Paper to be presented at
the DRUID16 20th Anniversary Conference
Copenhagen, June 13-15, 2016

Hiring New Key Inventors to Improve Post-Merger Innovation

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Abstract

Although mergers and acquisitions (M&As) are acknowledged as an important mean to access innovative assets and know-how, innovation performance often declines in the post-merger period. Reasons identified by the prior literature include financial, managerial and organizational constraints related to the M&A event. In consequence, inventor innovation performance declines and inventors leave the firm. Prior literature treats the acquiring firm as passive observer of inventor departure and innovation declines around the M&A event. This study argues that acquiring firms can take active measures against innovation performance declines by hiring key inventors. Drawing from the knowledge based view of the firm, we first establish that innovation performance declines in the postmerger period stem from two distinctive channels: inventor departure and innovation performance declines of inventors that stay with the firm. We argue and find that the latter effect is much stronger as compared to the well-studied phenomenon of inventor departure. Next, we show that the hiring of key inventors in the post-merger period can counteract these negative effects in two ways: on the one hand, there is a direct effect in the sense that these newly hired inventors increase corporate innovation performance after the M&A. On the other hand, the newly hired key inventors improve the innovation performance of the inventors already working for the acquiring firm hence mitigating the innovation performance decline associated with the corporate restructuring. The results suggest that an appropriate hiring

policy can counteract innovation declines in the aftermath of M&As.

Jelcodes:O32,G34

Hiring New Key Inventors to Improve Post-Merger Innovation Performance

1. INTRODUCTION

Mergers and acquisitions (M&As) are an important mean by which firms can access technological assets and know-how possessed by the acquisition target (Capron et al., 1998; Granstrand and Sjolander, 1990; Arora et al., 2001; Graebner, 2004; Cassiman et al., 2005). Firm acquisitions grant access to technological competencies and capabilities (Granstrand and Sjolander, 1990; Chaudhuri and Tabrizi, 1999) and to essential intellectual property rights (Grimpe and Hussinger, 2008; 2014), therewith complementing or extending the technology portfolio of the acquiring firm (Cassiman et al., 2005; Ahuja and Katila, 2001; Cloodt et al., 2006).

The expected benefits of M&As for innovation notwithstanding, most empirical studies report innovation performance declines in the post-merger years (see Veugelers, 2006, for a survey) due to a shift of managerial attention from daily business activities and innovation to the M&A event (Hitt et al., 1990), merger-induced financial constraints (Hitt et al., 1996) or organizational and cultural differences between target and acquiring firm (Chatterjee, 1986; Hitt et al., 1991). These implications of the M&A invent hamper the innovation performance of the individual inventors in the firm. According to the individualist tradition of the knowledge-based view of the firm (KBV) (Felin and Hesterly, 2007), individual talents are the sources of knowledge and innovation (Grant, 1996; Hoskisson et al., 1999), while firms facilitate the exploitation of their knowledge by developing routines which in turn define the context in which knowledge workers carry out their own routines (Nelson and Winter, 1982; Cyert and March, 1963). M&As and their organizational implications constitute a disruption to these

routines which creates uncertainties regarding job security and task definitions and therewith induce demotivation and cognitive barriers to knowledge exploitation (Minbaeva et al., 2003; Jensen and Szulanski, 2004). Inventors react with innovation performance declines or departure (Ernst and Vitt, 2000; Paruchuri et al., 2006; Kapoor and Lim, 2007). Prominent examples for key innovation employees leaving the firm around an M&A event include the acquisition of Gillette by P&G in 2005 (Kanter, 2009) and the acquisition of Pixar by Disney in 2006 (Ganco et al., 2015).

Prior studies that focus on the effects of M&As on innovation performance treat acquiring firms as passive observers that need to accept inventors' departure and innovation performance declines of incumbent inventors. We argue that acquiring firms can take active measures against innovation performance declines such as hiring key inventors in order to counteract innovation performance losses (Aggarwal and Hsu, 2012). Drawing from KBV, we argue that the hiring of key inventors has two effects on post-merger innovation performance. First, newly hired key inventors constitute new and superior sources of knowledge, strengthening the knowledge base of the acquiring firm. Hence, they are expected to have a direct positive effect on the innovation performance of the acquiring firm after the M&A. Second, we derive from KBV and the theory of organizational learning that there is an important indirect effect in the sense that these newly hired talents improve the innovation performance of incumbent inventors.

The contribution of our paper to the literature on M&As and innovation is twofold. First, we study the effect of M&As on the innovation performance of the acquiring firm through a KBV lens (Simon, 1991; Kogut and Zander, 1992; Grant, 1996). The KBV provides an alternative to firm level explanation for the often observed innovation performance declines after M&As, employing the inventor as the major source of knowledge and treating the M&A as a disruption to the knowledge exploitation procedure (Paruchuri et al., 2006). We add to the prior literature that focuses on inventor behavior around M&As (Ernst and Vitt, 2000; Paruchuri et al., 2006;

Kapoor and Lim, 2007) by disentangling different channels for the decline in post-merger innovation performance. We distinguish between inventor departure and innovation performance declines of incumbent inventors that stay with the merged entity. Moreover, we derive that the effect on innovation performance of the inventors that stay within the firm should be larger than the well-researched effect of inventor departure. This is an interesting finding given that prior literature pays a lot of attention to the consequences of inventor departure after M&As (Ernst and Vitt, 2000; Kapoor and Lim, 2007; Larsson and Finkelstein, 1999). Second, from the assumption that the inventor is the source of knowledge we derive that firm's can take means to counteract innovation performance declines in post-merger periods. We demonstrate that the hiring of key inventors has important direct and indirect effects on post-merger innovation performance where the latter effect refers to a positive effect of new key inventors' on incumbent inventors 'contribution to the firm's innovation performance. These results indicate that an appropriate human capital strategy around the M&A can help avoiding a temporary decrease in innovation performance in the post-merger period. Our findings have important practical implications for executives being involved in an M&A.

