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## **The Valuation of Technology Strategies: Examining the short and long-term financial returns of licensing**

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### **Abstract**

This paper empirically evaluates the short-term and long-term implications of inward licensing, patenting activity and a combined strategy on firm performance. The short-term effects relate to abnormal stock market returns and long-term effects relate to continuous changes in market share. Drawing on a dataset of 104 companies that belong to the energy, materials and consumer staples sectors from the Standard & Poors 500 index, we conduct our empirical analysis using an event study and a fixed effects model for the period 2006-2012. Results show that, in the short-term, companies capitalize on both developing and acquiring technologies. However, companies capture higher cumulative abnormal returns when purchasing intellectual property than when developing and protecting technologies per se. The announcement of licensing agreements in the consumer staples and energy sector yields the highest returns, while the impact is not significant in the materials sector. In the long-term, we find that patenting influences negatively the growth of a company's market share and this effect is stronger when patenting and in-licensing are performed simultaneously.

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**Key words:** Inward licensing, Patenting, Markets for Technology, Firm Performance.

**JEL Codes:** O320 , O310, L1

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## 1. Introduction

The balance between allocation of resources to technologies developed in-house, those acquired externally and those traded in the market is central to the design of R&D strategies. Albeit not new, this issue has become more crucial than ever, prompted by the intensification of competition and of knowledge tradability, as knowledge has become increasingly disembodied from individuals, organizations and products (Conti, Gambardella, & Novelli, 2013; Natalicchio, Petruzzelli, & Garavelli, 2014). The proliferation of markets for technology and ideas (Arora, Fosfuri, & Gambardella, 2001) has indeed opened up an ever-wider variety of opportunities and technological paths for modern corporations, leading R&D strategies to become more complex and challenging. As a result, in order to build competitive product portfolios, firms increasingly attempt to combine the benefits of economizing on transaction costs through vertical integration (Williamson, 1975) with the benefits of leveraging technological expertise and flexibility through strategic outsourcing (Powell, Dopot, & Smith-Doerr, 1996) and the sales of knowledge assets (Fosfuri, 2006). The recent examples of Apple and Boeing<sup>1</sup> indicate that companies simultaneously use markets for technology in multiple ways, both as sellers and buyers, depending on the technology at stake and on the competitive landscape. Alone in the United States, gross royalties receipts from licenses amounted to \$140 billion dollars in 2004, representing an average growth of 11 per cent per year for the period 1994-2004 (Robbins, 2006). Similar patterns have been estimated for G8 countries too, where technology royalty payments and receipts increased by an average annual rate of 10.7 per cent from 1980 to 2003 (Arora & Gambardella, 2010).

While the literature provides an advanced understanding of the factors that explain this growing trend, i.e. why firms become active in markets for technology as either licensors or licensees (Ceccagnoli, Graham, Higgins, & Lee, 2010; Ceccagnoli & Jiang, 2013; Fosfuri, 2006; Kani & Motohashi, 2012), the performance implications of R&D allocation decisions remain inconclusive (Mulotte, Dussauge, & Mitchell, 2013; Wang, Roijackers, & Vanhavrbeke, 2013). Even if several studies have investigated this issue, the findings are not consistent. Whereas the evidence is mostly positive for licensing decisions with respect to return on assets (Zahra, 1996),

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<sup>1</sup> Apple decided not to incorporate Google Maps in the iPhone 5 as it had done in previous versions, but rather to develop a similar application by itself. At the same time, it licensed its system on chip manufacturing to its main competitor Samsung. Boeing, on the other hand, realized that its true comparative advantage was not in manufacturing, but in systems integration. As a result, unlike its chief rival Airbus, it became the designer and systems integrator both of its planes and of many of the systems that go in them, changing its core business to focus less on manufacturing and more on design and integration services.

diversification (Granstrand, Bohlin, Oskarsson, & Sjöberg, 1992), value-added (Walter, 2012), product innovativeness (Tsai, Hsieh, & Hultink, 2011) and speed of invention (Leone & Reichstein, 2012), there is also indication of downsides. Negative effects of licensing have been found with respect to overall performance (in terms of product, market, and financial measures) (Jones, Lanctot JR., & Teege, 2001), patenting (Joshi & Nerkar, 2011) and subsequent market entry (Mulotte et al., 2013). Wang et al. (2013), in fact, found an inverted U relationship of the effects of licensing among Chinese companies, using patents granted as a proxy for innovative performance. Interestingly, Tsai and Wang (2008)'s results indicate that external technology acquisition does not enhance firm performance, but its contribution increases with the internal R&D efforts of firms.

In light of these conflicting results, it remains an open question how shareholders react to R&D allocation decisions (e.g. the announcement of a license deal or a patent issue). This is nevertheless a highly relevant question, not only because it determines a company's financial market value in the short term, but also because it has enduring effects on innovative behavior. In fact, the initial stock market reaction of a certain event has been found to be highly correlated to long-term performance (P. Kale, Dyer, & Singh, 2002), to the compensation schemes of managers (Dechow & Sloan, 1991; Degeorge, Patel, & Zeckhauser, 1999; Mizik, 2010) and to the company's true value (Akhtar & Oliver, 2009). Another key shortcoming is that the existing literature has mostly concentrated on the exclusive choice between internal and external sourcing of technology (Hagerdoorn & Wang, 2012; Mulotte et al., 2013). It has thus largely overlooked the combined approach to R&D strategy that characterizes many modern companies (such as Apple and Boeing) and that is subject to much controversy. While the economics tradition supports the specialization argument (i.e. either technology generation and selling or technology buying and commercialization), management research suggests that the optimal strategy is doing both selling and buying concurrently, in accordance with the open approach to innovation (Conti et al., 2013).

As a result of these limitations, *the performance implications of the different R&D strategies remains uncertain*. Understanding the implications of internal and external technology sourcing is however crucial in terms of theory and practice. It helps explain when firms should use the market option and when they should rely on internal capabilities, as well as make better predictions about what impact different types of R&D strategies have on firm performance (Walter, 2012). We address this issue by examining the effect of a firm's inward licensing and patenting activity on important financial variables. More precisely, we aim at examining the following research question: *What are the short-term and long-term effects of external technology acquisition and internal*

*technology development on financial performance?* The short-term effects relate to abnormal stock market returns and long-term effects relate to continuous changes in market share.

