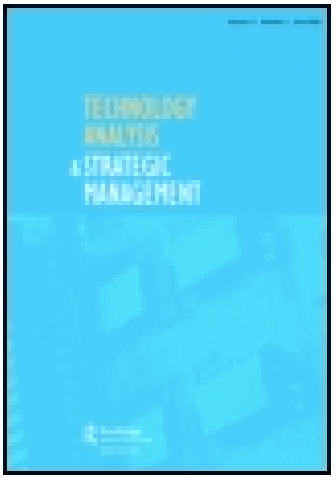

Technology Analysis & Strategic Management

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ctas20

Knowledge utilisation drivers in technological M&As

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Published online: 18 Mar 2015.

Technology Analysis & Strategic Management, 2015
http://dx.doi.org/10.1080/09537325.2015.1023788

Knowledge utilisation drivers in technological M&As

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Several contributions look at the effect of technological M&As on the acquirer's technological performance. The knowledge-based perspective highlights the critical role that the acquirer's target's knowledge absorption plays as the main driver in enhancing post-M&A technological performance. However, absorptive capacity is a rather complex construct, which includes assimilation, utilisation and transformation of the acquired knowledge. In this paper, we focus on knowledge utilisation and investigate two factors whose effects on post-M&A technological performance have been extensively highlighted: technological relatedness and managerial experience. We contribute to the existing literature with a better understanding of the factors underlying the utilisation of the knowledge acquired in M&As. This should help managers to enhance their capacity to manage integration process post-M&As. Our results are based on a cross-sectional data set of 152 biopharmaceutical acquirers that completed at least one M&A between 2001 and 2005.

Keywords: mergers and acquisitions; technological relatedness; M&A experience; alliance experience

1. Introduction

Mergers are back. This statement was claimed in a recent article published in *The Economist*.[1] In the first six months of 2014, mergers and acquisitions (M&As) around the world have been worth more than US$1.7 trillion, the highest half-yearly figure since 2007. However, the advent of this new wave of M&As has been viewed with some concern. The data on the percentage of M&A failures are not at all encouraging. Christensen et al. (2011) stated that the percentage of M&A failures ranges between 70% and 90%. McKinsey & Company stated that this percentage ranges between 66% and 75% (Deutsch and West 2010). No one would claim that this percentage is lower than 50%. However, managers continue to invest in M&As because they expect to be able to leverage the acquired know-how to improve their firm's innovative performance or renovate their firm's business model (Christensen et al. 2011; Deutsch and West 2010).

Consistent with such an expectation, scholars are placing increasing attention on knowledge and absorptive capacity as the main drivers of organisational change and innovation in M&As

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(e.g. Ahuja and Katila 2001; Cloodt, Hagedoorn, and Van Kranenburg 2006; Hagedoorn and Duysters 2002a; Makri, Hitt, and Lane 2010). Although these studies' results are not always consistent with each other, the findings highlight several factors that contribute to enhancing the acquirers' innovative performance in high-tech industries as a consequence of M&As: the optimal technological/cognitive distance (Ahuja and Katila 2001; Nooteboom et al. 2007); the acquirers' experience in the management of M&As and optimisation of their capacity to manage M&As (Hagedoorn and Duysters 2002a; Rothaermel and Deeds 2006) and knowledge complementarity (Makri, Hitt, and Lane 2010).

However, most of these papers rely on the assumption that technological performance post-M&A increases as a consequence of the knowledge absorbed from external partners (Vasudeva and Anand, 2011). However, knowledge absorption is a rather complex process and, in the above-mentioned studies, it is treated as a sort of black box. Utilisation of the knowledge acquired from an external partner requires that it be assimilated and transformed into new exploitable knowledge. Thus, in this paper, we focus on knowledge utilisation. Our objective is to understand which factors influence how acquirers assimilate and use the targets' knowledge post-M&As. Our findings contribute to a better understanding of external knowledge assimilation and utilisation as important aspects of absorptive capacity (Zahra and George 2002) and of the factors managers should leverage to enhance the capacity of their company to exploit the knowledge acquired in an M&A.

In order to investigate this issue we apply the ordinary least-squares (OLS) model on a cross-sectional data set of 152 biopharmaceutical acquirers that completed at least one M&A between 2001 and 2005. Our analysis focuses on two factors: technological relatedness, which has been assessed in terms of both similarity and complementarity (Makri, Hitt, and Lane 2010); and managerial experience, which has also been evaluated taking into account the experience accumulated by the acquirer in precedent strategic alliances.

Our analysis highlights that M&As result in an increase in the use of the targets' knowledge. However, the use of the targets' knowledge changes according to both the dissimilarity between the acquirers' knowledge and the targets' knowledge and the level of experience accumulated in the management of strategic alliances and M&As. In both cases, we found an inverted U-shaped relationship between these variables and the use of the targets' knowledge. Finally, we do not find any support for a positive relationship between technological complementarity and knowledge utilisation. This result raises some interesting questions about the kind of activities underlying the assimilation and utilisation of complementary bodies of knowledge and their transformation into valuable and novel areas of innovation and know-how.

