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"Resource allocation mechanisms, R&D organization and innovative performance in Business Groups."

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Abstract

The business group is the organizational form normally adopted by European firms to manage diversified activities. Italy is an interesting case of analysis given the importance of small and medium-sized business groups. Italian groups show a dichotomous structure: there are few groups of large size with a significant economic weight and many small and medium-sized groups. During the last decade, the number of business groups is increased and also their relevance within the Italian economy (ISTAT, 2015).

The phenomenon of business groups is widespread both in emerging and in developed markets. In fact, the literature emphasizes that this organization is widespread across all size classes and all countries (Bae et al., 2008; 2002; Fan et al., 2005; Ferris et al., 2003; Gopalan et al., 2007; Khanna & Yafeh, 2007). Nowadays, firms are realizing the importance of networking and clustering to develop and share knowledge and innovation. This is especially true when there are changes or market shocks. Collaboration and networking are fundamental to survive and grow. Belonging to a group may allow affiliated firms to enhance their performance compared to corresponding standalone firms.

The literature on business groups is wide and miscellaneous, and not always aligned in its results. Different findings may also depend on the different contexts in which business groups are observed.

In the past, business groups were generally associated with market inefficiencies. Indeed, their development stemmed from the need to replace inefficient institutions or they represented a way for majority shareholders to appropriate resources from minority shareholders. This means that the group assumed a negative meaning in the presence of expropriation of resources and a substitute role in case of market inefficiencies (Morck & Yeung, 2003). The common view was that groups should not be developed in the presence of stable and efficient markets. During the last decade, the consideration about the role of business groups shifted towards a positive view in which they are considered an efficient mechanics in fostering and stimulating the economic and innovative performance of affiliated firms (Belenzon & Berkovitz, 2010; Hamelin, 2011). Indeed, the growth of

groups is not just driven by a situation of inefficiency, but it is seen as an opportunity for firms to develop and foster innovative activities. In fact, the economic and innovative performance of business groups are favored by the superior capacity of affiliated firms to benefit from the internal capital market[1]. In this sense, the internal capital market does not represent a way to expropriate resources to controlled firms from the majority shareholders, but on the contrary, it fosters the development of all affiliated firms. In the last years, both the R&D expenses and the innovative performance have assumed a fundamental role for the growth and the survival of firms. R&D expenses and the innovative performance (such as patent activity) are risky investments and they need large financing. For this reason, business groups are advantaged in sustaining this type of investments by benefiting from both the internal capital market and an easier access to the external capital market (such as bank financing). Although the attention of researchers on resource allocation mechanisms and on the innovative performance in business groups is increasing, the literature is still underdeveloped. Specifically there are still some theoretical and empirical issues to be further investigated. A theoretical issue concerns the decision to centralize or decentralize the R&D activity in diversified firms (i.e. multidivisional firms and business groups) by considering the influence of several factors (such as diversification, the nature of R&D etc.). Empirical issues concern the relation between the diversification and the R&D organization in decentralized firms, the influence of the R&D organization into the innovative performance and the role played by the internal capital market in sustaining the R&D and innovative activities.

The Italian case represents a significant example to empirically investigate these issues, given the large presence of small and medium-sized business groups. I use a new and unique dataset of Italian manufacturing firms, developed using ownership information about joint stock companies drawn from the AIDA database and patenting information

[1] Internal capital market represents an important advantage for firms affiliated firms. The internal capital market allows affiliated firms to transfer resources within the group, without referring to external investors. On the contrary, standalone firms do not benefit from the internal capital market. In case of need, standalone firms may refer only externally (banks, private investors etc.).

from the ORBIS database. Furthermore, I consider the JRC-OECD database[2] containing patenting information on the world top corporate R&D investors (Demis et al., 2015).

The latter is used for a comparison with the Italian business groups, to investigate whether the organization of R&D follows common rules or depends on the context in which business groups operate.

The following thesis is therefore composed of three empirical papers, preceded by a theoretical paper on the organization of R&D, in terms of centralization or decentralization.

The first paper examines the state of the art about the organization of R&D in diversified firms: i.e. multidivisional firms and business groups.

R&D investments are becoming a key issue for the innovative performance of firms. In the case of business groups and other diversified organizations (such as multidivisional firms) the organization of R&D is relevant in influencing its impact on the innovative performance.

Most of the papers on this issue are empirical papers where the theoretical approaches are not always clear. For this reason, the main aim of this paper is to discuss the theoretical approaches that explain how R&D should be organized in diversified firms. Special emphasis is given to the degree of centralization or decentralization in the management of R&D. I identify three issues on which there are still open and controversial questions: 1) the nature of R&D (basic versus applied); 2) the interplay between the external acquisition of knowledge and the internal organization of R&D; 3) the role played by the degree of diversification. I also discuss the peculiarities of R&D organization in business groups as opposed to other forms of decentralized firms. The paper derives the main management implications for the organization of R&D in diversified firms and discusses the questions that remain open to further research.

From a theoretical point of view, there are contrasting views on the relation between diversification and the organization of R&D. I developed a work to investigate empirically the relation between the degree of diversification and the organization of R&D activity in

[2] The latter was developed by a collaboration between "OECD Directorate for Science, Technology, Innovation" and the "EC-JRC Institute for Prospective Technological Studies" (Demis et al., 2015) and it contains information on the patent and R&D activity at group level.

Italian business groups. Business groups represent an ideal setting to address this research question. Furthermore, I examine whether the findings related to Italian business groups are consistent with the sample of the world top corporate R&D investors (JRC-OECD database).

According to some authors (Hill, Martin, & Harris, 2000; Leiponen & Helfat, 2011), we should observe a positive relation between the degree of diversification and the decentralization of R&D. However, this conclusion is challenged by other approaches (Cassiman & Gambardella, 2009) that emphasize the benefits of a centralized R&D whose results may subsequently be applied to diversified units.

The decision to centralize or decentralized may be also influenced by the type of R&D (i.e. basic versus applied research), the type of diversification (i.e. related versus unrelated diversification) and the appropriability of R&D results (Guzzini & Iacobucci, 2014b).

There are few empirical papers examining these issues and analysing the relation between the organization of R&D and the innovative performance of firms.

I used the AIDA database containing information on manufacturing Italian companies. On the basis of ownership ties between companies, this dataset allowed me to construct a map of manufacturing business groups in 2012 and to know the position of the companies within the group.

The legal autonomy accorded to the individual companies in a group allows me to better measure the degree and type of diversification and relate it to R&D organization and the innovation performance. The dataset also provides information on the patenting activity of firms, taken from the ORBIS database.

As mentioned above, I also use the JRC-OECD database containing patenting information on the world top corporate R&D investors " (Demis et al., 2015).

The main results of this paper may be summarized as follows: a) the degree of diversification is positively related to the decentralization of R&D; b) in groups where R&D activities is conducted by controlled firms and not by heads (decentralized groups), there is a negative relation between the degree of diversification and the concentration of patents in a single controlled firm; c) regarding the innovative performance, the centralization of R&D activity may limit the patent production.

The paper highlights the tight relation between R&D organization and innovative performance. This means that it is important to know the implications of the organization of R&D on influencing the innovative performance.

As discussed before, R&D investments are highly risky and they require a large amount of resource allocation. Firms in business groups may use two different sources to support innovative activity, i.e. the external capital market (such as bank financing) and the internal transfer of funds between affiliated firms (internal capital markets). The presence of an internal capital market may help affiliated firms to overcome potential constraints in financing innovative activities.

The need to collect and allocate resources for firms may be stronger and evident in case of market instable situations, such as real and financial crisis.

Consequently, the main aim of the third paper is to analyse the presence and intensity of bank financial constraints in firms belonging to business groups compared to standalone companies. Moreover, it is examined the relation between the external capital market (bank financing) and the internal capital market to investigate whether they are complement or substitute. Furthermore, in case of bank financing, I examined whether banks finance the head of the group (centralized case or *portfolio effect*) or directly the controlled firm that requires a bank loan (decentralized case or *affiliation effect*).

I consider the period 2010-2012 when the financial crisis and the subsequent recession determined a situation of severe credit crunch. The paper uses the dataset of Italian manufacturing firms that includes standalone firms and firms affiliated to business groups.

I compare the financial constraints of companies and groups and analyse the characteristics of them. Findings may be summarized in the following way: a) The affiliation to a business group facilitates the access to bank financing; however, firms belonging to a business are less dependent on bank financing than standalone firms. b) The presence of an internal capital market is a substitute both for the decision to access bank financing and for the amount of such financing; c) When considering centralization versus decentralization in raising bank financing in business groups, the *portfolio effect* prevails on the *affiliation effect*.

In the last paper, it is analyzed the influence of the internal capital market into the innovative performance in business groups. The functioning of the internal capital market is an interesting issue to understand relations between controlling and controlled firms.

In fact, several studies demonstrated that firms belonging to business groups show a superior innovative performance. This is explained by the advantages of groups in providing resources to affiliated companies. One of these resources is the capital needed to sustain R&D investment. The head of a group is supposed to have a better knowledge about the innovative projects of affiliated firms than external investors (such as banks, private investors or the market). As a result, the group may partially overcome the problems arising from information asymmetries, which are specifically relevant for the financing of innovative projects. Group heads may provide financial resources to affiliated companies in several ways. The most important for the financing of innovative projects is equity capital. Equity capital may be provided in two ways: directly, through the issue of new shares; indirectly, by restraining the distribution of dividends and allowing controlled companies to retain profits. The easier access to equity capital by affiliated company is expected to play a relevant role for the financing of R&D investment and the innovative performance. The paper is based on financial and patenting data referring to Italian companies. R&D investment and patents are used as measures of innovation performance. I use the dataset of Italian manufacturing firms mentioned above, whose data are taken from the intersection between the AIDA database and the ORBIS database.

Using information from the balance sheets of companies, I analyse the equity 'policy' of companies belonging to groups and compare it with standalone companies. Data on the patenting activity of companies allow me to relate the innovative performance of companies to their equity 'policy' and measure to what extent the internal capital market observed in business groups influence the innovative performance.

Findings may be summarized in the following way: a) the supply of equity capital is positively related with the innovation performance; b) the distribution of dividends is negatively related with the innovation performance, c) these relations are stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources.

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Introduction

It is well known that the Italian industrial system represents an anomaly at international level. Previous studies have shown the importance of small and medium-sized enterprises (SMEs). According to ISTAT[3], only 1% of Italian firms has more than 250 employees. An industrial system represented by small and medium-sized businesses, with a manufacturing specialization focused on typical "made in Italy" products (mechanics, fashion, food industry, etc) (Giunta & Rossi, 2017). The salient features of the Italian production structure have not changed during the two recession phases that have affected our economy since 2008 (ISTAT, 2015).

When considering the size structure of Italian firms it is important to note that most of them should not be considered as standalone organizations because of the relevance of networking relations in local and global chains (Accetturo & Giunta, 2017), the importance of local cluster and of business groups.

A business group is defined as a set of legally independent firms controlled by the same person(s) through ownership ties. The vertex of the group can be an individual or a group of people, often belonging to the same family (Almeida & Wolfenzon, 2006). Business groups can also be defined on the basis of stable contractual relations among firms (Goto, 1982; Granovetter, 1994). However, it is only ownership that provides the control rights mentioned above. Thus, in the economic and management literatures, business groups are commonly defined and delimited on the basis of ownership ties (Almeida and Wolfenzon, 2006; Feenstra et al., 2003).

In the following, we will adopt this definition of business groups, and therefore, we will neglect other forms of relations among firms based on other ties other than ownership.

On the basis of data published by ISTAT, in 2013 Italian business groups were more than 92 thousand, controlling over 212 thousand Italian firms and they employed over 5.5 million persons. In the last decade, the number of groups increased by 2.2%, the persons

[3] National Institute of Statistics (Italy)

employed involved decreased by 0.8%. The weight of the groups, in terms of persons employed, was 56.8% if calculated it in comparison only to the corporations. The importance of business groups is continuously increasing not only in emerging markets but also in developed countries. Nowadays, firms realize the importance of the networking to develop themselves and share knowledge and innovation. Especially, this is true when there are crisis or market shocks. Collaboration and networking is fundamental to survive and grow. Belonging to a group may allow affiliated firms to enhance their performance compared to corresponding standalone firms. Indeed, ISTAT confirms the increasing trend of business groups during the financial crisis (ISTAT, 2015). In the Italian context, business groups have differentiated characteristics varying among few structures of large size with considerable economic weight and many groups of small and very small size.

In particular, 75.2% of the groups have an elementary structure (1-2 Italian firms); those with a more complex structure (more than 10 resident firms) are the minority but they play a strategic role in terms of employment, with nearly two million of persons employed.

82% of groups are all-resident groups, since they control firms resident in national territory.18% of groups with at least one Italian firm are multinational groups, of which 10.6% is controlled by a non-resident unit.

In 2014, business groups generate over 364 billion euro of value added (53% of total value added). About 70% of the value added is produced by firms in the sectors of industry and services and 73.2% by turnover (ISTAT, 2015). The increasing development of business groups recorded in the last decade is associated to the increasing importance of the R&D activities and the innovative performance in firms. In the past, business groups were generally associated with market inefficiencies. Indeed, their development stemmed from the need to replace inefficient institutions or they represented a way for majority shareholders to appropriate resources from minority shareholders. This means that the group assumed a negative meaning in the presence of expropriation of resources and a substitute role in case of market inefficiencies (Morck & Yeung, 2003). The common view was that groups should not be developed in the presence of stable and efficient markets. During the last decade, the consideration about the role of business groups shifted towards a positive view in which they are considered an efficient mechanics in fostering and stimulating the economic and innovative performance of affiliated firms (Belenzon &

Berkovitz, 2010; Hamelin, 2011). Indeed, the growth of groups is not just driven by a situation of inefficiency, but it is seen as an opportunity for firms to develop and foster innovative activities. In fact, the economic and innovative performance of business groups are favored by the superior capacity of affiliated firms to benefit from the internal capital market[4]. In this sense, the internal capital market does not represent a way to expropriate resources to controlled firms from the majority shareholders, but on the contrary, it fosters the development of all affiliated firms. In the last years, both the R&D expenses and the innovative performance have assumed a fundamental role for the growth and the survival of firms. Empirical evidences underline that those firms with more innovative behaviors during the period pre-crisis have showed a better economic performance during the crisis (Arrighetti et al., 2015).

R&D expenses and the innovative performance (such as patent activity) are risky investments and they need large financing. For this reason, business groups are advantaged in sustaining this type of investments by benefiting from both, the internal capital market and an easier access to the external capital market (such as bank financing).

Empirical evidences show that business groups are widespread both in emerging markets and in developed countries. As said before, one of the main advantages of belonging to a business group is the capacity to share internal resources. In fact, affiliated firms may benefit from the possibility to share the financial, technological and marketing resources available within the group (Carney et al., 2011; Hamelin, 2011).

The capacity to share the internal capital market distinguishes the affiliated firms from the standalone ones[5]. In the past literature, many works have underlined that the role of the internal capital market is particularly relevant in emerging markets, where there is the lack of financial institutions and incomplete markets. In emerging markets, the majority of sales, assets and value added is created by business groups (Siegel & Choudhury, 2012). Furthermore, firms belonging to business a group could take advantage with internal

[4] Internal capital market represents an important advantage for firms affiliated firms. The internal capital market allows affiliated firms to transfer resources within the group, without referring to external investors. On the contrary, standalone firms do not benefit from the internal capital market. In case of need, standalone firms may refer only externally (banks, private investors etc.).

[5] "Standalone" firm is a company not belonging to a business group.

movements of the capital, without referring to external financing. Most of papers are focused on business groups in emerging markets (e.g Bae et al., 2002; Bae et al., 2008; Fan et al., 2005; Ferris et al., 2003; Khanna & Yafeh, 2007). At the same time, however, this phenomenon is widespread all over the world. The latter aspect is emphasized by some authors (e.g Gorodnichenko et al., 2009; Hamelin, 2011; Khanna & Yafeh, 2005). "Business groups are common in many countries, especially in emerging economies" (Samphantharak, 2003). Indeed a business group is a corporate organizational form pervasive present both in developed and developing markets (Bianco & Nicodano, 2006). Also, other authors (Belenzon et al., 2013) underline the considerable presence of business groups, both in developing markets and in developed economies.

In the real world, external capital markets are imperfect. For this reason, the internal funding is less costly than external finances. These imperfections of the markets are evident in emerging economies, where, as said above, the markets are underdeveloped, there is a lack of institutions and firms are more subject to financial constraints than those in developed countries.

One of the most debated issues connected with the internal capital market is the diversion of resources from a firm to another firm of the same group (tunneling[6]). Many authors argue about this aspect (e.g Bertrand & Mullainathan, 2003; Cheung et al., 2006; Friedman et al., 2003; Gopalan et al., 2007; Khanna & Yafeh, 2007). These works refer to large groups in emerging markets. They consider the internal capital market as an advantage for the controlling shareholders but not for controlled firms.

As mentioned, business groups are also widespread in developed countries and in small business sectors (Cainelli & Iacobucci, 2011; Cayssialis et al., 2007; Iacobucci, 2002; Loiseau, 2001; Rosa & Scott, 1999). For these reasons, we cannot consider only the tunneling or propping phenomenon in order to justify the presence of business groups. Some papers show that the affiliation to business groups favors stability of returns and efficiency rather than expropriation of minority shareholders (Iacobucci, 2012), and

[6] It means the transfer of assets and profits out of controlled firms for the benefit of those who control them (the controlling shareholders). It is an expropriation of minority shareholders (Johnson et al., 2000).

eventually the expropriation is a way to maintain artificially the performance of the group in case of a negative business environment or economic shocks (Hamelin, 2011).

Following this idea, Almeida et al. (2015) highlight that during Asian crisis, internal market helps affiliated firms (chaebols) reduce the negative consequences of crisis relative to investments and performance. Moreover, the presence of an internal capital market is specifically relevant when there are difficulties in raising external finance (e.g Fan et al., 2005; Iacobucci, 2012; Komera & Jijo Lukose, 2014; Lee et al., 2009).

Concerning the performance of controlled firms, the literature is still uneven. Some researches support the idea that business groups influence positively affiliated firm performance (Hamelin, 2011; Khanna & Yafeh, 2007), others sustain their disruptive role on performance (Bae et al., 2002; Claessens et al., 2000; Joh, 2003; Lins, 2003).

It is worth considering the positive aspect of the stability that the business group may provide to its affiliated firms, both in developing markets (as substitute of institutions) and developed markets (such as overcoming financial constraints, the possibility of an entrepreneurial growth etc.).

In general, when the market environment is good, the phenomenon of tunneling is not present, since the controlling shareholders have interest in favoring the growth and the development of their group (Hamelin, 2011).

This shift in the consideration about the role of the business group from an anomalous organizational form developing in presence of market inefficiencies to an efficient mechanism of resource allocation, assumes a relevant role in fostering the R&D investments and the innovative performance. As discussed before, the superior capacity of business groups to transfer and allocate resource compared to standalone firms derived from the possibility to benefit of the internal capital market. For this reason, this thesis is focused on investigating the organization of R&D and its effects on the innovative performance and the importance of resource allocation mechanisms in supporting the R&D and innovation activities.

The thesis is therefore composed of three empirical papers, preceded by a theoretical paper on the organization of R&D, in terms of centralization or decentralization.

The period considered covers the “Great recession” started from 2008. The papers are the following:

-The organization of R&D (centralization or decentralization) in diversified firms and in particular in business groups;
-The relation between the degree of diversification and the organization of R&D and the implications on the innovative performance;
-Resource allocation mechanisms between affiliated firms and in particular the relation between the internal capital market and the bank financing (external capital market);
-The role played by the internal capital market on the innovative performance.
Also, a comparison is made between affiliated firms and standalone companies.
To test the research questions, I take advantage from a new and unique dataset of Italian manufacturing firms, using ownership information about joint stock companies drawn from the AIDA database and patenting information from the ORBIS database. Furthermore, regarding the issue between the organization of R&D and the degree of diversification[7], I also use another database, the JRC-OECD database, containing patenting information on the world top corporate R&D investors.
The latter was developed by a collaboration between "OECD Directorate for Science, Technology, Innovation" and the "EC-JRC Institute for Prospective Technological Studies" (Demis et al., 2015) and it contains information on the patent and R&D activity at group level. The latter is used for a comparison with the Italian business groups, to investigate whether the organization of R&D follows common rules or depends on the context in which business groups operate.
The thesis is organized as follow: the first chapter revisits the preexisting literature on business groups, even with references to the Italian context.
The second chapter is the paper focused on a theoretical analysis developed by the need to investigate the R&D organization in diversified firms and in business groups.
Indeed, the organization of R&D in business groups appears to be a novel and growing area of research, since it has effects on the R&D results and the innovative performance.
The main aim of this chapter is to understand how and to what extent the choice of centralizing or decentralizing the R&D activities depends on several aspects, such as the degree of diversification, the firm localization and the type of R&D. This paper highlights

[7] The 3rd Chapter: "Chapter 3. Diversification, R&D organization and innovative performance".

the main issues addressed by the authors and their theoretical perspectives that influence the decision on the centralization or decentralization of R&D.

Issues identified and discussed are: 1) the nature of R&D (basic versus applied); 2) the interplay between the external acquisition of knowledge and the internal organization of R&D; 3) the role played by the degree of diversification. Also, the peculiarities of R&D organization in business groups are discussed as opposed to other forms of decentralized firms. The paper shows that there are a few shared results and several controversial questions. This review is useful and helpful given the theoretical and practical importance of the subject.

