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External knowledge sourcing for R&D activities: antecedents and implications of governance mode choice

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This paper investigates how internal and external factors affect the choice between alliances and joint ventures (A&JVs) and mergers and acquisitions (M&As) for the external sourcing of research and development (R&D) activities, and whether or not such a choice is really contingent, that is, is it the best choice in terms of its impact on firms' innovative performance under those circumstances? We build a set of hypotheses based on both the transaction-cost theory and the resource-based view, and test them through a secondary data source analysis. We found that companies adopt either R&D M&A or A&JV depending on internal (e.g. resources and capabilities, innovation experience) and external (e.g. degree of industry specialisation) factors. Surprisingly, this contingent choice turns to be effective on innovative performance only for the internal factors, rather than the external. This paper contributes to inter-firm relationships literature by presenting the real advantages of using integrated and contingency theoretical models to understand contingent decisions.

Keywords: external knowledge sourcing; alliances and joint ventures; mergers and acquisitions; innovative performance; contingency approach

1. Introduction

As the competitive market scenario converted into a globalised and fast-changing demand for new and highly differentiated products and services – as realised by highly specialised organisations embedded in added-value networks of firms – so firm research and development (R&D) configuration has also changed. Indeed, such a changed scenario has pressured firms to shift their R&D configuration from the traditional paradigm of exclusively conducting R&D activities in-house to increasingly 'opening up' their R&D borders so as to rely on external sources of knowledge (Chesbrough 2003). Acquiring knowledge from outside allows firms access to similar and/or complementary resources and capabilities (R&Cs) faster and cheaper, and to be more effective in facing rapidly moving and differentiated market demand (Powell 1998; Christensen 2000; Foster and Kaplan 2001). By recognising the potential benefits of external knowledge sourcing, innovation managers who are willing to take such advantages must deal

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with many issues, of which R&D governance mode choice should be one of the first tasks on their agenda.

This paper addresses this issue by investigating which internal and external factors affect managerial decisions on governance mode for R&D external sourcing, and whether such a contingent decision (i.e. that which is determined by both internal and external factors) impacts on a firm's innovation performance. In particular, the internal factors we consider are as follows: (1) the firm's R&C related to the R&D activity and (2) the firm's innovation level prior to the deal. We use degree of industry specialisation as the external factor. In this study, we contemplate alliances and joint ventures (A&JVs) and mergers and acquisitions (M&As) as possible alternative choices for external knowledge sourcing. In fact, these two main groups of governance modes include the major open innovation practices that allow firms to transfer R&C from outside the firm to inside its boundary. A&JVs include licensing agreements, R&D agreements and R&D joint ventures, among others, while M&As embrace merger and acquisition agreements with target firms specialised in R&D activities.

Prior research on open innovation in the strategic management literature mainly investigates issues related to the choice between internal and external R&D, and the complementary and/or substitutable impact of these strategies on innovation performance (e.g. Cassiman and Veugelers 2006; Hagedoorn and Wang 2012; Berchicci 2013). Despite its potential implications for managerial practice, the open innovation literature does not explore the impact that different governance mode choices of external knowledge sourcing have on innovation productivity. Some studies investigate the most effective external technology sourcing modes in a specific industry context (Malik 2011), but do not consider the influence of contingent factors on that choice.

On the other hand, the strategic management literature on inter-firm relationships offers two main streams of research about governance mode choice issues (Leiblein 2003). The former – which mostly relies on the transaction cost economics (TCE) theory (Williamson 1975) – examines the factors that affect strategic governance mode choice. For example, Hagedoorn and Duysters (2002) find that high levels of innovation in the industry, as well as the degree of association between a firm's core business capabilities and its external ones, influences decisions regarding governance mode (alliances vs. M&A). Vanhaverbeke, Duysters, and Noorderhaven (2002) find that previously formed inter-firm linkages influence the choice between strategic alliances and acquisitions. Other studies examine how a firm's strategic intent drives networking decisions (Riccobono et al. 2014) and consequent business agreements (Riccobono, Bruccoleri, and Perrone 2013). The latter – which mostly relies on the resource-based view (RBV) (Barney 1986) – explores the way in which the R&D sourcing governance mode affects a company's performance (Goerzen 2007; Lavie 2007; Rothaermel and Alexandre 2009; Mazzola, Bruccoleri, and Perrone 2013). For example, Quintana-García and Benavides-Velasco (2011), by adopting a knowledge-based view, find that signing R&D alliances with partners that have similar technologies only enhances incremental innovation. Furthermore, some studies investigate the performance of the agreement itself, for example, in terms of the fulfilment of its strategic goals (Schreiner, Kale, and Corsten 2009).

In order to contribute to the strategic management literature on inter-firm relationships and open innovation, we conceptualise an integrated model around the governance mode for R&D external sourcing, which incorporates and links each of the other drivers and the effects of such a decision. Given the dual perspective offered by our model with which we can look at this phenomenon, we rely on both the transaction-cost and the RBV for hypotheses development.