2. Theoretical background and hypotheses

2.1. *The effect of technological relatedness: similarity versus complementarity*

Technological similarity is generally conceived as 'the degree to which companies are active in particular fields of technology that they share with (potential) partners in M&As' (Ahuja and Katila, 2001; Hagedoorn and Duysters 2002a). Technological similarity reduces the cost of absorbing the potential value of external knowledge by reducing the costs of assimilating and transforming external knowledge into exploitable knowledge, enhancing exploitative learning and innovation through a better understanding of available information, resources and knowledge, and fostering collaboration and cooperation in the combination and integration of the two

bases of knowledge (Ahuja and Katila 2001; Cohen and Levinthal 1990; Lane and Lubatkin 1998).

Moreover, Phene, Tallman, and Almeida (2012) suggested that similarity might encourage exploration in the presence of technological uniqueness of the knowledge base of the target, since this is more likely to be recognised as valuable and easy to assimilate. The absorptive capacity perspective further suggests that when two firms with similar knowledge bases enter an M&A, they share analogous sets of 'know-whats' and 'know-hows' (Lubatkin, Florin, and Lane 2001) and they experience fewer difficulties in absorbing, understanding and applying the new knowledge (Cohen and Levinthal 1990; Lane and Lubatkin 1998). Thus, knowledge similarity facilitates the exchange and combination of existing knowledge and encourages its usage, resulting in an increased number of post-M&A citations of the target's pre-M&A granted patents.

Furthermore, it has been posited that the relationship between technological similarity and the acquirer's innovative performance post-M&A might be curvilinear (Cloodt, Hagedoorn, and Van Kranenburg 2006). The presence of common skills, shared languages and similar cognitive structures enables and simplifies technical communication and learning (Cohen and Levinthal 1989; Lane and Lubatkin 1998). Nonetheless, when the knowledge bases of the target and the acquirer are too similar, the contribution to subsequent innovation performance may be minimal (Ahuja and Katila 2001). Therefore, there are few incentives to use that knowledge and transform it into new knowledge. In contrast, the higher the degree of dissimilarity between the acquired and owned sources of knowledge, the higher the number of potentially available innovative combinations. However, the accessibility of these opportunities for innovation decreases as the cognitive distance between the two sources of knowledge increases. This is because there are high costs involved in discovering, exploring and exploiting meaningful combinations between distant sources of knowledge. Therefore, there is an optimal trade-off between similarity and dissimilarity, which maximises the level of knowledge use post-M&A (Ahuja and Katila 2001; Noteboom et al. 2007).

Hypothesis 1: There is an inverted U-shape relationship between technological similarity and the acquirer's M&A-related knowledge utilisation.

Two dissimilar bits of knowledge may be either totally dissimilar, which means, at least ex-ante, that they do not have anything in common; or they may be complementary, which means that they are part of two different narrowly defined areas of knowledge within a common broadly defined area of knowledge (Makri, Hitt, and Lane 2010). Unlike dissimilar bits of knowledge, two complementary bits of knowledge present a high potential for combination and recombination (Makri, Hitt, and Lane 2010; Zahra and George 2002). Thus, a number of possible advantages can be derived from the acquisition of external and complementary sources of innovation, including: enabling a broadening of the firms' cognitive base, further development of its absorptive capacity due to access to a greater variety of knowledge, and exploration of new opportunities and stimulation of creativity and, thus, radical innovation (Burt 2005). These advantages hold in spite of the fact that complementary technology is more complex and challenging than similar technology, and its efficient integration might require significant effort (Grant 1996) with related high integration costs (Katila and Ahuja 2002). Thus, even if the costs and the risks associated with the assimilation and use of complementary knowledge are higher, we expect that complementarity positively affects M&A-related knowledge utilisation. Consequently, we posit:

Hypothesis 2: There is a positive relationship between technological complementarity and the acquirer's M&A-related knowledge utilisation.

2.2. *The role of alliance and M&A experience*

Managing an M&A is inherently a complex task. Success in an M&A depends on a combination of factors that should be managed in an integrated and flexible way. These factors include the capacity to select an appropriate partner with complementary resources and a positive attitude towards cooperation and friendliness; the capacity to breed and sustain mutual trust in both the negotiation and development phases and the experience accumulated by both parties in dealing with large-scale changes (Hitt, Keats, and DeMarie 1998). Furthermore, it has also been recognised that tacitness and causal ambiguity, which cause difficulties in the evaluation, selection and negotiation phases between potential partners, may cause sub-optimal redeployment of resources within the combined firm following an acquisition. This kind of problem particularly affects the transfer, assimilation, combination and integration of innovative capabilities that are characterised by a high degree of tacitness and causal ambiguity. Thus, M&As may harm the performance of the target as a consequence of the changes induced in particular routines, the loss of key staff or changes in the organisational context that underpins valuable capabilities (Hagedoorn and Duysters 2002a). This suggests that firms that are experienced in M&As have a higher capacity to evaluate and select external sources of knowledge and to assimilate and transform it into exploitable innovation than companies that are inexperienced.

Extant literature focuses only on the extent to which experience in establishing M&As affects the innovative performance of the combined firm following an M&A. However, experience with establishing strategic alliances may also play a role in enhancing the capacity of the acquirer to assimilate and transform the knowledge acquired in an M&A. There are two reasons why this claim might be true.