The third chapter is focused on the relation between the degree of diversification and the R&D organization. The main aim is to analyze empirically the influence of the group diversification into the centralization of R&D and the effects of the R&D centralization on the innovative performance. The research hypotheses may be summarized as follow: a) there is a positive relation between the degree of diversification and the decision of firms to decentralize R&D; b) when the decentralization of R&D prevails, there is a negative relation between the degree of diversification and the concentration of patents in a single controlled firm; c) there is a negative relation between the centralization of R&D and the innovative performance. Findings of the paper confirm these hypotheses.

The fourth chapter is focused on the topic of resource allocation mechanisms. Particularly, the work analyses the presence and the intensity of bank financial constraints in firms belonging to business groups compared to standalone companies during the financial crisis[8]. Moreover, I investigate whether the internal capital market and the external capital market (bank financing) in business groups are complement or substitute.

Furthermore, in case of bank financing, I examined whether banks finance the head of the group (centralized case or *portfolio effect*) or directly the controlled firm that needs bank loans (decentralized case or *affiliation effect*).

Findings may be summarized in the following way: a) The affiliation to a business group facilitates the access to bank financing; however, firms belonging to a business are less dependent on bank financing than standalone firms. b) The presence of an internal capital

[8] International financial crisis started from 2008.

market is a substitute both for the decision to access bank financing and for the amount of such financing; c) When considering centralization versus decentralization in raising bank financing in business groups, the *portfolio effect* prevails on the *affiliation effect*.

The fifth chapter is addressed to investigate how the 'equity' policy influences the innovative performance. In the internal capital market, equity financing is used to foster the innovative performance of affiliated firms. The head of a group is supposed to have a better knowledge about the innovative projects of affiliated firms than external investors. Group heads may provide financial resources to affiliated companies in several ways. The most important for the financing of innovative projects is equity capital. I expect that the easier access to equity capital by affiliated company plays a relevant role for the financing of R&D investment and the innovative performance.

Findings may be summarized in the following way: a) the supply of equity capital is positively related with the innovation performance; b) the distribution of dividends is negatively related with the innovation performance, c) these relations are stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources.

Each chapter will discuss the main findings and show the questions still open for further researches.

Finally, the last part presents the main conclusions of the following thesis on business groups, highlighting its contributions and novelties.

Chapter 1. The increasing relevance of business groups

1.1 Definition of business groups

The literature proposes several definitions of a business group. The main differences refer to the ownership and non-ownership links (Cainelli & Iacobucci, 2011).

In the first case, belonging to a group is determined by a majority share detained by one person or a groups of people (the controlling owner), often belonging to the same family (Almeida & Wolfenzon, 2006). In the second case (non-ownership links), the literature suggests several forms of stable relations resulting in business groups: subcontracting, franchising, alliances, etc. (Goto, 1982; Granovetter, 1994, Menard, 2004). In the economics and management literature the focus is on ownership ties, while the sociology literature considers also on non-ownership ties (Granovetter, 1994, 1995).

In the following work, we will adopt the definition of business groups followed by the economics and management literature, and therefore, we will not refer to other forms of relations among firms based on other ties other than ownership. When analyzing a company belonging to a group, the most suitable "unit" of analysis is the business group rather than the individual company (Cainelli & Iacobucci, 2011). However, it is only ownership that provides the control rights mentioned above. Thus, in the economic and management literatures, business groups are commonly defined and delimited on the basis of ownership ties (Almeida & Wolfenzon, 2006; Feenstra et al., 2003). Within business group, we distinguish between firms directly owned by the entrepreneur (horizontal groups) and firms controlled by other firms (vertical groups or pyramids). Horizontal business groups mimic the multidivisional structure, in which controlled companies are likely to 'play' the role of divisions.

However, there are two main differences between a multidivisional firm and a horizontal group. Firstly, as said above, controlled companies in a group are separated legal entities from the head. Secondly, the head may hold the control of the other group's companies

with ownership shares lower that 100%, which implies the presence of minority shareholders in controlled companies. In general, control is associated with ownership of more than 50 % of the shares. For both these reasons, controlled companies of a business group usually enjoy a higher degree of autonomy than divisions. While in horizontal business groups there are only two layers (head and controlled companies), in vertical business groups (pyramids) there could be several layers of controlled companies.

This introduces the distinction between the head of the group, the companies at the bottom of the group (i.e. controlled but not controlling other companies) and intermediate firms (i.e. companies which control other firms and which are controlled by another company). While in horizontal groups the head controls the other companies directly, in pyramids the head may control other firms directly or indirectly.

The issue whether associating the firm with the business group or with the individual legal unit is especially relevant given that business groups are highly widespread not only in emerging markets but also in developed countries and are not peculiar only to certain industries, countries or size classes (Cainelli & Iacobucci, 2011).

Managers and entrepreneurs, in order to maintain and develop business activities, adopt group form. In particular, this form may increase the segmentation of markets. In the small firm sector[9], the business group is also a mechanism for expanding the entrepreneurial organization in the start-up of new businesses (Rosa & Iacobucci, 2010). In fact, business groups are seen as a way to experiment new entrepreneurial activities, thank to major capacity of investments than standalone firms. Bena and Molina (2013) suggest that business groups facilitate the financing of entrepreneurial activities. Also, this aspect is highlighted also by Almeida and Wolfenzon (2006): the controlling shareholders could decide to create new firms when the original companies start to decline.

Belonging to a group may allow low-performance firms to survive compared to their corresponding standalone ones. This is particularly true in case of crisis or market shocks.

Although the organization in business groups appears relevant and important, most of statistical data is collected at the firm level, since information on the single unit is more easily identified and more constant over time than business group form. For these reasons,

[9] Sectors dominated by small firms.

most of empirical studies use quantitative datasets referring to legal units rather than to groups. For example, EU surveys on innovation (the Community Innovation Survey) collect information at the level of individual companies (Cainelli & Iacobucci, 2011).

In the management area, we find few discussions about business groups (Daft, 2007; Drucker, 2008; Schermerhon, 2009). This is because business groups are often considered as a financial expedient for controlling owners rather than a real organization (Cainelli and Iacobucci, 2011). This assumption could be valid only for the largest groups; for the majority of groups, which are not large, the predominant logic is organizational or entrepreneurial (Lechner & Leyronas, 2009; Rosa & Iacobucci, 2010; Rosa, 1998). Also, business groups are often considered to be a common form in emerging countries, such as Asia and South America, with little weight in developed countries. As mentioned above, business groups are widespread in all countries, and across all firm sizes (Almeida & Wolfenzon, 2006), and there is evidence that their importance is increasing (Cayssialis et al., 2007).

However, in the literature there are several studies demonstrating that business groups have a significant effect on the direction and results of R&D activity (Belenzon & Berkovitz, 2010; Cefis et al., 2009; Hsieh et al., 2010, Chenjqi et al., 2015). In the last decades, policy makers increase their attention on R&D and patent activities, because they may favor the technological development, innovation and competitiveness between companies, and in particular, this is more evident in business groups.

In general, R&D activities are often planned at group rather than firm level (Cainelli & Iacobucci, 2011). An example is shown by the EC-JRC/OECD COR&DIP© database, developed by a collaboration between 'OECD Directorate for Science, Technology and Innovation[10]' and 'EC-JRC Institute for Prospective Technological Studies[11]', that contains information on the R&D activity of the top 2,000 corporate R&D performers worldwide.

In this database, patents and trademarks owned by controlled firms are thus fully attributed to the 'mother' company of the group (Demis et al., 2015). This database is developed by the increasing attention on the R&D and patent activity, mainly in groups. The database

[10] Acronym 'STI'.

[11] Acronym 'IPTS'.

shows that total R&D investment of these groups is about EUR 539 billion in 2012 (90% of the total business R&D expenditure of OECD countries).
A huge amount of R&D investments justified by the idea that R&D spending fosters the technological development, innovation and competitive advantages.
This database, characterized by larger groups, will be discussed in the third chapter for a comparison with the database of Italian groups, composed mainly by small and medium-sized business groups, in order to understand the dynamics involved in the organization of R&D.

1.2 The main streams of business group literature

There are two main streams of literature that consider in a different way the "nature' of the business group:
a) business group as a substitute of inefficient institutions;
b) business group as a financial device.
a) Several papers consider the business groups as the consequence of inefficient or absent institutions. In fact, the development of business groups may be favored by underdeveloped financial markets or institutional and political instability or the lack of entrepreneurial power in private companies. Khanna and Palepu (1997, p. 41) argue that *"highly diversified business groups can be particularly well suited to the institutional context in most developing countries…"*.
According to this view, business groups should develop most frequently in countries with market inefficiencies, usually emerging countries with significant market information asymmetries (Koch & Guillen, 2001; Yiu et al., 2005).
Similarly, Chang (2006) referring to East Asian countries discusses that: "business groups are creatures of market imperfections, government intervention, and socio-cultural environments. I expect that as long as markets, especially capital markets, are imperfect and the East Asian governments influence resource allocation, business groups will continue to exist and even prosper in this region. As markets become more efficient and government

intervention subsides, business groups may lose their reason for existence and see their influence decline" *(p.413)*.

However, this interpretation on the presence of business groups in inefficient market contexts is contradicted by the large number of business groups in advanced economies, a growing rather a declining trend in recent years.

In fact, Khanna and Yafeh (2005), using a sample of large groups in several emerging countries, argue that *". . .other reasons are more likely to explain the ubiquity of business groups around the world"(p. 301).*

b) On the one hand there are papers showing that business groups are seen as a result of market failures in emerging markets (Chang, 2006; Khanna & Palepu, 1997, 2000) On the other hand researches in developed countries stress the interpretation of the group as a financial device in order to separate ownership and control (Cainelli & Iacobucci, 2011).

The control of companies derives from negotiated relationships between the main stakeholders, such as entrepreneurs, banks or managers, which may guarantee more stable control and may exploit the activities controlled through the equity capital invested by the controlling owners.

Controlling firms allocate resources in a more efficient way compared to the capital market and this aspect may justify the presence of groups.

In fact, Cainelli and Iacobucci (2011) argue that the presence of business groups can be justified by:

(1) the existence of the imperfect capital market (information, transaction and monitoring costs), which render convenient the portfolio diversification; and

(2) advantages deriving from the direct control of business activities.

Several studies have investigated the role of the internal capital market in business groups. In particular, an evident advantage of the affiliation to a group is the easiest possibility to renegotiate in case of financial problems. Moreover, the possibility to manage an internal capital market allows business groups to maintain a good reputation in external market (Gopalan et al., 2007).

The presence of an internal capital market is specifically relevant when there are difficulties in raising external finance. Thus, firms belonging to a group should be less constrained in their investment policy than standalones, because they can rely on the internal movements

of capital from other members of the group (Iacobucci, 2012; Lee et al., 2009). Some authors (Fan et al., 2005) support the idea that pyramids create an internal capital market that helps to alleviate their external financing constraints. Also, Samphantharak (2003) highlights that external funds are more costly than internal finances. Other authors (Lensink et al., 2003) show that firms belonging to business groups are less financially constraints than the corresponding standalones.

Buckuk et al. (2014) underline that it is more convenient for a group to use internal debt than internal equity in case of financial problems, because the first can be used immediately by the firm that borrows, while for internal equity the controlling shareholders have to contribute with their shares of dividends.

Buzzacchi and Pagnini (1994, 1995) using a sample of 510 large industrial firms, show that the amount of resources managed within the group is comparable to the financial resources collected by the group externally. This confirms the similarity between the group and the multidivisional firm as a mechanism for the allocation of financial resources.

However, the group has the possibility to increase external finance sources, since capital (debt and equity) can be collected by both the controlling firms and controlled firms (Cainelli & Iacobucci, 2011). According to Buzzacchi and Pagnini (1995), this allocation resource mechanism may generate some inefficiencies because of "tunneling".

This is not possible in the case of multidivisional firms since shareholders have the same shares in all divisions of the firm.

The conflicts of interests between controlling and minority shareholders has interested several authors that consider the group as a mechanism for separating ownership and control (Bae et al., 2002; Bertrand & Mullainathan, 2003; Claessens et al., 2000; Friedman, et al., 2003; Johnson et al., 2000; Morck & Yeung, 2003). This logic is due by the fact that the controlling shareholders have interests in all the companies of the group while minority shareholders have shares in individual companies. This interpretation is more appropriate for groups including listed firms and with a relevant divergence between the control and cash flow rights (Cainelli & Iacobucci, 2011).

Tunneling mechanisms may be more present in weaker economic institutions rather than in advanced regions, due to underdeveloped economy and absent institutions.

Although tunneling may be assumed the form of theft or fraud, Johnson et al. (2000) show that it may take place in developed countries as legal form.

However, the empirical evidence shows that most of groups are composed of unlisted companies and not significant divergence is found between control and cash flow rights (Faccio & Lang, 2002; Franks & Mayer, 2001). According to the latter view, Buchuk et al. (2014) find that loans do not typically go from the bottom of the control pyramid straight to the top of the pyramid, as tunneling suggests. In fact, small firms within group may get loans from the top of pyramid. This aspect contrasts with the idea of some authors that believe in the presence of tunneling in business groups, in which resources move from the bottom to the top of pyramid (Bae et al., 2002; Gopalan et al., 2007; Jian & Wong, 2010). Moreover, Almeida et al. (2015) show that belonging to a business group allow firms to transfer cash from low-growth to high-growth, but they don't mention the phenomenon of tunneling, because this transfer of resources is not relative to the position of the firm (i.e. top, intermediate or bottom of the pyramid).

Hamelin (2011), considering a panel of French SME, analyzes the "expropriation" hypothesis of minority shareholders in small groups. She finds that controlling shareholders develop groups principally to preserve their value and wealth rather than to expropriate minority shareholders. Moreover, the author underlines that tunneling is positively related to group size: while in smaller groups the controlling shareholders are involved in the firm management, in larger groups they are not directly connected in management activities; this is particularly true when the cash flow is low. Hamelin (2010) supports the idea that the risk of tunneling is correlated negatively by group size, due to the presence of *"patrimony securization"* strategies in small groups. The author also shows that the controlling shareholders may tunnel funds away from the minority shareholders, when the market is not favorable or when there are negative shocks.

The presence of business groups may also be justified when entrepreneurs intend to attract capitals for new companies from outside investors (Almeida and Wolfenzon, 2006).

According to Cainelli and Iacobucci (2011), these two strands of literature, that consider the business group with two different point of view, i.e. as a substitute for market mechanism or as a financial device, underestimate its role and its effects as an organizational form.

Moreover, this literature, focused mainly on large groups, undervalue the relevance and the implications of small and medium-sized business groups.

1.3 Performance of business groups: a debated issue

The literature shows contrasting results on the performance of affiliated firms.

In fact, some authors support the idea that business groups influence positively affiliated firm-performance (Hamelin, 2011; Khanna & Yafeh, 2007), others sustain their disruptive role on performance (Bae et al., 2002; Claessens et al., 2000; Joh, 2003; Lins, 2003). George et al. (2008) contribute to enrich the literature concerning the profit distribution within business groups. The results show that affiliated Indian firms have lower performance than independent firms. This analysis also examines if the profit redistribution is used by controlling shareholders to expropriate the minority shareholders and extent their control. Empirical evidence shows that firms with high levels of control and belonging to large groups are subject to severe profit redistribution. The lower performance of affiliated firms than independent firms derives from the profit redistribution that is made from high performing firms to low performing firms. This is the problem of the underperformance of group-affiliated firms.

Most of papers that show the low performance of affiliated firms refer to large business groups.

Almeida and Wolfenzon (2006) argue that affiliated firms may have lower performance compared to standalone firms, because business groups, benefiting from a higher amount of resources, may also invest in those projects less profitable.

Conversely, Hamelin (2011), considering a panel of French SME, shows a positive performance of affiliated firms. However, empirical results on group performance depends on country-specific characteristics. It is not easy to find common institutional features between emerging and developed countries. Using a sample composed by 14 emerging markets, Khanna and Rivkin (2001) show that affiliation effect could either increase or drop firm profitability. Authors sustain the idea that differences in profitability may depend on different institutional contexts. Indeed, results drawn in one specific market may not apply to another context.

For example, we notice an efficient contract enforcement in Israel or in South Korea, but poorer in Philippines, Brazil and Argentina (Khanna & Yafeh, 2007).

Country-specific institutional contexts may affect on the level of performance between affiliated firms. For this reason, the author (Khanna & Yafeh, 2007) argue that the performance of affiliated firms in diversified groups may result good, but it is necessary to analyze country-specific characteristics.

Furthermore, a recent study (Komera et al., 2014) on performance of 1185 firms in India, that failed for bankruptcy between 1992 and 2009, shows that firms belonging to business groups report less severe liquidity constraints than their standalone counterparts, due to the presence of "soft budget constraints".

The possibility to manage the internal capital market may help controlled firms to have a lower investment-cash flow sensitivity. In fact, Iacobucci (2012) shows that the cash-flow coefficient is positive and significant for standalones, but it is also positive for affiliated firms but not statistically significant. It confirms that for affiliated firms the cash-flow investment is less sensitive to the availability of internal capital market.

Lensik et al. (2003), using a data of Indian companies for the period 1989-1997, underline that the investment-cash flow sensitivity is higher for standalones than affiliated firms. This result confirms the idea that firms belonging to business groups can rely on the internal capital market. For example, Hoshi et al. (1991) and Kato et al. (2002), analyzing Japanese firms, find that affiliated firms show a lower-cash flow investment sensitivity than standalone firms. Also, Locorotondo et al. (2014) show that Belgian affiliated firms have less cash on their balance sheets than standalone counterparts, because they can access to the internal capital of the group. Furthermore, empirical evidences show that the sensitivity of investment-cash flow may depend on the group's size (Gorodnichenko et al., 2009).

On one hand, these authors, using a sample of German firms, find that affiliated firms of smaller groups have the investment-cash flow sensitivity reduced compared to standalone firms. On the other hand, there are no significantly differences in investment-cash flow sensitivity between affiliated firms of medium and large groups and standalone firms.

However, the literature also shows opposing results. For example, George et al. (2011) underlines that in India both affiliated firms and standalone firms may have a strong investment-cash flow sensitivity. Shin and Park (1999), considering Korean Chaebol and

non-Chaebol firms, show that there is no relation between cash flow and investment in firms belonging to business groups.
Therefore, different empirical evidences mainly depend on the sample characteristics and on the social, economic and environmental context.

1.4 An overview on the Italian context

The Italian industrial system has some specific peculiarities compared to the international industrial organization, characterized by the importance of small and medium-sized enterprises (SMEs) as confirmed by studies and research on our economic system. According to ISTAT only 1% of Italian companies have a number of employees over 250 in 2013 (ISTAT, 2015).
This framework is partially modified when considering the dense network of relationships that characterize the Italian SME system, which can overcome small-scale weaknesses.
The two most important forms of relationship are those connected with the common property ties (business groups) and those associated with input-output relationships (chains). These relations are further strengthened by territorial proximity and agglomeration economies developed in industrial districts. In fact, it is well known that a significant share of manufacturing SMEs operates within industrial districts, agglomerated of companies specialized in one of the different stages of the production process. This organization represents a characteristic phenomenon of our country as an alternative form of organization of production to the large integrated company.
There are several competitive advantages that district areas can provide to SMEs. They are, in fact, both the advantages of being able to cooperate with other companies in the same district and the spillovers of knowledge. In general, firms located in industrial districts show greater financial and innovative performance than non-district firms (De Blasio, et al., 2009; Foresti et al., 2009; Signorini, 2000).
Among the changes that industrial districts have characterized over the last few decades, there is the emergence of medium-sized and large-scale companies that have taken an increasingly important role in controlling district output and innovation processes. The

latter are normally organized in the form of a group, that is, sets of companies autonomous from a legal point of view, but with the same property. Empirical investigations have shown that business groups are more common in industrial districts, also because of acquisitions between businesses, facilitated by territorial proximity (Cainelli and Iacobucci, 2005).

Business groups are widespread in non-districts as well. This peculiar organizational form is present in all areas of businesses with increasing weight in relation to the size of the company. In fact, it may be assumed that the group represents the organizational form prevalent in the firm growth processes.

One of advantages to belong to a business group is represented by the diversification of the activities of the companies involved. This may reduce the risk of the portfolio and support those companies that perform negatively during a market shock, compensating with a better performance of other affiliates. In addition, as already mentioned, the group may favor technological development and innovative business processes (Belenzon and Berkovitz, 2010), thanks to the ability to transfer R&D and innovation results from a group company to all others. The ability to transfer and multiply results from one affiliate to another is one of the competitive advantages of belonging to a group.

One of the reasons justifying the advantages of belonging to a group is the possibility of benefiting from the internal capital market. At the same time, the group is also facilitated in accessing the external capital market in view of the multiplication of subjects who may require funding and the implicit guarantee of belonging to a diversified group.

The benefits of group can be significant in presence of real and financial shocks, such as those experienced by the Italian industrial system since autumn 2008. This is confirmed by ISTAT: between 2008 and 2014 the number of group firms increased, ranging from approximately 178,000 to approximately 218,000 in 2014; the number of groups increased from about 76,000 in 2008 to about 92,000 in 2014 (ISTAT, 2015).

In addition, literature on the Italian groups in pre-crisis period shows that business groups are more common within industrial districts than outside them and that business groups located in industrial districts are less diversified than groups located in non-districts (Cainelli et al., 2006).

In 2014, ISTAT has identified about 92 thousand business groups, of which 82% are "domestic groups", which only control firms localized in the country. These groups controlled around 218,000 firms and more than 2 million employees. Their weight on the total of joint stock companies was 23% in terms of firms and 57.3% in terms of employees. Although the number of firms and employees are higher for domestic groups, the average size of the firms is larger for multinational groups. Most of business groups in Italy are small and medium-sized, while large groups are the minority (Table 1).

