



The relationship between R&D, the absorptive capacity of knowledge, human resource flexibility and innovation: Mediator effects on industrial firms

Angel Martínez-Sánchez^{a,*}, Silvia Vicente-Oliva^b, Manuela Pérez-Pérez^a

^a Departamento de Dirección y Organización de Empresas. Escuela de Ingeniería y Arquitectura. Zaragoza, Spain

^b Centro Universitario de la Defensa. Zaragoza, Spain

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ABSTRACT

This paper analyzes data from 1666 Spanish industrial firms to test how some human resource (HR) flexibility dimensions mediate the relationship between research and development (R&D) efforts and the absorptive capacity of knowledge (AC). The results show that external R&D experts and core employee training partially mediate the relationship between R&D effort and AC, whereas temporary employment does not mediate that relationship. These findings seem to suggest that HR flexibility dimensions that are more knowledge-intensive are more influential on the development of absorptive capabilities. Another finding is that the mediator effects of HR and AC are positively related to innovation performance, suggesting that firms may combine them more effectively with R&D efforts to enhance innovation.

1. Introduction

There is a growing need for firms to respond quickly to market changes by innovating and adapting/improving their operations. To be innovative, firms need trained employees who can adapt to changes in their business environment. Firms also need updated knowledge portfolios from research and development (R&D) activities or external sources. The absorptive capacity of knowledge (AC) is essential to identify, assimilate, transform, and exploit valuable external knowledge that improves product innovativeness and other firm outputs (Escribano, Fosfuri, & Tribó, 2009; Su, Ahlstrom, Li, & Cheng, 2013). At the same time, human resource (HR) flexibility provides the capacity to adapt the firm's operations to the production volume and range required by the market, as well as to provide employees with new knowledge.

These capacities (AC and HR flexibility) are related from theoretical and practical perspectives. Highly innovative firms invest in R&D activities, use external technologies, and make efforts to assimilate and integrate them within in-house technical capabilities. Even though previous research considered AC to be a companion to a firm's prior R&D efforts (Cohen & Levinthal, 1990), some studies (e.g., Jansen, Van Den Bosch, & Volberda, 2005) indicate that the adoption of some practices like job rotation may enhance AC. The study of flexible HR systems as related to AC could be of interest to managers because a

firm's AC is strongly rooted within its prior tacit knowledge (Cohen & Levinthal, 1990), which is sometimes held by a few core employees (Volberda, Foss, & Lyles, 2010). The use of flexible HR systems may create a context in which firms can nurture as well as retrieve and utilize such knowledge among employees.

Various job types have different impacts on the development of flexible HR capabilities and their implications for AC and innovation within the firm. It is possible to differentiate job types from a knowledge perspective within a firm. First, a group of employees focused on core activities and competencies who usually have long-term contracts receive more training and have more access to social and work-family benefits from the firm. Second, employees with short-term contracts and those from temporary help agencies, who constitute the temporary workforce, have less access to a firm's training and social benefits but can support core employees. Third, a group of personnel with a limited contractual relationship to the firm but are focused on strategic themes, including innovation activities and knowledge management issues, collaborate with core employees. Each group of employees may contribute in their own way to the firm's flexible capabilities that could influence the management of AC and innovation.

The main purpose of this study is to link the firm's HR flexibility to its R&D and AC. There are two critical gaps in the literature where our study can contribute. First, we analyze if firms that are more flexible also have greater AC. The study of this relationship is important

* Corresponding author.

E-mail addresses: anmarzan@unizar.es (A. Martínez-Sánchez), silviav@unizar.es (S. Vicente-Oliva), manuela.perez@unizar.es (M. Pérez-Pérez).

because some HR flexibility dimensions (i.e., core trained and polyvalent employees) contribute to the in-house diffusion of knowledge, whereas other dimensions (i.e., external R&D experts) contribute to bringing knowledge of best industry experiences into the firm. Therefore, the HR flexibility of the firm may enhance the exploration of ideas outside of the firm's knowledge. However, the interrelationship between HR flexibility and AC has been scarcely explored in the literature, but such an interrelationship could help to explain the causal mechanisms that contribute to make the link between R&D and AC more efficient.

Second, our study analyzes if HR flexibility mediates R&D effort and AC. The literature of HR flexibility has typically focused on firm performance indicators such as financial measures (e.g., [Bhattacharya, Gibson, & Doty, 2005](#)). However, it has been conceptually proposed that flexible HR systems are instrumental in fostering enhanced innovation performance rather than immediate financial returns ([Wright & Snell, 1998](#)). Firm innovation performance is a less distal outcome than financial measures, and considerably less attention has been paid to how flexible HR systems contribute to innovation. Drawing on some organizational theories such as the knowledge-based view (KBV) and the AC concept, we assert that flexible HR systems affect innovation through their mediator effects on the R&D-AC link.

Both research objectives contribute to the extant research in several ways. First, HR flexibility is usually included in studies of human resource management and work performance, but the use of HR flexibility as an antecedent of innovation behavior and performance is much more recent and limited (e.g., [Martínez-Sánchez, Vela-Jiménez, Pérez-Pérez, & De-Luis-Carnicer, 2011](#); [De Spiegelaere, Van Gyes, & Van Hootegem, 2014](#); [Kleinknecht, van Schaik, & Zhou, 2014](#)). However, it is important to study how HR flexibility influences the process from R&D to innovation because firms need to be increasingly innovative. This is due to highly dynamic markets and other disruptions, including the COVID-19 pandemic, which force firms to change their production strategies and switch to remote work. This research may help determine how HR flexibility facilitates innovation, which could be even more important for firms that are intensive in knowledge activities.

A second contribution of this research is the analysis of how each group of employees that constitute separate HR flexibility dimensions influence AC. Some studies have demonstrated that not all HR flexibility dimensions are significantly related to innovation outputs (e.g., [Kleinknecht et al., 2014](#); [Martínez-Sánchez et al., 2011](#)). However, this would be the first research to study the impact of these differences on AC and more specifically as a mediator between R&D and AC. The use of mediator effects could contribute to a better understanding of the interrelationships between R&D, HR flexibility, AC, and innovation at the firm level. These contributions may also have important managerial implications by extrapolating from the proposition that firms seeking innovation should focus simultaneously on HR flexibility and AC to stay ahead of competitors.

