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Mots-clés : entreprise Spin-off, Start-ups, technology transfer

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INTRODUCTION

« Bien qu'elles ne puissent prétendre être exhaustives, nos recherches bibliographiques montrent que les phénomènes de “spin-off” souffrent d'un réel déficit de recherche scientifique », (Pirnay, 1998, p. 4). This is still true. In fact, in recent years we have assisted to a greater emphasis on the research spin-off phenomenon. Several analyses and empirical investigations have been published on this field (Muller, 2010). Notwithstanding, information on several aspects of the activities of a research spin-off firm is missing and, besides, most of the data is fragmentary (Shane, 2004; Mustar *et al.*, 2006; Wallin, Lindholm Dahlstrand, 2006; Gilsing *et al.*, 2010). Even if the commercialisation of university discoveries and the creation of research spin-offs is an interesting subject, with potentially important consequences, it is still not investigated enough (Lockett *et al.*, 2003; Shane, 2004; Lockett, Wright, 2005; Rasmussen, 2008). In this context, Italy is one of the European countries

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where the research spin-off phenomenon has not been investigated in depth and a comprehensive analysis of the effectiveness of a very particular kind of firm like the research spin-off is still lacking.

The main objective of this paper is to contribute to the literature on research spin-offs providing original empirical evidence on how effective are Italian research spin-offs. To this aim, I analyze a substantially larger data sample to present a broad range of evidence on Italian research spin-offs that was previously unavailable. In a recent book by Shane (2004) on academic entrepreneurship in the US and elsewhere, no reference is made to research spin-offs in Italy and in the latest book by Wright *et al.* (2007) on academic entrepreneurship in Europe, a description of Italian spin-offs is not provided, as well as in the book by Clarysse *et al.* (2007b) on entrepreneurship and the financial community in Europe.

Italy provides a good setting for such an analysis. Several initiatives have been carried out in recent years in order to improve the conditions for the establishment of this kind of firm: examples are given by spin-off regulations issued to date by 57 Italian universities following the legislative decree 297/1999 (Salvador, 2009), by the creation of Technology Transfer Offices (TTOs) and Industrial Liaison Offices (ILOs) following the law 262/2004, by the attention devoted to science park and incubator structures. The interest towards this phenomenon and the number of research spin-offs founded in Italy has increased so conspicuously that the importance of the spin-off phenomenon cannot be ignored and an overall investigation was really necessary and desirable.

The main findings of the present paper highlight a prevalence of micro-research spin-offs in Italy. The biopharmaceutical industry in 2007 had a lower level of sales compared to the ICT and the transport sectors. The North of the country revealed a better performance than the Centre and the South and Islands. The comparison between a sample of research spin-offs that accepted to answer to a questionnaire investigation and a matched sample of start-ups did not highlight a better performance of Italian research spin-offs in terms of sales in the year 2007. Finally, the number of years on the market had no impact on the level of sales.

The paper is structured as follows. First, a definition of research spin-off firm, a general survey of the nowadays Italian economic scenario as well as of the research spin-offs context (sections 1, 2 and 3). Then, a focus on the comparison between the sample of research spin-offs with a matched sample of start-ups (section 4). Furthermore, a comprehensive discussion of the empirical results and the proposition of an agenda for future research efforts are given in section 5, including implications of the findings. Finally, section 6 highlights my conclusions.

I. — DEFINITION OF A RESEARCH SPIN-OFF FIRM

As well as the literature on spin-offs « *has been growing in dispersed directions* » (Gilsing *et al.*, 2010, p. 12), similarly an agreed and a precise definition of research spin-off does not exist. This has been recently confirmed by Muller (2010, p. 189): « *when examining academic spin-offs, one comes across a wide variety of spin-off definitions throughout the literature* ». According to Pirnay *et al.* (2003, p. 356) « *“spin-off” is a fuzzy and general concept that covers a wide variety of phenomena among which the USO represents only one specific type. (...) In particular, a USO refers to a spin-off firm that is created from a particular type of “parent organization”, namely a university. Anyway, there have been many attempts to explicitly define a USO* ». The difference and heterogeneity in spin-off definitions highlight how the spin-off phenomenon is interesting for its own complexity.

First of all, according to Schumpeter (1934) research spin-offs can be defined « *innovative firms* » that aim to commercialize research results starting from R&D and reaching the market and the consumers. It is important to stress the need to develop and improve R&D activities with continuity, because a spin-off can be defined an innovative firm if it industrializes university research results and if it goes on with research work after the start-up stage. Furthermore, according to Lazonick (2005), the essence of the innovative firm, that is a social organization, is the organizational integration of a skill base that can engage in collective and cumulative learning. To fully comprehend the innovative firm, there is a need to understand the actual learning processes: the relation between tacit and codified knowledge, between individual and collective capabilities, and between what is learned at a point in time and how that learning cumulates over time. Spin-offs are a typical example of knowledge-based entrepreneurship, with the particularities of scientific knowledge and its mode of transfer (Witt, Zellner, 2007; Hindle, Yencken, 2004). Research spin-off firms are linked to the economics of tacit and codified knowledge (Gilsing *et al.*, 2010). Tacit knowledge can be acquired by experience on the job, in the case of scientific tacit knowledge, by conducting scientific research, and it is hard or quite impossible to encode (Witt, Zellner, 2007). The benefits of such tacit knowledge arise only through a culture of trust and knowledge-sharing within an organization, like a research spin-off firm. Spin-offs may be defined innovative firms which hold tacit knowledge.

