The effects of knowledge spillovers, digital capabilities, and innovation on firm performance: A moderated mediation model

João J.M. Ferreira [a,b,*], Cristina I. Fernandes [a,c], Pedro Mota Veiga [d,e]

[a] *Universidade da Beira Interior, Department of Management and Economics & NECE Research Unit in Business Sciences, Portugal*
[b] *QUT Australian Centre for Entrepreneurship Research, Brisbane, Australia*
[c] *Centre for Corporate Entrepreneurship and Innovation at Loughborough University, UK*
[d] *University of Maia, Maia, Portugal*
[e] *NECE Research Unit in Business Sciences, University of Beira Interior, Portugal*

ABSTRACT

Despite the growing importance of implementing digital technologies in business contexts, empirical research relating to digital capabilities, innovation, and business performance still remains scarce, particularly relevant in these times of disruption. This study proposes a mediated-moderated framework to describe, according to the level of economic development of the country of firm location, the direct and indirect effects (mediated by digital capabilities and innovation) of knowledge spillovers on firm performance. We carried out a quantitative study deploying the longitudinal World Bank Enterprise Surveys for 2019, 2020 and 2021 in a dataset that included 27,727 firms from 41 countries and territories. We applied the partial least square structural equation modelling (PLS-SEM) methodological approach to test the mediated-moderated model that explains business performance. The results identify how knowledge spillovers positively influence firm performance through digital capabilities and innovation. Furthermore, we empirically demonstrate that the national level of economic development moderates the direct and indirect impacts of knowledge spillovers on firm performance.

1. Introduction

Entrepreneurial activities contribute to the economic growth of countries and regions and foster the construction of national competitive advantages (Carree and Thurik, 2003; Van Stel et al., 2005; Aparicio et al., 2016) through lowering unemployment rates (Audretsch and Thurik, 2000) and driving unquestionably positive changes in the socioeconomic framework (Youssef et al., 2018). Hence, entrepreneurship stands out as a critical factor for prosperity and economic wellbeing and thus the fundamental nature of the diverse support policies underpinning entrepreneurial ventures (Acs et al., 2017; Audretsch and Belitski, 2017). Understanding entrepreneurial activities becomes still more important when, and despite all the results pointing to their relevance, the success rates of launching new firms remain relatively low, especially in knowledge based economies (GEM, 2020).

More recently, the literature has deployed knowledge spillover theory (KST) to explain the appearance of entrepreneurs (Belitski et al., 2016; Caiazza et al., 2020). KST now has a long tradition that emphasises the importance of knowledge as a source of economic growth

(Arrow, 1962; Romer, 1990; Audretsch and Keilbach, 2007). However, not all of the knowledge created is subject to exploration (Acs et al., 2013) and it is precisely this 'unleveraged' knowledge that needs transferring to entrepreneurs who may then apply it in new ventures. Therefore, knowledge spillovers, in their transfers of knowledge, are capable of transforming into new business opportunities, themselves perceived as core factors in entrepreneurial processes (Audretsch, 2007).

Currently, firms are also increasingly aware of the need to adapt to newly arising challenges (Loureiro et al., 2021). Knowledge spillovers are correspondingly playing an important role in optimising and improving the efficiency levels of company processes through strengthening digital skills so as to guarantee better business performance (Heredia et al., 2022). Hence, in a changing and turbulent environment, digital capabilities are taking on increasingly important roles (Zhen et al., 2021).

However, to this end, we need a deeper understanding of the mechanisms underlining these knowledge spillovers given that the literature has yet to reach any conclusions as regards the relationship

and interactions among the multiple actors that engage in the exchanges of knowledge that build up digital capabilities (Audretsch and Feldman, 2004; Breschi et al., 2005; Acs et al., 2013; Schmidt, 2015). Despite these considerations, we may also verify that there is no consensus on the relationship between digital capabilities and the performance levels of firms (Martínez-Caro et al., 2020). Some authors (e.g., Wang, 2007; Drnevich and Croson, 2013) maintain that digital capabilities generate positive impacts on performance through reducing costs and raising flexibility. Meanwhile, others report that digital capabilities have little or no effect on company performance. Furthermore, Usai et al. (2021) conclude that the innovative performance of firms does not stem from digital capabilities but rather from creativity and constantly ongoing research and development activities. We may thereby infer that digital capabilities in themselves are insufficient to successfully achieve innovative performance standards.

Hence, this study proposes a mediated-moderated framework to describe, according to the national levels of economic development of the host countries of firms, the direct and indirect effects (mediated by digital capabilities and innovation) of firm knowledge spillovers on their performance. We undertook a quantitative study and deployed the datasets from the longitudinal World Bank Enterprise Surveys in 2019, 2020 and 2021, which incorporated the business results of 27,727 firms from 41 countries and territories. We applied partial least square structural equation modelling (PLS-SEM) to test the mediated-moderated model that explains business performance through the relationship between knowledge spillovers, digital capabilities, innovation and economic development.

This dataset enabled the testing of the research hypotheses formulated and generated broader perceptions of the influence of knowledge on the performance and innovation of firms. We encountered support for our theoretical arguments alongside evidence that indicates that firms making recourse to knowledge spillovers enable them to achieve higher levels of innovation and performance as the digital capabilities themselves depend on the support provided through knowledge spillovers.

This study therefore returns three main contributions. Firstly, the study advances recent research on KST. Previous studies have concentrated on applying this theory to examine the innovative activities and consequent company performance levels (Audretsch and Feldman, 2004; Breschi et al., 2005; Acs et al., 2013). In contrast, this study measures the direct and indirect effects (measured by digital capabilities and innovation) of the knowledge spillovers on company performance.

Secondly, in contrast with earlier studies tending to focus exclusively on aspects related to digital capabilities, this study reports how digital capabilities generate positive effects on the relationship between knowledge spillovers and company performance. These discoveries enable us to highlight how digital capabilities, without any impact from knowledge spillovers, do not produce any impact on the innovation activities and performance levels of firms.

Finally, this study contributes to the literature in providing empirical evidence on the moderating effect of economic development on the relationships between knowledge spillovers, digital capabilities, the performance and innovation of firms.

2. Theory and hypotheses

2.1. Knowledge spillover theory

Knowledge spillover theory (KST) was first put forward by Audretsch (1995) based on concepts such as sources of knowledge and the importance of spillover mechanisms to entrepreneurial activities. In this article, Audretsch (1995) identifies entrepreneurs as crucial channels for the dissemination and commercialisation of knowledge with these facets becoming an extremely important variable to endogenous growth theory (Grossman and Helpman, 1991; Romer, 1986, 1990; Audretsch and Belitski, 2013).

Within this framework, Audretsch and Keilbach (2007) detail how KST opens up new insights into the origins and opportunities of entrepreneurship. Correspondingly, ever since its first proposition by Audretsch (1995), KST has been subject to application in the most diverse fields of study, including economic growth (Audretsch et al., 2017), absorptive capacity (Acs and Plummer, 2005; Proeger, 2020), business ecosystems (Yi et al., 2021), company alliances (Shu et al., 2014) and sustainable entrepreneurship (Colombelli and Quatraro, 2019). Despite the KST field including diverse studies that approach codified forms of knowledge, such as patents, publications and citations (Nonaka, 1994; Ghio et al., 2015), Audretsch and Keilbach (2007) defend how qualified individuals may incorporate knowledge that, at an aggregate level, represents the diverse tacit forms of knowledge available in a particular region (Audretsch and Feldman, 2004; Audretsch and Belitski, 2013; Ghio et al., 2015).

While various authors, the early pioneers of KST, maintain that the creation of knowledge takes place through diverse learning processes (Audretsch, 1995; Audretsch and Keilbach, 2007), Ghio et al. (2015) defend that this knowledge creation process occurs primarily in already established firms and in research institutions. Hence, this led to approaches studying entrepreneurial economies and the respective awareness as to how entrepreneurs are themselves a source of knowledge (Antonelli, 2019) and thereby portraying actors as creators and receivers of knowledge with a fundamental need to define these roles in knowledge spillover mechanisms (Acs et al., 2009) in which some create and others commercialise the knowledge (Braunerhjelm et al., 2010).

According to various authors, knowledge displays an uncompetitive and unexclusive property as the spillover mechanisms themselves generate the opportunities for entrepreneurs (Acs et al., 2004; Acs and Armington, 2006; Audretsch and Keilbach, 2008; Audretsch, 2007). Hence, Ghio et al. (2015) demonstrate how interactions between entrepreneurs and knowledge producers play a fundamental role in leveraging still unexplored knowledge. To this end, geographic proximity among these actors represents a necessary factor as otherwise these spillover mechanisms produce far weaker effects (Audretsch and Keilbach, 2007; Lee et al., 2013) and with these knowledge based opportunities driving the launch of new businesses (Audretsch and Keilbach, 2007; Iftikhar et al., 2020). The actors involved in these processes have engaged in increasingly diverse formal agreements reflecting how the tacit dimension of these knowledge spillover mechanisms, in conjunction with a broad range of actors, constitutes an essential input to ensuring their effectiveness and efficiency (Schmidt, 2015; Caiazza et al., 2020; Lattacher et al., 2021).

