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ESTUDIOS / *RESEARCH STUDIES*

Risk Perception and Relational Capital Strategies in Corporate Research and Development

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Abstract: R&D investment can have important benefits for companies, but it entails a high inherent risk and does not always produce the expected effects. One of the option to face R&D uncertainty is the collaboration with other entities. This study analyses whether perceptions by companies of risks associated with science and R&D are linked to relational capital strategies. This research is based on the results of the 'Scientific culture, perception and attitudes toward science and innovation in the Spanish business sector' survey. We identify five different patterns in companies' risk perception and test how relational capital strategies shaped them. The results evidence that R&D collaboration is related to perceiving R&D as a risky and uncertain investment. In contrast, companies' reluctance to join business associations is associated with particular concern about how this type of investment could affect employment within the company.

Keywords: risk perception; corporate R&D; relational capital; R&D collaboration; business association; cluster

Percepción del riesgo y estrategias de capital relacional en la I+D empresarial

Resumen: La inversión en I+D puede comportar importantes beneficios para las compañías, sin embargo conlleva un riesgo inherente y no siempre produce los beneficios esperados. Una de las posibles opciones para hacer frente a esta incertidumbre es la colaboración con otros agentes. Este estudio analiza la relación entre la percepción del riesgo en las empresas en materia de ciencia e I+D y las diferentes estrategias de capital relacional. La presente investigación está basada en los resultados de la encuesta "Cultura científica, percepción y actitudes sobre la ciencia y la innovación en el sector empresarial español". Se han identificado cinco patrones en función del tipo de riesgo percibido en las empresas y se ha comprobado cómo las estrategias de capital relacional han contribuido a darles forma. Los resultados evidencian que, si bien la I+D colaborativa está relacionada con una percepción de la investigación como una inversión arriesgada e incierta, la reticencia a asociarse está relacionada con una particular preocupación acerca de cómo este tipo de inversión podría afectar al empleo dentro de la empresa.

Palabras clave: percepción del riesgo; I+D empresarial; capital relacional; I+D en colaboración; asociación empresarial; clúster

1. INTRODUCTION

In recent years, the literature has highlighted how companies' decisions to invest in R&D are usually moderated by numerous economic and market factors, e.g., the activity sector (Padgett and Galan, 2010) and the company's competitive position within it (Van Bavel et al., 2006), competitors' levels of investment in R&D (Jaruzelski et al., 2005), the business cycle (Rafferty, 2003; Maliar and Maliar, 2004), the size or concentration of the market (Griffith et al., 2006; Jefferson et al., 2006), and the company's characteristics (Arvanitis and Woerter, 2014; Davies, 2011; Groot et al. 2011; Shefer and Frenkel, 2005). However, there is also fertile terrain – as yet explored in much less detail – in research which highlights the importance of attitudinal factors related to the characteristics of chief executive officers (CEOs) and business owners, or the company's scientific and innovative culture (Ahmed, 1998; Mezghanni, 2010; Zeng and Lin, 2011; Gao and Hafsi, 2015).

The importance of focusing on this latter type of variable lies in existing empirical evidence showing that traditionally, a non-negligible percentage of companies remain reluctant to make investments that require significant effort and commitment (Ahmed, 1998). Although R&D investment can have important benefits for companies, it does not always guarantee tangible returns in the short term. In addition, it entails a high inherent risk and does not always produce the expected effects or benefits (Jaruzleski et al., 2005).

Several studies have shown how the perception of and attitude towards risk affect decisions pertaining to R&D engagement (Shane, 1993; Ulijn and Weggeman, 2001; Westwood and Low, 2003; Sun, 2009; Kaasa and Vadi, 2010; Taylor and Wilson, 2012; Kaasa, 2015). In most cases the attitude towards risk has been measured with Hofstede's (2001) cultural dimension 'uncertainty avoidance' as a reference. According to this approach, the degree to which members of a society feel uncomfortable with uncertainty and ambiguity is expected to influence their expectations and incentives for embarking on R&D. However, most of these studies have focused on analysing the influence of risk aversion on differences between countries in R&D, and have reported a negative relationship between risk aversion and investment in or commitments to R&D.

In the context of this traditionally macro approach, the present study focuses on the company as a decision unit, and on the perceptions and attitudes of decision-making agents within companies towards the risks associated with science and R&D investment. This starting point is consistent with work by Mezghanni (2010) (among others), in that we assume that the attributes of a company's decision makers are likely to be related with the company's propensity to take risks, and therefore with its willingness to engage in R&D activities. However, the methodology used here to assess attitudes towards risk and to profile risk perception in businesses constitutes a differential aspect compared to previous work.

The present research is intended to elucidate the relationship between risk perception and investment in R&D. It explores the extent to which companies perceive risk in different ways according to assessments of its specific dimensions – e.g. economic risk, job loss, health or environmental risk – and how different profiles of risk perception relate to the implementation of associative strategies involving forms of cooperation with other agents, such as collaboration with other organisations, or membership in business associations whose purpose is to promote R&D or innovation.

In light of the previous knowledge and experiences summarised above, the hypothesis we set out to test in the present study is that there is a relationship between the perception of risks associated with science and firms' investment in R&D, on one hand, and their relational capital strategies based on R&D collaboration and membership in business associations intended to favour R&D or innovation, on the other hand.

The empirical analysis is based on the results of a survey administered to a representative sample of the universe of Spanish companies, which has allowed determining the profiles of Spanish firms' attitude and behaviour regarding R&D and risk perception, among other topics (see Rey-Rocha et al., 2019; Rey-Rocha et al., 2021; González-Bravo et al., 2021; López-Navarro et al., 2022). The results evidence that different patterns in companies' risk perception could be identified and relational capital strategies shaped them in different ways.

The following sections present a brief review of the concept of risk, and the perception of risk associated with business engagement in R&D and firms' relational capital strategies. The methodology used for this work is presented, followed by the research's main findings, going on to conclude with the discussion of their significance and implications for business and R&D management, together with the study's main conclusions.

2. THEORETICAL FRAMEWORK

2.1. The Concept of Risk

Risk and uncertainty are two terms that have a decisive influence on decision-making processes. The difference between these two concepts lies in the ability to measure the likelihood that a given outcome will occur (Amoroso et al., 2017). Risk is identified with those events that may have a negative impact on the decisions that have been taken. Risk implies measurability and the possibility of being able to estimate and quantify negative impacts by basically identifying two dimensions: the probability of occurrence of the event and the effect. Uncertainty involves a scenario in which the lack of information hinders the predictability of an event and therefore the consequences of a decision due to the difficulty to quantify the results derived from it. In a context of uncertainty, the probability of occurrence of an event cannot be estimated since there is no access to the information necessary for such an estimate (Amoroso et al., 2017). This lack of information may be caused by the absence of full knowledge about an event and its probability of occurrence or by the absence of information for the estimation and evaluation necessary in a specific decision-making process. This differentiation is suggested by Bronk (2011) in distinguishing 'ontological uncertainty' from 'epistemological uncertainty'. This focus on the quality of measurability was already emphasized by Knight (1921) suggesting that risk implies measurability by distinguishing between immeasurable uncertainty and measurable risk or 'risk as a measurable uncertainty'.

These two terms also have a decisive influence on R&D decisions. Companies that have a stake in processes leading to innovation thus assume a certain degree of uncertainty and risk (Eisenhardt and Martin, 2000; Greve, 2003). Uncertainty involves a scenario in which the lack of information makes it difficult to obtain a reasonable quantification of the benefits and losses associated with R&D. R&D processes are normally subject to imprecision in estimates of the amount and duration of possible returns, and even to uncertainties whether such returns will be realised, given the unpredictable nature of future demands or possible competition (Walker and Weber, 1984; Tripsas et al., 1995). When firms identify and evaluate the risks associated with R&D, they are in essence estimating the possible losses and negative impacts a given decision may have. These estimates imply the ability to measure specific aspects such as the cost of the required investment, the time needed, or possible job losses. In this sense, then, the likelihood that the risks are measurable is incompatible with the lack of solid information.