Second, if we look at the most diffused definitions in the literature, a spin-off firm is generally defined as a new firm created to develop commercially knowledge, technology, and university research results (Pirnay *et al.*, 2003; Clarysse *et al.*, 2002; Wright *et al.*, 2004). Shane (2004, p. 4) « *defines a university spin-off as a new company founded to exploit a piece of intellectual property created in an academic institution. Companies established by current or former members of a university, which do not commercialize intellectual property created in academic institutions, are not included in the definition of a spin-off employed here. Thus university spin-offs are a subset of all start-up*

companies created by the students and employees of academic institutions ». In recent years, studies on spin-off firms have adopted a narrow definition of this kind of firms, because of the difficulties involved in trying to identify the number of spin-offs. For example, Wright *et al.* (2007, p. 4) define university spin-offs as « *new ventures that are dependent upon licensing or assignment of an institution's IP for initiation* ». The authors justify the choice of a narrow definition on the grounds that this is the one which is most often used in empirical studies, even if not every study includes this specification. These spin-offs are by definition based upon university IP and thus they are the easiest to keep track of for the Technology Transfer Office (TTO). Nonetheless, given the reality of some universities in which IP is not necessarily owned by the university and the existence of many companies without formal, codified knowledge embodied in patents, the authors include in their study also « *start-ups by faculty based in universities which do not involve formal assignment of the institution's IP but which may draw on the individual's own IP or knowledge* » (Wright *et al.*, 2007, p. 4). They exclude from the analysis only those companies established by graduates.

We can assume that the main problem is to identify specific criteria in order to define whether a firm is a spin-off or not. The focus is on « knowledge » : the key difficulty is to evaluate whether there has been knowledge transfer from the parent institute to the firm or not. According to this new stream of literature that adopts different and narrow or larger definitions of research spin-off, in this paper I define research spin-offs all the firms coming from the research world with or without a university share and a patent, but established by current or former university/research centre members – professors, technical and administrative staff, PhD candidates – and aiming to exploit research results.

II. — THE ITALIAN SCENARIO : UNCERTAINTY, STAGNATION AND INSTABILITY

With a total population of nearly 60 million of habitants subdivided in 20 Regions and in particular in the North of the country, Italy shows several structural problems that hinder the innovation potential and the economic performance. Bureaucracy, political instability and a marked delay in fostering and supporting the new information and communication technologies (Colombo, Delmastro, 2001, 2002 ; Bassanetti *et al.*, 2004 ; Finlombarda, 2006), are affecting the Italian context (1). These factors have a pivotal consequence on the

(1) « *A major change is now expected with the launch of the E-government 2012 plan that, starting from an intervention for ICT diffusion in public administration, should act as a major instrument to stimulate economic recovery* », Inno-Policy TrendChart (2009), p. 9.

performance of the business world and in particular on the establishment, survival and growth of a very particular kind of firm like the research spin-off one.

According to the Inno-Policy TrendChart (2008, 2009), the Italian economic scenario is presently characterised by economic uncertainty and stagnation as well as severe financial constraints. The Italian economy is still affected by a problem of low growth. Special factors such as low-skilled workers entering the labour market, weak investments on R&D, firms specialising in traditional sectors and the prevalence of small family businesses which are less prone to innovate, and insufficient product market competition, can have contributed to depress measured productivity growth. Since the 1990s, Italy's performance has substantially lagged behind that of other main European Union economies. In spite of a widespread entrepreneurship oriented towards traditional/mature sectors, Italy is behind in promoting the creation of new technology-based firms (Colombo, Delmastro, 2001, 2002; Finlombarda, 2006). Notwithstanding some positive signals of revival in 2006 and 2007, the Italian scenario is still anaemic in terms of growth rates. Furthermore, the worsening of the international macroeconomic scenario are all pointing to the downside. In terms of innovation performance Italy is still considerably behind its main European partners even if its overall performance has marginally increased over the past years. Italy is in the group of « moderate innovators », with a performance below EU average but above the group of « catching up » countries (Inno-Policy TrendChart, 2008, 2009), while according to Fondazione Rosselli (2007; 2008) Italy is in the group of « scarcely innovative countries ». The market of early-stage and venture capital funding is relatively young and underdeveloped; nevertheless, it has started to show signs of improvement (Inno-Policy TrendChart, 2009). Furthermore, the Italian governance system has been characterised by the presence of many policymaking entities undertaking innovation policy tasks that are sometimes fragmented, uncoordinated and conflicting. A strong fragmentation of instruments and measures, often conceived as short term or even *una-tantum* initiatives, has characterised till now research and innovation policy intervention in Italy (Inno-Policy TrendChart, 2008, 2009).

Given this general context, it is important to stress also the main changes in the regional governance system occurred in recent years. Since 2005, the contribution of Italian regions to the innovation policy formulation process and the management of measures favouring R&D and innovation increased due to the reform of Title V of the Constitution in 2001 and its implementation through the Law 131/2003. Thanking to the new power acquired by the Regions in the field of scientific research and technological innovation policy, R&D and innovation regional policy initiatives have been developed. Nevertheless, the duality between the central government and the regional actors' intervention is still affecting the Italian system (Inno-Policy TrendChart, 2008, 2009). Main challenges for the Italian system are given by the improvement of technology transfer mechanisms to reduce the existing gap between research and the market, by innovation financing, in particular ventu-

re capital, and by mobility of talents, especially brain drain. Several policy interventions had been introduced in order to address these challenges. To the aim of this analysis, it is important to underline the creation of Industrial Liaison Offices (ILOs) and Technology Transfer Offices (TTOs) in the main Italian universities (2) (O’Gorman *et al.*, 2008 ; Siegel *et al.*, 2007 ; Clarysse *et al.*, 2007 ; Jain, George, 2007 ; Wright *et al.*, 2006, 2007).

To the aim of the present analysis it is also important to highlight that it is observable a lack of data on new technology-based firms in general. One of the first surveys to fill this gap has been undertaken by the Department of Management, Economics and Industrial Engineering of Polytechnic of Milan with the Osservatorio Rita (3) on high-technology start-ups. The survey of 2005 (Rapporto Rita, 2005) revealed that two thirds of a sample of 2,000 Italian new technology-based firms are active in the service sector and the geographical distribution shows a strong concentration in the North, especially in Lombardy, and an underrepresentation in the Centre and the South.

All these recent initiatives are key signals of the importance of the research spin-off phenomenon in Italy. There has been a wave of research spin-offs in Italy in recent years. Nonetheless, the context of Italian research spin-offs is still limited and the results in terms of growth are not rapid. The scenario described above can justify and explain the main difficulties encountered by this kind of firms and the following empirical investigation will prove these assumptions. Furthermore, the confusion surrounding the research spin-off world in Italy and the absence of a clear and focused policy at national and/or regional level are deep problems that delay the potential of this kind of firms. This confused context and the difficulties which characterize the Italian research spin-off scenario are investigated further in the following section.