By simultaneously integrating contextual drivers and the effects of the governance mode choice (for external knowledge sourcing) in a single conceptual model, this paper provides contributions to the strategic management literature on both inter-firm relationships and open innovation, while also providing interesting practical implications. We integrate two phenomena that are usually analysed separately, namely the factors influencing a choice and the consequences of such choice. This approach brought about interesting findings that would not have arisen by studying the two phenomena separately. It also contributes to calls for future research such as ‘... Future research would benefit from the construction of integrated models of firms’ strategic choices as well as the drivers and performance implications of those choices’ (Leiblein 2003) and also ‘... Examining the types of R&D ... merits further inquiry. How do firms structure their external R&D activities? How diverse is their R&D collaboration portfolio?’ (Berchicci 2013).

This paper is organised as follows. The next section examines the literature on R&D configuration and governance mode choice, and on the benefits and drawbacks of R&D A&JVs and M&As. Following this, we propose a set of hypotheses using the transaction-cost theory and the RBV. The third section describes the research method. Finally, the results are elaborated and discussed, and some conclusions are drawn.

2. Theory and hypotheses’ development

A&JVs and M&As for external knowledge sourcing allow firms to open up their innovation processes. Both of these two governance modes provide risks (Billitteri, Lo Nigro and Perrone 2013) and advantages, and their adoption depends on various internal (i.e. firm-related) and external (i.e. industry-related) drivers. We expect that these drivers also act as moderators of the effect of such a choice on the innovative performance of a company. Despite this, the strategic management literature on inter-firm relationships largely recognises the dependence of management decisions on both internal and external environmental conditions (e.g. Hagedoorn and Duysters 2002; Gassman 2006). However, the literature does not simultaneously evaluate the role of contingency factors as drivers (of the governance choice) or as moderators (of the effect of this choice on innovative performance). For this purpose, we have adopted an integrated (Leiblein 2003) and contingency (Gassman 2006) approach, and developed a conceptual model. Figure 1 presents the conceptual model that will be explained in the paper.

2.1. Firm R&C relatedness to the deal (internal context factors)

A firm that is willing to conduct specific R&D activities first assesses its R&C to carry out such activities, and consequently realises either it owns all the necessary R&C or not. In both cases, the company can gain advantage in acquiring further R&C from external sourcing.

When the R&C which are requested to carry out the R&D activities are highly related to those owned by the firm, it is likely that the firm will still look for similar further external R&C. Indeed, the firm may wish to exploit the benefits associated with the economies of scale and scope in R&D activities. In this case, M&As allow firms to achieve these kinds of advantages by spreading the fixed costs of innovation across more R&D outputs and/or projects (Cassiman et al. 2005). Given the high levels of asset specificity investment required to achieve economies of scope, scale and learning in R&D activities (from a TCE perspective), R&D M&As should be preferred over A&JV, as they allow the firm to reduce the high opportunism risk generated by the high level of asset specificity investment. From a RBV perspective, previous empirical works

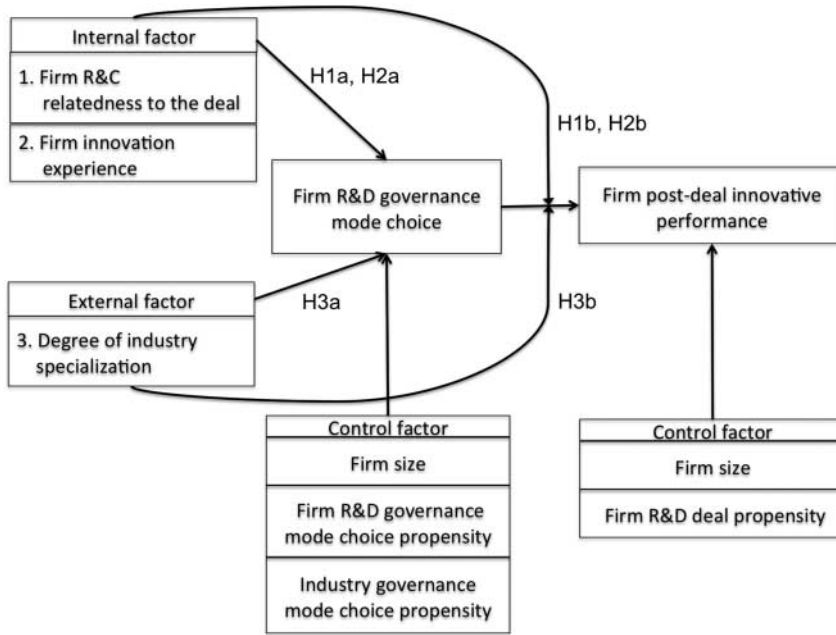


Figure 1. Conceptual model.

found that assets similarity among the merging companies allows for easy integration of the companies' R&C and accordingly reduces the reorganisation risk connected, for example, to the loss of key scientific personnel (Ernst and Vitt 2000), while positively affecting the firm's post-merger innovation productivity (Park and Sonenshine 2012). Indeed, if the reorganisation risk decreases, the firm can more easily exploit the benefits associated with R&D M&As, e.g. access to intangible assets (Bresman, Birkinshaw, and Nobel 1999) and the creation of knowledge synergies (Hall 1990; Ornaghi 2009). Moreover, by acquiring companies with similar R&Cs, the firm reduces the number of its competitors (i.e. makes the market more concentrated) and deprives them of those R&C, thus increasing the firm's competitive advantage and innovativeness (Schumpeter 1950).

