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Open Innovation Community for University–Industry Knowledge Transfer: A Colombian Case

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Abstract: Academia–enterprise collaboration is understood as a determinant that improves innovation and competitiveness. The mechanisms by which this collaboration occurs have awakened increasing interest among academics, as well as in the business sector. This research aims to identify how open innovation communities can mediate the academia-enterprise relationship, as well as the factors that are more affected by this mediation. Based on the literature, the article addresses the definition of open innovation communities (OICs), university–enterprise cooperation, knowledge transfer (KT), as well as an understanding of OICs as a mechanism for academia–enterprise transfer. An analysis of twelve OICs, conformed by professors, students, graduates, and experts from a Colombian higher education institution is performed. For the data analysis, a factor analysis involving structural equation modeling is carried out. Our results highlight the most important characteristics to take into account in the study of knowledge transfer when OICs are involved, and they also indicate the level of connection between these factors.

Keywords: open innovation community; knowledge transfer; knowledge management

1. Introduction

During the long history of higher education institutions, their value to society has suffered several changes. Since the emergence of the Humboldtian approach to higher education in the 19th Century, research has gained a role as important as that of teaching, and both have become interdependent functions of education [1]. In the 20th and 21st Centuries, research in higher education takes new prominence as factors like globalization and the boom of new technologies give rise to so-called knowledge societies, where knowledge is seen as an asset for economic development [2]. In this context, educational institutions have had to reform their educational models, getting closer to the needs of society and the productive sector. Then, the educational sector has been required to capitalize on the needs of the productive sector to generate greater added value and new applicable knowledge [3]. However, this connection between academia and the productive sector should not be seen as education institutions being subordinates to business demands. Higher education institutions must take into account their own mission and purpose, for they can have a transformative power on the productive sector to reevaluate its practices, values, and general role in modern societies [4,5].

The topic of university–industry cooperation is very prolific in the literature [6–9], and there are many different mechanisms (and formal or informal channels) for universities to liaise with enterprises that do not necessarily involve knowledge transfer [10–13]. This article focuses on understanding an uncoded tacit knowledge transfer channel, which allows continuous collaborative work: open innovation communities (OICs), understood as spaces that facilitate the exchange and use of tacit knowledge, collective learning, problem solving, and opportunities to innovate [14,15]. The objective of this study is to analyze what are the relationships among different factors involved in university–industry knowledge transfer (including the characteristics of the company and the higher education institution), how they are connected to knowledge management, and how the implementation of OICs between academia and companies can stimulate these relationships. This objective can be summarized in the following three research questions:

- Q1. What indicators could explain the proposed OIC model?
- Q2. Which variables act together in the OIC model, and which ones act independently?
- Q3. To what extent does the creation of OICs stimulate the academia–company relationship?

In order to address these research questions, this article starts with a literature review that explores university–enterprise cooperation, discusses the definition of open innovation communities and knowledge transfer, and establishes a model of OICs as a mechanism for academia–enterprise knowledge transfer. The empirical source of this study comes from 112 self-administered questionnaires answered by students and graduates that participated in 12 OICs of a higher education institution in Bogotá, Colombia, from 2014 to 2018. Based on these data, we use quantitative analytical methods to highlight the most important characteristics to take into account in the study of knowledge transfer when OICs are involved, as well as to suggest the deepest connections between these factors or, conversely, which of them act more independently.

We must stress two limitations of our empirical study that should be taken into account to properly appreciate its interpretation. First, the relation between factors is analyzed at the level of correlations and not of causal relations. The latter would require much more data with control variables; for instance, data from students that did not participate in OICs would be required. This limitation could be overcome in other studies. Second, the factors are measured in a reflective manner through the perception of the students and graduates that participated in an OIC during their internships. Due to this feature, this work pays special attention to the participation of university students as the linchpin of knowledge transfer within OICs. Furthermore, this analysis from the perception of the participants can be interpreted in the light of indicators that have been found relevant in the literature [16]. Putting students at the center of the knowledge transfer process also allows addressing concerns related to closing the knowledge gap between academia and the productive sector, and in this way, it helps to understand how this challenge should be tackled in the face of the future employment of young people [17]. In this sense, the International Labour Office (2020) has demonstrated that youth participation in the labor market has been decreasing globally during the last 20 years [18]. Colombia is no stranger to this phenomenon, and it aggravates this problem with the characteristics of its productive sector, which has low sophistication and a focus on low value-added services that do not need a skilled labor force. Therefore, identifying strategies that contribute to the generation of value and the sophistication of the productive sector also gains special interest for this study.

The present research contributes to different bodies of knowledge: First is the need for more empirical studies at the micro-level that analyze the academic and industrial perspectives [6,19–22], especially in small and medium-sized enterprises (SMEs) [9,23]. By exploring knowledge interactions at the micro-level, it is possible to reveal the factors that contribute to successful knowledge transfer schemes between universities and industry [6]. This aspect is especially relevant when we consider that this study is done in Colombia, since university–enterprise relations are little studied for developing countries [12,24]. Second is to broaden our understanding of the relational processes of the production and transformation of knowledge as a result of the articulation of different actors [14,25–27]. Consequently, our work contributes to understanding the flows of knowledge, as well as the mechanisms and strategies of shared work between universities and industry based on the generation of knowledge networks, which is an issue of increasing significance. Finally, since we explain our quantitative methods in great detail, we also think that this work can act as a reference for researchers wanting to perform similar data analyses.

