University and Industry Collaboration in the Era of Smart Specialisation: Empirical Research on Sustainable Knowledge Transfer

Carla Mascarenhas[1], Anderson Galvão[2], Telma Mendes[3], Carla Marques[4] and João Ferreira[5]
[1]Centre for Transdisciplinary Development Studies (CETRAD) and University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[2]CETRAD and UTAD, Vila Real, Portugal; School of Technology and Management (ESTG), Polytechnic Institute of Porto (P. Porto), Porto, Portugal
[3]Centre for Research and Innovation in Business Sciences and Information Systems (CIICESI), ESTG, P. Porto, Porto, Portugal; University of Vigo, Vigo, Spain
[4]CETRAD and UTAD, Vila Real, Portugal
[5]Research Centre for Business Science (NECE) and University of Beira Interior, Covilhã, Portugal
carlam@utad.pt
anderson@utad.pt
tilm@estg.ipp.pt
smarques@utad.pt
jjmf@ubi.pt

Abstract: The coronavirus disease-19 pandemic has forced universities worldwide to develop stronger crisis responses in order to support the surrounding communities more effectively. These solutions are based on collaborations between higher education institutions and industries that facilitate knowledge co-creation. Historically, universities have been knowledge-intensive institutions capable of producing additional findings through research. Currently, these organisations' most important contributions to national economies are related to universities' development of fresh knowledge and technical expertise. In parallel, all industries' business environments have become extremely dynamic, which requires companies to focus on new solutions, rapid development and cost efficiency. To cope with these pressures, industries have been forced to search for new partners, so university-industry collaboration (UIC) has become a key resource for managers seeking to promote innovation and technological development. This study explored the relationship between research and innovation based on smart specialisation strategies and UIC, including the roles of university-industry (U-I) joint research and academics' motivations for interacting with industries. Based on data collected from 841 Portuguese and Spanish researchers, the results reveal that smart specialisation policies' effects on UIC are driven by U-I joint research development and university faculty members' motivations for co-operating with industry professionals. The findings indicate that U-I research activities and universities' incentives to collaborate with industries fully convert smart specialisation strategies' effects into higher levels of U-I knowledge transfer.

Keywords: university-industry (U-I) collaboration; knowledge transfer; smart specialisation strategies; motivation; U-I joint research

1. Introduction

Previous studies of innovation management have highlighted innovation processes' potential in terms of recombination, co-creation and path dependence (Porter, 1998). These findings have led researchers to construct complex theories that seek to explain the triple helix model of government-industry-university collaboration and these ecosystems' importance to successful innovation and economic growth (Geels, 2002). Policymakers have started to develop policies and programmes based on this research, such as Europe's smart specialisation strategies and Canada's Innovation Superclusters Initiative (Aksoy *et al*., 2022). However, the literature on this topic suggests that these new policies still lack a solid foundation in empirical research, with strategies sometimes formulated based on purely anecdotal evidence (Balland *et al*., 2019).

Every country has felt the coronavirus disease-19 pandemic's impacts to a greater or lesser extent, and organisations must deal with complex situations generated by collateral events that threaten each nation's prosperity and long-term survival (Terán-Bustamonte *et al.*, 2021). Industries by nature are adaptative and evolutionary, but this crisis is unprecedented. Firms must thus seek alternative solutions that increase their innovativeness and competitiveness. One possible strategy is to form links with universities and the wide range of services that they offer (Boardman and Ponomariov, 2009). The literature has highlighted this type of co-operation's benefits, including positive effects on the relevant universities' competitiveness and productivity (Teixeira *et al*., 2019).

In this context, university-industry collaboration (UIC) is defined as any activity involving interactions between academic and industry professionals (Ankrah *et al*., 2013; Chedid *et al*., 2020). UIC's main purpose is to create and share knowledge (Daria and Kostiantyn, 2018) that offers significant benefits to research team members, the organisations involved and thus the surrounding societies (Boyarchuk *et al*., 2018). UIC relies heavily on knowledge sharing and management practices (Philbin, 2008), which provide mechanisms that help professionals create, capture, analyse and act on knowledge (Chedid *et al*., 2020). Universities and industries with a broad knowledge base offer better conditions that meet their researchers' needs and foster stronger collaborations (Daria and Kostiantyn, 2018).

Although the existing literature indicates that UIC is an important research topic, few studies have focused on knowledge management in UIC (Hansen *et al*., 2017; Teixeira *et al*., 2019). In addition, a gap exists in terms of research that clarifies the link between UIC and the process of smart specialisation strategy development (Bukhari *et al*., 2021). Understanding how these collaborations can best be conducted has become extremely important because successful co-operation is essential to ensure not only UIC's viability but also its sustainability (Roncancio-Marin *et al*., 2022).

The present study thus explored the ways in which smart specialisation strategies influence UIC while taking into consideration university-industry (U-I) joint research and academics' motivations for interacting with industries. The remainder of this paper is organised as follows. Section two briefly characterises smart specialisation strategies and then discusses topics related to UIC and knowledge transfer. Section three introduces the data collection and analysis methodology used. The results are covered by section four, and section five provides the conclusions drawn and suggestions for future research.