These arguments suggest the following hypothesis:

Hypothesis 1: In R&D external knowledge sourcing, the higher the firm's internal R&C to carry out the deal R&D activity, the higher the likelihood that the firm will choose M&A over A&JV (H1a) and the higher the positive effect of this contingent choice on post deal innovation performance (H1b).

2.2. Firm innovation experience (internal context factors)

Firms that have a high proliferation of R&D outputs, such as patents or new products, demonstrate the ability to build an internal stock of knowledge. Innovation-rich firms that decide to jointly conduct R&D activities offer their external partners the opportunity to accumulate their R&D knowledge and skills (Balakrishnan and Koza 1993; Kogut 2000) through imitation, learning and the acquisition of their intangible resources (Hamel 1991; Kale, Singh, and Perlmutter 2000). In this way, firms with high levels of innovation experiences that collaborate with external

partners for R&D activities lose part of the benefits generated by their valuable R&C, since other firms can exploit the acquired resources when the R&D collaboration agreements are completed. In order to limit such drawbacks for the firm, complex and expensive coordination and monitoring activities are adopted. This boosts transaction costs, which are already high due to the intangible nature of the assets involved in the transaction. Also, in light of this risk, innovative-rich firms could obstruct the value creation of R&D collaborative agreements by inhibiting their propensity to share the intangible assets they own. In this context, more hierarchy-oriented governance modes (e.g. M&As) would allow the firm to drastically reduce the risk of valuable innovative R&C appropriation, and also fully exploit the benefits coming from the pooling of different R&C. Furthermore, firms that possess high levels of R&D know-how generally develop 'absorptive capacity' (i.e. the ability to select and learn from external sources) and can therefore easily 'recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends' (Cohen and Levinthal 1990). As a result, a company incurs low coordination and monitoring costs, does not obstruct the value creation of R&D collaboration, creates an organisational 'fit' with its R&D partners, efficiently assimilates and uses their knowledge, and increase its innovative performance (Arora and Gambardella 1994; Rothaermel and Deeds 2006; Berchicci 2011).

These arguments lead us to state the following hypothesis:

Hypothesis 2: In R&D external knowledge sourcing, the higher the firm innovation experience, the higher the likelihood that the firm will choose M&A over A&JV (H2a) and the higher the positive effect of this contingent choice on post deal innovation performance (H2b).

2.3. Degree of industry specialisation (external context factor)

The trend of developing more complex technologies and product systems has led to the disaggregation of many industry value chains, and a consequent trend towards more R&D outsourcing and alliances (Hagedoorn and Duysters 2002). This trend can be observed in the electronics industry where, while new electronics manufacturing services and original design firms were emerging, original equipment manufacturers had since moved their business into solely designing, marketing and selling their brand's final products rather than designing or manufacturing components. When the firm is embedded in a network of business relationships, it enhances its innovative performance by accessing the resources that are owned by its specialised partners through its ties to these partners (Gulati 1999; Gnyawali and Madhavan 2001; Lavie 2006). In this context, a sustainable competitive advantage is achieved by adopting a less hierarchy-oriented governance mode (e.g. A&JV) for external knowledge acquisition. In fact, A&JVs allow the firm to source from multiple valuable and complementary R&C, and to take advantage from a drastic reduction of product development cycle times (Harrigan 1983; Linnarson 2005; Gilsing, Lemmens and Duysters 2007), which in turn increases the firm's innovation productivity. The highly specialised form of intermediate markets also diminishes the uncertainty associated with the success of R&D activities being developed, and consequently lowers transaction costs. In line with the above argumentations, the following hypothesis can be stated:

Hypothesis 3: In R&D external knowledge sourcing, the higher the degree of industry specialisation, the higher the likelihood that the firm will choose A&JV over M&A (H3a) and the higher the positive effect of this contingent choice on post deal innovation performance (H3b).

3. Methods

3.1. Sample

To test our hypotheses, we used secondary data sources. Secondary data sources consist of data collected by someone else, not specifically for the research questions at hand, but that can still be used to attain a better understanding of a theoretical concept (Stewart 1984; Frankfort-Nachmias and Nachmias 1992). For the sample construction, we first collected all the A&JVs and M&As announced and completed between 2000 and 2010 by the first 100-ranked members of the Fortune 500 (2000) from the Securities Data Corporation (SDC) database. In particular, for the M&As deals we specified in the request form of the SDC database, to report all the M&As where the focal firm, among those included in the first 100-ranked firms of the Fortune 500 (2000) list, acted as acquiror (not as target). From this sample, we selected the deals in which R&D activities were cited either in the ‘deal text’ SDC field (for A&JV) or in the ‘target full business description’ SDC field (for M&A). For example, we selected the R&D agreement between Asahi Optical Co Ltd (AO) and Hewlett-Packard Co (HP), which was announced and effective in 2000. The description of the agreement provided in SDC is

AO and HP formed a strategic alliance to provide research and development services for new digital camera platforms. HP would provide digital imaging technologies while AO would offer its expertise in optical design and precision instrument development. HP would brand the jointly developed cameras under the HP name and AO would use its Pentax brand.

This reduced our sample from 4316 to 812 deal observations, and the firms from 100 to 62. Table 1 reports the descriptive statistics of the deals by firm distribution as resulting from the final sample. For these firms – hereafter called ‘focal firms’ – we collected information about their revenues from the CNN Money (2000). We then collected patent data on these firms from 1976 (the starting year of patent information available in the United States Patent and Trademark Office (USPTO)) from the USPTO database. Finally, we used the ORBIS database to screen for companies that operate in the same major industry group as the focal firms.