This article is structured as follows: First, the concept of university–industry cooperation, its relationship with the knowledge transfer process, and open innovation communities as a mechanism of action are discussed. Next, the quantitative research design is described; the instrument used is a questionnaire applied to open innovation communities created around different topics in SMEs and a higher education institution in Bogotá. Subsequently, the results of the study are detailed, and the most important elements for the success of OICs as a mechanism for university–enterprise knowledge transfer are discussed. Finally, the conclusions, contributions, and limitations are presented.

2. Literature Review

This revision of the literature starts with elements that allow us to understand the university–enterprise cooperation as an end to be achieved. Afterwards, it focuses on knowledge transfer as a more specific mechanism in which this cooperation occurs and on OICs as a useful channel to achieve it. Finally, a more specific OIC model is presented as the theoretical foundation of our research. This model is the most appropriate for our study because it allows an understanding of the interaction of all the actors within the OIC. The exchange of knowledge in this research can then be understood as a process of social participation and the construction of identities through practice itself [27]. OICs allow this exchange of knowledge to be translated into improvements of shared practice, thus allowing the transfer of knowledge [5,28], and the development of a "collective intelligence" in the face of shared practice [29]. Although the literature on university–enterprise knowledge transfer communities is extensive, the development of empirical cases should be further developed [30], especially its implementation as an OIC [31,32].

2.1. University–Enterprise Cooperation

Understanding how the relationship between academia and industry emerges means understanding also the changes that occur in the production system, the pressures placed on higher education models related to globalization, new technologies, and the high demands of a knowledge-based economy [33], as well as the transformation of knowledge into innovation as an engine of wealth generation [4]. This has opened the way for the creation of cooperation networks between both sectors. These relationships have been described in the literature from different approaches, such as the triple helix model [2,25,34]. All these approaches are useful to explain different interactions and the necessary arrangements in the institutional spheres that allow fostering innovation. "All approaches share in common key principles such as boundary spanning, interactive learning, and innovation's evolutional nature" [21].

There is an extensive literature that allows getting a grasp on the factors that determine the university–industry relationship, among which some are related to perceived channels, drives, and benefits [12]; geographical proximity, entrepreneurial ecosystems, transfer mechanisms, implications for public policy [35]; the availability of resources such as incentives, infrastructure, and continuous channels, as well as experience in this type of processes [36,37]. Furthermore, a very important aspect from the point of view of academia is the possibility of obtaining as a result an exchange of relevant knowledge and learning [36,38].

2.2. The University–Enterprise Knowledge Transfer

Knowledge transfer (KT) must be understood as a process with different stages and units [39], but also as a learning process, the purpose of which is to generate value, develop competitive advantages, and carry out innovation processes [40–42]. It is a process that allows the modification of attitudes, behaviors, skills, and competences in the workplace. In KT, the parties need to be aware of the opportunity to exchange knowledge, the generation of value for both parties, the importance of this being a continuous process [43], the effective recombination of sources, the availability of knowledge [44,45], the message and the context, the decoding scheme, channel, and receiver, as well as the assignment of meaning to the decoded message [39].

Gupta and Govindarajan analyzed knowledge transfer based on communication theory in order to establish the elements that determine the flows of knowledge to transfer: the value of knowledge, the disposition to share knowledge, the existence and richness of transmission channels, and the capacity to absorb and use knowledge [46]. Similarly, the theoretical models of knowledge creation and management allow understanding how the described elements participate in the process. Some of the analyzed models regarding the construction of knowledge transfer interaction proposed in this research are the following: conversion of tacit and explicit knowledge [47]; the ACCELERA model, which starts from understanding knowledge as a product of networking [48]; the knowledge life cycle proposal [49]; the knowledge management framework for educational organizations [50]; and the circular model [15].

Regarding research on KT between university and industry, numerous studies have addressed the topic, but the research is very fragmented and lacks an integrative perspective [7]. Nevertheless, there are elements that allow understanding the importance of this process, such as the development of a network that promotes competitiveness through innovation [8,45]. In this sense, this type of collaboration with SMEs plays an important role since these companies are able to establish informal relationships with universities due to their need for resources, time, people, knowledge, and trust, which represents an opportunity to carry out innovation processes [6], although the perception of risk regarding SMEs is higher than with a large company. The transfer of knowledge between universities and enterprise can happen through formal or informal mechanisms linked to the benefits they seek to obtain from it. In that sense, it is important to identify channels that allow an informal understanding of transfer as a continuous process of dialogue and trust building [51], finding in OICs a mechanism that contributes to solving this problem and capitalize on the tacit knowledge of participants in an efficient way [52].

2.3. Open Innovation Communities as a University–Enterprise Transfer Mechanism

Different authors have approached knowledge as a resource for organizations [53]; in this context, the concept of community has gained relevance, going from occupational communities [53] through learning communities [54,55], communities of practice [14,27,56,57], to open innovation communities, which focus on the generation of added value [31,32].