2.2. Hypotheses

2.2.1. Knowledge spillovers, digital capabilities, performance and innovation

The growth in the productivity and performance of any company essentially depends on the characteristics of their human capital (Ramadani et al., 2016). According to Acs et al. (2009), the capacity to transform new knowledge into economic opportunities requires a set of abilities and skills that are not equally endowed and only obtained by certain individuals. Hence, firms investing in human resources with rare skills will enable them to build up the knowledge spillover mechanisms capable of returning better performance as they are able to transform individual capabilities into value (Saito and Gopinath, 2011; Fernandes and Ferreira, 2014).

Various researchers have dedicated their studies to the impact of knowledge spillovers in the most diverse contexts, for example in the appearance of and ongoing innovation at scientific and technology parks (Sanchez et al., 2011), in internationalisation processes (Kneller and Pisu, 2007; De Clercq et al., 2008), in commerce (Rod et al., 2004). However, one particularly positive effect derives from the growth registered by organisations (Acs et al., 2013).

Knowledge spillovers impact on company performance in two ways: on the one hand, they enable firms to access new knowledge and, on the

other hand, in accessing this knowledge, firms are able to weaken the performance of their competitors (Bloom et al., 2013). Hence, various authors adopt a position advocating how knowledge spillovers generate strongly positive impacts on the performance and growth of businesses and firms (Jaffe et al., 1993; Coe and Helpman, 1995; Saito and Gopinath, 2011; Acs et al., 2013; Hashi and Stojcic, 2012). We, thus, formulate the following hypothesis:

H1. : Knowledge spillovers have a positive impact on the performance of firms.

2.2.2. The mediating effect of digital capabilities and innovation

Hence, diverse researchers have concluded that innovation and knowledge spillovers return positive impacts on company performance (Ornaghi, 2006; Faria and Lima, 2012). Nevertheless, this needs to take into account how the externalities differ in accordance with the type of innovation. On the one hand, firms assimilate more knowledge from process based innovations than product innovations (Faria and Lima, 2012), on the other hand, product innovations generate greater technological dissemination than process innovation (Ornaghi, 2006). Firms receiving valuable knowledge spillovers from interactions with a specific partner, as a means of boosting their innovation efforts, display a greater propensity to collaborate with this type of partner as well as turning in better levels of performance (Belderbos et al., 2006; Bernal et al., 2022).

It is thus fundamental for firms to be able to identify the knowledge spillovers most able to contribute towards their innovation processes and consequent performance (Eisenhardt and Martin, 2000). This recourse to the spillover mechanism is also a means for firms to instil a greater propensity to collaborate with different partner types (Goerzen, 2007; Holloway and Parmigiani, 2016; Bernal et al., 2022).

Based on these arguments, we arrive at the following hypothesis:

H2. : Innovation has a positive mediating effect on the relationship between spillovers and company performance.

Digital capabilities essentially consist of the ability of firms to conjugate innovation processes with the development of new products and services (Wang, 2007). These capacities involve knowledge and the ability to acquire, apply, absorb, adapt, improve and generate new technologies (Malhotra et al., 2021). These capabilities enable the development of new products and technologies, refining manufacturing processes and the means of controlling quality and forecasting technological changes in the industry (DeSarbo, 2005). Thus, digital capabilities emerge as specific internal procedures that serve to the advantage of the supplier-user relationship and create value for firms acquiring such capabilities (Yoo et al., 2012; Srivastava and Shainesh, 2015; Lyytinen et al., 2016).

These digital capabilities underpin the means necessary for organisations to generate the opportunities that enable them to solidify their competitive advantages (Heredia et al., 2022). Hence, understanding the dynamics that influence the adoption of and search for digital capabilities emerges as a fundamental factor for the success attained by some firms through incorporating technology into their organisations (El-Haddadeh, 2020); adopting the dynamic capacities of digital disruption (Karimi and Walter, 2015) conveying some of the digital capabilities that foster improvements to the performance and consequent competitive advantages of firms (Sutherland, 2018). We may thus state the following research hypotheses:

H3a. : Digital capabilities return a positive mediating effect on the relationship between knowledge spillovers and company performance.

H3b. : Digital capabilities and innovation sequentially mediate the positive impact between knowledge spillovers and company performance.

2.2.3. The moderating effect of the level of economic development

Knowledge spillovers play an undebatable role in innovation and economic development (Arrow, 1962; De Bondt, 1997). According to Frenken et al. (2007), different types of economic clusters may emerge as a result of knowledge spillovers. The literature foresees that the first type of knowledge spillovers comes from nearby sources with geographic and technological proximity while the second spillover type arises in local firms with geographic proximity. Within this framework, the literature on knowledge spillovers and the geography of innovation has opened debate on the channels through which knowledge spreads and the extent to which these are geographically located (Audretsch and Feldman, 2004). Correspondingly, geographic proximity probably boosts the capacity of firms to exchange ideas and acquire new knowledge and thereby reducing the costs of scientific discovery and commercialisation through means of innovative clusters or innovative environments (Breschi and Lissoni, 2001).

The studies analysing the importance of knowledge spillovers to the dynamics of firms and economies generally concentrate on the impact of spillovers on the performance indicators of firms and economies, for example, the rate of GDP growth per capita (Rodríguez-Pose and Crescenzi, 2008); and innovation, such as the number of innovations introduced (Beise and Stahl, 1999) or the number of patents awarded (Bode, 2004). Thus, research studies have approached the dynamics of firms and economies through knowledge spillover variables including patents in neighbouring regions (Bode, 2004), R&D (Rodríguez-Pose and Crescenzi, 2008) and accessibility (Andersson and Karlsson, 2007). Various authors furthermore maintain that economies always benefit from any proximity to others that are innovative and record higher levels of knowledge spillover (Bode, 2004; Funke and Niebuhr, 2005). Hence, we arrive at the following research hypotheses:

H4. : The level of economic development moderates the impact of knowledge spillovers on: a) performance; b) digital capabilities; and c) company innovation.

H5. : The level of economic performance moderates the impact of innovation on company performance.

Collaborative economies assist in reconfiguring capacities and resources through digital capabilities and knowledge spillover mechanisms (Fu et al., 2023). Similarly, developing new company skills and capacities may lead to disruptive opportunities. Fainshmidt et al. (2016) defend how new capacities contribute more significantly to company performance in emerging economies than in their developed counterparts. Institutional factors, such as informality and structural shortcomings bring about collaborative economies in emerging markets (Boateng et al., 2019; Heredia et al., 2022). Therefore, the concept of collaborative economies holds more significant advantages in emerging economies precisely because this economy type involves lower levels of investment and more direct implementation (Dokko, 2015). In developing economies, recourse to collaborative economic practices correspondingly significantly reduces intermediation costs (Dokko, 2015).

The literature also states that, despite emerging economies displaying low levels of human development, they nevertheless register high levels of creativity with collaborative economies thus increasingly expanding in emerging economies (Leung et al., 2020). We may thus propose our final research hypothesis:

H6. : The level of economic development moderates the impact of digital capabilities on: a) performance; b) company innovation.

Fig. 1 sets out the conceptual model under analysis alongside the respective research hypotheses.
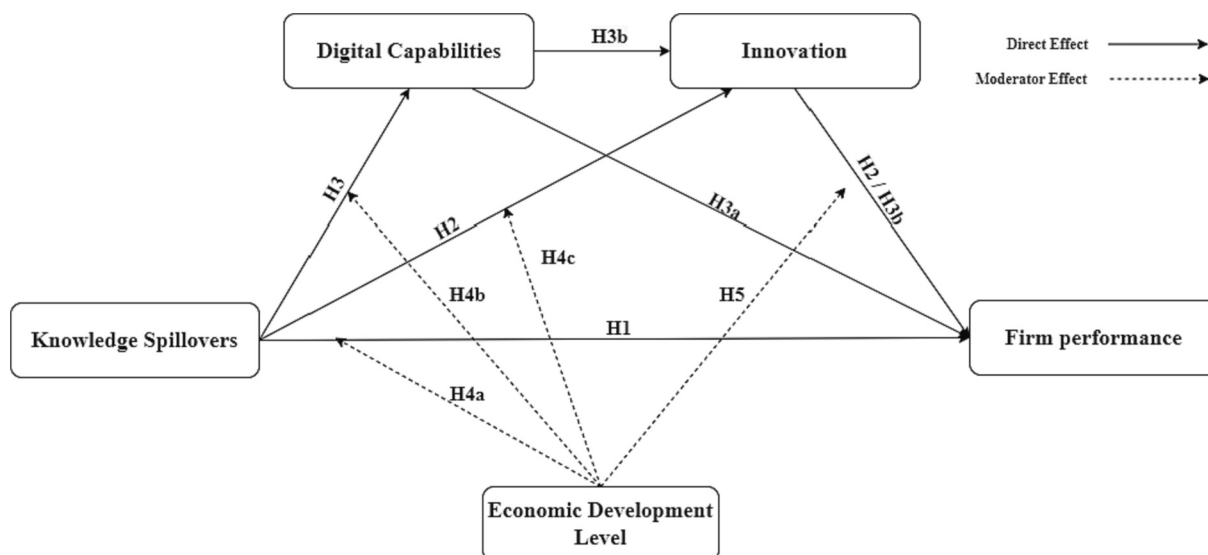
Fig. 1. Conceptual model.