3.2. Variables

3.2.1. Dependent variables

Our conceptual model includes two dependent variables: *firm R&D governance mode choice* and *firm post-deal innovative performance*. We used a dummy variable for the governance mode choice. This variable takes the value 0 if the deal is an alliance or a joint venture; or 1 if the deal is a merger or an acquisition. To measure the *firm’s post-deal innovative performance*, we chose

Table 1. Descriptive statistics of deals by firm distribution.

	R&D A&JV by firm	R&D M&A by firm	All R&D deals by firm
Average	7.661	5.435	13.097
Min.	0	0	1
Max.	88	63	148
Std. dev.	14.585	11.568	22.602
Total no. of deals	475	337	812

the number of patents granted to the focal firm, with issue dates (i.e. the date the patent was officially issued by the USPTO) between the date the deal was effective and the same date three years after. This type of measure is often used in innovation studies (Cloodt, Hagedoorn, and Van Kranenburg 2006; Sampson 2007; Lin et al. 2012). Different kinds of measures for innovative performance could have been certainly used, for example, new products, product and process innovations, etc. However, despite some shortcomings, patents are generally accepted as the most appropriate indicator for comparing the innovative performance of companies (Archibugi 1992) and are strongly correlated with new products (Comanor and Scherer 1969), literature-based invention counts (Basberg 1982), and non-patentable innovations (Patel and Pavitt 1997).

Regarding the dates range, we made this choice because the time between patent application and patent granted can last up to two or three years, as emerged from the patent filing activity history in the USA (Park and Sonenshine 2012). Moreover, other studies that measure firm innovative performance, base their innovation related-proxy on a time lag of three years (Caloghirou, Kastelli, and Tsakanikas 2004; Vega-Jurado et al. 2008; Tsai 2009).

3.2.2. Independent and interaction variables

We measured the *firm R&C relatedness to the deal* (hypotheses 1a and 1b) as the ratio between the number of the focal firm four-digit SIC codes that are equal to the transaction four-digit SIC codes divided by the total number of transaction four-digit SIC codes. In particular, in the case of A&JVs, the transaction four-digit SIC codes refer to the deal four-digit SIC codes; while for M&As these refer to the four-digit SIC codes of the target firm. Accordingly, the variable ranges from the value 1 if all of the SIC codes related to the transaction are also ascribed to the firm; 0 if none of the SIC codes related to the transaction are ascribed to the firm, and a percentage value between (0, 1) in other cases. Data about firm and deal SIC codes were obtained from SDC. We relied on the firm four-digit SIC codes in order to account for the most detailed level of firm-related activities information. In fact, while the first two digits individualise just the industry major group (e.g. 35, 'industrial and commercial machinery and computer equipment'), and the first three digits the industry group (e.g. 351, 'engines and turbines'), the entire four digits of the sic code individualises the firm specialty in term of product/service inside that industry (e.g. 3519, 'internal combustion engines'). Our variable wishes to measure the relatedness between the firm R&C and the R&C that is needed to conduct the business activity that is the object of the deal. Accordingly, we basically assume that the more the products/services of the company (i.e. its four-digit SIC codes) are similar to the products/services that are the object of the transaction (i.e. the four-digit SIC codes of the deal), the higher the likelihood the firm already owns at least the basic R&C needed to conduct the business activity/s which is the object of the deal. For instance, a larger firm which is very diversified has more and diversified SIC codes. This increases the likelihood that the ratio is higher, that is, the likelihood that the firm has more R&C-related to the transaction. Although this measure of the R&C-relatedness has several limitations due to the fact that it does not take into account the specific kinds of R&C (e.g. human resources, machines, equipment, and so on) that are used by the firm to offer a given product/service, many other papers have already used the proximity in the SIC codes of the focal firm and the deal (or target firm) as a measure of relatedness between two different companies (e.g. Morck, Shleifer, and Vishny 1990; Berger and Ofek 1995; Villalonga and McGahan 2005).

The *firm innovation experience* (hypotheses 2a and 2b) was measured as the natural logarithm of the number of patents assigned to the focal firm involved in the deal from 1976 until the date the deal was effective (as signalled by SDC). Despite many studies generally measuring a

firm's R&D intensity through R&D spending, we preferred to account for a measure that not only considered the amount of R&D activities conducted by the firm, but also their effectiveness and efficiency. In fact, patents are generally recognised as better measures of the output of R&D activities than R&D spending (Comanor and Scherer 1969; Griliches 1990). Moreover, many studies found a positive association between R&D spending and R&D patents production (Czarnitzki and Hussinger 2004). The *degree of industry specialisation* (hypotheses 3a and 3b) was measured as the ratio of firms that operate in the same major industry as the focal firm (but not in the same specific industry) compared with the total number of firms that operate in the same major industry. The numerator was computed by collecting from ORBIS database all of the companies whose first two digits (of their primary SIC code) were the same as the focal firm, but simultaneously whose last two digits were different respect to the focal firm. Our construct wishes to measure the degree of disaggregation/specialisation of the total value of products/services produced in a specific major industry group. We basically assume that the higher the number of firms that, while operating in the same major industry group as the focal firm, have different specialisations respect to those owned by the focal firm, the higher the likelihood that the value of products/services produced in that major industry group will be disaggregated across different firms owning different specialisations. Fan and Lang (2000) found a strong correlation between SIC-based and other kinds of variables that aim at measuring complementary relatedness among firms.