First, the organisational capabilities developed through establishing and managing strategic alliances may have a positive effect on the firm's capacity to exploit the knowledge acquired in an M&A. As suggested by Hitt, Keats, and DeMarie (1998), it is a firm's experience with change rather than only its experience with M&As that enhances the likelihood of the success of an M&A. Thus, engaging in repeated strategic alliances may teach companies to constantly redefine themselves in light of the absorption of new knowledge and their exposure to different cultures, and managerial styles. Furthermore, there are many areas of overlap between strategic alliances and M&As. These are two alternative organisational solutions to the access and transfer of knowledge (Hagedoorn and Duysters 2002a; Rothaermel and Deeds 2006). Thus, even if the intensity of the required capabilities might be different, the experience accumulated in the management of strategic alliances may help managers enhance their capacity to use the knowledge acquired in an M&A.

Finally, experience with the management of strategic alliances may help firms build competencies that might not otherwise be available and that are useful to enhancing the acquirer's capacity to exploit the sources of the innovation capabilities acquired in an M&A. This is especially true in the case of trust. Trust is a key element of alliance success (Gulati 1998) and the lack of it is a major cause of alliance failure (Ireland, Hitt, and Vaidyanath 2002). Trust is a critical factor in supporting the exchange and combination of knowledge, both within and between organisations (Ghoshal and Moran 1996; Nahapiet and Ghoshal 1998; Tsai and Ghoshal 1998). Thus, greater experience with strategic alliances may reflect the firm's willingness to deal with another company on the basis of trust to facilitate knowledge exchange/combination between the parties

involved in an M&A. Conversely, a firm with a greater experience with M&As may have a positive attitude towards this form of integration (Hagedoorn and Duysters 2002a) and an obsession for control (Ghoshal and Moran 1996).

In regard to the influence that managerial experience has on managing partnering, some scholars have suggested that there might be diminishing marginal returns (e.g. Hoang and Rothaermel 2005). Inter-organisational learning and knowledge accumulation diminish over time (Darr, Argote, and Epple 1995). In addition, companies usually enter the most promising collaborations first, with the consequence that the contribution of subsequent M&As, in terms of opportunities and outcomes, is relatively limited or even negative (Silverman and Baum 2002). Furthermore, since these capabilities are path dependent, firms might tend to focus, continuously, on similar deals, providing little or no additional learning (Sampson 2002). Hence, we assume:

Hypothesis 3: The acquirer's M&A management experience is curvilinearly (inverted U-shape) related to M&A-related knowledge utilisation.

Hypothesis 4: The acquirer's alliance management experience is curvilinearly (inverted U-shape) related to M&A-related knowledge utilisation.

3. Methodology

The hypotheses listed above were tested with reference to the biopharmaceutical industry. Biotechnology is one of the most prominent technologies to have emerged over the last 40 years. It is a high-technology and knowledge-intensive industry with a complex and rapidly expanding knowledge base (Chang 2008). It consists of heterogeneous networks of technology-devoted companies and it has the highest frequency of alliances (Rothaermel 2001; Senker and Sharp 1997). Finally, it has witnessed considerable M&A activity (Goldman Sachs 2001). Mergers and acquisitions and strategic alliances occur for identical reasons: pharmaceutical companies need access to the knowledge and research capabilities embedded in biotech companies. Nonetheless, such capabilities have been shown to be context-specific and difficult to transfer, so many of the pharmaceutical acquisitions have not yet generated benefits (Bower 2001).

3.1. *Sample and data sources*

We tested our hypotheses on a cross-sectional data set encompassing the acquisitions, patenting activities and R&D alliances of 152 North American and European[2] firms from the biopharmaceutical industry that were engaged in 218 M&As completed from 2001 to 2005

Operationally, the final sample was identified through a three-step process. First, a complete list of all of the deals in the biopharmaceutical industry was obtained from Medtrack. We then selected all of the M&As completed between 2001 and 2005 that involved either a North American or European company as an acquirer classified as active in 2005. We selected a six-year window of observation, as suggested by Singh (1971) and Vasudeva and Anand (2011), since the level of our analysis refers to the companies engaged in M&As and not to individual M&As (e.g. Ahuja and Katila 2001; Diestre and Rajagopalan 2012; Hagedoorn and Duysters 2002b). Hence, in this step, the resulting sample involved 229 companies as acquirers and 401 companies as targets in 404 M&As.

Medtrack provided the data for the construction of our control variables. We proceeded with a double check of their reliability and we gathered missing information. We utilised three distinct

data banks: Amadeus, Compustat and Orbis. Corporate data about European firms were obtained from Amadeus. Compustat was used to gather information about non-European listed companies, and Orbis was employed to obtain data on unlisted sampled firms. Additionally, missing data were directly obtained from the official websites of the studied companies.

Data regarding patents were collected through the Orbit-QPat database. For each firm we exported patents from the period of 1995 to 2011 within the PlusPat collection. Many companies had to be excluded from our sample because they were not granted patents in the determined time window. Hence, our ultimate sample was reduced to 152 acquirers engaged in 218 M&As.

3.2. *Variables*

3.2.1. *Dependent variable*

M&A-related knowledge utilisation is the metric we used to measure the acquirers' efficiency in the assimilation and use of the knowledge acquired in an M&A. It is based on patent citations as a proxy of the acquirer's capacity to assimilate the knowledge discovered by the target. It was difficult to calculate a growth rate between pre- and post-M&A citations because of the number of zeros in the pre-M&A's 'combined acquirer–target citations'. To capture the change in the 'combined acquirer–target citations' pre- and post-M&A, we calculated the total number of citations that the target firm's patents get from the acquiring firm's patents during the post-M&A period and divided that by the total number of acquirer patents produced in the same period (i.e. we created an average citations-per-patent ratio post-M&A). We did the same for the six-year window pre-M&A, creating an average citations-per-patent ratio pre-M&A. Thus, we constructed a continuous variable given by the difference between the citations-per-patent ratio pre- and post-M&A.