2.2 Risk and Business Engagement in R&D

Perhaps the most frequently analysed dimension of risk derived from corporate R&D decisions is the economic one. The effort implied by the cost of R&D activities usually acts as a deterrent on decisions to carry them out (Varsakelis, 2001). However, the perception of risk associated with science and R&D includes other dimensions that have been addressed less often in the literature, and which are associated with factors such as possible job destruction and associated health and environmental risks (Friedrichs and Schulte, 2007; Harrison et al., 2014). In this connection, the risk associated with possible outcomes from investment may influence decisions made by firms in two major ways. Firstly, it can modify investment decisions if the risk is believed to outweigh the potential benefits when both are viewed against a background of uncertainty. Secondly, it can condition investment strategies, i.e., how R&D activities are carried out, in ways that moderate, reduce, or correct the perceived risk.

The situation summarised above underlies the positive relationship between aversion to risk and uncertainty, and resistance to innovation (Hofstede, 2001). A lack of certainty about the results and benefits of R&D will cause individuals highly averse to uncertainty to be less committed to this type of decision (Dwyer et al., 2005). Firms tend to diminish their R&D efforts when they face markedly uncertain environments (Amoroso et al., 2017). Also, low risk tolerance means that the risk R&D processes are subject to in terms of cost, time and success will discourage such decisions by these individuals, basically because higher-level management is unable to diversify the high risk of failure (Hirshleifer and Thakor, 1992).

How R&D processes are related with risk and uncertainty has been analysed in numerous studies, most of which found a direct relationship between acceptance of uncertainty and risk and proactivity in these processes. In other words, aversion to risk (including areas other than economic factors) is an impediment to R&D investment (Shane, 1993; Waarts and van Everdingen, 2005; Kaasa and Vadi, 2010; Rujirawanich et al., 2011; Taras et al.,2012; Kaasa, 2015). In the specific context of business decisions, Mezghanni (2010) found a positive relationship between CEOs' tendency to forego risky strategies and reductions in R&D expenditure.

Accordingly, investment in R&D is often promoted within companies with a positive attitude towards change and long-term horizons (Ahmed, 1998) – an approach that requires an adequate level of acceptance of uncertainty along with high risk tolerance (Shane, 1993; Dobni, 2008). Likewise, positive perceptions and assessments of R&D will favour motivation and encourage action and commitment to further investment (Gao and Hafsi, 2005).

2.3. Risk Perception and Relational Capital Strategies

The types of perceived risk associated with R&D investment, as well as uncertainties and insecurity regarding the results, can give rise to different strategies to manage R&D processes in businesses (Dwyer et al., 2005; Kaasa, 2015). For example, when risks arise in situations that are to a certain extent foreseeable, they can be managed through contractual agreements with other parties (Teece et al., 2016).

The study of firms' R&D collaboration can be contextualised within the framework of open R&D and open innovation literature. Based on an overview by Enkel et al., (2009: 312), three core processes can be identified in open R&D and innovation: a) the outside-in process, or 'inbound process'; b) the inside-out or outbound process, through which companies bring or externalise to the market the knowledge they generate intramurally; and c) the coupled process or co-creation of knowledge through collaborative strategies with partners. The networking imperative, i.e. the need to be open to outside knowledge and outside innovation, and to work with people outside the company (Chesbrough, 2003; Saint-Paul, 2003), can lead companies to move toward open R&D and open innovation environments, where organisational boundaries are porous and firms strongly interact with each other and with their environment.

Some authors have pointed out that the propensity to cooperate increases when innovation activities are perceived as risky (Bayona et al., 2001). There is in fact evidence that risk aversion can contribute to the establishment of solid cooperative relationships that allow companies to minimise uncertainty, protect themselves from future results, and diversify the costs of R&D activities (Didero et al., 2008), as well as propitiating fruitful knowledge exchange (Arza, 2010; Soh and Subramanian, 2014). Opting for collaborative R&D is a decision that can improve efficiencies in resources usage, by sharing, favouring specialisation by each partner, or minimizing investment costs. These potential advantages are desirable when the results of R&D investment are highly unpredictable, or when the company lacks sufficient knowledge stock to carry out a particular innovation. Risk-averse individuals may try to minimise risks through safety and security measures (Didero et al., 2008) which may increase the likelihood that their company will use cooperative strategies with other public or private entities to carry out R&D activities.

Such strategies are part of a company's relational capital, and afford some protection against possible adverse outcomes while ensuring and strengthening its own capacity to carry out R&D. In fact, belonging to innovation networks is a characteristic treated in the available literature as a factor that can help explain a given company's behaviours regarding R&D processes (Sternberg and Arndt, 2001). In addition, this type of agreement allows collaborating entities to share R&D risks (Teece, 1988).

Many firms may lack adequate infrastructure, resources, and organisational processes to deal with the risks and uncertainties of engaging in R&D, and performing R&D implies considerable financial risks that they may not be able to afford if they rely on intramural R&D. Under these conditions we may argue, as others have done in connection with open innovation (Chesbrough, 2003, 2006; Keupp and Gassman, 2009), that collaborative and open approaches to R&D seem a promising way to diversify and share uncertainties and risks.

The most common forms of cooperation in corporate R&D involve collaboration with other private or public organisations, and membership in business associations whose purpose is to promote research, development, or innovation (e.g. a scientific or technological park, or a cluster). Such collaborative and associative strategies can present opportunities to adapt to unstable environments, thereby allowing a firm to strengthen its survival capacity. This outcome is reflected in an analysis by Holl and Rama (2016), who found a positive relationship between R&D cooperation and adaptation to periods of crisis. However, a study by López Campo and Rossell Martínez (2007) showed that in recessive environments, the tendency to collaborate decreases.

Nevertheless, collaboration is not without its own risks and costs associated with oversight to detect and prevent opportunistic behaviour by any of the parties involved, the need for coordination, the complexity of the agreement, the loss of control, or problems that may arise from the appropriation of results (Enkel et al., 2009; Rosenbusch et al., 2011). Clusters and other types of business asso-

ciations intended to favour R&D provide a flexible formulation that does not necessarily involve the execution of R&D between partners, but rather encourages the creation of an environment that can generate the alliances needed to favour R&D activities, thus reducing their inherent risk (Freeman, 1991; Porter and Stern, 2001; Freel and Harrison, 2006; Skålholt and Thune, 2014). Collaboration through clusters facilitates access to funding and other resources – not only economic in nature, but also related to learning (Henry, 2006; Giuliani, 2007) – and the possibility of sharing the costs associated with R&D projects (Makedos, 2014), or sharing key information (Hall and Teal, 2013). In this connection, De la Maza-y-Aramburu et al., (2012) consider clusters as mechanisms potentially able to generate trust between companies that carry out innovation activities, including R&D. Accordingly, the decision to take part in a cluster association goes beyond a simple consideration of the costs associated with R&D or the exposure to risk from uncertainties in the outcomes. Companies participating in a cluster seek to belong to an environment of trust that facilitates knowledge exchange and innovation (Makedos, 2014) and thereby reduces the uncertainty of some activities, particularly those which partner companies may already be willing to undertake.