We test our hypotheses on a sample of 104 companies that have been selected from the Standard & Poors 500 index and that belong to the energy, materials and consumer staples sectors. Our period of analysis comprises seven years (from 2006 to 2012, both included). Results show that, in the short-term, both internal technology development and external technology acquisition yield positive market reactions. However, companies capture higher cumulative abnormal returns when purchasing intellectual property than when developing and protecting technologies per se. Also, the impact of licensing agreements in the shock market is different depending on the sector. Specifically, results show that the announcement of licensing agreements in the consumer staples and energy sector yields the highest returns in the stock market, in comparison to the materials sector (for which it is not significant). In the long-term, we show that patenting influences negatively the growth of a company's market share and this effect is even stronger when patenting and in-licensing are performed simultaneously.

We advance prior research in two key ways. First, we extend the discussion of implications of markets for technology by comparing the impact of externalizing vs. internalizing technology development in the short and in the long term. Second, complementing previous studies that have focused on internal or external technological acquisition in isolation, we investigate the performance implications of a combined approach to R&D strategy where a portfolio of in-house technology development and external technology acquisition is considered. As the recent review of Conti et al. (2013:754) contends, “a key research question concerns the extent to which, and the contingencies under which, specialization is less beneficial than an “ambidextrous” open-innovation approach”.

The paper is organized as follows. Section 2 presents the theoretical arguments underpinning the hypotheses development. Section 3 describes the data, variables and methodology. Section 4 reports the results, followed by a discussion of the initial findings. Section 5 concludes the paper and presents implications for theory and practice.

## **2. Theory and Hypotheses**

To obtain technological know-how, companies can choose between their own internal R&D and external methods, such as entering into a technology sourcing agreement with an outside party (Walter, 2012). Recent research in this field can be categorized in three streams. The focus of the

first stream is to investigate whether companies treat in-house R&D and external sourcing as substitutes or complements, i.e. if an increase in one strategy raises or decreases the marginal payoffs of the other. The literature has provided mixed empirical evidence in this regard. While the works of Pisano (1990), Laursen and Salter (2006) and Vega-Jurado, Gutiérrez-Gracia, and Fernández-de-Lucio (2009) have supported the substitution viewpoint, the majority of studies, such as Cohen and Levinthal (1989), Arora and Gambardella (1990), Lowe and Taylor (1998), Cassiman and Veugelers (2006) and Forman, Goldfarb, and Greenstein (2008) have found evidence for the complementary view.

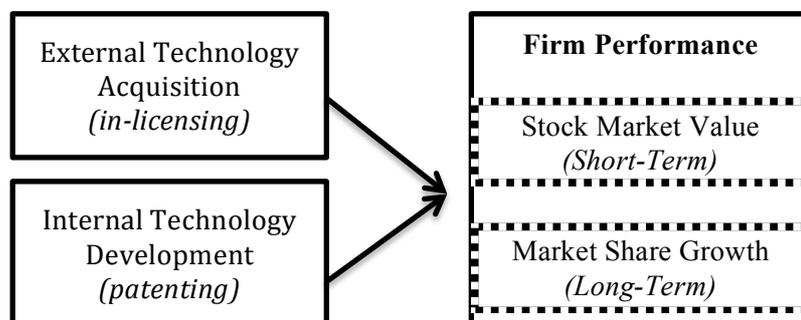
The second research stream contemplates the decision to acquire or sell technologies. The aspect that has received most consideration in the literature is the supply-side determinants of external knowledge sourcing (Conti et al., 2013), that is, the factors that influence the decision to license or sell technologies and the implications thereof (e.g. Bianchi, Chiaroni, Chiesa, & Frattini, 2011; Cockburn, MacGarvie, & Müller, 2010; Fosfuri, 2006; Gambardella, Giuri, & Luzzi, 2007; Kani & Motohashi, 2012; Kim & Vonortas, 2006). By contrast, the demand-side conditions of licensing behavior have only recently received pronounced attention. These are the factors that explain the motivations and costs of integrating licensed technology, as well as heterogeneity in the behavior of licensees (e.g. Ceccagnoli et al., 2010; Ceccagnoli & Jiang, 2013; K. Laursen, Leone, & Torrisi, 2010). Taken together, these studies indicate that the decision to license-in and -out depend on a myriad of interrelated factors: the institutional setting (e.g. the strength of intellectual property rights), industrial structure (e.g. degree of competitive pressure), firm characteristics and resources endowments (e.g. R&D productivity, co-specialized complementary assets) and individual-level characteristics (e.g. prior experience of licensing managers).

The third research stream is concerned with investigating the relationship between external technology acquisition and firm performance. Most studies have evaluated the effects of licensing on innovation results, as measured by product innovativeness (Tsai et al., 2011), subsequent market entry (Mulotte et al., 2013), patenting (Joshi & Nerkar, 2011; Wang et al., 2013) and speed of invention (Leone & Reichstein, 2012). Few have gathered empirical evidence on firm performance as the outcome variable (Jones et al., 2001; Tsai & Wang, 2008; Zahra, 1996). These three studies suggest nonetheless opposing results. Zahra (1996) has found that external technology acquisition is positively associated with firm performance in terms of return on assets (ROA) on the basis of a multi-industry sample of manufacturing company from a southeastern American state. Drawing on data from U.S. subsidiaries of both domestic (U.S.) and foreign firms that operate in various

manufacturing sectors, Jones et al. (2001) have in contrast shown that external technology acquisition is negatively associated with product, market and financial performance measures (the latter assessed in terms of profitability and return on investment). Conversely, Tsai and Wang (2008) did not gather any evidence of the direct relationship between external technology acquisition and firm performance per se (as of value added), when examining Taiwanese electronics-manufacturing firms in the period 1998-2002. Moreover, these studies do not consider the impact of R&D strategies in different terms, nor the combined effect of externalization and internalization of technology on firm performance. This comprehensive view is important, as R&D strategies may serve to different purposes over time. While short-time considerations resolve typically around current market positions (e.g. reaction to competitors), long-time horizons may be connected to the development of new capabilities and the search for upcoming technological that will shape future offerings.

