckman 2-stage estimator

Dependent Variable:	Total R&D expenses	Total R&D expenses with own personnel	Total R&D expenses performed by third parties
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	0,201**	0,203**	0.272
	(0,107)	(0,11)	(0,2)
Science-based firms	1,002***	0,98***	0,48**
	(0,150)	(0,15)	(0,28)
Specialized suppliers	0,231**	0.16	0,29*
	(0,113)	(0,1)	(0,21)
Scale-intensive firms	0,82***	0,8***	0,64***
	(0,146)	(0,14)	(0,27)
Size	-0,05	-0,07	0.127
	(0,054)	(0,07)	(0,1)
Age	-0,173***	-0,16***	-0,3***
	(0,05)	(0,05)	(0,09)
Constant	2,19***	2,2***	-1,5
	(0,84)	(0,83)	(1,55)
Mills (λ)	0,28**	0,31*	0,2**
	(0,19)	(0,19)	(0,3)
Rho	0.2	0.22	0.17
Wald χ^2	1417,67***	1415,2***	1285,08***
Number of observations	10028	10028	10028

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 6: The effects of M&As on firm Innovation Expenses. Heckman 2-stage estimat

Dependent Variable:	Innovation Expenses	In-house Innovation Expenses	External Innovation Expenses (performed by third parties)
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	0,174*	0,336*	0.122
	(0,107)	(0,203)	(0,24)
Science-based firms	0,56***	0,973***	0,7***
	(0,148)	(0,08)	(0,024)
Specialized suppliers	-0,1	0,22***	0,27*
	(0,11)	(0,08)	(0,2)
Scale-intensive firms	0,58***	0,71***	0,36*
	(0,144)	(0,09)	(0,25)
Size	-0,15	0,69***	0,63***
	(0,073)	(0,6)	(0,1)
Age	-0,157***	-0,36	-0,09
	(0,049)	(0,37)	(0,09)
Constant	-2,6***	0.9	0.76
	(0,83)	(1,03)	(1,2)
Mills (λ)	0,26*	0,8***	0.1
	(0,19)	(0,28)	-0.24
Rho	0.19	0.27	0.06
Wald χ^2	1384,5***	1285,08***	489,7***
Number of observations	10022	10022	10022

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 7: Effects of M&As on the decomposition of R&D expenses BiTobit estimator.

Dependent Variable:	Total in-house R&D expenses	Total external R&D expenses
	Coef. (std. error)	Coef. (std. error)
Merged in t-1	0,253**	0.316
	(0,110)	(0,2)
Science-based firms	0,95***	0.236
	(0,105)	(0,193)
Specialized suppliers	-0,018	-0,003
	(0,105)	(0,193)
Scale-intensive firms	1,007***	0,67***
	(0,107)	(0,19)
Size	-0,83**	0.005
	(0,03)	(0,06)
Age	-0,95**	-0,31***
	(0,041)	(0,07)
Constant	-4,3***	-6,7***
	(0,3)	(0,55)
Wald χ^2	231,04***	231,04***
Number of observations	3578	3578

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% lev

Table 8: The effects of M&As on the decomposition of Innovation Expenses BiTobit estimator

Dependent Variable:	In-house Innovation Expenses	External Innovation Expenses (performed by third parties)
	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	0.04	-0,02
	(0,06)	(0,013)
Science-based firms	0,43***	-0,024**
	(0,05)	(0,01)
Specialized suppliers	0.004	-0,02
	(0,05)	(0,01)
Scale-intensive firms	0,202***	-0,04***
	(0,05)	(0,12)
Size	-0,7***	-0,109***
	(0,08)	(0,02)
Age	0.355	0.02
	(0,23)	(0,05)
Constant	2,65**	0,42*
	(0,6)	(0,14)
Wald χ^2	203,02***	203.02***
Number of observations	3578	3578

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% lev

Table 9: The effects of M&As on firm R&D and innovation efficiencies

Dependent Variable:	R&D efficiency in terms of new products for the firm	R&D efficiency in terms of new products for the market	Innovation cost efficiency in terms of new products for the firm	Innovation cost efficiency in terms of new products for the market
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	-1,480***	0.842**	-1,291***	0,967***
	(0,408)	(0,349)	(0,404)	(0,374)
Science-based firms	0,238	-1,973***	-1,425**	-4,055***
	(0,630)	(0,594)	(0,584)	(0,679)
Specialized suppliers	0,025	-0,963**	-0,569	-1,675***
	(0,476)	(0,406)	(0,436)	(0,471)
Scale-intensive firms	0,085	-1,564***	-1,410**	-3,647***
	(0,616)	(0,583)	(0,565)	(0,650)
Size	0.690**	-0.751**	-0,532*	-1.920***
	(0,293)	(0,313)	(0,285)	(0,343)
Age	0,511***	-0,443**	-0,027	-1,074***
	(0,196)	(0,193)	(0,190)	(0,214)
Constant	-4,038	14,415***	10,282***	-29,865***
	(3.367)	(3,635)	(3,206)	(3,865)
Mills (λ)	0,435	-4,140***	-2,344***	7.481***
	(0,747)	(0,834)	(0,743)	(0,896)
Rho	0.091	-0,775	-0.436	-0.971
Sigma	4.758	5.345	5.377	7.704
Wald chi2	1126,51***	1165,54***	1231,11***	1268,84***
Observation	9673	9819	9958	9967