The paper is structured in the following way. The first section reviews the literature and justifies the research hypotheses. The second section explains the methodology of the empirical study. The third and fourth sections include the results and discussion, respectively, which are followed in the final section by our conclusions and research limitations.

2. Theoretical foundation and hypothesis development

2.1. Theoretical concepts

From a theoretical perspective, this paper focuses mainly on a knowledge-based view (KBV) because of the potential to explain the influences of HR flexibility and AC on innovation as a dynamic capability. The KBV is an organizational perspective that views the firm as a pool of knowledge resources that, if employed in a unique style, can create competitive advantages ([Barney, 2001](#); [Peteraf, 1993](#)). This is

based on the dynamic capabilities perspective (or the ability to integrate, build and reconfigure resources), which explains firm-level success and failure in a "Schumpeterian world" ([Kohlbacher, 2013](#); [Teece, Pisano, & Shuen, 1997](#)). The ability to combine external and internal knowledge resources may give the firm a greater competitive advantage, and the KBV may help to explain why some firms are better at this than others. First, knowledge is a strategic resource that must be carefully managed. This is particularly true for tacit knowledge because it is more difficult to observe and codify for subsequent use, making it more difficult to imitate by other firms ([Grant, 2013](#)). Second, knowledge is not evenly distributed among firms, and as a consequence, organizations that search more widely may create better knowledge because they increase their knowledge diversity and are potentially able to create more knowledge combinations ([Un, Cuervo-Cazurra, & Asakawa, 2010](#)). Finally, knowledge creation is conditioned by the organizational context that influences employees to have the ability to search for and integrate internal and external knowledge ([Nonaka & von Krogh, 2009](#)).

An important concept within the management of knowledge is the idea of absorptive capacity (AC) ([Cohen & Levinthal, 1990](#)), which suggests that firms must develop the ability to recognize the value of external knowledge to assimilate and successfully use it. AC is a dynamic capability because it is difficult for competitors to imitate due to the specific prior knowledge and trajectory of a firm ([Volberda et al., 2010](#)). The literature operationalizes the concept of AC as a group of intangible capabilities to manage knowledge (e.g., [Saiz, Pérez Miguel, & Manzanedo del Campo, 2018](#)) or as a number of sequential stages such as acquisition, assimilation, transformation, and exploitation (e.g., [Zahra & George, 2002](#)). Each AC group of capabilities or dimensions coexists and mutually reinforces each other to encourage innovation and improve performance ([Patterson & Ambrosini, 2015](#)). Given this, highly intensive AC firms may be more responsive to a customer's needs and have more efficient innovation processes and greater firm performance ([Dobrzykowski, Leuschner, Hong, & Roh, 2015](#); [Lane, Koka, & Pathak, 2006](#)).

Our research contributes to knowledge management studies by including the firm's HR flexibility as a mediator in the link among R&D, AC, and innovation. HR flexibility has been mainly studied as a subfield of human resource management, but recent studies have also included HR flexibility as an antecedent of innovation (e.g., [De Spiegelaere et al., 2014](#); [Kleinknecht et al., 2014](#); [Preenen, Vergeer, Kraan, & Dhondt, 2017](#)). There are two main sources of HR flexibility, internal and external ([Atkinson, 1984](#)), and both have implications for innovation. Internal flexibility contributes to increase the firm's ability to adjust to uncertainty by modifying the internal labor market or work organization, whereas external flexibility uses changes in the external labor market through layoffs or temporary employees. According to the KBV, we might expect that long-term and high-commitment-based employment policies (internal HR flexibility) would be more favorable to innovation because it is easier to accumulate tacit and explicit knowledge over long periods of time. In contrast, temporary employees who are hired only for low-cost purposes may have more difficulty in enhancing the firm's innovation outputs due to their reduced ability to improve products and processes during their short-term stay in the firm ([Beugelsdijk, 2008](#)).

A review of the literature shows greater agreement regarding the positive contribution of internal HR flexibility to innovation. In contrast, the contribution of external HR flexibility is less conclusive and needs to differentiate between types of jobs like temporary employees or external R&D experts ([De Spiegelaere et al., 2014](#); [Martínez-Sánchez et al., 2011](#)). Accessing external technology and expertise is important because firms do not have all the resources required to innovate. External resources may bring the best knowledge from outside into a firm and may stimulate the exploration of new processes and ideas beyond the firm's knowledge stock. In addition, most studies show a negative influence of temporary employees on innovation, whereas external R&

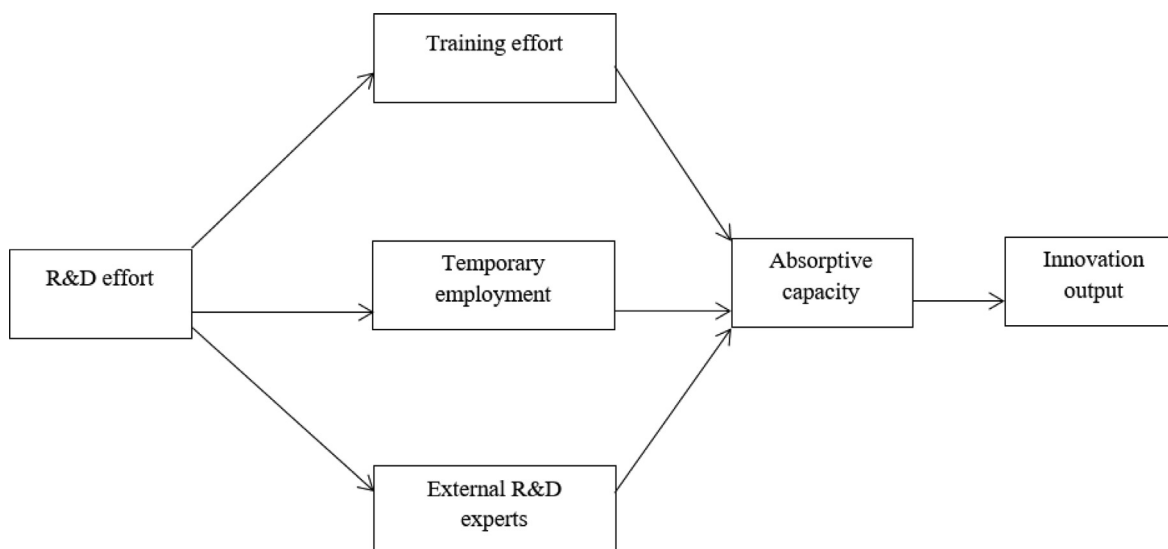


Fig. 1. Research model.