The concept of open innovation communities has common ground with the principles of communities of practice. Communities of practice are based on the social theory of learning [27], understanding learning as a process of social participation and the construction of identities through practice. Communities of practice can be defined as a learning space mediated by a dialogue that seeks to improve shared practice [14], or as a relational space between theory and practice [15], from the perspective of innovation [56], and as a mechanism for organizational change. Wenger (1998) argued that in order for a community of practice to be possible, it is necessary to count on a domain of common knowledge, an established community that encourages dialogue and shared actions or practice, as well as useful tools for generating innovation through learning [58,59].

The different definitions share some common characteristics: they are made up of a group of people who interact in person or virtually; their objective might be to share knowledge, transfer knowledge, solve problems, or promote innovation by generating a competitive advantage for the organization; the shared knowledge is the tacit and explicit knowledge that can be produced. Different factors make it possible to measure the success of the communities [27,60,61], such as the organizational context, factors related to community development, the characteristics of the community, and the results.

2.4. Conceptual Model for OICs

The model implemented in this work was proposed in the umbrella research carried out by Vélez [62], based on the study of the processes and mechanisms of knowledge management and knowledge transfer and the way they can be potentiated from the development of an OIC. This model was crucial in the conceptual design of our work, the elaboration of the questionnaire, and in the theoretical latent factors of our analysis. From this model, it is possible to analyze the variables that influence the best transfer of applied knowledge, in such a way that tangible results are promoted in the university–industry relationship. The model fulfills the following characteristics:

(i) Interaction between academia and industry that guarantees bidirectional knowledge flow and the generation of value for both entities [43].
(ii) A shared domain based on an understanding of the business needs, a university–industry community, and a shared practice [63].
(iii) Tangible results for both industry and universities [61].
(iv) A perspective of action-participation research, developed by Kurt Lewin [64], given that it aims to transform action and allows students to be participants of change in companies, while acting as researchers within them, in a continuous cycle of dialogue and training and application within both the university and company.
(v) The use of ICTs as facilitators of the process, since they allow constant communication, the maintenance of the collective memory of the OIC, as well as visibility regarding the production carried out [65–67].

From the multiple forms of relationships between academia and the company, this model starts from the understanding of the relationship since the creation of OICs, beginning with a common consensual theme based on the particular needs of companies, the experience of the tutor/teacher, and the direct observation from students in practice, which ultimately allows for incremental innovations for the company and new knowledge for the university. The model arises from analyzing different models of knowledge management [15,47,48].

3. Research Methodology

3.1. Population and Sample

The study analyzed twelve OICs composed of educators, students, and graduates of a higher education institution in Bogotá, Colombia. In some of these communities, there were also external experts as additional participants. The educational method of this institution was inspired by the German dual training model, in which education alternates between the classroom and the company where students undertake an internship. These communities were active from 2014 to 2018 and had a total of 206 participants. Each one of these communities emerged from inquiries posed by tutors/educators after observing and supervising the interns' performance. Hence, the OICs in our study originated from questions that sought to solve the specific needs of small and medium-sized enterprises (SMEs) in the city of Bogotá. Our data came from a sample of 112 self-administered questionnaires answered by students and graduates who participated in the aforementioned OICs. Since the maximum number of possible answering participants was 206, this sample of 112 questionnaires can be considered significative. Besides, we obtained answers from participants of all twelve OICs connected to the higher education institution. This sample was not chosen randomly; it just represents the set of adequately answered questionnaires.

3.2. Analysis Method

The data collected in this study were analyzed using the R programming language, especially the lavaan package (v.0.6.7). Our analysis proceeded as follows: First, sample composition frequencies were calculated in order to obtain the characteristics of survey respondents. Second, exploratory reliability analysis was performed to assess the validity and reliability of the survey items. Third, confirmatory factor analysis was conducted to verify the overall validity of the reflective measurement model that emerged after the exploratory analysis. Fourth, the correlation structure of the measured latent factors was obtained using an (unconstrained) structural equation model (SEM), where all latent factors could be correlated. Finally, very high or very low correlations were highlighted by conducting paired chi-squared difference tests between the unconstrained and the constrained models. In the constrained models, the correlation between a pair of latent factors was set either to zero or to one.

The second and third steps could be rather described as methodological details, but they addressed our first research question: What indicators could explain the proposed OIC model? The fourth step is the very center of our quantitative analysis, and it addressed our second and third research questions since it established the network of connections among the latent factors of our study. The aim of the fifth step is to aid in the interpretation of the results of the fourth step, by providing a well-established criterion to identify very low and very high correlations in an SEM model. In the following section, we provide thorough details of our analysis method. While some of these details can be technical, we commit to this level of precision in order to make our analysis transparent, reproducible, and statistically robust.