The remainder of the paper is organized as follows. The next section provides a review of the existing literature and derives our hypotheses. Section 3 describes the database and the definitions of the variables. The following section presents the empirical strategy and the regression results. The last section concludes.

2. THEORY DEVELOPMENT & HYPOTHESES

The knowledge production process

The knowledge-based view of the firm (KBV) recognizes knowledge as the most important strategic resource for the firm (Grant, 1996), pointing out the essential role of knowledge in value creation and for achieving a competitive advantage (Barney, 1991; Felin and Hesterly,

2007). Individuals are viewed as the sources of knowledge, while the role of organizations is knowledge application (Grant, 1996). Acknowledging that knowledge and creativity are embodied in talented people (Rao and Drazin, 2002), individual talents and human capital deserve important attention as key ingredients to the knowledge creation process (Kogut and Zander, 1992; Zucker et al., 2002; Song et al., 2003). Firms present a platform that allows individuals to interact and to exchange knowledge (Grant, 1996). Through an emerging common knowledge base, individuals have access to the knowledge of each other (Grant, 1996). The common knowledge base permits the individuals to share and integrate aspects of knowledge that are not common between them. The process of transferring knowledge, skills and talents of people into innovations is, however, complex. KBV argues that knowledge characteristics such as tacitness (Zander and Kogut, 1995), complexity (Hansen, 1998) and causal ambiguity (Szulanski, 1996), as well as difficulties in establishing interpersonal interactions (Szulanski, 1996) impede the transfer of knowledge.

Firms facilitate the process of knowledge exploitation by defining a context and organizational routines in which knowledge workers carry out their own routines (Nelson and Winter, 1982; Cyert and March, 1963). Routines provide guidedance for the individuals within an organization and in order to facilitate coordination (Winter, 1986; Kapoor and Lim, 2007). Inventors get used to work within the context of these routines, which include the physical setting as well as formal and informal procedures and communication flows (Szulanski, 2000). Even though routines can be simple sequences, they are able to support complex patterns of interactions between individuals (Grant, 1996), making them key in the knowledge production process (Levitt and March, 1988). M&As constitute a disruption to these routines, inducing uncertainties and task-outcome ambiguity for inventors and other employees, impeding the process of knowledge integration with implications for their productivity (Ranft and Lord, 2002; Ranft and Lord, 2000; Ernst and Vitt, 2000; Kapoor and Lim, 2007).

The impact of M&As on innovation performance

Prior studies have largely documented the negative impact of M&As on corporate innovation performance (e.g. Prichett, 1985; Ravenscraft and Scherer, 1987; Cassiman et al., 2005, see Veugelers, 2006, for a survey of the literature). This decline of innovation performance can be traced back to several firm level factors: First, managerial attention shifts away from daily activities and R&D to the M&A event (Hitt et al., 1990). Second, from a financial point of view, the pressure imposed by the acquisition investment (Miller, 1990; Hitt et al., 1991) and the introduction of cost saving programs aimed at eliminating duplicative research efforts (Lengnick-Hall, 1991; Veugelers, 2006) may induce cutbacks of R&D budgets. Finally, insufficiently planned and poorly executed post-merger integration has shown to hamper inventor innovation performance significantly (e.g. Jemison and Sitkin, 1986; Haspeslagh and Jemison, 1991; Pritchett, 1985). These effects are stronger in the presence of cultural and organizational differences between acquirer and target as well as low technological proximity (Ernst and Vitt, 2000; Ahuja and Katila, 2001; Cassiman et al., 2005).

These firm level factors affect the performance of individual inventors by impeding inventors' routines and organization environment. The post-merger integration process typically goes along with strategic reconfigurations and restructuring activities (Karim and Mitchell, 2000), higher fluctuations rates of personnel and changes in job definitions and positions (Walsh, 1988; Ernst and Vitt, 2000) that may create a sense of dislocation and even trauma (Cartwright and Cooper, 1993; Paruchuri et al., 2006). Inventors within the acquiring firm become concerned about the future strategic direction of the firm and the implications for their employment safety and the future definition of their position within the firm and their tasks (Souder and Chakrabarti, 1984). The psychological reactions generated by the disruptive nature of the merger event limit the cognitive ability of inventors and their capability to deal with and process

new information (Fugate et al., 2008). Inventors' attention is focused on coping with the disruptive situation rather than processing work-related information (Staw et al., 1981; Fugate et al., 2008). This creates a cognitive barrier to the exploitation of the inventors' knowledge (Minbaeva et al., 2003; Jensen and Szulanski, 2004) which impedes the individuals' incorporation of new information and the exploitation of the existing knowledge. Thus, the productivity decline of the individual inventors that remain in the firm decreases acquiring firms' innovation performance in the post-merger period.

Baseline Hypothesis 1: A decline of acquiring firms' post-merger innovation performance is associated with an innovation performance decline of the incumbent inventors that remain in the firm.

Financial cutbacks and elimination of redundant activities imposed after the M&A (Hitt et al., 1991; Lengnick-Hall, 1991) may translate in layoffs or relocations of inventors. This uncertainty as well as the organizational changes accompanying the merger can result in the departure of R&D employees (Ernst and Vitt, 2000; Paruchuri et al., 2006; Kapoor and Lim, 2007). Because the locus of knowledge resides on individuals (Simon, 1991; Grant, 1996), the unintended departure of inventors implies an immediate loss of knowledge and human capital, which affects the post-merger innovation performance of the firm (Ernst and Vitt, 2000).