3.2.3. *Control variables*

We controlled for a number of firm and industry behaviours that may be associated with the R&D governance mode choice, including *firm R&D governance mode choice propensity* and *industry governance mode choice propensity*. We controlled for the association between the *firm R&D governance mode choice propensity* and the R&D governance choice mode as previous studies indicate that routines with a preference for M&As or A&JVs determine the firm's current preference for each of these modes as a main strategic mechanism for acquiring innovative capabilities (Hagedoorn and Duysters 2002). We measured *firm R&D governance mode choice propensity* as a dummy variable coded 0 if in the time window between 2000 and 2010 the focal firm has adopted more R&D A&JVs than R&D M&As, and 1 otherwise. Data for this control were collected from SDC. Finally, for the R&D governance mode choice we controlled for the *industry governance mode choice propensity* since from an institutionalisation perspective companies search for 'rules of conduct' with regard to different modes of organisation that become institutionalised in particular industrial settings (Osborn and Hagedoorn 1997). The variable takes the value 0 if the number of A&JVs is bigger than M&As; 1 otherwise. Data for this variable were collected from SDC by screening for A&JVs and M&As between 2000 and 2010 related to firms with the same primary SIC code of the focal firm.

We also controlled for factors that may be associated with the firm post-deal innovative performance, including *firm R&D deal propensity*. In fact, since the recognition that the interaction among actors deeply affects innovation (Pammolli, McKelvey, and Orsenigo 2004), we controlled for *firm R&D deals propensity*, that we measured as the as the natural logarithm of the total number of R&D A&JV and M&A deals undertaken by the focal firm between 2000 and 2010.

Finally, for both of the two dependent variables, we controlled for the *firm size*, in term of revenue, since it has been recognised that innovations are more likely to come from larger firms because the high fixed costs of research projects can only be covered if revenues are sufficiently

large (Acs and Audretsch 1987; Symeonidis 1996). Also we controlled the impact of *firm size* on the governance mode choice. In fact, many studies found that the preference for A&JVs over M&As increases with the size of companies. We operationalised the firm size as the natural logarithm of firm revenue (Vanhaverbeke, Duysters, and Noorderhaven 2002). Data for this control were collected from the CNN Money 2000 and refer to the company revenue in the year 2000, the same year in which the company was listed in the Fortune 500.

3.3. Analysis

Due to the multi-stage nature of the research model, a system of equations is desirable when approaching hypothesis testing. However, we could not use the structural equations modelling (SEM) approach commonly applied to similar models because of the following inconsistent conditions in relation to our purposes: (1) SEM does not handle endogenous moderation effects efficiently (Ping 1995); and (2) SEM requires that the variables of interest be latent, rather than observed, and measured using multi-item scales (Anderson and Gerbing 1988). Moreover, even if a series of seemingly unrelated regressions (SUR) has been demonstrated as effective for estimating models depicting mediating and/or moderating conditions (Preacher, Rucker, and Hayes 2007), we still could not use this procedure, because SUR uses ordinary least squares (OLS) regressions that do not fit well with our dependent variables: the *R&D governance mode choice* – a dummy variable which can be better evaluated through a binary logistic regression; and the *firm post-deal innovative performance* – a count variable taking only non-negative integer values. Therefore, the negative binomial estimation provides a better fit. For these reasons, we finally chose two different statistical models to test our hypotheses. We used a binary logistic regression to test the first halves of our hypotheses (hypotheses 1a, 2a and 3a). For the second halves of our hypotheses (hypotheses 1b, 2b and 3b), we used a negative binomial regression. In particular, we used in the estimations cluster robust standard errors to account for the lack of independence within firms.

We regressed the two models in STATA 12. The ‘logit’ and the ‘nbreg’ procedures of the STATA programme were used to run the logistic and the negative binomial regression models, respectively.

4. Results

Descriptive statistics and correlation coefficients for all variables included in this study are reported in Table 2. The interaction terms between independent variables are mean-centred to reduce potential multicollinearity issues. We computed the variance inflation factors (VIFs) to assess the multicollinearity among research variables. The average VIF value is 2.96 and the highest individual VIF value is 4.13. Since prior research stated that 10 or less is a widely used guideline for such a test (Luo and Deng 2009), the multicollinearity of variables is not a serious problem in our analysis.

Table 3 provides the results for the binary logistic regression analysis that tests the first parts of our hypotheses (hypotheses 1a, 2a and 3a), regarding the impact of both internal and external factors on the likelihood a firm will choose A&JV over M&A to carry out R&D activities. We gradually entered variables into the models to examine the robustness of the results. Model 1 only includes the control variables. In Model 2, we added the two firm internal factors. Finally, Model 3 includes the main effects of the external factor. The overall model fit improves from Model 1 to Model 3 (the Wald chi-squared likelihood ratio increased from 45.56 to 64.89 with a

Table 2. Descriptive statistics and correlation matrix.