Table 1- Italian business groups in 2014

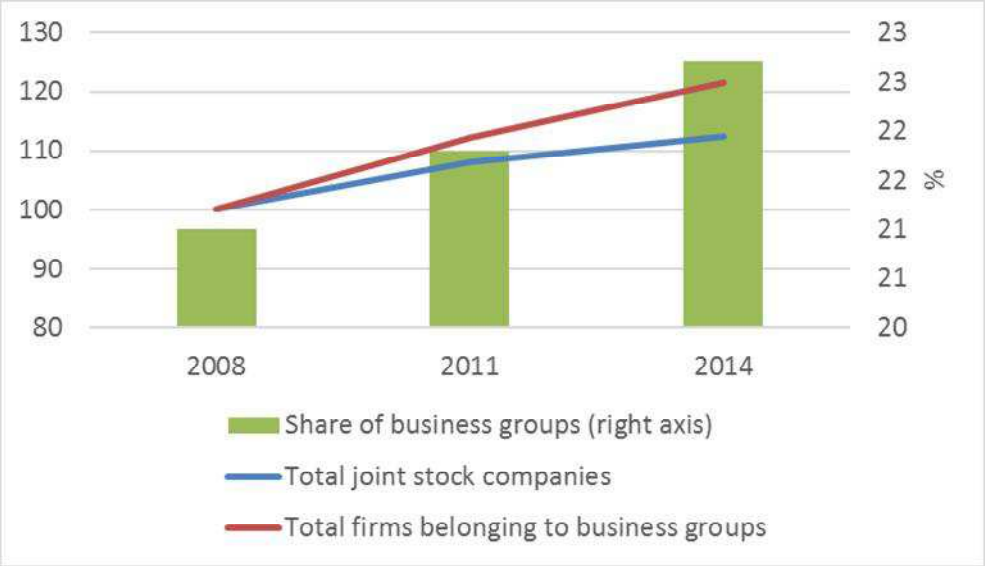
	N. of groups	*N. of firms*	*Employees*	*Firm average*
Domestic groups	*79,238*	*178,508*	*2,226,814*	*12.5*
Multinational groups with the vertex localized abroad	*9,454*	*16,097*	*1,265,032*	*78.6*
Multinational groups with the vertex localized in Italy	*6,891*	*24,333*	*2,124,380*	*87.3*
TOTAL	***95,583***	***218,938***	***5,616,226***	***25.7***

Source: Elaboration using data by ISTAT

Furthermore, during the same period (2008-2014) the number of the heads located in Italy has increased from about 67,000 in 2008 to about 86,000 in 2014 (ISTAT, 2015).

Figure 1 shows the increasing share of business groups during the period 2008-2014, with a significant increase in the number of firms belonging to groups. In the same period, there was an increase in the total number of joint stock companies, even if lower than those belonging to groups.

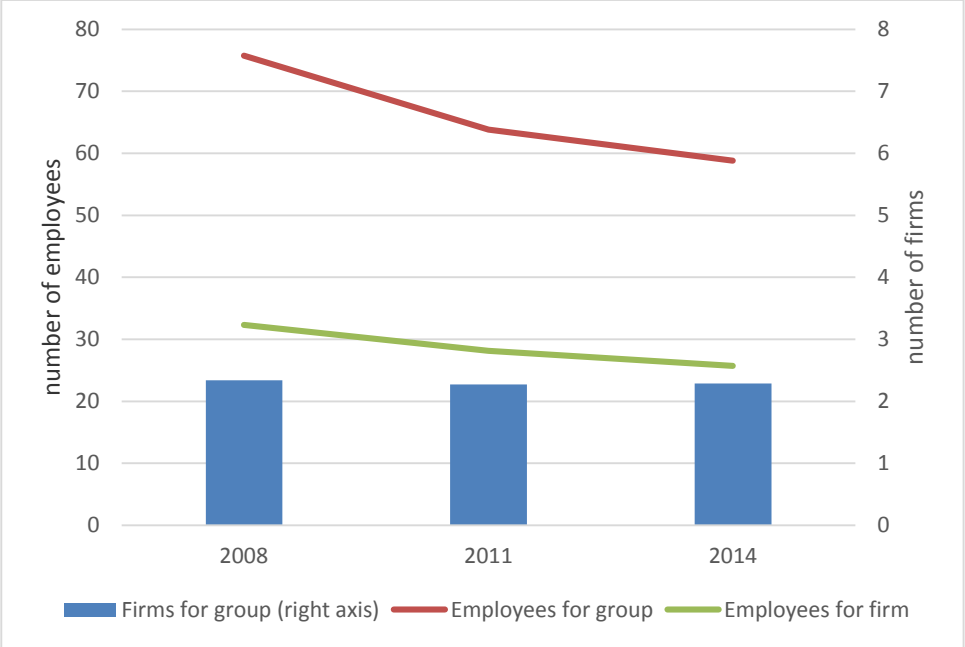
Figure 1 –Trend of joint stock companies (index 2008=100) and the share of business groups.



Source: Elaboration using data by ISTAT

Although the number of firms and the number of groups has increased considerably since 2008, the average size in terms of employees has decreased (from 76 in 2008 to 59 in 2014), as the result of the strong economic recession (Figure 2).

Figure 2 – Number in terms of employees and firms in business groups.



Source: Elaboration using data by ISTAT

In addition, Figure 2 also shows a decrease of the average in terms of employees for firm (from 32 in 2008 to 26 in 2014). There is also a decrease in the number of firms per group (from 2.34 in 2008 to 2.29 in 2014). This means that the increase in the number of firms and the number of groups showed between 2008 and 2014 did not affect the size of the existing groups but it is the consequence of the development of new small and medium-sized groups.

Moreover, ISTAT confirms the higher productivity of firms belonging to a group than "standalone" companies, regardless of their size (ISTAT, 2015). Belonging to a group may incentivize the networking between firms. This phenomenon is particularly evident in periods of crisis, where the group represents an implicit guarantee for the survival of its affiliated firms, especially for the lower performing ones. This mechanism is evident for "standalone" companies, which have more difficulties in facing financial and economic

crises. This is due to the lack of positive effects deriving from the internal capital market in business groups.

In situations of instable markets, the belonging to a group may be also a guarantee for external investors. This aspect will be discussed in the Chapter 4.

This latter part confirms the increasing relevance of the business group, which represent an efficient mechanism of resource allocation, allowing affiliated firms to invest easier in R&D activity and to foster the innovative performance.

Chapter 2. R&D organization in diversified firms: multidivisional firms and business groups[12]

2.1 Introduction

Despite the diffusion of open innovation models in large as well as in small firms, the ability to perform internal R&D remains a key issue for the growth and competitiveness of firms (Henry William Chesbrough, 2003).

The organization of R&D within the firm is likely to determine the efficiency of investment in R&D as well as firm's ability to translate the new knowledge into profitable innovations. This issue is specifically relevant for firms operating in different lines of businesses and that have adopted decentralized forms of organization, such as the multidivisional form (M-form) or the business group form.[13] Managers of diversified organizations must decide whether it is better to decentralize R&D, giving it the same degree of autonomy of other business functions (such as production, marketing and distribution), or to centralize R&D at the corporate or business group level.

Centralization may be chosen for several reasons: exploiting economies of scale in R&D, favoring the cross fertilization between knowledge creation in different areas, and facilitating the applications of the R&D results in all the businesses in which the firm operates. At the same time, centralization may reduce the ability of R&D employees to remain close to the specific needs of each business, thus deteriorating the alignment between R&D and customers' needs and reducing the time to market of innovations.

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[12] Thanks to my supervisor Prof. Donato Iacobucci and Prof. Enrico Guzzini for the collaboration.

[13] A business group is a set of legally independent companies owned by the same person(s) (Almeida & Wolfenzon, 2006). Individual companies in a business group may be assimilated to M-form's divisions. For more information on business groups see **Section 1**. Multidivisional firms are common in the USA while the business group is the prevailing form for managing diversified activities in European and Asian countries (Alfred D Chandler, 1982; Khanna & Yafeh, 2005).

Overall, R&D centralization seems to favor a 'technology push' (top-down) rather than a 'demand pull' (bottom-up) approach to innovation.

The latter problems could be avoided through R&D decentralization. However, decentralization of R&D at divisional (in an M-form) or individual company (in a business group) raises the likelihood that results potentially relevant for other divisions (or companies) will not be fully exploited.

Between these two extremes it is possible to observe a continuum of intermediate cases in which there are both; a corporate level R&D unit, devoted to more basic and long-term research, and decentralized units devoted to more business-specific R&D. This is specifically observed in multinational firms (Håkanson & Zander, 1988). However, these 'hybrid' organizational structures of R&D do not completely solve the problems previously mentioned.

The aim of this paper is to present an up-to-date survey about the way R&D is organized in diversified firms.

This survey is important for several reasons. The subject has been addressed in both management and economic literature and there are several issues in which the results are controversial; for example, the relation between the degree of diversification and the centralization of R&D. It is worthwhile analyzing whether these differences depend on the different theoretical approaches used by the authors or on the different empirical contexts considered in the papers. At the same time, this review is aimed at identifying those issues on which the literature shows a general agreement, though starting from different theoretical backgrounds. The number of papers on this topic has grown substantially during the last few years, especially when considering R&D in business groups. This is a signal of the increasing interests in the topic. However, to the best of my knowledge, I do not know of a comprehensive review that provides a synthesis of the main results and points out to the questions that are still open for further research.

This analysis is carried out by selecting all the relevant papers. From the analysis of these papers, I isolated the following issues, which are considered pertinent when explaining the choice between centralization and decentralization or R&D: 1) the nature of R&D (basic versus applied); 2) the interplay between the external acquisition of knowledge and the internal organization of R&D; 3) the role played by the degree of diversification.

One of the emerging issues is the organization of R&D in business groups. Differently than multidivisional firms, in a business group there is the possibility to differentiate the ownership structure of individual companies. This may affect the incentives of affiliated firms to invest in R&D and to share their results with the other companies in the same group.

The paper is organized as follows. The section 2 presents the methodology adopted to select the papers and the sources used to retrieve them. The section 3 discusses the main issues emerging from the literature. Section 4 discusses the specificities of R&D management in business groups. Section 5 provides a framework to classify papers according to their theoretical approach and empirical results. Section 6 draws the main conclusions and identifies the research questions that are still open.

2.2 Methodology

To carry out a comprehensive search of the literature I took advantage of the Elsevier's database Scopus. It is a bibliographic database containing abstracts and citations for academic journal articles. Scopus covers about twenty thousand peer-reviewed journals in the scientific, technical, medical, and social sciences. I adopted the approach normally used for systematic reviews (Dahlander & Gann, 2010). In particular, I searched the Scopus database for articles containing specific terms and keywords (see below) in the title, the keywords or the abstract. This broad search produced more than 500 papers. It has also allowed me to consider all the relevant papers but, looking at titles and abstracts, I realized that this search has also selected papers that had little to do with our topic. For this reason, I then restricted the paper selection by searching only on titles and keywords and on the Scopus subject areas of 'Business, management and accounting' and 'Economics, econometrics and finance'. This allowed me to narrow the results without excluding relevant papers. In this way I identified about 80 papers.[14]

In the search I used different keywords that emerged from a preliminary analysis of the topic. The list of terms and keywords and the corresponding results are provided in Table 2.

[14] I performed the same search strategy on ISI web of Science. I found that Scopus contained more papers than ISI and that those extracted from ISI were a subset of Scopus.

Table 2 - Results from the Database "Scopus"

Keyword used	**No. of papers**	**No. of papers published since 2000**	***% of papers published since 2000***	**No. of papers published since 2005**	***% of papers published since 2005***
"R&D" AND ("centralization" OR "autonomy" OR "decentralization")	39	25	*64.1*	19	*48,7*
"R&D" AND "diversification"	36	31	*86.1*	29	*80.5*
"R&D" AND "division*"	43	22	*51.1*	20	*46.5*
"R&D" AND "business groups"	8	8	*100.0*	8	*100.0*

Source: Scopus

It must be noted that the intersections between the searches are not necessarily empty; thus, the number of total papers is lower than the sum of the query's results.

The topics analyzed in this survey have received increasing attention in recent years. This is confirmed by considering the high number of papers published after 2005 and it is especially true for the literature about the organization of R&D in business groups.

When examining the full papers I did not take into consideration some of them that were not relevant for our purposes or that did not introduce novelties compared to previous papers. In this phase I also included a few papers that did not emerge from the 'key words' search but were cited in the selected paper; although the latter were not specifically dealing with our topic, they discussed issues that I consider important for the analysis. The list of the relevant papers and the issues they address is provided in Table 3.

Table 3 – Selected articles by topics

Topics	Papers
Basic vs applied R&D and organization of R&D	Teece (1982), Kay (1988), Argyres and Silverman (2004), Jansen et al. (2006),Leiponen and Helfat (2011)
External acquisition of knowledge and organization of R&D	Argyres and Silverman (2004), Jansen et al. (2006), Leiponen and Helfat (2011), Garcia Granero et al. (2014), Arora et al. (2014)
Degree of diversification and organization of R&D	Hill et al. (2000), Cassiman and Gambardella (2009), Lichtenthaler (2010), Leiponen and Helfat (2011), Guzzini and Iacobucci (2014a)
R&D organization in business groups	Filatotchev et al. (2003), Piga and Vivarelli (2004), Blanchard et al. (2005), Cefis et al. (2009), Belenzon and Berkovitz (2010) Guzzini and Iacobucci (2014b), Gavious et al. (2015)

Source: elaboration from Scopus

2.3 Centralization and decentralization of R&D

According to the early literature on the subject, the most efficient organizational form to manage a portfolio of diversified businesses is the divisional form, i.e. the M-form (A D Chandler, 1962; Williamson, 1975). The benefits of the M-form are associated with its ability to reduce internal transaction costs, such as costs of coordination among different business units and the costs of exchanging information, as well as being closer to customers' needs.

In European and Asian countries, the M-form is more often mirrored by the business group, which is composed by a set of legally independent businesses owned and controlled by the same people (Alfred D. Chandler, 1982; Khanna & Palepu, 2000). M-form and business groups are decentralized organizational forms in which divisions (in the M-form) or affiliated companies (in the business group) are responsible for the operative functions of their businesses. However, some functions may remain centralized at the corporate (business group) level whenever this guarantees better efficiency or superior results. One of the functions that are more likely to be centralized is R&D.

When considering the organization of R&D in diversified organizations we may observe three possibilities: a) centralization; b) decentralization; c) hybrid organization (i.e. the contemporaneous presence of a centralized R&D unit and decentralized units at the divisional (or affiliated firm) level (Argyres & Silverman, 2004).

Centralization refers to the case in which R&D is carried out in a single organizational unit. In this case, the R&D unit is generally located at the corporate level (i.e. the R&D executives report directly to the executive committee) and R&D concerns all the divisions/units and their productions. Decentralization refers to the case in which R&D is carried out at the business unit level (division or individual company). In this case, there are several R&D units located at the division level. The hybrid organization of R&D presents both a central R&D unit and divisional ones. From a historical perspective, the 'hybrid form' is an evolution of the 'M-form': it is a sort of 'reaction' to the limitations that were present in a pure 'decentralized form' (Hounshell & Smith, 1988).

Each type of organization of R&D has both advantages and disadvantages that should be carefully assessed. The empirical and theoretical literature on this subject has identified three main issues to explain the choice between centralization and decentralization: the prevailing nature of R&D, i.e. basic versus applied R&D; the need for external acquisition of knowledge; the degree of diversification.

2.3.1 Basic versus applied R&D

Williamson (1975, 1985) emphasizes the benefits of the decentralized 'M-form' over the centralized 'U-form' when internal transaction costs (such as the costs of exchanging information) are absent or not relevant. However, when internal transaction costs are relevant, and this is usually the case of R&D activities, the centralization of R&D is preferable. This is true especially in the case of basic R&D, that can be potentially applied to a plurality of products/technologies (Kay, 1988). Indeed, a centralized structure may facilitate the sharing of knowledge among the various business units (Teece, 1982). On the contrary, the decentralization of R&D is preferable for applied R&D because of its closer relationship with market needs and because of its short-term orientation (Kay, 1988).

More recently, the link between the organization of R&D and the corresponding types of innovation was empirically explored by Argyres and Silverman (2004). Consistent with the implications of the above mentioned literature (Kay, 1988), they find that "firms in which R&D activities are centralized tend to pursue R&D that has greater impact on future technological development, and spans a broader set of technological domains, than do firms in which R&D activities are decentralized" (Argyres & Silverman, 2004, p. 954). They also find that firms that centralize R&D obtain more innovations compared to firms with decentralized R&D. The same argument is put forward by Leiponen and Helfat (2011) who find that decentralization is positively associated with imitative innovation (i.e. market-specific innovation), and is not beneficial for new-to-market innovations.

A different view on centralization is put forward by Jansen et al. (2006). In this paper they focus on the interplay between explorative and exploitative innovation, which, in theory, should be associated to basic and applied research, respectively. They put forward the hypothesis that centralization has the effect of limiting the amount and quality of new ideas (exploratory innovation) and promoting exploitative innovations. Centralization also has the effect of reducing the 'incentive' for 'unit members' to find innovative solutions. Jansen et al. (2006) stress that explorative innovation requires non-routine procedures and non-conventional knowledge. Centralization is likely to result in a 'burocratization' of R&D and, as a result, in the reduction of explorative knowledge. Moreover, they emphasize the importance of individuals' incentives in developing new knowledge, and warn about the shortcomings of centralization and formalization on individual incentive and on stifling the emergence of new valuable knowledge.

2.3.2 External acquisition of knowledge

The literature on external acquisition of R&D (or R&D outsourcing) is abundant and its review is beyond the scope of this paper.[15] Within this literature, many authors have highlighted the interplay between external R&D and internal R&D. In general, authors agree on the positive relationships between internal and external R&D, based on the importance of developing absorptive capacity within the firm (e.g. Veugelers, 1997; Cohen & Levinthal 1989, 1990). This has led some authors to explore the complementarities between internal production and external acquisition of knowledge (Cassiman & Veugelers, 2006) and to analyze the conditions under which internal and external R&D are complements or substitutes (Hagedoorn and Wang 2012).

Despite the large number of papers addressing the relation between internal and external R&D, the literature addressing the interplay between the external acquisition of knowledge and the internal organization of R&D (centralized vs. decentralized R&D) is rather scant.

Argyres and Silverman (2004) put forward the hypothesis that firms with centralized R&D are more likely to rely on external sources of knowledge (i.e. innovations developed by other organizations) compared with firms with decentralized R&D. This hypothesis arises from the considerations that innovation projects carried out in centralized organization are more generic, are more likely to have a 'broader impact' on future technologies and productions; for this reason, they need to rely on a plurality of knowledge sources, some of which are found externally. Using a sample of 71 large diversified corporations they find empirical support for this hypothesis.

Using a large data set of US companies Arora et al. (2014) find empirical evidence supporting the opposite conclusion: i.e. that the external acquisition of knowledge is positively associated with the decentralization of R&D. Specifically, they find that firms that develop their knowledge internally and invest in basic and long-term projects, are more likely to centralize R&D: in this case, external knowledge is only used as a complement of internal R&D. On the contrary, firms that invest in applied R&D and innovate around

[15] For recent surveys see Stanko and Calantone (2011) and Hsuan and Mahnke (2011).

existing products are more likely to decentralize R&D activities in business units: in this case the firm is more likely to rely on external sources of knowledge (Arora et al., 2014).

These opposite findings may also be the result of the different metrics used by the authors in their analysis. While Argyres and Silverman (2004) measure the external search of knowledge using 'patent citations' (i.e. how many times the firm cites external patents), Arora et al. (2014) also consider other forms of external knowledge acquisition such as mergers and acquisitions. Capitalizing on the literature on 'dynamics of resource recombination' (Helfat & Eisenhardt, 2004; Karim, 2006), Arora et al. (2014) argue that centralized structures are less like to rapidly integrate and assimilate larger acquisitions, while a decentralized organization (a modular organization) has less constraints on the integration/assimilation side.

Furthermore, in line with the results of Karim and Mitchell's (2004), Arora et al. (2014) find that the external acquisition of knowledge provides more value in decentralized organizations: "Whereas centralized firms have more value from internal R&D, decentralized firms have major benefits from externally acquired patents" (Arora et al., 2014, p. 335).

Garcia-Granero et al. (2014) analyze the tension between internal/external R&D and formalization/decentralization (see also above, Jensen et al, 2006). Using a sample of Spanish ceramic firms, they find that formalization has a detrimental effect on the use of external knowledge. The reason is that formalization usually generates rigid organizations, which prevent the integration and assimilation of external knowledge. Moreover, they find that formalization has a negative effect on explorative innovation, since it negatively impacts individuals' autonomy and motivation and therefore hampers their willingness to look for novel solutions.

Leiponen and Helfat (2011) contrast two different streams of literature, the resource-based view (e.g. Grant, 1996; Kogut & Zander, 1993) and cost theory (e.g. Argyres & Silverman, 2004), which have different implications on the relation between decentralization and the innovation output. The resource-based view emphasizes the benefits of decentralization, as it should facilitate the acquisition of external knowledge; cost theory, on the contrary, emphasizes the benefits of R&D centralization to achieve scale and scope economies. Using economic data on Finnish manufacturing firms, Leiponen and Helfat (2011) find

evidence that decentralization is more likely to enhance market-specific innovations ('imitative innovation'). They also find that the positive association between decentralization and 'imitative innovation' is enhanced by knowledge outsourcing. In other words, the decentralization of R&D allows companies – pursuing imitative innovation – to access a wider set of external resources/knowledge and to benefit from knowledge spillovers. On the contrary, the decentralization of R&D is not beneficial for new-to-market innovations.

