Chapter 18
A Conceptual Approach to the Dilemma of R&D Integration: Further Insights into the Innovating Entrepreneur's Toolkit

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Abstract In an age of deep crisis and uncertainty, those entrepreneurs who think of difficulties as chances hold the key for a way out. Innovation, as a result of R&D investing, is one of the items in their toolkit. Unfortunately, even though decision-making on the area of vertical integration has been extensively studied, there is no agreement yet about the effects of uncertainty on the optimal degree of R&D integration. Consequently, entrepreneurs wishing to innovate are missing a sound criterion to choose the governance form for their project.

Some authors claim that the reason for this is that the research conducted so far on the relation between uncertainty and R&D integration is incomplete. We provide further support to this claim by putting forward a model that reconciles the most important results discussed in the available literature. After reviewing the main past contributions available, we highlight the most significant variables driving decision-making on R&D integration in the face of uncertainty, and we discuss their mutual interrelations. We argue why and how specificities comprise key factors in this regard.

18.1 Introduction

Decision-making in the area of vertical integration remains a current research topic in the academic literature, and the conclusions of different studies tackling optimal decision-making in the area of business performance do not seem to be consistent. Rather, making a well-informed decision on the degree to which a governance form should be integrated appears to be conditional on different circumstances surrounding the relationship.

The lack of agreement among researchers in the area of vertical integration is particularly acute when it comes to the topic of innovation and R&D-related

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activities (Rodríguez-López et al. 2013). These are characterized by the presence of uncertainty and the need for protection, particularly relevant in a context of crisis like the present one. Besides, the usual requirements to encourage developing the activity in-house—among others, the availability of resources and the absence of market failures—can hardly be satisfied in this scenario (Santamaría and Surroca 2004), thus encouraging an outsourced activity (Howells 1999; Silipo 2008) or, at least, a properly balanced combination of in-house and outsourced activities (Harrigan 1986; Van de Vrande et al. 2006).

With all of the above in mind, our research is focused on discerning which are the most significant parameters or variables in making a decision on the degree of R&D integration and on gaining a proper understanding of their different role in this context. While it is accepted that uncertainty and specific assets, together with the risks ensuing from opportunistic behavior, can be highlighted as key elements in the optimality of integration, no agreement on the meaning and significance of the interrelations among them has been attained yet.

The disagreement among researchers on the features of the twofold interrelation that vertical integration can have—with uncertainty on the one hand, with specificities on the other—has brought as a consequence a general dismissal of the existence of interactions among these two variables. Nonetheless, such a possibility is contemplated in two research venues. The first one puts forward some mathematical model following a second degree law. According to it, there is a positive relation between those variables as long as one of them remains at one side of the law's critical point, becoming negative as soon as it crosses over to the other side (Oriani and Sobrero 2008). In the second research proposal, it is considered that the nature of the interaction is such that uncertainty can impinge on specificities in such a way that it can change its relation with vertical integration (Mahoney 1992). In this line of thought, Gervais et al. (2008) proved the existence of a negative relation between environmental uncertainty and specific human assets by introducing a particular mathematical model. In such a down-to-earth setting as the car industry, it has been proved that, both in the USA and in Japan, technological uncertainty increases specificities, whereas market uncertainty is not a significant variable (Bensaou and Anderson 1999).

The authors cited above introduce a measuring system composed of items combining physical with human specificities. This does not seem to us particularly fortunate, at least when considering the issue of appropriability, because any type of specificity must be carefully distinguished from any other.

Other researchers have addressed topics related to the optimal degree of R&D integration, both from a single-sector and from a multi-sector perspective. But even though uncertainty and specificities are discussed profusely, their interaction is not considered. Thus, Gooroochurn and Haley (2007) address the issue of whether to develop R&D in-house or have it outsourced, but nonetheless they do not provide an assessment in terms of a joint function of uncertainty and specificities. Wong et al. (2008) make their own analysis of the effects of outsourcing on innovative activity, but they obliterate discussing the contributions of uncertainty and specificities in this regard.

Our aim with this contribution is testing whether the existence of a relation between specificities and integration, on the one hand, and between integration and uncertainty, on the other, embeds some kind of interaction between specificity and uncertainty. Moreover, we aim to ascertain whether, in the affirmative, the features of those interactions have something to do with the specific kind of assets on scope. This could provide a coherent framework encompassing different research venues on the subject matter of R&D integration, thus enhancing the corresponding decision-making criteria and procedures.

We proceed by discussing in the next sections the effects that the multifaceted sources of uncertainty and specificities can have on choosing a particular governance form. We consider the relations ensuing from transaction costs theory (TCT), from the resource-based view (RBV), and from Real Options Theory (RO). Building upon this, we put forward the propositions standing at the core of our contribution. In a final section, we discuss the conclusions of our conceptual analysis.