3. Methodology

3.1. Data and sample

We obtained our sample from data produced by the Enterprise Surveys carried out by the World Bank (https://www.enterprisesurveys.org) according to a data collection methodology uniformly applied on a global scale. Business owners and senior managers respond to the Enterprise Survey with manufacturing industry and services as the main sectors of activity. This process collects data on various topics including the respective company's characteristics, gender participation rates, access to financing, annual sales, costs of consumables/labour, composition of the workforce, utilisation of capacities, lands and authorisation, taxation, informality, innovation and technology and performance measures.

Data collection takes place through in-person interviews with the selection of the firms involving a stratified random sample that takes into consideration company size, the business sector and host region. This study applies longitudinal statistics collected over three points in time: the Enterprise Surveys produced between November 2018 and January 2020 (ES2019), between July 2020 and October 2020 and between January 2021 and March 2021 (ES2021). The sample consists of 8928 firms with their respective characteristics summarised in Table 1.

3.2. Variables

3.2.1. Dependent variables

3.2.1.1. Performance. The dataset provides information about the variations in demand for the products and services of this establishment in comparison with the same month of 2019 as well as the variations in sales since this latter month (Ferreira et al., 2023).

3.2.2. Independent variable

3.2.2.1. Knowledge spillovers. In order to measure the knowledge spillovers, we applied the data portraying the acquisition of External Knowledge prior to 2019 or whether the company deploys any of its resources on R&D within the Establishment or R&D Contracted Outside the Establishment items (Yi et al., 2021; Ferreira et al., 2023).

Table 1
Sample characteristics.

		N	%
Country	Bulgaria	499	5.6 %
	Croatia	327	3.7 %
	Cyprus	172	1.9 %
	Czech Rep.	396	4.4 %
	Estonia	289	3.2 %
	Georgia	481	5.4 %
	Greece	543	6.1 %
	Hungary	643	7.2 %
	Italy	424	4.7 %
	Jordan	448	5.0 %
	Latvia	263	2.9 %
	Lithuania	222	2.5 %
	Malta	193	2.2 %
	Moldova	281	3.1 %
	Mongolia	233	2.6 %
	Morocco	432	4.8 %
	Poland	1013	11.3 %
	Portugal	770	8.6 %
	Romania	468	5.2 %
	Russia	580	6.5 %
	Slovenia	251	2.8 %
Sector	Manufacturing	4905	54.9 %
	Retail services	1504	16.8 %
	Other services	2519	28.2 %
Size	Small	6144	68.8 %
	Medium	2163	24.2 %
	Large	621	7.0 %

3.2.3. Mediator variables

3.2.3.1. Digital capabilities. In order to analyse the digital capabilities, we deployed data describing the variations in online activities and delivery and the adoption of remote working practices (Yi et al., 2021).

3.2.3.2. Innovation. As regards innovation, both questionnaires inquired into whether the firms introduced any new or improved product or services (Ferreira et al., 2020).

3.2.4. Moderating variable

3.2.4.1. Level of development. In relation to the national level of development, we adopted the development stages defined by the World Economic Forum, therefore Stage 1, Transition from stage 1 to stage 2,

Stage 2, Transition from stage 2 to stage 3 and Stage 3 (Santos et al., 2020).

3.2.5. Control variables

The variables applied in this analysis were economic activity, company size and turnover (thousands of euros). In the case of economic activity, we attributed dummy variables ("to which sector does the company belong") (Ferreira et al., 2020; Ferreira et al., 2023).

Table 2 details all of the items and variables incorporated into this research study.

3.3. Data analysis

In order to validate the study hypotheses, we applied the structural equation models (SEM) in conjunction with the partial least squares (PLS) methodology for estimates, an approach widely deployed in the business science field (Hair et al., 2020; Wichaisri & Sopadang, 2017). The adoption of PLS-SEM as an alternative to covariance based SEMs (CB-SEM) stemmed from the complexity of the research model (direct, mediating and moderating effects) without imposing any distributive premises on the indicators and the constructs included are composite (Hair et al., 2019, 2020; Sarstedt et al., 2019). It offers flexibility and can handle complex relationships in data (Venkatesh et al., 2012). PLS-SEM is a widely used methodology in innovation-related fields (e.g., Forliano et al., 2023; Petraite et al., 2022; Rubio-Andrés et al., 2023). PLS-SEM is valuable for exploring multidimensional innovation processes and offers advantages over traditional approaches and contributing here to a deeper understanding of innovation dynamics.

Firstly, to confirm the factorial structure of the instrument applied, we needed to examine the measurement model. The PLS-SEM evaluation of measurement model took place according to the reliability and validity of the indicators serving for the representation and measurement of each theoretical concept (Hair et al., 2019, 2020; Sarstedt et al., 2019). Construct validity stems from the extent to which a set of items reflect the theoretical construct designed to measure and ascertain the reliability of the aforementioned instrument in terms of the properties of its

consistency and the reproducibility of the measurement (Hair et al., 2019, 2020; Sarstedt et al., 2019).

The present study evaluated the validity of these constructs through: (1) composite reliability (CR), (CR > 0.70), as this is not subject to the influence of the number of items existing in each construct, to the contrary of Cronbach's Alpha, as this deploys item weightings extracted from the estimated model; (2) factorial validity (factorial weightings >0.5 and ideally above 0.7); (3) convergent validity measured through average variance extracted (AVE), assuming there is convergent validity whenever AVE > 0.50; and (4) discriminant validity in which the AVE of the two constructs needs to return a weight in excess of the squared correlation between these two factors (Barroso et al., 2010; Fornell & Larcker, 1981; Sarstedt et al., 2019).

Within the scope of the global evaluation of the structural model and the respective validation or otherwise of the hypotheses, we examined the global adjustment of the estimated model, the estimates of the coefficient of the paths depicting the direct and indirect effects and the moderators and their respective statistical significance in accordance with the bootstrap and determinant coefficient results (R^2) (Benitez et al., 2020). In estimating the structural models in order to determine the t-statistics and their respective statistical significance, we applied the bootstrapping procedure (with a sample of 10,000 bootstraps). All these calculations made recourse to SmartPLS software version 4.0.8.4 (Ringle et al., 2022).

4. Results and discussion

4.1. Measurement model

Table 3 displays the results relating to the descriptive statistics, the reliability and validity of the composite constructs for each model. For all of these constructs, the factorial weightings and composite reliability results come in above the levels required. In order to test whether the constructs were sufficiently mutually different, we inspected the discriminant validity through applying the Fornell and Larcker criteria (1981) that require the AVE of any construct to be greater than the

Table 2
Definition of constructs and indicators.