2.3.3 The degree of diversification

Despite the abundant literature on the causes and consequences of firm diversification, only a few papers address the relation between the degree of diversification and the organization of R&D.

Argyres and Silverman (2004) put forward the hypothesis that when R&D is centralized it is more likely to have a positive impact on the emergence of new products compared with a decentralized R&D. If the 'plurality' of innovations stemming from the centralization of R&D is interpreted as a proxy for the firm's degree of diversification, the implication of this hypothesis is that we should observe a positive relation between R&D centralization and firm diversification.

Cassiman and Gambardella (2009) explicitly make a link between the R&D organization and the range of a firm's products (diversification). They argue that the organization of R&D depends on the market in which the firm operates and consider two opposite cases: i) the firm faces a large and homogenous product market with the possibility of exploiting economies of scale in the innovation process; ii) the firm faces a series of fragmented product markets with the possibility of exploiting economies of scope in technology development. Cassiman and Gambardella (2009) argue that firms facing homogeneous markets have less incentives to carry out general (i.e. basic) R&D as generic R&D is likely to affect several production lines. Scale economies are more relevant than scope economies. Therefore, the firm is more likely to invest in dedicated and market-specific R&D.

In case of firms operating in fragmented markets, Cassiman and Gambardella (2009) suggest that R&D should be more generic and less market-specific in order to achieve

scope economies. Indeed, in this case, the fragmentation of the market does not justify the presence of a plurality of unit labs. Moreover, since R&D is not 'controlled' by individual business units and since the corporate level may find it difficult to manage the externalities that may arise, the proposed solution is to give independence to the centralized R&D unit.

On a different perspective, Hill et al. (2000) find that diversified companies are less likely to opt for a centralized organization of R&D, but they also acknowledge that the reverse relation, i.e. less diversification promotes more centralization, is less clear-cut. The authors argue that the choice between centralization and decentralization depends on the degree of technological sharing among business units. Companies can make different choices also in the case of similar situations, because other important variables such as the degree of product/process innovation, customers' needs, brands and the concentration of bargaining power of their own company may play an important role. However, in the two sectors they analyze (i.e. Food and Drink and Mechanical engineering), they find that decentralization of R&D is associated with greater diversification.

Leiponen and Helfat (2011) put forward two mutually exclusive hypotheses. According to the first one, which is based on the resource-based view, since decentralization of R&D should assure an easier access to a plurality of technologies, then the resulting innovation could affect a wider variety of productions. On the other hand, according to organizational economics, the decentralization of R&D should result in more market-specific R&D and therefore the resulting innovations should have a more limited range of products. By using economic data on Finnish firms, Leiponen and Helfat (2011) find evidence which support the hypothesis that the decentralization of R&D should be associated with a wider product range.

The relation between R&D organization and diversification is also analyzed by Lichtenthalter (2010) although in a specific context: how differentiated firms decide to organize the external technology exploitation, such as, for example, technology licensing. Following Arora et al. (2001) and Chesbrough (2007), Lichtenthalter (2010)argues that the best practice is the hybrid form between centralization and decentralization. A certain degree of centralization is beneficial since business unit managers may not be willing to share 'their' technology, even if this is beneficial at the corporate level. At the same time, however, the importance of developing knowledge at the business unit level suggests some

degree of decentralization in technology transfer transactions. For these reasons, Lichtenthalter (2010) concludes that corporate centralization is beneficial up to a certain point, i.e. that corporate centralization has an inverted U-shaped relation with the intensity of external technology exploitation[16]. By using data on German, Swiss and Austrian firms, the empirical evidence supports this hypothesis about the benefits of a hybrid form of R&D organization. Furthermore, Lichtenthalter (2010) emphasizes the need of a proper alignment between corporate and business unit levels in managing the exploitation of external technology.

Referring to business groups rather than multidivisional firms, Guzzini and Iacobucci (2014a) put forward the hypothesis that in less diversified business groups it is more likely to observe the centralization of R&D; this is mainly because of the possibility to exploit scale economies. On the contrary, in more diversified groups it is more likely to observe a greater autonomy of affiliated companies in the management of R&D. Indeed, when technologies are different, the benefits of economies of scale are less relevant compared with the benefits of a more focused R&D effort. Furthermore, diversification requires a greater effort to manage and monitor different products that could go beyond managerial capabilities (Baysinger & Hoskinsson, 1989; Hitt et al., 1990). The empirical analysis carried out on Italian manufacturing groups provides support to the hypothesis of a positive association between the degree of diversification and the degree of autonomy in R&D.

Business groups show some similarities with other forms of decentralized organizations (notably the M-form). However, they also have some peculiarities, most of all the legal autonomy of the business units and the resulting complexity of ownership ties between the affiliated firms. These peculiarities cause the emergence of specific issues in addition to those examined in the previous sections. These specific issues will be discussed in the following section.

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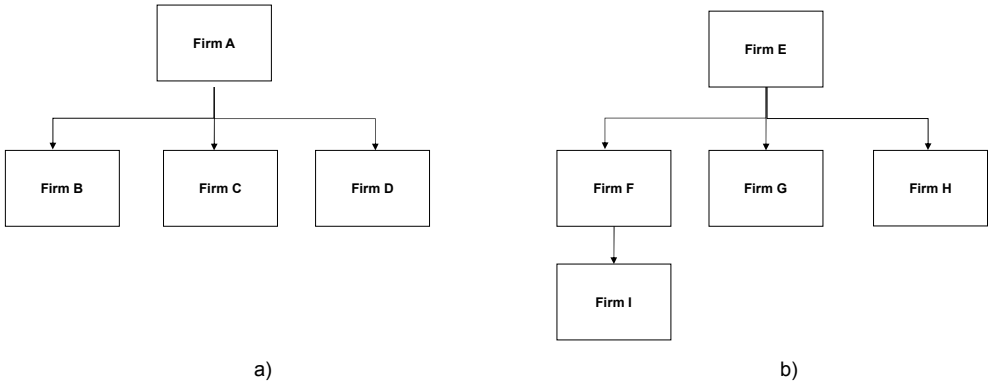
16 As previously observed when discussing the role of the external acquisition of knowledge, the latter issue is closely connected to the issue of diversification.

2.4 The organization of R&D in business groups

A business group is defined as a set of legally independent firms controlled by the same person(s) through ownership ties. The summit of the group can be an individual or a group of people, often belonging to the same family (Almeida & Wolfenzon, 2006). The importance of ownership ties in business groups allows us to better analyze the issues concerning the appropriability of R&D results, which is an important topic when considering R&D investment carried out in business groups.

We can distinguish between horizontal groups and vertical groups or pyramids (see Figure 3).

Figure 3 – Example of business groups



Horizontal business groups (Figure 3 a) mimic the multidivisional structure, in which controlled companies are likely to 'play' the same role of the divisions in an M-form. However, there are two main differences between a multidivisional firm and a horizontal group. Firstly, controlled companies in a group are separate legal entities. Secondly, the head may hold the control of the other group's companies with ownership shares lower than 100%, which implies the presence of minority shareholders in controlled companies. For

both these reasons, controlled companies in a business group usually enjoy a higher degree of autonomy than divisions in an M-Form.

While in horizontal business groups there are only two layers (head and controlled companies), in vertical business groups (pyramids) there could be several layers of controlled companies (Figure 3 b). This introduces the distinction between the head of the group, the companies at the bottom of the group (i.e. controlled but not controlling other companies, e.g. firm I, G and H in Figure 3 b) and intermediate firms (i.e. companies which control other firms and which are controlled by another company, e.g. firm F in Figure 3 b).

One of the first papers addressing the relationship between firms' R&D and the position of affiliated firms in business groups is Filatotchev et al. (2003). By using Italian data, they show that R&D intensity is positively related to the position of the firm within the group: the higher the position, the greater the R&D investment (see also Piga and Vivarelli, 2004). The reason for this result is the same already discussed when referring to multidivisional companies: centralization of R&D facilitates the exploitation of its results in the different companies composing the group (divisions in the case of the M-form).

In general, papers addressing the issue of R&D in business groups share the hypothesis that R&D intensity (however measured) is higher for companies belonging to groups than for stand-alone firms with the same characteristics. This is also because firms belonging to groups have a greater possibility of internalizing knowledge spillovers, and this advantage is higher for companies at the head of the group (Blanchard et al., 2005, Cefis et al., 2009, Belenzon and Berkovitz, 2010). However, the presence of complex ownership structures and of different layers of companies may reduce the incentives to share R&D results; in fact the head (and the other affiliated companies) might not be able to appropriate the benefits of innovation. The appropriation depends on the share owned by the head in the controlled company. This means that when analyzing R&D in business groups it is necessary to take into account the internal structure of the group, in terms of company position and the ownership shares of the head in the affiliated companies.

Following these insights, Guzzini and Iacobucci (2014b) develop a model to explain the R&D intensity in business groups from which they derive two results: a) the R&D

propensity of head and intermediate companies[17] are higher than companies at the bottom of the group b) the level of R&D intensity of controlling companies depends positively on the their ownership shares and on the size on their controlled companies (i.e. the size of controlled activities). In other words, the greater are the controlled activities, the higher is the possibility to internalize knowledge spillovers. The empirical analysis conducted on a sample of Italian business groups support these conclusions. They are in accordance with previous findings by Filatotchev et al. (2003) and extend them.

Contrary to these results, a recent paper by Gavious et al. (2015) finds that companies at the bottom of the group exhibit higher R&D than companies in a higher position within the pyramid. The reason for this discrepancy may be the fact that their analysis refers to biotech firms. As argued by the authors "the pyramidal structure serves to transfer the immense investment risk inherent in them away from the ultimate owners further down the pyramid where they have a smaller stake in profits and losses. In this sense, investment in innovation in high-risk firms further down the pyramid acts as a particular type of 'down-stream' tunneling" (Gavious et al., 2015, p. 7). The paper by Gavious et al. (2015) introduces a further issue in explaining the centralization or decentralization of R&D, i.e. the share of the risk associated to R&D investment. This issue is not relevant in multidivisional firms where the ownership structure is homogeneous across the different business units. In business groups it can be an important issue given the possibility to differentiate the ownership structure of individual companies.[18]

2.5 Theoretical approaches

The papers examined follow a large array of theoretical approaches (see Figure 4).

[17] An intermediate company is a firm that is owned by another firm (e.g. a 'head') and that owns one or more firms. For example, firm B in Figure 3 is an intermediate firm, while firms C, D and E are firms at the 'bottom' of the group.

[18] Indeed, the possibility of differentiating the ownership structure of specific business units is one of the main reasons for the choice of the group form when managing a portfolio of diversified companies (Almeida & Wolfenzon, 2006; Cainelli & Iacobucci, 2011).

Figure 4 – Issues and theoretical approaches

	Resource-based view[1]	Organizational learning[2]	Economies of scale/scope	Transaction costs	Economics of organization[3]
Basic vs applied R&D and organization of R&D	Teece (1982), Leiponen and Helfat (2011)	Jansen (2006)	Kay (1988), Argyres and Silverman (2004), Leiponen and Helfat (2011)	Argyres and Silverman (2004), Leiponen and Helfat (2011)	
External acquisition of knowledge and organization of R&D	Leiponen and Helfat (2011), Arora et al. (2014)	Jansen et al. (2006), Garcia Granero et al. (2014) Arora et al. (2014)	Argyres and Silverman (2004), Leiponen and Helfat (2011)	Argyres and Silverman (2004), (Leiponen & Helfat, 2011), (Arora et al., 2014)	
Degree of diversification and organization of R&D	(Cassiman & Gambardella, 2009), (Lichtenthaler, 2010), Leiponen and Helfat (2011)	(Hill et al., 2000)	(Cassiman & Gambardella, 2009), Leiponen and Helfat (2011), (Guzzini & Iacobucci, 2014a)	(Cassiman & Gambardella, 2009), Leiponen and Helfat (2011)	(Cassiman & Gambardella, 2009), Guzzini and Iacobucci (2014a)
R&D organization in business groups		Filatotchev et al. (2003)	Guzzini and Iacobucci (2014a)	Belenzon and Berkovitz (2010)	Guzzini and Iacobucci (2014b), Gavious et al. (2015), Blanchard et al. (2005), Cefis et al. (2009), Belenzon and Berkovitz (2010), Piga and Vivarelli (2004)

Source: elaboration from Scopus

[1] Within resource-based view I include the concept of dynamic capabilities.

[2] Within organizational learning, I include the concept of absorptive capacity.

[3] Within this approach I include works based on agency theory, property rights theory and game theory

I classified them in five broad areas: resource-based view, in which the concept of dynamic capabilities is also included; organizational learning, in which the concept of absorptive capacity is also considered; cost theory (i.e. economies of scale and scope); transaction costs theory; economics of organization. Within this latter approach, I include agency theory, property rights theory and game theory.

The associations of issues and theoretical approaches (Figure 4) show the presence of some relations between them. However, all the issues that have emerged from this review were addressed using different theoretical approaches. One of the reasons for this is that most of the papers are empirical papers and tend to be eclectic in their theoretical approaches. Their starting point is a specific empirical issue which is tackled using different theories, either to contrast them against the empirical results or because they concur in explaining the available empirical evidence. Of all the papers examined, only three papers are purely theoretical (Kay, 1988; Teece 1982; Cassiman & Gambardella, 2009).

In some papers there is an attempt to combine different approaches when deriving the hypotheses to be tested (Arora et al., 2014; Cassiman & Gambardella, 2009); in other cases the authors contrast different approaches to assess their abilities to explain empirical evidence (Leiponen & Helfat, 2011); only a few authors follow a specific theory (Argyres & Silverman, 2004; Kay, 1988).

It is worthwhile to note that none of the papers addressing the first two issues (i.e. basic vs applied R&D and external acquisition of knowledge) refers to agency theory or property rights theory (see Figure 4). This is a limitation since the issue of individual incentives (that are emphasized in agency and property rights theories) is relevant when dealing with R&D activities in diversified firms. For example, Jansen et al. (2006) find that centralization is likely to bring about a 'bureaucratization' which is likely to reduce individual incentives and discourage explorative R&D. This result is in contrast with the majority of works, according to which centralization is more likely to be associated with basic R&D and explorative research. Other interesting suggestions and (possibly) results could arise on this issue when more explicitly considering the role of individual incentives within organizations.

Papers addressing the issue of R&D organization in business groups tend to use theories belonging to the economics of organization and neglect other approaches. This may be due to the specific features of business groups, most of all the importance of considering the ownership ties between companies belonging to the same group.

2.6 Conclusions and open questions

Only recently the literature has started investigating the factors explaining the choice between centralization and decentralization of R&D in diversified firms and analyzing the advantages and disadvantages associated with this choice. Although the literature on this topic is not abundant, it has been growing in recent years, thus confirming its relevance. This is especially true for the literature about the organization of R&D in business groups.

The analysis of the literature shows that there are a few consolidated results but also several controversial issues and research gaps. One of the most debated issues is the relation between the degree of diversification and the organization of R&D (i.e. centralization versus decentralization). While the majority of papers find that there is a positive relation between the degree of diversification and the likelihood of observing the decentralization of R&D, there are also papers arguing for the opposite results.

Also for the relation between external acquisition of knowledge and the degree of centralization of R&D there are contrasting results. Most papers favor the idea of a positive association between centralization of R&D and the degree of reliance on external acquisition of knowledge. However, there are also authors who find the opposite results.

When considering the relation between basic and applied R&D, authors generally agree with the idea that firms relying on internal R&D are more likely to make investments in basic and long-term research; these firms typically centralize R&D to exploit economies of scale and scope (Kay, 1988). On a different perspective, Jansen et al. (2006), though not explicitly with the hypothesis that basic R&D is more likely to be centralized, show that centralization is likely to bring about a 'bureaucratization' and, therefore, discourage explorative (i.e. basic) R&D.

The literature on the organization of R&D in business groups has emerged only recently. All the papers addressing this issue share the idea that companies belonging to a group have a higher propensity of investing in R&D compared with standalone firms with the same characteristics. However, there are conflicting views about the better way of organizing the R&D activities within the group, i.e. when and how it would be preferable to concentrate R&D in the head of the group rather than spreading the investment through the affiliated companies.

The most important difference between business groups and other decentralized forms is the possibility of differentiating the ownership structure of the business units (companies in the case of a group). The ownership structure of affiliated companies may have consequences on the incentives to invest in R&D and, most of all, to share its results with the other companies in the group. These arguments emphasize the importance of individual incentives in developing and sharing new knowledge. These incentives are specifically relevant for the managers and owners of affiliated firms, since they will not necessarily share all the costs and benefits of R&D. The provision of proper incentives is a valuable instrument to align the interest of controlled and controlling firms in a group. Up to now, these issues have not been fully investigated.

This is also true when considering how the organization of R&D may influence the individual incentives of managers and researchers directly involved in R&D (Aghion & Tirole, 1994; Jansen et al., 2006; Cassiman & Gambardella, 2009).

The large majority of the papers considered in this review are empirical papers and are generally eclectic in the choice of the theoretical approach. They refer to samples of firms that show great differences in their characteristics and in the institutional context in which the firms operate. This means that it is not always easy to understand to what extent the presence of contrasting results may be attributable to differences in the sample and context rather than to the underlying explanatory theory.

To further our knowledge about the issues addressed in this review, it is necessary to adopt a more theory-driven approach. More insight may be gained by considering a specific theoretical approach and deriving its consequences on the degree of centralization or decentralization of R&D. This may provide a better understanding of the role played by the many factors influencing the organization of R&D in decentralized organization, and how this influence may change according to the context in which firms operate.

Chapter 3. Diversification, R&D organization and innovative performance

3.1 Introduction

The efficiency of investments in R&D activity in firms is likely to be determined by the organization of R&D. This topic is particularly significant when considering companies involved in several lines of businesses and that are characterized by decentralized organizations, such as the multidivisional form (M-form) or the business group form[19]. In diversified firms, managers decide whether to opt for the decentralization of R&D or for the centralization of R&D at the corporate or business group level.

The capacity to perform better R&D activity is a strategic point for the development of firms (Henry William Chesbrough, 2003). For this reason, the choice between centralization and decentralization of R&D should evaluate the degree of diversification within the firms or the business group. Although there is an extensive literature about the causes and effects of firm diversification (Arikan & Stulz, 2013; Lang & Stulz, 1994; Biggadike, 1979; Tatsuo, 2015), only few papers consider the relation between the degree of diversification and the organization of R&D.

The attention on the relationship between innovation and diversification has increased during the last decades, since it may represent a valuable strategy to sustain firm performance and achieve competitive advantages (Muthuki G. K., 2013). Regarding the concept of industrial diversification, there are two main views: "agency view" and "resource-based view". The former sustains that diversification derives from conflicts between managers and shareholders, and consequently it would show a negative impact on firm value. On the contrary, the latter argues that diversification is a way to increase productive factors and resources, and consequently it would enhance firm value (Rong Z. & Xiao S., 2016). Following the "resource-based view" and considering the innovation as a new determinant of diversification's effect on

[19] A business group is a set of legally independent companies owned by the same vertex (Almeida & Wolfenzon, 2006). Individual companies in a business group may be associated to M-form's divisions. While the business group represents the dominant form for managing diversified activities in European and Asian countries (Alfred D Chandler, 1982; Khanna & Yafeh, 2005), multidivisional firms are widespread in the USA.

firm value, the authors show that firm innovation has significant and positive effects on diversification (Rong Z. & Xiao S., 2016).

Given the growing interest on the connection between diversification and innovation, the choice on the degree of diversification becomes a relevant decision for firms. Previous literature on this issue is debated. Most of papers find that a positive relation exists between the degree of diversification and the likelihood of observing the decentralization of R&D, even if there are also papers supporting the opposite results. It is worthwhile investigating whether different findings depends on the different theoretical methodologies or on the different empirical contexts considered in the papers. The best organization of the R&D for firms, given their own degree of diversification is the one that allows them to find the perfect matches for "their organizational capabilities" (Matsusaka, 2001). Generally, the R&D organization shows characteristics that fit strongly to the firm in which it develops, and which may make the process of the R&D integration difficult for other firms (Helfat, 1994). From a theoretical point of view, there are conflicting views on the relation between firm diversification and the organization of R&D. According to some papers, we should observe a positive relation between the degree of diversification and the decentralization of R&D. However, this result is criticized by other approaches, which underline the benefits of a centralized R&D applied to the diversified units.

Thus, the aim of this work is to investigate the issue on the relation between the degree of diversification and the organization of R&D and to investigate the influence of the organization of R&D into the innovative performance. I also examine the allocation of patents between controlled firms of decentralized groups.

These issues are particularly relevant for firms belonging to business groups, where the decision whether to centralize or decentralize the R&D activity has an impact on all affiliated firms.

To analyze these points, the paper uses a novel dataset of Italian business groups developed using ownership information about joint stock companies taken from the AIDA database. This allowed me to build a map of Italian manufacturing[20] business groups in 2012. Moreover, from the AIDA database I obtained financial and economic data for companies belonging and non-belonging to groups for the year 2012. Data refers to 5,791 Italian joint stock companies belonging to groups in manufacturing sectors. I

[20] The sample considers business groups with at least two firms in the manufacturing sector, in order to test the research hypotheses.

also took advantage from the ORBIS database of European companies, in order to identify patenting firms. The number of business groups considered are 2,262 and the number of groups with patents is 685.
Furthermore, I use another database containing patenting information on the world top corporate R&D investors. The latter was built by using a database developed by a collaboration between "OECD Directorate for Science, Technology, Innovation" and the "EC-JRC Institute for Prospective Technological Studies". This database contains information on the patent and R&D activity at group level.
The latter is used for a comparison with the Italian business groups, to investigate whether the organization of R&D follows common rules or depends on the context in which business groups operate.
As results, in the empirical analysis I expect to find the following relations:

H1 – There is a positive relation between the degree of diversification and the decision of firms to decentralize R&D.