Our study contributes to the third research stream by addressing these shortcomings. In the following, we theorize about the distinct consequences of internal and external technological sourcing on a firm's short-term and long-term financial performance.

Figure 1 provides an illustration of our theoretical framework:



*Figure 1: Theoretical Model*

## 2.1. Stock market reaction

Internal technology development signals to the market that the company is a frontrunner, i.e. it is a pioneer in the industry leading the creation of technologies that will result in radical product and process innovations. Pioneer advantages include high-quality products, broad product lines and lower prices. As the technological frontrunner moves offensively to be ahead of competition, the market likely expects it to outperform rivals in a number of ways. Frontrunners tend to capture premium market segments, achieve economies of scale, set industry standards, shape consumer

preferences, control distribution channels and thereby gain a strong market position. The favorable reputation frontrunners often enjoy is thus likely to influence positively their market value (Ali, 1994; Zahra, 1996).

Besides, a company that shows technological prowess via its patenting activities signals to the market “good management practices”. It demonstrates not only the efficacy of its technological investments (Zahra, 1996), but also the ability to attract and hire competent R&D professionals and to foster an innovative environment. In opposition to the situation of inward licensing, the company has control, autonomy and understanding over proprietary technology. It is thus able to retain full discretion over strategic decisions that are crucial for its forthcoming technological development and for a sustained competitive advantage (Walter, 2012). In accordance with the resource-based view of the firm (Barney, 1991), the possession of competitive resources (patents) and capabilities (innovation capabilities) generates positive expectations about the firm’s performance.

Lastly, internal R&D generates less uncertainty in the market. The use of internally developed technologies is less uncertain than the use of externally sourced ones because it is contextualized; it does not need to be translated to the company’s needs, routines and competences. As prior research indicates, knowledge is “situated”, in that it is defined in relation to a given social and physical setting (Tyre & Von Hippel, 1997). It is characterized by a certain degree of interdependence in specific contexts that limits its reproducibility and expropriation (Natalicchio et al., 2014). Hence, an internally developed technology is expected to be readily deployed and commercialized. In contrast, external knowledge transactions imply a variety of costs such as transaction costs, entry costs, agency costs, appropriability and integration costs (Arora, Fosfuri, & Roende, 2013; Arora & Gambardella, 2010) that are likely to prolong new product development projects (Knudsen & Mortensen, 2011). When working with externally developed technologies, licensees need to adapt and integrate external technologies into their specific product markets (Huston & Sakkab, 2006; Lin, 2003). Since licensees gain only limited access to licensor’s knowledge (Mulotte et al., 2013), this is a far from a straightforward endeavor, which depends on the licensor’s ability to transfer knowledge and the licensee’s ability to absorb external knowledge (Ceccagnoli & Jiang, 2013).

One visible example is Nokia. On February 11, 2011, it announced a plan to develop a new global mobile ecosystem with Nokia switching its smartphone from its software Symbian to Windows Phone platform. The licensing deal was expected to catapult Microsoft, whose Windows Phone operating system lagged behind Apple, Google Android, RIM and Symbian, into second place worldwide, behind Android. Nokia planned to augment the Windows Phone Operating system

with proprietary software, enabling brand differentiation. After the announcement, shares in Nokia fell 14% (Alcacer, Khanna, & Furey, 2011), indicating that shareholders reacted negatively to the announcement of external technology acquisition.

Taken altogether, our arguments suggest that the global marketplace rewards firms more for developing and protecting technologies than for purchasing intellectual property per se. Thus, we propose:

*Hypothesis 1: Companies that announce internal technology development (patent issues) will capture greater cumulative abnormal returns than companies that announce external technology acquisition (in-licensing deals), all else being equal.*

## **2.2. Future financial returns**

Two main streams of research have analyzed the implications of markets for technologies for a firm's long-term financial performance: the economics and the management literature. As these literatures have arrived at opposite conclusions with respect to the optimal R&D strategy, we develop competing hypotheses accordingly.

The literature on the economics of innovation and technological change emphasizes the long-term and industry-wide consequences of markets for technology that encourage an improved division of labor and learning economies. According to this logic, firms should specialize in the activities in which they enjoy comparative advantage and then trade the outputs of those activities (Arora & Gambardella, 2010; Conti et al., 2013). Even if recognizing the limited transparency and strong inefficiencies of markets for technology (Arora et al., 2001), the more economic-oriented contributions often take technology as easily replicated and transferred, to the extent that it is embodied in blueprints, machines and materials (Lin, 2003). In this way, it supports the organizational separation between the production and the use of technology, also known as "synergetic division of knowledge labor" (Zhao & Chen, 2011). While licensees should carry out only a subset of tasks necessary to introduce a new product (such as manufacturing, assembly and sales), licensors should undertake the initial tasks of a new product development project, such as technical development and product design. By becoming a pure licensing company, for instance, a firm no longer is directly involved in the product market and is increasingly remote from the manufacturing, the design of the product and all other activities in which it is relatively less proficient. From the perspective of economic theories, this is viewed as an efficient and socially

optimal strategy, because any other solution could potentially increase the total cost of innovation and thereby affect the well being of society as a whole. By the same token, a decrease in R&D productivity due to, for instance, low technological opportunities, is expected to reduce the incentives to invest in R&D and increase the relative payoff of external technological sourcing in more developed markets for technology (Ceccagnoli et al., 2010).

The specialization argument finds resonance in the strategy literature too, which advocates for a focus on core competencies. Defined as particular strengths companies have relative to other organizations in the industry, core competencies are alleged to provide the fundamental basis for the provision of added value. Deviating too far from core competencies may, nevertheless, generate lack of clarity and managerial distraction that tend to have harmful consequences for a firm's competitive advantage (Prahalad & Hamel, 1990).

The pharmaceutical industry is an example of a setting where companies enjoy distinct advantage- sourcing and advantage- leveraging advantages along their value chain. Whereas large pharmaceutical firms have advantages in clinical testing, manufacturing and distribution, small biotechnology firms have comparative advantages in generating early stage discoveries (Ceccagnoli et al., 2010; Walter, 2012). Following the economics argument, licensing deals among them is complementary and desirable because these firms benefit from leveraging their distinct competences while accessing those of the other (Zhao & Chen, 2011).