2. Theoretical Background

The European Commission recognises smart specialisation strategies' value as a way to reduce developmental differences between European Union (EU) regions. In 2011, the European Commission established a platform to monitor smart growth development and provide regional information, methods and expertise to national and local decision makers (Bukhari *et al*., 2021). Smart specialisation initiatives also seek to enable regions to foster growth in specific areas in order to exploit their competitive advantages, generate jobs, support academia and businesses and develop long-term strategies supported by entrepreneurial universities (McCann *et al.*, 2012).

Smart specialisation strategies appear to be directly related to UIC's ability to address increased environmental constraints and gaps in institutions and industries, thereby helping regional clusters find better positions in global value chains (Bukhari *et al*., 2021). Universities' mission is no longer limited to research and training but instead incorporates a third mission: contributing to the surrounding regions' economic growth (Terán-Bustamonte and Colla-De-Robutis, 2018; Rasmussen and Wright, 2015). Smart specialisation has become one of the most common approaches to innovation policies seeking to encourage entrepreneurial universities, regions and countries' growth (Bukhari *et al*., 2021). Based on research and knowledge development, smart specialisation strategies seek to integrate knowledge, technology and production networks (Radosevic and Stancova, 2018; Ling, 2020).

Bukhari *et al*. (2021) report that smart specialisation innovation policies are perceived as supporting and enhancing regional UIC. This effect is achieved by linking universities with industries since weak connections create barriers for entrepreneurial universities. Bukhari *et al*. (2021) also point out that higher education institutions perceive smart specialisation strategies as positive but only if they take into consideration at least some of researchers' motivations. Based on these finding, the present study's first hypothesis was formulated as follows:
H1. *Smart specialisation strategies have a positive effect on UIC.*

UIC is defined as a relationship involving exchange and cooperation that allows universities to advance in terms of scientific and academic research and industries to exchange technological developments and solve specific problems (Terán-Bustamonte *et al*., 2021). This approach appears to be directly related to the push for specialisation and technological contiguity that is at the heart of debates regarding European smart specialisation policies (Aksoy *et al*., 2022), namely, universities' contribution to economic and social development through teaching, research and entrepreneurial activities (Qiu *et al*., 2017). European universities have experienced cuts in long-term research funding, so smart specialisation strategies can also function as an alternative source of funds and additional incentives for UIC (Marinelli and Elena-Perez, 2017).

According to Ankrah and Al-Tabbaa (2015), UIC's interaction channels can be classified into six categories of which the first is knowledge exchange (e.g. publications, conferences and informal contacts). The second is research and development (R&D) projects (e.g. contract R&D, consulting, and joint R&D). The third is licenses and patents, while the fourth category is business (e.g. purchase of prototypes developed by scientists, creation of physical facilities and university spin-offs. The fifth is training (e.g. supervision of doctoral and masters theses), and the last is human resources (e.g. personal mobility and recent graduates' job placement). Given universities and companies' intensive reliance on knowledge, UIC requires the integration of specialised knowledge (Chedid *et al*., 2020) and smart specialisation frameworks characterised by entrepreneurial opportunities that identify how that knowledge can be applied (Bukhari *et al*., 2021). The current research thus included two more hypotheses:
H2. *Smart specialisation strategies have a positive impact on U-I joint research development.*
H3. *Smart specialisation strategies have a positively effect on academics' motivations for interacting with industries.*

U-I knowledge transfer is a complex iterative process (Aksoy *et al*., 2022). Various authors (e.g. Llopis *et al*., 2018; Centobelli *et al*., 2019) have observed that academic researchers participate in UIC to earn more recognition from their peers or ensure findings are actually applied to real problems. Other studies of industries' motivations (e.g. Fischer *et al*., 2018; Soetanto and van Geenhuizen, 2019) have found that companies seek financial returns through private appropriations of knowledge (i.e. patents and licenses), purchases of university spin-offs or the establishment of joint laboratories. However, knowledge and technology transfer between these two heterogenous actors can be challenging to achieve (Roncancio-Marin *et al*., 2022).

Research on UIC has revealed that individuals' diverse reasons for engaging in collaboration activities depend on whether the relevant professionals are employed by academia or an industry (Perkmann *et al*., 2021). Motivations common to both industry and university staff include responses to institutional policies, financial gain, human capital development, greater efficiency, an improved institutional image, intentions to buy or sell research results and expanded personal contacts (Cunningham and Menter, 2020; Perkmann *et al*., 2021). University faculty are specifically motivated by their institutions' need for social legitimacy, researchers' quest for recognition and a good reputation and academia's dedication to a third mission, that is, contributing to economic growth (Breznitz *et al*., 2008). In general, UIC has focused on outcomes that generate financial benefits for all parties involved (Roncancio-Marin *et al*., 2022). Based on the above findings, the present study's next two hypotheses postulated that:
H4. *U-I joint research development has a positive impact on UIC.*
H5. *Academics' motivation for interacting with industries has a positive effect on UIC.*