Variable	Mean	Std. dev.	Min.	Max.	1	2	3	4	5	6	7	8	9
1. Firm R&D governance mode choice	0.415	0.493	0	1	1.000								
2. Firm R&C relatedness to the deal	0.397	0.432	0	1	0.122	1.000							
3. Firm innovation experience	7.390	2.854	0	12.644	-0.063	0.145	1.000						
4. Degree of industry specialisation	0.911	0.114	0.7	0.998	-0.012	0.167	0.307	1.000					
5. Firm size	10.437	0.600	9.787	12.15	0.141	-0.092	0.298	-0.058	1.000				
6. Firm R&D governance mode choice propensity	0.26	0.439	0	1	0.550	-0.057	-0.241	-0.215	0.308	1.000			
7. Industry governance mode choice propensity	0.213	0.41	0	1	0.172	-0.333	-0.486	-0.268	-0.062	0.336	1.000		
8. Firm post-deal innovative performance	2860.339	3658.011	0	18,225	0.331	0.281	0.568	0.238	0.274	-0.216	-0.256	1.000	
9. Firm R&D deal propensity	3.471	1.111	0.693	5.011	0.017	0.366	0.538	0.38	-0.109	-0.281	-0.441	0.531	1.000

Table 3. Logistic regression predicting firm R&D governance mode choice.

Variables ^a	Model 1	Model 2	Model 3
Constant	0.821 (3.231)	-0.24 (2.463)	-1.142 (2.263)
<i>Control</i>			
Firm size	-0.182 (0.303)	-0.186 (0.249)	-0.121 (0.241)
Firm R&D governance mode choice propensity	3.126*** (0.508)	3.358*** (0.466)	3.491*** (0.512)
Industry governance mode choice propensity	-0.153 (0.367)	0.609* (0.359)	0.658* (0.377)
<i>Internal factors</i>			
Firm R&C relatedness to the deal		1.116*** (0.402)	1.076*** (0.388)
Firm innovation experience		0.134* (0.087)	0.114* (0.085)
<i>External factor</i>			
Degree of industry specialisation			2.353* (1.496)
Number of observations	812	812	812
Log likelihood	-420.89	-402.12	-398.14
Wald chi-squared	47.56***	67.77***	64.89***

Note: Cluster robust standard errors are in parentheses.

^aDependent variable (firm R&D governance mode choice).

* $p < 0.1$.

*** $p < 0.01$.

$p < 0.01$), indicating that both internal and external factors contribute to the explanatory power of the model.

Table 4 presents the negative binomial regression results of testing the second parts of our hypotheses (hypotheses 1b, 2b and 3b), regarding the impact of the interaction between the governance choice and the internal and external factors (that conditioned such a choice) on the post-deal firm's innovative performance. Model 1 includes the control variables. Model 2 introduces the main effects on a firm's post-deal innovative performance. In Model 3, we finally added the interaction of R&D governance mode choice and firm's internal and external factors. The overall model fit improves from Model 1 to Model 3 (the Wald chi-squared likelihood ratio increased from 115.11 to 1704.79 with $p < 0.01$), indicating that both the direct and interactive effects contribute to the explanatory power of the model.

Given that the last full model (Model 3) for both of the analyses presented in Tables 3 and 4, respectively, fits the data better than the others, we will use it to test our theoretical hypotheses.

The majority of the control variables are significantly associated with the respective dependent variables (i.e. *firm R&D governance mode choice* and *firm post-deal innovative performance*).

In particular, with regard to the governance mode choice, the results of Table 3 show that both the *firm R&D governance mode choice propensity* ($r = 3.491$, $p < 0.01$) and *industry governance mode choice propensity* ($r = 0.658$, $p < 0.1$) are positively and significantly associated with the likelihood that a firm will choose M&As over A&JVs to conduct R&D activities. In accordance with previous empirical studies based on an institutionalisation perspective (e.g. Osborn and Hagedoorn 1997; Hagedoorn 2002), this result confirms that firms tend to adopt

Table 4. Negative binomial regression predicting firm post-deal innovative performance.

Variables ^a	Model 1	Model 2	Model 3
Constant	- 3.706 (3.397)	2.402* (1.64)	3.186*** (1.535)
<i>Control</i>			
Firm size	0.752*** (0.286)	0.093 (0.143)	- 0.02* (0.136)
Firm R&D deal propensity	0.966*** (0.129)	0.604*** (0.077)	0.565 (0.079)
Firm R&D governance mode choice		0.464*** (0.156)	0.452 (0.519)
Firm R&C relatedness to the deal		- 0.065 (0.081)	- 0.207 (0.198)
Firm innovation experience		0.417*** (0.063)	0.352*** (0.102)
Degree of industry specialisation		2.007 (2.162)	5.07** (0.581)
(Firm R&D governance mode choice) × (firm R&C relatedness to the deal)			0.319* (0.215)
(Firm R&D governance mode choice) × (firm innovation experience)			0.132** (0.078)
(Firm R&D governance mode choice) × (degree of industry specialisation)			- 4.902** (2.383)
Number of observations	812	812	812
Log likelihood	- 6506.01	- 6128.601	- 6076.719
Wald chi-squared	115.11***	318.8***	1704.79***

Note: Cluster robust standard errors in parentheses.

^aDependent variable (firm post-deal innovative performance).