Constructs	Indicators	Questions	Scale	Source
Knowledge Spillovers	**External Knowledge**	During Last 3 Yrs, Establishment Spent On Acquisition of External Knowledge? (KS1)	0 - No; 1 – Yes	ES2019
	R&D within the Establishment	During Last 3 Yrs, Establishment Spent On R&D Within the Establishment? (KS2)	0 - No; 1 – Yes	ES2019
	R&D Contracted Outside the Establishment	During Last 3 Yrs, Establishment Spent On R&D Contracted Outside the Establishment? (KS3)	0 - No; 1 – Yes	ES2019
Digital capabilities	**Activity Online**	Since the COVID-19 outbreak, started or increased business activity online? (DC1)	0 - No; 1 – Yes	ES 2020 and ES 2021
	Delivery or Carry-out	Since COVID-19 outbreak, started or increased delivery or carry-out? (DC2)	0 - No; 1 – Yes	ES 2020 and ES 2021
	Remote Work	Since COVID-19 outbreak, started or increased remote working arrangements? (DC3)	0 - No; 1 – Yes	ES 2020 and ES 2021
Innovation	**Products**	Since COVID-19 outbreak, introduced new or improved product or services (INNOV)	0 - No; 1 – Yes	ES 2020 and ES 2021
Performance	**Variation in demand**	The demand for this establishment's products and services with the same month in 2019 (PERF1)	1 - Decreased; 2 – Equal; 3 – Increased	ES 2021
	Changes to sales	Change in sales for the last month compared with the same month in 2019 (PERF2)	1 - Decreased; 2 – Equal; 3 – Increased	ES 2021
Level of development	**Stages of development**	World Economic Forum classification of the stage of development (DEV)	1 – Stage 1 1.5 – Transition from stage 1 to stage 2 2 – Stage 2 2.5 – Transition from stage 2 to stage 3 3 – Stage 3	World Economic Forum
Control variables	**Type of industry**	The sector the company belongs to	Industry, Commerce, Services	ES 2019
	Size of company	Full time contracted staff at the end of December 2019	Number of employees	ES 2019

Table 3
Construct validity and reliability.

Name	Median	DP	Range	Factor loadings	CR	AVE	AVE > Corr^2
Knowledge Spillovers					0.805	0.582	0.58 > 0.38
KS1	0.26	0.67	0–1	0.683			
KS2	0.40	0.80	0–1	0.867			
KS3	0.20	0.60	0–1	0.727			
Digital Capabilities					0.762	0.517	0.52 > 0.22
DC1	0.23	0.42	0–1	0.725			
DC2	0.19	0.40	0–1	0.786			
DC3	0.32	0.47	0–1	0.639			
Innovation					NA	NA	NA
INN	0.35	1.31	0–1				
Performance					0.751	0.564	0.52 > 0.38
PERF1	1.53	1.77	1–3	0.534			
PERF2	1.46	0.68	1–3	0.918			
Development Level					NA	NA	NA
DEV	2.26	0.50	1–3				

NA – Not Applicable.

square root of its greatest correlation with any other construct. Given these results, we would state that in general terms these different constructs display high levels of reliability as well as factorial validity, convergent validity and discriminant validity and correspondingly classed as valid and reliable for application.

4.2. Analysis of the structural model

Table 4 and Fig. 2 set out the results of the structural model estimated only with the respectively validated hypotheses. The structural model hereby estimated returns acceptable levels of predictive power

Table 4
Results of the structural model.

Hypothesis	Path	B	t	p
	Economic Development Level -> Innovation	0.01	0.46	0.324
	Economic Development Level -> Digital capabilities	0.03	4.02	0.000***
	Economic Development Level -> Performance	0.09	5.59	0.000***
	Industry -> Performance	0.12	4.50	0.000***
	Size -> Performance	0.05	4.65	0.000***
H1	Knowledge Spillovers -> Performance	0.16	5.13	0.000***
H2	Knowledge Spillovers -> Innovation	0.11	1.70	0.044*
	Innovation -> Performance	0.07	3.79	0.000***
	Knowledge Spillovers -> Innovation -> Performance	0.01	1.74	0.041*
H3	Knowledge Spillovers -> Digital capabilities	0.14	6.68	0.000***
H3a	Digital capabilities -> Performance	0.15	4.66	0.000***
	Knowledge Spillovers -> Digital capabilities -> Performance	0.02	3.87	0.000***
H3b	Digital capabilities -> Innovation	0.18	1.69	0.045*
	Knowledge Spillovers -> Digital capabilities -> Innovation -> Performance	0.01	1.96	0.025*
H4a	Economic Development Level x Knowledge Spillovers -> Performance	0.10	3.39	0.000***
H4b	Economic Development Level x Knowledge Spillovers -> Digital capabilities	0.01	0.69	0.245
H4c	Economic Development Level x Knowledge Spillovers -> Innovation	0.06	2.33	0.010**
H5	Economic Development Level x Innovation -> Performance	0.06	1.78	0.037*
H6a	Economic Development Level x Digital capabilities -> Performance	0.04	1.16	0.124
H6b	Economic Development Level x Digital capabilities -> Innovation	0.00	0.10	0.462

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

(Performance: $R^2 = 34.0$ %; Digital capabilities: $R^2 = 24.1$ %; Innovation: $R^2 = 7.9$ %).

In the case of *H1: Knowledge spillovers have a positive impact on the performance of firms*, our findings report there is a statistically significant positive impact of knowledge spillovers on performance ($\beta = 0.14$; $p < 0.001$), hence supporting H1. Our results thus align with those of other researchers defending how the relationship between firms and knowledge spillovers influences performance (Rod et al., 2004; Kneller and Pisu, 2007; De Clercq et al., 2008; Sanchez et al., 2011; Acs et al., 2013).

Knowledge spillovers represent fundamental factors for the ability of firms to take dominant positions as regards their competitors and to leverage competitive advantages in comparison with their peers given their possession of spillover generated knowledge that enables them to weaken the position of competitor firms (Jaffe et al., 1993; Coe and Helpman, 1995; Saito and Gopinath, 2011; Acs et al., 2013; Hashi and Stojcic, 2012).

As regards *H2: Innovation has a positive mediating effect on the relationship between spillovers and company performance,* the results provide support to this hypothesis. They display the statistically significant positive effect of knowledge spillovers on innovation ($\beta = 0.11$; $p < 0.05$) alongside an equally statistically significant and positive effect of innovation on performance ($\beta = 0.07$; $p < 0.001$). The mediating effect of innovation on the impacts of knowledge spillover on performance also attained statistical significance ($\beta = 0.01$; $p < 0.05$). In keeping with other research findings, we may also report that innovation is a product of knowledge spillovers and correspondingly representing a fundamental contribution to the performance of organisations (Ornaghi, 2006; Faria and Lima, 2012).

In accordance with the validation of this hypothesis, we may state that innovation itself has a positive effect on the relationship between knowledge spillovers and performance. This result leads us to conclude that the intention to innovate and innovation as an output are crucial to firms seeking out the most appropriate knowledge spillovers for their activities, thereby fostering better levels of performance and the consequent innovation, which may serve to establish a virtuous circle: knowledge spillover-performance-innovation-knowledge spillover (Belderbos et al., 2006; Ornaghi, 2006; Bernal et al., 2022).

In terms of H3, the results convey the existence of a statistically significant positive impact of knowledge spillovers on digital capabilities ($\beta = 0.14$; $p < 0.001$). Digital capabilities return a statistically significant positive effect on performance ($\beta = 0.15$; $p < 0.001$). The mediating effect of digital capabilities on the impact of knowledge spillovers on performance also achieves statistical significance ($\beta = 0.02$; $p < 0.05$) and thereby validating hypothesis *H3a: Digital capabilities return a positive mediating effect on the relationship between knowledge spillovers and company performance*. In the case of the sequential mediation of digital capabilities and innovation on the effects of knowledge
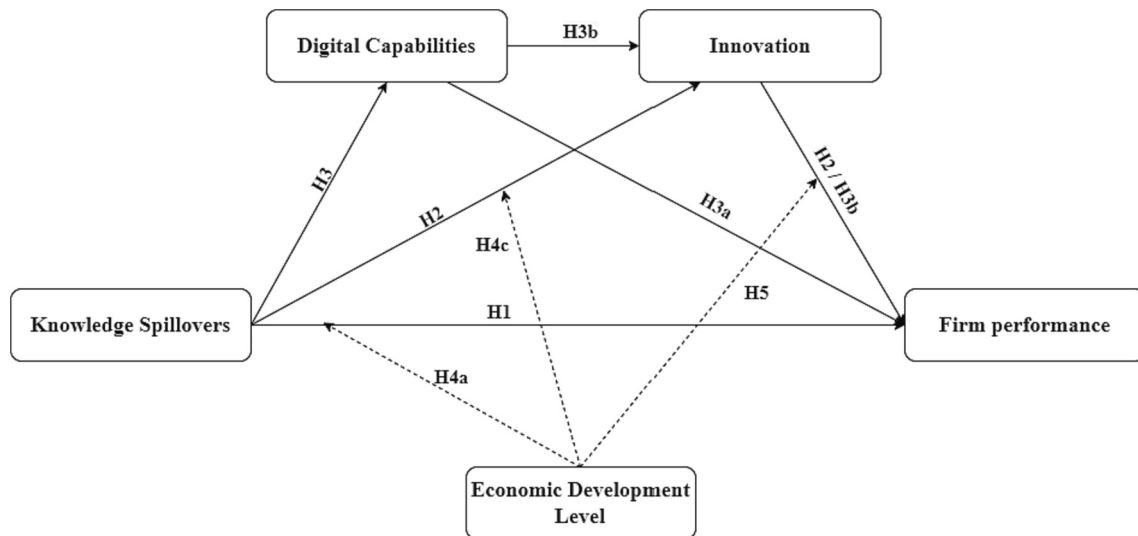
Fig. 2. Structural model of the validated hypotheses.

spillovers on performance, we may again affirm the statistically significant sequential mediation effect of digital capabilities and innovation on the effect of knowledge spillovers on performance ($\beta = 0.01$; $p < 0.05$). We thus corroborate hypothesis *H3b: Digital capabilities and innovation sequentially mediate the positive impact between knowledge spillovers and company performance.* This defends the perspective that digital capabilities endow the capacity for firms to conjugate innovative processes with the development of new products and services, involving the knowledge and abilities inherent to acquiring, using, absorbing, adapting, improving and generating new technology (Wang, 2007; Malhotra et al., 2021).