The risks a firm associates with R&D may be a consequence of previous experience with these activities; other firms may remain unaware of the risks until they have faced them through direct experience. In this connection, several studies reported that firms that became involved in R&D acquired enough experience to evaluate the problems associated with these activities and become aware of the efforts they involve (Mohnen and Rosa, 2000; Baldwin and Lin, 2002; D'Este et al., 2012). This learning and experience can lead firms to seek alternatives aimed at moderating the risk. As argued by D'Este et al., (2012), learning will increase a firm's awareness of barriers, but does not prevent it from engaging in these activities. In contrast, when experience is lacking, risk evaluation is much more subjective, and risk-adverse firms may tend to overestimate the risks associated with undertaking R&D activities. These overestimates, in turn, may become disincentives to R&D; on the other hand, if firms are aware that investment is necessary to support their competitiveness and survival, they will seek ways to manage these risks.

In light of the previous knowledge and experiences summarised above, the hypothesis we set out to test in the present study is that there is a relationship between the perception of risks associated with science and firms' investment in R&D, on one hand, and their relational capital strategies based on R&D collaboration and membership in business associations intended to favour R&D or innovation, on the other hand.

3. MATERIAL AND METHODS

3.1 Population, Sample and Fieldwork

The results reported and discussed here are from the *Scientific culture, perception and attitudes toward science and innovation in the Spanish business sector survey (shortened to Scientific Culture at Enterprises, SCe),* which was distributed to a representative sample of the universe of Spanish companies. The specially designed SCe questionnaire (Rey-Rocha et al., 2016) seeks to elicit the opinions, attitudes, motivations, expectations and images towards science, R&D and innovation among entrepreneurs and company managers.

A detailed description of the methodology used in this survey has been published elsewhere (Rey-Rocha et al., 2019; Rey-Rocha et al., 2021; González-Bravo et al., 2021; López-Navarro et al., 2022). However, to facilitate the comprehension of the present article, the most relevant aspects are summarized below.

The questionnaire was administered by computer-aided telephone interviews to a sample of informants consisting of people with management responsibilities in companies, selected through segmentation by activity sector and company size, i.e., the number of employees.

The original population consisted on 451,181 active Spanish firms with full economic, activity sector, number of employees, turnover and contact telephone data, in the Iberian Balance Sheet Analysis System (SABI database, Sistema de Análisis de Balances Ibéricos in Spanish). The selection resolves the excessive specificity of the samples used in prior studies on the business sector (Cumming and MacIntosh, 2000; Doloreux et al., 2016; Máñez et al., 2015; Mohnen, 2019; Rosenbusch et al., 2011).

Based on the structure of this population by sector and size, cluster sampling was used with a fixed number of 20 companies per cell (sector per size) and distribution of the remaining sample by simple affixation to the sector. Sample size within each sector was determined by affixation proportional to the weight of each company size, for a sample size of 700 cases. The final sample size after the telephone surveys was n = 707 companies, with an error of ±3.7%, for a 95% confidence level. The distribution of the final sample by activity sector

Table I. Distribution of the final sample by company size and activity sector.

Sector	Size (Number of employees)					
	Micro < 10	Small 10-49	Medium 50-249	Large ≥250	Total number of companies	Margin of error
Agriculture (primary sector)	36	24	20	20	100	± 9.8%
Industry	100	53	27	22	202	± 6.9%
Energy	34	24	21	22	101	± 9.6%
Construction	37	24	20	20	101	± 9.7%
Services	118	40	23	22	203	± 6.9%
Total number of companies	325	165	111	106	707	± 3.7%
Margin of error	±5.4%	±7.7%	±9.2%	±9.4%	±3.7%	

and company size is shown in Table I. To match the internal representativeness of the sample to the actual distribution of the universe, prior to data processing the proportion of each cell was weighted to determine its true proportional weight based on the SABI distribution of the population.

3.2 Study Variables

Table II explains the variables used in this study and provides their basic descriptive statistics. Appendix 1 presents the correlation matrix.

3.2.1 Risk Perception

One of the distinctive features of this study compared to previous work is how we measured the perception of risk specifically associated with science and R&D activities at businesses. The SCe questionnaire includes two items that investigate perception of risk in relation to science in general and particularly in relation to investments in R&D by participating companies, as described below.

Respondents were asked to rate the extent to which a series of ideas come to mind when thinking about 'science'. One of these ideas is 'risk', which is the focus of this study (variable 'science_risk').

The questionnaire also addresses the benefits and risks for companies of investing in R&D (variables listed under 'investment R&D_risks' in Table II). Respondents were asked to rate their degree of agreement with a series of statements. In this study, benefits/advantages and risks/disadvantages are considered separately in order to avoid the drawbacks of treating them as a two-dimensional continuum (Laspra, 2014).

3.2.2 Relational Capital

The extent to which companies collaborate in R&D activities with other public or private institutions is considered in this research as a proxy for their relational capital in R&D. The questionnaire solicits information on the use of collaborative R&D strategies in the last five years (R&D_c).

Additionally, the questionnaire explores whether the company operates within a scientific or technological park, or belongs to a business cluster or any other group of companies whose purpose is to promote research, development or innovation (R&D_business_association). This variable is also considered as an indicator of firm's relational capital in the present study.

3.2.3 Engagement in other R&D activities

To analyse how the relationship between risk perception and corporate R&D was associated not only with firms' engagement in collaborative R&D, but also with their use of other complementary R&D strategies, the other two possible R&D strategies, i.e. intramural (R&D_i) and extramural (R&D_e), were included as variables.

Information about risk perception by businesses was obtained with reference to the time the survey was carried out (2016), whereas information on research activity was determined as engagement in R&D during the previous five years. These different timeframes made it possible to identify firms with sustained R&D activities, and also allowed us to consider the notion of 'revealed barriers' proposed by D'Este et al., (2012), i.e., perceived risks that are manifested once the firm has become involved in these processes, as a form of learning. It should be noted that no causal relationship is assumed in this study for either of these measures.

3.2.4 Control Variables

Existing evidence shows that a firm's characteristics and industrial structure matter for expenditure and engagement in R&D (Arvanitis and Woerter, 2014; Davies, 2011; Groot et al., 2011;