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

APPENDIX:

Table 5.a: The effects of M&As on firms R&D input.
The decomposition of R&D expenses. Random Effects Estimator

Dependent Variable:	Total R&D expenses	Total R&D expenses with own personnel	Total R&D expenses performed by third parties
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	0,216*	0,183*	0,038
	(0,123)	(0,097)	(0,078)
Size	-0,067*	-0,106***	-0,398***
	(0,037)	(0,034)	(0,026)
Age	0,027	-0,045	-0,095***
	(0,055)	(0,045)	(0,038)
Science-based firms	1,812***	1,133***	0,745***
	(0,128)	(0,110)	(0,087)
Specialized suppliers	0,713***	0,300***	0,372***
	(0,116)	(0,109)	(0,078)
Scale-intensive firms	1,688***	0,911***	0,753***
	(0,135)	(0,116)	(0,091)
d1998	-0,323***	0,193***	-0,151***
	(0,073)	(0,052)	(0,062)
d2002	0,336***	-0,651***	-0,076
	(0,079)	(0,047)	(0,067)
Constant	-3,066***	1,126***	-1,540***
	(0,355)	(0,309)	(0,245)
R-squared (overall)	0,086	0,182	0,066
Wald chi2	348,85***	468,05***	365,20***
Number of observations	4604	2574	4382

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 6.a: The effects of M&As on firms innovation expenses. Random Effects estimator

Dependent Variable:	Innovation Expenses	Innovation Expenses within the firm (internally)	Innovation Expenses performed by third parties (externally)
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	0,418***	0,098*	0,010
	(0,132)	(0,052)	(0,026)
Size	0,217***	0,160***	0,082***
	(0,039)	(0,016)	(0,007)
Age	0,011	-0,007	-0,025**
	(0,058)	(0,023)	(0,010)
Science-based firms	1,656***	0,648***	0,211***
	(0,134)	(0,054)	(0,023)
Specialized suppliers	0,511***	0,098**	0,067***
	(0,121)	(0,049)	(0,020)
Scale-intensive firms	1,376***	0,427***	0,178***
	(0,141)	(0,057)	(0,024)
d1998	0,544***	0,195***	-0,024
	(0,079)	(0,031)	(0,016)
d2002	-0,513***	-0,290***	-0,059***
	(0,086)	(0,033)	(0,018)
Constant	-2,618***	0,093	-0,101
	(0,372)	(0,150)	(0,064)
R-squared (overall)	0,094	0,119	0,074
Wald chi2	381,38***	478,19***	277,07***
Number of observations	4604	4604	4604

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level

Table 9.a: The effects of M&As on firms R&D and innovation efficiencies.
Random Effects estimator

Dependent Variable:	R&D efficiency in terms of new products for the firm	R&D efficiency in terms of new products for the market	Innovation cost efficiency in terms of new products for the firm	Innovation cost efficiency in terms of new products for the market
	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)	Coef. (std. error)
M&As (t-1)	-0,298***	0,347***	-0,114***	0,155***
	(0,059)	(0,075)	(0,040)	(0,054)
Size	0,028**	0,018	0,017*	0,020
	(0,014)	(0,018)	(0,010)	(0,013)
Age	0,044***	0,023	0,029***	0,025**
	(0,012)	(0,015)	(0,008)	(0,011)
Science-based firms	-0,017	0,097*	-0,035	0,051
	(0,043)	(0,054)	(0,029)	(0,039)
Specialized suppliers	-0,016	0,063	-0,003	0,054*
	(0,036)	(0,046)	(0,025)	(0,033)
Scale-intensive firms	0,003	0,005	-0,031	-0,001
	(0,051)	(0,064)	(0,035)	(0,046)
d1998	-0,514***	-0,857***	-0,130***	-0,562***
	(0,036)	(0,045)	(0,024)	(0,033)
d2002	0,239***	-0,640***	0,282***	-0,435***
	(0,039)	(0,049)	(0,027)	(0,035)
Constant	0,117	0,575***	-0,111	0,281***
	(0,102)	(0,130)	(0,069)	(0,093)
R-squared (overall)	0,237	0,202	0,154	0,175
Wald chi2	510,46***	415,53***	300,28***	349,09***
Number of observations	3021	3021	3021	3021

Note: Standard error in parantheses; statistically significant at: *** 1% level; ** 5% level;* 10% level