Baseline Hypothesis 2: A decline of acquiring firms' post-merger innovation performance is associated with inventor departure.

Inventor departure has gained a lot of attention in the previous literature (Ernst and Vitt, 2000; Paruchuri et al., 2006; Kapoor and Lim, 2007; Hussinger, 2010). From a KBV perspective, this effect is rather straightforward because the loss of inventors implies a loss knowledge (Simon, 1991). However, because of inventors' interactions within the firm, knowledge of departing inventors is not completely lost, but partly remains in the firm as it has been transferred to the

leaving inventor's coworkers. On the one hand, explicit knowledge is shared via communication (Polanyi, 1962; Zander and Kogut, 1995). On the other hand, tacit knowledge is also transferred to some extent within the firm as individuals are exposed to the tacit knowledge of each other which they observe in applications or by working together (Grant, 1996). In this way, by the voluntary cooperation and interaction of individuals knowledge is also embedded in the organizations (Kogut and Zander, 1992).

A productivity decline of the inventors that remain in the acquiring firm might be much more important, in contrast. The uncertainties that the M&A event creates and the resulting decrease in motivation and raise of cognitive barriers can block the knowledge creation of all remaining inventors rendering access and exploitation of their own knowledge and the knowledge that they acquired from their departing colleagues. Thus, we hypothesize:

Hypothesis 1: The decline of acquiring firms' post-merger innovation performance is more strongly associated with incumbent inventors' innovation performance decline than with inventor departure.

The effect of newly hired key inventors on post-merger productivity declines

While providing ample evidence on post-merger innovation performance declines and their causes (e.g. Ravenscraft and Scherer, 1987; Hitt et al., 1991; 1996; Ernst and Vitt, 2000; Paruchuri et al., 2006; Kapoor and Lim, 2007), the previous literature is silent about possible remedies that can be employed by the acquiring firm. We suggest the hiring of key inventors as one specific mean acquiring firms can employ to counteract post-merger innovation performance declines.

Individuals have been shown to be heterogeneous in terms of the knowledge they possess (Zucker and Darby, 1995; Zucker et al., 1998). Accordingly, the innovation performance distribution of inventors is highly skewed (Lotka, 1926; Price, 1965; Narin and Breitzman,

1995). Within each technological domain and each organizational context, there are some key inventors that are crucial for the process of innovation creation due to their superior technical knowledge and expertise (French and Raven, 1959), but also because of the tacit knowledge they carry (Zucker et al., 2002; Hess and Rothaermel, 2011). The significance of key scientists is widely acknowledged. Zucker and Darby (1995), for instance, highlight the importance of a few key individuals in embodying and generating knowledge contributing to the emergence of entirely new industries such as the biotech industry.

Acquiring firms can hire new key inventors[1] to actively counteract an innovation performance declines after M&As. Newly hired key scientists are expected to positively contribute to the process of organizational learning and knowledge creation, in particular, thus having an important effect on post-merger innovation performance. The reason originates from the principles of organizational learning which can take place either by the inclusion of new members carrying knowledge new to the organization or by the learning of its members (Simon, 1991).

In line with the theory of organizational learning, we argue that the effect of newly hired key inventors is twofold (Simon, 1991). On the one hand, newly hired key inventors are expected to have a positive direct effect on the innovation performance of the acquiring firm, since they represent new knowledge to the firm that can be exploited. The expected positive direct effect of newly hired key inventors on post-merger innovation performance is grounded in key scientists' superior previous past performance, skills endowment and talent. The hiring of key inventors will provide acquiring firms with access to these skills, competencies and experiences (Rao and Drazin, 2002) and also to the knowledge gathered at their former employer (Barney,

[1] We refer here to the hiring of key inventors that are external to both the acquiring and acquired firms.

1991). As an additional input to the firm's knowledge production process we expect a positive effect on the firm's innovation performance. Hence, we hypothesize:

Hypothesis 2: Newly hired key inventors are positively associated with the acquiring firm's post-merger innovation performance (direct effect).

One the other hand, newly arriving key inventors are expected to have a positive impact on the innovation performance of incumbent inventors at the acquiring firm that are often found to experience an innovation productivity decline after an M&A, through the mechanism of internal learning or transmission of information within members of the organization (Simon, 1991). KBV research of organizational learning has explored the mechanisms of transfer and diffusion of knowledge within organizations (Simon, 1991). Levitt and March (1988) explore different processes of diffusion of knowledge and point out that transmission of information takes place in a similar way to the spread of a disease. Thus, the movement of personnel, which facilitates the contact between incumbent inventors and newly hired inventors, is the mechanism that favors the transmission of knowledge and organizational learning (Biggart, 1977). Moreover, inventors learn about innovation routines from incumbent inventors so that the knowledge creation process is affected by the relations between inventors within a firm (Kogut and Zander, 1992).

This transmission mechanism is documented in prior empirical literature (e.g., Sacerdote, 2001; Mas and Moretti, 2009; Paruchuri, 2010).[2] Prior studies argue that social interactions between inventors are an important channel to knowledge recombination (Nerkar and Paruchuri, 2005) and knowledge spillovers (Zucker and Darby, 1997). Since a newly hired key inventor is likely to receive a key position within the acquiring firm she will be in contact with many other

[2] Other studies that relate to the influence of key inventors on their colleagues are: Azoulay et al. (2010) show that the productivity of peers decreases by 5%-8% if a star collaborator dies unexpectedly; Oettl (2012) shows that the negative effect refers in the first place to the quality of the scientists's output; Waldinger (2013) shows long-lasting effects on the quality of recruits of star dismissals in Nazi Germany.

inventors within the firm. Accordingly, the newly hired key inventor has more channels for knowledge dissemination as compared to inventors in less central positions so that the newly acquired knowledge can spread fast throughout the organization (Bonacich, 1987; Krackhardt, 1990). Thus, we expect that newly hired key inventors disseminate their knowledge within the organization fast and effectively.