4. Results

4.1. Sample Characteristics

More than half of the respondents were female (55.4%), and the rest (44.6%) were male. The programs pursued by participating students were distributed as follows: international business (30.4%), business administration (17.9%), international business and finance (16.1%), marketing and logistics (10.7%), industrial engineering (10.7%), public accounting (8.9%), and tourism management (5.4%). Twenty-five percent of the respondents were graduates, 10.7% in the 10th semester of their programs, 30.4% in the seventh semester of their programs, and the rest (33.9%) in earlier stages of their studies. Finally, most of the internships were in private sectors: 67% in the private service sector, 22% in the private industrial sector, 9% in commerce, while only 2% in the public sector.

4.2. Exploratory Factor Analysis

When an originally devised questionnaire is applied for the first time and there are analytical methods and theoretical constructs in mind, special care must be taken in order to find which items can be considered good measurement indicators of the latent theoretical factors [68]. The starting point should be a critical examination of the items, both in terms of statistical consistency and in the light of the theoretical background. This subsection of exploratory factor analysis and the next one on confirmatory factor analysis perform this critical assessment of the observed variables in the questionnaire.

The questionnaire consisted of 87 items in addition to 14 sample composition questions like gender or educational program. All 87 items were marked by a five-point Likert scale. Since the number of points in the ordinal scale was so low, polychoric correlations were performed instead of Pearson correlations for they are better suited to the scale of the data [69]. The questionnaire intended to assess eight theoretical variables involved in knowledge transfer between academia and industry as perceived by the respondents. A first exploration of the polychoric correlation matrix revealed that many of the items were not adequate for the proposed method for different reasons:

- Some items were perfectly correlated with others, and due to this redundancy, the matrix had zero non-positive eigenvalues. In this situation, the algorithm would crash.
- There were also many anti-correlated items that questioned the perceived relative relevance of certain aspects that could influence university–industry knowledge transfer. This anti-correlation could not be easily associated with any of the theoretically proposed factors as they were almost independent of any construct.

- Some questions showed little validity with respect to the construct with which they were supposed to be associated. A second conceptual assessment revealed that the way the question was phrased greatly reduced this validity.

All the items that suffered from these problems were omitted thereafter. The remaining items were labeled with a prefix and a number according to the theoretical construct associated with it: participants or interns (Pa), educators or tutors (Ed), university (Un), enterprise size (ES), enterprise involvement (EI), open innovation community (OIC), knowledge transfer (KT), and knowledge management (KM). The questionnaire indicators involved in these latent factors are expanded in the Discussion Section, where they are also contrasted with the theoretical background.

After the questionnaire items involved in the study were selected, exploratory factor analysis was usually done on the data [70]. We used this technique to validate our measurement scheme as follows. On one side, this analysis examines how the questionnaire items cluster among different abstract factors, ignoring any possible theoretical association among them. These abstract factors (including their number) are deduced solely by statistical correlations, and each measured item can be related to any possible abstract factor. On the other side, we theoretically associated each item with a theoretical construct (latent factor). If the theoretical factors are properly chosen and they are actually reflected in the items, there should be a high correspondence between these labels and the "blind" association of exploratory factor analysis.

More specifically, we performed a maximum likelihood exploratory factor analysis with polychoric correlations. The number of abstract factors was six (as suggested by parallel analysis), and the rotation method was oblimin. The results of this analysis are shown in Table 1. Despite the high flexibility of this analysis, a very high correspondence was observed between the item prefix and the principal latent factor related to it, so we have good confidence that our theoretical measurement scheme was supported by data [68]. Only the un-prefixed and OIC-prefixed items were scattered among different latent factors, but the weights in those cases were not very significative. Furthermore, there were two pairs of prefixes that were associated with a single factor: Pa-Ed-prefixed items and KM-KT-prefixed items. This suggests a strong correlation between the theoretical constructs associated with those items, a conclusion that will be confirmed by other means in further analysis.

Table 1. Exploratory factor analysis. The highest latent abstract factor standardized weight is presented for each observed questionnaire item. At the bottom, the proportion of item variance is expressed for each factor. Seventy-seven percent of all the variance between items is explained by six latent abstract factors. Participants or interns (Pa), educators or tutors (Ed), university (Un), enterprise size (ES), enterprise involvement (EI), open innovation community (OIC), knowledge transfer (KT), and knowledge management (KM)

Item	F1	F2	F3	F4	F5	F6	Item	F1	F2	F3	F4	F5	F6
Pa1	0.59						EI1			0.77			
Pa2	0.56						EI2			0.83			
Pa3	0.68						EI3			0.76			
Pa4	0.71						EI4			0.75			
Ed1	0.69						OIC1	0.56					
Ed2	0.95						OIC2				0.34		
Ed3	0.80						OIC3				0.80		
Ed4	0.94						OIC4					0.36	
Un1		0.52					KT1					0.57	
Un2		0.65					KT2					0.68	
Un3		0.92					KT3					0.62	
Un4		0.51					KT4					0.74	
Un5				0.48			KM1					0.84	
Un6				0.63			KM2					0.73	
Un7		0.47					KM3					0.37	
ES						0.72	KM4					0.78	
ES						0.53							
ES						0.89							
Proportion of Var.	0.19	0.17	0.13	0.11	0.10	0.08							

4.3. Confirmatory Factor Analysis

The exploratory factor analysis described in the previous subsection assumes that there is no reason to cluster items under specific latent factors. This assumption is not correct in the light of the theoretical design of the questionnaire. In this section, a concept validity and reliability analysis is performed by means of a confirmatory factor analysis of each cluster of prefixed items. The aim of this analytical step is to statistically confirm that the indicators and latent factors chosen in the previous step are robust so that the further steps are based on solid ground. This step is customary in SEM analysis [70,71].