At an individual level, researchers' age remains controversial as an explanation for academics' engagement in UIC (Perkmann *et al*., 2021). Abreu and Grinevich (2013) detected a positive relationship between these two variables in their United Kingdom study, but Lawson *et al*. (2019) report a non-linear effect, with the youngest and oldest academic researchers participating less in these projects than middle aged faculty. In addition, Iorio *et al*.'s (2017) study produced evidence for age's non-significant effect in an Italian context, while various scholars (e.g. D'Este and Patel, 2007; Jensen *et al.*, 2008; Giuliani *et al*., 2010) have found a negative link between researchers' age and academic engagement. Another set of studies also confirmed that younger academics focus on publishing articles and neglect UIC (Zhou *et al*., 2016). Older researchers, in contrast, are more involved in UIC, prioritising funded research in order to produce relevant scientific knowledge (McNally, 2010; Betsey, 2017). Overall, UIC is thought to be strongly associated with researchers' age, gender, prior work experience and academic rank (D'Este and Perkmann, 2011; Perkmann *et al*., 2021). Given the existing research, the current study's last two hypotheses were as follows:
H6. *Researchers' age has a positive impact on U-I joint research development.*
H7. *Researchers' age has a negative effect on UIC.*

The seven hypotheses defined were incorporated into the research model (see Figure 1).

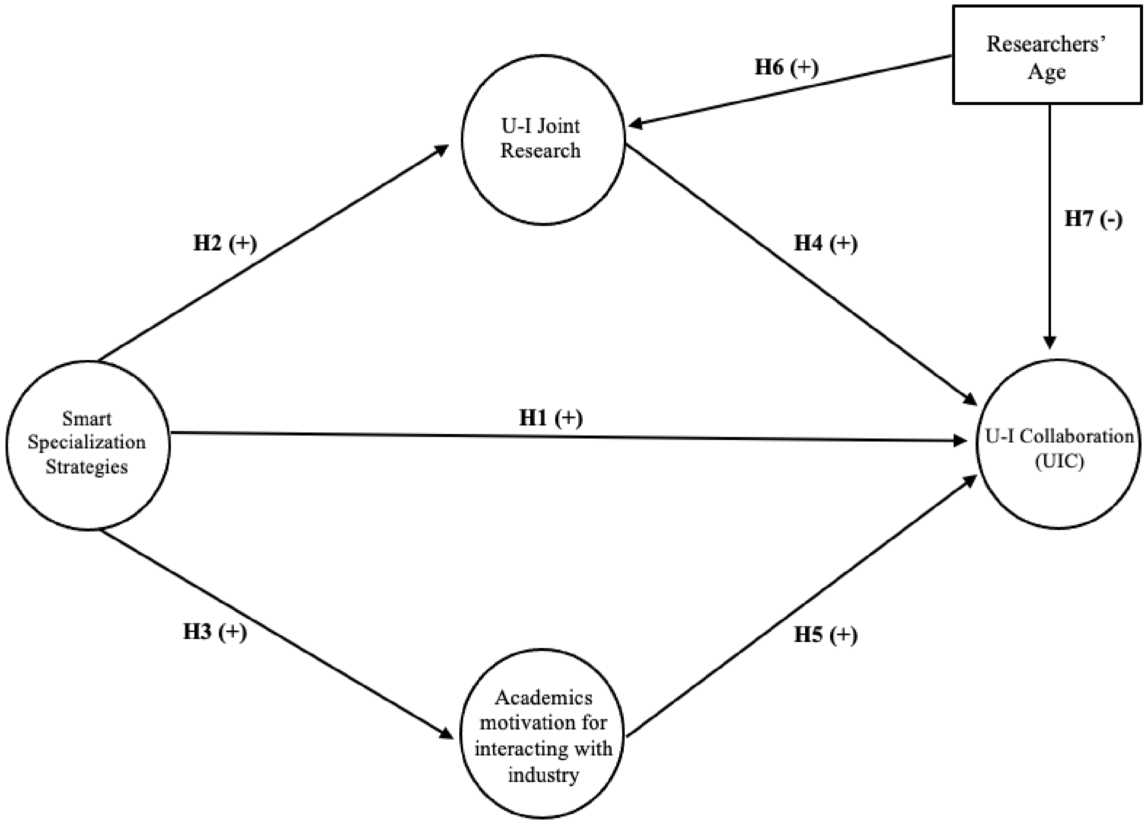

Figure 1: Research Model

3. Methodology

3.1 Data Collection and Sample

To achieve the pre-defined objectives, data were collected via a large-scale survey of selected universities to obtain information on their faculty members' interactions with industries. The questionnaire was administered to academics working in research centres or units of public universities in the North region of Portugal and Castile and Leon region of Spain. The survey was distributed to 4,095 researchers – 1,990 Portuguese and 2,105 Spanish – between March 2018 and March 2019. By the end of the data collection period, the sample included 841 academics – 464 Spanish and 377 Portuguese (response rate = 20.5%).

The latent variable model was tested using SmartPLS v3.3.3 software (Ringle *et al*., 2015). Partial least squares (PLS) structural equation modelling (SEM) is widely viewed as a valid alternative to Jöreskog's (1973) covariance-based (CB) SEM, which is limited by restrictive assumptions. CB-SEM is usually conducted with the help of software packages as LISREL and AMOS in order to develop a covariance matrix of the data and estimate model parameters while only considering common variance. In contrast, PLS-SEM uses data's total variance to estimate models (Hair *et al*., 2017). As suggested by Hair *et al*. (2019), the current research conducted PLS-SEM primarily because, first, the analyses focused on developing a theoretical framework that would allow predictions to be made. Second, the structural model was complex as it included multiple constructs. Third, distribution issues, such as lack of normality,[1] were a concern, and, last, the present research's primary objective was to understand more fully UIC's increasing complexity by exploring extensions of established theories (i.e. exploratory research to develop theory).