Table II. Variables included in the study

Variable Question/Description		**% surveyees** **Mean (Std dev)**
Science_risk		
Q6. When you think of 'science' to what extent do these ideas come to mind? Idea: Risk		1=Not at all / 2=A little / 3=To an average extent / 4=Quite a lot / 5=A lot / Don't know 12.7% / 14.5% / 29.2% / 19.0% / 22.9% / 1.8%
Investment R&D_risks		
Q15. Studies done in different countries have identified different benefits and risks of research and development or R&D for businesses. In this connection, could you tell us to what extent you agree with the following statements? The company investing in R&D...		1=Don't agree / 2=Slightly agree / 3=Somewhat agree / 4=Strongly agree / 5=Fully agree / Don't know / No answer
Investment R&D_risky-investment		
…makes a very risky investment with a high degree of uncertainty		8.0% / 18.0% / 34.4% / 22.6% / 16.1% / 0.7% / 0.1%
Investment R&D_job-lost		
…will be forced to lay off workers, as its production and service delivery processes become more efficient		36.2% / 26.3% / 21.9% / 9.5% / 5.2% / 0.6% / 0.2%
Investment R&D_waste-time		
…wastes time, since it is always more profitable to use the knowledge generated by others		62.7% / 24.0% / 8.1% / 4.3% / 0.3% / 0.5% / 0.1%
Investment R&D_risk-health-environment		
…may generate risks for health and the environment		48.0% / 22.5% / 20.3% / 6.5% / 1.8% / 0.9% / 0.1%
Risk_perception		
K-means cluster analysis Dichotomic: 1 for cluster appartenance		See Table 3
Relational capital		
R&D_business_association		
Q3. Does your company belong to a scientific or technological park, a cluster or any other group of companies whose purpose is to promote research, development or innovation?		1=Yes / 0=Otherwise 11.1% / 88.9 %
R&D_c		
Q17. In the last five years (2011-2015), has your company carried out any of the following activities? Please tell me whether they have been tried, or tried but not completed, or never tried Q17.3. Collaborative research or R&D (i.e., carried out jointly with other public or private organisations)		1=Yes / 0=Otherwise 20.6% / 79.4%
R&D		
R&D_i	Q17.1. Intramural research or R&D (i.e. within the company)	29.1% / 70.9%
R&D_e	Q17.2. Acquisition of extramural research or R&D (i.e. carried out by other public or private organisations)	18.9% / 81.1%
Company age Years since creation		18.7 (10.8)
Company size Number of employees		Micro (<10) / Small (10-49) / Medium (50-249) / Large (≥250) 80.0% / 16.8% / 2.6% / 0.6%
Sector Dummies based on the sector aggregation of the CNAE (the Spanish acronym for Spain's National Classification of Economic Activities) classification of 44 sectors (see López-Navarro et al., 2021)		Agriculture (primary sector) / Industry / Energy / Construction / Service 3.4% / 13.1% / 0.7% / 13.4% / 69.4%
Economic variables		
Resource capability		
Return on assets (ROA) = Earnings before interest and tax (EBIT)/Total Assets zROA: Typified by sector. Ordinal 1 to 5 (quintiles)		0.02 (0.01)
Return on equity (ROE) = Net income (NI)/Equity zROE: Typified by sector. Ordinal 1 to 5 (quintiles)		0.09 (0.05)
Profit margin (PM) = EBIT/Sales zPM: Typified by sector. Ordinal 1 to 5 (quintiles)		-0.26 (0.29)
Asset turnover (AT) = Sales/Total assets		1.6 (0.05)
Leverage		
Leverage (LEV): thousand euros zLEV: Typified by sector. Ordinal 1 to 10 (deciles)		70.2 (2.9)

Shefer and Frenkel, 2005). We additionally included economic data for the firms surveyed here, as well as three firm- and industrial-level variables potentially related to a company's decision to engage in R&D: company size, company age, and activity sector.

As a high-investment-cost activity, R&D requires firms to have the necessary resources. For this reason the firms' economic characteristics were quantified with generally accepted measures commonly used in microeconomic business as indicators of firm capability to generate resources, and its profitability: return on assets (ROA), return on equity (ROE), profit margin (PM), and asset turnover (AT). These measures provided information on each firm's strong points regarding their efficiency and ability to generate income. The first three are associated with the accounting measures of internal resources generated by a company: earnings before interest and tax (EBIT) and net income (NI). Moreover, PM and AT provide information on the firm's strong points as regards its efficiency and its ability to generate income (González-Bravo and Mecaj 2011). The surveyed companies' economic data were obtained from the Iberian Balance Sheet Analysis System (SABI database: Sistema de Análisis de Balances Ibéricos).

The variables ROA, ROE and PM showed a distribution with a thick right tail. Asymmetry in the distribution of financial and accounting data may lead to inappropriate results and conclusions when they are included in the regression models (De Andrés, 2001; So, 1987, 1994). In order to avoid the size effect and resolve this asymmetry, these variables were typified to relativize each firm's value to the average in its sector, and then transformed into ordinal variables with five categories based on quintiles of the original variable. The variable AT showed an appropriate distribution, so its original formulation was used as a continuous variable.

One of the alternatives to obtain funds to execute R&D projects is to opt for external financing. However, an excessive level of leverage can become a barrier to obtaining financing. The variable leverage (LEV) rates the ability to obtain additional resources and the extent to which a firm may find its hands tied by a high dependence on outside capital, or by the need to negotiate without further compromising its situation (Mecaj and González-Bravo, 2013). Leverage also showed an asymmetric distribution with a long right tail, so it was typified by sectors and later classified in ten intervals according to deciles.

Transformations of the economic variables are further described at González-Bravo et al., (2021).

3.2.5 Analysis

Firstly, a cluster analysis was performed in order to identify homogeneous groups of respondents based on their perception of risk associated with science and R&D investment. We performed separate non-hierarchical, K-means cluster analysis with standardised variables, using the five variables described above for the perception of risk specifically associated with science and R&D activities at businesses (see Table II). After exploring different possibilities (with four, five and six clusters, each of comparable quality according to commonly used statistical criteria), we opted for a solution based on five clusters, a number that yielded a reasonably suitable classification of the possible groups of profiles. We considered these clusters to be plausible in the sense that they can be interpreted convincingly as risk perception profiles, and included a reasonable number of firms per cluster. This choice was validated with discriminant analysis, which yielded a high hit rate (i.e., the percentage of total cases correctly classified) of over 85%. The resulting groups can thus be considered to have good predictability and to characterise the clusters accurately, with limited overlap among them.

The resulting clusters were characterised not only in terms of the perception indicators used in cluster analysis itself, but also by the firms' main features. Relational capital was indicated by collaboration in R&D activities with other public or private institutions, and by participation in a scientific or technological park, a business cluster, or any other group of companies whose purpose is to promote R&D or innovation. In addition, engagement in other (intramural or extramural) R&D activities, economic profile, and structural characteristics of the firms (size, age, and sector) were used to characterise clusters.

After cluster analysis, logistic regression analysis was conducted to explore the relationships between firms' relational capital strategies in R&D and firms' risk perception. The coefficients obtained for explanatory variables with suitable levels of significance estimate their relationship with the different profiles of firms according their perception of risk associated with science and R&D. Expβ coefficients above 1 indicate that an increase in the explanatory variable is related to an increase in the likelihood of a firm belonging to a risk perception profile (Table V).

Statistical analyses were done with the Statistical Package for Social Sciences (SPSS) v. 25.

4. RESULTS

More than 70% of entrepreneurs and business managers associate science with the idea of risk ('to an average extent', 'quite a lot' or 'a lot') and moderately to fully agree that R&D investment is a risky and uncertain investment (Table II) (average 3.2 on a scale of 1 to 5 in both cases; see Table III). Weaker agreement is reported with other statements that reflect other risks associated with R&D, such as wasted time because it is always more profitable to use knowledge generated by others (average 1.5) or risks to health and the environment (average 1.9). Most companies had not undertaken R&D activities during the previous five years, and most did not belong to any business cluster or association intended to encourage R&D or innovation.

The cluster analysis yielded five groups of firms differing from each other in their perception of risk specifically associated with science and R&D activities. The results of the cluster analysis of risk perception are displayed in Table III, which shows the final cluster centres along with average values on an original scale from 1 to 5. Table IV shows the firms' characteristics, by cluster. On the basis of the data and evidence presented in Tables III and IV, the five clusters can be interpreted as distinct modes of risk perception, and the characteristics of each cluster are described below.

Clusters 1 and 2 are the largest, each containing about one third of the sample. Individuals in cluster 1 are characterised by a low perception of risk associated with science and R&D investment. They disagree slightly more than the average for the whole sample with the view that R&D investment is a waste of time for the company and affects employment, health and the environment. On the basis of this risk perception profile, this cluster is termed *No risk perception* hereafter. As in all groups identified by our cluster analysis, the non-associative strategy predominates, and most companies do not belong to business associations intended to favour R&D or innovation (e.g. scientific and technological parks, or clusters). This indicates that although this type of association can have many benefits, in the Spanish business sector these potential advantages do not seem to play an essential role in mitigating the perceived risks and uncertainties associated with R&D. Companies in this cluster are the oldest on average, and are prone to internalise their R&D activities, rather than engaging in either extramural or collaborative R&D involving third parties. It includes a below-average proportion of micro-companies and the largest percentage of large companies. This cluster also includes a slightly above-average number of service businesses. Firms in this cluster are the only ones that are not profitable in terms of ROA. In contrast, they stand out in terms of equity profitability (ROE). Together with companies belonging to cluster 2, cluster 1 companies are characterised by an above-average level of leverage.