The formula is:

$$\text{M\&A} - \text{related knowledge utilization} = \frac{\sum_{i=1}^{n.\text{post}} n.\text{citing.post}_j}{n.\text{acq.pat.post}} - \frac{\sum_{i=1}^{n.\text{pre}} n.\text{citing.pre}_j}{n.\text{acq.pat.pre}},$$

where i is the ith acquirer patent, n.post and n.pre are the total number of patents granted to the acquirer, respectively, over the six-year post- and pre-M&A period, n.citing.post$_j$ is the number of citations received by the target patents in the six-year post-M&A period, n.citing.pre$_j$ is the number of citations received by the target patents in the six-year pre-M&A period, and n.acq.pat.post and n.acq.pat.pre are the total number of the acquirer's patents during the pre- and post-M&A periods.

To better understand the measure of M&A-related knowledge utilisation, consider the following example of an M&A between two firms: A (Acquirer) and T (Target). In the six-year window before the M&A, A patented 100 inventions and cited T's patent portfolio five times. In the six-year period post-M&A, A, the acquirer, patented 150 inventions and cited T's patents 20 times. Thus, M&A-related knowledge utilisation is $(20/150) - (5/100) = +0.08$. We assumed that the higher the value of this variable, the greater the ability of the acquiring firm to assimilate the innovative knowledge created by the target firm. *M&A-related knowledge utilisation* involved in multiple acquisition processes was estimated by considering an average value.

3.2.2. *Explanatory variables*

Technology similarity is a measure of technological relatedness. It captures the extent to which the two firms have secured patents in the same classes; that is, the extent to which they have

employed similar technological knowledge (Ahuja and Katila 2001; Diestre and Rajagopalan, 2012; Makri, Hitt, and Lane 2010). We operationalised this using the number of patents filed in the same four-digit subclasses from one to six years before the M&A in order to attenuate fluctuations and capture relevant knowledge stocks (Diestre and Rajagopalan 2012; Rothaermel and Boeker 2008). We calculated technological similarity as the product between two ratios: the total number of patents the partners applied for in the same technological subclasses divided by the total number of patents of the acquirer and the target; the total number of patents of the acquirer in all common subclasses divided by the total number of the acquirer's patents (Makri, Hitt, and Lane 2010). To better understand the measure of technology relatedness, consider the following hypothetical example of an acquisition between two firms. The case presents a high degree of similarity: A and T each have 80 patents in the same subclasses, thus $(80 + 80)/200 = 0.80$, and the importance of each common patent subclass for the acquirer is weighed: $(80/100) = 0.80 = > 0.80 * 0.80 = 0.64$.

The following formula was used:

$$\text{Similarity} = \frac{\text{Overlap all patent subclasses}}{\text{Total patents Aquirer} + \text{Target}} * \frac{\text{Total acquirer patents in common subclasses}}{\text{Total acquirer patents}}.$$

We calculated *technology similarity* for companies engaged in multiple agreements as an average value.

Technology complementarity is the other measure of technological relatedness (Makri, Hitt, and Lane 2010). It is the number of patents applied for in the same section (one digit) but in different subclasses (four digits) by the partners in the one- to six-year period preceding the M&A – using the following formula:

$$\text{Complementarity} = \frac{\text{Overlap all patent sections}}{\text{Total patents Aquirer} + \text{Target}} - \frac{\text{Overlap all patent subclasses}}{\text{Total patents aquirer} + \text{Target}} * \frac{\text{Total acquirer patents in common section}}{\text{Total acquirer patents}}.$$

To better understand the measure of technology complementarity, consider the previous hypothetical example of an acquisition between. The case presents a high degree of complementarity between A and T: A and T each have 100 patents in the same sections but 50 out of 100 in the same subclasses, thus $[(100 + 100)/200] - [(50 + 50)/200] = 0.50$. The importance of each common patent subclass for the acquirer is then weighed: $(100/100) = 1 = > 0.50 * 1 = 0.50$.

Alliance experience is a measure that captures the acquirer's ability to manage deals with other firms. We measured alliance management capabilities using a simple count of each firm's alliances (Anand and Khanna 2000; Hoang and Rothaermel 2005; Sampson 2002). In particular, we considered the total number of R&D alliances (excluding alliances with the target) during the one to six years before the acquirer entered its first M&A in the focal period. We then squared the variable in order to test for diminishing marginal returns on technological performance.

Finally, a measure of *M&A experience* was introduced, calculated as the number of acquisitions the acquirer completed in the period before completion of the first M&A process (Diestre and Rajagopalan 2012).

3.2.3. *Control variables*

Technological diversification of the acquirer and *technological diversification of the target* operationalised through a diversification measure based on the Shannon Entropy index:

$$\sum_{j=1}^{n} P_j * \ln\left(\frac{1}{P_j}\right),$$

where P_j was defined as the percentage of a firm's patents in the four-digit patent classes *j*, and $\ln(1/P_j)$ was the weight for each of the patent classes *j*, with *n* as the total number of classes the firm patented in.

Pre-M&A citations: Calculated as the number of acquirer's citations of target's patents exclusively for patents in the period before the M&A.