The arrival of new key inventors can counteract the discouraging effect of the M&A event on the inventors at the acquiring firm. First of all, the hiring of key inventors emphasizes the importance of innovation for the firm during the merger period so that incumbent inventors' uncertainty about their future is reduced. Second, the new key inventors can spur the motivation of inventors at the acquiring firm because scientists have a strong preference to work with higher qualified colleagues (Barabasi et al., 2002; Wagner and Leydesdorff, 2005). Third, the new key inventors can leverage their position and resource access to reduce task and job insecurity among the inventors. This is because key inventors provide new leadership and strategic direction to their peers (Paruchuri, 2010; Kehoe and Tzabbar, 2015). We thus hypothesize:

Hypothesis 3: Newly hired key inventors are positively associated with the contribution of incumbent inventors to the acquiring firm's post-merger innovation performance (indirect effect).

3. METHODS

Data set

The analysis is based on a large, tailor-made dataset set that draws from several different databases. It includes information on all publicly listed U.S. firms involved in M&As over the period 1980-2010 where at least one of the M&A parties is actively involved in innovation activities in the sense that it has applied for at least one patent at the United States Patent and

Trademark Office (USPTO) since its foundation. Information about the M&A deals is extracted from the database Thomson One Banker provided by Thomson Reuters. We consider only those deals that were completed and which involved majority ownership. The M&A data was linked to firms' financial records which were retrieved from Compustat. The match between the two databases was done based on the firm name, state, CUSIP and PERMNO (taken from the Center for Research in Security Prices (CRSP) database).[3]

Information on the patent activity of firms and inventors is taken from the NBER patent database and the Coleman Fung Institute for Engineering Leadership database (Li et al., 2014)[4]. Patent information is matched to the firm database using each firm's identifiers and name. Also, data on mobility of inventors is also taken from Coleman Fung Institute for Engineering Leadership (Li et al., 2014). This database assigns an inventor id to all individuals that are listed on USPTO patent documents. Based on this ID, inventors can be traced across different organizations by their reappearance on patent documents. We use patent numbers to link the inventors to the different firms and to track their mobility. Throughout the whole linking process, we conducted manual checks for firms for which we discovered missing or ill-defined linkages between the datasets due to misspellings in the firm names or identifiers.

We keep a 4-year window before and after the M&A for our analysis of the merger period. The resulting sample consists of a panel data set including 1,402 deals, corresponding to firms in 62 different industries over a 31-year window.

Variables

[3] The CRSP database tracks companies (including their names and CUSIPs) throughout their life time and provides them with a unique identification (PERMNO). We matched the Thomson Reuters' M&As database and Compustat to CRSP, assigning to both databases' companies a PERMNO. In a next step, we matched Thomson Reuters' M&A database to Compustat via PERMNO. This helped us to recover deals for which the CUSIP changed over time.

[4] Formerly the Patent Network Dataverse from Harvard Institute for Quantitative Social Science.

Dependent Variable

The dependent variable in our model is the firms' innovation performance. Innovation performance is proxied by the number of granted patents per year of the acquiring firm. Patents are an established innovation indicator (e.g. Cohen and Levin, 1989; Griliches, 1990; Archibugi, 1992). Patents reflect the immediate result of R&D activity and hence depict successful R&D projects before the market introduction of the product (Griliches, 1990; Ernst, 1995). We use granted patents and not patent applications because the former is an indicator of successful innovation (Ahuja and Katila, 2001).

Inventor Departure

The dataset provided by the Coleman Fung Institute for Engineering Leadership allows us to trace inventors over time across different organizations (Li et al., 2014). Mobility is defined based on the appearance of inventors of patent documents of different applicants. An inventor is defined to move from firm *i* to firm *j* if after filing the last patent application with firm *i*, he starts filing application with firm *j*, and no longer with firm *i*. We measure departing inventors as the ratio of inventors departing the firm at time *t* over total number of inventors at time *t*. This cascade specification avoids multicollinearity.

Key inventors

Regarding the concept of key inventors, previous literature has employed different definitions. There are studies that classify key inventors in terms of productivity – number of patents granted (e.g. Narin and Breitzman, 1995) –, in terms of quality – number of citations (e.g. Goetze, 2010) –, and others that use a combination of the two (Ernst and Vitt, 2000; Rothaermel and Hess, 2007; Pilkington et al., 2009). We define key inventors relative to the quality - as measured by the number of citations their patents received in the past - of the inventors already working at the acquiring firm.

We chose a citation-based measure for two reasons. First, patent citations have been shown to be a proxy for the market value of innovations (Harhoff et al., 1999, Hall et al., 2005). The market value of her invention contributes to the importance of the inventor for the firm and correlates with her access to resources. Second, forward citations reflect the economic and technological importance as perceived by knowledgeable peers in the same technology field (Albert et al., 1991). The recognition of the so defined key inventor by her colleagues is important for her influence on the colleagues for her firm. On the other hand, in line with Aggarwal and Hsu (2012), we define newly hired key inventors relative to the majority of inventors that are already working for the firm. We prefer this relative definition of key inventors for several reasons. First of all, star inventors in their field of technology as defined by Zucker and Darby (1999, 2001) are rare so that they might not show up frequently in firms involved in M&As. Second, from a conceptual point of view, we are interested in depicting inventors that are key relative to the incumbent inventors within the acquiring firm.

Regarding our specific measure, we identify key inventors as those receiving more patent citations than the top 75% of inventors (between one and two standard deviations of the mean) of the acquiring firm. We define key inventors which are new to the firm as the ratio of key inventors hired by the firm at time *t* over the total number of inventors at time *t* in order to avoid multicollinearity issues.