Table III. Perception of risk associated with science and R&D investment. Final cluster centres and average values (in the original 1 to 5 scale)

Cell figures: Final cluster centres, and *(average values)*	**Risk perception (cluster)**					**Total *(average)***
	1 No risk perception	**2 Risky investment**	**3 Risky investment, job loss**	**4 Distrustful Unamunian**	**5 Focused Unamunian**	
science_risk	**-0.76** ***(2.3)***	0.49 (3.9)	0.28 (3.6)	0.38 (3.8)	-0.06 (3.2)	(3.2)
investmentR&D_risky-investment	**-0.94** ***(2.1)***	**0.60** ***(3.9)***	**0.58** ***(3.9)***	0.42 (3.7)	-0.33 (2.8)	(3.2)
investmentR&D_job-lost	-0.34 (1.8)	**-0.62** ***(1.5)***	**1.29** ***(3.7)***	0.15 (2.4)	**0.57** ***(2.9)***	(2.2)
investmentR&D_waste-time	-0.50 (1.1)	-0.42 (1.2)	-0.01 (1.5)	**2.22** ***(3.4)***	**1.29** ***(2.6)***	(1.5)
investmentR&D_risk-health-environment	-0.47 (1.4)	-0.09 (1.8)	0.25 (2.2)	-0.43 (1.4)	**1.61** ***(3.6)***	(1.9)
% of cases in each cluster (4.2% missing)	30.1%	30.5%	18.8%	7.4%	9.1%	n=707

Non-hierarchical, K-means cluster analysis with standardised variables. Cluster analysis hit rate calculated with discriminant analysis = 88%

Table IV. Characteristics of firms, by cluster

		Risk perception (cluster)				
		1 No risk perception	**2 Risky investment**	**3 Risky investment, job loss**	**4 Distrustful Unamunian**	**5 Focused Unamunian**
R&D_business_association	(% Yes)	12.7%	15.0%	4.5%	13.5%	9.7%
R&D_c	(% Yes)	18.4%	30.4%	20.3%	9.6%	11.3%
R&D_i	(% Yes)	32.1%	37.6%	17.4%	30.8%	19.4%
R&D_e	(% Yes)	17.9%	27.1%	15.7%	9.6%	14.5%
Company age	Mean (Std dev) Range min/max	19.25 (11.66) 2.33/117.17	16.26 (9.63) 2.67/127.00	17.45 (11.97) 2.50/110.83	17.20 (11.47) 4.00/61.00	16.96 (8.04) 2.83/51.17
Company size	Micro <10	76.5%	79.4%	83.3%	82.7%	81.3%
	Small 10-49	19.2%	17.8%	14.4%	15.4%	17.2%
	Medium 50-249	3.3%	2.3%	2.3%	1.9%	1.6%
	Large ≥250	0.9%	0.5%	0.0%	0.0%	0.0%
Sector	Agriculture (primary sector)	3.3%	3.7%	3.0%	5.8%	1.6%
	Industry	13.6%	11.6%	13.4%	17.3%	11.1%
	Energy	0.9%	0.9%	0.7%	0.0%	0.0%
	Construction	10.3%	8.8%	23.9%	17.3%	15.9%
	Service	72.0%	74.9%	59.0%	59.6%	71.4%
Return on assets (ROA)	Mean (Std dev) Range min/max	-0.01 (0.18) -1.37/0.47	0.02 (0.21) -0.71/0.73	0.06 (0.20) -0.55/0.69	0.08 (0.11) -0.23/0.33	0.01 (0.11) -0.37/0.56
Return on equity (ROE)	Mean (Std dev) Range min/max	0.24 (2.07) -26.74/14.89	-0.09 (1.47) -11.22/5.74	0.11 (0.63) -2.59/1.32	0.15 (0.29) -0.41/0.78	0.06 (0.30) -0.78/1.73
Profit margin (PM)	Mean (Std dev) Range min/max	-0.08 (0.36) -2.58/0.75	0.00 (0.32) -4.39/0.70	-1.02 (17.78) -609.72/0.82	-0.29 (3.06) -30.36/0.24	0.00 (0.15) -0.68/0.31
Asset turnover (AT)	Mean (Std dev) Range min/max	1.49 (0.98) 0.02/6.15	1.71 (1.58) 0.01/9.82	1.69 (1.39) 0.00/5.70	1.55 (1.05) 0.00/4.78	1.50 (1.25) 0.17/5.52
Leverage (LEV)	Mean (Std dev) Range min/max	71.75 (44.47) 0.49/285.18	76.01 (117.62) 1.32/946.21	64.78 (31.77) 5.60/213.97	61.27 (23.63) 1.62/153.87	53.75 (39.82) 0.00/228.98

Cluster 2 (*Risky investment*) is composed of individuals characterised by their awareness of the risks posed by science and, above all, business investment in R&D. They consider R&D to be a rather risky and uncertain investment for their company, although they clearly disagree that investing in R&D can increase the risk that jobs will be affected as a result of increased company efficiency. The extent to which they associate science with risk is usually moderate, although the proportion of respondents who report this level of risk was largest in this cluster compared to the other four clusters in our sample; in other words, respondents in this cluster most clearly perceive risk as an idea inherent to science. Like members of cluster 1, they tend to disagree that investing in R&D is a waste of time for the company or may generate risks to health and the environment. Entrepreneurs and managers who perceive R&D as a risky investment are employed mainly at companies that tend to opt for engaging in all three execution strategies (collaboration together with intra- and extramural R&D). These companies use relational capital-based strategies – i.e., firms in this cluster are the most willing to associate and to engage in collaborative R&D – and seek diversification of R&D – perhaps as a way to diversify risk management. Accordingly, in addition to collaborative R&D, they also run intramural R&D projects, which can pose the greatest investment risk for the company, combined with the acquisition of extramural R&D. *Risky investment* firms are the youngest companies, on average, together with *Focused Unamunian* companies (see below). Along with cluster 1, cluster 2 also includes the largest companies, albeit in a smaller proportion. These companies are the only ones that on average do not achieve profitability on their equity capital. However, they stand out in their ability to generate income considering their average level of ROA. In addition, companies in cluster 2 are those with the highest levels of leverage.

Individuals in cluster 3 (*Risky investment, job loss*) account for less than 20% of the entire survey sample. Together with cluster 2, these are the only respondents who clearly perceive R&D investment as risky and uncertain. However, they differ from their cluster 2 counterparts in their perception of R&D investment as a clear risk for employment. Their association of science with the idea of risk is slightly stronger than the average for the whole sample. Companies in this cluster are the least likely to be involved in business associations whose purpose is to promote R&D or innovation. They are not characterised by high rates of any type of R&D engagement, but are the only ones that prefer collaborative R&D over other strategies. Compared to the average for the entire sample, micro-companies are over-represented in this cluster, as are those in the construction sector, whereas service companies are under-represented. Concerning their economic characteristics, cluster 3 companies show an unusual combination of low efficiency but high ability to generate resources. They present, on average, the lowest profit margin, at a significant distance from the rest of the clusters, but nevertheless have the highest level of asset turnover, together with risky investment (cluster 2) companies.