D experts are positively related to innovation (e.g., Martínez-Sánchez et al., 2011; McKeown & Cochrane, 2017). Firms may use external R&D experts to obtain knowledge and new ideas, which when combined with their own knowledge can be a source of innovation (Voudouris, Deligianni, & Lioukas, 2017). These external R&D experts may help a firm to profit more by accessing and using outside knowledge and industry best practices since they can contribute to new ideas more quickly.

Our two main concepts in this paper, AC and HR flexibility, are conducive to innovation behaviors and outputs and have been separately studied quite extensively in the literature. However, the prospect of HR flexibility as an antecedent to AC has been seldom discussed (Roy, 2018), and the mediator role of HR flexibility between the firm's R&D effort and its AC has had even less discussion in the literature. Therefore, we aim to find empirical evidence on how HR flexibility and AC are interrelated to R&D and innovation.

2.2. Hypothesis development

Fig. 1 depicts the theoretical framework of this research. Our basic argument is that HR flexibility and AC are the driving forces behind the flow of knowledge within the firm; however, their interrelationship has been scarcely explored in the literature. The study of such an interrelationship could help explain the causal mechanisms that transform R&D efforts into innovative outputs. We use R&D effort as the starting point of the R&D-AC-innovation link because several studies indicate that R&D expenditure is an antecedent to AC and contributes to improved innovation (e.g., Fosfuri & Tribó, 2008; Kostopoulos, Papalexandris, Papachroni, & Ioannou, 2011). Not all firms have to make R&D expenditures to innovate, but those that invest in R&D need to manage this process very carefully because of the heavy risks involved. However, the causal mechanisms that explain the R&D-AC-innovation link have not been well studied, and some research gaps remain unexplored (Zou, Ertug, & George, 2018). A firm's AC depends on its own knowledge, which is embedded in the products, processes, and people within the organization. Thus, many of the firm's innovation drivers may also be drivers of AC, and this explains why it is difficult to isolate the impact of R&D efforts on innovation performance, if one had posited a direct effect.

Furthermore, the use of mediator effects such as those depicted in Fig. 1 could contribute to a better understanding of the interrelationships between R&D effort, HR flexibility, AC, and innovation at the firm level. The mediator effect of knowledge-related variables has already

been used in recent studies that analyzed antecedents of firm performance (e.g., Coder, Peake, & Spiller, 2017; McDowell, Peake, Coder, & Harris, 2018). Nevertheless, our analysis focuses on HR flexibility dimensions and AC as intermediate variables, which has not been studied before. Fig. 1 proposes three mediator effects of HR flexibility between R&D effort and AC. According to Cohen and Levinthal (1990) and Volberda et al. (2010), AC resides in individual employees, whereas the learning behavior of these employees is what collectively shapes the firm's AC. We must differentiate among the main job roles because not all employees are equally relevant for the firm's AC. For core knowledge employees who are more critical for creating new knowledge, firms that develop employee skill and knowledge bases and redeploy their workforce in a flexible way are making organizational efforts to develop their AC and innovate (e.g., Chang, Gong, Way, & Jia, 2013). Thus, skilled and trained employees are important to build the firm's AC because highly trained employees may be more capable of combining outsourced technological knowledge with in-house knowledge. This is because they are better at learning and integrating knowledge than employees with a low level of skill or training. The higher an employee's training is, the more efficient they may be in combining external knowledge with internal knowledge to create new knowledge (Teece, 1986; Nonaka, 2007). These integration capabilities are important since employees use and transform external knowledge in combination with in-house knowledge from R&D, manufacturing, or marketing departments.

Employees with a broader knowledge base may be able to more easily recognize and integrate information from different external sources because they are more likely to have used or learned prior related knowledge. The level of employee training increases the firm's HR flexibility dimension, internal functional flexibility. This flexibility dimension is more frequent among core employees focused on innovation and those in knowledge-intensive jobs. The development of these core employees with more training may facilitate the link between in-house R&D and the exploitation of acquired and transformed external knowledge. Even a broader training that it is not constrained to the core knowledge of an employee's current job may improve his or her reactions to customer demands. HR internal flexible practices such as cross-functional teams encourage employees to take on different tasks and expand their knowledge base, thus enabling firms to transform better their R&D efforts into AC capabilities. Although the process of identifying and acquiring external knowledge may be performed by a single key individual or department, the knowledge application process is rarely accomplished in an isolated way and instead occurs

collaboratively among departments (Nonaka, 2007). This is when the availability of core trained employees with internal flexibility becomes relevant. Firms with polyvalent and trained employees that fulfill different functions may apply and transfer knowledge more intensively to create or maintain competitive advantages. Again, HR internal flexible practices like cross-functional teams may contribute to a wider dispersion of skills and knowledge that make the deployment of individual employees to tasks more adaptable. In addition, this may positively influence the development of knowledge and the combination of in-house and outside knowledge (Martínez-Sánchez et al., 2011). In a study of project-oriented companies, Popaitoon and Siengthai (2014) find that this type of HR practice not only facilitates knowledge management from the current project to future projects but also strengthens the relationship between a project team's AC and long-term project performance. Un (2017) also finds that firms with more trained employees and more internal R&D investment tend to invest more in external R&D as well. Based on these previous studies, we propose that the development of a core of employees with more training and internal flexibility would facilitate the conversion of R&D efforts into AC abilities. Therefore, we propose hypothesis H1 from Fig. 1:

H1. The firm's HR internal functional flexibility positively mediates the relationship between R&D effort and absorptive capacity.