Overall, the main tenet of this literature is that, via vertical specialization, “the overall pie companies produce jointly is larger than it would be if they all internalized both research and commercialization activities” (Conti et al., 2013: 753). Thus, we propose:

*Hypothesis 2a: A combined R&D strategy has inferior impact on long-term financial performance than internal technology development or external technology acquisition carried out independently.*

In opposition to the economics rationale, the management literature advocates for a combined or ambidextrous approach to R&D strategy. Following the logic of openness (Chesbrough, 2003), companies can and should use external ideas and external paths to the market to supplement in-house R&D efforts. Inbound and outbound practices ought to be implemented simultaneously, as a means of accelerating internal innovation processes and of increasing the value of innovative efforts (Chesbrough & Bogers, 2014; Dahlander & Gann, 2010; Fosfuri & Tribó, 2008). In spite of the significant costs related to knowledge absorption, time and managerial attention (Knudsen &

Mortensen, 2011; Keld Laursen & Salter, 2006), open innovation is expected to facilitate access to resources, knowledge and competencies otherwise unavailable to the firm, as well as enable companies to better realize the monetary and strategic potential of the active commercialization of knowledge (Faems, de Visser, Andries, & van Looy, 2010; Gassman, Enkel, & Chesbrough, 2010; Huizingh, 2011). The underlying assumption is that in-house R&D and external sourcing are complementary (Cassiman & Veugelers, 2006).

According to this line of reasoning, decisions related to the governance mode (open vs. closed) should be taken at the problem level, where trade-offs can be best evaluated. Instead of pursuing a specialized R&D strategy, companies should define the optimal governance of innovation depended on the nature of the innovation problem to be solved (Pisano & Verganti, 2008). As each governance form offers access to different types of communication channels, incentives and property rights, it supplements each other (Felin & Zenger, 2014). The use of varied types of solution, i.e. a combined R&D strategy, is thus supported.

Moreover, the open literature defends a balanced view of attitudes to knowledge, according to which companies should search for useful knowledge regardless of its source of origin. Protective attitudes against knowledge sourcing and knowledge sharing in the form of the not-invented-here (NIH) and the not-shared-here (NSH) syndromes are alleged to have detrimental consequences for the innovation performance of firms (Burcharth, Knudsen, & Søndergaard, 2014; Katz & Allen, 1982).

Anecdotal evidence showing substantial increase (nearly 60%) in the R&D productivity of companies that implemented of an open innovation approach (Huston & Sakkab, 2006) further supports the management idea for a combined R&D strategy.

Overall, the main argument of this literature is that, “firms should use external knowledge internally, on the one hand, but also exploit their internal knowledge by selling or sharing it on the other” (Conti et al., 2013:753). Thus, we propose:

*Hypothesis 2b: A combined R&D strategy has greater impact on long-term financial performance than internal technology development or external technology acquisition carried out independently.*

### **3. Data, Variables & Methods**

#### **3.1. Sampling**

Our empirical analysis is based on a dataset of 104 companies that have been selected from the Standard & Poors 500 index (as of 31 December 2006). Widely regarded as the best single instrument of the U.S. equities market, this index includes 500 leading companies listed on the NYSE or the NASDAQ stock market. It selects constituent companies based on their asset and revenue location (U.S. company), level of market capitalization (minimum US\$ 4 billion), public float (at least 50%), financial viability (four quarters of positive reported earnings) and sector representation. The companies were selected for our study according to their sector classification, i.e. if they belonged to the energy, materials or consumer staples sectors in the terminology of the Global Industry Classification Index (GICS). These sectors were chosen because they encompass only manufacturing firms and are characterized by medium-levels of technology intensity. For the purpose of our study, it would be a problem to deal with companies that obtain, for instance, 3,000 patents in a year (as it happens in the electronics, pharmaceuticals and chemical sectors, for instance). In this case, patent announcements would be so common that would hinder us from isolating their effect. The period chosen for analysis is 2006-2012.

The dataset extracted from Standard & Poors 500 index is integrated with information gathered from multiple additional sources, including Compustat, Factiva and United States Patent and Trademark Office (USPTO), using firm level identifiers (gvkey), as explained below.

## **3.2. Variables**

### **3.2.1. Dependent variables**

The two dependent variables of interest are *Cumulative Abnormal Returns*, CARs (first hypothesis), and *Continuous Change in the Company's Market Share* (second hypothesis).

*Cumulative Abnormal Returns* measures how much a stock price deviates from its expected value during an event window (Gulati, Lavie, & Singh, 2009; P. Kale, Dyer, & Singh, 2003). CARs were calculated in the following way: First, for each firm  $i$ , we computed the abnormal returns using the market model (Fama, Fisher, Jensen, & Roll, 1969), which assumes a stable linear relationship between market returns and returns on the financial instrument, as well as accounts for market trends and firm risk. In this way, the market model improves the chances of isolating the effect of specific events (Campbell, Lo, & MacKindley, 1997). To estimate the coefficients  $\alpha_i$  (average return of the firm compared with the market average) and  $\beta_i$  (sensitivity of its return to the market return or risk of the stock), we used ordinary least squares (OLS) with the 200 trading

days in the estimation, which correspond to the interval (-240, -41) according to daily return data from the Center of Research of Security Prices (CRSP) database. Formally:

$$R_{it} = \alpha_i + \beta_i \times R_{mt} + e_{it},$$

where  $R_{it}$  is the return on the stock of company  $i$  on day  $t$ ,  $\alpha_i$  is the intercept,  $\beta_i$  is the systematic risk of stock  $i$ ,  $R_{mt}$  is the daily return of the equally weighted CRSP market portfolio, and  $e_{it}$  is the daily risk-adjusted residual for firm  $i$ . The corresponding estimated return on the stock for firm  $i$  on day  $t$  is given by:

$$\hat{R}_{it} = \alpha_i + \beta_i \times R_{mt}.$$

Next, we calculated the abnormal daily return (AR) of company  $i$  on day  $t$  as follows:

$$AR_{it} = R_{it} - \hat{R}_{it}.$$

Finally, we computed the cumulative abnormal returns (CARs) for each time interval by summing up the abnormal returns within the specific time window (-1,0). As a robustness check, we also considered the [-1,1] and [-3,3] windows.

$$CAR(-1,0) = \sum_{t=-1}^0 A\bar{R}_t$$

Several studies have taken stock market reaction as a measure of value creation (Flammer, 2013; Fosfuri & Giarratana, 2009; Walter, 2012).