Hence, and as proposed by Usai et al. (2021), the simple possession of digital capabilities does not in itself generate innovation as this necessarily requires balancing within the scope of the knowledge spillover relationships that drive the production of innovation and consequent improvements to company performance (Yoo et al., 2012; Srivastava and Shainesh, 2015; Lyytinen et al., 2016).

In the case of the moderating effect of the stage of economic development on the diverse direct effects of the model, this returns a statistically significant and positive moderating effect on the impact of knowledge spillovers on innovation ($\beta = 0.06$; $p < 0.05$) and of knowledge spillovers on performance ($\beta = 0.10$; $p < 0.05$). However, the moderating effect of the stage of economic development on the impact of knowledge spillovers on digital capabilities did not obtain statistical significance ($\beta = 0.01$; $p = 0.245$). These results therefore corroborate the hypotheses in *H4: The level of economic development moderates the impact of knowledge spillovers on: a) performance; b) digital capabilities; and c) company innovation.* These results also demonstrate the existence of a positive moderating effect of the economic development stage on the impact of innovation on performance ($\beta = 0.06$; $p < 0.5$), validating hypothesis *H5: The level of economic performance moderates the impact of innovation on company performance.* Following the validation of the hypotheses above (apart from H4 b), we may state that the economic conditions of countries shape the better or worse performance of firms as well as their respective innovative activities (Frenken et al., 2007).

Furthermore, we may also state that lesser developed economies in close proximity to economies with more developed spillover mechanisms may benefit from them due to their proximity and thereby boost their innovation activities and performance levels (Breschi and Lissoni, 2001). Our results clearly portray that the economic development of countries generates a positive effect for the impact of the knowledge spillovers on innovation and performance as well as on the latter's mutual interrelationship (between innovation and performance) (Bode,

2004; Funke and Niebuhr, 2005; Andersson and Karlsson, 2007; Rodríguez-Pose and Crescenzi, 2008).

In terms of H6, the research findings did not register any statistically significant moderating effect for the economic development of countries on the impact of digital capabilities on performance (H6a) ($\beta = 0.04$; $p = 0.124$) and innovation (H6b) ($\beta = 0.00$; $p = 0.462$) and correspondingly failing to validate the hypotheses in *H6: The level of economic development moderates the impact of digital capabilities on: a) performance; b) company innovation.* The non-validation of these hypotheses demonstrates our alignment with the perspective of Usai et al. (2021), hence, irrespective of the level of national development, digital capabilities in themselves, without any spillovers, will not have any effect on innovation and performance.

5. Implications

5.1. Theoretical implications

The results of our research indicate an association between knowledge spillovers, digital capabilities, innovation and performance. There are various theoretical implications deriving from the empirical evidence obtained.

Firstly, knowledge spillovers and innovation are relevant to company performance (Acs et al., 2013). We may even state that knowledge spillovers are fundamental to boosting the overall performance of firms (Ornaghi, 2006) as they alert them to the new opportunities returned by innovation (Faria and Lima, 2012) as well as raising their awareness of market dynamics.

Furthermore, earlier research argues that knowledge spillovers influence innovation just as much as performance (Belderbos et al., 2006; Ornaghi, 2006). Knowledge spillovers provide a stimulant to innovation as they assist firms in recovering already produced but not commercialised knowledge (as firms intentionally seek out partnerships for recourse to specific knowledge). They correspondingly serve to challenge cognitive thinking and guide the direction of company innovation, leading to performance improvements.

Thus, our research findings highlight how knowledge spillovers sustain the innovation and performance of firms, contributing towards their creation of value. As a result, there are clear benefits to knowledge oriented leadership developing and encouraging the knowledge sharing practices capable of facilitating the appropriation of the value of this knowledge (Bernal et al., 2022). Hence, managers should focus on supporting the "knowledge agents" involved in knowledge sharing

practices among firms and actively seek out those knowledge spillovers of greatest advantage to the innovation efforts of their firms.

Secondly, we verify how digital capacities are highly important to the relationship between spillovers and company performance. However, after analysing the relationship between digital capabilities and innovation and performance mediated by economic development, we are unable to validate this hypothesis. Furthermore, we may therefore report that, as maintained by other authors, digital capabilities, in and of their own right, without inputs from knowledge spillovers, do not generate the otherwise expected impact (Usai et al., 2021). Digital capabilities essentially constitute the capacities firms deploy to manage new technologies. In turn, knowledge spillovers are essential to the identification of new opportunities and the creation of new knowledge that enables the perception of the opportunities arising from the application of these same digital capabilities (Lyytinen et al., 2016). Thus, digital capabilities function in conjunction with the spillovers that nurture innovation and consequent improvements to the performance of firms.

Thirdly, we identified a positive moderating effect of the stage of economic development on the relationship between knowledge spillovers and performance and innovation. The literature defends that the higher the level of economic development, the greater the access to knowledge and new market opportunities (Santos et al., 2020). However, we also need to state that the literature also defends that even when one country displays a higher level of economic development than another, a lesser developed neighbour may still benefit from the knowledge spillover mechanisms prevailing in the former due to their respective geographic proximity (Frenken et al., 2007).

Our research therefore also conveys how higher levels of economic development combined with strong knowledge spillover mechanisms drive innovation and consequent improvements to company performance.

5.2. Practical implications

Our research concludes that the commitment of the management to the value of knowledge helps in establishing and maintaining knowledge sharing practices that boost innovation and performance. Furthermore, our research highlights three particular implications for management practices.

Firstly, we would suggest that the success of firms depends on how managers value the creation and sharing of knowledge not only among members of the respective organisation but also with their peers, whether nationally or internationally (Acs et al., 2017; Audretsch and Belitski, 2017). Knowledge spillovers take on particular importance in their ability to help firms manage the flows of knowledge, whether deliberate or fortuitous. Therefore, we would propose that company managers should strive to take advantage of all the potentials of knowledge and engage with various spillovers and direct the focus of thinking of organisational members towards knowledge sharing enabling firms to undertake innovation processes within the scope of meeting the needs of their clients (Zhen et al., 2021). Hence, knowledge spillovers represent the best means of searching for, accessing, absorbing and applying knowledge from external origins to validate innovation activities.

Secondly, we would propose that the digital capabilities of firms constitute a strategic asset for leveraging sustainable competition and improvements to performance at the organisational level (Schmidt, 2015). Hence, we would suggest that firms strive to instal processes and functional systems in support of digital capabilities to leverage market opportunities and overcome their competitors (Martínez-Caro et al., 2020). We would recommend managers adopt a philosophy of openness towards innovation in order to ensure their firms are responsive to the needs of their clients and the emerging technological opportunities.

Thirdly, the level of economic development returns an important moderating effect on the relationship between knowledge spillovers and innovation and performance. It is therefore correspondingly important to adopt public policies that foster knowledge sharing in order to leverage or create the digital capabilities essential to innovative processes and consequent improvements to performance. The higher the level of value creation attained by firms, the higher the economic performance of countries.

6. Final considerations, limitations and future lines of research

This study proposed a mediated-moderated framework to describe, according to the level of national economic development of the firm's host country, the direct and indirect effects (mediated by digital capabilities and innovation) of the knowledge spillovers of firms on their respective levels of performance.

Our results demonstrate the positive impact of knowledge spillovers on both performance and innovation, reflecting the sheer importance of knowledge spillovers to the creation of value by firms. We also verify how digital capabilities, fundamental to innovation practices, are in themselves unable to generate this impact without recourse to knowledge spillovers. Hence, there is a need for a transfer of knowledge, with already existing knowledge or with new knowledge, in order to trigger the capacity and even the practices necessary for innovation. We also conclude that the level of economic development has a positive moderating effect on the relationship between knowledge spillovers and innovation and performance. This conveys how the resources of a country hold a positive influence over the types of partnership that firms mutually engage in.