3.2 Variables

3.2.1 Dependent Variable

The target variable was UIC. The respondents were asked to indicate how important various benefits of UIC were to them during the four calendar years from 2014 to 2017, using a 5-point Likert scale ranging from 1 ('Not important') to 5 ('Extremely important'). The questionnaire included a scale developed by Azagra-Caro *et al.*

(2006) that contained 12 items: (1) formation of long-term relationships with industries, (2) better understanding of industry problems, (3) ideas for new products or processes, (4) generation of patents, (5) creation of new equipment or instruments including software, (6) development of new and/or improved research procedures or techniques, (7) problem-solving assistance, (8) joint publications, (9) industrial internships for students, (10) commercialisation of products or technologies, (11) funding for research and (12) graduate student training.

3.2.2 Independent Variables

The explanatory variables were academics' motivations for interacting with industries, U-I joint research, smart specialisation strategies and researchers' age. Faculty members' motivations to engage with industry professionals were determined based on the respondents' responses to the following item: 'Please rank the following reasons for your involvement with industries according to their importance.' The researchers surveyed scored each item's importance on a 5-point Likert scale ranging from 1 ('Not important') to 5 ('Extremely important'). The scale was taken from D'Este and Perkmann's (2011) work, including 11 indicators: (1) research income from industry projects, (2) research income from government funds, (3) information on industry problems, (4) knowledge of industry research, (5) feedback from industry professionals, (6) research applicability, (7) membership in networks, (8) use of materials, (9) access to research expertise, (10) use of equipment and (11) intellectual property rights.

U-I joint research, in turn, was assessed by asking respondents this question: 'How frequently did you engage in the following activities in the four calendar years from 2014 to 2017?' The researchers surveyed were given a choice of 5 intervals: 0 times, 1–2 times, 3–5 times, 6–9 times and 10 times or more. This scale was also based on D'Este and Perkmann's (2011) study. The responses were coded with values ranging from 0 (i.e. the researcher was not involved in any type of activity) to 4 (i.e. the researcher participated 10 times or more in U-I projects).

Smart specialisation strategies were measured by three items (i.e. (1) 'Are you familiar with smart specialisation?' (2) 'Are you familiar with smart specialisation strategic priorities in your region?' and (3) 'Please rank how strongly you agree with the following statements.'). This scale was derived from previous studies (e.g. Capello and Kroll, 2016; Foray, 2017). The responses were coded as follows. Items 1 and 2 were translated as dummy variables (1 = yes vs 0 = no). Item 3 used a 5-point Likert scale ranging from 1 ('Totally disagree') to 5 ('Totally agree'). Finally, the respondents' age was quantified as how old each academic was on his or her last birthday (D'Este and Patel, 2007; Giuliani *et al*., 2010).

4. Results

As recommended by Sarstedt *et al*. (2017), the present analyses included assessing the model's internal consistency reliability and convergent and discriminant validity (see Table 1). The Cronbach's alpha (CA), composite reliability and average variance extracted (AVE) values exceed the established thresholds of 0.70, 0.70 and 0.50, respectively (Fornell and Larcker, 1981; Hair *et al*., 2019). Only academics' motivations for interacting with industries has a CA closer to 0.70, but the value is still acceptable (Hair *et al*., 2019). To confirm discriminant validity, the correlations between each pair of constructs were checked to ensure the values did not exceed the square root of AVE for each construct (Fornell and Larcker, 1981). The heterotrait-monotrait ratio of correlations' values are also lower than 0.85 (Henseler *et al*., 2015). The current results thus indicate that the measurement models' have adequate internal consistency reliability and convergent and discriminant validity.

Table 1: Evaluation of Reflective Measurement Models[2]

Constructs	Number of Items	AVE	CR	CA
Smart Specialisation Strategies	2	0.774	0.873	0.710
UIC	9	0.676	0.949	0.940
Academics' motivations for interacting with industries	2	0.752	0.858	0.670

Note: AVE = Average variance extracted; CR = composite reliability; CA = Cronbach's alpha.

To assess the structural model's soundness, analyses were carried out to detect any collinearity issues by examining the inner variance inflation factor (VIF) values. All the VIF values are below to the recommended cut-off value of 5 (Hair *et al*., 2019), so multicollinearity is not a problem according to the partial regressions conducted. The path coefficients range between –0.132 and 0.338, with different statistical significance levels.

In addition, the explained variance (R^2) values for UIC and U-I joint research are, respectively, 15.9% and 9.5%. The effect size (f^2) further complements the R^2-based assessment, which focuses on determining exogenous variables' relative impact on endogenous constructs based on changes in R^2 values (Cohen, 1988). According to the latter cited author, f^2 values of 0.02, 0.15 and 0.35 represent small, medium and large predictor variable effects, respectively. Higher f^2 values were obtained for the relationships between academics' motivations for interacting with industries and UIC (0.127) and between smart specialisation strategies and U-I joint research (0.105).