Regarding HR external flexibility, our research model differentiates between temporary employees and external R&D experts. Both may be short-term hires for the firm, but their implications related to knowledge are quite different. First, temporary employees (including employees from temporary help agencies) may contribute to reduce labor costs, but they may also negatively influence knowledge development and integration because of their lower organizational commitment (Michie & Sheehan, 2005). Similarly, other scholars (e.g., Broschak & Davis-Blake, 2006) find that temporary employees are negatively related to employee trust, internal workers' attitudes, and the quality of employee-supervisor relationships, which may negatively influence the management of knowledge. For instance, new product development teams perform worse when there are poor labor relations. As a consequence, several authors (e.g., Beugelsdijk, 2008; Franceschi & Mariani, 2016; Kato & Zhou, 2018; Martínez-Sánchez et al., 2011) find a negative relationship between the use of temporary employees and the firm's innovation performance. Training, recruitment, and hiring costs are lower for temporary than for permanent core employees, and firms can manage knowledge accordingly. However, the firm's AC requires that tacit knowledge from external sources is transformed into explicit in-house knowledge. This process of transformation requires time and cross-functional interactions that can be out of reach for some temporary employees, especially those hired under specific purposes and with limited knowledge requirements. These temporary employees may even be left out from long-term innovation projects that can reduce the benefits of developing greater AC in firms with large percentages of temporary employment.

Given these limitations to incorporate temporary employees into R&D projects and to contribute to the tacit knowledge that is so necessary for AC, firms with a large percentage of temporary employees in the workforce would have more difficulty in linking in-house R&D to the development of AC. Grinza and Quatraro (2019) find that employees' replacements damage innovation performance, although this effect is mitigated in areas with high knowledge spillovers. We could then even distinguish between 'good' and 'bad' categories of HR flexibility regarding the degree of knowledge involved in each dimension. The previous hypothesis H1 would include a 'good' HR dimension, whereas temporary employment would be in most cases an example of 'bad' HR flexibility from a knowledge perspective. Following these arguments, we propose hypothesis H2 from Fig. 1:

H2. The percentage of temporary employees (external numerical flexibility) negatively mediates the relationship between R&D effort

and absorptive capacity.

The other dimension of HR external flexibility, external R&D experts, is more related to the knowledge processes within AC. These external R&D experts may stimulate the exploration of innovative ideas beyond the firm's knowledge stock. This dimension allows firms to develop their core competences and integrate them with external knowledge. Sometimes, the hire of external R&D experts with tight legal contracts is more productive from a knowledge perspective than participating in networks (Hoecht & Trott, 2006). Similarly, firms with R&D that seek external knowledge related to their core competences can incorporate this knowledge more effectively (Bierly, Damanpour, & Santoro, 2009). Thus, external R&D experts may constitute a solid base for the firm's AC because they may be more familiar with the best external knowledge or at least have the tacit knowledge required to make improvements, for example, improving the technology acquired by the firm in machinery or equipment.

At the same time, external R&D experts could contribute to link the firm's R&D effort with its AC by combining external knowledge with in-house knowledge more efficiently than core employees alone. External R&D experts who bring industry best practices into the firm may help to reduce the uncertainty of applying in-house R&D efforts into innovations that need external knowledge. External R&D experts are another type of 'good' HR flexibility from a knowledge perspective because it involves a high degree of knowledge. These experts contribute directly to the firm's innovation activities with their tacit knowledge and expertise that also improves the firm's AC. Therefore, we propose hypothesis H3 from Fig. 1:

H3. The use of external R&D experts (external functional flexibility) positively mediates the relationship between R&D effort and absorptive capacity.

Finally, Fig. 1 also includes a link between AC and innovation output. The relationship among R&D effort, AC, and innovation output is well established by the foundational work of Cohen & Levinthal, 1989, p. 569: "the R&D generates new information and enhances the firm's ability to assimilate and exploit existing information." Our research model analyzes the mediator effect of HR flexibility on the link between R&D and AC. Firms invest resources in R&D that are combined with the absorptive capacity of external knowledge to develop innovations. HR flexibility could help explain the causal mechanisms that are at work to make the relationship between R&D and AC more effective and efficient. However, we think it is also necessary to demonstrate that in our sample of firms, AC is positively related to innovation, as reported previously (e.g., Ferreras-Méndez, Newell, Fernández-Mesa, & Alegre, 2015; Huang, Lin, Wu, & Yu, 2015; Maldonado, Salaiz, Vera, & Keller, 2019; Zou et al., 2018). Thus, our research will emphasize that by managing HR adequately, the firm's R&D effort may positively influence AC for external knowledge and innovation outcomes. Therefore, we also propose the following:

H4. The firm's absorptive capacity is positively related to innovation.

The next section explains the methodology of the study, followed by the results and a discussion.

3. Methodology

We use the Spanish Survey of Business Strategies (SBS) questionnaire, which contains a set of statements that permit the analysis of a large number of manufacturing firms. The SBS is an annual survey undertaken since 1990 and conducted by the SEPI Foundation¹ in

¹ The SEPI Foundation is responsible for the survey design and control through the Economic Research programme. More information about the SBS can be found in the webpage <https://www.fundacionsepi.es/investigacion/eese/en/spresentacion.asp>.

collaboration with the Spanish Ministry of Industry with the objective of knowing the evolution of the characteristics and strategies of Spanish industrial firms. This survey contains information about markets, customers, products, employment, technological activities, and economic/financial data of the firms. The reference population comprises industrial firms operating in Spain with 10 or more employees, classified by their main activity belonging to the divisions 10–32 of NACE-2009, excluding division 19 (industrial activities related to petrol refinement and fuel treatment). The SBS uses a systematic and stratified random sample from the Spanish Social Security directory. Representativeness is one of its characteristics (the firm's response rate is high, approximately 91%), and as Almodóvar and Rugman (2014) argue, "it assures anonymity; it asks mostly for non-perceptual measurements; and Foundation SEPI carries out different criteria for content validity (if there is a failure to comply with the consistency controls the company is required to submit documental justification)." The response rates for different sectors and sizes are consistent with the overall response pattern. All the information collected by the SBS is subject to validation and logical consistency controls.

We use data available from 1,666 industrial firms in the year 2015 (the statistical relationships we found for this year are consistent for the previous two years that were also available at the time of our research). The distribution of surveyed firms by size indicates that 17.5% have more than or equal to 200 employees, and 82.5% have less than 200 employees. In terms of economic activity, the sample is highly diversified because none of the industries exceeds 15% of the total firms. We differentiate our descriptive statistics between innovative and noninnovative firms: innovative firms are those that have developed at least one product innovation, one process innovation, or a patent.