As a rule, all studies of this type display limitations and this is clearly not an exception. In particular, we do not here analyse differences in terms of sectors of activity and thus future research might expand this study to examine the behaviours prevailing in different sectors to evaluate whether there are any differences between industries and thereby suggest ways of fostering knowledge and assisting policy makers to develop policies focused on the context prevailing in each specific sector to better support firms and businesses undertaking innovative practices. We would also recommend exploring micro level variables (for example, trust, owner/manager personality characteristics, staff involvement) to ascertain whether they help or hinder the innovation focused orientation of firms and their relationships with the knowledge spillovers they encourage in future research.

Finally, the quantitative approach deployed here contains its own respective limitations. As such, we would suggest future studies adopt mixed methodologies, with qualitative techniques in order to research how and in what way the knowledge spillovers, the digital capabilities and innovation influence and which specific conditions best facilitate knowledge sharing practices.

CRediT authorship contribution statement

João J.M. Ferreira: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Cristina I. Fernandes:** Data curation, Investigation, Methodology, Writing – original draft. **Pedro Mota Veiga:** Data curation, Software, Validation, Writing – original draft.

Declaration of competing interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability

Data will be made available on request.

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References

Acs, Z.J., Armington, C., 2006. Entrepreneurship, Geography and American Economic Growth. Cambridge University Press, Cambridge.

Acs, Z.J., Plummer, L.A., 2005. Penetrating the "knowledge filter" in regional economies. Ann. Reg. Sci. 39 (3), 439–456. https://doi.org/10.1007/s00168-005-0245-x.

Acs, Z.J., Audretsch, D.B., Braunerhjelm, P., Carlsson, B., 2004. The missing link: the knowledge filter and endogenous growth. In: CEPR Discussion Paper (4783), pp. 1–42.

Acs, Z.J., Braunerhjelm, P., Audretsch, D.B., Carlsson, B., 2009. The knowledge spillover theory of entrepreneurship. Small Bus. Econ. 32 (1), 1530. https://doi.org/10.1007/s11187-008-9157-3.

Acs, Z.J., Audretsch, D.B., Lehmann, E.E., 2013. The knowledge spillover theory of entrepreneurship. Small Bus. Econ. 41 (4), 757–774. https://doi.org/10.1007/s11187-013-9505-9.

Acs, Z.J., Stam, E., Audretsch, D.B., O'Connor, A., 2017. The lineages of the entrepreneurial ecosystem approach. Small Bus. Econ. 49 (1), 1–10. https://doi.org/10.1007/s11187-017-9864-8.

Andersson, M., Karlsson, C., 2007. Knowledge in regional economic growth - the role of knowledge accessibility. Ind. Innov. 14, 129–149. https://doi.org/10.1080/13662710701252450.

Antonelli, C., 2019. The Knowldege Growth Regime. A Schumpetarian Approach. Palgrave, Macmillan, Cham.

Aparicio, S., Urbano, D., Audretsch, D.B., 2016. Institutional factors, opportunity entrepreneurship and economic growth: panel data evidence. Technol. Forecast. Soc. Change 102, 45–61. https://doi.org/10.1016/j.techfore.2015.04.006.

Arrow, K.J., 1962. Economic welfare and the allocation of resources for invention. In: Nelson, R. (Ed.), The Rate and Direction of Inventive Activity. Princeton University Press, Princeton, pp. 609–626.

Audretsch, D.B., 1995. Innovation and Industry Evolution. MIT Press, Cambridge.

Audretsch, D.B., 2007. Entrepreneurship capital and economic growth. Oxf. Rev. Econ. Policy 23 (1), 63–78. https://doi.org/10.1093/oxrep/grm001.

Audretsch, D.B., Belitski, M., 2013. The missing pillar: the creativity theory of knowledge spillover entrepreneurship. Small Bus. Econ. 41 (4), 819–836. https://doi.org/10.1007/s11187-013-9508-6.

Audretsch, D.B., Belitski, M., 2017. Entrepreneurial ecosystems in cities: establishing the framework conditions. J. Technol. Transfer. 42 (5), 1030–1051. https://doi.org/10.1007/s10961-016-9473-8.

Audretsch, D.B., Feldman, M.P., 2004. Knowledge spillovers and the geography of innovation. In: Henderson, J.V., Thisse, J.-F. (Eds.), Handbook of Regional and Urban Economics. Elsevier, Amsterdam, pp. 2713–2739.

Audretsch, D.B., Keilbach, M., 2007. The theory of knowledge spillover entrepreneurship. J. Manag. Stud. 44 (7), 1242–1254. https://doi.org/10.1111/j.1467-6486.2007.00722.x.

Audretsch, D.B., Keilbach, M., 2008. Resolving the knowledge paradox: knowledge spillover entrepreneurship and economic growth. Res. Policy 37 (10), 1697–1705. https://doi.org/10.1016/j.respol.2008.08.008.

Audretsch, D.B., Thurik, R., 2000. Capitalism and democracy in the 21st century: from the managed to the entrepreneurial economy. J. Evol. Econ. 10, 17–34. https://doi.org/10.1007/s001910050003.

Audretsch, D.B., Obschonka, M., Gosling, S.D., Potter, J., 2017. A new perspective on entrepreneurial regions: linking cultural identity with latent and manifest entrepreneurship. Small Bus. Econ. 48 (3), 681–697. https://doi.org/10.1007/s11187-016-9787-9.

Barroso, C., Carrión, G.C., Roldán, J.L., 2010. Applying Maximum Likelihood and PLS on Different Sample Sizes: Studies on SERVQUAL Model and Employee Behavior Model. In: Handbook of Partial Least Squares. Springer Handbooks of Computational Statistics, Springer-Verlag, London, United Kingdom, pp. 427–447.

Beise, M., Stahl, H., 1999. Public research and industrial innovations in Germany. Res. Policy 28, 397–422. https://doi.org/10.1016/S0048-7333(98)00126-7.

Belderbos, R., Carree, M., Lokshin, B., 2006. Complementarity in R&D cooperation strategies. Rev. Ind. Organ. 28 (4), 401–426. https://doi.org/10.1007/s11151-006-9102-z.

Belitski, M., Desai, S., 2016. Creativity, entrepreneurship and economic development: city-level evidence on creativity spillover of entrepreneurship. J. Technol. Transf. 41 (6), 1354–1376. https://doi.org/10.1007/s10961-015-9446-3.

Benitez, J., Henseler, J., Castillo, A., Schuberth, F., 2020. How to perform and report an impactful analysis using partial least squares: Guidelines for confirmatory and explanatory IS research. Inf. Manag. 57, 103168 https://doi.org/10.1016/j.im.2019.05.003.

Bernal, P., Carree, M., Lokshin, B., 2022. Knowledge spillovers, R&D partnerships and innovation performance. Technovation 115, 102456. https://doi.org/10.1016/j.technovation.2022.102456.

Bloom, N., Eifert, B., Mahajan, A., McKenzie, D., Roberts, J., 2013. Does management matter? Evidence from India. Q. J. Econ. 128 (1), 1–51. https://doi.org/10.1093/qje/qjs044.

Boateng, H., Kosiba, J.P.B., Okoe, A.F., 2019. Determinants of consumers' participation in the sharing economy: a social exchange perspective within an emerging economy context. Int. J. Contemp. Hosp. Manag. 31 (2), 718–733. https://doi.org/10.1108/IJCHM-11-2017-0731.

Bode, E., 2004. The spatial pattern of localized R&D spillovers: an empirical investigation for Germany. J. Econ. Geogr. 4, 43–64. https://doi.org/10.1093/jeg/4.1.43.

Braunerhjelm, P., Acs, Z., Audretsch, D.B., Carlsson, B., 2010. The missing link: knowledge diffusion and entrepreneurship in endogenous growth. Small Bus. Econ. 34 (2), 105–125. https://doi.org/10.1007/s11187-009-9235-1.

Breschi, S., Lissoni, F., 2001. Knowledge spillovers and local innovation systems: a critical survey. Ind. Corp. Chang. 10 (4), 975–1005. https://doi.org/10.1093/icc/10.4.975.

Breschi, S., Lissoni, F., Montobbio, F., 2005. The geography of knowledge spillovers: conceptual issues and measurement problems. In: Breschi, S., Malerba, F. (Eds.), Clusters, Networks and Innovation. Oxford University Press, Oxford, New York, pp. 343–378.

Caiazza, R., Belitski, M., Audretsch, D.B., 2020. From latent to emergent entrepreneurship: the knowledge spillover construction circle. J. Technol. Transfer. 45 (3), 694–704. https://doi.org/10.1007/s10961-019-09719-y.

Carree, M.A., Thurik, R., 2003. The impact of entrepreneurship on economic growth. In: Acs, Z., Audretsch, D. (Eds.), Handbook of Entrepreneurship Research. Springer, Boston, pp. 437–471.