5. Discussion

The present findings support most of the pre-defined research hypotheses (see Table 2 and Figure 2). The results for H2 and H3 confirm that smart specialisation strategies have a positive relationship with U-I joint research development (H2: beta value [β] = 0.309; p < 0.001) and with academics' motivations for interacting with industries (H3: β = 0.171; p < 0.001). The outcomes also reveal that smart specialisation strategies' impact on UIC is fully mediated by U-I joint research and academics' motivations. In other words, smart specialisation strategies' direct effect on UIC is not statistically significant, so H1 was not confirmed (H1: β = –0,001; p = 0.494). The findings also suggest that U-I joint research development and academics' motivations for engaging with industries are responsible for smart specialisation strategies' effect on UIC. The evidence produced by this empirical research thus supports the assumption that, when smart specialisation strategies are properly implemented, they facilitate knowledge and technology transfer between universities and industries (e.g. Paiva *et al*., 2020).

Table 2: Evaluation of Structural Model

Direct Effects	R^2	f^2	f^2 Value	β	p-value	Hypothesis Supported?
U-I joint research → UIC	0.159	0.007	–	0.083 (2.432*)	< 0.010	Yes
Researchers' age → UIC		0.020	Small	–0.132 (4.460***)	< 0.001	Yes
Academics' motivations for interacting with industries → UIC		0.127	Small	0.338 (9.308***)	< 0.001	Yes
Smart specialisation strategies → UIC		< 0.001	–	–0.001 (0.015 ^{ns})	0.494	No
Researchers' age → U-I joint research	0.095	< 0.001	–	0.016 (0.472 ^{ns})	0.319	No
Smart specialisation strategies → U-I joint research		0.105	Small	0.309 (9.774***)	< 0.001	Yes
Smart specialisation strategies → Academics' motivations for interacting with industries	0.029	0.030	Small	0.171 (5.323***)	< 0.001	Yes

Indirect Effects	β	p-value	Mediating Effect?
Smart specialisation strategies → U-I joint research → UIC	0.026 (2.298 $^{+}$)	< 0.050	Yes
Smart specialisation strategies → Academics' motivations for interacting with industries → UIC	0.058 (4.843***)	< 0.001	Yes

Note: R^2 = endogenous variables' explained variance; f^2 = effect size; β = beta value; path coefficients' significance: ^{ns} = not significant, $^{+}$ p < 0.05; * p < 0.01; ** p < 0.005; *** p < 0.001; values in parentheses represent t-values; t-value thresholds for one-tailed test with alpha = 0.05 and 5,000 resamples: t(0.05; 4,999) = 1.645; t(0.01, 4,999) = 2.327; t(0.005, 4,999) = 2.576; t(0.001; 4,999) = 3.091.

The results for H4 show that a positive relationship exists between U-I joint research and UIC (H4: β = 0.083; p < 0.01). The development of research activities, therefore, contributes to greater collaboration between these two types of organisations since these projects are related to researchers' role in knowledge transfer activities that help industries deal with dynamic markets' challenges (D'Este and Patel, 2007). H5 was also confirmed because a positive relationship exists between academics' motivations for interacting with industries and UIC (H5: β = 0.338; p < 0.001). This finding shows that researchers who receive incentives for collaborating with industry professionals (e.g. shares in royalties and spin-offs) increase their U-I activities, which corroborates D'Este and Perkmann's (2011) results.

The results for H7 included a negative standardised coefficient between researchers' age and their UIC (H7: β = –0.132; p < 0.001), suggesting that being older is inversely proportional to knowledge transfer to industries (i.e. UIC). Various other authors have reached this conclusion, such as D'Estel and Patel (2007), Jensen *et al*. (2008)

and Giuliani *et al*. (2010). Finally, the relationship between researchers' age and their development of U-I joint research is not statically significant (H6: β = 0.016; p = 0.319).