Control variables

Since we are interested in firms' innovation the most important control variable capture the firm's ability and capability. Previous literature has pointed out that patenting activity increases with firms' size (Mansfield, 1986; Cohen and Levinthal, 1989). We include total assets as proxy for firm size. We use the logarithm of this measure in order to account for the skewness of this variable's distribution.

We use the number of inventors as the stock of knowledge, which is the major ingredient to the patent production function. Due to multicollinearity concerns, we normalize the number of inventors by total assets.

Further, we use a set of year dummies in order to control for time trends in corporate patenting. Industry dummies are not explicitly entering our specification because they are time-invariant and hence absorbed by the firm specific fixed effects which we use.

All independent and control variables are lagged by one year in order to limit endogeneity concerns.

4. EMPIRICAL FINDINGS

Descriptive statistics

Table 1 shows the descriptive statistics of the variables of interests. For comparison purposes, in Table 2 we also show the means before and after the M&A event, as well the result for the t-test on the equality of means for both groups of observations.

---------- Insert Table 1 about here ----------

---------- Insert Table 2 about here ----------

The acquiring firms of our sample have an average of 17 granted patents per year, but with a large standard deviation. A characteristic of the distribution of patents is the right skewness and the large number of zero observations (Blundell et al., 1995; Kapoor and Lim, 2007). As for the before and after M&A comparison of the means, the t-test reveals no significant difference between the two periods. Acquiring firms have an average of 876 million in assets, with firms' assets being significantly bigger after the M&A. On the other hand, the share of inventors is reduced after the M&A. This is explained by the pattern of inventors' mobility before and after the M&A. On average, about 17% of the R&D workers leave their firms during the period

surrounding the M&A. The t-test reveals that this number is significantly higher on the post-merger period with leavers representing a 20% of the inventors. The share of new key inventors hired by the acquiring firms is about 6%, with a significant lower hiring rate after the M&A.

Regression results

We employ fixed-effects Poisson regressions with robust standard errors in order to account for the count data nature of the dependent variable and for unobserved firm specific effects (Wooldridge, 2010). Table 3 presents the estimation results. The first column shows the basic specification including firms' size and the share of inventors and leaving inventors as well as time dummies. In addition, a post-merger dummy is included to test whether the patent outcome declines after the M&A. The estimated coefficients show the expected signs. We find that patent outcome is positively associated with firm size and the share of inventors. Furthermore, we find that firms' innovation performance decreases after the M&A. Finally, the year dummies are jointly significantly different from zero, as the likelihood ratio shows, implying that there are changes on the acquiring firms' patenting over time.

---------- Insert Table 3 about here ----------

The second and third specifications include the variables capturing sources of innovation declines at the firm level after the merger event. First, we find a significant and negative effect of the interaction term between the inventor share and the post-merger dummy, indicating that after the M&A patent productivity of inventors declines. This effect is in line with our baseline hypothesis 1. The change of inventor productivity after the M&A equals to -1.19 percentage points (=exp(0.33-1.92)-exp(0.33)). This corresponds to a loss of 0.21 patents at the sample mean value[5]. Second, we find a negative and significant effect of the inventors leaving the firm before the M&A supporting our baseline hypothesis 2. Leaving inventors account for a

[5] See Shang et al. (2015) for a discussion of the interpretation of interaction effects in poisson models.

productivity decline of 0.29 percentage points (=exp(0.07-0.32)-exp(0.07)). We also find that the productivity decline of the inventors that remain in the acquiring firm is larger than the patents lost due to inventor departure. A t-test of both coefficients shows that the difference is significant (Chi^2=139.07; p-value=0.000), which supports hypothesis 1.

The 4th to 7th specifications include the share of new key inventors before and after the M&A in order to test our hypotheses 2 and 3. The results show that while hiring a key inventor in the immediate pre-merger years is counterproductive we find that newly hired key inventors have a significant and positive effect on the post-merge patent outcome. Direct positive impact of newly hired key inventors on firms' patenting productivity accounts for 0.56 percentage points. This finding is in line with hypothesis 2.

The last specification presents the test of hypothesis 3. We find that there is a positive and significant indirect association between newly hired key inventors on the productivity of the existing inventor force. Impact of newly hired key inventors on firms' patenting productivity through the positive effects on incumbent inventors accounts for 0.62 percentage points. Moreover, the positive effect of the newly hired key inventors outweighs the negative effect of the M&A on the inventors productivity as the coefficient size suggests (Chi^2=13.32; p-value= 0.000). Overall, the results show that an acquiring firm can actively counteract innovation declines after an M&A by hiring key inventors in order to benefit from their knowledge and skills and in order to improve the productivity of the inventors that are already there.

Robustness Check

As robustness check, we re-estimate the model distinguishing industries according to the level of technology intensity. We follow the OECD (2011) classification and distinguish between low-tech and high-tech industries. Tables 4 and Table 5 show the results. Baseline hypothesis 1 holds for both groups of industries when analyzed separately. This implies that regardless of

the level of technological intensity of the industry, M&As are disruptive events that negatively affect the innovation performance of inventors that remain at the firm. The negative effect of departure of inventors after the merger event (baseline hypothesis 2) is supported in the low-tech subsample but we find the effect to be positive and significant in the case of the high-tech. For Hypothesis 1, the subsample of low-tech firms confirms the results from the main analysis. Regarding the hiring of key inventors after the merger event (hypothesis 2), the effect is positive in high-technology sectors, but negative and significant for low-technological industries. Tables 4 and 5 support the positive effect of key inventors on their peers (Hypothesis 3).