This allowed us to understand the influence of the stock of *citations* on the change in the *M&A-related knowledge utilisation* of the acquirer, according to the following formula:

$$\text{Pre M\&A citations} \sum_{i=1}^{n} n.\text{citing.pre}_j,$$

where *i* is the *i*th acquirer patent, *n* is the total number of patents granted to the acquirer in the one to six-year window pre-M&A and n.citing.pre$_j$ is the number of citations received by the target patents in the one to six-year window pre-M&A.

Absolute acquirer knowledge base size was calculated as the total number of patents granted by the acquirer (one to six years before the M&A). This control variable allowed us to measure the influence of the pre-M&A patents on the *M&A-related knowledge utilisation* of the acquirer. The patents granted are used to measure, in an indirect way, the technological competence owned by a company.

Absolute target knowledge base size was calculated as the total number of patents granted by the target firm (one to six years before the M&A). This control variable also allowed us to measure the influence of pre-M&A patents on the *M&A-related knowledge utilisation* of the acquirer.

Relative knowledge base size was calculated as the ratio between the acquirer's number of patents pre-M&A (in the one- to six-year window) and the number of patents the target applied for in the same period. This variable controls for the relationship between the degree of similarity in terms of the size of the patents portfolio of companies involved in M&As and the technological performance of the acquiring firms (Hagedoorn and Duysters 2002a).

Quality of the acquirer knowledge base was calculated as the number of citations from one to six years after the M&A date on all patents for which a firm applied in our one- to six-year pre-M&A window, and that was divided by the total number of patents during that period (i.e. we created an annual citations-per-patent ratio).

The other control variables are: *firm's size* (the number of employees in the year of the [first] M&A), *age*, *country of origin* (dummy 1 = North America, 0 = Europe), *Public* (dummy 1 = firm's stock publicly traded in 2005, 0 = otherwise), *products* (number of drugs developed in the past), *post-M&A* (number of M&As completed in the one to six years after the sampled M&A), *total M&As* (number of M&As completed in the focal period) and *international M&As* (share of international M&As in the total number of M&As in the focal period).

3.3. *Statistical analysis*

Since the change in *M&A-related knowledge utilisation* pre- and post-M&A is a continuous variable, an OLS model is applied.

Independent variables are not highly correlated among themselves or with control variables, with the exception of *technological similarity* and *complementarity*, whose correlation is large and negative (-0.765). However, this is not surprising, since we have argued that similarity and complementarity are the two fundamental components of technological relatedness; hence, we expected them to be somewhat correlated. In addition, it is reasonable to assume that if the acquirer's knowledge base and the target's knowledge base are similar, their level of complementarity decreases; in the case of dissimilarity, the likelihood of complementarity increases.

Some of the control variables show important correlations, notably *firm size* and *products* (0.777). This is plausible, since larger companies are likely to have more products on the market, and this latter measure can be conceived of as an alternative proxy of firm size. Hence, we decided to exclude the control variable, *products*, from our regression models.

Specific diagnostics were examined by applying additional tests to detect possible multicollinearity. In particular, the variance inflation factors (VIF) test shows values lower than suggested at a cut-off point of 10 (Rothaermel and Deeds 2006). The maximum VIF in the full model (Model 6) is 6.48. Table 2 provides the regression results reporting the coefficients and standard errors in parentheses. The adjusted R^2 as well as the F tests are also reported.

3.4. *Results*

Table 1 displays the descriptive statistics and the correlations for each of the variables.

In Model 1, only the control variables are included. This model highlights three major aspects. First, it confirms the importance of knowledge diversification as a driver of knowledge utilisation. The number of combinations that can be produced by the interactions between two bases of knowledge increases with their degree of diversification (Ahuja and Katila 2001; Makri, Hitt, and Lane 2010; Zahra and George 2002). Second, the model highlights location as a significant factor in the level of post-*M&A-related knowledge utilisation*. Thus, location (e.g. the USA) is confirmed as relevant in shaping the acquirer's attitude towards and capacity to use acquired knowledge. Third, we found that the absolute size of the acquirer's knowledge base positively influences the acquirer's *M&A-related knowledge utilisation*. Past research has found a positive relation with respect to the absolute size of the target's knowledge base (Ahuja and Katila 2001). The acquirer of a larger base of knowledge is expected to benefit from improved economies of scale, scope and recombination. Furthermore, the acquisition of a larger base of knowledge is expected to contribute to innovative performance in terms of better absorptive capacity. Importantly, our findings suggest that the size of the acquirer's available knowledge base is also relevant. There are two reasons for this. First, a larger base of available knowledge implies greater absorptive capacity and, indeed, a greater capacity to assimilate and transform an acquired base of knowledge. Second, the acquisition of a base of knowledge by a firm that already owns a large base of knowledge can also generate increased economies of scale, scope and recombination. Other significant variables are: the age of the acquirer, which, as expected, negatively impact the acquirers' *M&A-related knowledge utilisation*; and the quality of the acquirer's knowledge base. The latter, different from what was expected, has a negative influence on *M&A-related knowledge utilisation*. Thus, a higher quality of the available base of knowledge seems

Table 1. Descriptive statistics and correlation matrix.