H2 – When the decentralization of R&D prevails, there is a negative relation between the degree of diversification and the concentration of patents in a single controlled firm.

H3 - There is a negative relation between the centralization of R&D and the innovative performance.

The latter hypothesis is tested by considering when all the R&D activity is done by a single firm, regardless if a head or a controlled firm.

The main results may be summarized in the following way:
a) the degree of diversification is positively related to the decentralization of R&D;
b) in decentralized groups, there is a negative relation between the degree of diversification and the concentration of patents in a single controlled firm;
c) regarding the innovative performance, the centralization of R&D activity may limit the patent production.

The paper is organized as follows. The second section reviews the existing literature about the role played by the degree of diversification on the organization of R&D.
The third section discusses the data and methodology used. The fourth section illustrates the main empirical results. Finally, the fifth section presents the conclusions.

3.2 Background

The early literature on the topic affirms that the most efficient organizational forms for diversified businesses is the divisional form, i.e. the M-form (Chandler, 1962; Williamson, 1975). There are several advantages of the M-form connected with the capability to minimize internal transaction costs, such as costs of coordination and costs of sharing information. Furthermore, the divisional form allows firm to be closer to customers' needs. Williamson (1975, 1985) points out the benefits of the decentralized 'M-form' compared to the centralized 'U-form' when internal transaction costs are not relevant. In general, when internal transaction costs are significant, such as R&D activities, the centralization of R&D is better. In Europe and Asia, the M-form is often represented by the business group, (Chandler, 1982; Khanna & Palepu, 2000). In business groups, affiliated companies become responsible for activities of their businesses. However, some functions and operations remain centralized at the corporate level in case this guarantees better results and efficiency. Generally, the R&D activity is likely to be centralized.
However, there are three possibilities to organize the R&D in diversified organizations we may observe three possibilities: a) centralization; b) decentralization; c) hybrid organization[21].
Existing literature deals with the causes and effects of firm diversification (Arikan & Stulz, 2013; Lang & Stulz, 1994; Biggadike, 1979; Tatsuo, 2015), but only few papers consider the relation between the degree of diversification and the organization of R&D. Indeed, the previous literature on the choice between centralization and decentralization of R&D and the degree of diversification has showed controversial results and open questions.
Some authors support the idea that diversified firms opt for the centralization of R&D.
Indeed, Argyres and Silvermann (2004) support the hypothesis that when R&D is decentralized it is more likely to have a negative impact on the development of new products compared with a centralized R&D.

[21] For details see Argyres and Silverman (2004).

As proxy for the firm's degree of diversification, they consider the 'plurality' of innovations and what they expect to find is a positive relation between R&D centralization and firm diversification.

Cassiman and Gambardella (2009) argue that R&D should be more generic and less market-market specific in fragmented markets. They create a link between the R&D organization and the diversification, using the range of firm's products. They affirms that the organization of R&D depends on the type of market in which the firm works. Considering two different types of market (homogenous product market *vs* fragmented product markets), the authors (2009) argue that firms operating in homogeneous product markets have less incentives to carry out general R&D. The firm is more likely to invest in dedicated and market-specific R&D. On the contrary, Cassiman and Gambardella (2009) suggest that R&D should be more generic and less market-specific in fragmented markets.

A different perspective is given by Hill et al. (2000), finding that diversified companies are more likely to opt for a decentralized organization of R&D.

The authors support the idea that the choice between centralization and decentralization depends on the level of technological sharing between different units. In similar situations, there are also other relevant variables influencing firms on the organization of R&D (centralization *vs* decentralization), such as the degree of product/process innovation, costumers' needs, brands etc.

According to this view, Leiponen and Helfat (2011), using economic data on Finnish firms, support the hypothesis that the decentralization of R&D should be associated with a wider product range.

They suggest that decentralization of R&D should guarantee an easier access to a variety of technologies and consequently the latter could foster a higher variety of productions.

Also, Lichtenthalter (2010) deals with the relation between R&D organization and diversification. According to Arora et al. (2001) and Chesbrough (2007), the author consider the hybrid structure the best organizational form between centralization and decentralization. On one hand, there is a certain degree of centralization favorable for business unit managers when they are not available to share 'their' technology. On the other hand, the importance of developing and sharing knowledge at the business unit level suggests a certain degree of decentralization. Using data on German, Swiss and Austrian firms, his findings support the hypothesis about advantages of the hybrid form for R&D organization.

Regarding the organization of R&D in business groups rather than multidivisional firms, Guzzini and Iacobucci (2014a) argue that in more diversified business groups it is more likely to observe a

decentralization of R&D. On the contrary, in less diversified groups it is more likely to observe a lower autonomy of affiliated companies in the R&D organization. Their findings, based on Italian manufacturing groups, support the hypothesis of a positive relation between the degree of diversification and the decentralization of R&D.

As mentioned above, business groups show some similar peculiarities with the M-form. However, they have some specific features associated with the legal autonomy of the affiliated firms and the complexity of ownership ties between the controlling and controlled firms.

3.3 Data and Methodology

3.3.1 *The dataset of Italian manufacturing sample*

Business groups represent the ideal setting to address the research questions of the paper. The business group is the common organizational form chosen by European firms to manage diversified activities. The legal autonomy accorded to the individual companies of a group allows me to better measure the degree of diversification and to relate it to R&D organization and innovative performance.

I use the ORBIS database of European companies and the AIDA database of Italian companies. These datasets allowed me to build a map of business groups, based on ownership links between companies. From the AIDA database, I obtained financial and economic data for Italian manufacturing companies belonging to groups for the year 2012.

The ORBIS database also provided information on the patenting activity of firms. I do not have data on the R&D investment of companies. For this reason, patents will be used as a proxy for the input of R&D activity and for measuring the performance of innovative activities.

To analyse how the organization of R&D (centralization versus decentralization) influences the innovative performance of firms in terms of number of patents, I relate the organization of R&D in terms of centralization or decentralization of R&D with the number of patents produced in each group. The dataset refers to 5,791 Italian manufacturing joint stock companies, belonging to groups. Specifically, these affiliated firms belong to business groups composed by other companies (Italian firms in other sectors and foreign companies) which are not included in our analysis. The main reason is that in Italy most of R&D investments are addressed to companies in manufacturing sectors.

The ORBIS Europe database, containing patenting information at firm level, allowed me to obtain the total number of patents for each group.

The main variables of the dataset are shown in Table 4.

Table 4 – List of variables

Variable	Description
Head	Dummy variable used to discriminate heads of groups (1) from other affiliated firms (2)
Max_quote	The highest value of patents in each group
Tot_Patents	Log of total patents for each group for the period 2007-2015
Mean_Patents	Log of mean patents for each group for the period 2007-2015
Group_Centralization	Dummy variable used to discriminate R&D centralized (1) and R&D decentralized (0) at group level. It is equal to 1 if the max value of patents in the same group is allocated in the head. Otherwise it is equal to 0
E2	Entropy index indicating the unrelated diversification *(2digit NACE classification) at group level* in 2012
E4	Entropy index indicating the overall diversification (4 *digit NACE classification) at group level* in 2012
EW2	E4-E2 indicating the related diversification at group level in 2012
Age	Mean of age group
Size_group	Log of revenues on total assets for group in 2012
Patents_Controlled	Dummy variable used to discriminate the allocation of patents between controlled firms when the variable "Group_Centralization" is equal to 0. It is equal to 1 if more than 75% of patents in controlled firms are allocated in only one. Otherwise it is equal to 0.

Table 5 shows the main descriptive statistics at group level.

Table 5 – Descriptive statistics at group level

Variable	Obs	Mean	Std. Dev	Min	Max
E4	2,262	0.3545	0.3355	0	2,729
E2	2,262	0.2092	0.2952	0	2.169
EW2	2,262	0.1452	0.2409	0	1.265
Size_group (absolute value)	2,262	0.9859	0.4681	0.015	5.22
Age (mean)	2,262	24.70	14.738	5	150
Max_quote	685	0.941	0.1358	0.33	1
Tot_Patents (absolute value)	685	20.3	52.25	1	551
Mean_Patents (absolute value)	685	7.82	21.57	0.14	273.5
Group_Centralization	685	0.27	0.4458	0	1
Patents_Controlled	498	0.85	0.3619	0	1

Source: elaboration from Aida and Orbis datasets

The number of business groups considered is 2,262, and the mean number of firms belonging to groups is about 2.5. The number of groups with patents is 685, about 30% of the total.
From Table 6, the number of affiliated firms in patenting groups is 2,088; of those 862 are patenting firms and the number of their patents is 13,919. Furthermore, in patenting groups about 41% of firms does patent activities.

Table 6 – Difference of frequency in patenting firms between heads and controlled firms

Head*	Patenting firms	Total firms	% patenting firms
1	198	969	20.4
2	664	4,822	13.7
Total Firms	862	5,791	14.9

*Controlling firms for Head=1

*All controlled firms from Head=2

Source: elaboration from Aida and Orbis datasets

From the descriptive statistics, the frequency of patenting heads is higher than patenting controlled firms (20% vs 14%), but the number of patents produced shows the greater presence of patents in controlled firms compared to heads. In fact, the number of patents for controlling firms is 2,813 while the number of patents for controlled firms is 11,106 (see Table 7).

Table 7 – Number of patents in manufacturing business groups

Variable	Number of patents	Freq. %
Head	2,813	20.2
Controlled	11,106	79.8
Total patents	13,919	100.0

*Controlling firms for Head=1

*All controlled firms from Head=2

Source: elaboration from Aida and Orbis datasets

At first glance, without considering the degree of diversification at group level, data show a higher propensity for groups to have R&D activity between controlled firms rather than heads.

3.3.2 Methodology for Italian manufacturing sample

The analysis is divided in three steps, following the research hypotheses.

The database allowed me to know the number of patents both in heads (controlling firms) and in controlled firms. From this point, I generated a variable to measure the centralization of R&D. It is a continue variable relative to the max quote of patents for each group. It increases more when the group is centralized, regardless from the position of the firm. The variable increases when the group centralizes R&D (independently if the R&D is done by the head or by a controlled firm).

In order to test the second hypothesis, first I generated a dummy variable denominated "Group_Centralization" that is equal to 1 if the max quote of total patents in each group is allocated in head, otherwise it is equal to 0.

The dummy "Group_Centralization" concerns if the R&D is done in head or in controlled firms.

An example is represented by the group "UNIMEC SPA", in which about 66% of patents are allocated in one controlled firm, while the residual is concentrated in the head (34%). Given that the maximum value of patents is allocated in controlled firms, the variable "Group_Centralization" assumes value equal to 0.

A case in which a centralized structure prevails is the group "TEKNA S.R.L", where the total of patents are concentrated in the head. In this case, the variable "Group_Centralization" is equal to 1.

Second, I only considered groups in which the dummy variable "Group_Centralization" is equal to 0 (it is the case in which the max quote of patents is allocated between controlled firms) and I generated another dummy variable denominated "Patents_Controlled". It is equal to 1 if more than 75%[22] of total patents in each group is allocated in only one between controlled firms, otherwise it is equal to 0. The latter aspect relates only to business groups in which the dummy variable "Group_Centralization" at group level is 0.

In order to analyze the relation between the degree of diversification and the R&D organization, I built the Entropy index to study the group's diversification. The Entropy index is a quantitative indicator and

[22] Considered p50 value.

measures the "distance" between diversified activities, already used in other papers (Baldwin, Beckstead, Gellatly, & Peters, 2000; Cainelli & Iacobucci, 2016; Frenken, Van Oort, & Verburg, 2007; Jacquemin & Berry, 1979). The overall diversification[23] (E4) can be split in two main parts[24]. Indeed, the overall diversification (E4) is the sum between the unrelated diversification (E2) and related diversification (EW2= E4-E2). Specifically, E4 and E2 are calculated by considering the quote of revenues for each group with the same ATECO code (4 digit for total diversification and 2 digit for unrelated diversification). Regarding the first research hypothesis about the relationship between the degree of diversification and the organization of R&D, the OLS model is used. The dependent variable is the "max_quote", increasing if the group has a centralized R&D structure, regardless from the position of the firm (head or controlled firm). The explanatory variables considered are E4, E2 and EW2. The control variables are the group's size and age. The sectors variables are already included when calculating the Entropy index (E4, E2, and EW2). The second research hypothesis is to investigate the allocation of patents in groups where the max quote of patents is allocated in controlled firms, ergo the variable "Group_Centralization" has value 0.

In this case, I use the following Logit model:

$$\Pr(Y_{1=} 1|E4, E2, EW2, X)=F(x)^{**}$$

$$^{**}F(x)=[1+e^{-} (\beta_{0+} \beta_1 E4+ \beta_2 E2+ \beta_3 EW2)]^{-1}$$

where $F(x)$ is the cumulative logistic distribution and **X** is the vector of control variables including: group's size, group's age.

The dependent variable Y_1 is a dummy that takes value 1 when most of patents between controlled firms are allocated in one controlled firm. Otherwise, it is equal to 0. This Logit model estimates the

[23] Entropy index $(E4)= \sum q_i \ln_2 (1/q_i)$, where q_i is the share of revenues i in the group's total revenues.

[24] $E4= \sum q_i \ln_2 (1/q_i) = \sum\sum q_j (EW2) + E2$

determinants of the probability of concentrating patents in one controlled firm assuming that the explanatory variables – the E4, E2 and EW2 variables– are exogenous.

Regarding the last research hypothesis, I test the effects of the centralization of R&D on the innovative performance, through the OLS model. As dependent variable, I consider both the total number of group's patents and the mean of patents of each group. As independent variables, I consider the continue variable "max_quote", that indicates whether the business group centralizes the R&D activity in a single firm or not, regardless if in the head or in a controlled firm.

As the control variables: the group's size and age.

3.3.3 The JRC-OECD database

Furthermore, I use another database containing patenting information on the world top corporate R&D investors. The latter was built by using a database developed by a collaboration between "OECD Directorate for Science, Technology, Innovation" and the "EC-JRC Institute for Prospective Technological Studies" (Demis et al., 2015). This database contains information on the patent and R&D activity at group level.

The latter is used for a comparison with the Italian business groups, to investigate whether the organization of R&D follows common rules or depends on the context in which business groups operate.

Moreover, I investigate the influence of the centralization of R&D into the patent production (number of patents). As the last step, I also examine the relation between the diversification and the centralization of R&D in terms of territorial proximity between corporate and its patenting controlled firms. In the latter case, I consider a group with a centralized R&D when most of patents (more than 50%) are produced in the same country of the corporate.

The database from JRC and OECD presents the map of 2,000 world corporate top investors in 2012 and each information is aggregated at group level. The controlled firms belonging to these groups are more than 500,000, but they do not figure out in the database. Therefore, even if the number of patens is associated to the controlling[25] firms, those patents may belong to group's controlled firms.

[25] Headquarters.

The report (Demis et al., 2015) shows that while the controlling firms are allocated in a few set of countries (mainly USA, Japan, Germany and China); the controlled affiliated firms are widespread around the world. The amount of R&D investments between the world top corporate R&D investors was about EUR 539 billion in 2012.

R&D investors localized in Europe have many controlled firms widespread worldwide, particularly in Eastern Europe, North and South America, Russia and Australia (Demis et al., 2015).

Moreover, the report shows how controlling firms favor the geographical proximity[26] with their own controlled firms. This closeness between firms may be explained by the possibility to minimize costs in terms of organization and communication. Between the 2,000 top corporate, I consider those corporate with patents recorded at EPO. The final database considers 1,518 top corporate R&D.

Patents are available from 2010 to 2014. Financial and economic data are aggregated at corporate level and they are available for three years, from 2009 to 2012. To generate the indicator for the group's size and the R&D intensity, I consider the R&D spending and the net sales at the beginning of the period (year 2009). Table 8 shows the list of variables used in the following database.

Table 8-List of variables for the JRC-OECD database

Variable	Description
Max_quote	The highest value of patents in each group
Tot_Patents	Log of total patents for each group for the period 2010-2014
Mean_Patents	Log of mean patents for each group for the period 2010-2014
H2_2	Diversification index indicating the unrelated diversification (2digit IPC classification) at group level
H4_4	Diversification index indicating the overall diversification (4 digit IPC classification) at group level
R&D_Intensity	The ratio between R&D spending and net sales in 2009
Group_size	Log of net sales for group in 2009

[26] Affiliated firms localized in the same nation of the headquarter.

Geographical dummy	Corporate's continent (America, Africa, Asia, Europe or Oceania)
Centralization_country_patent	Dummy variable equal to 1 if more of 50% of patents in each group is produced in the same country of the corporate. Otherwise it is 0.

Source: elaboration from the JRC-OECD dataset

Table 9 shows the descriptive statistics.

Table 9- Descriptive statistics for the JRC-OECD database at group level

Variable	Obs.	Mean	Std. Dev.	Min	Max
Max_quote*	1,444	0.25	0.21	0.0011	1
Tot_Patents (absolute value)	1,518	277.5	771	1	11,272
Mean_Patents (absolute value)	1,518	140.7	393.7	1	5,454.5
H2_2	1,518	0.91	0.14	0	0.99
H4_4	1,518	0.70	0.25	0	0.98
R&D_Intensity*	1,428	0.08	0.11	0.0002	0.99
Group_size	1,481	7.5	1.95	2.94	12.34
Centralization_country_patent	1,518	0.11	0.31	0	1

Source: elaboration from the JRC-OECD dataset

*Max_quote<=1, R&D_intensity<=1

Affiliated firms with at least one patent are 9,447 and of the latter about 60% are localized in the same country of the corporate. This confirms the tendency to the geographical proximity between firms of the same group. The total number of patents are 421,176. Of the latter, about 84% is produced in the same country of the corporate (Table 10).

Table 10 - Patenting firms and number of patents for the JRC-OECD database

	Same country of corporate	Total	%
Patenting firms	5,715	9,447	60.5
Patents	351,250	421,176	83.4

Source: elaboration from the JRC-OECD dataset

3.3.4 Methodology for the JRC-OECD database

In order to pursue the main aim, i.e. the relation between the organization of R&D and the degree of diversification, I worked backwards to know which are the controlled firms associated to groups and their patents. For this reason, I used REGPAT database where there are all patents recorded. In REGPAT, I consider the patents recorded at European Patent Office (EPO). These patents have also an applicant's name (the applicant firm) and a publication's number. The latter is the same included in an additional file made available by the JRC-OECD. This allowed me to match the patent file from REGPAT and the patent file from JRC-OECD by the publication's number. In this way, I also obtained the applicant's name (which is not included in the additional file from JRC-OECD). At this point, I built a database with all controlled firms associated to their own corporate and with all info on patents. The latter database is useful to calculate the degree of diversification for each group. The degree of group's diversification is considered as the distance from patent activities defined by IPC class (4 digit and 2 digit). First, I calculated the quote of patents for each group by considering those patents with the same IPC4 class to investigate the total diversification. Then, I calculated the quote of patents for each group by considering those patents with the same IPC2 class to investigate the unrelated diversification. In this part, I use patents and not the revenue of activities for the group diversification, because economic and financial data of controlled firms are not available. At this point, as an index of diversification at group level, I use the complementary of "Herfindahl index[27]" (Berry, 1975), since the index measures the concentration of activities developed by firms.

To analyze the centralization or decentralization of R&D, I generated the max quote of patents[28] for each group, through both patents of each controlled firm belonging to the same group and the total patents of the group. The OLS model is used to test the relationship between the centralization of R&D at group level and the degree of diversification. The dependent variable is represented by the max quote of patents for each group and it is an index for the centralization of R&D. The explanatory variables are: the total diversification (variable "H4_4") and the unrelated diversification (variable "H2_2"). As control

[27] Herfindahl index==$\sum q_i^2$, where q_i is the patent quote of affiliated firms based on their IPC (IPC4 and IPC2).

[28] Each group has a maximum quote of patents held by an affiliated firm.

variables, I use the group's size, the R&D intensity of each group and geographical dummies related to the corporate's location (continent).

Moreover, I test the effects of the centralization of R&D on the innovative performance using the OLS model. As dependent variable, I use the total number of group's patents and the mean of patents of each group. As independent variable, I consider the continue variable "max_quote", as the indicator of R&D centralized. As the control variables: the group's size, R&D intensity and geographical dummies related to the corporate's location.

The JRC-OECD and REGPAT databases give information on the country of both corporate and patenting firms. For this reason, it is investigated whether the degree of diversification may influence the centralization of R&D in terms of territorial proximity between the corporate and its patenting controlled firm. In order to investigate this part, the quote of patents produced in the same country of the corporate for each group is calculated. Consequently, I generated the dummy "centralization_country_patent" equal to 1 if more of 50%[29] of patents is produced in the same country of the corporate. Otherwise, it is equal to 0.

I use the following Logit model:

$$\Pr(Y_{1=} 1|H4\_4, H2\_2, X)=F(x)^{**}$$

$$^{**}F(x)=[1+e^{-} (\beta_{0+} \beta_1 H4\_4+ \beta_2 H2\_2)]^{-1}$$

where $F(x)$ is the cumulative logistic distribution and **X** is the vector of control variables including: group's size, R&D intensity, geographical dummies.