---------- Insert Table 4 about here ----------

---------- Insert Table 5 about here ----------

5. DISCUSSION

Although mergers and acquisitions (M&As) are acknowledged as an important mean to access innovative assets and know-how, innovation performance often declines in the post-merger period (Hitt et al., 1990, 1996; Ornaghi, 2009, Valentini, 2012; Comanor and Scherer, 2013; Veugelers, 2006). We investigate the reasons for these post-merger innovation declines by focusing on the individual inventors as the sources of firms' innovation performance and declines thereof. We further suggest the hiring of key inventors as a remedy.

In our analysis, we distinguish two channels by which the contribution of individual inventors to firms' innovation performance can be reduced, inventor departures and a reduced contribution to firm innovation performance of incumbent inventors that remain with the acquiring firm. Our results for a sample of U.S. acquiring firms in the period 1980-2010 show that post-merger innovation performance declines are driven by both a lower contribution of the inventors that remain with the merged company and by the loss of contributions of departing inventors. Inventor departures imply a downsizing of the firm's knowledge base with direct

implications for innovation performance. The lower productivity of incumbent inventors that remain within the firm suggests that there are significant barriers to knowledge exploitation introduced by the M&A event. Strategic reconfiguration and restructuring (Karim and Mitchell, 2000), high fluctuations rates of personnel and changes in job definitions (Walsh, 1988; Ernst and Vitt, 2000) create a sense of dislocation (Cartwright and Cooper, 1993; Paruchuri et al., 2006). This impacts the cognitive ability of inventors (Fugate et al., 2008) who have to cope with the disruptive situation rather than processing work-related information (Staw et al., 1981; Fugate et al., 2008) and creates a cognitive barrier to the exploitation of the inventors' knowledge (Minbaeva et al., 2003; Jensen and Szulanski, 2004).

An interesting result appears as the finding that the firms' innovation performance decline corresponds to a larger extent to the lower contribution of incumbent inventors that remain with the merged firm than to the loss of contributions of leaving inventors. This finding puts prior literature that emphasizes the phenomenon of inventors leaving after an M&A and the innovation performance implications thereof into perspective (Paruchuri et al., 2000; Ernst and Vitt, 2000; Kapoor and Lim, 2007).

One of the measures that firms can take to enhance innovation performance is the hiring of key inventors (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Groysberg and Lee, 2009; Singh and Agrawal, 2011; Ganco, 2013). We show empirically that the hiring of key inventors in the post-merger period corresponds to lower levels of post-merger innovation declines. We further demonstrate that the hiring of key inventors affects innovation performance in two ways: on the one hand, there is a direct effect in the sense that these newly hired key inventors increase corporate innovation performance after the M&A by increasing the knowledge base of the acquiring company and, hence, accelerating the firm's innovation performance. The newly hired key inventors provide the acquiring firm with new skills, competencies and experiences (Rao and Drazin, 2002) and also the knowledge gathered at their former employer (Barney,

1991; Groysberg et al., 2008). On the other hand, the newly hired key inventors improve the productivity of the inventors already working for the acquiring firm. This means that newly hired key inventors do not only add to firms' knowledge base (Rao and Drazin, 2002), but that they also improve the exploitation of the existing knowledge base of the firm (Hackman, 2002). The reasons for this indirect positive effect of newly hired key inventors are manifold. Hiring new key inventors sets a positive signal to the innovative staff reassuring that innovation is of importance for the firm even in times of corporate restructuring. New key inventors can also increase the motivation and productivity of incumbent inventors (Allison and Long, 1990) because scientists have a strong preference to work with higher qualified colleagues (Barabasi et al., 2002; Wagner and Leydesdorff, 2005). In addition, newly hired key inventors can leverage their position and resource access to facilitate the innovation within the firm. Overall, the results suggest that an appropriate hiring policy can counteract innovation declines in the aftermath of M&As.

A closer look at acquiring firms in high and low tech industries shows some interesting differences regarding the effectiveness of hiring new inventors. For high tech sectors, an interesting effect appears for the effect of inventors leaving the firm. While there is an overall negative association of leaving inventors and innovation performance (specification (1)-(7)), we find that this effect is explained by inventors that leave before the M&A takes place (specification (3)). Inventors leaving afterwards are neutral with regards to innovation performance (specification (3))[6]. This suggests that inventors that make valuable contributions to the firm's innovation performance tend to leave in the years prior to the M&A when uncertainty about future reorganization means is highest. Inventors that leave in the post-merger

[6] We test whether the departing inventors coefficient and the departing inventors after M&A coefficient were equal in magnitude, i.e. whether -068+0.69=0, and obtain that we cannot reject the null hypothesis of equality of coefficients (Chi^2= 0.03; p-value= 0.871).

years might be those that did not find a new position earlier or those that leave with the changes induced after the M&A event.

In low tech sectors, we find support for a positive association between new key inventors and a higher contribution of incumbent inventors to the post-merger performance of the acquiring firm. The magnitude of the effect is higher than for the high tech sector. The reason is likely to be that the distribution of skills in low-tech sectors within one firm varies more than in high-tech sectors implying that the contribution of a new arriving key inventor to the knowledge base of the acquiring firm is more significant for low tech firms than for high tech firms. Incumbent inventors can, hence, learn more from incoming key inventors in these sectors.

In contrast to the main results and the results for the high tech sector, we miss to find evidence for a direct effect of new key inventors for post-merger innovation performance in low tech sectors (specification (5) and (7)). This might be explained by the lack of infrastructure, complementary work practices (Peteraf, 1993; Ichniowski et al., 1997) and qualified co-workers (Hackman, 2002; Groysberg et al., 2008) for incoming key inventors that would allow them to exploit their knowledge immediately after arrival. This finding is also in line with Groysberg et al. (2008) who find that star analysis experience a performance decline when moving to a firm with lower capabilities. The fact that we still find a positive association with new key inventors and the contribution to firm performance by incumbent inventors is in line with Groysberg's and Lee's (2009) finding that incoming key individuals are better for reinforcing existing activities - by joining in existing projects as visible by an increase in incumbent inventors contribution to firm innovation performance - than for initiating new activities – which would be visible in a direct positive contribution of the new key inventors to firm performance.