Regarding the assessment of AC, we use the measure developed by Saiz et al. (2018) for the SBS. The measure is a construct of six items (dummies): the evaluation of alternative technologies by firms, the evaluation of technological change, the contracting of outside consultants as a mechanism for obtaining information about technology, the existence of a firm's technology management or committee, the preparation of a plan, and the measurement of results obtained in this management process. This variable uses values from 0 to 6. This methodology provides a capability 'profile' for each firm by identifying a differentiated set of practices that it is a more adequate measure of dynamic capabilities than other measures of AC that are based on managers' subjective perceptions of different constructs (e.g., Zahra & George, 2002). We think that our approach is a more direct result of applying the KBV to the measurement of AC and that it enables us to differentiate AC from the firm's R&D effort. Although early AC studies used R&D expenditures as a proxy measure of AC, in recent years, some scholars have considered R&D to be an antecedent of AC (e.g., Fosfuri & Tribó, 2008), and more comprehensive measures of AC that include the firm's tacit knowledge and its management are preferred. Our measure of AC assesses the firm's intangible capability to manage knowledge, which could be affected by the firm's flexible HR policies.

We use some direct and indirect measures of HR flexibility provided by the SBS. There are no direct measures of HR internal flexibility in the SBS, but proxy measures such as the percentage of sales invested in training or training expenditure by employee can be used. These indicators are proxy measures of the firm's core workforce flexibility because core employees receive more training and organizational support to adopt internal flexible practices. Regarding external flexibility, the SBS does include some direct measures of this flexibility, namely, the percentage of temporary employees in the workforce, the percentage of employees from temporary help agencies in the workforce, the use of external R&D experts from the private industry, and the use of external experts from the public R&D sector. Although other studies (e.g., Bhattacharya et al., 2005) used direct measures of HR flexibility related to employees' attitudes, behavior, and skills, our measures of internal and external HR flexibility are more classic (see for instance the flexible firm's analysis of Atkinson, 1984) but also more quantitative

and objective than measures based on manager or employee perceptions. In addition, other scholars have already used training expenditure by employee as a proxy for HR internal flexibility (e.g., Arvanitis, 2005) and have used the percentage of temporary employees (e.g., Franceschi & Mariani, 2016) and the hire of external R&D experts (e.g., Martínez-Sánchez et al., 2011) as measures of HR flexibility.

Mediator effects are tested with the 'PROCESS' procedure (Hayes, 2018) for SPSS statistical software. PROCESS is a computational tool -a "macro"- available for SPSS and SAS that simplifies the implementation of mediation, moderation, and conditional process regression analysis with observed variables using ordinary least squares regression and logistic regression path analysis modeling tools. Based on a set of conceptual and statistical diagrams defined by a model number, the user chooses a model preprogrammed into PROCESS corresponding to the model he or she wants to estimate. Arguments are provided to the macro about what variables are serving which roles in the model (i.e., independent variable, dependent variable, mediator, moderator, covariate), and PROCESS estimates all the path coefficients, standard errors, t- and p-values, confidence intervals, and various other statistics. For models that are based entirely on observed variables, the results of PROCESS do not differ from those of other methodologies such as structural equation modeling (Hayes, Montoya, & Rockwood, 2017).

The dependent variable in the multivariate analysis is the number of product innovations divided by the number of products in a firm. The explanatory variables are the R&D effort (R&D expenditures by sales), the six-item measure of AC, and the three mediators between R&D effort and AC mentioned above: training effort (training expenditures by employee, as a proxy measure of internal functional flexibility), temporary employment (percentage of temporary employees and employees from temporary help agencies in the workforce; a measure of external numerical flexibility), and the hire of external R&D experts (R&D private experience, R&D public experience, and engineering and technology experts, a three-item measure of external functional flexibility = ER&DE). The variable R&D effort is frequently used in studies of innovation and AC because it indicates the relative importance of R&D within the firm. Firms that invest in R&D are more likely to access external knowledge and even hire external R&D experts compared to firms that innovate without investing in R&D. Similar to other studies that link R&D inputs and innovation outputs, we take into account a lagged effect in our mediation analysis: we measure the dependent variable (number of product innovations) for the year 2015 and the other independent and mediator variables for the year 2014.

The dimensionality, discriminant validity, and reliability were evaluated for the two scales (other variables are only simple ratios) before testing the hypotheses. All tests for discriminant validity were supportive; specifically, the estimated correlations between constructs were not 1.00, and the square roots of the AVE values for the constructs were found to be greater than the correspondent correlations. Reliability analyses indicate that Cronbach's coefficient alpha exceeded 0.7 for all constructs (AC = 0.880; ER&DE = 0.792) and that the average variance extracted (AVE) exceeded 0.5 (AC = 0.625; ER&DE = 0.511), indicating satisfactory simple reliability. In addition, the factor loadings of items were above 0.5 in all cases. We also computed composite reliability (CR) scores to assess the construct reliability. In all cases, factors had a CR scores greater than the minimum recommended level of 0.6 (AC = 0.704; ER&DE = 0.691). Confirmatory factor analysis (CFA) with AMOS also confirmed the composition of scales (RMSEA = 0.074, NFI = 0.91, CFI = 0.92).

4. Results

Table 1 shows descriptive statistics (means, deviations, and correlations) of the main variables in Fig. 1. Although there is a strong correlation between variables such as AC and external R&D experts, the test for the effects of multicollinearity indicates that all the factors were less than the threshold value of 10, indicating the presence of

Table 1
Descriptive statistics: means, standard deviations and correlations.

	Mean	S.D.	1	2	3	4	5
1. R&D effort	0.82	2.81					
2. Absorptive capacity	1.28	1.96	0.377**				
3. Training effort	100.9	271.2	0.072**	0.151**			
4. Temporary employment	12.7	18.1	-0.031	0.010	-0.030		
5. External R&D experts	0.27	0.58	0.219**	0.523**	0.132**	0.059*	
6. Innovation output	0.76	6.02	0.053*	0.127**	0.005	-0.010	0.092**

Level of significance:

* p < 0.05.