	Variables	Mean	Std. dev.	1	2	3	4	5	6	7	8	9	10
1	M&A-related knowledge utilisation	0.04	0.27	1									
2	Technology similarity	0.45	0.33	0.131	1								
3	Technology complementarity	0.31	0.24	− 0.009	− 0.765	1							
4	Alliance experience	8.02	15.44	0.160	0.066	0.016	1						
5	M&A experience	0.45	1.19	0.074	− 0.104	0.101	0.328	1					
6	Acquirer diversification	1.66	0.67	0.164	− 0.165	0.090	0.183	0.219	1				
7	Target diversification	1.41	0.70	0.163	0.141	− 0.105	0.075	0.143	0.231	1			
8	No. of citations pre-M&A	9.96	30.71	0.071	0.303	− 0.231	0.163	− 0.017	0.087	0.082	1		
9	Public	0.66	0.47	0.085	0.112	− 0.011	0.235	0.084	0.025	0.039	0.166	1	
10	Region	0.58	0.50	0.192	0.108	0.010	0.063	0.001	0.146	0.044	0.147	0.128	1
11	Firm size	7821.91	20688.37	0.020	− 0.091	0.105	0.537	0.367	0.307	0.042	0.058	0.210	0.047
12	Products	121.60	259.95	0.012	0.042	0.051	0.579	0.268	0.085	− 0.069	0.086	0.170	− 0.041
13	Firm age	31.30	36.09	− 0.104	− 0.166	0.012	0.335	0.271	0.091	− 0.027	0.124	0.047	− 0.061
14	Total M&As in focal period	1.46	1.08	0.050	− 0.165	0.165	0.322	0.306	0.271	− 0.010	0.020	0.110	0.167
15	International M&A ratio	0.51	0.63	− 0.094	− 0.008	− 0.046	− 0.123	0.170	− 0.028	0.037	− 0.107	0.032	− 0.400
16	Absolute acquirer knowledge base size	893.66	2779.13	0.120	0.067	0.092	0.686	0.357	0.176	0.020	0.044	0.154	0.028
17	Absolute target knowledge base size	154.62	787.24	− 0.036	− 0.062	− 0.033	− 0.036	0.068	− 0.029	0.366	0.022	− 0.029	− 0.031
18	Relative knowledge base size	92.97	579.44	− 0.012	− 0.164	0.082	0.089	0.515	0.097	− 0.017	− 0.028	0.083	− 0.066
19	Quality of the acquirer knowledge base	14.01	16.15	− 0.104	− 0.007	− 0.052	− 0.045	− 0.021	0.041	0.118	0.135	0.147	0.148

(*Continued*).

Table 1. Continued.

	Variables	Mean	Std. dev.	11	12	13	14	15	16	17	18	19
1	M&A-related knowledge utilisation	0.04	0.27									
2	Technology similarity	0.45	0.33									
3	Technology complementarity	0.31	0.24									
4	Alliance experience	8.02	15.44									
5	M&A experience	0.45	1.19									
6	Acquirer diversification	1.66	0.67									
7	Target diversification	1.41	0.70									
8	No. of citations pre-M&A	9.96	30.71									
9	Public	0.66	0.47									
10	Region	0.58	0.50									
11	Firm size	7821.91	20688.37	1								
12	Products	121.60	259.95	0.777	1							
13	Firm age	31.30	36.09	0.434	0.372	1						
14	Total M&As in focal period	1.46	1.08	0.584	0.470	0.264	1					
15	International M&A ratio	0.51	0.63	− 0.003	0.003	0.114	− 0.079	1				
16	Absolute acquirer knowledge base size	893.66	2779.13	0.657	0.660	0.365	0.465	0.023	1			
17	Absolute target knowledge base size	154.62	787.24	0.000	− 0.037	0.186	− 0.064	0.205	− 0.022	1		
18	Relative knowledge base size	92.97	579.44	0.161	0.098	0.176	0.084	0.297	0.473	− 0.030	1	
19	Quality of the acquirer knowledge base	14.01	16.15	− 0.057	− 0.066	− 0.104	0.024	0.073	− 0.065	− 0.059	− 0.014	1

Table 2. The effect of technology similarity and complementarity, alliance and M&A experience on M&A-related knowledge utilisation.

		Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
	Model 1: controls	Model 2: similarity	Model 3: complementarity	Model 4: M&As	Model 5: alliances	Model 6: all variables
Variables	Coeff. (Std. err.)	Coeff. (Std. err.)	Coeff. (Std. err.)	Coeff. (Std. err.)	Coeff. (Std. err.)	Coeff. (Std. err.)
Results of OLS regression predicting M&A knowledge utilisation (152 obs.)						
Intercept	− 2.349	− 3.197	− 2.347	− 2.486	− 2.356	− 6.609
	(0.879)**	(1.089)**	(0.923)*	(0.95)**	(0.897)**	(2.544)**
Technology similarity		3.080				6.64
		(1.075)***				(1.391)***
Technology similarity^2		− 2.296				− 3.164
		(0.843)**				(1.380)*
Technological complementarity			− 0.007			3.722
			(0.884)			(2.608)
M&A experience				1.497		1.289
				(0.530)**		(0.589)**
M&A experience^2				− 0.280		− 0.294
				(0.124)*		(0.139)*
Alliance experience					0.068	0.053
					(0.023)**	(0.019)**
Alliance experience^2					− 0.001	− 0.001
					(0.000)*	(0.000)*
Acquirer diversification	0.477	0.656	0.477	0.393	0.352	0.767
	(0.287)*	(0.383)*	(0.286)*	(0.166)*	(0.205)*	(0.371)*
Target diversification	0.560	0.485	0.560	0.721	0.586	0.684
	(0.179)**	(0.229)*	(0.179)**	(0.347)*	(0.212)**	(0.371)*
Public	0.360	0.323	0.359	0.569	0.107	0.340

(*Continued*).