18.2 Implications of Environmental Uncertainty Regarding the Degree of R&D Integration

As we have been saying, there is in the academic literature an acute disagreement about the relation between uncertainty and vertical integration. Thus, we find contributions stating that uncertainty has random effects on the optimal degree of integration (Krickx 2000). Other researchers, approaching the problem from the perspective of TCT, claim that there is a positive relation between uncertainty and integration based on the increased chances for opportunistic behavior in any scenario of environmental uncertainty or volatility (Carson et al. 2006; Skarmeas et al. 2006). And there is also a fraction of the literature where the authors, building up from the same theoretic foundations, claim that uncertainty—whether market-based (Gençtürk and Aulakh 2007; Levy 1985; MacMillan et al. 1986) or technological (Joshi and Stump 1999; John and Weitz 1988; Masten 1984; Masten et al. 1991; Gulati 1995; Oxley 1997, 1999; Gulati and Singh 1998)—can eventually encourage a larger degree of vertical integration.

Founded upon these considerations, different approaches have tested the proposition that technological intensity discourages vertical integration (Lambertini and Rossini 2008) and encourages cooperation (Schartinger et al. 2002; Pangarkar and Klein 2001) with the aim to remain locked onto the pace of innovation (Gooroochurn and Haley 2007).

High levels of technology and market uncertainty, together with fast technological change, discourage a large degree of integration and encourage a strategy based upon a wise combination of in-house and outsourced R&D (Harrigan 1986; Van de Vrande et al. 2006). Much in the way that is suggested by Strategy Theory, environmental uncertainty and volatility demand a greater flexibility (Sharfman and Dean 1997; Bello and Gilliland 1997) and a smaller commitment (Skarmeas et al. 2006).

According to both RBV and RO, it is concluded that, in front of a high level of environmental uncertainty, delaying the decision as to whether or not to invest in R&D will increase its value, since this allows to make the best out of the resources provided by other agents and adds flexibility to the company (Oriani and Sobrero 2008; Pateli 2009), thus encouraging those forms with a smaller degree of integration (Pateli 2009). The enhanced flexibility that belongs in the character of non-integrated forms, together with the possibility of establishing synergetic trading relationships with specialized agents, provides further support for this thesis (Harrigan 1986).

The differences of the conclusions in Oriani and Sobrero (2008) with respect to those of the preceding contributions are combined by testing the existence of more sophisticated relations between different types of uncertainty and the value of investing into R&D. They conclude that the value of the latter decreases with market uncertainty as long as uncertainty remains above a certain threshold, but as soon as it drops below it, the effect is reversed. In regards to technological uncertainty, it will be the other way around; the latter contributes to increasing the value of R&D investing until this type of uncertainty crosses over a certain threshold, showing a negative effect from that point on.

This can be summarized in terms of the following proposition:

Proposition (1): *Environmental uncertainty shows a quadratic effect on R&D integration*.
Proposition (1a): *Market uncertainty has a quadratic positive effect on R&D integration*.
Proposition (1b): *Technology uncertainty has a quadratic negative effect on R&D integration*.

18.3 Implications of Specificities on the Degree of R&D Integration

According to TCT, endogenous uncertainty is a consequence of the existence of specific assets in scenarios of asymmetric information together with the possibility of the presence of opportunistic behavior (Pateli 2009). Under such circumstances, those governance forms allowing for a tighter control (Gençtürk and Aulakh 2007; Das and Teng 2001) and the provision of the latest technology (Nakamura and Odagiri 2005) are the ones to be preferred. These correspond precisely to the structure of a firm (Heide 2003). Therefore, according to this theory, there is a positive relation between endogenous uncertainty and the degree of vertical integration (Krickx 2000).

As for specificities, most of the empirical tests conclude that it encourages integration. This is a result of the protection it provides against the possibility of expropriations (Williamson 1989). In the same way, TCT suggests that a larger degree of integration provides further protection to specific technological knowledge (Hashai and Almor 2008).

Whenever there is a large sustituibility and a possibility for replication, the need for protection becomes even more critical and, consequently, so does a larger degree

of integration (Lambertini and Rossini 2008). In those cases, innovation must be developed in-house (Gooroochurn and Haley 2007). Increasing the degree of integration when the interdependence degree between assets is low makes the risk of opportunism smaller (Lee and Fixson 2008).

On the other hand, RO suggests that, while the innovation process moves forward, the decrease of uncertainty will lead to changes on the preferences regarding R&D integration (Van de Vrande et al. 2006). According to RO, a decrease of uncertainty among partners encourages compromising a larger fraction of the resources and quitting hierarchies progressively.

Moreover, a negative relation between specificity and integration has been justified on the basis of the compliance warranty ensuing from such a specificity (López Bayón et al. 2002). This warranty becomes particularly significant when the assets are prone to appropriability (Klein 1996; Dyer 1997; Nakamura and Odagiri 2005). Brocas (2003) and Bulan (2005) provide an analytical proof for the argumentation above in terms of the possibility to increase the licensing prices and therefore to obtain all the surplus resulting from innovation.

Along the same lines, we can find RBV, adding to the above that the larger the specificity in technological knowledge, the deeper the extent to which it contributes to the competitive advantage of the company, making at the same time more difficult any possibility of replication and of illegitimate appropriation; hence, the need for protection is smaller (Hashai and Almor 2008). In this way, specificities will become protective only once the intensity of R&D is high enough; whenever there is specificity to some degree, as long as it is small, it is necessary to resort to protection mechanisms, which in turn could encourage a larger degree of integration.