** p < 0.01.

multicollinearity. Of the 1666 firms included in the 2015 SBS, 42.4% were innovative firms: 15% of firms developed at least one product innovation, 37% had at least one process innovation, and 4% filed at least one patent or utility model. Regarding the performance of R&D activities, 17.6% of firms outsourced and had in-house R&D, 11.3% of firms had in-house but no outsourced R&D, and 3.8% of firms contracted R&D activities externally but not in-house (67.3% of surveyed firms did not conduct any R&D).

Table 2 shows the mean differences in some HR flexibility indicators between innovative and noninnovative firms. Measures related to internal flexibility such as training and full-time qualified employees indicate that innovative firms have larger percentages of employees who are more qualified and receive more training than in noninnovative firms. Innovative firms also hire more external R&D experts for innovation purposes. All these differences are statistically significant. Innovative firms have a greater percentage of temporary employees, but this difference is not statistically significant. However, there is a statistically significant difference when looking at the higher use of temporary help agencies for innovative firms. Similarly, Table 3 indicates that most HR flexibility indicators are greater for high-AC firms than for low-AC firms, and the differences are statistically significant except for temporary employment.

Fig. 2 shows the results of the research model with HR flexibility mediators between R&D effort and AC. The model is statistically significant ($R^2 = 0.234$; $F = 20.87$; $p < 0.000$). Regarding the hypothesized links, first, the relationship between R&D effort and innovation is not significant (direct effect = 1.27, $p = 0.842$ BootLLCI = -11.29 BootULCI = 13.84). However, the total indirect effects are significant (indirect effect = 10.44 BootLLCI = 3.42 BootULCI = 23.51). There are several indirect effects that are relevant for our analysis. First, the link among R&D effort, internal functional flexibility (training effort), AC and innovation is statistically significant

Table 2
Mean differences of HR flexibility measures between innovative and non-innovative firms.

	Innovative firms (n = 711)	Non-innovative firms (n = 955)
<i>HR internal flexibility</i>		
Percentage of full-time permanent employees in the workforce	82.3**	79.7
Percentage of part-time permanent employees in the workforce	3.2*	4
Percentage of R&D employees in the workforce	3.5**	0.8
Percentage of engineers and scientists in the workforce	9.5**	7.2
Percentage of sales invested in external training of employees	7.4**	4.1
Percentage of firms that invest in engineering & technical training for employees	36**	15
Percentage of firms that invest in computer training for employees	26**	12
<i>HR external flexibility</i>		
Percentage of temporary employees in the workforce	10.7	9.7
Percentage of employees from Temporary Help Agencies in the workforce	4.3**	1.9
Percentage of firms that hire external R&D personnel with private experience	11**	1
Percentage of firms that hire external personnel with experience in public R&D	3**	1

Level of significance:

* p < 0.05.

** p < 0.01

Table 3
Mean differences of HR flexibility measures according to the firm's level of AC.

	AC	
	High	Low
<i>Internal HR flexibility</i>		
Percentage of full-time permanent employees in the workforce	85**	79
Percentage of R&D employees in the workforce	5.1**	0.7
Percentage of engineers and scientists in the workforce	12.1**	6.6
Percentage of sales invested in external training of employees	0.07*	0.05
Percentage of firms that invest in engineering & technical training for employees	45**	15
Percentage of firms that invest in computer training for employees	35**	11
<i>External HR flexibility</i>		
Percentage of temporary employees in the workforce	9.4	10.4
Percentage of employees from Temporary Help Agencies in the workforce	4.6**	2.3
Percentage of firms that hire external R&D personnel with private experience	17**	1
Percentage of firms that hire external personnel with experience in public R&D	6**	0

High AC ≥ 1.2 . Low AC < 1.2.

Level of significance:

* p < 0.05.

** p < 0.01.

(indirect effect = 0.11 BootLLCI = 0.01 BootULCI = 0.7). There is also a strong significant indirect effect in the relationship among R&D effort, external functional flexibility (external R&D experts), AC, and innovation (indirect effect = 2.18 BootLLCI = 0.49 BootULCI = 5.86). This means that internal and external functional flexibility mediate the relationship between R&D and AC, whereas the indirect effect of external numerical flexibility (temporary employment) is not statistically significant (indirect effect = 0.0009 BootLLCI = -0.029

Variables' level of significance: **p<0.01
R² model = 0.234; F=20.87; p<0.000

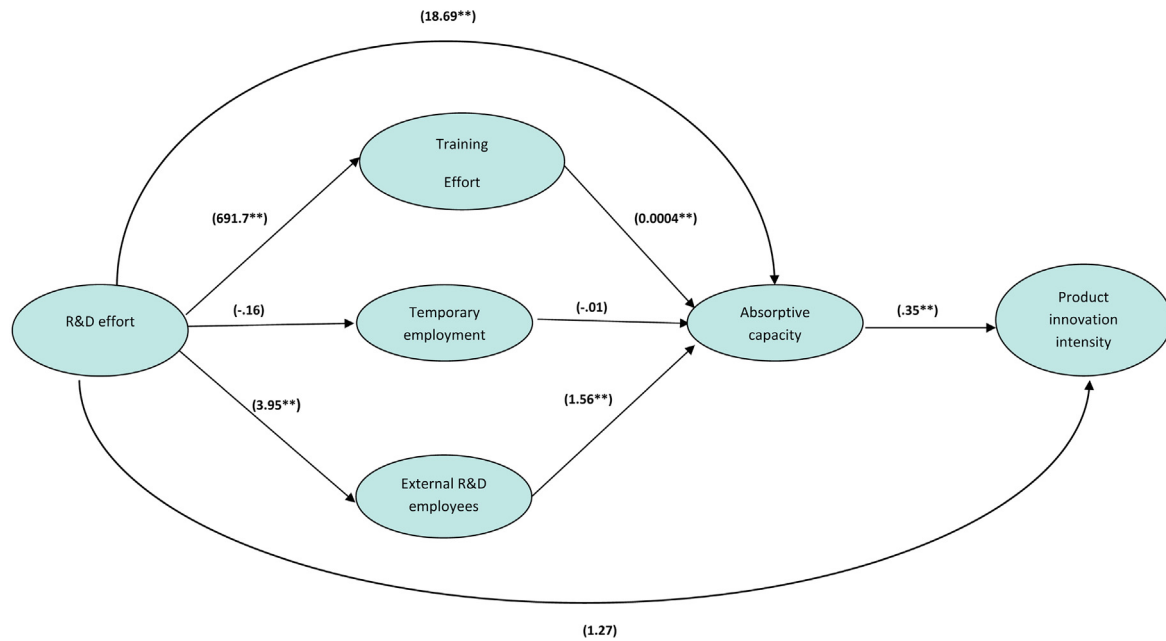


Fig. 2. Results of research model.