Table 2. Continued.

	(0.443)	(0.447)	(0.443)	(0.463)	(0.464)	(0.502)
Region	0.939	0.854	0.939	0.867	1.137	0.817
	(0.322)**	(0.484)*	(0.320)**	(0.491)*	(0.416)**	(0.431)*
Firm size	0.000	− 0.005	0.000	− 0.067	− 0.005	− 0.081
	(0.107)	(0.107)	(0.107)	(0.114)	(0.110)	(0.119)
Firm age	− 0.294	− 0.269	− 0.295	− 0.255	− 0.360	− 0.162
	(0.173)*	(0.104)*	(0.175)*	(0.118)*	(0.214)*	(0.082)*
Total M&As in focal period	− 0.115	− 0.098	− 0.115	− 0.175	− 0.078	− 0.086
	(0.207)	(0.211)	(0.209)	(0.234)	(0.202)	(0.245)
International	0.122	0.039	0.121	0.192	0.273	0.208
M&A ratio	(0.398)	(0.412)	(0.4)	(0.424)	(0.413)	(0.458)
No. citations pre-M&A	0.005	0.003	0.005	0.005	0.004	0.002
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)
Absolute acquirer knowledge base size	0.106	0.087	0.106	0.064	0.021	0.014
	(0.037)**	(0.028)**	(0.037)**	(0.022)**	(0.008)**	(0.005)**
Absolute target knowledge base size	− 0.253	− 0.176	− 0.253	− 0.459	− 0.239	− 0.459
	(0.365)	(0.386)	(0.365)	(0.411)	(0.385)	(0.486)
Relative knowledge base size	− 0.278	− 0.009	− 0.028	− 0.065	− 0.015	− 0.135
	(0.477)	(0.047)	(0.048)	(0.084)	(0.046)	(0.095)
Quality of acquirer knowledge base	− 0.015	− 0.016	− 0.015	− 0.016	− 0.018	− 0.018
	(0.006)*	(0.007)*	(0.006)*	(0.009)*	(0.008)*	(0.009)*
Adjusted R^2	0.342	0.367	0.339	0.354	0.358	0.391
F (df)	2.201	2.211	2.155	2.197	2.185	2.492
	(13)	(15)	(14)	(15)	(15)	(20)
p-Value	.011	.008	.012	.009	.009	.001

Note: Standard errors are reported in parenthesis.
*$p < .1$.
**$p < .01$.
***$p < .00$.

to reduce the incentive to invest in knowledge assimilation and transformation. Among the non-significant variables, the number of citations before the M&A is especially interesting. It suggests that a certain awareness of the target's knowledge base, resulting in pre-M&A citations from the acquirer, is not related to the change in post-*M&A-related knowledge utilisation*.

In Model 2, we test Hypothesis 1. The results confirm the existence of an inverted U-shaped relationship between *technology similarity* and *M&A-related knowledge utilisation*. Hypothesis 2 is tested in Model 3. However, we do not find any significant relation between technological complementarity and *M&A-related knowledge utilisation*. Models 4 and 5 provide support for Hypotheses 3 and 4 with respect to the U-shaped relationship between experience in establishing M&As and alliances, on the one hand, and *M&A-related knowledge utilisation*, on the other hand.

Model 6 provides the full representation. The full model does not change the findings of the prior models. Thus, the coefficients appear to be robust over the different models (Table 2).

4. Discussion and managerial implications

The empirical findings highlight that technological similarity plays a larger role than technological complementarity as a driver in the assimilation and transformation of the knowledge acquired in an M&A. On the one hand, we found a statistically relevant inverted U-shaped relationship between longitudinal exploration, from technologically closer to technologically faraway, and *M&A-related knowledge utilisation*. This implies that there is an optimal distance between technological similarity and technological dissimilarity, maximising M*&A-related knowledge utilisation* (e.g. Cloodt, Hagedoorn, and Van Kranenburg 2006; Katila and Ahuja 2002; Lane and Lubatkin, 1998; Noteboom et al. 2007). Therefore, when selecting a partner to buy or to merge with, managers should take into account the trade-off between technological similarity and dissimilarity. Marriage with a partner that is too similar or too dissimilar reduces the opportunity to leverage the target's knowledge to produce new exploitable innovation capabilities. On the other hand, different from what Makri, Hitt, and Lane (2010) reported, we did not find any significant relationship between exploration of technological adjacent (focusing on the complementarity between the acquirer's knowledge base and the target's knowledge base) and *M&A-related knowledge utilisation*.

Our result relative to the effect of the technology complementarity of M&A-related knowledge utilisation raises some relevant considerations. With respect to the significance of technology similarity, it may provide some insight as to the reasons why most M&As fail to keep their promises. The hypothesis is the following. In order to minimise the risk of failure, managers prefer to focus on the assimilation and the use of the most similar parts of the acquired base of knowledge. This enables them to reduce the difficulties and conflicts that might arise from the initial cognitive distance between the parties being integrated; it might also enable them to sustain their communication, collaboration and cognitive convergence. However, in so doing, managers undermine the innovative potential of an M&A for two major reasons. They reduce the degree of discontinuity generated by the M&A process and they stimulate the assimilation and the use of the targets' culture to the acquirers' culture.