The *Continuous Change in the Company's Market Share* in the second year after signing a licensing-in contract or after patenting is the dependent variable that we use to test our second hypothesis. Following a similar approach to Ferrier, Smith, and Grimm (1999), the first step to calculate this variable was to compute the company's market share using the ratio between the company's sales and the total sales in the company's industry reported in Compustat. The industry sales were calculated on the basis of all companies operating within the same four-digit SIC code at year  $t$ . We excluded firms for which information on sales was missing. Our final measure is derived from the differences in the logarithm of the company's market:

$$\text{Continuous Change in Market Share} = \ln(MS_{t+2}) - \ln(MS_{t+1})$$

where  $\ln(MS_{t+2})$  represents the company's market share in the second year after signing the license-in contract or after patenting; and  $\ln(MS_{t+1})$  the company's market share in the first year.

Due to skewness in the market share data, a logarithmic transformation was applied. This measure can be interpreted as yielding positive values when there is an increase in a firm's relative market share, and as yielding negative values when there is a decrease in a firm's relative market share after two years. One potential issue in estimating the relative changes in the company market share after an inward licensing or a patent announcement regards the fact that a firm already experiencing performance problems may also be more likely to engage in licensing deals or patents which would produce biased estimates due to simultaneity (Verbeek, 2000). In order to try to deal with this problem, we added the change on the company market share in the previous year as one of the predictors that should capture the effect of the past performance on the subsequent changes in the licensor market share. As a robustness check, we also applied the Wooldridge (2002) test for autocorrelation in panel data and the estimators indicated no evidence of first-order autocorrelation.

### **3.2.2. Independent variables**

Our main independent variables are *external technology acquisition* and *internal technology development*.

*External technology acquisition* is measured by the number of inward licensing agreements available in the press. The data originates from the Factiva database, a comprehensive database of global news and business information that includes local newspapers, same-day newswires, company reports and media programs. Factiva contains business news from more than 14.000 news sources, 12.000 websites and 4.000 blogs, covering sources from more than 159 countries in 22 languages. In a recent study, Flammer (2013) has attained the high accuracy and reliability of the data contained in this database.

Using the Factiva database, we extracted related news articles in the period of interest (2006 – 2010) using the following search term: "company name" near30 "licensing agreement". The resulting hits were all individually examined by a specially trained graduate research assistant and scrutinized for information regarding licensing agreements. The codification captured the names of the licensor and licensee and the date of announcement. Further, two dummy variables captured whether the license is a cross-licensing agreement and whether the agreement is an amendment. Finally, to the degree possible, the economic conditions and the content of the licensing agreements were obtained. There were 96 licensing agreements identified from our searches, where 57 covered inward deals and 39 covered outward deals. However, after matching our database with the one of

CRSP, we lost 3 observations<sup>2</sup>, resulting in a final dataset with 54 inward licensing deals. One concern with this analysis is that we only capture the tip of the iceberg with regards to the actual number of licensing agreements, as we may suspect that not all licensing agreements are reported in the media and therefore not included in our dataset (it is not compulsory for companies to report licensing revenues as a separate item in the income statement). However, as Schilling (2009: 258) claimed, “even though each database only captures a sample of alliance activity, it may yield reliable results for many – if not all – purposes”. In this study, the fact that we could not measure all licensing agreements goes against our research in that we have a conservative measure. Specifically, if we are not identifying all the licensing agreements, we are not considering all these “increases” in the stock market. In consequence, the “normal” returns used to make the prediction should be greater than in the case of identifying the whole population and, therefore, obtaining significant “abnormal returns” should be more difficult for us.

*Internal technology development* is proxied by patents granted by the USPTO in the period of interest (2006-2010). Patents are preferred over R&D investments because they constitute an output measure related to a firm’s innovation efforts (and not an input measure). Even if a limited amount of a firm’s internally developed technologies is granted exclusive property rights, patents provide a suitable approximation for in-house inventive activity. As our dataset contains exclusively American companies, we deemed appropriate to only include patents granted by the American patent office (in line with previous studies such as Fosfuri and Giarratana (2009)). In the electronic USPTO patent database (<http://patft.uspto.gov/netahtml/PTO/search-bool.html>), we used two terms in our query, accordingly: 1) "company name" in "assignee name" and 2) "1/1/2006->12/31/2010" in "issue date". Using a web crawler, we searched the USPTO database using the terms described above for each of our sample companies. These searches resulted in more than 24.000 patents. Using the web crawler, we extracted the relevant information for each patent, e.g. date granted, US patent number, US class, assignee name. Due to the nature of the search term, a number of patents from companies with names similar to those of our sample companies were collected, as were patents registered to subsidiaries and joint ventures of our sample companies. To clean these patents from our sample, we manually examined the extracted data. Patents registered to subsidiaries or companies with similar names were removed from the sample. In the cleaning process, we considered that 'name of the company'='name of the company+ co'='name of the company+ company'. After cleaning the data, we had 13.398 patents. However, after the matching

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<sup>2</sup> We lost three observations because three licensing agreements were announced during weekends. As stock market is closed we decided not to use the next labor day to avoid capturing unrelated events.

with CRSP, our final sample is equal to 12.270 patents. For the event study conducted for Hypothesis 1, we considered only one observation per day for a more conservative measure (for the cases in which a company had several patents issued in the same day), what further reduced our sample to 4.547 patents.