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

M&As rather than A&JVs for conducting R&D activities when a more hierarchy-oriented governance mode is adopted either inside or outside the boundaries of the firm. On the other hand, in contrast with prior research results (e.g. Vanhaverbeke, Duysters, and Noorderhaven 2002), the *firm size* ($r = -0.121$, $p > 0.1$) did not demonstrate a significant relationship with the governance choice. Regarding the *firm post-deal innovative performance*, the result (Table 4) is that the *firm size* ($r = -0.02$, $p < 0.1$) is significantly related to it, while *firm R&D deal propensity* ($r = 0.565$, $p > 0.1$) is not associated with it. In particular, *firm size* ($r = -0.02$, $p < 0.1$) has a negative effect, which is in contrast with some other studies (e.g. Acs and Audretsch 1987; Symeonidis 1996).

The results in Table 3 consistently support the first part of our first hypothesis (Hypothesis 1a), suggesting that the higher the level of *firm R&C relatedness to the deal* ($r = 1.076$, $p < 0.01$),

with respect to the sourced R&D activities, the higher the likelihood that a firm will choose M&As over A&JVs. Also, the results of Table 4 show a partial support for the second part of this hypothesis (Hypothesis 1b). In particular, the result shows that the interaction of *firm R&D governance mode choice and firm R&C relatedness to the deal* is positively related to *post-deal innovative performance* ($r = 0.319, p < 0.1$).

The results of Tables 3 and 4 support both parts of the second hypothesis (Hypothesis 2a and 2b), and suggest that the higher the *firm innovation experience*, the higher the likelihood that the firm will choose R&D M&As over R&D A&JVs ($r = 0.114, p < 0.1$), and the higher the positive effect of this contingent choice on *firm post-deal innovative performance* ($r = 0.132, p < 0.05$). Moreover, it is interesting to underline that the *firm innovation experience* is significantly and positively associated with the *firm post-deal innovative performance* ($r = 0.352, p < 0.01$), strongly supporting the positive role played by absorptive capacities in enhancing the post-deal innovative performance (e.g. Berchicci 2013).

Finally, the results of Table 3 show the opposite scenario for the first part of the third hypothesis (Hypothesis 3a), suggesting that the higher the level of *degree of industry specialisation* ($r = 2.353, p < 0.1$), the higher the likelihood that the firm chooses R&D M&As over R&D A&JVs. On the other hand, the results in Table 4 show complete support for the second part of this hypothesis (hypothesis 3b). In particular, the results show that the interaction of *firm R&D governance mode choice and degree of industry specialisation* is significantly and negatively related to the *firm post-deal innovative performance* ($r = -4.902, p < 0.05$). Moreover, it is interesting to underline that *degree of industry specialisation* has a significant positive direct impact on *post-deal innovative performance* ($r = 5.07, p < 0.05$), confirming our expectations about the productiveness of this type of industrial environment for innovation.

5. Discussion and conclusion

This study adopts a contingency approach to investigate the role played by firms' internal and external factors on the choice of R&D governance mode for external knowledge sourcing (i.e. R&D M&As vs. R&D A&JVs), and the consequent effect of such a contingency choice on firms' post-deal innovative performance. We relied on both the transaction-cost theory and the RBV in order to develop hypotheses that explain factors driving the R&D governance mode choice.

According to these theories, the right governance choice should enhance the value of the firm that makes it, while controlling for the cost of the transaction.

We selected and analysed a sample of 812 M&As and A&JVs undertaken by 62 of the first 100-ranked members of the Fortune 500 (2000) between 2000 and 2010. We found that the firm's decision to adopt one of the two considered R&D governance modes is not always a real contingent choice, i.e. it seems to be not always the best choice in terms of its effects on the post-deal innovative performance.

In particular, regarding the internal factors, the results demonstrate that a firm that already owns the R&C requested to carry out the R&D activities and high innovation stock tends to externally source knowledge using a more hierarchy-oriented governance mode (i.e. R&D M&As over R&D A&JVs), with such a conditioned choice having a positive impact on its innovative performance. This would suggest to managers that, in the above-discussed circumstances, R&D M&As are more suitable than R&D A&JVs. This conclusion was expected because, according to the scientific literature, more hierarchy-oriented governance modes allow firms to completely control the high level of knowledge appropriation risk, and leads the newly integrated entity to efficiently and effectively create innovative value from the pooling of similar R&C for R&D

activities. Regarding the firm's innovation experience, our findings contribute to the previous literature findings by showing that firms' internal R&C capacity is not just positively associated with the intensity of innovation cooperation (Clausen 2013) or their innovative performance (Petruzzelli, Rotolo, and Albino 2012), but also suggests the particular governance mode needed for external knowledge sourcing in order to increase a firm's innovativeness.

Regarding the external factor, it is important to notice that, although most of theoretical constructs that we have operationalised, measured and tested in our study are not new in both the inter-firm relationship and open innovation literature, the external factor *degree of industry specialisation* has not yet been investigated. Specifically, we found that firms that operate in highly disaggregated industries tend to choose a more hierarchy-oriented governance mode (i.e. R&D M&A over R&D A&JV), with this conditioned choice having a negative impact on post-deal innovative performance. This surprising finding stands as a warning to managers, since they do not seem to be actually aware that R&D A&JVs perform better (at least in terms of innovative performance) than R&D M&As for external knowledge sourcing when the industry is highly disaggregated. Indeed, as we also argued in the hypothesis development section, less hierarchy-oriented governance modes for R&D activities allow firms to take advantage of drastic reductions in the product development cycle by exploiting the high level of specialised R&C offered in its industry. Similarly, managers should consider this factor when the number of specialised firms in the same industry is quite low, as merging with or acquiring the external knowledge owned by a few firms would make the advantages obtained in terms of innovative performance more sustainable.