In light of Makri, Hitt, and Lane (2010), who found a positive relationship between technological performance and *technology complementarity*, technological complementarity may either not play any relevant role in the utilisation of targets' knowledge or its role is not consciously recognised as complementary patents are not explicitly cited. In the first case, we should conclude that other moderators, different from assimilation and transformation, are involved in the

use of complementary sources of knowledge. According to the second hypothesis, it looks like the acquisition of complementary knowledge capabilities enhances the acquirers' knowledge utilisation, but in a way that remains largely unconscious as the target's patents are not explicitly cited.

Our results also highlight experience in establishing M&As and alliances as being relevant to enhancing a firm's capacity to assimilate and transform acquired knowledge into *M&A-related knowledge utilisation* (e.g. Anand and Khanna 2000; Sampson 2002). We found that both of these variables had an inverted U-shaped relationship with *M&A-related knowledge utilisation*. This confirms that the marginal gain derived from establishing an additional M&A or alliance decreases with the number of alliances and the number of M&As already established. This is because the most promising M&As and alliances are usually entered into first (Silverman and Baum 2002), learning opportunities decrease with the experience accumulated in the management of a specific task (Darr, Argote, and Epple 1995; Sampson 2002), and there is a limit to a firm's capacity to manage alliances and M&As (Rothaermel and Deeds 2006). Despite the decreasing relevance, the experience in establishing both strategic alliances and previous M&As positively influences a firm's capacity to assimilate and transform acquired knowledge.

Even though, to some extent, the positive effect of managerial experience related to M&As could be expected, the effect related to managerial experience associated with strategic alliance is less obvious. Consistent with what is claimed in the hypothesis, this result suggests that the experience in the management of strategic alliances can be successfully redeployed in the management of M&As. However, this is not only due to the similarities between the M&As and the strategic alliances as alternative organisational solutions to govern and manage the combination between two sources of knowledge; it is also, and especially, due to the availability of additional managerial skills, such as trust, whose formation is supported by the firm's experience in the management of strategic alliances. The use of trust as a mechanism of social integration, as opposed to power and hierarchical control, might also support a more informal, communicative and cooperative knowledge assimilation and sharing process in M&As. Thus, it may improve the acquirer's capacity to exploit a complementary source of knowledge. Furthermore, it is also a determinant that could enhance the exchange and combination of knowledge (Nahapiet and Ghoshal 1998; Ghoshal and Moran 1996; Tsai and Ghoshal 1998). Thus, managers are required to set up organisational solutions that also support the flowing of and access to these kinds of managerial skills in the management of M&As.

5. Concluding remarks, study limitations and future research recommendations

In this paper, we focus on knowledge utilisation in order to understand the extent to which the knowledge acquired in an M&A contributes to support acquirers' technological performance. Our findings suggest that technological similarity plays an important role in fostering knowledge utilisation, and that experience in establishing alliances and M&As is a critical determinant of the ability of the acquirer to exploit and enjoy benefits from an M&A. Different from other studies, we did not find any significant support for the positive effect of knowledge complementarity on M&A-related knowledge utilisation. However, we suspect this is due to two major reasons. First, we believe managers prefer to focus on the assimilation and use of similar knowledge in order to boost mutual trust and collaboration in the start-up phase of an M&A with possible negative effects on the sustainability of the M&A. Integration driven by similarity stimulates mutual trust and collaboration based on cultural convergence rather than mutual recognition of the value of each other's competencies and know-how. Second, either assimilation is not

a primary factor in the exploitation of complementary sources of knowledge, and thus other moderators are involved, or its role is not explicitly recognised. Thus, to a large extent, the process of assimilating complementary sources of knowledge is tacit. In both cases, however, additional research is required.

This study has several limitations. First, we focus on a single industrial context. Although such a focus increases internal validity, our results might, therefore, reflect some industry- and period-specific factors that limit the generalisability of the findings to other industries. Moreover, our sample of independent acquirers from North America and Europe necessarily provides no evidence of acquirers from countries on other continents, such as those that are now emerging (e.g. as 'developing' and 'newly developed').

Second, we used patent citations and data to construct our dependent and independent variables. This led us to exclude from our sample any firms for which no data on patents were available in the consulted data sets. However, although patents and patent citations are generally regarded as good indicators of innovative output and the ability to acquire and exploit a target's knowledge base, they are also usually considered to be intermediate outcomes along the value chain. Hence, a better and more comprehensive evaluation of the effects that knowledge relatedness has on innovation and technological performances should rely not only on patents but also on products or processes generated by the patents obtained in the post-M&A period that are based on the pre-M&A target knowledge and also, perhaps, effectively commercialised.

Third, we reiterate Makri, Hitt, and Lane's (2010) argument that International Patent Classification, although fairly adequate and clear, has been created and developed for purposes other than providing researchers with a picture of the knowledge bases of firms.

Finally, while we advanced a measure to proxy the acquirer's knowledge utilisation capability related to the target's knowledge base, we only assessed the pre- and post-M&A variation for this variable at one point in time. Certainly, firms develop this capability over time. Future research could attempt to draw the evolution of the acquirer's knowledge utilisation over time and, thus, enhance our understanding of the underlying dynamics of the M&A-related knowledge utilisation process. In this case, a regression with panel data would better represent the dynamics described above.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. 2 May 2014, 9:54 by R.D. | NEW YORK http://www.economist.com/blogs/freeexchange/2014/05/mergers.
2. The EU countries plus Switzerland.

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