The dependent variable Y_1 is the dummy "centralization_country_patent". This Logit model estimates the determinants of the probability of concentrating patents in the same country of the corporate assuming that the explanatory variables – the H4_4, H2_2– are exogenous.

[29] Considered p50 value.

3.4 Empirical results

3.4.1 Results from the Italian manufacturing sample

Table 11 presents the econometric result referring to the relationship existing between the degree of diversification at group level and the choice to centralize or decentralize R&D activities (H1).

Table 11– Relationship between the degree of diversification (total, related and unrelated) and centralization of R&D for groups in 2012

Dependent variable:	max_quote	max_quote	max_quote
Estimation method:	OLS	OLS	OLS
E4 (total)	-0.0738*** [-4.02]	-	-
E2 (unrelated)	-	-0.0720*** [-3.53]	-
EW2 (related)	-	-	-0.034 [-1.44]
Group_size	-0.006 [-0.89]	-0.007 [-0.86]	-0.009 [-1.20]
Age	-0.001 [-1.19]	-0.001 [-1.28]	-0.001 [-0.90]
Number of obs.	685	685	685

*** significant at 99%; ** significant at 95%; * significant at 90%.

Source: elaboration from Aida and Orbis datasets

Given that the literature on this theme is uneven, I tested the main two theoretical point of views mentioned in the "3.2 Background".

From the estimates (Table 11), the degree of diversification, total and unrelated, shows a negative and significant relation with the centralization of R&D.

This result confirms the most shared idea by the literature. The centralization of R&D is positively related with less diversified structures. Although the coefficient for the related diversification is negative, the latter does not show a significant relation with the degree of diversification. Both the group's size and the

group's age do not affect the dependent variable. However, when the degree of diversification increases, it is more likely to find a decentralized organization of R&D.

Table 12 shows the estimate on the allocation of patents between controlled firms, when the decentralized R&D prevails at group level (H2). In this case, more the group is diversified and it is more likely to find different controlled firms doing R&D activity.

Table 12– Relationship between the degree of diversification (total, related and unrelated) and the allocation of patents in controlled firms when the decentralization of R&D prevails at group level in 2012

Dependent variable	Controlled_patents	Controlled_patents	Controlled_patents
Estimation method:	Logit*	Logit*	Logit*
E4 (total)	-0.1355*** [-3.77]	-	-
E2 (unrelated)	-	-0.1526*** [-4.15]	-
EW2 (related)	-	-	-0.0146 [-0.22]
Group_size	-0.0004 [-0.02]	0.001 [0.05]	-0.007 [-0.30]
Age	-0.001 [-0.48]	-0.001 [-0.62]	-0.002 [-0.15]
Number of obs.	498	498	498

*** significant at 99%; ** significant at 95%; * significant at 90%.

*considered marginal effects.

Source: elaboration from Aida and Orbis datasets

The finding is valid when considering the total diversification and the unrelated diversification. Even in this case, the related diversification may not seem to influence the choice on the allocation of patents between controlled firms.

There is no significant relation between the allocation of patents and the group's size and age.

Table 13 show the influence of the centralization of R&D into the innovative performance in terms of number of patents (H3).

Table 13–The influence of R&D centralization on innovative performance in terms of group patents

Dependent variable	Tot_Patents	Mean_Patents
Estimation method:	OLS	OLS
Max_Quote	-1.27** [-2.37]	-2.24*** [-5.61]
Group_size	-0.01 [-0.18]	0.05 [0.62]
Age	0.02*** [4.15]	0.01** [3.50]
Number of obs.	685	685

*** significant at 99%; ** significant at 95%; * significant at 90%.

Source: elaboration from Aida and Orbis datasets

Patents refers to a specific period, from 2007 to 2015 and the mean and the total number of patents produced in each group are used as the dependent variable. The latter hypothesis is tested by considering when all the R&D activity is done by a single firm, regardless if a head or a controlled firm.

Findings show that a centralized R&D may limit the innovative performance in terms of patent production.

Generically, this means that the centralization of R&D in a single firm restricts patent production. In this case, while the group's size has not a significant relation with the patent production, the firm's age shows a positive and significant relation with the innovative performance.

3.4.2 Results from the JRC-OECD database

Table 14 shows the analysis on how the degree of diversification affects the organization of R&D, when considering the sample of groups with the highest R&D spending (H1).

Table 14- Relationship between the degree of diversification (total and unrelated) and centralization of R&D for the JRC-OECD database

Dependent variable	max_quote	max_quote
Estimation method:	OLS	OLS
H4_4 (total)	**-0.113***** [-3.67]	-
H2_2 (unrelated)	-	**-0.932***** [-21.1]
R&D_intensity	-0.141** [-2.64]	-0.010 [-0.29]
Group_size	-0.009** [-2.57]	-0.031 [-1.10]
Geographical dummy	Yes	Yes
Number of obs.	1,359	1,359

*** significant at 99%; ** significant at 95%; * significant at 90%.

Source: elaboration from the JRC-OECD dataset

The finding confirms what the most followed stream of literature supports, i.e. a positive relation between the degree of diversification and the decentralization of R&D. More diversified groups prefer committing R&D activities between different controlled firms, specialized in a specific technology.

This is also verified when considering unrelated diversification. When relating the total diversification with the centralization of R&D, both the group's size and the R&D intensity effects are significant and negative. On the contrary, the latter do not have a significant relation in the case of the unrelated diversification, even if the negative coefficients remain.

Table 15 shows the influence of the centralization of R&D into the innovative performance in terms of number of patents (H3).

Table 15- The influence of R&D centralization on innovative performance in terms of group patents

Dependent variable	Tot_Patents	Mean_Patents
Estimation method:	OLS	OLS
Max_Quote	-0.036*** [-3.48]	-0.039*** [-3.74]
Group_size	0.472*** [18.90]	0.362*** [14.9]
R&D_intensity	0.007*** [5.49]	0.005*** [4.86]
Geographical dummy	Yes	Yes
Number of obs.	1,359	1,359

*** significant at 99%; ** significant at 95%; * significant at 90%.

Source: elaboration from the JRC-OECD dataset

As in the Italian case, the centralization of R&D may limit the innovative performance in terms of patent production. We may generalize that the R&D decentralized fosters the innovative performance, regardless if we consider large or small and medium-sized groups and different contexts.

As last step, the Table 16 shows the relation between the diversification and the centralization of R&D in terms of territorial proximity (between the corporate and its patenting controlled firms). In the latter case, the centralization of R&D refers to the concentration of patents in the same country of the corporate[30]. Otherwise, the group is considered decentralized. In fact, the concept of centralization or decentralization of R&D may refer both to the allocation of patents at firm level and to the allocation of patents at country level.

[30] When more than 50% of patents of affiliated firms of a group are produced in the same country of their corporate.

Table 16- The influence of the degree of diversification into the centralization of R&D in terms of territorial proximity.

Dependent variable	Centralization_country_patent	Centralization_country_patent
Estimation method:	Logit	Logit
H4_4 (total)	**-0.081***** [-2.67]	-
H2_2 (unrelated)	-	**-0.735***** [-8.13]
R&D_intensity	-0.385** [-2.34]	-0.128* [-1.66]
Group_size	-0.010 [-1.62]	0.003 [0.82]
Geographical dummy	Yes	Yes
Number of obs.	1,359	1,359

*** significant at 99%; ** significant at 95%; * significant at 90%.

*considered marginal effects.

Source: elaboration from the JRC-OECD dataset

The Table 16 confirms the negative relation between the degree of diversification and the centralization of R&D, even when the centralization is in terms of territorial proximity between the corporate and its patenting controlled firms. More patenting controlled firms are localized in the same country of the corporate (centralization of R&D in terms of territorial proximity) and it is more likely to find groups less diversified. On the contrary, more patenting controlled firms are localized in different countries of the corporate and it is more likely to expect groups more diversified.

3.5 Conclusions

The previous literature on the choice between centralization and decentralization of R&D and the degree of diversification has showed controversial results and open questions. The most followed stream of literature supports the idea that diversified firms opt for the decentralization of R&D. However, as we have seen, this result is criticized by other approaches, which underline the benefits of a centralized R&D applied to the diversified units.

The aim of this paper is to present an empirical analysis on the relation between the degree of diversification and the organization of R&D, i.e. centralization and decentralization.

From the estimates, I find a positive relation between the degree of diversification, total and unrelated, and the choice to decentralize the R&D activity (H1).

It means that it is more likely to find diversified groups involving more affiliated firms in R&D activities.

The sample refers to Italian manufacturing business groups, because in Italy most of R&D activities are done by firms in manufacturing sectors.

In the Italian context, when the degree of diversification increases, the choice on the decentralization of R&D may not be influenced by the group's size.

The H1 is also confirmed when considering the JRC-OECD database that includes the world largest groups in terms of R&D spending.

The relation between the degree of diversification and the decentralization of R&D results unvaried, even with different samples and contexts. The interesting aspect is that the same negative relation between the degree of diversification and the centralization of R&D remains even when the concept of centralization is in terms of territorial proximity between the corporate and its controlling controlled firms. Specifically, less diversified groups show most of patenting firms localized in the same country of the corporate (centralization of R&D), while more diversified groups show most of patenting firms localized in different countries of the corporate (decentralization of R&D).

In the case of controlled firms of decentralized[31] groups, I find that more diversified groups allocate patents in more than one controlled firm rather than concentrate them in only one. On the contrary, in less

[31] Decentralized groups means that most of patents activity are done between controlled firms and not in heads (the variable Group_Centralization is equal to 0).

diversified groups it is likely to find a concentration of patents in one controlled firm. This result is verified using the Italian sample.

As I expected, the innovative performance is positively associated to the decentralization of R&D between controlled firms. The centralization of R&D may limit the innovative performance. This means that the patent production is limited when there is a single patenting firm.

On the contrary, the decentralization of R&D may foster the patent production and consequently the innovative performance. This is verified both in the Italian database (small and medium-sized business groups) and in the OCSE database (larger groups).

This work confirms the most followed stream of literature that supports the positive relation between the degree of diversification at group level and the decentralization of R&D. This relation is confirmed at firm level and at country level.

Finally, the decentralization of R&D activity may foster the innovative performance.

Chapter 4. Bank financing vs internal capital market during the financial crisis. A comparison between business groups and standalone firms[32]

4.1 Introduction

The main aim of this paper is to analyse the presence and intensity of bank financial constraints in companies belonging to business groups compared to standalone companies. The period considered is 2010-2012 when the financial crisis determined a severe situation of credit crunch. In Italy, this was even more evident because the international financial crisis of 2008-2009 was followed by a domestic recession that lasted up to 2012 and that prolonged the situation of difficulties in accessing bank financing.

The focus is on bank financing since it represents the main external source of finance for Italian companies; in fact, in Italy as well as in other European countries, banks are more important than financial markets in allocating resources to firms (Mieli, 2009).

Previous studies demonstrated that business groups allow affiliated firms to have an easier access to bank financing compared to standalone companies (Belenzon et al., 2013; Iacobucci, 2012; Lee et al., 2009; Samphantharak, 2003). Moreover, business groups create internal capital markets that may help controlled companies in case of financial problems (Fan et al., 2005). Thanks to the presence of the internal capital market investment by affiliated firms are less dependent on their own cash flows and more sensitive to the cash flows of other group's firms (Ang et al., 2014). Firms belonging to groups may not only benefit from internal resources but also from the superior ability to raise external financing given the implicit guarantee resulting from group affiliation (Gopalan et al., 2007). Up to now, the literature focussed on the internal capital market rather than on the latter.

[32] Thanks to my supervisor Prof. Donato Iacobucci and Prof. Enrico Guzzini for the collaboration.

The paper investigates the relationship between these two mechanisms (i.e. internal capital market versus external financing) and whether in collecting external resources the centralization at the head of the group prevails on the financing of controlled companies (decentralization). If decentralization is prevalent, I expect that controlled companies in business groups received a higher amount of bank loans than corresponding standalone companies. In fact, given the guarantee effect, banks prefer firms belonging to groups compared to standalone firms (*affiliation effect*). On the contrary, if centralization in the acquisition on external financing is prevalent, banks prefer financing the head of a group for the implicit guarantee deriving from the diversification of controlled companies (*portfolio effect*) (Maksimovic and Phillips, 2007). In this case, controlled companies will benefit from the internal financing provided by the head. If centralization is prevailing, I expect that controlling firms (heads) are more financially exposed to banks than controlled ones, because heads collect funds that are transferred to controlled firms.[33]

The paper uses a dataset of Italian standalone and affiliated firms developed using ownership information about joint stock companies taken from the AIDA database. This allowed me to build a map of Italian business groups in 2012. Moreover, from the AIDA database I obtained financial and economic data for companies belonging and non-belonging to groups for the period 2010-2012 in manufacturing sectors. Data refers to about 64,000 Italian manufacturing joint stock companies, of which 15,000 belonging to groups. I compare the financial constraints of companies and groups and analyse the characteristics of them.

The main results may be summarized in the following way: a) The affiliation to a business group facilitates firms to access bank financing; however, belonging to a business group reduces the amount of bank financing. b) The presence of an internal capital market is a substitute both for the decision to access bank financing and for the decision about the amount of such financing; c) When considering centralization versus decentralization in raising bank financing in business groups, the *portfolio effect* prevails on the *affiliation effect*.

[33] The transfer of financial sources in business groups may refer to equity or loans. I consider only loans as it has been showed that when the main reason for the group is to alleviate the financial constraints of a firm it is easier to use internal debt than internal equity (Buchuk et al., 2014; Chang, 2003).

The paper is organized as follows. The second section reviews the existing literature on the internal and external financing of business groups compared to standalone companies and put forward the hypotheses to be tested. The third section discusses the data and methodology used at firm and business group level. The fourth section illustrates the main empirical results. Finally, the fifth section presents the conclusions.

4.2 Background

The literature on business groups is abundant and variegated. Most of research papers are empirical works and it is important to notice the different peculiarities of business groups and the context in which they operate.

Most of previous works refer to large groups and to emerging countries (Iacobucci, 2012). In the latter case, the development of business groups is a consequence of weak financial institutions and market imperfections (Bae et al., 2008; 2002; Ferris et al., 2003; Khanna & Yafeh, 2007). At the same time, this phenomenon is widespread all over the world. The latter aspect is emphasized by some authors (Gorodnichenko et al, 2009; Hamelin, 2011; Khanna & Yafeh, 2005). "Business groups are common in many countries, especially in emerging economies" (Samphantharak, 2003, p.2). According to the literature, business groups are a corporate organization widespread both in developed and developing markets (Bianco & Nicodano, 2006).

Most of research works deal with the mechanisms of the internal capital market (ICM) within the same group as a way to overcome financial constraints. Contrasting the idea of tunneling[34], Buchuk et al. (2014) show that the direction of internal loans depend on specific financial problems of affiliated firms, independently from their position in the pyramid. Indeed, ICM may help affiliated firms in case of financial problems (Fan et al., 2005). Also, a recent paper (Santioni et al., 2017) confirms the benefits deriving from the internal capital markets in the presence of financial distressed situations. Moreover, firms belonging to business groups may have an easier access to bank financing compared to standalone

[34] It means the transfer of assets and profits out of controlled firms for the benefit of those who control them (the controlling shareholders). It is an expropriation of minority shareholders (Johnson et al., 2000).

companies (Belenzon et al., 2013; Iacobucci, 2012; Lee et al., 2009; Samphantharak, 2003). Firms belonging to business groups may be less financially constrained than standalone firms, thanks to the implicit guarantee resulting from group affiliation. According to Belenzon et al. (2013), ICM may represent a guarantee for raising external resources, in addition to more direct way to finance affiliated firms using cash-flow. Further empirical works (Lensink et al, 2003; Shin and Park, 1999) suggest that firms belonging to a business group have better access to external funds than standalone firms. Many of them refer to large groups, but there are similar findings also for smaller and medium-sized firms (Iacobucci, 2012).

Consequently, the internal capital market allows affiliated firms to maintain a good reputation in external market (Gopalan et al., 2007). For this reason, the presence of internal capital market may be more efficient than external financing both in developing and developed countries (Belenzon et al., 2013).

Previous works also show that affiliated firms are less dependent on cash-flow, thanks to the availability of internal capital market (Gorodnichenko et al., 2009; Iacobucci, 2012; Lensink et al., 2003; Locorotondo, et al, 2014). A recent work (Ang et al., 2014) shows that investments of affiliated firms in family groups are less sensitive to their own cash flows and more sensitive to the cash flows of other firms of the same group, especially those with less financial constraints.

Up to now, literature focused more on the functioning of internal capital markets rather than the ability of firms belonging to business groups to raise external financing, compared to standalone firms. In fact, concerning the bank financing, the focus is more on the choice to allocate resources between SME and large firms, or between firms in developed and developing countries (Beck et al., 2008). This means that firms belonging to groups may not only benefit from internal financing but also from the superior ability to raise external resources given the guarantee resulting from group affiliation.

When considering external financial resources I focus on bank financing since it represents the main external source for Italian companies. In fact, in Italy as well as in other European countries, the banking system is the primary way in allocating resources to firms (Mieli, 2009). For this reason, it is relevant to consider the period from 2010-2012, in order to analyse deeply the impact and the consequences of financial crisis on bank financing of firms belonging to business groups and standalones. Specifically, the crisis period may be divided in two sub-periods: i) 2009-2010 which are the immediate aftermath of the

international financial crisis; ii) 2011-2012 which are characterized by the Italian recession, which prolonged the situation of credit crunch.
During the financial crisis and the subsequent recession period, I expect that firms belonging to groups were less financially constrained than standalone firms. As a result, I expect to verify the following hypothesis:

H_1: During the financial crisis, firms belonging to business groups are expected to show an easier access to bank financing.

Moreover, I investigate whether in financing business groups funds are preferably allocated to controlled firms, that take advantage from the affiliation to a group (*decentralization)*, or are allocated to the head of groups (*centralization)*, that may benefit from the implicit guarantee associated with the diversification of controlled activities (Maksimovic and Phillips, 2007). It is important to investigate also this latter aspect, in order to better understand how bank financing works under unfavourable conditions and which of the two effects, the affiliation or the portfolio effect, is more important.
For this aim, I test the following alternative hypotheses:

H_{2a}: If the *portfolio effect* is prevalent, I expect that heads of groups are more likely to raise bank financing than affiliated firms;

H_{2b}: If the *affiliation effect* is prevalent, there should be no difference in raising bank financing between heads and controlled firms.

4.3 Data and Methodology

In this paper, I use the dataset of Italian standalone and affiliated firms developed using ownership information about joint stock companies taken from the AIDA database. This allowed me to build a map of Italian business groups in 2012. Moreover, from the AIDA database I obtained financial and economic data for companies belonging and non-belonging to groups for the period 2010-2012 in manufacturing sectors. Data refers to 63,909 Italian manufacturing joint stock companies, of which 15,095 belonging to groups. I compare the financial constraints of companies and groups and analyse the characteristics of them.

In order to test H1, in the empirical analysis I use as main dependent variable the ratio between bank loans and total liabilities, that it is considered as an index measuring the intensity of bank financing.

As independent variables, I consider a set of explanatory and control variables. The main explanatory variable is the *group* dummy that equals 1 for firms belonging to groups and 0 for standalones. The second explanatory variable is *Infra*-group: i.e. the amount of debts towards other companies belonging to the same group. Also in this case I consider the ratio between internal debts and total liabilities. In order to avoid reverse causality problems, I use the value of the variable *Infra-group* at the beginning of the period. Furthermore, I also run carry out the estimations in the two sub-periods (i.e. year 2010 and year 2012) in order to check the robustness of the results at different time-periods.

As control, I use the following variables: *Firm size* at 2008, the *Age* of firm at 2012, firm's cash-flow at 2008, the localization in an industrial cluster, the *industry* sector to which the company belongs to.

To test H2, in the empirical analysis I use as main dependent variable both the ratio between bank loans and total liabilities and the amount of debts towards other companies belonging to the same group. The explanatory variable is the *head* dummy that equals 1 for controlling firms and 0 for controlled firms. As control, I use the following variables: *Firm size* at 2008, the *Age* of firm at 2012, firm's cash-flow at 2008, the localization in an industrial cluster, the *industry* sector to which the company belongs to.

Table 17 summarizes the list of variables used in the empirical analysis and how they are defined and calculated.

Table 17– List of variables

Variable	Description
Bank loans	Index of external financing: ratio between bank loans on the total assets
Infra-Group	Index of internal financing: ratio between the sum of debts towards controlled and controlling companies and the total assets
Group	Dummy variable used to discriminate whether the firm belongs to a group (1) or not (0)
Head	Dummy variable used to discriminate heads of groups from affiliated firms
Age	Firm's age at year 2012
Cash-flow	Ratio between the sum of net profit and amortization on total assets
Sector	Dummies for industry sectors (22 manufacturing sectors)
District	Dummy variable used to discriminate whether the firm belongs to an industrial district (1) or not (0)
Firm size	Logarithm of the employees of the firm (year 2008)

Table 18 represents some descriptive statistics for the variables included in the empirical analysis: I note that firms belonging to groups are usually larger and older than standalones. Furthermore, firms belonging to groups exhibit a higher value of the variable *Bank loan*.