The parameters for each latent factor were calculated by unweighted least squares with mean and variance adjusted (ULSMV), using polychoric correlations. The results are shown in Table 2 where the loadings are shown in ascending order. For instance, the four loadings for Pa correspond to Pa1, Pa2, Pa3, and Pa4, respectively. All factor loadings were greater than 0.62, which means that they can be considered significative, as the standard lower limit was 0.05. The *p*-values of all the loadings were below 10^{-4}.

Table 2. Confirmatory factor analysis of the tested model. SRMR, standard root mean squared residual.

Latent Factor	Standardized Loadings	χ^2	df	SRMR	α	AVE
Pa	0.846, 0.718, 0.854, 0.738	0.862	2	0.0279	0.868	0.627
Ed	0.872, 0.969, 0.945, 0.973	0.234	2	0.0145	0.969	0.885
Un	0.894, 0.826, 0.855, 0.892, 0.853, 0.876, 0.884	9.027	14	0.0539	0.956	0.755
ES	0.687, 0.764, 0.985	0	0	0	0.849	0.675
EI	0.918, 0.911, 0.926, 0.904	1.385	2	0.0353	0.953	0.837
OIC	0.929, 0.745, 0.786, 0.755	0.421	2	0.0195	0.879	0.652
KT	0.852, 0.822, 0.822, 0.908	1.744	2	0.0396	0.913	0.726
KM	0.955, 0.838, 0.623, 0.817	1.405	2	0.0356	0.881	0.667

Convergent validity was tested by means of several fit indices of the reflective measurement scales of each factor. Accordingly, Table 2 shows the chi-squared statistic (χ^2), the degrees of freedom (df), and the standard root mean squared residual (SRMR). As for the latter, it was always below 0.08 (in fact, it was below 0.054), confirming the validity of the measurements (other indexes were also examined, such as the root mean squared error of approximation (RMSEA, always below $0.001 < 0.08$) and the comparative fit index (CFI; always above $0.999 > 0.9$), but their values were so close to their ideal value that there was no need to show them in the table).

Reliability and internal consistency were tested with Cronbach's alpha coefficient (α) and the average variance extracted (AVE). Cronbach's coefficient surpassed the 0.084 threshold in all cases, well above the standard of 0.07. Regarding the AVE parameter, it was always above 0.062, which is beyond the usual threshold of 0.5. Therefore, all constructs were statistically acceptable [72,73].

4.4. Model Estimation and Adequacy

After validating the measurement scheme for each construct, our main statistical result was established: a structural equation model (SEM) estimating the correlation between each pair of latent factors. The major parameters estimated in the model, as well as its graph structure are represented in Figure 1. Four estimated correlations are not discernible in the figure; the values of these correlations are Pa-OIC: 0.82, Ed-ES: 0.34, EI-KM: 0.55, and Un-KT: 0.63. This model was estimated by fixing the latent factor's variances to one. The estimation method was unweighted least squares with mean and variance adjusted (ULSMV). All observed variables were treated as ordinal, and hence, all the observed parameters to explain were in the polychoric correlation matrix. The adequacy of the model is evidenced in Table 3, where several fit indices are presented. The GFI (goodness-of-fit index) and AGFI (adjusted goodness-of-fit index) values are above the standard of 0.95. The CFI (>0.9) and RMSEA (<0.08) are within their acceptable values, and even their scaled versions are acceptable. Only the SRMR is very slightly above the usual standard of 0.08 [68,74,75].

Notice that, in our SEM, we only extracted correlations between latent factors and not regression coefficients. The former are indicators of a statistical connection between latent factors, while the latter would estimate a causal link between them. We abstained from proposing causal links in our statistical model due to the micro-empirical character of our data, the lack of contrasting measurements from other populations, and several other limitations that could be overcome in future works. Nevertheless, the correlation network depicted in Figure 1 is an excellent starting point for proposing hypotheses on how the different factors can be related.