Clusters 4 and 5 together account for 16.5% of informants. The common characteristic that differentiates them from the rest of the sample is that they consider that business investment in R&D is a waste of time, and that it is more profitable to use knowledge generated by others. We may therefore say that they support the 'let others invent' idea, in line with the well-known and often quoted aphorism by philosopher Miguel de Unamuno, which has become something of a Spanish national stereotype[1]. Accordingly, we call these groups *Unamunian*2. Members of the *Distrustful Unamunian* cluster (cluster 4) perceive science and R&D as risky activities overall, while those in the *Focused Unamunian* cluster (cluster 5) are more likely to identify specific social risks associated with investment in R&D – i.e. the risk of job loss and risks to health and the environment – and do not share a general view of risk as inherent to science and R&D investment. Respondents in these clusters are characterised by their perception of R&D as a waste of time for businesses; it is thus unsurprising that they account for major proportions (64.7% and 73.8%) of the companies that do not carry out any type of R&D activity. It is also unsurprising that they tend to forego options for R&D collaboration, given that they do not believe that this option would lead to a more favourable perception of the opportunity costs of R&D activities. The possibility that they choose to outsource such risky investments bears consideration, but the low proportion of companies involved in extramural R&D rule out this hypothesis. Cluster 4 includes a higher-than-average percentage of micro-firms, as well as a high proportion of companies in the industrial, agricultural and construction sectors. These companies show the best ROA of all clusters. Firms in cluster 5 are comparatively young micro-firms characterised mainly by their low level of leverage.

In summary, the five clusters represent five archetypes of entrepreneurs and managers that differ significantly regarding their perception of risks associated with science and firms' investment in R&D. These categories show that the perception of risk cannot be viewed as a common attitude among entrepreneurs and business managers. On the contrary, their perceptions reflect how different sub-dimensions contribute to different business positions according to the emphasis on and nuanced views regarding each sub-dimension. Among entrepreneurs and managers who perceive risks related to research, some are concerned with the overall risks and uncertainties generated by R&D investment, or perceive engagement in generating new knowledge – as opposed to the option of using knowledge generated by others – as a waste of time. Others, in contrast, focus on particular risks such as potential job losses, or the risks to health and the environment. In some cases, a combination of several of these risks is perceived.

4.1 Risk perception, R&D strategy and relational capital

In the previous section we identify five different patterns in companies' risk perception and describe their main characteristics in terms of R&D engagement, economic and structural characteristics. The next and final step consists of exploring the relationships between risk perception and relational capital strategies in businesses. For this purpose, regression analysis is used to estimate the influence of companies' relational capital strategies in shaping managers' perceptions about the risk associated with science and R&D investment.

Table V presents the results of five logit estimations which relate the probability of belonging to each specific cluster to the set of indicators that reflect firms' relational capital strategies and other R&D engagement strategies. Overall, the results show that after controlling for companies' structural and economic characteristics, relational capital strategies (i.e., joining a business association or engaging in collaborative R&D) are associated with the two groups of companies characterised by

Table V. Results of regression analyses. Explained variable: Risk perception (cluster categories)

Variables	1 No risk Perception	2 Risky investment	3 Risky investment, job loss	4 Distrustful Unamunian	5 Focused Unamunian
	Expβ (Standard error) Percent increase odds				
R&D business association	1.234 (0.282) 23.40	1.165 (0.276) 16.50	**0.352**** (0.463) -64.80	1.660 (0.479) 66.00	0.972 (0.509) -2.80
R&D_c	0.695 (0.268) -30.50	**1.682**** (0.250) 68.20	1.651 (0.318) 65.10	**0.343*** (0.558) -65.70	0.436 (0.517) -56.40
R&D_i	1.415 (0.219) 41.50	1.187 (0.218) 18.70	**0.436***** (0.286) -56.40	1.471 (0.363) 47.10	0.708 (0.388) -29.20
R&D_e	0.859 (0.279) -14.10	1.432 (0.263) 43.20	0.831 (0.350) -16.90	0.483 (0.558) -51.70	1.268 (0.491) 26.80
Company age	**1.020**** (0.009) 2.00	**0.981**** (0.010) -1.90	1.001 (0.010) 0.10	0.998 (0.015) -0.20	0.986 (0.015) -1.40
Company size (Micro <10, benchmark)					
Small 10-49	1.288 (0.233) 28.80	0.904 (0.242) -9.60	0.943 (0.290) -5.70	0.835 (0.428) -16.50	0.986 (0.393) -1.40
Medium 50-249	1.302 (0.543) 30.20	0.848 (0.564) -15.20	0.955 (0.720) -4.50	1.177 (0.955) 17.70	0.592 (1.195) -40.80
Large ≥250	2.069 (1.192) 106.90	0.724 (1.314) -27.60	0.591 (1.956) -40.90	1.573 (2.204) 57.30	0.049 (10.344) -95.10
Sector (Service, benchmark)					
Agriculture (primary sector)	0.616 (0.510) -38.40	1.027 (0.477) 2.70	1.135 (0.588) 13.50	2.764 (0.675) 176.40	0.657 (0.962) -34.30
Industry	0.808 (0.264) -19.20	0.869 (0.272) -13.10	1.326 (0.310) 32.60	1.651 (0.427) 65.10	0.881 (0.456) -11.90
Energy	1.155 (0.987) 15.50	0.623 (1.044) -37.70	1.616 (1.174) 61.60	1.806 (1.718) 80.60	0.241 (3.127) -75.90
Construction	**0.583*** (0.280) -41.70	**0.597 *** (0.285) -40.30	**2.252***** (0.263) 125.20	1.512 (0.403) 51.20	1.081 (0.381) 8.10
zROA	**0.751**** (0.125) -24.90	1.043 (0.120) 4.30	**1.350**** (0.137) 35.00	**1.549**** (0.204) 54.90	**0.647**** (0.204) -35.30
zROE	**1.357**** (0.126) 35.70	**0.777**** (0.112) -22.30	0.959 (0.121) -4.10	1.001 (0.217) 0.10	1.004 (0.138) 0.40
zPM	1.058 (0.121) 5.80	1.066 (0.138) 6.60	**0.806*** (0.131) -19.40	0.907 (0.186) -9.30	1.510 (0.266) 51.00
zLEV	1.031 (0.113) 3.10	**1.214*** (0.113) 21.40	0.897 (0.152) -10.30	0.845 (0.291) -15.50	**0.427***** (0.319) -57.30
AT	0.922 (0.084) -7.80	0.942 (0.082) -5.80	1.127 (0.093) 12.70	1.026 (0.143) 2.60	1.082 (0.132) 8.20
Constant	0.374*** (0.250) -62.60	0,596** (0.255) -40.40	0.207*** (0.291) -79.30	0.073*** (0.425) -92.70	0.125*** (0.414 -87.50
Nagelkerke's R^2	0.073	0.080	0.096	0.068	0.064

***, **, * Statistically significant at the 99%, 95% and 90% levels

perceiving R&D investment as risky and uncertain, in two different patterns. In one group, relational capital strategy focused on joining a business association intended to encourage R&D or innovation is inversely related to managers' perception of R&D investment as detrimental to employment. This inverse relationship is observed only in both groups supporting the idea that investment in R&D may cause job losses (clusters 2 and 5), and it is particularly significant in Risky investment, job loss companies. That is, a lower propensity to join a business association aimed at promoting R&D or

innovation is associated with perceiving job loss as a likely risk of R&D investment. Those companies identifying risks for employment are also the less prone to engage in intramural R&D projects. In the other group, engaging in collaborative R&D is significantly associated with perceiving risk only in economic terms (i.e., Risky investment companies). In contrast, a significant inverse relationship with engaging in collaborative R&D is seen for the Distrustful Unamunian companies.