Table 18- Descriptive statistics

Variable	Standalone firms					Firms belonging to business groups				
	N. obs	Mean	Std. Dev.	Min	Max	N. obs	Mean	Std. Dev.	Min	Max
Bank loans (2012)	48,520	0.0251	0.2815	0	57.7	15,071	0.0927	0.2032	0	13.79
Bank loans (2010)	48,520	0.0289	0.1032	0	3.52	15,071	0.0979	0.1641	0	2.40
Infra-Group (2012)	-	-	-	-	-	15,056	0.0115	0.0586	0	1.70
Infra-Group (2010)	-	-	-	-	-	15,071	0.0128	0.0586	0	1.79
Infra-Group (2008)	-	-	-	-	-	15,080	0.0124	0.0618	0	2.22
Firm size	37,671	2.05	1.06	0	7.39	12,377	3.28	1.48	0	10.1
Cash-flow	48,541	0.054	0.132	-5.6	11.1	15,080	0.052	0.098	-2.3	2.91

(2008)										
Age	48,531	20.9	13.47	4	142	15,079	24.3	15.27	4	147
District	48,541	0.424	0.494	0	1	15,080	0.407	0.491	0	1

Source: elaboration from Aida

Table 19 presents the correlation matrix.

Table 19– Correlation matrix

	Group	**Infra-Group (2008)**	**Firm size**	**Age**	**District**	**Cash-flow (2008)**
Group	1					
Infra-Group (2008)	0.1919	1				
Firm size	0.4114	0.1525	1			
Age	0.1038	0.0368	0.3070	1		
District	-0.0144	-0.0244	0.0249	-0.072	1	
Cash-flow (2008)	-0.0101	-0.0317	0.0103	-0.0344	-0.0033	1

Source: elaboration from Aida

To test the hypotheses I use a Heckman two-step estimation in order to control for the possible presence of two distinct mechanisms at work: the first one (selection equation) for the decision to access to bank financing; the second one (outcome equation) to decide the amount of such debt. More precisely, in the first step I estimate a Probit model (selection equation) for the probability to raise a bank loan. This allows me to calculate the inverse Mill's ratio, which is employed in the second step. In the second step, I estimate an OLS model for the variable *Bank loan* only for those firms exhibiting positive values of this variable; in this second step I use the inverse Mill's ratio as regressor. In order to avoid identification problems, I have to exclude from the outcome equation at least one variable employed in the selection equation (Cameron and Trivedi, 2005). As it is known, this choice is complex, since the excluded variables should be significant in the selection equation and should not be significant in the outcome equation. I decides to exclude the industry dummies, since most of them satisfy these conditions.

4.4 Empirical results

Table 20 presents the econometric results referring to the comparison between affiliated companies and standalones in accessing bank financing.

Table 20– Determinants of bank loans (Heckman two-step estimation)

	Bank loans (2012)	**Bank loans (2012)**	**Bank loans (2010)**	**Bank loans (2010)**
Group	-0.0315***	-0.0221***	-0.0288***	-0.0186***
	(0.000)	(0.000)	(0.000)	(0.000)
Infra-Group	.	-0.4621***	.	-0.4808***
	.	(0.000)	.	(0.000)
Firm size	-0.0292***	-0.0284***	-0.0298***	-0.0289***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash-flow	-0.8661***	-0.8842***	-0.5866***	-0.6107***
	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.0008***	-0.0008***	-0.0009***	-0.0011***
	(0.000)	(0.000)	(0.000)	(0.000)
District	0.0140**	0.0118**	0.0159***	0.0137***
	(0.009)	(0.027)	(0.000)	(0.000)
Industry dummies	NO	NO	NO	NO
	Dummy Bank loans	Dummy Bank loans	Dummy Bank loans	Dummy Bank loans
Group	0.4438***	0.4542***	0.4213***	0.4212***
	(0.000)	(0.000)	(0.000)	(0.000)
Infra-Group	.	-0.6826***	.	0.0041
	.	(0.001)	.	(0.238)
Firm size	0.6358***	0.6387***	0.6304***	0.6304***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash-flow	-0.5171***	-0.5287***	-0.6209***	-0.6208***
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.0080***	0.0081***	0.0078***	0.0078***
	(0.000)	(0.000)	(0.000)	(0.000)
District	0.0396**	0.0376***	0.0428**	0.0428**
	(0.017)	(0.024)	(0.007)	(0.007)

Industry dummies	YES	YES	YES	YES
Mills	-0.0819***	-0.0814***	-0.0741***	-0.0755***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	49,910	49,910	50,020	50,020
Wald Chi-squared	71.4838	127.2542	119.6647	237.5282

P>|z| in parentheses

* p<0.10, ** p<0.05, ***p<0.01

Source: elaboration from Aida

From the Heckman model, I observe that there are two different mechanisms at work. Concerning the decision to take out a bank loan, I note that the dummy variable *Group* has a positive and highly significant coefficient. This means that firms affiliated to business groups have a higher probability to obtain bank financing. This confirms the first hypothesis that affiliated firms are more facilitated in receiving a bank loan because of the implicit guarantee represented by group affiliation. At the same time, however, in the outcome equation, I note that the dummy variable *Group* exhibits a negative sign. This means that those affiliated firms which benefit from bank financing have associated, on average, a lower amount of bank financing, compared to standalones. We may argue that because of the affiliation to business groups, and the possibility to use the internal capital market, affiliated firms have a lower necessity to 'use' bank financing compared to standalones companies.

When considering the variable *Infra-Group* in the estimates, I notice that this variable is highly significant and its coefficient is negative both in the selection and in the outcome equation. This means that the presence of an internal capital market is a substitute of bank financing, both in the decision to access bank financing and in the decision concerning its amount. Therefore, we may summarize the results in the following way:

- The affiliation to a business group (*Group*) facilitates affiliated firms in the access to bank financing. In this sense, belonging to a business group is a *complement* to bank financing (Hypothesis 1). At the same time, however, belonging to a business group reduces the amount of bank financing: in this sense, the affiliation to a business group is a *substitute* to bank financing.
- The presence of an internal capital market (*Infra-Group*) is a substitute both for the decision to access bank financing and for the decision about the amount of such financing.

- Finally, the affiliation to a business group (*Group*) reduces the necessity of bank financing, even when controlling for the presence of internal capital market (*Infra-Group)*: this means that, in general, business groups provide further financial benefits to affiliated firms besides the internal capital market.

At the end, I note that these results are overall verified in 2010 and 2012. Furthermore, I notice that a mechanism similar to the affiliation to a business group is present for the size of firms. Larger firms are more facilitated in accessing to bank financing (selection equation). At the same time, the variable *Firm size* has a negative impact on the amount of bank financing (outcome equation). This result is in accordance with the fact that larger firms are usually less constrained in accessing bank financing and that they usually have more possibilities to access to various source of funding compared to SMEs. This same mechanism holds also for the firm's age. As expected, the variable cash-flow has a negative and significant impact on accessing to bank financing (selection equation) and on the amount of bank financing (outcome equation).

With reference to the second hypothesis, the results provided in Table 21 show that the *portfolio effect* seems to prevail on the *affiliation effect*.

Table 21– Determinants of Bank loans for affiliated firms

	Bank loans (2012)	**Bank loans (2010)**
Head	0.0345***	0.0385***
	(0.000)	(0.000)
Firm size	-0.0318***	-0.0328***
	(0.000)	(0.000)
Cash-flow	-0.7836***	-0.5176***
	(0.000)	(0.000)
Age	-0.0006**	-0.0008***
	(0.016)	(0.000)
District	0.0123	0.01757***
	(0.122)	(0.000)
Industry dummies	NO	NO

	Dummy Bank loans	Dummy Bank loans
Head	0.2696***	0.2557***
	(0.000)	(0.000)
Firm size	0.5527***	0.6278***
	(0.000)	(0.000)
Cash-flow	-0.8027***	-1.1176***
	(0.000)	(0.000)
Age	0.0477***	0.0042***
	(0.000)	(0.000)
District	0.1261***	0.1090***
	(0.000)	(0.000)
Industry dummies	YES	YES
Mills	-0.0704***	-0.0716***
	(0.003)	(0.000)
Observations	12,358	12,369
Wald Chi-squared	68.7693	120.9084

P>|z| in parentheses

* p<0.10, ** p<0.05, ***p<0.01

Source: elaboration from Aida

Indeed, the variable *Head* is significant both in the selection and in the outcome equation with a positive sign. This confirms that the head of the group has on average both a higher probability to receive a bank loan and also a higher amount of financing. I also notice that these results hold both in 2010 and 2012.
I also notice from Table 22 that when considering *Infra-Group* as dependent variable, the variable *Head* has a negative and significant sign both in the selection and in the outcome equation.

Table 22- Determinants of Infra-group debts

	Infra-Group (2012)	Infra-Group (2010)
Head	-0.0329***	-0.0406***
	(0.000)	(0.000)
Firm size	-0.0121**	-0.0176***
	(0.038)	(0.001)
Cash-flow	-0.1416***	-0.2204***
	(0.000)	(0.000)
Age	-0.0003**	-0.0004***
	(0.003)	(0.000)
District	-0.0159***	-0.0141**
	(0.000)	(0.002)
Industry dummies	NO	NO
	Dummy Infra-group	Dummy Infra-Group
Head	-0.3479***	-0.4503***
	(0.000)	(0.000)
Firm size	0.4043***	0.4577***
	(0.000)	(0.000)
Cash-flow	0.0986	-0.1867
	(0.490)	(0.185)
Age	0.0004	0.0002
	(0.598)	(0.771)
District	-0.0078	-0.0568**
	(0.780)	(0.045)
Industry dummies	YES	YES
Mills	-0.0143	0.0021
	(0.482)	(0.913)
Observations	12,358	12,369
Wald Chi-squared	89.1153	144.4530

P>|z| in parentheses

* p<0.10, ** p<0.05, ***p<0.01

Source: elaboration from Aida

This further confirms the *portfolio effect*, i.e. the fact that once collected external funds, heads of groups 'distribute' them among affiliated firms through the internal capital market.

4.5 Conclusions

The main aim of this paper is to analyse the presence and intensity of bank financial constraints in companies belonging to business groups compared to standalone companies during a period of credit crunch. Specifically, this period appears interesting to be investigated because it is characterized by the financial crisis of 2008-2009 and by the consequent credit crunch. In Italy the situation of credit rationing has continued for several years after the international financial crisis.

It is generally considered that companies belonging to groups may be less financially constrained than standalone firms in raising bank loans, given the implicit guarantee provided by group diversification. However, up to now it is not clear how these financial advantages are appropriated by firms belonging to groups. Specifically, I investigate if bank financing is allocated directly to needy affiliated firms, without distinction between controlling and controlled firms or if it is collected directly by the head of group.

In this latter case, the head decides how to use and distribute financial resources among affiliated firms, through internal capital markets.

Findings are in line with the research hypotheses.

Concerning the decision to take out a bank loan, I find that affiliated firms to business groups have a higher probability to get bank financing. This confirms the first hypothesis that affiliated firms have easier access to receive a bank financing, because of the implicit guarantee represented by group affiliation. At the same time, however, I note that those affiliated firms, which benefit from bank financing have a lower necessity to 'use' bank financing compared to standalone firms, given the possibility to take advantage of the internal capital market. In fact, findings show that the presence of an internal capital market is a substitute of bank financing, both in the decision to access bank financing and in the decision regarding its amount.

Moreover, I investigate whether in financing business groups banks prefer to allocate funds directly to controlled firms, relying on the affiliation to a group, or prefer to allocate funds to the head of groups, benefiting of the diversification of portfolio. I refer to the first situation as *decentralization* and to the

second situation as *centralization*. I consider whether centralization of bank loans towards the head of the group (*portfolio effect*) prevails to the decentralization of loans to controlled companies (*affiliation effect*). In the first case banks benefit from the diversification effect and heads transfer resources to affiliated companies; in the second case, banks may benefit from the guaranteed effect of belonging to a group.

With reference to the second research hypothesis, I show that the *portfolio effect* seems to prevail to the *affiliation effect*. Indeed, the variable the head of the group has on average both a higher probability to receive a bank financing and also an higher amount of financing. Accordingly, prevailing the *portfolio effect,* once collected external funds, heads of groups transfer them among affiliated firms through the internal capital market.

At the end, we note that the results are overall verified both in the immediate aftermath for the international financial crisis (i.e. 2009-2010) and in the following years characterized by the Italian recession (i.e. 2011-2012).

Chapter 5. Internal capital market and innovative performance

5.1 Introduction

The aim of this paper is to investigate how the internal capital market in business groups influences their innovative performance. Business groups are widespread in emerging markets where they are supposed to substitute for the deficiency of market institutions (e.g Khanna & Yafeh, 2005; Samphantharak, 2003; Gorodnichenko, Schaefer, & Talavera, 2009). Moreover, a recent literature has demonstrated that the phenomenon of business groups is relevant also in developed countries given their ability to improve the efficiency and innovative performance of affiliated firms compared to standalone ones (e.g Belenzon, Berkovitz, & Rios, 2013; Cainelli & Iacobucci, 2011; Hamelin, 2011). In all countries, business groups are responsible for the allocation of significant amount of resources in the private sector.

One of the advantages of companies belonging to groups, compared to standalone companies, is the possibility to benefit from the internal capital market: i.e. funds transferred between companies belonging to the same group. Previous researches on internal capital market showed that business groups may have a greater capacity to invest in one sector using the cash flow generated in other sectors (Boutin, Cestone, Fumagalli, Pica, & Serrano-Velarde, 2013). Affiliated firms may invest in projects, such as innovative projects, that would be difficult to finance for standalone companies due to financial constraints in raising external funds (Belenzon & Berkovitz, 2010; Boutin et al., 2013). Group heads may provide financial resources to affiliated companies in several ways. The most important for the financing of innovative projects is equity capital. Equity capital may be provided in two ways: directly, through the issue of new shares; indirectly, by restraining the distribution of dividends and allowing controlled companies to retain profits. The easier access to equity capital by affiliated company is expected to play a relevant role for the innovative performance because R&D investment are preferably financed with equity capital, given the risk attached to such investment. In fact, the literature confirms that firms belonging to business groups show a superior innovative performance compared to standalone companies (Belenzon & Berkovitz, 2010; Blanchard, Huiban, & Sevestre, 2005; Cefis, Rosenkranz, & Weitzel, 2009; Guzzini & Iacobucci, 2014b). This is explained by the advantages of groups in providing resources to affiliated companies. One of these resources is the capital needed to sustain R&D investment. The head of a group is supposed to

have a better knowledge about the innovative projects of affiliated firms than external investors (such as banks, private investors or the market). As a result, the group may partially overcome the problems arising from information asymmetries which are specifically relevant for the financing of innovative projects. At the same time the head of a group may be facilitated in collecting financial resources by centralizing the flow of funds within the group and using the 'portfolio effect' for the acquisition of external resources (Maksimovic & Phillips, 2007).

The aim of this paper is to investigate if and to what extent the internal capital market in business groups influence the innovative performance of affiliated firms. I use R&D and patents as proxies for the innovative performance. The empirical part of the paper refers to Italian manufacturing companies. Data are taken from the AIDA and ORBIS Europe database provided by Bureau Van Dijk. Using information from the annual report of companies, it is possible to analyse the equity 'policy', i.e. the issue of new shares and the dividend distribution. Overall, the empirical analysis supports the hypotheses that the heads of groups play a strong role in the allocation of resources for R&D to controlled companies. This selection role is performed for different controlled firms at the same time or for the same controlled firms in different periods, by collecting resources from controlled companies and allocated them to those who need to finance R&D projects.

As results, in the empirical analysis I expect to find the following relations:

- H_1. The supply of equity capital (raising of new stock) is expected to be positively related with the innovation performance;
- H_2. The distribution of dividends in negatively related with the innovation performance;
- H_3. These relations are stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources.

The paper is organized as follows. Section 2 reviews the existing literature and proposes the research questions to be tested. Section 3 presents the dataset and the methodology used in the paper. Section 4 presents and discusses the empirical results. Section 5 draws the main conclusions and discusses possible extensions to this study.

5.2 Background

Several papers demonstrate that firms belonging to business groups show a superior innovative performance compared to their standalone firms. In fact, affiliated firms show a higher propensity to be involved in R&D (Belenzon & Berkovitz, 2010; Blanchard et al., 2005; Cefis et al., 2009; Guzzini & Iacobucci, 2014b). This result is explained by considering the advantages of groups in providing resources to affiliated companies. Guzzini and Iacobucci (2014b) also show that the R&D propensity of affiliated companies depends on their position within the group. Heads and intermediate firms show a higher R&D propensity than the corresponding standalone companies, while there is no differences in R&D propensity between standalone companies and those at the bottom of a group. For these authors, the higher propensity to invest in R&D activities by the heads of groups depends on the possibility to internalize the knowledge spillovers that flow to controlled companies.

Firms belonging to a business group can share financial, technological and marketing resources (Carney et al., 2011; Hamelin, 2011). There is an extended stream of literature underlining how belonging to a group favors the propensity of firms to invest in R&D and boost their innovation capabilities and economic performance (Filatotchev et al. 2003; Mahmood & Mitchell 2004; Mahmood & Chang-Yang 2004; Chang et al. 2006; Belenzon & Berkovitz 2010; Cefis et al. 2009; Blanchard et al. 2005). Belenzon et al. (2010) find that belonging to a business groups is important for innovation in industries that rely on external funding and in more diversified groups; these findings are line with the view that the presence of an internal capital market may facilitate the financing of R&D projects. In particular, the internal capital market is expected to mitigate the asymmetry of information, which is considered one of the main problems when financing R&D projects. The head of a group is supposed to have a better knowledge about the innovative projects of its affiliated firms than external investors (such as banks, private investors or the market). Moreover, the head of a group may be facilitated in collecting financial resources by centralizing the flow of funds within the group and using the 'portfolio effect' for the acquisition of external resources (Maksimovic & Phillips, 2007).

Unlike standalone companies that cannot benefit of an internal capital market, firms in groups may have a greater capacity to invest in one sector using cash generated in other sectors. The easier access to financial resources by affiliated firms may affect their propensity and intensity on R&D activities (Boutin et al., 2013). Moreover, empirical studies show that affiliated firms have a lower amount of cash

compared to their corresponding standalone companies, since the former can have the access to the internal capital market of the group (Locorotondo et al., 2014). Almeida et al. (2015) show how Korean business groups (*chaebol*) transferred cash among affiliated firms using equity investments during the 1997 Asian financial crisis and this mechanism allowed them to alleviate the negative effects of the crisis compared to the corresponding standalone companies.

Up to now there are no works analysing the relation between the functioning of the internal capital market and the innovative performance of affiliated firms. Group heads may provide financial resources to affiliated companies in several ways. As mentioned above, the most important source for the financing of innovative projects is equity capital. Equity capital may be provided in two ways: directly, through the issue of new shares; indirectly, by restraining the distribution of dividends and allowing controlled companies to retain profits. At the same time, through the dividend 'policy', heads of groups may 'extract' financial resources from controlled companies that are allocated to more promising projects in other affiliated companies.

As a result, I expect to observe the following relations:

- $H_{1.}$ The supply of equity capital (raising of new stock) is expected to be positively related with the innovation performance
- $H_{2.}$ The distribution of dividends in negatively related with the innovation performance
- $H_{3.}$ These relations are stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources.

5.3 Data and methodology

5.3.1 Data

The paper is based on financial and patenting data referring to Italian manufacturing companies. Data are taken using two different but connected databases, both provided by Bureau Van Dijk: the AIDA database on Italian companies and the ORBIS database on European companies. From the first database, I extracted the financial and economic data on Italian companies in the manufacturing sectors from the period 2007 to 2012. This dataset allowed me to construct a map of business groups, based on ownership links between companies. Even though the focus is on manufacturing companies, I reconstructed the business groups by considering affiliated firms operating in any sectors and foreign firms with ownership links in Italian business groups. From the ORBIS database, I obtained data on the patenting activity of firms.

Data on patents refers to the period 2007-2012.

The final dataset refers to 63,909 Italian manufacturing joint stock companies, of which 15,095 belonging to groups.

The equity 'policy' of companies is measured in two ways: the acquisition of equity capital through the issue of new shares; the decrease of equity capital determined by the distribution of dividends.

In the case of R&D, it is not possible to measure the amount of investments but only discriminate whether the company invests or not in R&D. As a result, in the empirical estimates I will use a dummy variable to identify the companies that invest in R&D during the period considered.

The innovative performance is measures by counting the number of new patents granted each years by companies.

The variables used in the empirical analysis are listed in Table 23.

Table 23 - List of variables

Variable	Description
Group	Dummy variable used to discriminate affiliated firms (1) from standalone companies (0)
Head	Dummy variable used to discriminate heads of groups (1) from other affiliated firms (2) and standalone companies (0)
Patents$_t$	Number of patents at firm level per year (2007-2012)
R&D	Dummy variable used to discriminate firms with R&D expenses (1) from those without them (0) per year (2007-2012)
Stock 'policy'$_t$	Issue of new shares / Total assets per year (2007-2012)
Dividend 'policy'$_t$	Dividends paid / Total assets per year (2007-2012)
Internal loans$_t$	Financial debts among affiliated firms / total liabilities (only in business groups) per year (2007-2012)
Sector	Dummies for industry sectors (*2digit NACE classification*)
Firm size$_t$	Logarithm of the revenues on total assets of the firm per year (2007-2012)
Age	Firm's age

From Table 24 to Table 27, I present the descriptive statistics. As I expected, Table 24 highlights that firms in business groups are bigger in terms of assets and older than standalone ones.

Table 24- Descriptive statistics of the sample: standalone companies and affiliated firms (heads and controlled firms)

	Total firms*	Age *(mean)*	Firm size** *(mean absolute value)*	ROA (mean)	Internal loans *(mean)*
Standalone	48,814	20	2,809	0.017	-
Head of groups	3,711	27	22,554	0.045	0.0012
Controlled companies	11,384	23	31,264	0.032	0.0192
Total	63,909	21	9,024	0.021	0.0147

* Number of firms for each year from 2007 to 2012.