III. — THE RESEARCH SPIN-OFF PHENOMENON IN ITALY : A CONFUSED CONTEXT ?

The research spin-off scenario in Italy is complex, confused and difficult to qualify.

If it is true that the spin-off phenomenon is a new reality for a country like Italy and it has acquired more and more importance in recent years, it is also true that it is a not well definite subject. First of all, in Italy there is not an agreement on the definition of research spin-off firm. Second, an official, com-

(2) For a comprehensive discussion on the role of these structures in Italian universities, see Netval (2007, 2009, 2010).

(3) The databank Rita (Researches on High Technology Entrepreneurship) has been created in 2000 and updated in 2002 and 2004. It contains detailed information on about 2,000 high-tech firms and on about 1,500 founders of these firms.

plete and updated list of Italian research spin-offs at the regional or national level does not exist. The absence of an agreed definition of spin-off firm has consequences on the identification criteria of the effective number of this kind of firms. In the absence of an official list at the national/regional level, it is also impossible to identify how many spin-offs have been established in Italy and how many of them are working. In this context, each university adopts an autonomous policy. Technology Transfer Offices (TTOs) and Industrial Liaison Offices (ILOs) are in charge of supporting spin-off firm initiatives. The difficulty of identifying the actual number of spin-offs has been highlighted more than ten years ago by Carayannis *et al.* (1998, p. 10): « *Our research in New Mexico and in Japan suggests that spin-offs are not very visible, at least in their early years. Thus the number of spin-offs in an area is often underestimated, even while they play an important role in technology transfer* », and this is still confirmed by the yearly report Netval (2007, 2009, 2010).

Finally, Italy has not adopted till now a specific policy instrument focused on the research spin-off world. Notwithstanding the great attention towards this phenomenon given by the increased number of firms established, lack of clarity and information characterizes the Italian research spin-off context. The increasing number of spin-offs over the past few years has prompted many Italian universities to establish rules to control the spin-off process and address related issues systematically following the Legislative Decree n° 297/1999 (Salvador, 2009).

At the moment, it is difficult to obtain data on research spin-offs because of this confused context and also because they have only recently began to attract public interest. Most of all, nonetheless, it is difficult to identify and isolate research spin-offs in the larger new technology-based firms (4) population. Nevertheless, recently some studies are beginning to provide interesting information. The main problem related to the Italian context is that there have been over the last ten years non-sistematic and non-coordinated attempts at mapping academic spin-offs. At national level these include the contributions by Netval (2007, 2009, 2010) and Piccaluga and Balderi (2006). These studies try to assess the evolution of the research spin-off phenomenon in Italy. The first one is the yearly report on the valorisation of research in Italian universities undertaken by the network Netval, and the second one is the research report on the Italian research spin-off consistency undertaken by Scuola Superiore Sant'Anna of Pisa in 2006. The former is based on a survey undertaken through a questionnaire, but, even if their number has grown in recent years, the respondents are not the universe of Italian universities and research spin-offs are investigated only in part. The latter is not updated, because it was com-

(4) According to Hogan and Hutson (2007, p. 91), « *NTBFs are defined as independent ventures less than 25 years old that supply a product or service based on the exploitation of an invention or technological innovation* ».

missioned only in 2006. Nevertheless, they are useful starting points in order to better understand the nowadays research spin-off context in Italy.

The first report is undertaken by Netval, that is a network for the valorization of public research results created in 2002 with the participation of many Italian universities and evolved in a chartered association in 2007. Since 2002, Netval has published a report on the valorization of research through a questionnaire compiled by a sample of Italian universities. To the aim of my analysis, it is important to consider the section on research spin-off firms. In particular, in order to understand the relevance of the results I found in my empirical investigation, I am going to compare them, if applicable, with those of Netval (2007), that analyses data from 2002 to 2006, Netval (2009), that relates to the survey undertaken in 2008 with data concerning the year 2007, and Netval (2010), that is the survey 2009 with data related to the year 2008.

The second report is the one on the consistency and evolution of Italian research spin-offs dated 2006. In the introduction of the study it is said that the aim was to write the most detailed research report available on the research spin-off phenomenon in Italy (Piccaluga, Balderi, 2006, p. 8). This report underlines the growing creation of spin-offs and the low level of death rate, as well as a modest turnover and in general a poor growth. These authors identified 454 research spin-offs in Italy, of which more than 80 % established since 2000. Piccaluga and Balderi (2006, p. 17) underlined the difficulty of obtaining significative data on the performance and the dimensions: data available was not enough to guarantee an analysis with results of statistical significance. Furthermore, they highlighted the difficulty of identifying the actual number of spin-offs because of the absence of an official and agreed definition of research spin-off firm (Piccaluga, Balderi, 2006, p. 51), that is consistent with my previous assumptions.

From these considerations, we can assume that the analysis of the research spin-off context in Italy has several methodological difficulties. The phenomenon is relatively recent; as a consequence the data is hard to find. Furthermore, it is still undergoing evolution; it is therefore difficult to estimate the effect of the various support measures on the spin-offs' performance. Last but not least, the phenomenon is difficult to isolate from other characteristics of the context in which it is developed: measures to support spin-offs fall within a larger context of interventions in favour of the creation of high-tech firms and of policies for research and innovation (Finlombarda, 2006).

To sum up, we can assert that the nowadays research spin-off context in Italy is very confused and difficult to identify. This confusion is not helpful in trying to undertake an empirical analysis on this phenomenon and reliable official data does not exist. As a consequence, in order to compare a sample of research spin-offs with a matched sample of start-ups I thought useful to start from the list of respondents to a questionnaire investigation focused specifically on Italian research spin-offs and undertaken from January to June 2008.