Coe, D., Helpman, E., 1995. International R&D spillovers. Eur. Econ. Rev. 39 (5), 859–887. https://doi.org/10.1016/0014-2921(94)00100-E.

Colombelli, A., Quatraro, F., 2019. Green start-ups and local knowledge spillovers from clean and dirty technologies. Small Bus. Econ. 52 (4), 773–792. https://doi.org/10.1007/s11187-017-9934-y.

De Bondt, R., 1997. Spillovers and innovative activities. Int. J. Ind. Organ. 15 (1), 1–28. https://doi.org/10.1016/S0167-7187(96)01023-5.

De Clercq, D., Hessels, J., Van Stel, A., 2008. Knowledge spillovers and new ventures' export orientation. Small Bus. Econ. 31 (3), 283–303. https://doi.org/10.1007/s11187-008-9132-z.

DeSarbo, W.S., 2005. Revisiting the Miles and Snow strategic framework: uncovering interrelationships between strategic types, capabilities, environmental uncertainty, and firm performance. Strateg. Manag. J. 26 (1), 47–74. https://doi.org/10.1002/smj.431.

Dokko, J.M., 2015. Workers and the online gig economy. The Hamilton Project 1–8.

Drnevich, P.L., Croson, D.C., 2013. Information technology and business-level strategy: toward an integrated theoretical perspective. MIS Q. 37 (2), 483–509. https://www.jstor.org/stable/43825920.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? Strateg. Manag. J. 21, 1105–1121. https://doi.org/10.1002/1097-0266.

El-Haddadeh, R., 2020. Digital innovation dynamics influence on organisational adoption: the case of cloud computing services. Inf. Syst. Front. 22 (4), 985–999. https://doi.org/10.1007/s10796-019-09912-2.

Fainshmidt, S., Pezeshkan, A., Lance Frazier, M., Nair, A., Markowski, E., 2016. Dynamic capabilities and organizational performance: a meta-analytic evaluation and extension. J. Manag. Stud. 53 (8), 1348–1380. https://doi.org/10.1111/joms.12213.

Faria, P., Lima, F., 2012. Interdependence and spillovers: is firm performance affected by others' innovation activities? Appl. Econ. 44, 4765–4775. https://doi.org/10.1080/00036846.2011.560108.

Fernandes, C., Ferreira, J., 2014. Knowledge spillovers: cooperation between universities and KIBS. R D Manag. 43 (5), 461–472. https://doi.org/10.1111/radm.12024.

Ferreira, J., Fernandes, C., Ferreira, F., 2020. Wearing failure as a path to innovation. J. Bus. Res. 120, 195–202. https://doi.org/10.1016/j.jbusres.2020.08.006.

Ferreira, J., Fernandes, C., Veiga, P., Dooley, L., 2023. The effects of entrepreneurial ecosystems, knowledge management capabilities and knowledge spillovers on international open innovation. R D Manag. 53 (2), 322–338. https://doi.org/10.1111/radm.12569.

Forliano, C., Orlandi, L.B., Zardini, A., Rossignoli, C., 2023. Technological orientation and organizational resilience to Covid-19: the mediating role of strategy's digital maturity. Technol. Forecast. Soc. Chang. 188, 122288 https://doi.org/10.1016/j.techfore.2022.122288.

Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Mark. Res. 18, 39–50.

Frenken, K., Van Oort, F.G., Verburg, T., 2007. Related variety, unrelated variety and regional economic growth. Reg. Stud. 41 (5), 685–697. https://doi.org/10.1080/00343400601120296.

Funke, M., Niebuhr, A., 2005. Regional geographic research and development spillovers and economic growth: evidence from West Germany. Reg. Stud. 39, 143–153. https://doi.org/10.1080/0034340052000321904.

X., Fu, X., Fu, Ghauri, P., Hou, J., 2023. International collaboration and innovation: Evidence from a leading Chinese multinational enterprise. J. World Bus. 57, 101329.

GEM, 2020. Global Entrepreneurship Monitor 2019/2020 Global Report. Retrieved from: https://www.gemconsortium.org/report/gem-2019-2020-global-report.

Ghio, N., Guerini, M., Lehmann, E.E., Rossi-Lamastra, C., 2015. The emergence of the knowledge spillover theory of entrepreneurship. Small Bus. Econ. 44 (1), 1–18. https://doi.org/10.1007/s11187-014-9588-y.

Goerzen, A., 2007. Alliance networks and firm performance: the impact of repeated partnerships. Strateg. Manag. J. 28 (5), 487–509. https://doi.org/10.1002/smj.588.

Grossman, G.M., Helpman, E., 1991. Innovation and Growth in the Global Economy. MIT Press, Cambridge.

Hair, J.F., Risher, J.J., Sarstedt, M., Ringle, C.M., 2019. When to use and how to report the results of PLS-SEM. Eur. Bus. Rev. 31, 2–24. https://doi.org/10.1108/EBR-11-2018-0203.

Hair, J.F., Howard, M.C., Nitzl, C., 2020. Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. J. Bus. Res. 109, 101–110. https://doi.org/10.1016/j.jbusres.2019.11.069.

Hashi, I., Stojcic, N., 2012. The impact of innovation activities on firm performance using a multi-stage model: evidence from the community innovation survey 4. Res. Policy 42 (2), 353–366. https://doi.org/10.1016/j.respol.2012.09.011.

Heredia, J., Castillo Vergara, M., Geldes, C., Gamarra, M., Flores, A., Heredia, W., 2022. How do digital capabilities affect firm performance? The mediating role of technological capabilities in the "new normal". J. Innov. Knowl. 7 (2), 100171 https://doi.org/10.1016/j.jik.2022.100171.

Holloway, S.S., Parmigiani, A., 2016. Friends and profits don't mix: the performance implications of repeated partnerships. Acad. Manag. J. 59 (2), 460–478. https://doi.org/10.5465/amj.2013.0581.

Iftikhar, M.N., Ahmad, M., Audretsch, D.B., 2020. The knowledge spillover theory of entrepreneurship: the developing country context. Int. Entrep. Manag. J. 16 (4), 1327–3146. https://doi.org/10.1007/s11365-020-00667-w.

Jaffe, A., Trajtenberg, M., Henderson, R., 1993. Geographical localization of knowledge spillovers as evidenced by patent citations. Q. J. Econ. 108 (3), 577–599. https://doi.org/10.2307/2118401.

Karimi, J., Walter, Z., 2015. The role of dynamic capabilities in responding to digital disruption: a factor-based study of the newspaper industry. J. Manag. Inf. Syst. 32 (1), 39–81. https://doi.org/10.1080/07421222.2015.1029380.

Kneller, R., Pisu, M., 2007. Industrial linkages and export spillovers from FDI. World Econ. 30 (1), 105–134. https://doi.org/10.1111/j.1467-9701.2007.00874.x.

Lattacher, W., Gregori, P., Holzmann, P., Schwarz, E.J., 2021. Knowledge spillover in entrepreneurial emergence: a learning perspective. Technol. Forecast. Soc. Chang. 166, 120660 https://doi.org/10.1016/j.techfore.2021.120660.

Lee, I.H., Hong, E., Sun, L., 2013. Regional knowledge production and entrepreneurial firm creation: spatial dynamic analyses. J. Bus. Res. 66 (10), 2106–2115. https://doi.org/10.1016/j.jbusres.2013.02.037.

Leung, T.Y., Sharma, P., Adithipyangkul, P., Hosie, P., 2020. Gender equity and public health outcomes: the COVID-19 experience. J. Bus. Res. 116, 193–198. https://doi.org/10.1016/j.jbusres.2020.05.031.

Loureiro, R., Ferreira, J.J., Simões, J., 2021. Approaches to measuring dynamic capabilities: theoretical insights and the research agenda. J. Eng. Technol. Manag. 62, 101657 https://doi.org/10.1016/j.jengtecman.2021.101657.

Lyytinen, K., Yoo, Y., Boland Jr., R.J., 2016. Digital product innovation within four classes of innovation networks. Inf. Syst. J. 26 (1), 47–75. https://doi.org/10.1111/isj.12093.

Malhotra, A., Mathur, A., Diddi, S., Sagar, A.D., 2021. Building institutional capacity for addressing climate and sustainable development goals: achieving energy efficiency in India. Clim. Pol. 1–19 https://doi.org/10.1080/14693062.2021.1984195.

Martínez-Caro, E., Cegarra-Navarro, J.G., Alfonso-Ruiz, F.J., 2020. Digital technologies and firm performance: the role of digital organisational culture. Technol. Forecast. Soc. Chang. 154, 119962 https://doi.org/10.1016/j.techfore.2020.119962.