BootULCI = 0.037). These results support H1 and H3 and do not support H2. Nevertheless, the mediator effects of HR flexibility are only partial because there is still a significant relationship among R&D effort, AC, and innovation (indirect effect = 6.61 BootLLCI = 1.76 BootULCI = 14.68). The relationship between R&D and AC seems to be strong enough to be overridden only by HR flexibility, but the mediator effect does exist and could help explain the causal relationships between R&D effort, AC, and innovation. Finally, AC and innovation are positively related ($\beta = 0.35, p < 0.01$), which supports H4.

5. Discussion

The knowledge-based view (KBV) suggests that, as a rare, inimitable, valuable, and nonsubstitutable resource, knowledge is the most critical asset developed, shared, and systematized by a firm for establishing a sustainable competitive advantage. Furthermore, previous studies suggest that firms exploit such knowledge through strategic capabilities, such as innovation or human resources, to improve performance (Nonaka & von Krogh, 2009). In line with this view, we examine how HR flexibility mediates the relationship among R&D, AC, and innovation. Our results indicate that these variables are inter-related topics for firms focused on knowledge development. The fact that R&D effort, AC, and innovation are positively associated supports the findings from previous studies (e.g., Fosfuri & Tribó, 2008; Kostopoulos et al., 2011) and suggests that AC is an essential complement to internal innovation (Lichtenthaler, 2016). However, our study makes some additional contributions that are discussed from both theoretical and practical perspectives in the next paragraphs.

The main contribution of our research is evidence of the role that HR flexibility seems to play in the R&D-AC-innovation relationship. The descriptive statistics show that firms with greater AC, R&D effort, and innovation outputs have less ‘bad’ HR flexibility (external numerical flexibility from temporary employees and temporary help agencies) and more ‘good’ HR flexibility (internal and external functional flexibility). In contrast, firms with minimal or nonexistent innovations and AC efforts have the highest levels of temporary employment and do not hire external R&D experts. We stated in the theoretical section that the difference between ‘good’ and ‘bad’ HR flexibility resides exclusively in

the degree of knowledge creation and diffusion associated with each dimension of HR flexibility. The hire of external R&D experts (external functional flexibility) contributes to knowledge development within the firm, whereas polyvalent trained core employees (internal functional flexibility) contribute to the diffusion of knowledge throughout cross-functional teams that develop product and process innovations.

The positive association between the more knowledge-oriented HR flexibility dimensions of some types of jobs and innovation performance supports other studies (e.g., Bendickson, Muldoon, Liguori, & Midgett, 2017; Coder et al., 2017; Martínez-Sánchez et al., 2011). However, our research has developed this argument further by demonstrating that HR flexibility is a partial mediator between R&D effort and AC, which may offer a causal explanation about the links between R&D effort, AC, and innovation performance. Other scholars like Chang et al. (2013) found that flexible HR systems are determinants of AC. However, our research is different because it has explored the mediator effects of HR flexibility from a knowledge perspective. It is perhaps not a coincidence that there was not any significant mediator effect of temporary employment (external numerical flexibility), which is a source of change that it is not knowledge-intensive.

Significant mediator effects are only found for the functional flexibilities (training and external R&D experts) of jobs that are more knowledge-intensive. One of the mediator effects, internal training, does not seem very strong in comparison to the other, external R&D experts. This could be partially due to the use of a proxy measure instead of a direct measure of internal HR flexibility, which is unavailable in the SBS database. Despite this limitation, our results indicate that the ‘good’ HR flexibility can contribute to the development and diffusion of knowledge, which occurs through the firm’s AC and result in innovation outputs such as new products or patents. For example, external R&D experts may enhance the development of AC in combination with in-house R&D by stimulating the exploration of ideas outside the firm’s knowledge base. Similarly, the enhancement of core employees through the firm’s training efforts could facilitate the operation of cross-functional teams that combine in-house R&D resources with acquired external knowledge.

The categorization and enhancement of ‘good’ HR flexibility to support the R&D-AC link is both a theoretical and practical contribution

because it requires the need to assess the impact of any HR practice in the management of knowledge and innovation. Although there are other reasons to adopt flexible HR practices, it is important to take into account how each practice could enhance or discourage the knowledge processes within the firm. According to the KBV, it is the firm's ability to integrate external and internal knowledge to create new knowledge that gives the firm a competitive advantage (Grant, 2013). Moreover, AC was recently proven to be an essential complement to internal innovation by Zou et al. (2018). Our study contributes by suggesting that HR flexibility may influence this knowledge integration process since the use of knowledge-intensive HR flexibility dimensions reinforces the link between R&D effort and AC.

The nonsignificant mediator effect of temporary employment is also relevant by itself. Contrary to other scholars (e.g., Beugelsdijk, 2008; Franceschi & Mariani, 2016; Grinza & Quattraro, 2019; Kato & Zhou, 2018; Michie & Sheehan, 2005) that found a negative association between temporary employment and innovation with some limitations, our research explores the mediator effect. Mediator effects are closer to causal relationships than associative measures such as correlations (Hayes, 2018, p. 121; Pieters, 2017). In addition, our proposed mediator effect is not significant. This suggests that temporary employment does not play any causal role in the relationship between R&D and AC. Firms may hire temporary employees for other reasons than innovation; they could even use short-term hires to enhance core employees' focus on innovation activities. Whatever the association may be between temporary employment and innovation, our study indicates that the mediator effect of HR flexibility is only restricted to dimensions that are more knowledge-intensive.