IV. — ITALIAN RESEARCH SPIN-OFFS AND START-UPS: A COMPARISON

The aim of this comparison is to highlight whether there have been any differences in sales between research spin-offs and start-ups in the year 2007. I decided to utilize sales and the year 2007 for the following reasons. According to McDougall and Oviatt (1996), to Gupte (2007) and to Rothaermel and Thursby (2005 ; 2005b), measuring the performance of organizations is always a complex problem, and it is especially thorny for new ventures. According to data availability, I decided to follow the same choice of Gupte (2007) and I employed sales, which is the growth measure suggested in entrepreneurship literature (Covin, Slevin, 1991 ; Lumpkin, Dess, 1996). This measure may be considered as a relevant one, providing reliable and consistent results (Chandler, Hanks, 1993). Therefore, given these constraints and the difficulty of obtaining reliable data on a particular kind of firm like the research spin-off, I decided to limit the comparison in terms of sales levels. Furthermore, as it was mentioned above, the attempts to study empirically research spin-offs in Italy have been rare and confused. On the other hand, there have been more recent attempts to look at the phenomenon at both regional and national level. Chiesa and Piccaluga (2000) investigated 48 research spin-offs, Colombo and Delmastro (2002) analysed 45 on-park and 45 off-park companies, Clarysse *et al.* (2007) included 29 Italian research spin-offs in a sample of European case-studies, Salvador (2007) investigated 17 research spin-offs located in the North of Italy, Fini *et al.* (2009) surveyed 47 research spin-offs located in Emilia Romagna region, Nosella and Grimaldi (2009) analysed spin-offs created by 37 Italian universities, Salvador (2010) focused on the case study of Turin research spin-offs.

I decided to limit the analysis on the year 2007 not only because of the difficulty of obtaining data but also because my starting point was a questionnaire investigation on the universe of Italian research spin-offs (January-June 2008). In order to overcome the main problem of identifying the actual number of research spin-off firms founded in Italy, I looked at the ILO or TTO website of each university as well as each Italian university website for a list of spin-offs and the second step was to verify the completeness and updating of this list. Another problem was due to the fact that the university takes care only of spin-offs participated by the university itself. Because of the fact that I decided to adopt a large definition of spin-off including also spin-offs not participated by the university, the university list had to be completed with the Italian science park and incubator tenants list. A final problem was due to the fact that science parks and incubators do not make any difference between start-ups and spin-offs. Telephone and e-mail contacts with university staff as well as science park and incubator personnel were pivotal in excluding start-ups from the final list which included 419 companies. I was able to contact 394 firms. I carried out a questionnaire investigation from January to June 2008 : I received 155 questionnaires compiled (response rate : 39.5 %). Starting from this list of questionnaire respondents, I decided to undertake an analysis in

order to compare this sample of research spin-offs with a matched sample of start-ups, which means firms not created by university staff and therefore not linked to the academic world, but with similar characteristics to the sample of spin-offs. Given the absence of reliable data from official national statistics on the universe of Italian new-technology-based firms (Colombo *et al.*, 2004), I thought that the only feasible action in order to provide a comprehensive analysis was to collect data from the balance sheets. In order to choose the balance sheets' variables to be included in the model I started from the main results of the questionnaire investigation. According to section A of the questionnaire, Italian research spin-offs are essentially young firms, they are most of all limited companies and there is a prevalence of companies established in the North (58 %) and Centre (23 %) of the country. The capital is low and few are the increases in capital registered. These firms are not a success in terms of employment and less than 20 % left the university position to work full time in the spin-off firm. Two thirds of these companies are service oriented while only one third is product oriented. The industry sectors show a strong prevalence of the ICT sector (33 %) followed by the biopharmaceutical (25 %). Interesting findings are the ones about the marked prevalence of the national-international attitude (46 % and 43 % respectively) and the willingness to use research results (58 %). Section B highlighted the importance of personal and family capital as a source of financing, as well as the availability of public funds. Finally, section G surprisingly highlighted the prevalence of « indifference » (49 %) in the assessment on the geographical location. The fact that the research spin-off firm was born in an Italian region located in the North, the Centre or the South of the country seemed not to be relevant. The collaboration provided by the Region, showed, instead, a prevalence of aid from regions located in the North compared to the ones of the Centre and the South of Italy.

4.1. Sample frame construction and selection : methodological aspects

I obtained interesting answers from the questionnaire investigation and I had a confirmation of the fact that these are in reality all research spin-off firms. The questionnaire data suggested me how to build the comparison between this sample of spin-offs with a matched sample of start-ups.

Therefore, given the young age of these firms I investigated whether time on the market was a significant factor and given the poor success in terms of employment I used total assets as a size variable. Furthermore, given the indifferent evaluation on the geographical location and the positive judgment on aid provided by North regions, I aimed at highlighting potential differences among firms located in the North, the Centre and the South of the country by introducing three dummy variables. The importance of the ICT sector emerged from the questionnaire results has been the reason for investigating different performance of the industry sectors of these firms by employing five dummy variables. Finally, the strong national and international attitude of research spin-offs notwithstanding the small size, the desire to transfer the research

results to the market and the availability of public funds, suggested me to investigate potential differences in the performance between spin-offs and start-ups. I organized these variables and I built the regression model as follows.

According to the criteria followed by Colombo and Delmastro (2002), that resorted to Rita data bank to build the control sample, in order to undertake the analysis on the comparison between the sample of spin-offs with a sample of start-ups I identified similar firms in terms of sector of activity, age and geographical location. In order to find firms that complied with the above mentioned criteria, I resorted to Aida data bank (5). The matching strategy was successful as concerns all the criteria. Given the difficulty of obtaining data on Italian research spin-offs, I was able to find 98 research spin-offs (63.5 %) starting from the original sample of 155, and I compared these firms with 299 start-up firms. I did not find the other 57 research spin-offs on the data bank Aida because 9 companies established in 2008 as well as 22 of the firms created in 2007 had not yet deposited the balance sheet at the time of my investigation; 5 spin-offs in the form of limited partnerships were not available on Aida, because this data bank takes account only of capital firms; finally 21 firms were not yet available on Aida because of their low level of capital. Nevertheless, according to the sample size and to the response rate in general achieved (6), we may consider this sample as reasonably representative.