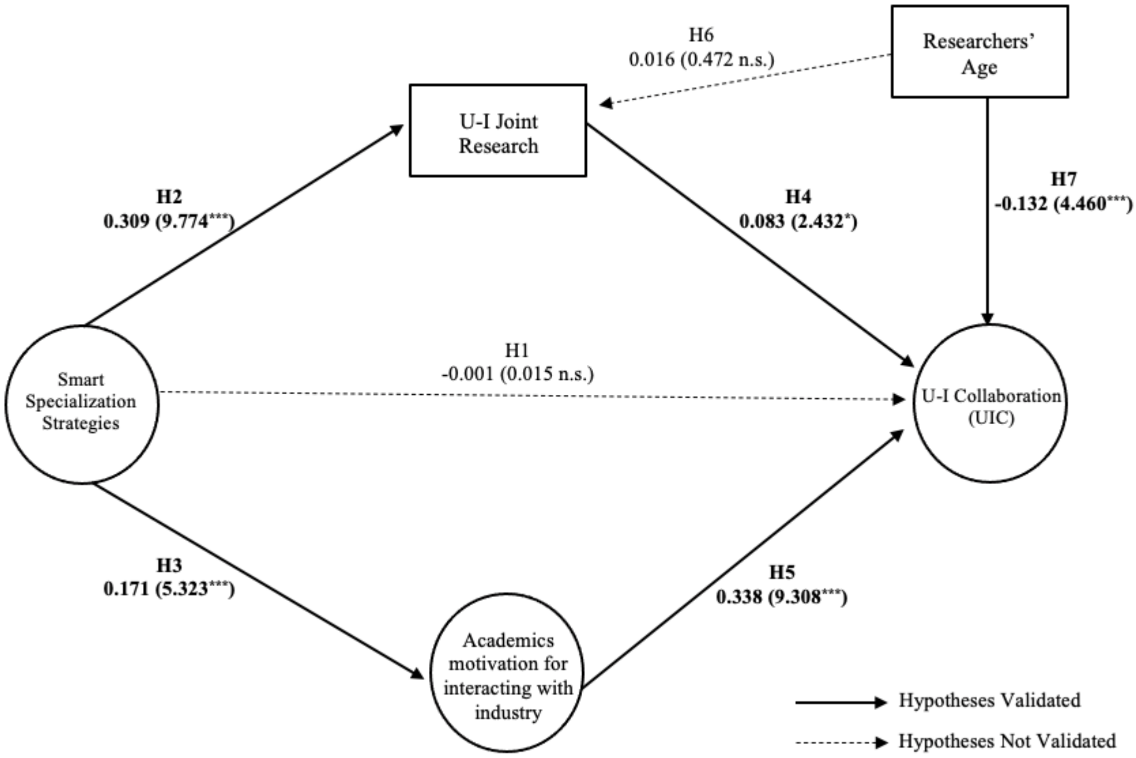

Figure 2: Path Analysis (Number = 841)

6. Conclusion

The present study's findings contribute to a better understanding of the relationship between UIC and smart specialisation strategies that seek to promote research and innovation, including clarifying the role played by U-I joint research and academics' motivations for interacting with industries. UIC offers multiple benefits for both parties. This collaboration allows firms to find solutions for most problems because universities offer a wide range of knowledge derived from different scientific fields, specialists and training programmes. Higher education institutions can also get involved with specialised professionals and industries' real world projects, which in turn support faculty members' research and educational endeavours.

These results have theoretical implications including that universities need to define more clearly their policies towards engagement with industries. Well-defined strategies could encourage internal and external collaboration by establishing institutional channels that facilitate relevant communication between universities and companies. In this way, academia will create a more favourable environment for collaborations that can provide holistic forms of support.

From a managerial perspective, the present findings can help U-I managers define strategies and develop future initiatives that promote an organisational culture based on sustainable knowledge transfer. This approach is extremely important given the emergence of local schemes such as smart specialisation and superclusters. In addition to investment policies that leverage UIC, smart specialisation policies need to be improved. UIC depends heavily on community funding, so fund managers should focus more closely on smart specialisation to strengthen the links between universities and industries. Smart specialisation strategies must become more inclusive, identifying the right priorities for UIC so that all the relevant stakeholders can get involved (i.e. universities, industries, governments and societies).

Regional policymakers should also support financial boundary spanners, for example, by creating science parks and prototyping facilities, so that full use can be made of universities as valuable sources for innovation and economic development. Smart specialisation monitoring and governance policies are also crucial ways to provide industries with what they need, including an efficient use of EU funds to support UIC more fully. Mandatory measures are already in place that encourage this collaboration through U-I joint research development. However, entrepreneurial systems are mostly composed of small and medium-sized enterprises, which have economic and financial constraints. Concurrently, quite inactive universities are still looking for industrial partnerships. Thus, UIC needs to be rethought, and more specialised structures encouraging interrelationships must be set up, for instance, taxation reductions for firms and monetary and/or non-monetary rewards for universities.

Although the above findings comprise important contributions, this study was not exempt from limitations. First, the analyses only covered two cross-border regions rather than two countries. Future research could thus compare data on Portugal, Spain and other European nations to determine whether the current results are applicable to other contexts. Second, since only public universities were surveyed, scholars may generate interesting results by evaluating whether the outcomes differ for polytechnic institutes and private universities.

The current findings highlight the importance of providing incentives and supporting structures that encourage UIC. Social media can potentially enhance knowledge management processes and encourage participation in UIC, so future studies should evaluate whether these platforms are an environment in which academics and industry managers can work more easily together. Finally, another avenue for future research could be the development of a holistic, systematic model of governance and management procedures that ensure UIC can reach its full potential.

Endnotes

[1] Many scholars suggest that the absence of distributional assumptions is the main reason for selecting PLS-SEM (Hair *et al*., 2012). This feature is clearly an advantage in social sciences studies, which almost always rely on non-normal data, but it is not a sufficiently strong justification (Hair *et al*., 2019). In a limited number of situations, non-normal data can also affect PLS-SEM results (Sarstedt *et al*., 2017), producing peaked and skewed distributions (Hair *et al*., 2019). BC and accelerated (BCa) bootstrapping addresses this issue since these techniques adjust confidence intervals to avoid skewness (Efron, 1987). For this reason, the present study used BCa bootstrapping to estimate the structural model.

[2] The rules followed to decide whether to maintain reflective indicators is based on outer loadings. All the items were included in this study's PLS-SEM, and outer loadings above 0.60 were retained (Hair *et al*., 2013). In the current research, the variable U-I joint research only kept one indicator, so this factor was treated as a single variable instead of as a construct.

Acknowledgments

Telma Mendes acknowledges the support received by national funds through FCT - Fundação para a Ciência e Tecnologia under the project UIDP/04728/2020.

References

Abreu, M., and Grinevich, V. (2013) "The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities", *Research Policy*, Vol 42, No. 2, pp 408-422.

Aksoy, A. Y., Pulizzotto, D., and Beaudry, C. (2022) "University-Industry partnerships in the smart specialisation era", *Technological Forecasting and Social Change*, Vol 176, pp 121438.

