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Social Networks and Open Innovation: Business Academic Productivity

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Abstract: Is there any type of relationship between the academic productivity of business researchers and their social networking activity? What does this mean in terms of open innovation? With these objectives, in this paper we have focused on the Technology Acceptance Model and the concept of performativity, filling the gap that exists in the current scientific literature. At the empirical level, we carried out a review of 211 articles from the Web of Science (SSCI), obtaining a total set of 12,939 data points. Our statistical model has showed a clear symbiotic relationship between productivity in Google Scholar and presence in ResearchGate. Furthermore, researchers with a greater presence on LinkedIn or Twitter have low Google Scholar or Web of Science h-indices. We concluded that there is currently a dissociation between academic and professional online networks, something that does not help the applicability of research in business and society, the enduring aim of any search for knowledge. Information Science can play an important role in helping to bridge the gap between academia and the real world. Furthermore, in order to contribute to enhancing the role of universities in open innovation practices, it is essential to design and implement new tools such as online communities that stimulate interaction and facilitate network effects.

Keywords: online social networks; open innovation; LinkedIn; Twitter; h-index; ResearchGate; business researchers

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1. Introduction

Information technologies, specifically online social networks (OSNs), are a focus of interest at the international level, and not only concerning individuals but also organizations [1].

On this subject, the emergence of OSNs such as Facebook, LinkedIn, and Twitter has caused a global phenomenon with a strong economic and social impact [2], and OSNs are recognized as important tools that allow large groups of users to be freely united and exchange knowledge, experiences, and perceptions [3].

In this regard, given the wide popularity of these networks, the study of user attitudes and behaviour in the use of these sites is fundamental to the understanding and development of these not-so-new technologies [4]. While some educators promote social media skills, more emphasis is still placed on the perceived dangers and abuses of the media in practice [5].

For their part, Kietzmann et al. [6] explain how consumers have traditionally used the Internet to read, watch, or buy products and services but now increase their use of platforms to create, share, and discuss content [7].

Given the high level of social network utilization in users' daily lives, these networks are analysed in many different disciplines, providing benefits for researchers and professionals who wish to collect and analyse social network data [8].

Further on the issue, the literature on social networks contributes to expanding the current knowledge concerning how motivations and emotions are coordinated to increase user satisfaction while identifying specific patterns for which these factors are important and greatly influence user satisfaction [9]. The review of these studies shows us the

broad benefits of OSNs and academic social networks (ASNs) in everyday life and their importance as working tools for researchers [10].

However, an analysis of the relationship between the academic productivity of researchers and their activity in ASNs and OSNs has not yet been carried out, and the influence it can have on open innovation processes between universities and companies. This research aims to understand the degree of connection that may exist between academic productivity and activity in the main academic networks, such as ResearchGate, and professional networks, such as LinkedIn or Twitter. Thus, our study attempts to address the first research question: Is there a relationship between academic activity and presence or activity in social networks?

Furthermore, it should be noted that the notion of open innovation is becoming more and more widespread both in academia and among policy makers [11]. It was defined by Chesbrough [12] as the possibility for firms to leverage external ideas and technologies. At the same time, they share internal ideas and technologies on which they do not take full advantage with external actors.

This definition directly associates the concept of open innovation with the business. Lichtenthaler is the most prolific author in the study of the impact of open innovation on the business world. His research is related to outbound open innovation with firm performance [13], firm absorptive capacity and performance related to open innovation [14], the importance of external knowledge acquisition in relation to technology [15], and the transformation of innovation processes in new business environments [16], among others.

The contribution of universities in this regard plays an increasingly prominent role in open innovation models [17]. In fact, Link el al. [18] and Johnson et al. [19] highlight the important role played by social networks in the exchange of knowledge between university and business. These same ideas are shared by [20] in their research on the main factors affecting knowledge transfer in an open innovation context. Among their conclusions, they highlight that social networks are the most important factor affecting the exchange of ideas and methods from the university to the business.

After this introduction, the following section sets out the conceptual and theoretical framework, as well as the identification of key study concepts. The hypotheses are set out in the third section, as well as the methodology used, the model variables and the approach followed in sections four, five, and six. The seventh section addresses the results obtained, while the eighth section contains the discussion to finally establish the conclusions, limitations, and future lines of research.

2. Conceptual and Theoretical Framework of the Research Question

The scenario in which we move presents a common denominator that appears in most organizations today and is the fact that workers use different social technologies to communicate while sharing knowledge with each other [21].

Social networks have become a standardized and global technological means of communication with great social, organizational, and even academic impact [22]. Therefore, this techno-social phenomenon [2] that has taken place since the mid-twentieth century has become the normal life of millions of users, becoming integrated into most organizations and environments, where workers value their presence and use and organizations realize their potential value [23].

There is a plurality of definitions of OSNs as working environments have become increasingly connected through these networks in different ways. Kaplan and Haenlein [3] (p. 61) define them as "a group of Internet applications that are based on the ideological and technological foundations of Web 2.0 and that allow the creation and exchange of user-generated content." They are also referred to as online communities between people with common interests, activities, backgrounds, and/or friends [24].

There are authors who have already introduced in the definition the idea of the creation of limited groups that are managed according to the interests of each one, such as Boyd and Ellison [25] (p. 211): "social networking sites are like web-based services

that allow people to build a public or semi-public profile within a limited system and then articulate a list of other users with whom they share a connection, and try to see and browse their list of connections and those made by others within the system."

However, researchers such as Donath and Boyd [26], Ellison et al. [27], and Forest and Wood [28] have analysed the challenges that can arise when people use social networks widely. These challenges take the form of fear of losing the power of knowledge [29] or lack of confidence [30].