In order to build the control sample, I proceeded as follows. In order to compare the sectors of activity I used the Ateco 2007 classification (7); in order to compare the age I considered the same year of creation of the firm. Finally, I

- (5) AIDA is a databank that provides company accounts, ratios, activities for 950,000 Italian companies; ownership and management for the top 20,000 companies. Consolidated accounts are available for over 3,800 companies. AIDA also incorporates a database of scanned images of the year end reports and accounts for over 300,000 companies. The accounts are in a detailed format and include 50 ratios as standard. News relating to the companies are also included. AIDA offers personal data with a description of the company's activity and it allows the access to the detailed balance sheet of every Italian company following the complete scheme of the IV EC Directive. The balance sheets are available in historical series till 10 years. The search and analysis programme is developed by Bureau van Dijk Electronic Publishing.
- (6) Sheehan (2001) finds response rates to oscillate between 21.6 % and 36 % and Jobber and Saunders (1993) indicate that the rate of response in business-oriented studies is more sensitive than consumers' ones to characteristics as the number of questions, the length of the survey, etc. [cited in Squicciarini, 2008, p. 50].
- (7) Since the 1st of January 2008 a new classification of economic activities called Ateco 2007 is in force as the single rule of classification for public administration. This new classification in Italy is published by Istat (National Institute of Statistics) and it is the national version of the European nomenclature NACE Rev. 2, established by the Regulation EC n° 1893/2006 of the European Parliament and the European Council, published on the *Official Journal* on the 30th of December 2006.

identified start-ups established in the same Province or, when not possible, in the same Region of the original sample of spin-offs. Starting from 98 research spin-offs I identified 299 start-ups. Therefore, the final dataset included 397 firms. Always because of the lack of data on Italian research spin-offs it was not possible to undertake a longitudinal analysis. Therefore, I provided a cross-sectional analysis on the year 2007, which was the latest year available on Aida and it is coherent with the period of investigation through questionnaires (January-June 2008). An important advantage relative to my data is that Aida has a record of every company included in the data bank. As a result, Aida data is free from survivor bias, a sample selection problem that is endemic to studies of young companies (Shane, Stuart, 2002). All the firms of my dataset were still active at the date of investigation.

A series of regression analyses were conducted to examine whether research spin-offs exhibited different levels of sales in the year 2007 compared to the sample of start-ups. For each measure under examination, control variables were added sequentially to the regression in order to show their relative importance in explaining observed differences.

4.2. Dependent and independent variables

I decided to build the regression model using « sales » as dependent variable. The independent variables I employed were as follows: « flagspinoff » for spin-off and start-up firm; « total assets » as a variable for firm size; « time » measured as the number of years on the market; « geographical location » (North, Centre, South and Islands); « sector of activity » (five groups of Ateco code of two digit).

I measured the variable « flagspinoff » by using a binary variable which took the value 1 if the firm was a spin-off and 0 otherwise. I decided to measure the firm size in terms of « total assets » (8), because it has not been possible to have enough and reliable data on the number of employees. Research spin-offs are not a success in terms of employment (Mustar, 1997; Pérez Pérez, Sánchez, 2003; Zhang, 2009; Clarysse *et al.*, 2007): the questionnaire investigation revealed that in most of the cases the number of employees is between 2 and 4, but the respondents made no difference among full employee, part-time employee, and the different kinds of contracts. Finally, the balance sheets are not helpful to this aim, because the number of employees is not required by law. I measured the variable « time » starting from 0 if the firm was created in 2007; 1 if it was established in 2006; 2 if it was founded in 2005, and so on. I measured the variable « geographical location » by introducing 3 dummy variables for North, Centre and South and Islands of Italy. Finally, I

(8) This variable has been calculated as total assets minus fixed assets.

controlled for industry effects by employing 5 dummy variables for the industrial sectors of ICT, transport, biopharmaceutical, engineering, other. These variables take a value of 1 if the company is in the sector and 0 otherwise. These sectors were identified starting from the Ateco 2007 classification: I formed groups of firms with the same Ateco code of two digit. In the sector named « other » were included the few firms dealing in general in the consultancy industry and in the commerce and editory industries.

Descriptive statistics of the continuous variables are shown in table 1. More specifically, table 2 and table 3 provide descriptive statistics respectively of the spin-off sample and of the start-up sample. The average level of sales for the total sample in 2007 was Euros 722,851, while the average research spin-off firm had a level of sales of Euros 280,775, and the average start-up firm had a level of sales of Euros 867,745. The average total assets of the overall sample was Euros 826,678, while the average total assets of a spin-off firm was Euros 466,208 compared to Euros 944,825 of the start-up firm. Finally, the average age of the firms of the overall sample was 3.3 years. The average age of a spin-off firm was 2.7 years while the average age of a start-up firm was 3.5 years.

TABLE 1 : Descriptive Statistics : total sample

Variable	Observations	Mean	Std. Dev.	Min	Max
Sales 2007	397	722850.6	1733043	0	1.96e+07
Total assets 2007	397	826678.2	2030309	11459	2.76e+07
Time	397	3.327456	2.753066	0	12

TABLE 2 : Descriptive Statistics : Spin-offs

Variable	Observations	Mean	Std. Dev.	Min	Max
Sales 2007	98	280775.5	613575.2	0	4204749
Total assets 2007	98	466208.2	844899.6	11459	4124147
Time	98	2.744898	2.714266	0	12

TABLE 3 : Descriptive Statistics : Start-ups

Variable	Observations	Mean	Std. Dev.	Min	Max
Sales 2007	299	867744.8	1945063	0	1.96e+07
Total assets 2007	299	944825.5	2277864	43997	2.76e+07
Time	299	3.518395	2.743295	0	12

From this data we can assume that research spin-off firms are smaller and younger than the matched start-ups.

4.3. Method adopted and main results

The regression models with sales as dependent variable were estimated using ordinary least squares (OLS) regression analysis. Table 4 presents the correlations among the continuous variables. Total assets and sales are the only variables significantly correlated. The high positive correlation between these two research variables suggests that firms with a high total assets had also more sales.