Ankrah *et al*. (2013) "Asking both university and industry actors about their engagement in knowledge transfer: What single-group studies of motives omit", *Technovation*, Vol 33, No. 2-3, pp 50-65.

Ankrah, S., and Omar, A. T. (2015) "Universities–industry collaboration: A systematic review", *Scandinavian Journal of Management*, Vol 31, No. 3, pp 387-408.

Azagra-Caro *et al*. (2006) "Faculty support for the objectives of university–industry relations versus degree of R&D cooperation: The importance of regional absorptive capacity", *Research Policy,* Vol 35, No. 1, pp 37-55.

Balland *et al*. (2019) "Smart specialization policy in the European Union: relatedness, knowledge complexity and regional diversification", *Regional Studies*, Vol 53, No. 9, pp 1252-1268.

Betsey, C. L. (2017) "Faculty research productivity: Institutional and personal determinants of faculty publications", In *Historically black colleges and universities* (pp 49-84), Routledge.

Boardman, P. C., and Ponomariov, B. L. (2009) "University researchers working with private companies", *Technovation*, Vol 29 No. 2, pp 142-153.

Boyarchuk, A., Kharchenko, V., and Sklyar, V. (2018) "Models and cases for sustainable university-industry cooperation in IT sector". *2018 IEEE 9th International conference on dependable systems, services, and technologies (DESSERT)* (pp 667–671), Kyiv, Ukraine: IEEE.

Breznitz, S. M., O'Shea, R. P., and Allen, T. J. (2008) “University commercialization strategies in the development of regional bioclusters”, *Journal of Product Innovation Management*, Vol *25* No. 2, pp 129-142.

Bukhari *et al.* (2021) “Entrepreneurial university: The relationship between smart specialization innovation strategies and university-region collaboration”, *Technology in Society*, Vol 65, pp 101560.

Capello, R., and Kroll, H. (2016) “From theory to practice in smart specialization strategy: emerging limits and possible future trajectories”, *European Planning Studies*, Vol 24 No. 8, pp 1393-1406.

Centobelli, P., Cerchione, R., and Esposito, E. (2019) “Exploration and exploitation in the development of more entrepreneurial universities: A twisting learning path model of ambidexterity”, *Technological Forecasting and Social Change*, Vol 141, pp 172-194.

Chedid, M., Carvalho, T., and Teixeira, L. (2020) “University-software industry collaboration: an empirical study based on knowledge management”, *Knowledge Management Research & Practice*, pp 1-13.

Cohen, J. (1988) *Statistical Power Analysis for the Behavioral Sciences,* Lawrence Erlbaum Associates.

Cunningham, J.A., and Menter, M. (2020) “Micro-level academic entrepreneurship: a research agenda”. *Journal of Management Development*, Vol 39, pp 581–598.

Daria, S., and Kostiantyn, D. (2018) “Evaluation of knowledge management system for university-industry cooperation”, *Proceedings of 2018 IEEE 9th international conference on dependable systems, services and technologies, DESSERT 2018* (pp 672–676), Kyiv, Ukraine: IEEE.

D’Este, P., and Patel, P. (2007) “University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry?”, *Research Policy,* Vol 36, No. 9, pp 1295-1313.

D’Este, P., and Perkmann, M. (2011) “Why do academics engage with industry? The entrepreneurial university and individual motivations”, *The Journal of Technology Transfer*, Vol 36, No. 3, pp 316-339.

Efron, B. (1987) “Better bootstrap confidence intervals”, *Journal of the American statistical Association*, Vol 82, No. 397, pp 171-185.

Fischer *et al.* (2018) “Quality comes first: university-industry collaboration as a source of academic entrepreneurship in a developing country”, *The Journal of Technology Transfer*, Vol 43, No. 2, pp 263-284.

Foray, D. (2017) “The economic fundamentals of smart specialization strategies”, In *Advances in the theory and practice of smart specialization* (pp 37-50), Academic Press.

Fornell, C., and Larcker, D. F. (1981) “Evaluating structural equation models with unobservable variables and measurement error”, *Journal of Marketing Research*, Vol 18, No. 1, pp 39-50.

Geels, F. W. (2002) “Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study”, *Research Policy*, Vol 31, No. 8-9, pp 1257-1274.

Giuliani *et al*. (2010) “Who are the researchers that are collaborating with industry? An analysis of the wine sectors in Chile, South Africa and Italy”, *Research Policy*, Vol 39, No. 6, pp 748-761.

Hair *et al*. (2017) “A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM)”, Sage, Thousand Oaks, CA.

Hair *et al*. (2013) “A primer on partial least squares structural equation modelling”, *Long Range Planning*, Vol 46, No. 1–2, pp 184–185.

Hair *et al*. (2019) “When to use and how to report the results of PLS-SEM”, *European Business Review*, Vol 31, No. 1, pp 1-25.

Hair *et al*. (2012) “An assessment of the use of partial least squares structural equation modeling in marketing research”, *Journal of the Academy of Marketing Science*, Vol 40, No. 3, pp 414-433.

Hansen, I.-E., Mork, O. J., & Welo, T. (2017) “Knowledge management of university-industry collaboration in the learning economy”, *2017 2nd international conference on knowledge engineering and applications (ICKEA)* (pp 173–177), London, UK.