Also worth noting is that the estimates of the coefficients for control variables have interesting implications. Company size and activity sector have no effect on firms' specific risk perceptions, except in the particular case of construction companies. The type of risk profile is clearly related to the age of the firm, with the oldest companies perceiving less risk associated with science and R&D investment than younger companies. This observation is grounded on the positive association between older company age and the No risk perception cluster, and the negative association with the Risky investment cluster. Moreover, risk perception is mediated differently by resources capability (measured as ROA), by profitability (measured as ROE), by leverage (LEV) and by profit margin (PM).

5. DISCUSSION

Identification of five categories or archetypes of entrepreneurs and managers indicate that the perception of risk in relation to science and R&D cannot be viewed as a common attitude among entrepreneurs and business managers. Managers' perceptions reflect how different sub-dimensions contribute to different business positions toward R&D according to the emphasis on and nuanced views regarding each sub-dimension. This result gives supporting evidence for a change in R&D policies addressed to the business sector: if firms can be deterred to invest in R&D due to different reasons, then efficient R&D policies should be diversified and adjusted to the particularities of different targets.

There is no single relationship between the perception of risk associated with science and R&D investment, and the use of R&D relational capital strategies, but rather multiple variants and ways of coping with different perceptions. In this regard, our data reveal that firms' perception of risk in relation to science and investment in R&D is associated with relational capital strategies –R&D collaboration and business association membership- mainly when the risk is related to the economic dimension implicit in R&D.

Our findings suggest that collaborative R&D strategies have a particularly strong association with respondents whom we call Risky investment individuals. Collaboration can be viewed as a worthwhile option because diversification of this financial risk across two or more agents may mitigate the perception of R&D as a risk for businesses. These companies opt for an open R&D strategy by carrying out R&D not only in collaboration, but in all its variants (i.e., intramural, extramural and collaborative R&D). This is a clear example of how measurable uncertainty can be managed. According to authors such as Teece et al., (2016), when risk is associated with relatively foreseeable outcomes, it can be counteracted with (for example) contractual agreements with other parties. Being open to outside knowledge and outside innovation, and to working with people outside the company (Chesbrough, 2003; Saint-Paul, 2003), can lead companies to move toward open R&D and open innovation environments, where organisational boundaries are porous and firms strongly interact with each other and with their environment.

Financial constraints have been pointed out in previous works as one of the barriers that negatively affect firms' investment in R&D (Hall et al., 2016), jointly with innovative capabilities (Hottenrot and Peters, 2012). However, our results show that the companies most concerned about this dimension are those more involved in all types of R&D.

The fact that companies that perceive R&D activities mainly as risky and uncertain investments are also the most active in internal and external R&D suggests that awareness of the economic risks involved in R&D investment is apparently not associated with a tendency to avoid R&D engagement. These results are consistent with the effect that D'Este et al., (2012) called the 'revealed effect of risk', that is, awareness of the risks involved in performing R&D, which may modulate the company's R&D strategy. According to this line of thinking, firms engaged in R&D are more likely to have experienced the risks associated with these activities, and are thus more likely to recognize their importance (Mohnen and Rosa, 2000; Baldwin and Lin, 2002). It is thus plausible that intensive engagement in R&D provides businesses with a more complex and realistic view of the likely risks that this type of investment represents, and does not act as a deterrent to their R&D goals. Previous experience in R&D may refine risk assessments by managers. Once aware of the risks, some firms may be keen to either engage in relational capital or associative strategies, or to diversify the type of R&D they undertake, as a risk reduction strategy. This possibility is consistent with the interpretation by Baldwin and Lin (2002) and Tourigny and Le (2004) that 'the obstacles to innovation should not

be interpreted as preventing innovation or technology adoption, but rather as an indication of how successful the firm is at overcoming them' (D'Este et al., 2012: 483).

When risk perception is not associated with investment issues but rather with concerns over job loss, wasted time, and health and environment awareness, then no relational capital or R&D strategy shows any particular association with these profiles.

Respondents from this type of company, in general, report reduced engagement in R&D. When experience in R&D is lacking, risk-averse firms may tend to overestimate the risks associated with undertaking R&D activities – a situation that can create disincentives for these activities if the firm considers that certain specific risks outweigh the potential benefits, and cannot be managed appropriately. In other words, although financial risk can be diversified to seek more efficient alternatives for the firm, such as outsourcing or collaboration, the firm cannot evaluate the extent to which these alternatives might mitigate or reduce the risks associated with job losses or risks to health or the environment. This situation, in turn, may lead to a vicious cycle which prevents firms from gaining experience in R&D, and thus repeatedly overestimate its associated risks.

The above points to an interesting societal implication: concern about risk and uncertainty does not constituted a deterred barrier for R&D engagement, except when firms perceive a risk for employment, in which case firms reduce engagement in both intramural and extramural R&D and opt for collaborative projects. Therefore, risk and uncertainty associated to R&D does not constitute a brake on the contribution of companies to an innovative and knowledge-based economy. This is especially relevant in countries such as Spain, with a weak culture of science and innovation in the business sector and whose business fabric is mainly made up of small and medium-sized companies, in sectors of low technological and innovative value (Castro García and Fernández de Lucio, 2006; Cotec, 2014; European Union, 2020, and previous editions; MINECO, 2013a, 2013b). Furthermore, this contribution has a dual effect on employment. Firstly, the country benefits from the effect that R&D has on the creation of quality employment. And secondly, by favouring knowledge-based, high added value sectors, the country becomes more resilient to crises. Therefore, policies that favour those companies with a reduced R&D engagement because they fear it will affect employment, aimed at guaranteeing in some way potential job losses, may have the beneficial effect of increasing their engagement in R&D and therefore promote employment, helping to create a virtuous circle.

Our results also suggest interesting conclusions about no risk perception firms, in light of the main features related to this lack of concern about a type of investment – R&D – which is usually perceived as risky per se. In this case, neither R&D investment strategies nor relational capital strategies show any association with this perception. The variables that help to explain this perception are company age and profitability. Operating for longer periods (i.e. greater age of the company) may help companies to acquire sufficient knowledge and understanding of a particular R&D strategy (e.g. internalisation), as the description of this cluster suggests. These firms may hold the view that R&D involves no risks and that the best alternative is to generate capital internally, or may believe that R&D execution has not brought any risks to light, and thus see no need to combine this approach with other risk-mitigating strategies.

However, most of the measures aimed at strengthening R&D in companies have approached the R&D challenge from a mainly economic point of view, even when financial aversion does not seem an authentic deterred barrier. Public policies have paid less attention to the rest of the risk dimensions associated with R&D activities that could be acting as authentic deterred barriers to companies since they are effectively associated with low levels of R&D.

Some recommendations emerge from our work for the design of innovation and R&D policies. First, the need to expand the innovative business fabric. Current public policies, intensely focused on financial aids, do not cover the spectrum of perceived risks that can act as deterred barriers for companies when investing in R&D. Policies addressed to foster innovation culture and mentoring could be more effective in the case of firms that perceive other risks non related to financial resources, especially young and small firms.

Secondly, it would be pertinent to prevent public policies from perpetuating a vicious circle in which public funds are assigned to most experienced and profitable companies, which are those that according to our results do not feel especial aversion to any type of risk related to R&D activities. If the main purpose of an agency is to fund R&D projects that would not be otherwise carried out because of market failures, instruments should be more suitable for those firms that would not engage in R&D without the incentive of external aid, and not for those that would do so despite not receiving them.