TABLE 4 : Correlation Matrix

(obs=397)	Sales 2007	Time	Total assets 2007
Sales 2007	1.0000		
Time	0.1500	1.0000	
Total assets 2007	0.7391	0.1595	1.0000

I now discuss the regression results. My aim was to verify whether research spin-offs had higher or lower levels of sales than start-up firms in the year 2007. I tested three different regression models. All the three models were overall highly significant. Model 1 included only the continuous variables and the flagspinoff. Model 2 included both these variables and the dummy variables related to the geographical location of the companies. Finally, Model 3 was my full model which included all these variables and the dummy variables of the sector of activity of the firms. All the three equations were strongly significant the results of which are presented in Model 1, Model 2 and Model 3 tables.

In Model 1 I found a $Prob>F = 0.0000$, a $R-squared$ of 0.55 and two significant coefficients. More specifically, there are strongly significant coefficients ($P<0.01$) relating to the total assets variable and the flagspinoff. According to the results of Model 1, research spin-off firms in 2007 had a lower level of sales compared to start-ups of Euros 277,088 in average. Furthermore, the firms with a higher level of total assets had also a higher level of sales of Euros 0,62 in average. Therefore, the impact is very low. The number of years on the market was not a statistically significant variable in this model, which means that time on the market had no impact on the level of sales.

In Model 2 I found a $Prob>F = 0.0000$ and the $R-squared$ increased to 0.56. The strongly significant coefficient ($P<0.01$) relating to the total assets variable remains the same and the flagspinoff is now a significant coefficient

($P < 0.05$). Furthermore, in this model I found a significant coefficient for the North of Italy in relation to the dummy variables of the geographical location. According to the results of Model 2, research spin-offs in 2007 had a lower level of sales compared to start-ups of Euros 177,757 in average. Furthermore, the low impact of total assets remained the same. This model highlighted that firms located in the North of Italy had a higher level of sales compared to firms located in the Centre of Euros 384,672 in average. Again, the number of years on the market was not a significant coefficient.

MODEL 1 : Linear regression

Number of obs	=	397
F(3, 393)	=	35.92
Prob > F	=	0.0000
R-squared	=	0.5520
Root MSE	=	1.2e+06

Sales 2007	Coef.	Robust Std. Err.	t	P> t	[95 % Conf. Interval]	
Time	16097.27	25972.88	0.62	0.536	-34965.89	67160.43
Total assets 2007	.6214365	.1010466	6.15	0.000***	.4227771	.8200959
Flagspinoff	-277087.9	75582.69	-3.67	0.000***	-425684.9	-128490.9
Constant	223959.2	83674.85	2.68	0.008	59452.91	388465.5

*** Significant at 1 % statistical level

MODEL 2 : Linear regression

Number of obs	=	397
F(5, 391)	=	29.10
Prob > F	=	0.0000
R-squared	=	0.5622
Root MSE	=	1.2e+06

Sales 2007	Coef.	Robust Std. Err.	t	P> t	[95 % Conf. Interval]	
Time	9472.796	26208.92	0.36	0.718	-42055.24	61000.83
Total assets 2007	.6257311	.098956	6.32	0.000***	.4311787	.8202835
North	384671.8	162918.8	2.36	0.019**	64365.34	704978.3
Centre	(dropped)					
South and Islands	-64460.78	227001	-0.28	0.777	-510756.1	381834.5
Flagspinoff	-177757.1	76584.13	-2.32	0.021**	-328325.3	-27188.9
Constant	-59312.55	133196.2	-0.45	0.656	-321182.9	202557.8

*** Significant at 1 % statistical level

** Significant at 5 % statistical level

MODEL 3 : Linear regression

Number of obs	=	397
F(9, 387)	=	20.09
Prob > F	=	0.0000
R-squared	=	0.5768
Root MSE	=	1.1e+06

Sales 2007	Coef.	Robust Std. Err.	t	P> t	[95 % Conf. Interval]	
Time	22714.96	20428.12	1.11	0.267	-17449.03	62878.95
Total assets 2007	.6260546	.0963485	6.50	0.000***	.4366226	.8154866
North	334553.9	155656.3	2.15	0.032**	28516.1	640591.6
Centre	(dropped)					
South and Islands	-70253.07	217913	-0.32	0.747	-498694.6	358188.4
ICT	-40025.54	113559.4	-0.35	0.725	-263296.1	183245
Transport	(dropped)					
Biopharmaceutical	-238112.5	126499.9	-1.88	0.061*	-486825.6	10600.55
Engineering	-218437.2	176778.7	-1.24	0.217	-566004.1	129129.7
Other	760922.8	750950.3	1.01	0.312	-715530.2	2237376
Flagspinoff	-153189.9	80393.38	-1.91	0.057*	-311252.4	4872.517
Constant	16692.16	160180.5	0.10	0.917	-298240.7	331625

*** Significant at 1 % statistical level

** Significant at 5 % statistical level

* Significant at 10 % statistical level

In Model 3 I found again a $Prob>F = 0.0000$ and the $R\text{-squared}$ increased to 0.57. The strongly significant coefficient ($P<0.01$) relating to the total assets variable and the significant coefficient ($P<0.05$) relating to the geographical location dummy for the North of Italy remain the same. The flagspinoff is now weak significant ($P<0.10$). Furthermore, in this model I found a weak significant coefficient relating to the sector of activity dummy for the biopharmaceutical sector. According to the results of Model 3, research spin-offs in 2007 had a lower level of sales compared to start-ups of Euros 153,190 in average. Furthermore, the low impact of total assets remained the same. In my full model, firms located in the North of Italy had a higher level of sales compared to firms located in the Centre of Euros 334,554 in average. Finally, this model highlighted that the biopharmaceutical sector in 2007 had a lower level of sales of Euros 238,112 in average compared to the transport sector. The other sectors of activity did not show a significative impact, as well as again the number of years on the market.

In conclusion, my regression models highlighted that, in general, in the year 2007 Italian research spin-off firms showed a lower level of sales compared to the control sample of start-up firms. Furthermore, the geographical location revealed that firms located in the North of the country had a higher level of sales compared to firms located in the Centre. Another model run by dropping the South dummy revealed that also in this case firms located in the North per-

formed better than firms located in the South and Islands of the country (significant coefficient, $P < 0.05$).