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015) “A new criterion for assessing discriminant validity in variance-based structural equation modelling”, *Journal of the Academy of Marketing Science*, Vol 43, No. 1, pp 115-135.

Iorio, R., Labory, S., and Rentocchini, F. (2017) “The importance of pro-social behaviour for the breadth and depth of knowledge transfer activities: An analysis of Italian academic scientists”, *Research Policy*, Vol 46 No. 2, pp 497-509.

Jensen *et al*. (2008) “Scientists who engage with society perform better academically”, *Science and Public Policy*, Vol 35, No. 7, pp 527-541.

Jöreskog, K.G. (1973) “A general method for estimating a linear structural equation system”, In: Goldberger, A.S. and Duncan, O.D. (Eds), *Structural Equation Models in the Social Sciences*, Seminar Press, New York, NY, pp 255-284.

Lawson *et al.* (2019) “Citizens of somewhere: Examining the geography of foreign and native-born academics’ engagement with external actors”, *Research Policy*, Vol 48 No. 3, pp 759-774.

Ling, M. (2020) “Advanced Technologies”, Internal Market, Industry, Entrepreneurship, and SMEs – European Commission, [online], https://ec.europa.eu/growth/industry/strategy/advanced-technologies_en.

Llopis *et al*. (2018) “Scientists’ engagement in knowledge transfer and exchange: Individual factors, variety of mechanisms and users”, *Science and Public Policy*, Vol *45*, No. 6, pp 790-803.

Marinelli, E., and Elena-Perez, S. (2017) “Catalan universities and the entrepreneurial discovery process: Challenges and opportunities emerging from the RIS3CAT communities”, *Industry and Higher Education*, Vol 31, No. 6, pp 360-372.

McCann *et al*. (2012) *Guide to Research and Innovation Strategies for Smart Specialization (RIS 3*), Publications Office, Luxembourg.

McNally, G. P. (2010) “Scholarly productivity, impact, and quality among academic psychologists at group of eight universities”, *Australian Journal of Psychology*, Vol 62, No. 4, pp 204-215.

Paiva, T., Ribeiro, M., and Coutinho, P. (2020) “R&D Collaboration, Competitiveness Development, and Open Innovation in R&D”, *Journal of Open Innovation: Technology, Market, and Complexity*, Vol 6. No. 4, pp 116-134.

Perkmann *et al*. (2021) “Academic engagement: A review of the literature 2011-2019”, *Research Policy*, Vol 50, No.1, pp 104114.

Philbin, S. (2008) “Process model for university-industry research collaboration”. *European Journal of Innovation Management*, Vol 11, No. 4, pp 488-521.

Porter, M. E. (1998) *Clusters and the new economics of competition* (Vol 76, No. 6, pp 77-90), Boston: Harvard Business Review, [online], http://marasbiber.com/wp-content/uploads/2018/05/Michael-E.-Porter-Cluster-Reading.pdf.

Qiu, S., Liu, X., and Gao, T. (2017) “Do emerging countries prefer local knowledge or distant knowledge? Spillover effect of university collaborations on local firms”, *Research Policy*, Vol *46*, No. 7, pp 1299-1311.

Radosevic, S., and Stancova, K. C. (2018) “Internationalising smart specialisation: Assessment and issues in the case of EU new member states”, *Journal of the Knowledge Economy*, Vol 9, No. 1, pp 263-293.

Rasmussen, E., and Wright, M. (2015) “How can universities facilitate academic spin-offs? An entrepreneurial competency perspective”, *The Journal of Technology Transfer*, Vol 40, No. 5, pp 782-799.

Ringle, C. M., Wende, S. and Becker, J. M. (2015) “SmartPLS 3, Boenningstedt: SmartPLS GmbH”, [online], http://www.smartpls.com.

Roncancio-Marin *et al.* (2022) “University-Industry joint undertakings with high societal impact: A micro-processes approach”, *Technological Forecasting and Social Change*, Vol 174, pp 121223.

Sarstedt M., Ringle C.M., and Hair J.F. (2017) “Partial Least Squares Structural Equation Modeling”, In: Homburg C., Klarmann M., Vomberg A. (eds) *Handbook of Market Research*, Springer, Cham.

Soetanto, D., and van Geenhuizen, M. (2019) “Life after incubation: The impact of entrepreneurial universities on the long-term performance of their spin-offs”, *Technological Forecasting and Social Change*, Vol 141, pp 263-276.

Terán-Bustamante, A., and Colla-De-Robertis, E. (2018) “Vinculando el talento de investigadores y emprendedores para la innovación”, *Revista Mexicana de Economía y Finanzas*, Vol 13, No. 4, pp 547-569.

Terán-Bustamante *et al.* (2021) “University–Industry Collaboration: A Sustainable Technology Transfer Model”, *Administrative Sciences*, Vol 11, *No.* 4, pp 142-159.

Teixeira, S. J., Veiga, P. M., and Fernandes, C. A. (2019) “The knowledge transfer and cooperation between universities and enterprises”, *Knowledge Management Research & Practice*, Vol 17 No. 4, pp 449-460.

Zhou *et al*. (2016) “Research performance and university–industry–government funding sources in Taiwan’s technological and vocational universities”, *Innovation*, Vol 18, No. 3, pp 340-351.