6. CONCLUSION

Our study contributes to the literature that illustrates the importance of the transferability of knowledge across and within firms through individual talents (Song et al. 2003; Kim 1997; Zander and Kogut 1995) and to the literature on the role of key individuals for knowledge exploitation. We add to prior literature by showing that key inventors are an essential mean of such knowledge transfer also for firms in periods in organizational reorganization and that they can as such mitigate negative innovation performance effects in post-merger periods.

Interestingly, our understanding of the crucial role of newly hired key inventors, who are both directly and indirectly associated with the post-merger innovation performance of firms, echoes the classical statement by Joseph Schumpeter who mentioned that "… innovations are always associated with the rise to leadership of New Men …" (and women, we would like to add) (Schumpeter, 1982(1939), p. 96). These newly hired key inventors act as Schumpeterian agents of change who not only change existing routines and introduce and generate new knowledge that impacts the innovation performance of the firms, through their key position within the firm they can also use their leadership position to disseminate knowledge to others, to motivate colleagues, and to create an innovative environment within the firm.

7. MANAGERIAL IMPLICATIONS

Our results suggests that managerial attention during the M&A period should focus rather on the inventors that stay with the firm than on the leavers. When disentangling the sources of knowledge incumbent inventors cause are associated with the largest part of innovation performance declines. This can be seen as good news for managers because it is relatively easier to foster the innovation activities of inventors that stay then to design attractive contracts for those that are planning to leave the company. In fact, appropriate internal policies to foster innovation can also hinder inventors from departing (Groysberg and Lee, 2010).

Our results further show that a clever hiring policy can help overcoming the often found negative effect of M&As on innovation. Dixon and Nelson (2005) reported that HR professionals are often not included as part of the M&A team which is typically almost entirely comprised of people from finance, IT and other disciplines seen as essential to making the deal work.

As also shown by the acquisition of Gillette by P&G, an integration team that monitors and manages the merger process can prevent the foregoing of the expected benefits from the M&A. Moreover, to avoid brain drain and to ensure pre-merger levels of innovation, P&G conducted a key-inventors' hiring policy. Because of these two strategies, P&G-Gillette has been regarded as one of the most successful M&As in the recent past.

8. LIMITATIONS

As any, our study is not free of limitations. First, the analysis presented in this paper has to be considered as largely descriptive. The results have to be interpreted as associations rather than as causal effects. The reason is that the effects that we analyze occur in an endogenous system of strategic choices. Firms selectively decide to engage in M&As and they do so for various reasons. Around the M&A event, major organizational and strategic decisions are taken, sometimes while managerial attention being absorbed by the M&A event itself. We attempted to address the endogeneity concerns of leaving and joining inventors, but were not able to find appropriate instrumental variables. A likely explanation is that the decisions of individuals to stay with an acquiring firm are largely dependent on personal and organizational factors that are not observable for us.[7] These limitations is one that our study shares with the majority of inventor mobility studies (Trajtenberg et al., 2006; Hoisl, 2007; Li et al., 2014; Ge et al., 2016).

[7] We were able to address the selection of firms into the M&A event in a specific year using selection models and previous M&A activities as an exclusion restriction. The results did not change and are available upon request.

We can only define mobility based on patent documents so that we miss mobility of inventors that change their job so that they do not appear on patent documents any more. Furthermore, we cannot distinguish these inventors from those that retire. We checked an alternative method to define inventor mobility based on their LinkedIn profile, but the overlap with our sample was very small so that the mobility definition which is more established in the literature is superior in our case[8] . Given the limitations of our study, it should be complemented by case study evidence investigating the mechanisms behind a decline of inventors and the effect of new key inventors in a specific firm after an M&A. This would be an interesting task for future research.

[8] Ge et al. (2016) propose an alternative for tracing inventor mobility using LinkedIn. Their approach however suffers from several drawbacks as well. First, a problem of self-selection bias arises from the fact that in LinkedIn inventors are the ones that create the profile and can choose to keep it private. Ge et al. (2016) only observe those inventors that have created a profile and decide to make it public. Second, since inventors are the ones that provide the information, there exists the possibility that they provide misleading, wrong or lack of complete information. Inventors may, for instance, purposely decide not to include some of their previous jobs on their profiles. Nevertheless, we made an effort to use the LinkedIn approach proposed by Ge et al. (2016) as an alternative to trace mobility of inventors in our sample. It turned out that the overlap of all inventors registered on our companies' patents and the inventors in the sample provided by Ge et al. (2016) was very small. From the 488,765 inventors that we identified from the NBER and the Coleman Fung Institute database, only 6,678 could be found in their database using the unique inventor id provided in both datasets; from the 1402 target and acquiror firms we have in our database, only 164 targets 427 acquirors are identified; and from the 864,832 patents our dataset covers, theirs only contains 24,812. Because of these shortcomings, we decided to follow previous literature (e.g. Trajtenberg et al., 2004; Parachuri et al., 2006; Hoisl, 2007) and use the patent data as indicator for mobility.

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TABLES

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Patents per year	6105	17.575	87.131	0	1612
ln(Assets)	6105	6.776	2.127	0.001	14.449
Inventors	6105	0.041	0.086	0	0.694
Leavers	6105	0.179	0.234	0	1
Key New Inventors	6105	0.062	0.176	0	1

Table 2. Comparison of means before and after the M&A event.