This study provides important contributions to both the strategic management and the open innovation literature. According to contingency theory, we may claim that there is no preferred approach to governance mode decisions regarding external knowledge sourcing; in fact, the best choice is contingent (dependent) upon the internal and external situation (Morgan 2007). We confronted this issue by adopting an integrated model that was centred on the governance mode choice and integrated antecedents, on the one hand, and the implications of this contingent choice on innovations, on the other hand (Leiblein 2003). As a result of this approach, we were able to assess the actual effectiveness of a contingent management decision that was influenced by both firm (internal) and industry (external) factors.

Our findings demonstrate the utility of adopting this kind of integrated model to investigate a contingent management issue, such as the external sourcing of knowledge. In particular, this model enabled us to find two interesting results that we would not have found with conceptual models focused solely on the first or second part of our hypotheses.

First, if we had only tested the first part of our hypotheses, we would have found that when the industry is highly disaggregated, managers are more inclined to adopt hierarchy-oriented governance modes (e.g. M&As). From this evidence, we would have probably deduced that R&D M&A is the right choice in that kind of industry, which would have weakened our theory-grounded arguments that, through suggesting the adoption of R&D A&JVs in a highly disaggregated industry, caused us to state hypothesis 3a. Contrarily, thanks in part to our contingency and integrated model, we were able to verify that R&D A&JVs have to be preferred in this kind of industry context because of their higher effectiveness – at least in terms of innovative performance – with respect to R&D M&As. For this reason, we believe that this study contributes to both the open innovation and inter-firm relationship literature stream that is focused on investigating the drivers of external knowledge sourcing decisions.

Second, if we had explored only the second part of our hypotheses, we would have found some evidence of the influence of governance mode choices on innovative performance, and how such

a relationship is moderated by internal and external factors. Once again, apart for some degree of originality in our choice of internal and external factors under study, this is not something very new in the literature. The real contribution relies on the dual role that internal and external factors play in our integrated model: they moderate the relationship between governance mode choice and innovative performance at the same time act as being an antecedent of the governance mode choice itself. Through this approach, we were able to understand real contingent decisions, that is, decisions that are not only influenced by the specific context, but that should represent the best decision in that context.

The above-mentioned considerations enable us to suggest that we have contributed to the scientific literature – at least in terms of the call for the construction of integrated models on the strategic choices of firms, and the drivers and performance implications of those choices (Leiblein 2003).

Apart from this major theoretical contribution related to the contingency and integrated mode, this study also provides minor interesting contributions to the open innovation literature on governance mode decisions. To the best of our knowledge, the majority of papers study the choice of internal vs. external R&D practices, and the complementary and/or substitutable impact of such a choice on innovative performance (e.g. Hagedoorn and Wang 2012; Berchicci 2013). Contrarily, in trying to answer the call for research into how firms structure their external R&D activities (Berchicci 2013), this study concentrates and deeply investigates external knowledge sourcing practices, particularly the choice between two different governance modes (A&JVs vs. M&As) which are characterised by a different level of hierarchy-orientation (medium vs. high).

This study contains some important limitations. First, a longitudinal data set analysis could provide greater exploratory power for innovative performance implications. Second, the results could be generalised to industry systems that are similar to the first 100-ranked Fortune 500 firms, so that our findings could be generalised to American firms with high revenues. Third, this study only focuses on innovative performance implications without considering implications for other performance dimensions, for example, financial. Fourth, the adoption of secondary data source brings some limitations to our research. In fact, even if the use of secondary data source allows to easily collect a great amount of observations, it cannot grant that data, reported by the data set under request, exactly cover what happens in the real world. We are not sure, for example, of the existence of R&D A&JV and M&A that, even if announced, are not listed in the database we are using (SDC). Also, the use of secondary data source limits the level of specificity of the information we use to measure our variables. For example, we know that the governance mode choice for R&D external sourcing is not always a decision taken by the firm on its own. Indeed, whereas in the case of acquisitions the decision is mainly taken by the acquiror, for A&JV the decision is taken by the two firms. In other words, we just consider the deals (M&A and A&JV) of the first 100-ranked members of the Fortune 500, and we assume that the governance mode choice is a decision of the focal firm only. Again, while this sounds fine for M&A, it could not be the case for A&JV. Taking into account this factor would be very interesting for our analysis. Future research should, for instance, assess the weight of the focal firm in making this decision respect to the partner one.

Summing up, relying on primary data source, for example by conducting a survey, and considering different items for each variable, could overlap the limitations related to the measurement of our variables.

Further research should first overcome the above-mentioned limitations of this work. We also believe that future research should focus on analysing the impact of other contingent R&D management decisions by adopting a similar integrated model, for example, decisions about the entire 'knowledge supply-base' of the firm, their contextual drives, and their impact on innovative and financial performance.

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