Intermediate R&D intensity will demand a larger degree of integration, because the possibility of market failure must be considered, and specificity is not high enough to become protective. For R&D intensity increasing up to a certain threshold, the optimal degree of integration rises accordingly, but once that threshold is crossed over, specificities are protective enough and the optimal degree of integration is smaller. Thus, the relation has the shape of an inverted "U." We get in this way to Proposition 2:

Proposition (2): *Specificities have a negative quadratic effect on R&D integration*.
Proposition (2a): *Physical specificities have a negative quadratic effect on R&D integration*.
Proposition (2b): *Human specificities have a negative quadratic effect on R&D integration*.

Any proposal to reconcile organizational theories and the different conclusions that they appear to support must necessarily consider a joint assessment of the role of specificities and uncertainty. The effect of uncertainty on the optimal degree of vertical integration is conditioned by assets specificities. If the latter remain constant, the relation between uncertainty and integration will be positive, whereas if specificities decrease due to uncertainty, the relation between uncertainty and integration might even become negative (Mahoney 1992).

Nevertheless, the two types of specificities—physical and human—display very distinctive features in regard to their susceptibility to being appropriated. Physical

Table 18.1 Propositions

Proposition	Independent variable	Sign	Dependent variable
Proposition 1	Environmental uncertainty (market/technology)	∪/∩	R&D integration
Proposition 2	Specificities	∩	R&D integration
Proposition 3	Environmental uncertainty	–	Physical specificities
Proposition 4	Environmental uncertainty	+	Human specificities

specificities are in full sight, which makes their replication an easy task when they are successful. Besides, they are tightly bound to their owner, hence they are difficult to remove when they prove a failure. Thus, physical specificities should decrease in front of uncertainty and consequently lead to governance forms which are integrated only to a smaller degree. This is stated as Proposition 3.

In turn, human specificities, if successful, can be replicated by others only with difficulty—they need time to be developed to the necessary extent. Besides, they prove helpful in the generation of capabilities that allow for a better fit to environmental changes and to the generation of innovations underlying competitive advantage. In this sense, uncertainty should encourage investing into human specificities. This is considered in Proposition 4.

Proposition (3): *Environmental uncertainty has a negative effect on physical specificities*.

Proposition (3a): *Market uncertainty has a negative effect on physical specificities*.

Proposition (3b): *Technology uncertainty has a negative effect on physical specificities*.

Proposition (4): *Environmental uncertainty has a positive effect on human specificities*.

Proposition (4a): *Market uncertainty has a positive effect on human specificities*.

Proposition (4b): *Technology uncertainty has a positive effect on human specificities*.

The theoretic approach discussed in our paper suggests the five propositions that we have put forward. These are statements collecting and giving open expression, on the one hand, to the different interrelation modes existing between the degree of uncertainty and the optimal degree of R&D integration; on the other, to the binding effect between the former and the latter due to specificities. As a summary, we compile in Table 18.1 those propositions.

18.4 Conclusions

The lack of consensus on the relation between specificities and vertical integration, on the one hand, and between uncertainty and vertical integration, on the other, seems to have led to a general dismissal of the possibility of specificities and

uncertainty interacting with each other. As an immediate consequence of this disagreement, entrepreneurs wishing to innovate based on the outcome of R&D activity are missing the grounds on which they can base their decisions on how to devise their projects' governance forms and strategies. This is a gap that needs to be filled urgently, because innovating entrepreneurship is one of the paths to follow in order to get out of our current crisis scenario.

Nonetheless, two research venues have been suggested which contemplate the possibility of an interrelation existing between uncertainty and integration and which, through it, hopefully pave the way to a more comprehensive and unified approach to the dilemma of R&D integration. The first one, in terms of a mathematical model, following a quadratic law (Oriani and Sobrero 2008). In the second approach, it is considered that uncertainty can impinge on specificities and in this way change its relation with vertical integration (Mahoney 1992).

With the above in mind, plus the relevant literature reviewed, it is shown how it is nonetheless possible to find some coherence in the different results obtained on R&D integration, and therefore to establish some guidelines for those entrepreneurs wishing to innovate in the presence of uncertainty.

Our paper develops a foundational discussion pointing to a number of propositions that add up to the statement that the relations between specificities and integration, on the one hand, and between uncertainty and integration, on the other, embed interactions among specificities and uncertainty. Environmental uncertainty decreases physical specificities and increases human specificities. Besides, specificities have a negative quadratic effect on R&D integration. In this way, developing R&D in-house is advised only for those business sectors which are not knowledge-based and for those enjoying high specific investments.

In accordance with the objectives put forward, those propositions account for the features distinguishing the results that had been obtained previously about the relations involved among the variables uncertainty, specificities, and R&D integration. An appropriate understanding of these interactions will provide more coherent grounds to the different research venues in this subject matter, thus moving forward the state of the art. In regard to empirical approaches and applications, the results obtained herein will enhance the decision-making criteria, and the corresponding procedures, on the optimal degree of R&D integration.

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