Nonaka, I., 1994. A dynamic theory of organizational knowledge creation. Organ. Sci. 5 (1), 14–37. https://doi.org/10.1287/orsc.5.1.14.

Ornaghi, C., 2006. Spillovers in product and process innovation: evidence from manufacturing firms. Int. J. Ind. Organ. 24, 349–380. https://doi.org/10.1016/j.ijindorg.2005.07.002.

Petraite, M., Mubarak, M.F., Rimantas, R., Von Zedtwitz, M., 2022. The role of international networks in upgrading national innovation systems. Technol. Forecast. Soc. Chang. 184, 121873 https://doi.org/10.1016/j.techfore.2022.121873.

Proeger, T., 2020. Knowledge spillovers and absorptive capacity—institutional evidence from the German mittelstand. J. Knowl. Econ. 11 (1), 211–238. https://doi.org/10.1007/s13132-018-0539-8.

Ramadani, V., Abazi-Alili, H., Dana, L.-P., Rexhepi, G., Ibraimi, S., 2016. The impact of knowledge spillovers and innovation on firm-performance: findings from the Balkans countries. Int. Entrep. Manag. J. 13 (1), 299–325. https://doi.org/10.1007/s11365-016-0393-8.

Ringle, C.M., Wende, S., Becker, J.M., 2022. SmartPLS 4.

Rod, F., Neil, F., David, G., 2004. Imports, exports, knowledge spillovers and growth. Econ. Lett. 85 (2), 209–221. https://doi.org/10.1016/j.econlet.2004.04.007.

Rodríguez-Pose, A., Crescenzi, R., 2008. Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe. Reg. Stud. 42 (1), 51–67. https://doi.org/10.1080/00343400701654186.

Romer, P.M., 1986. Increasing returns and long-run growth. J. Polit. Econ. 94 (5), 1002–1037. https://www.jstor.org/stable/1833190.

Romer, P.M., 1990. Endogenous technological change. J. Polit. Econ. 98 (5), 71–102. https://www.jstor.org/stable/2937632.

Rubio-Andrés, M., del Mar Ramos-González, M., Sastre-Castillo, M.Á., Gutiérrez-Broncano, S., 2023. Stakeholder pressure and innovation capacity of SMEs in the COVID-19 pandemic: mediating and multigroup analysis. Technol. Forecast. Soc. Chang. 190, 122432 https://doi.org/10.1016/j.techfore.2023.122432.

Saito, H., Gopinath, M., 2011. Knowledge spillovers, absorptive capacity, and skill intensity of Chilean manufacturing plants. J. Reg. Sci. 51 (1), 83–101. https://doi.org/10.1111/j.1467-9787.2010.00677.x.

Sanchez, M.A., Ortiz-de-Urbina-Criado, M., Mora-Valentin, M.E., 2011. Effects of knowledge spillovers on innovation and collaboration in science and technology parks. J. Knowl. Manag. 15 (6), 948–970. https://doi.org/10.1108/13673271111179307.

Santos, E., Fernandes, C., Ferreira, J., 2020. The moderating effects of economic development on innovation and shadow entrepreneurship: grey or pink? R D Manag. 50 (5), 599–613. https://doi.org/10.1111/radm.12404.

Sarstedt, M., Hair, J.F., Cheah, J.H., Becker, J.M., Ringle, C.M., 2019. How to specify, estimate, and validate higher-order constructs in PLS-SEM. Australas. Mark. J. 27, 197–211. https://doi.org/10.1016/j.ausmj.2019.05.003.

Schmidt, S., 2015. Balancing the spatial localisation 'tilt': knowledge spillovers in processes of knowledge-intensive services. Geoforum 65, 374–386. https://doi.org/10.1016/j.geoforum.2015.05.009.

Shu, C., Liu, C., Gao, S., Shanley, M., 2014. The knowledge spillovers theory of entrepreneurship in alliances. Entrep. Theory Pract. 38 (4), 913–940.

Srivastava, S.C., Shainesh, G., 2015. Bridging the service divide through digitally enabled service innovations. MIS Q. 39 (1), 245–268. https://doi.org/10.25300/MISQ/2015/39.1.11.

Sutherland, W., 2018. The sharing economy and digital platforms: a review and research agenda. Int. J. Inf. Manag. 43, 328–341. https://doi.org/10.1016/j.ijinfomgt.2018.07.004.

Usai, A., Fiano, F., Petruzzelli, A.M., Paoloni, P., Briamonte, M.F., Orlando, B., 2021. Unveiling the impact of the adoption of digital technologies on firms' innovation performance. J. Bus. Res. 133, 327–336. https://doi.org/10.1016/j.jbusres.2021.04.035.

Van Stel, A., Carree, M., Thurik, R., 2005. The effect of entrepreneurial activity on national economic growth. Small Bus. Econ. 24 (3), 311–321. https://doi.org/10.1007/s11187-005-1996-6.

Venkatesh, V., Thong, J.Y., Xu, X., 2012. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Q. 36 (1), 157–178. https://doi.org/10.2307/41410412.

Wang, C.L., 2007. Dynamic capabilities: a review and research agenda. Int. J. Manag. Rev. 9 (1), 31–51. https://doi.org/10.1111/j.1468-2370.2007.00201.x.

Wichaisri, S., Sopadang, A., 2017. Integrating sustainable development, lean, and logistics concepts into a lean sustainable logistics model. Int. J. Logist. Syst. Manag. 26, 85–104. https://doi.org/10.1504/IJLSM.2017.080631.

Yi, L., Wang, Y., Upadhaya, B., Zhao, S., Yin, Y., 2021. Knowledge spillover, knowledge management capabilities, and innovation among returnee entrepreneurial firms in emerging markets: does entrepreneurial ecosystem matter? J. Bus. Res. 130, 283–294. https://doi.org/10.1016/j.jbusres.2021.03.

Yoo, Y., Boland Jr., R.J., Lyytinen, K., Majchrzak, A., 2012. Organizing for innovation in the digitized world. Organ. Sci. 23 (5), 1398–1408. https://www.jstor.org/stable/23252314.

Youssef, A., Boubaker, S., Omri, A., 2018. Entrepreneurship and sustainability: the need for innovative and institutional solutions. Technol. Forecast. Soc. Chang. 129, 232–241. https://doi.org/10.1016/j.techfore.2017.11.00.

Zhen, Z., Yousaf, Z., Radulescu, M., Yasir, M., 2021. Nexus of digital organizational culture, capabilities, organizational readiness, and innovation: investigation of SMEs operating in the digital economy. Sustainability 13 (2), 720. https://doi.org/10.3390/su13020720.

João J.M. Ferreira is Associate Professor w/Habilitation at the University of Beira Interior (UBI), Portugal. He holds a PhD in Entrepreneurship and Small Business Management from the Autonomous University of Barcelona (UAB), Spain. He has coordinated the UBI Research Unit for Business Sciences (NECE), Portugal. He has edited or co-edited several books on innovation and entrepreneurship and published over 200 papers in premier international journals, including *IEEE Transactions on Engineering Management*, *Technological Forecasting & Social Change*, *Journal of Business Research*, *Journal of Cleaner Production*, *Management Decision*, and *Service Business*. He is Senior Editor of *Journal of Small Business and Enterprise Development* and Associate Editor of *Management Decision*, and his research interests include strategy, competitiveness and entrepreneurship.

Cristina Fernandes is Assistant Professor w/Habilitation at the University of Beira Interior (UBI), Portugal. She holds a PhD in Management from the University of Beira Interior. She is researcher at the NECE – Research Centre for Studies in Business Sciences at the University of Beira Interior and Centre for Corporate Entrepreneurship and Innovation at Loughborough University, UK. She is part of the editorial board of Management Decision; has several dozen scientific articles published in international journals, including Journal of Technology Transfer, Journal of Knowledge Management, R&D Management, and Journal of Business Research. Actively, she participates in scientific meetings and international conferences on these topics, having been distinguished several times with awards for best article, and she has participated in several international projects.

Pedro Mota Veiga is graduated in Probabilities and Statistics (University of Lisbon, Portugal), and he holds a PhD in Management (University of Beira Interior, Portugal) and post-graduation in Applied Economics (University of Coimbra, Portugal). He is Assistant Professor at Polytechnic Institute of Viseu and University of Beira Interior where he teaches subjects in Marketing and Management. Currently, he is the scientific coordinator of the Entrepreneurship, Competitiveness and Innovation research line of the research center NECE - Center for Studies in Business Sciences at the University of Beira Interior. His research is focused on Competitiveness, Strategy, Marketing, Innovation, Entrepreneurship, Knowledge Management and Quantitative Methods. He has published several articles in international journals and book chapters and he works as consultant for several organisations.