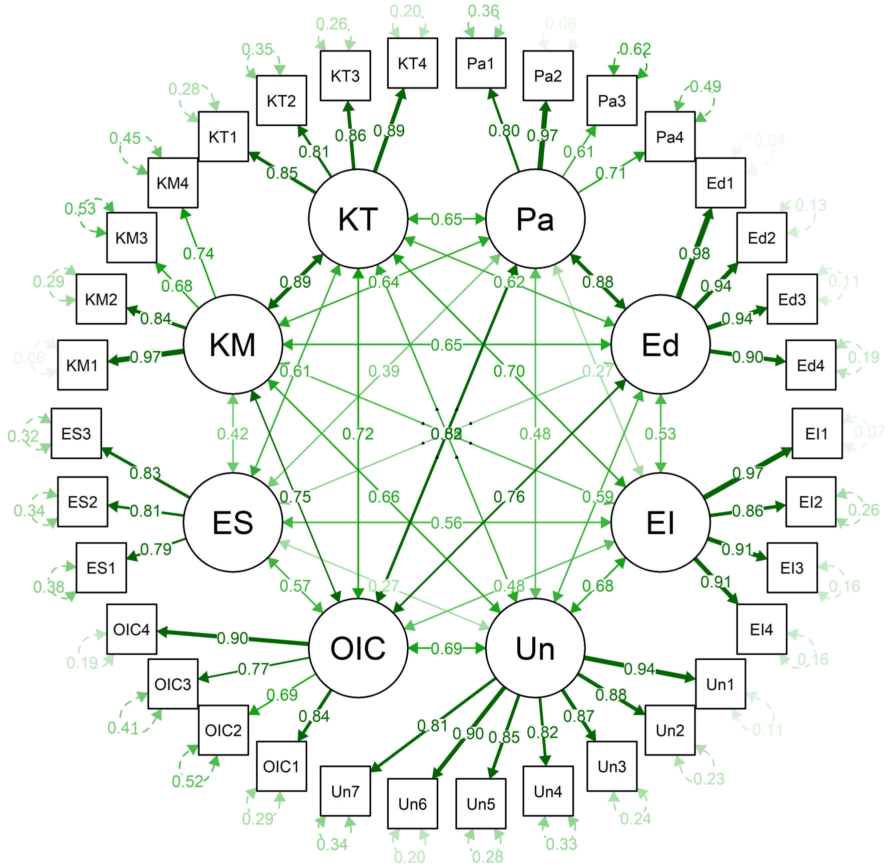

Figure 1. Graph of our main structural equation model showing the correlation between each pair of latent factors and the standardized loadings with respect to each observed item in the questionnaire. The individual standardized exogenous error variance for every observed item is also displayed.

Table 3. Fit indices of the structural equation model of Figure 1. AGFI, adjusted goodness-of-fit index; CFI, comparative fit index.

χ^2	df	GFI	AGFI	RMSEA	SRMR	CFI	Scaled CFI	Scaled RMSEA
193	499	0.987	0.982	<0.001	0.081	>0.999	0.930	0.068

In the graph, the level of correlation is indicated both by a number and by the darkness and thickness of the double arrows that represent the link between the latent factors. From this network, answers to the second and third research questions of this work can be deduced. First, notice how the pairs KM–KT and Pa–Ed are strongly linked, which is an indicator that the factors in each pair act mostly together as a single composite factor. This conclusion was already anticipated in the exploratory factor analysis. Second, notice how enterprise size is highly detached from everything else, which implies that this is not a relevant factor in the model. Third, notice that the Pa–Ed pair is less connected to KM–KT than it is to OIC and that OIC is strongly linked to the KM–KT pair. This suggests that the OIC is a mediator between the academic individual actors (students and educators) and the process of knowledge management and knowledge transfer. Finally, enterprise involvement is strongly linked to KT (and to a minor extent, to KM) but it is rather independent of the other factors. A similar pattern is observed for the university factor. This contrasts with the previous observation, and it means that, even though these factors are important for KM and KT, they act in a much more independent manner. This final conclusion is stronger for the enterprise than it is for the university. We will make further comments on these conclusions in the Discussion Section.

4.5. Latent Factor Correlation Analysis

Even though correlations are numbers that can take values in a definite interval, there is not an absolute way of identifying a value as a low correlation or as a high one. The interpretation will strongly depend on the statistical context in which these numbers are obtained (sample size, analysis method, etc). The aim of this subsection is to validate that the conclusions extracted from the correlations of Figure 1 are correct in the context of our data and the SEM model. Apart from negative values that did not come out in our results, correlations have two extreme values: zero, when there is no linear link between factors; and one, when the linear link is perfect. The objective is to test both extremes: whether it is possible to reject that the correlation between a pair of latent variables is one (akin to a discriminant validity test) and also whether it is possible to reject that the correlation is zero (akin to a linear independence test).

Given that our latent variable scores were inferred from an SEM, chi-squared difference tests can be performed comparing the null hypotheses of the restricted models (correlations equal to one or equal to zero) and the model estimated in the previous section [76,77] (tests based on the inferred values of the latent variables, such as a t-test, are not suited for this study, since they are designed for directly observed continuous variables that are assumed to be normal). The restricted models were estimated with the same procedure as in the unrestricted one, and the chi-squared difference tests were performed using a Satorra–Bentler corrected test that accounts for the use of ordinal variables as indicators. This test was done for each pair of latent variables and for both null hypotheses: correlation equal to zero and correlation equal to one. Therefore, a total of 56 tests were performed; the p-values of those tests are shown in Table 4. If a p-value is marked in the upper triangle of the table, it means that the corresponding pair of factors is highly correlated. Similarly, if a p-value is marked in the lower triangle of the table, it means that the pair of factors has low correlation. The conclusion is that the interpretations made in the previous subsection are correct and statistically significant.