### **3.2.3. Control variables**

Data on control variables was gathered primarily from the Compustat database. A number of control variables related to firm characteristics and investments have been included in the second part of the analysis focused on future returns, namely *firm size*, *firm age*, *firm sector*, *investments* and *year*. We have controlled for *firm size* by using the natural logarithm of number of employees available in Compustat, as larger firms are expected to deter a bigger portion of the market due to potential benefits of economies of scale. *Firm age* was defined as the natural logarithm of years since its foundation, computed by the following difference: 2006 (first year of analysis) minus the foundation year of each company. Data on the foundation year was gathered via Internet searches in the companies' websites and Wikipedia. Older companies who have been operating for longer time are likely to possess larger market shares (e.g. acquired via brand differentiation or learning economies). To account for our cross-industry approach, *firm sector* was computed by using two dummies related to the sector classification in the Standard & Poors 500 index (energy, materials or consumer staples); where 1= if the company belonged to a given sector; 0= if it did not belong. *Investments* were measured as capital expenditures and acquisitions, as provided by Compustat. As they refer to the purchase of assets other than technology to provide future income, they represent other growth strategies that may affect a firm's potential market share. Specifically, capital expenditures represent the funds used for additions to property, plant, and equipment, excluding amounts arising from acquisitions and including property and equipment expenditures. Acquisitions, in turn, refer to the fixed assets of purchased companies. Finally, *year* dummies were included to account for our longitudinal approach.

### **3.3. Methods**

Regarding the first hypothesis, whose objective is to capture the stock price reactions to licensing announcements and patent issues, we ran an event study using the Eventus Software. This package performs event studies using data read directly from CRSP stock databases. In order to run the event study, we examined the stock price reaction by analyzing the average CARs during the

event window. These CARs captured how much the stock price deviated from its expected value on the day of the licensing or patenting announcement. This methodology relies on the assumption that stock markets are efficient and that prices perfectly reflect all public information related to the prospects of the company. Thus, the effect of a specific event should be reflected almost immediately in the stock market. That is, when an event occurs, the market updates its forecast, causing a shift in market value.

To avoid including unrelated events that might influence stock returns, the event window needs to be sufficiently narrow (Gulati et al., 2009). A common approach is to set the event day (day 0) as the day of the announcement and to consider the possibility that the event might have happened on the previous day, before the stock market closed (day -1) (MacKinlay, 1997). Previous research has indicated that a two-day window is more effective for capturing stock market reactions than longer windows, since longer windows are more likely to capture confounding effects that make difficult to obtain reliable statistical inference (Crutchley, Guo, & Hansen, 1991). We therefore use the two-day event window (-1,0) as our main specification. Yet, as our study relies on the announcement date of corporate news (in the case of the licensing deals), which may not necessarily be the date of the actual event, we may run into the problem of “event uncertainty”. To deal with this potential drawback, we followed previous literature on event studies (e.g. Flammer, 2013) and expanded the event window. Thus, as a robustness check, we also considered the three-day (-1,1) and six-day (-3,3) windows.

To determine if the resulting mean CARs differed significantly from zero, we performed two different tests. One of them is parametric: Patell Z test (Patell, 1976), while the other one is non-parametric: Generalized Sign Z (Cowan, 1992). After analyzing the significance of the cumulative abnormal returns, a necessary next step is to discern if the differences between the mean CAR of the compared groups are significant. We used the t-statistic to compare the means between two groups.

In order to test our second hypotheses, we used a fixed effects model as a way to account for the substantial unobserved firm heterogeneity that commonly affects studies dealing with corporate performance measures (Coles, Lemmon, & Felix Meschke, 2012). Indeed, to test whether the use of fixed effects is appropriate, we applied a Hausman (1978) test. The results indicated significant differences between the random and fixed effects estimators ( $\chi^2 = 11.69$ ,  $p < 0.005$ ), confirming the suitability of fixed effects. Finally, robust standard errors were used to rule out heteroskedasticity concerns (Wooldridge, 2002).

## 4. Results and Discussion

Table 1 provides the means, standard deviations, and Pearson correlation coefficients of the variables used in the fixed effects model. The correlation does not warrant further examination with respect to multicollinearity. Additionally, the maximum variance inflation factor (VIF) associated with any of the independent variables was 1.46 (mean VIF = 1.18), which is well below the rule-of-thumb value of ten (Wooldridge, 2012).

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Insert Table 1  
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### 4.1. Short-term effects

Our analysis starts with the event study to test Hypothesis 1, concerning whether companies capture higher cumulative abnormal returns with the announcement of patent issues than with the announcement of licensing agreements.

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Insert Table 2  
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The results are presented in Table 2. For each event window, we report the mean CAR as percentage, counts of positive and negative individual CARs, their corresponding Patell z-statistics and Generalized Sign Z. For patent issues, the average CAR in the main event window is 0.10 percent and significant at the 0.001 level (Patell  $z = 3.573$ ). It is also significant under the Generalized Sign Z test (5.071) at the 0.001 level. For licensing agreements, the average CAR is also positive (0.60 per cent) and significant under all tests (Patell  $z = 2.880$  at 0.01 level and Generalized Sign Z test =1.787 at 0.05 level). Our results thus indicate that, in the short-term, companies capitalize on both developing and acquiring technologies. They resonate the findings of Walter (2012), who analyzed the effects of inward and outward licensing transactions on abnormal stock market returns in the US computer and pharmaceutical industries for the period 1990-2000. Table 3 breaks down these results by sector. It reveals that the announcement of licensing agreements in the consumer staples and energy sector yields the highest returns in the stock market, in comparison to the materials sector (for which it is not significant).

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Insert Table 3  
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In order to test the difference of CARs between the announcement of patents and licenses, we ran a t-test that compares the mean CARs resulting from licensing-in with the mean CARs resulting from patenting. The null hypothesis is that the mean CARs of both groups are not different. The t-test is equal to 5.3524 and we reject the null hypothesis at the 1% level, suggesting that the CARs from both groups are statistically different and that the effect of announcing licensing-in in the stock market is stronger than the effect of announcing patents.