**Value of total assets in thousand Euros.

Source: elaboration from Aida and Orbis datasets

Our sample contains 11,790 patenting firms with an overall number of patents of 24,785 (Table 25).

Table 25– *Information on the R&D expenses and patenting activity of firms from 2007 to 2012*

	Total firms	Number of firms with R&D expenses	% Freq.	Patenting firms	% patenting firms	Number of patents	Mean (patents)
Standalone	48,814	9,847	20.1	4,604	9.43	6,636	1.44
Head of groups	3,711	3,252	87.6	2,020	54.4	4,371	2.16
Controlled companies	11,384	8,359	73.4	5,166	45.4	13,778	2.66
Total	63,909	21,458	33.5	11,790	18.4	24,785	2.10

Source: elaboration from Aida and Orbis datasets

The frequency of patenting firms is higher for firms in groups than standalone companies and the number of patents produced is higher in the former. As expected, the average number of patents per firm is much higher for affiliated firms (heads and controlled firms) rather than standalone companies (Table 25).

Table 25 shows firms having R&D expenses during the period considered (2007-2012). Firms in business groups have a higher frequency in R&D investments compared to standalone companies.

Table 26 and Table 27 show some descriptive statistics about the equity 'policy' (raising of new stock and dividend 'policy'). The raising of new stock is an occasional operation and for this reason it has interested only a minority of firms during the period of observation. When related to the total amount of assets, controlled companies in business groups are those who benefited the most from the raise of new shares (Table 26). However, the major difference between standalone and companies belonging to groups is in the absolute amount operations.

Table 26– Information on the firm capital stock and the issue of new shares (stock 'policy') for standalone companies and affiliated firms (panel)

	Capital stock		Firms with the issue of new shares			
	N. Obs	Mean absolute value*	Freq.	% Freq.	Mean (stock 'policy')	Mean absolute value*
Standalone	292,884	6.22	12,047	4.1	0.095	151
Head of groups	22,266	94.81	1,224	5.5	0.056	1,725
Controlled companies	68,304	115.7	3,370	5.1	0.115	2,346

*Thousand Euros.

Source: elaboration from Aida and Orbis datasets

Regarding the dividend 'policy', on the one hand I find that standalone companies have a higher propensity to distribute dividend to their shareholders than controlling firms (Table 27).

Table 27-Dividend 'policy' for standalone companies and affiliated firms (panel)

	N. Obs	Mean (dividend 'policy')	Mean absolute value*
Standalone	292,884	0.0180	35.5
Head of groups	22,266	0.0138	398.4
Controlled companies	68,304	0.0205	756.3

*Thousand Euros.

Source: elaboration from Aida and Orbis datasets

On the other hand, the controlled firms show the highest propensity to distribute dividends of both standalone companies and of controlling firms (Table 27). This higher propensity to distribute dividends of controlled firms may be a mechanism for the head of the group to transfer resources among its affiliated firms, benefiting from the internal capital market and avoiding collecting resources externally.

5.3.2 Methodology

To test if and to what extent the internal capital market in business groups influence the innovative performance of affiliated, I use a Heckman two-step estimation in order to control for the possible presence of two distinct mechanisms at work: the first one (selection equation) for the decision to invest in R&D activities; the second one (outcome equation) to decide the amount of patenting activity (in terms of number of patents).

Table 28 shows this mechanism. More precisely, in the first step I estimate a Probit model (selection equation) for the probability to invest in R&D. In the second step, I estimate an OLS model for the variable *patents* only for those firms exhibiting positive values of R&D; in this second step I use the inverse Mill's ratio as regressor.

For the selection equation, as dependent variable I use the dummy R&D to discriminate if a firm has R&D expenses (1) or not (0). For the outcome equation, as dependent variable I use the number of patents. As explanatory variables, I use group, stock 'policy', dividend 'policy', ROA[35]. As the control variables: size, age and sectors[36].

In order to avoid identification problems, I have to exclude from the outcome equation at least one variable employed in the selection equation (Cameron and Trivedi, 2005). As it is known, this choice is complex, since the excluded variables should be significant in the selection equation and should not be significant in the outcome equation. I decide to exclude the industry dummies, since most of them satisfy these conditions.

Table 29 shows the role of internal capital market on the innovative performance in terms of R&D investments. This refers to only firms belonging to business groups. I use the following Probit Model:

$$\Pr(Y_{1=}\ 1|\text{Stock}_{t-1}\ \text{'policy'},\ \text{Dividend}_{t-1}\ \text{'policy'},\ \text{Internal\_loans}_{t-1},\ X)=F(x)^{37}$$

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[35] The explanatory variables stock 'policy', dividend 'policy', ROA are considered at time t-1, while the dependent variables (R&D and patents) are considered at time t.

[36] See Table 23 for the description of variables.

[37] $F(x)=[1+e^{-}\ (\beta_{0+}\ \beta_1\ \text{Stock}_{t-1}\ \text{'policy'}+\ \beta_2\ \text{Dividend}_{t-1}\ \text{'policy'}+\ \beta_3\ \text{Internal\_loans}_{t-1})]^{-1}$

where F(x) is the cumulative distribution function of the standard normal random variable and **X** is the vector of control variables including: firm's size, firm's age, firm's sector (2digit NACE classification), years (2007-2012). The dependent variable Y_1 is a dummy that takes value 1 if an affiliated firm invests in R&D and 0 otherwise. This Probit model estimates the determinants of the probability of firm investing R&D activities assuming that the explanatory variables are exogenous.

5.4 Empirical results

The analyses confirm the assumptions that firms belonging to business groups tend to invest more in R&D compared to standalone companies, benefiting from both incentive effects and financing effects. As showed by Table 26, the equity 'policy' (issue of new shares) in firms belonging to business groups is much higher compared to standalone companies when considering the amount of new shares.
Table 28 is related to analyse the influence of the equity 'policy' into the innovation performance of companies.

Table 28– Influencing factors on innovative performance

Dependent variable:	**Patents (t)**
Group*	1.145*** [6.83]
Stock 'policy' (t-1)	3.175*** [3.78]
Dividend 'policy' (t-1)	-0.224** [-2.12]
ROA (t-1)	0.034** [2.26]
Size	1.773*** [7.69]
Age	0.011*** [4.64]
Sectors	No

Years	Yes
	Dummy R&D (t)
Group*	0.2214*** [23.9]
Stock 'policy' (t-1)	0.749*** [7.84]
Dividend 'policy' (t-1)	-0.270*** [-4.42]
ROA (t-1)	0.017*** [4.17]
Size	0.323*** [107.4]
Age	0.002*** [9.77]
Sectors	Yes
Years	Yes
Mills	6.154*** [7.16]
N. Obs	319,485

* Group=0 for Standalone companies; Group=1 for affiliated firms

* p<0.10, ** p<0.05, ***p<0.01

Source: elaboration from Aida and Orbis datasets

From the Heckman model, we can observe that there are two different mechanisms at work. Concerning the decision to invest in R&D, I note that the dummy variable *Group*[38] has a positive and highly

[38] I also executed the same analysis first only for affiliated firms and then only for standalone firms. In firms belonging to business groups, the equity 'policy' has a stronger relation with both the decision to invest in R&D and the innovative performance in terms of patent production, compared to standalone firms.

significant coefficient. This means that firms affiliated to business groups have a higher probability to invest in R&D activity. This also confirms previous literature that affiliated firms are more inclined to invest in innovative activities because of the implicit guarantee represented by group affiliation. However, in the outcome equation, I note that the dummy variable *Group* exhibits a positive sign as well. This means that those affiliated firms which invest in R&D have associated, on average, a higher amount of patents, compared to standalones. Also, in the selection equation I find that the stock 'policy' may represent a way to finance R&D expenses, while the dividend 'policy' may subtract resources to invest in R&D. The same findings are also confirmed when I consider the outcome equation. The stock and the dividend 'policy' are substitute mechanisms for patenting activities. The variable *ROA* affects positively (***) both in the selection equation and in outcome equation. The firm's performance has a positive impact on the choice to invest in R&D and on the amount of patents. Thus far, the findings follow what I expected, that is to find a stronger relevance of the equity 'policy' in terms of issuing new shares for firms belonging to business groups than standalone companies and that the 'equity policy' may have affected positively on innovation performance. Moreover, I control for firm's size, age and sectors. As I expected, older and bigger firms have a higher probability to invest in R&D e to product patents. Table 29 investigate the influence of the internal capital market into the innovative performance in affiliated companies.

Table 29 – Relation between the role of internal capital market and the innovation performance of affiliated firms* in terms of R&D expenses

Dependent variable: **R&D (t)**	[Probit**]
Stock 'policy' (t-1)	0.156*** [5.05]
Dividend 'policy' (t-1)	-0.272*** [-6.67]
Internal loans (t-1)	-0.023 [-1.15]

Size	0.048*** [51.55]
Age	-0.0001 [-0.57]
Sectors	Yes
Years	Yes
N. Obs	45,529

* Controlled firms.
**Considered marginal effects. * p<0.10, ** p<0.05, ***p<0.01
Source: elaboration from Aida and Orbis datasets

Table 29 shows that mechanisms used by the internal capital market to foster the innovative performance in terms of R&D expenses are the stock 'policy' and the dividend 'policy', even if in an opposing way. Specifically, stock 'policy' between affiliated firms show a positive and significant relation with the innovative performance. Conversely, the dividend 'policy' may influence negatively the R&D expenses. This confirms the previous result (Table 28). Internal loans between affiliated firms may not affect the investment in R&D. The reason may derive from the high risk related to R&D investments.
The control variable "size" is positively related with the R&D spending. Business groups prefer investing in R&D activities through stock 'policy', given the risk attached to such investment. The analysis showed by Table 29 refers to controlled firms. I also executed the same analysis both for all affiliated firms and for heads, but the results obtained are in line with those showed in Table 29, but less significant. This means that while the head, assuming more an organizational and managerial role, decides how to distribute and allocate resources within the group through the internal capital market, the R&D and patent activities are mainly executed by its controlled firms.

5.5 Conclusions

The aim of this paper is to investigate the influence of the internal capital market of business groups into the innovative performance. The focus is on the stock 'policy' and dividend 'policy' in firms belonging to business groups compared to standalone companies, because the most important for the financing of innovative projects is equity capital.

Indeed, group heads may provide financial resources to affiliated companies in several ways, but equity capital is the most common system to invest in innovative projects. In fact, equity capital may be provided in two ways: directly, through the issue of new shares; indirectly, by restraining the distribution of dividends and allowing controlled companies to retain profits. The easier access to equity capital by affiliated companies is expected to play a relevant role for the innovative performance because R&D investment are preferably financed with it, given the risk attached to such investment.

The findings confirm the main hypotheses.

The supply of equity capital, i.e. the raising of new stocks, has a positive and significant relation with the innovative performance, in both terms of R&D spending and the patent production ($H_{1)}$. Conversely, the distribution of dividends may restrict the possibility to invest in R&D activities, allocating profits to shareholders ($H_{2)}$. This mechanism may affect the R&D spending and on the patent production.

Moreover, the innovative performance is much higher for affiliated firms compared to standalone companies.

The firm's performance influences the decision on investing in R&D and on the amount of patents. Regarding the role of internal capital market on the innovative performance in terms of R&D expenses, I test the effect of the stock 'policy' and 'dividend 'policy' on the R&D investments in firms belonging to business groups. Findings show a robust relation between R&D investments and the equity 'policy. In particular, findings confirm that affiliated firms may prefer the issue of new shares to invest in R&D. Furthermore, the dividend 'policy' has a negative impact on the R&D activity and may limit the innovative performance. This confirms the previous result in which the dividend 'policy' may subtract resources to the R&D spending and to the patent production.

Internal loans may not represent a way to finance R&D investments, given the risk attached to such investment.

The influence of the internal capital market into the innovative performance is stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources ($H_{3)}$.

A further development may be to extend the analysis to larger business groups in European countries and to investigate the role covered by holdings[39] in managing the internal capital market between controlled firms.

[39] A holding is the head of a group which operates in financial sectors without doing productive activities.

Concluding Remarks

This thesis examines the role of business groups in resource allocation, specifically to sustain R&D investment and the innovative performance of firms.

In so doing, it points out the shift that occurred in the literature during the last decade about the role of business groups.

Most of the literature consider business groups as an anomalous organizational form widespread in inefficient and instable markets. On the contrary, this work starts from the idea that groups may represent an efficient mechanism of resource allocation, which allow affiliated firms to foster their economic and innovative performance. Unlike standalone companies, firms in business groups may benefit from the internal capital market, i.e. the transfer of resources between affiliated firms. This may help them to overcome financial constraints and sustain the investments in R&D and in innovative activities in general. Indeed, the latter are increasing their relevance for the competitive advantage of firms. Consequently, there is an increasing need of allocating financial resources to invest in such activities, which are difficult to finance because of the high risk attached to them and the information asymmetry between firms and the provider of financial resources. For this reasons, the belonging to a business group may facilitate this type of investments.

On the one hand, the internal capital market is an easier way to transfer resources between affiliated firms of a same group, without referring to external investors, thus benefiting from cost and time cutting. On the other hand, the belonging to a business group may represent an implicit guarantee for external investors in case of financing.

Given these premises, this thesis presents three essays investigating the role of the business group as an efficient mechanism of resource allocation. Before presenting the main essays, I provide a theoretical analysis on the organization of the R&D in decentralized organizations since the organization of R&D has relevant consequences on the innovative performance of firms.

This theoretical paper, focused on the organization of R&D in diversified firms and in business groups, identifies some issues affecting the choice to centralize or decentralize the R&D.

Only recently, the literature has started investigating the factors explaining the choice between centralization and decentralization of R&D in diversified firms and in business groups, analyzing advantages and disadvantages associated with this decision. Indeed, literature shows few consolidated results and some controversial issues and research gaps. The reason is that most of the papers are empirical works and are generally eclectic in the choice of the theoretical approach. They refer to samples of firms that show great differences in their features and in the institutional and social context in which the firms operate. For this reason, it is not always simple to understand to what extent the presence of conflicting results may be attributable to differences in the sample and context rather than to the underlying explanatory theory. It is necessary to adopt a more theory-driven approach in order to understand the reasons and motivations affecting the organization of R&D activity (centralization *versus* decentralization). From this starting point, the thesis develops three empirical papers that represents the main essays.

The first essay analyses the relation between the degree of diversification of the group and the organization of R&D, and consequently the influence of the R&D organization into the innovative performance.

The second one focuses on resource allocation mechanisms within the groups and investigates the relation between the internal capital market and the bank financing (external capital market).

The last essay discusses how the internal capital market may influence the innovative performance of affiliated firms.

To investigate the first essay, I developed a paper on the influence of the diversification into the organization of R&D. Using two different samples, i.e. Italian business groups and the world top corporate R&D investors, the main finding is that there is a positive relation between the degree of diversification and the decentralization of R&D activity. This is true both in Italian manufacturing business groups (mainly small and medium-sized groups) and in the world business groups with the highest R&D spending. We find the same negative relation between the degree of diversification and the centralization of R&D in terms of territorial proximity between the corporate and its controlled firms. Specifically, less diversified groups show most of patenting firms localized in the same country of the corporate (centralization of R&D), while more diversified groups show most of patenting firms localized in different countries of the corporate (decentralization of R&D).

Also, more diversified groups prefer allocating patents in more affiliated firms, in particular when unrelated diversification is higher. Finally, the centralization of R&D in a single firm of the group may limit the innovative performance, in terms of the patent activity. On the contrary, the decentralization of R&D may foster the innovative performance of the group.

The second essay is focused on resource allocation mechanisms within business groups and investigates the relation between the internal capital market and the bank financing (the external capital market). First of all, the paper analyses the presence and intensity of bank financial constraints in companies belonging to business groups compared to standalone companies after the financial crisis of 2008. Then, the work shows the relation existing between the bank financing and the internal capital market (if they are complement or substitute) in the same period. One of the main findings is that the internal capital market is a substitute of the bank financing, both in the decision to access bank financing and in the decision regarding the intensity. Specifically, affiliated firms are more facilitated in receiving a bank loan because of the implicit guarantee represented by group affiliation. At the same time, affiliated firms have a lower necessity to 'use' bank financing compared to standalones companies, thanks to the possibility to benefit from the internal capital market. Furthermore, findings show that banks prefer to allocate funds to the head of groups, benefiting of the diversification of portfolio (*portfolio effect*), instead of financing directly controlled firms *(affiliation effect)*. Prevailing the *portfolio effect,* once collected external funds, heads of groups transfer them among affiliated firms through the internal capital market.

Results refer to a specific period characterized by a strong credit crunch due to the international financial crisis started from 2008. Therefore, findings are valid in presence of market shocks and economic recessions.

The last essay refers to the internal capital market. Specifically, it discusses how the equity *'policy'* and the dividend *'policy'* may affect the innovative performance of affiliated firms. As discussed, group heads may provide financial resources to affiliated companies through the equity capital, in order to finance innovative projects.

In the internal capital market, equity financing is used to foster the innovative performance of affiliated firms. Findings of the paper confirm these hypotheses.

Specifically, findings show that the supply of equity capital is positively related with the innovative performance while the distribution of dividends is negatively related with the innovation performance.

Furthermore, the innovative performance is better for firms belonging to business groups compared to standalone firms. Moreover, these relations are stronger in the case of controlled companies (compared with heads), given the role played by heads in the allocation of resources. This means that the head has more an organizational role in collecting and distributing funds to its controlled firms, through the internal capital market.

Innovation represents a key factor for achieving long-run economic growth. In developed countries, the innovative performance of firms is more and more dependent on R&D investments and patent activities. For this reason, it is important to examine the mechanisms of resource allocation to R&D and other innovative activities. Business groups represent a way to foster the innovative performance of affiliated firms, given the benefits from the belonging to a group, such as the use of the internal capital market. Recent contributions consider the role of this organizational form to support the innovative performance of affiliated firms compared to standalone firms, for example by guarantying a superior capacity in R&D investments and in patent activities. It is not a coincidence that in the last decade we witnessed an increasing relevance of business groups in developed countries.

The main advantages of belonging to a business group may be summarized as follows:

- the possibility to share internally resources through the internal capital market;
- the possibility to transfer R&D results between controlled firms;
- the possibility to benefit from the portfolio diversification in order to reduce the risk of activities;
- the possibility to get easier external financing, given the implicit guarantee of the group.

For these reason, the group should not be considered as an anomalous organization resulting from inefficient market institutions but as an efficient mechanism of resource allocation. The belonging to a business group brings several benefits to affiliated firms, especially when operating in turbulent times and when innovation and change are the main driver of the company performance.

In conclusion, we may suggest some policy and management implications resulting from this analysis.

Regarding ‘policy’ implications, the main debate is whether taxation and corporate law should favour or discourage the development of business groups.

Contrary to the USA legislation[40], the Italian law does not discourage the presence of business groups and in some cases it may favour them. Indeed, from 1986 Italy introduced the fiscal consolidation[41] as an optional taxation system for firms belonging to business groups. Although this introduction was aimed at making the Italian tax system homogeneous to the most efficient ones in the EU Member States, it also contributed the tax recognition of firms belonging to business groups.

There are two ways of tax consolidation: a) national consolidation between firms localized in Italy; b) world consolidation in case of affiliated firms localized abroad.

The main advantages of the fiscal consolidation are:

- the opportunity to offset tax profits and losses between affiliated firms of the same group;
- the possibility to offset tax credits and debts between firms involved in the fiscal consolidation;
- there are no tax liabilities for controlled firms because the only firm responsible for the payment of taxes is the head of the group.

In general, the Italian legislation seems to recognize the positive role played by business groups. Indeed, the increasing relevance of business groups in the Italian economy during the last decade may represent an indirect demonstration of a favourable Italian legislation.

Regarding the 'management' implications, it is important to raise the awareness of managers and management researchers towards the group as an efficient organization structure. Indeed, it is important for managers to have a better understanding of specific characteristics of business groups and the role played by firms belonging to them. One of the key elements is that in a business groups firms remain legally independent. For this reason, the degree of autonomy of each affiliated firm is a crucial point, which influences the efficiency of the firm and of the group as a whole. On one hand, to leave a total autonomy to affiliated firms may mean losing the meaning of the group and the possibility to share resources internally. On the other hand, the total loss of their autonomy may mean considering the group as a multidivisional firm. Consequently, the management should find the most efficient equilibrium between autonomy and centralization, considering the specific characteristics of the group. The awareness

[40] The USA legislation discourages the development of pyramidal business groups through the double taxation of dividends (Morck & Yeung, 2003).

[41] Artt. 117-142 TUIR.

in the group's potentialities means to understand how to manage resources between affiliated firms. For example, it is not always easy to observe the internal transfer of resources (internal capital market); this may be due to the fact that firms belonging to a group are so efficient that there is no need to use internal transfers or that management has no a real awareness of the internal capital market.

In general, the awareness of who governs the group assumes a great relevance in managing the portfolio activities and in decisions on the R&D and other innovative activities.

Moreover, evidence from this thesis shows that the decentralization of R&D may favour the innovative performance in terms of patents compared to a centralization of R&D. A development of this thesis may be to investigate whether the decentralization of R&D, which may allow groups to have a higher innovative performance, also supports an efficient sharing of knowledge between patenting firms and the others of the same group. This means understanding to what extent and how innovative results developed in an affiliated firm may be shared with other companies of the group.

Regarding long-term effects, a further development may be to examine whether the advantages arising from the belonging to a group, also including the possibility under-performing firms to survive in the short run, is offset by an increase in growth capabilities in the long-term. This means to investigate how decisions taken in the short-term affects the efficiency of business groups in the long-term.

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