The distribution of the industry sectors revealed that only the biopharmaceutical sector in 2007 had a lower level of sales compared to the transport sector. Other models run by dropping one of the other sectors, revealed that the biopharmaceutical sector in 2007 had also a lower level of sales compared to the ICT sector (weak significant coefficient, $P < 0.10$). The independent variable time had never a statistically significant coefficient: the number of years on the market did not seem to have a positive or negative impact on the level of sales of research spin-offs and start-ups. Finally, the variable total assets had always a strong significant coefficient, but with a weak impact on the level of sales. These results tend to show that start-up firms outperformed research spin-offs in terms of sales in the year 2007.

4.4. Limitations

According to Zhang (2009) and Shane (2004), despite the well-recognized value of studying the research spin-off phenomenon, empirical investigations on this topic are continuously constrained by the limited availability of data. As a result, many researchers tend to focus on a small number of universities and rely on case studies or small-scale survey data. Furthermore, we must highlight that several limitations are common to the majority of empirical investigations in this field (9). Nonetheless, despite these limitations, all these studies shed more light on several unexplored issues.

Zhang (2009) argued that the data sample he utilized on US venture-backed spin-offs was constructed from a database that was not originally designed for the purpose of studying research spin-offs. As a result, the sample covered venture-backed firms only, not representative of the population of all research spin-offs. The empirical results were subject to potential sample selection biases. A similar limitation was observable in my empirical investigation on the comparison between spin-offs and start-ups, because I built the dataset using data acquired from Aida data bank. Therefore, firms not available on Aida had to be excluded from my analysis. Nevertheless, as for Zhang (2009) analysis, it was not possible to correct for such potential biases due to a lack of information. For these reasons, also my analysis is exploratory in nature and the empirical results are mostly suggestive rather than definitively conclusive. And, of course, also my investigation has several limitations. First of all, I had a population of research spin-offs that did not cover the universe. Nevertheless, the sample was well above the current sample size of empirical analyses on the Italian context and in line with most empirical investigations on the research

(9) On this topic see: McDougall and Oviatt, 1996; Colombo and Delmastro, 2002; Lindelof and Lofsten, 2004; Heirman and Clarysse, 2004; Rothaermel and Thursby, 2005; Zahra *et al.*, 2007; Clarysse *et al.*, 2007; Squicciarini, 2008; Schwartz, 2009; Fini *et al.*, 2009.

spin-off phenomenon (10). Second, my study is limited to the Italian context and do not attempt at providing a cross analysis with other European countries. Nonetheless, my goal was to shed some light on the growing wave of Italian research spin-offs. Third, a last limitation is that my analysis relies on data covered on a given time period. Nonetheless, we have to take into account that the research spin-off phenomenon has attracted the attention of researchers and policy makers only in recent years : 2007 was therefore the first year for which it has been possible to have complete data from Aida data bank and it was in line with my questionnaire survey. Despite these limitations and potential biases, the originality of my empirical investigation is given by the running of an analysis that, starting from a questionnaire investigation, obtained a list of « effective » spin-offs and useful insights in order to choose the variables for the regression model that compared these firms with a matched sample of start-ups. My analysis highlighted interesting findings and it was useful for better understanding the Italian research spin-off phenomenon and for stimulating further research along this line.

V. — DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The universe of research spin-off firms (11) I identified in Italy was 419. The variety of spin-off definitions makes it difficult to formulate unequivocal recommendations on the number of firms identified. Nevertheless, the growing number of research spin-offs in recent years can be given for granted. In fact, the increasing number of this kind of firms is confirmed by the yearly Netval report : Netval (2007) identifies a universe of 549 spin-offs, Netval (2009) identifies 710 spin-offs and Netval (2010) argues that the universe is 806 spin-offs. Nonetheless, according to Harrison and Leitch (2007), the number of spin-offs alone is not a sufficient indicator of success because this ignores their initial scale as well as their potential to grow and survive.

My empirical investigation revealed that Italian research spin-offs are very small, « micro firms » rather than SMEs according to the present classification of the European Union (12). This result is a confirmation of the evidence coming from the empirical investigation undertaken by Chiesa and Piccaluga (2000) on a sample of 48 Italian spin-offs at the end of the 1990s. Additionally, this result is in line with existing literature. Autio and Lumme (1998) highlighted that according to extensive empirical data most new technology-based firms are small and do not aspire to grow. The conceptions concerning the growth dynamics of this kind of firms are still largely simplistic. A growth

(10) See, for example, Autio, 1997; Mustar, 1997; Steffensen *et al.*, 1999; Druilhe and Garnsey, 2004; Fontes, 2005; Clarysse *et al.*, 2007; Gupte, 2007.

(11) This list is updated at June 2008 (year of the empirical investigation through a questionnaire).

(12) The Commission of the European Communities, Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (2003/361/EC).

myopia and the absence of a rapid growth (Autio, 1997; Harrison, Leitch, 2007) characterize the great majority of new technology-based firms: « *Successful NTBFs in the Information Society could prefer to remain small and be less concerned with growth* » (Autio, Yli-Renko, 1998, p. 974).

According to Netval (2007, 2009, 2010), over 50 % of the spin-offs identified is located in the North of Italy: this result is in line with my questionnaire investigation and in the regression models the North of Italy showed better results than the Centre and the South and Islands of the country.

The industry sector distribution revealed a prevalence of research spin-offs in the ICT and in the biopharmaceutical sectors: this result is again consistent with Netval report (2007, 2009, 2010), that identifies ICT as one of the leading sector (35 % on average). While the Internet revolution (13) (Benghozi *et al.*, 2009) had certainly a deep influence in the high number of companies in the ICT industry, according to Shane (2004) and to Zhang (2009) possible explanations for biopharmaceutical being fertile grounds for the creation of spin-offs are linked to the long product development horizons and to the expertise of universities in the creation of biomedical inventions. Young firms in the biopharmaceutical industry usually spend many years on R&D activities before putting the first product on the market. This longer product life cycle may justify the result of the lower level of sales. And my result in terms of industry sectors is coherent with other empirical surveys at the European level, like the one on German spin-offs (Gupte, 2007) and the one on French spin-offs (Mustar, 1997). The dummy variables introduced in the model for the industry sectors highlighted a better performance of the ICT and the transport sectors compared to the biopharmaceutical one.