Hence, these findings lead to the rejection of *Hypothesis 1*. Contrary to our expectations, shareholders react less positively to the announcement of internal technology development than to the announcement of external technological acquisition. This may reflect the preference of the market of legitimized technologies. While licensed technologies are proven to work (sanctioned technologies that have been accepted by others), this is not necessarily the case of new inventions that have just been patented. Widely applied as instruments of market protection, many patented inventions are never put into practice. This surprising result may also be seen as a consequence of the “institutionalization” of open innovation (Chesbrough & Bogers, 2014). There has recently been a lot of media attention towards openness (e.g. Pisano & Verganti, 2008), where firms are facing increasing external pressure to comply with an open approach to R&D strategy. This high external pressure may amplify shareholders’ positive reaction to the announcement of open practices such as inward licensing. Another possible explanation is that, by purchasing the newest technologies in the market, companies signal to shareholders their effort to be up-to-date with technical developments and thus commitment to be at the technological frontier. Moreover, as they are willing to use outside knowledge, they show that they do not suffer from NIH tendencies.

#### **4.2. Long-term effects**

Hypotheses 2 tests the two opposite implications of markets for technologies for a firm’s long-term financial performance that were previously pointed in the literature: economics vs. management literature. The panel data analysis based on the fixed effects model is presented in Table 4, where models 1 and 2 include the control variables and the direct effects of the independent variables and model 3 incorporates the interaction effect. A hierarchical approach is thus followed, as this is a relatively conservative approach that evaluates the statistical significance of interaction terms after controlling for lower-order effects (Frazier, Tix, & Barron, 2004; Hayes, 2013)

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Insert Table 4

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The results of Table 4 reveal that neither the coefficient of number of patents, nor the coefficient of number of inward licensing agreements were significant in Models 1 and 2 (at the 5% significance level), indicating that separate R&D strategies do not influence the growth of a company's market share in isolation. These findings are in line with Tsai and Wang (2008), who discovered a non-significant effect of external technology acquisition on firm value added for a sample of 341 Taiwanese electronics-manufacturing firms in the period 1998-2002. The lack of evidence of a direct association between the independent variables and the dependent variable is not a concern for our analysis. We follow Hayes (2013), who strongly encourages the test of moderation even in the absence of significant direct effects, which are “not required for moderation analysis” (p. 223). In fact, the results of Model 3 show that the coefficient of the interaction term between the number of licensing-in and the number of patents is negative ( $\hat{\beta} = -0.00210$ ) and significant at the 1% level, suggesting contrary to our expectations, that the combination of R&D strategies has a negative impact on the growth of a company's market share in a two-year time lag. Thus, they lead to the confirmation of *Hypothesis 2a* (the economics argument) and to the rejection of *Hypothesis 2b* (the management argument).

### 4.3. Sensitivity analysis

As a robustness check, we have also checked the results using binary variables. Given the nature of our independent variables, we found it appropriate to recalculate our model, treating them as dummy variables (where 1= if a firm had a patent/license; 0 =if a firm had no patent/ license). As Table 5 shows, results are robust across the two model specifications and thus validate our findings. The direct effects of inward licensing and patenting are not significant, while the interaction term between them is negative ( $\hat{\beta} = -0.301$ ) and significant at 10%, what confirms Hypothesis 2a.

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 Insert Table 5  
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## 5. Conclusions (preliminary)

A lively scholarly debate exists around the role played by inputs used for firms to expand technological knowledge for innovation, where internal R&D investments and external technology acquisitions are seen as important strategies for developing new products and processes. The

objective of this paper is to empirically evaluate the short-term and long-term impacts of a firm's inward licensing and patenting activity on performance. As most extant research has investigated the trade-offs between internalizing and externalizing knowledge sourcing in isolation, an additional objective is to assess the results of a combined R&D strategy.

Both internal technology development and external technology acquisition were found to yield positive market reactions in the short-run. Companies capture nevertheless higher cumulative abnormal stock market returns when purchasing intellectual property than when developing and protecting technologies per se. However, in the long run patenting and in-licensing lead to a relative decrease in the companies' market share when performed simultaneously. These findings have implications for theory and practice.

From a theoretical perspective, our study contributes to the literature on technology markets and innovation management in two important ways. First, it expands the analysis of outcomes of technology markets by relating theoretical arguments explaining the benefits and costs of internal and external knowledge sourcing to abnormal stock market returns and changes in relative market share. In this way, it provides a comparative analysis of the differing outcomes in the short and in the long term. Second, our study provides an empirical test of opposing arguments related to the performance implications of a combined approach to R&D strategy, where a portfolio of in-house technology development and external technology acquisition is considered simultaneously. We found support for the economics argument, according to which a combined R&D strategy yields inferior returns to long-term performance. Put differently, firms are better off if they specialize in the activities in which they enjoy comparative advantages. In this way, it questions the highly popular open innovation approach (Chesbrough, 2003), which argues for an ambidextrous R&D strategy.

From a practical perspective, our study prompts managers to be cautious in delineating their R&D strategies. Even though internalization and externalization may generate immediate positive returns, they may not pay off in the future. They are encouraged to reflect upon a specialized R&D strategies based on the companies' core competencies – either developing and selling technologies or purchasing and commercializing them.

Our study has nevertheless a number of noteworthy limitations. Our sample is restricted to large American firms and should be replicated in other contexts in order to validate our findings. Besides, long-term financial performance may be assessed in a number of ways. While we consider relative changes in a company's market share a valid measure, as it assesses performance relative to

prior performance and to other competitors in the industry, additional performance variables such as value added should be tested as to confirm our findings. Besides, our measure of external technology acquisition unlikely captures all inward licensing agreements of the sampled companies. More complete license databases are not available and constitute a noteworthy effort for future scholarly work. Additionally, the use of patents as an indication of internal technology development remains a first approximation. Not all internally developed technologies are patented and inter-firm differences are also subject to differing IP strategies.