Variable	Mean Before	Mean After	t-test (Welch)	Significance level
Patents per year	17.296	17.840	-0.243	0.808
ln(Assets)	6.298	7.229	-17.504	0.000
Inventors	0.054	0.028	11.803	0.000
Leavers	0.159	0.198	-6.456	0.000
Key New Inventors	0.0744	0.051	5.132	0.000

Table 3. Fixed-effects Poisson regression for firms' patenting output.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assets	0.12*** (-0.01)	0.11*** (-0.01)	0.10*** (-0.01)	0.10*** (-0.01)	0.09*** (-0.01)	0.10*** (-0.01)	0.09*** (-0.01)
Inventors	0.23** (-0.1)	0.43*** (-0.1)	0.33*** (-0.1)	0.45*** (-0.1)	0.40*** (-0.1)	0.69*** (-0.1)	0.57*** (-0.11)
Leavers	-0.17*** (-0.03)	-0.20*** (-0.03)	0.07 (-0.06)	-0.18*** (-0.03)	-0.20*** (-0.03)	-0.18*** (-0.03)	-0.20*** (-0.03)
After M&A	-0.13*** (-0.01)	-0.01 (-0.02)	0.09*** (-0.02)	-0.01 (-0.02)	-0.05*** (-0.02)	0 (-0.02)	-0.03** (-0.02)
Leavers*After M&A			-0.32*** (-0.06)				
Inventors*After M&A		-1.85*** (-0.13)	-1.92*** (-0.13)	-1.89*** (-0.13)	-1.92*** (-0.13)	-1.90*** (-0.13)	-2.04*** (-0.14)
Key New Inventors				-0.23*** (-0.04)	-0.60*** (-0.06)	-0.04 (-0.05)	-0.38*** (-0.08)
Key New inventors*After M&A					0.70*** (-0.07)		0.49*** (-0.09)
Inventors*Key New inventors						-3.68*** (-0.58)	-2.81*** (-0.76)
Inventors*Key New inventors*After M&A							2.43** (-1.15)
Observations	6105	6105	6105	6105	6105	6105	6105
Likelihood Ratio	2148.89	2174.72	2042.39	2180.33	2158.14	2173.95	2160.53

Note: *p<0.10, **p<0.05, *** p<0.01

Table 4. High Technology Sectors: FE Poisson regression for firms' patenting output.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assets	0.19*** (-0.01)	0.18*** (-0.01)	0.21*** (-0.01)	0.18*** (-0.01)	0.17*** (-0.01)	0.17*** (-0.01)	0.16*** (-0.01)
Inventors	0.32** (-0.13)	0.38*** (-0.13)	0.63*** (-0.14)	0.38*** (-0.13)	0.33** (-0.13)	1.11*** (-0.14)	0.95*** (-0.15)
Leavers	-0.11** (-0.04)	-0.12*** (-0.04)	-0.68*** (-0.1)	-0.12*** (-0.05)	-0.16*** (-0.05)	-0.12*** (-0.05)	-0.15*** (-0.05)
After M&A	-0.03* (-0.02)	0.01 (-0.02)	-0.17*** (-0.03)	0.01 (-0.02)	-0.06*** (-0.02)	0.02 (-0.02)	-0.03 (-0.02)
Leavers*After M&A			0.69*** (-0.1)				
Inventors*After M&A		-0.62*** (-0.15)	-0.55*** (-0.15)	-0.62*** (-0.15)	-0.54*** (-0.15)	-0.64*** (-0.15)	-0.76*** (-0.17)
Key New Inventors				0.03 (-0.05)	-0.88*** (-0.06)	0.38*** (-0.06)	-0.27** (-0.12)
Key New inventors*After M&A					1.28*** (-0.11)		0.79*** (-0.13)
Inventors*Key New inventors						-12.8*** (-1.19)	-11.8*** (-1.6)
Inventors*Key New inventors*After M&A							5.76*** (-2.11)
Observations	2670	2670	2670	2670	2670	2670	2670

Note: *p<0.10, **p<0.05, *** p<0.01

Table 5. Low Technology Sectors: FE Poisson regression for firms' patenting output.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assets	0.05*** (-0.01)	0.05*** (-0.01)	0.01 (-0.01)	0.04*** (-0.01)	0.05*** (-0.01)	0.04*** (-0.01)	0.04*** (-0.01)
Inventors	0.46*** (-0.16)	1.08*** (-0.15)	0.68*** -0.16	1.08*** -0.15	1.11*** (-0.15)	0.75*** (-0.17)	0.98*** (-0.17)
Leavers	-0.19*** (-0.04)	-0.24*** (-0.04)	1.00*** -0.08	-0.23*** -0.04	-0.23*** (-0.04)	-0.25*** (-0.04)	-0.26*** (-0.04)
After M&A	0.01 (-0.02)	0.33*** (-0.03)	0.84*** (-0.04)	0.33*** (-0.03)	0.38*** (-0.03)	0.34*** (-0.03)	0.44*** (-0.03)
Leavers*After M&A			-1.47*** (-0.08)				
Inventors*After M&A		-4.96*** (-0.24)	-5.66*** (-0.24)	-5.01*** (-0.24)	-4.88*** (-0.24)	-5.00*** (-0.24)	-6.13*** (-0.27)
Key New Inventors				-0.36*** (-0.06)	-0.14* (-0.07)	-0.66*** (-0.08)	-0.20* (-0.11)
Key New inventors*After M&A					-0.69*** (-0.13)		-1.53*** (-0.17)
Inventors*Key New inventors						3.49*** (-0.59)	0.27 (-0.78)
Inventors*Key New inventors*After M&A							16.0*** (-1.64)
Observations	3435	3435	3435	3435	3435	3435	3435

Note: *p<0.10, **p<0.05, *** p<0.01