Table 4. p-values of the chi-squared difference tests for latent variable correlations. The upper triangle has as null hypothesis that the correlation is one. The lower triangle has as null hypothesis that the correlation is 0. Especially high values are marked: underlined referes to values higher than 0.01, **boldfaced** refers to values higher than 0.05, and * (asterisk) refers to values higher than 0.1.

	ES	Pa	Ed	EI	Un	OIC	KM	KT
ES		1.38×10^{-6}	6.56×10^{-5}	9.78×10^{-5}	5.33×10^{-5}	0.0039	2.15×10^{-5}	0.00031
Pa	0.0162		**0.101** *	0.0015	0.0037	0.0250	0.0090	0.0110
Ed	**0.0543**	1.62×10^{-12}		0.00103	8.22×10^{-5}	0.0052	0.0048	0.0038
EI	0.00055	**0.270** *	0.00296		4.13×10^{-5}	0.00208	0.00667	0.0221
Un	**0.184** *	0.0197	0.000296	3.61×10^{-6}		0.000605	0.0146	0.00115
OIC	0.00252	1.17×10^{-11}	3.15×10^{-11}	0.0138	2.22×10^{-5}		0.0112	0.0069
KM	0.0235	4.90×10^{-5}	7.81×10^{-6}	0.00546	0.0019	6.86×10^{-10}		**0.143** *
KT	0.00015	0.00017	8.76×10^{-6}	2.77×10^{-6}	0.00032	2.79×10^{-9}	1.25×10^{-12}	

5. Discussion

The present research highlights the importance of students who participate in OICs, given their active role in the development of networking between higher education institutions and enterprises.

This study explored three main questions: What indicators could explain the proposed OIC model? Which variables act together in the OIC model, and which ones act independently? To what extent does the creation of OICs mediate the academia–enterprise relationship? In this sense, we considered the factors that most influence the generation and transfer of applied knowledge through academia–enterprise OICs: knowledge management, knowledge transfer, the characteristics of participating students and educators in the classroom and the company, the characteristics of the enterprise and the higher education institution, the organizational characteristics of the OIC as a space for knowledge sharing, and enterprise size.

Regarding the indicators that best explain each factor of the proposed OIC model, KM is perceived as a mechanism that is necessary to create innovations, to mobilize knowledge creation initiatives, and to improve and develop disciplinary competences in the application of projects within companies, which concur with the findings of different authors [15,78,79], who related the production of knowledge and innovation to networking. On the other hand, Hoof [80] and Lederman et al. [81] suggested that companies that independently seek innovation spend unnecessary efforts and resources that can be supplemented by networking with universities. KT is related to favoring this process in order to apply the knowledge obtained in the classroom to the enterprise and the relationship that exists between them, as well as to improving professional practice and highlighting the importance of the contribution and support of training entrepreneurs in it. This agrees with the findings of Gupta and Govindarajan [46], who stated that, for the transfer to take place, it is necessary to have a good disposition in the source unit, to know the value of each organization's knowledge stock, the existence of adequate channels, as well as the capacity to absorb such knowledge.

We found that knowledge management and knowledge transfer can be analyzed as a single factor. This can be explained following the logic of the knowledge spiral [47,82], with KM and KT being necessary processes for the integration and conversion of knowledge from a tacit to an explicit form in the academia–enterprise relationship through OICs. However, this relationship is clearer when the role of the higher education institution is examined, instead of the role of the enterprise; that is, the flow of knowledge is still occurring in a unidirectional way. Likewise, it is evidenced that OICs do mediate the academia–enterprise relationship, which, again, is related to the characteristics of the academic participants, and independent of the characteristics and size of the enterprise and higher education institution. Thus, participants, students and trainers, are the factors that are very clearly mediated by OICs.

The concept of OIC as a space for knowledge sharing is related to (i) didactic strategy, coinciding with Barrera-Corominas et al. [60], who described how clarity in the objectives and structure of OICs allows participants to focus on the themselves. Likewise, Gessler [83] maintained that the context in which training occurs is important to improve performance, and this is conditioned by the didactic strategies and computer tools used. Hinrichs [84] explained that improvement in performance in the workplace is also favored by a good didactic design of course contents, while Baldwin and Ford [85] concluded that the design of training is a key factor for knowledge transfer. (ii) It is also related to a sense of belonging. Brown and Duguid [56] and Lave [14] argued that the conditions in which OICs and learning occur are important, emphasizing that knowledge resides in learners and their interest in participating in these open innovation communities. (iii) It is also related to collaborative work and (iv) the usefulness of knowledge, aspects that coincide with the works of Pearson and Brew [86], who described how OICs guide the creation of "productive learning environments". Likewise, Tomkin et al. [87] found that OICs are a useful mechanism to improve student learning and student retention based on active participation.