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## Tables

**Table 1. Descriptive Statistics and Pairwise Correlations**

Variable	Obs	Mean	Std. Dev.	Min	Max	GMS (2lags)	PAT	LICIN	PAT*LICIN	EMP	AGE	CE	ACQ	GMS (1lags)
Growth Market Share (GMS2l)	342	0.001496	0.5021776	-3.723231	3.879266	1								
Number Patents (PAT)	630	20.12381	71.82338	0	597	-0.0876	1							
Number Licensing in (LICIN)	630	0.0888889	0.3499312	0	4	-0.1519	0.2603	1						
Dummy: PAT*LICIN	630	8.320635	92.3228	0	1680	-0.283	0.4686	0.6104	1					
Logarithm of Employees (EMP)	630	3.091741	1.225205	0.2231435	7.649693	-0.0038	-0.1218	-0.0439	-0.0682	1				
Logarithm of Age (AGE)	623	4.018186	1.035122	0	5.393628	-0.0039	-0.0936	0.0432	-0.0274	0.0211	1			
Capital Expenditures(CE)	555	427.1212	3574.371	9.6	26871	-0.0287	-0.0601	0.0154	-0.0153	0.2021	-0.0241	1		
Acquisitions (ACQ)	745	395.6766	1599.526	-204	21087	0.0234	0.1614	0.01	0.0042	0.0343	-0.0014	0.0948	1	
Growth Market Share (GMS1lag)	435	-0.0066795	0.5078976	-3.723231	3.879266	-0.0569	-0.0732	-0.0301	-0.0409	-0.0929	-0.0231	-0.0128	0.0171	1

**Table 2. CARs around the Announcement of Patents and Licensing-in**

Event Window	Patents Announcement					Licensing In Announcement				
	N	Mean CAR	Positive: Negative	Patell Z	Generalized Sign Z	N	Mean CAR	Positive: Negative	Patell Z	Generalized Sign Z
(-30,-2)	4547	-0.15%	2264:2283	0.088	0.264	54	0.51%	30:24:00	0.639	0.97
(-1,0)	4547	0.10%	2395:2152>>>	3.573***	5.071***	54	0.60%	33:21>	2.880**	1.787*
(-1,+1)	4547	0.07%	2349:2198>>>	2.268*	3.706***	54	0.65%	33:21>	2.538**	1.787*
(-3,+3)	4547	-0.05%	2278:2269)	-0.769	1.600\$	54	0.67%	33:21>	1.720*	1.787*
(+2,+30)	4547	0.11%	2336:2210>>>	2.198*	3.336***	54	1.28%	31:23:00	1.601\$	1.243

**Table 3. CARs around the Announcement of Licensing-in Agreements**

Event Window	Consumer Sector				Energy Sector				Materials Sector			
	N	Mean CAR	Patell Z	Generalized Sign Z	N	Mean CAR	Patell Z	Generalized Sign Z	N	Mean CAR	Patell Z	Generalized Sign Z
(-30,-2)	31	0.80%	0.106	0-710	8	-0.26%	-0.112	-0.067	15	1.61%	1.14	0.868
(-1,0)	31	0.81%	3.048**	2.147*	8	1.41%	1.673*	0.64	15	-0.56%	-0.138	-0.165
(-1,+1)	31	0.66%	2.233	1.429\$	8	1.81%	1.862*	2.055*	15	-0.49%	0.245	-0.165
(-3,+3)	31	0.40%	0.897	1.069	8	3.03%	1.753*	1.347\$	15	-1.05%	0.692	0.868
(+2,+30)	31	1.90%	2.233*	1.069	8	-6.03%	-1.675	-0.775	15	2.62%	1.05	1.384\$

**Table 4. Fixed Effects Regression. DV: Growth of the Logarithm of the Market Share Lagged Two Years. IV: Count Variables. Robust Standard Errors.**

	(1) Growth of the Logarithm of the Market Share Lagged two years	(2) Growth of the Logarithm of the Market Share Lagged two years	(3) Growth of the Logarithm of the Market Share Lagged two years
<i>Number of Patents</i>	-0.000918+ (0.088)		0.000433 (0.306)
<i>Number of Licensing-in Agreements</i>		-0.241 (0.174)	0.0670 (0.112)
<i>Number of Patents*Numbers of Licensing In</i>			-0.00210*** (0.000)
<i>Logarithm of Number of Employees</i>	-0.00233 (0.903)	-0.00327 (0.874)	-0.00159 (0.933)
<i>Logarithm of Age</i>	-0.0129 (0.423)	0.00246 (0.870)	-0.00180 (0.902)
<i>Capital Expenditures</i>	-0.00000701 (0.276)	-0.00000482 (0.497)	-0.00000709 (0.270)
<i>Acquisitions</i>	0.0000110 (0.710)	0.0000128 (0.661)	0.0000187 (0.525)
<i>Previous Growth</i>	-0.0726* (0.012)	-0.0669* (0.015)	-0.0779** (0.005)
<i>Year dummies</i>	YES	YES	YES
<i>Constant</i>	-0.0258 (0.770)	-0.0777 (0.392)	-0.0676 (0.438)
<i>Number of Observations</i>	303	303	303

*p*-values in parentheses

+  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**Table 5. Fixed Effects Regression. DV: Growth of the Logarithm of the Market Share Lagged Two Years. IV: Binary Variables. Robust Standard Errors.**

	(1) Growth of the Logarithm of the Market Share Lagged two years	(2) Growth of the Logarithm of the Market Share Lagged two years	(3) Growth of the Logarithm of the Market Share Lagged two years
<i>Patenting Dummy</i>	-0.0327 (0.557)		-0.00731 (0.894)
<i>Licensing-In Dummy</i>		-0.0737 (0.555)	0.170 (0.201)
<i>Patenting Dummy*</i> <i>Licensing-In Dummy</i>			-0.301+ (0.091)
<i>Logarithm of Number of Employees</i>	0.000365 (0.985)	-0.000344 (0.986)	-0.000621 (0.974)
<i>Logarithm of Age</i>	-0.00426 (0.762)	-0.00331 (0.819)	-0.00312 (0.831)
<i>Capital Expenditures</i>	-0.00000626 (0.352)	-0.00000522 (0.429)	-0.00000530 (0.452)
<i>Acquisitions</i>	0.0000109 (0.714)	0.0000109 (0.714)	0.0000122 (0.682)
<i>Previous Growth</i>	-0.0612* (0.037)	-0.0640* (0.023)	-0.0624* (0.039)
<i>Year dummies</i>	YES	YES	YES
<i>Constant</i>	-0.0693 (0.436)	-0.0834 (0.385)	-0.0757 (0.420)
<i>Number of Observations</i>	303	303	303

*p*-values in parentheses

+  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$