Third, our data warn about the importance of designing public instruments taking into account the particularities of the economic context and its influence on certain sectors. In the Spanish case (and it can be extrapolated to other southern European countries) this influence is particularly relevant in the construction sector, one of the most severely hit by the last economic crisis and with a remarked aversion to risk related to job loss. Programs aimed at fostering and promoting scientific and innovative culture that show the particular sectorial benefits of R&D, can show these companies the relationship between R&D and quality employment (Autor, 2003). It is not about promoting a generalist discourse on the benefits of R&D, but about showing companies concrete examples related to their sector that could inspire new attitudes towards R&D and innovation in unsuspected areas as in the case of archeology sector (Parga-Dans et al., 2012; Parga-Dans et al., 2017).

Finally, in view of the positive relationship between collaboration with other actors and R&D engagement, as well as the inverse relationship between membership in a cluster and the aversion to financial risk and job loss related to R&D activities, it would be advisable for Spain to make an effort to promote public policies aimed at fostering relational capital strategies.

Our results support the implementation of collaboration and cluster policies aimed at enhancing and promoting the firms´ relational capital. The co-creation of knowledge through collaborative strategies with partners is a powerful tool for the engagement of companies in R&D activities, especially those companies more aware of the risks and uncertainty associated with R&D. Determined support for R&D projects carried out in cooperation with other companies and R&D agents can move companies toward R&D environments and to interact with other stakeholders in such environments. These strategies can increase the prospects for success through the participation of institutions experienced in R&D, which can act as 'mentors' for novice firms. Also, senior firms can provide resources through their national and international R&D projects, reduce (or at least share) economic risks and increase the opportunities to obtain external financial support.

Adaptation to periods of crisis, instability and/or recession can either boost collaborative and associative strategies that may present opportunities to adapt to these unstable environments, thereby allowing a firm to strengthen its survival capacity (Holl and Rama, 2016) or, on the contrary, discourage collaboration (López Campo and Rossell Martínez, 2007).

Results and reflections showed in this study come in a very particular European scenario in which they could be particularly relevant. In a context of social and economic crisis derived from the covid-19 pandemic, European Union has chosen to respond by abandoning its austerity policy -that characterized its response to the economic and financial crisis of 2008- to move to a recovery plan based on direct aids to member countries. These funds provide an opportunity to implement policies to support research and innovation in the business sector, aimed at improving their competitiveness based not on cost reduction and job insecurity, but on high added value services and products. However, if these type of measures want to tackle the diversity of risks that can paralyze companies when it comes to engaging in R&D activities, governments should avoid one-size-fits-all policies and promote specific instruments suitable for different firms' profiles related to R&D and innovation.

This research constitutes an initial attempt to study the relationship between firms' engagement and relational capital strategies in R&D, in combination with their structural, economic and financial characteristics, and their risk perception toward science and R&D. Future research is needed to elucidate whether and under which conditions the relationship between risk perception and relational capital strategies in corporate R&D acts as a two-way, mutually reinforcing relationship, or rather as a cause-and-effect relationship. The cross-sectional nature of our data constrains the possibility of testing causal links, but does shed light on the presence of cumulative and two-way linkages between risk perception and relational capital strategies in corporate R&D.

Further work should also examine whether companies with reduced engagement in R&D and in which the perceived risk factors are predominantly non-economic choose to engage in non-R&D based innovation or in softer types of innovation (for example, organisation or marketing innovation). Thus, additional research is called for to identify whether the relationship between the perception of risk and R&D engagement may be influenced by individual factors such as workforce experience or education (Czarnitzki and Hottenrott, 2011).

We are aware of the importance of organizational change. Further research could reveal variations in response to social, institutional and political shifts that affect companies and their relationship with science and R&D – e.g. changes arising from the evolution of the economic environment, from the implementation of science and innovation policies, or from particular organizational changes in the companies.

Finally, during the publication process of this manuscript, several important events have taken place in the political, economic, and health sphere (for example, the COVID-19 pandemic or the recent conflict in eastern Europe). For this reason, it would be pertinent to repeat the survey in the near future to study whether firms' attitudes towards the risk of investing in R&D have changed, and whether these events have had any influence.

6. CONCLUSION

To conclude, our findings support the hypothesis of a relationship between the perception of risks associated with science and firms' investment in R&D, and the use of relational capital strategies. This relationship is found to be positive when relational capital is based on collaborative R&D. The perceptions of risk reported by our respondents reflect a number of sub-dimensions and nuances that must be taken into account in efforts to understand how these perceptions are related with different R&D strategies. At present, we can venture the provisional conclusion that engagement in collaborative R&D is mainly associated with a perception of risk from a strictly economic perspective which considers R&D as a risky and uncertain investment. However, these companies also are likely to try any of the several available strategies to carry out R&D activities in addition to approaches based on their use of relational capital, thereby diversifying their R&D strategies. In contrast, perceiving risks mainly in non-economic terms and focusing on other factors of a social nature is not associated with any particular R&D strategy, although this perception is common among companies with weak engagement in R&D activity.

Enhancing our knowledge of how businesses perceive the risks associated with science and R&D and innovation will provide policy makers with better evidence to develop actions aimed at increasing business sector engagement in science funding and initiatives in R&D and innovation. Ultimately, policies that are sensitive to the concerns of the business sector may help to strengthen the culture of science and innovative culture within the business sector.

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8. NOTAS

1 Román, a character in the essay titled El pórtico del templo (The Portico of the Temple) by Miguel de Unamuno (1906), states: 'Invent; then they and we will take advantage of their inventions. I trust and hope that you are convinced, as I am, that the electric light shines as brightly here as it does where it was invented'.

2 Santos et al. (2017) previously used the word Unamunian to refer to Spanish citizens with a negative attitude towards science.

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Appendix 1. Correlation matrix

	R&D_business_association	R&D_c	R&D_i	R&D_e	Company age	Company size	ROA	ROE	PM	AT	LEV	science_risk	Investment R&D_ risky-investment	Investment R&D_job-loss	Investment R&D_waste-time	Investment R&D_ risk-health-environment
R&D business association	1															
R&D_c	0.306*	1														
R&D_i	0.256*	0.401*	1													
R&D_e	0.300*	0.560*	0.440*	1												
Company age	0.013	0.028	-0.017	-0.022	1											
Company size	0.070	0.162*	0.237*	0.164*	0.190*	1										
ROA	0.073	0.159*	0.086*	0.148*	-0.139*	0.043	1									
ROE	0.008	-0.004	-0.101*	-0.007	-0.058	-0.045	0.163*	1								
PM	0.008	-0.015	-0.012	-0.017	-0.022	0.017	0.048	-0.004	1							
AT	-0.050	0.061	0.030	0.132*	-0.259*	0.007	0.093*	0.015	0.042	1						
LEV	-0.078*	-0.057	-0.080*	-0.038	-0.066	-0.045	-0.388*	0.022	-0.004	0.451*	1					
Science_risk	-0.089*	0.030	-0.030	0.000	0.030	0.007	0.079*	-0.064	-0.004	-0.011	-0.034	1				
Investment R&D_ risky-investment	-0.019	0.150*	0.018	0.091*	-0.098*	-0.053	0.174*	-0.016	-0.017	0.062	-0.010	0.331*				
Investment R&D_ job-lost	-0.137*	-0.068	-0.084*	-0.099*	0.054	-0.054	0.089*	-0.014	-0.038	0.014	-0.074*	0.099*	0.155*	1		
Investment R&D_ waste-time	-0.006	-0.125*	-0.038	-0.109*	0.006	-0.014	0.090*	-0.038	-0.013	-0.073	-0.072	0.138*	0.117*	0.293*	1	
InvestmentR&D_ risk-health-environment	-0.131*	-0.162*	-0.127*	-0.112*	-0.072	-0.129*	-0.072	0.027	-0.008	0.028	0.055	0.150*	0.075*	0.197*	0.224*	1

Pearson correlations. * Statistically significant at the 95% level