Regarding the characteristics of participants, the study found that the most relevant factors are related to an improvement in the participants' ability to transfer knowledge from the classroom to the business sector, the use of computer tools, their commitment and motivation to apply and transmit all knowledge, and again, the important support of training entrepreneurs to implement proposals in their organizations. Baldwin and Ford [85] described the following as participant characteristics that affect the process: ability, personality, and motivation, which agrees with our findings. Likewise, Gessler [83] and Hinrichs [84] suggested that motivation, workplace conditions, that is the work environment, and the orientation of transfer are predictors of success. On the other hand, commitment to transferring knowledge can be associated with the perception of self-efficacy in participants, described by Bandura [88] as a belief in someone's own actions and their effect on changes in others. Chiaburu et al. [89] stated that the support of superiors has a positive influence on motivation to transfer knowledge and on their sense of self-efficiency, provided that the learning objectives are clear.

Regarding the characteristics of the tutors, that is the moderating professors of the OICs and training entrepreneurs, participants mentioned that the most important indicators are motivation, confidence in the tutor's knowledge, as well as clarity regarding the organization of the OIC. Authors such as Gessler and Hinrichs [16], Hinrichs [84], and Kirkpatrick [90] suggested that knowledge development and learning are influenced by the coach and his/her disposition to share knowledge, which coincides with the postulates of Gupta and Govindarajan [46]. This observation could further explain why trainers and participants acted in strong synchrony as a single factor.

The higher education institution–training enterprise organizations play a very important role for KM and KT to occur. Hinrichs [84] stated that it is the conditions of the enterprise that allow the transfer to take place instantly; in other words, it allows what the author calls collateral transfer. However, our results show that the characteristics of the educational institution are still very significant for a successful process, and it can be seen as an independent factor. In our study, the most valued characteristics of higher education institutions are related to the existence of stimuli for the development of new ideas in enterprises, the promotion of work networks between different OICs, the availability of technological resources, the support and recognition of top management, and the promotion of innovations.

Among the characteristics of the enterprise, the following are considered relevant: recognition of the employer of the participant's work, the company's support to develop new ideas, commitment to learning, and consideration of the participant's opinions or suggestions. In this regard, Kaiser et al. [79] showed that positive results in innovation within organizations are related to work networks that favor knowledge flows, while Chiaburu et al. [89] described how, despite the existence of business incentives, the guidance of supervisors or tutors is necessary for the transfer to occur. Hinrichs [84] pointed out in her study that the establishment of a support system in the enterprise allows and promotes the transfer of training content in the context of work; this same conclusion can be extrapolated to the present research.

6. Conclusions

By means of our empirical analysis, we provide answers to our three research questions, and we compare these answers with the theoretical background of our literature review. The factors analyzed are focused on understanding those that explain knowledge management and its relationship with innovation, the factors that mediate the process of knowledge transfer understood from understanding the knowledge to be transferred and the conditions that allow it, especially the channels, stock, and disposal of sources, the characteristics of the OICs against the development of their success factors, and finally, the characteristics of the participants and organizations.

Our findings show that knowledge management and transfer must be understood as a single process, that is to say, it is not only important to create knowledge, but also to be able to transfer it, it being important that the flow of knowledge takes place in a bidirectional way. This process from the postulated model must have as an end the generation of value for both organizations, innovation being a fundamental factor that must be promoted and measured in future investigations.

According to the students' vision, the open innovation community is pivotal to the relationship between academia and the company, but it depends on the characteristics of the participants and educators. These individual actors (students and educators) are found to act as a single factor. On the other hand, the characteristics of the company and the higher education institution are not related to the success of the OIC, but these characteristics are relevant to the capacity to implement knowledge. Finally, the company size shows only a minor relation to the other factors, including knowledge transfer and management.

This study finds that the analyzed factors can be interpreted in the light of indicators that are relevant in the literature. Knowledge management and knowledge transfer in the academia–enterprise relationship can be interpreted as a single factor that mediates the flow and use of knowledge. The open innovation community is pivotal to the relationship between academia and enterprise, but it depends more on the characteristics of the participating educational institutions, students, and educators, and not on the characteristics and size of the enterprise. Nevertheless, these characteristics are relevant to the ability to implement knowledge.

Implications and Limitations of the Research

This article offers contributions in several ways. First, based on an empirical case and the collection of microdata, it allows understanding how the academia–enterprise relationship can be potentiated through the implementation of OICs. On the other hand, it helps to identify what elements must be considered so that a model like this can be successful. It also contributes to the discussion on how to close the gaps between academia and industry, an increasingly relevant discussion on the role of higher education in the 21st Century.

Concerning the limitations, our study did not consider many sources of data, despite their relevance. For instance, we did not include micro-narratives and other qualitative data in our study. It is also important to address in more detail the vision of the companies participating in the OICs, to analyze the improvement indicators, and to be able to monitor the results post-study over time. Another limitation of the study is related to the size of the research sample and the need to investigate the vision of training entrepreneurs, as well as to contrast our findings with data from interns that did not participate in an OIC. Despite this limitation, the findings are statistically significant at the micro-level, and it opens the way to future research on different relational contexts and results in terms of tangible innovation products.

Our study addresses a current and relevant issue for the development of the country, as it is the relationship between academia and business, finding a gap to be addressed in future research on innovation management in SMEs.

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Abbreviations

OIC	open innovation community
ICT	information and communication technology
KM	knowledge management
KT	knowledge transfer
SME	small and medium-sized enterprise
SEM	structural equation model

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