According to Muller (2010) the evidence is mixed while according to Shane (2004) research spin-offs perform better than typical start-up companies. My comparison between the sample of research spin-offs and a matched sample of start-ups highlighted a better performance of start-ups. If confirmed by future investigations on the Italian research spin-off context, this result could represent an important evidence of the performance of Italy in this field compared to other European countries. The results of my empirical investigation on the Italian research spin-off phenomenon are in line with the literature finding that most attention has been focused on spin-off creation and not on increasing the probability that these firms are sustainable in the long run (Siegel *et al.*, 2007). Following what I suggested in Salvador (2010), an effective synergy among the main actors involved in the research spin-off phenomenon, namely universities, incubators, science parks, TTOs and ILOs (Johnson, 2008; Rasmussen *et al.*, 2006; Grimaldi, Grandi, 2005; Lofsten, Lindelof, 2005; Vedovello, 1997), at the national level could be of pivotal importance for a spin-off working « well ». An official monitoring activity of the Italian research spin-off context

(13) For a brief survey on the Internet effect on the economy, see the Introduction of Benghozi and Chamaret (2010).

should be introduced. This monitoring activity should be undertaken by a structure like a single Technology Transfer Office or a network of relevant stakeholders linked to university and incubator-science park staff, dedicated to monitor constantly the changes in the Italian research spin-off context. This structure could gather data « directly » from every company on an annual basis through the submission of a copy of the balance sheet and through the compilation of a standard questionnaire aimed at collecting data on the main difficulties and problems encountered by the firms. According to Inno-Policy TrendChart (2009, p. 12), « *Universities, technology parks, incubators, business angels and venture capitalists operate in separate contexts, following their own specific criteria and with low levels of communication* ». Furthermore, according to Netval (2007, 2009) and in line with my questionnaire results, personal and family capital and public funds are the leading sources of financing for spin-offs, while venture capital and business angels financing are less utilized even if there has been more attention towards these finance sources in recent years. An official and efficient synergy among the numerous actors that support the creation of new firms could reduce the fragmentation given by the local/regional dimension of many initiatives and it could help in achieving systemic objectives as well as in stimulating investment opportunities in the market.

This work differs from the empirical literature on this issue in two respects. A more comprehensive set of indicators, which means data from balance sheets, was more used than in previous studies. Second, the analysis of the Italian case is an interesting addition to the literature, which so far mainly focused on other European countries. Nonetheless, the limitations of my work suggest directions for future research. More specifically, in order to collect fine-grained, longitudinal data on Italian research spin-offs I suggest as a suitable solution to analyse data gathered directly from every research spin-off on an annual basis through the submission of a copy of the balance sheet. Following my suggestions, the intermediation of the main actors involved in the research spin-off phenomenon could foster a yearly collection of these data. In my opinion, this could be the best solution in order to undertake a more comprehensive empirical investigation on the Italian research spin-off phenomenon and it could also give the possibility to overcome potential biases in terms of error or absence of data, because it would no more be necessary to obtain data from secondary sources, like data banks, but it would be possible to analyse data from primary sources. I am aware that this is a difficult challenge, but I recommend this solution as a useful policy implication on this issue. This solution could also give the possibility to really understand the performance of these firms and, therefore, to introduce policy strategies in order to improve the effectiveness of Italian research spin-offs. The results reported here could be tested in even larger samples in the future in order to prove my findings and future research with comparisons between Italy and other European countries could be advisable. Furthermore, following the evolution of the analysis undertaken by Mustar (1997) in France, it would be interesting to undertake a longitudinal analysis in the near future on the same sample of spin-offs and start-ups using data acquired from Aida data bank after 2007 and to analyse the rate of survival and death of these firms.

VI. — CONCLUSIONS

In this paper I provided original evidence on how effective are Italian research spin-offs. The empirical investigation was based on an objective assessment based on data gathered through Aida data bank. Therefore, I made use of secondary data sources that captured data from outside the company.

The main contribution of this paper was analyzing a substantially larger data sample to present a broad range of evidence on Italian research spin-offs that was previously unavailable. In my opinion, this is an important addition to the literature on this issue.

At best, the evidence suggests that start-up firms performed better than research spin-offs in 2007 in terms of sales, and firms located in the North of Italy performed better than firms located in the Centre and in the South and Islands. Finally, the ICT and the transport sectors performed better than the biopharmaceutical one.

This study is not without its limitations and potential biases. These limitations are, however, a common problem well highlighted in the literature on this field. In fact, the set of factors that influence the performance of new companies is broad, but it has not been the subject of extensive research by scholars. The reason is linked to the availability of relatively few data to test on research spin-offs the effects of those factors that prior research has shown to influence the performance of new companies in general. Therefore, the ability to draw strong conclusions from scholarly investigation of the performance of research spin-offs is limited (Shane, 2004). In my opinion, these limitations can only be overcome in future research by collecting more and reliable data that actually are not available. If it can be said that we passed from a « pyramid » structure with few expert universities and many interested universities to a « barrel » structure with many universities engaged in valorisation of research results (Netval 2009, 2010), I suggested the creation of a synergy not only among Italian universities but among the main actors involved in the research spin-off phenomenon with the goal of monitoring research spin-offs at country level. This structure should be a network of relevant stakeholders linked to university and incubator-science park staff. It could gather data « directly » from every company on an annual basis. In my opinion, this could be the best solution in order to understand better the effectiveness of Italian research spin-offs and to undertake a more comprehensive empirical investigation on this phenomenon in the future, because it would no more be necessary to obtain data from secondary sources, like data banks. The collection of balance sheets directly from each Italian research spin-off could give the possibility to undertake a really objective analysis in order to confirm or not my findings and the evidence coming from recent empirical surveys on this issue. Therefore, this solution could highlight useful policy implications. Obviously, the collaboration of universities, science parks, incubators, TTOs and ILOs should be necessary.

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