Our interpretation that HR flexibility seems to act like a 'coin' with two opposite sides, 'good' vs 'bad', has consequences for managers and employees as well. This research shows that not all HR flexibility dimensions are relevant for innovation management, suggesting that there may be 'win-win' and 'win-lose' flexibility situations from an employer-employee perspective. It is very important to analyze the best options available because the strategic process of the firm that understands the environment contributes to the growth of the firm (Chebo & Kute, 2019). In our case, we find that enhancing the employees' ability to learn and adapt to new situations while interacting with external R&D experts at the same time might have positive consequences for the firm (innovation outcomes) but may also improve the employability of employees and their quality of working life. Similar to this, other scholars (e.g., Denicolai, Ramirez, & Tidd, 2016) show that knowledge from external sources is faster to absorb and exploit than internal knowledge, which reinforces our result that some mediator effects of HR flexibility could operate simultaneously to improve the R&D-AC-innovation link. In contrast, other HR flexibilities such as temporary employment might offer firms options to adapt changes in production volume. However, these flexibilities cannot fulfill the employees' expectations for career development in some job types because it impedes the employees' involvement in innovation efforts and knowledge development.

Managers should then focus on training core employees and hiring the best external R&D experts to reinforce the combination of in-house R&D efforts and absorptive capacities of external knowledge. Adding knowledge-intensive HR practices to this combination should result in an improvement in the firm's innovation performance. Some organizations could even use temporary employees to liberate core employees from routine tasks and enhance their contribution to innovation.

Another managerial implication is that firms should build flexible HR capabilities before developing and implementing AC. On the one hand, innovations, especially radical innovations, require more tacit knowledge than innovations such as process improvements, which can be supported by more explicit knowledge and procedures (Lin, Su, & Higgins, 2016). Our finding that HR flexibility mediates between R&D and AC suggests that HR flexibility strengthens the link between R&D efforts and AC, which are the best way to support the development of

tacit knowledge. On the other hand, trained core employees and external R&D experts contribute to combine in-house R&D and external knowledge more efficiently. This combination of internal and external knowledge is what supports the firm's innovation performance over time.

Finally, time is an important variable in the innovation process. Any assimilation and transformation of knowledge requires time. However, the development of flexible HR capabilities may contribute to reduce research uncertainty and cut innovation development times. Therefore, HR flexibility may also enhance innovation by making early stages of the process such as design or prototyping much more efficient. These early stages of the innovation process are more knowledge-intensive than later stages such as market testing. Therefore, the development of flexible HR flexible capabilities may reinforce and facilitate the combination of in-house R&D efforts and AC of external sources of knowledge.

6. Conclusions and research limitations

This study analyzed the influence of HR flexibility in the R&D-AC relationship. Our results indicate that HR flexibility mediates the relationship between R&D and AC. On the one hand, the firm's training efforts and the hire of external R&D experts may contribute to combine the in-house R&D and the absorptive efforts of external knowledge more effectively. Firms that successfully make that combination could enhance their innovation performance. On the other hand, temporary employment does not mediate the relationship between R&D and AC, although it is negatively correlated to both variables. Therefore, the main conclusion of the paper is that the HR flexibility dimensions, which are more knowledge-intensive, better explain the development of AC and contribute more to R&D and AC to improve innovation performance.

This research has some limitations due to the use of cross-sectional data and a single measure of AC. Although our study suggests several causal relationships from the mediator effects of HR flexibility, longitudinal studies are needed to confirm these relationships. Future studies could also analyze the interaction of HR flexibility with separate measures of AC such as potential or realized AC. Different measures of HR flexibility could also be used to find stronger or more robust mediator effects. This is especially true for HR internal flexibility, which is measured through a proxy measure instead of a direct measure of functional polyvalence in this study. Finally, the absence of control variables such as firm size, age, or industry may be regarded as a limitation as well. The models included in PROCESS restrict the number of variables that can be tested. In addition, there may be other issues at play that may influence our findings and could be of interest to explore with another type of methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Angel Martínez-Sánchez is a Professor at the Department of Business Management at the University of Zaragoza in Spain. He received his Ph.D. in Engineering from the University of Zaragoza and holds a Master in Business Administration from the Polytechnic University of Madrid. He has been a Research Fellow at universities in Europe, North America, Australia and Japan. Dr. Sánchez's research interests focus on innovation and technology management, production and supply chain management, and organizational flexibility. He has published in journals such as: *Journal of Management Studies*, *British Journal of Management*, *International Journal of Operations and Production Management*, *International Journal of Automotive and Technology Management*, *Journal of Product Innovation Management*, *R&D Management*, *Technovation*, *Small Business Economics*, *Supply Chain Management*, *International Journal of Project Management*, *Personnel Review*, *Management International Review*, as well as numerous conference proceedings, books and research reports. He is a member of the Editorial Board of *Technovation* and Honorary Member in the Board of the International Academy of Management and Business Association.

Silvia Vicente-Oliva is an Assistant Professor of Innovation Management and Technology Policy at the Centro Universitario de la Defensa – Academia General Militar (Zaragoza, Spain). This center provides the Management Engineering degree course to officer cadets in the General Corps of the Spanish Army. She received her Ph.D. in Project Engineering from the University of Zaragoza and her research interests include R&D project management, technology foresight and innovation. Her research has been published in, among others, the *International Journal of Project Management*, *International Journal of Innovation Management*, *Foresight*, and *Baltic Journal of Management*.

Manuela Pérez-Pérez is a Professor at the Department of Business Management at the University of Zaragoza in Spain. She received her Ph.D. in Economic and Business Sciences from the University of Zaragoza and holds a Master in Economics of Commercial Distribution from the University of Zaragoza. She has been a Research Fellow at the Eastern Illinois University (USA) and has lectured on ICT and telework in Spain and several foreign universities (USA and France). Professor Pérez's research interests focus on remote work, organizational flexibility, innovation and technology management and production and supply chain management. She has published in journals such as: *Journal of Management Studies*, *Journal of Enterprise Information Management*, *British Journal of Management*, *International Journal of Operations and Production Management*, *International Journal of Automotive and Technology Management*, *Journal of Product Innovation Management*, *R&D Management*, *Technovation*, *Supply Chain Management*, *International Journal of Project Management*, *Personnel Review*, *Management International Review* among others. She has also participated in numerous conference proceedings, books and research reports.