The basis for the study of OSNs is found in the technology acceptance model (TAM), an information systems theory that models how users come to accept and use a technology [31–34]. Hence, authors such as Rauniar et al. [4] and Verma et al. [35] have focused their work on the validation of this model to obtain key variables that provide more information on user behaviour in big data or OSNs. TAM has also been proposed as one of the 20 models that Aboelmaged and Mouakket [36] have extracted from their bibliometric analysis on emerging models and theories that shape the adoption of big data analytics adoption. TAM has evolved to become the key model in understanding the predictors of human behavior toward potential acceptance or rejection of the technology. The strength of the model is confirmed by numerous studies emphasizing its broad applicability to various technologies [37].

The increase in the use and popularity of social networking sites makes academics and professionals want to understand the behaviour of people using these applications [38–40]. Hence, the purpose of this research is to deepen a part of that behaviour through knowledge of the degree of connection between academic productivity and presence in professional social networks such as LinkedIn and Twitter by researchers.

In this regard, it is useful to introduce two concepts related to our research. These are the concept of productivity and the concept of the WOS h-index.

The concept of productivity, in general terms, is understood as the relationship between the results or outputs obtained in the work process and the inputs or supplies used to obtain those results [41]. Applied to the present case, the productivity of academics is measured by their h-index. The h-index, introduced by Jorge Hirsch in August 2005, indicates that a scientist has an h-index if h of his Np papers have at least h citations each and the other papers (Np-h) do not have more than h citations each. This aroused great interest in computer circles, and within a short time, the h-index was applied to compare scientists [42].

The Web of Science h-index represents an indicator of productivity used for the elaboration of academic rankings of universities in the world [43]. The aim is to verify whether there is a relationship between the Web of Science h-index and the activity of academic business researchers in social networks [44].

These online networks are social spaces where interactions can be both personal and professional, and therefore academic. In these spaces, users can create a personal network with multiple connections to friends, acquaintances, and professional colleagues. They provide interactive and easy-to-use communication, while allowing people to follow the lives of their friends and family, discover useful information, and engage in business transactions [45]. Hongjie et al. [46] recently studied how measures to contain pandemics such as COVID-19 can be communicated.

Open innovation emphasises the interaction and participation of diverse social actors as a central element of innovative processes; the use of these networks is essential [17]. Innovation takes place through interaction in the framework of knowledge networks [47] and does not depend on the isolated performance of specific actors, but on the quantity and quality of the relationships that link these actors in networks of knowledge exchange and creation [48,49].

Every second, an average of 6000 tweets are produced, which means that, over the course of a year, approximately 200 billion tweets will be generated [50]. This figure shows us the capacity of communication and interaction that this platform can have, not only on a social level but also on a professional level. Twitter is not only an online social network

but also an increasingly important means of communication [51] with different types of users, some of them very influential [52].

Academic researchers recognize the value of studying Twitter data to gain a better understanding of its users, uses, and impacts on society and culture from different perspectives [25,53,54].

LinkedIn, as a broad professional network covering all professions, also provides researchers with access to the entirety of all users' careers, which is embodied in a site where professional relationships can also be built academically and where members self-select the groups to which they want to belong and can initiate specific international relationships not otherwise possible [55]. Meanwhile, ResearchGate is reserved only for researchers seeking to promote their work and connect with users working in the same area or field of research.

ResearchGate is one of the most important academic social networks. It provides a wide range of bibliometric indicators, including ResearchGate Score as a point system combining publication downloads, citations, etc. Thelwall and Kousha [56] found that ResearchGate usage data indicate esteem or influence within the scientific community. Researchers increasingly use the various online profiles provided by ASNs to show their experience and academic and scientific achievements [57–60].

This connectivity at a global level has led authors such as Jarrahi and Sawyer [61] to consider the performativity of LinkedIn and Twitter, understanding this performativity according to Austin [62] as the capacity that some expressions or practices carried out in OSNs may have to become actions and therefore transform reality or the environment. Science and Technology studies have completed and enriched the concept of performativity, highlighting that the meaning and effectiveness of scientific statements cannot be dissociated from the socio-technical aspects [63]. The realist and constructivist perspective of the concept is provided by Latour [64], since he exposes on the one hand that it is not possible to make anything exist, and on the other hand constructivist because for any entity there are thousands of ways to exist. Hacking [65] perfectly captured this double dimension of scientific practices.

The performativity of technology is based on the implementation of particular social practices for each of these social technologies. In this line, the performativity of Twitter provides access to an interorganizational network of social contacts, while in the case of LinkedIn, this performativity related to the practices of locating experts is the opportunity to expand the capabilities of people to find specialists in different topics and the opportunity to connect with people who can provide valuable solutions to work-related problems from a different perspective [61].

ASNs are being used by an increasing number of early career researchers to build their international profile and connect with researchers around the world [66]. ResearchGate scores are an effective indicator of reputation [67] that provides information on academic productivity, and as Yu et al. [68] point out, the ResearchGate score has shown potential as an alternative performance indicator for academic institutions and could be an "effective indicator to measure the performance of an individual researcher."

At this point, the first research question we raise is:

Is there any relationship between the academic productivity of researchers in business and their activity in social networks, whether academic or professional?

Fraser et al. [69] found in this same line that accounting practitioners' perception of academia and use of academic research is very low, and due to a disconnect from real-world practice, academic business researchers and business schools will become increasingly vulnerable to adverse research funding decisions in the future [70]. Johnson and Orr [71] included academic leaders and business stakeholders in their study on academic researchers considering the influence of the Framework for Research Excellence. Van Dalen [72] detected a clear division among economists regarding the "publish-or-perish" principle.

Veletsianos and Kimmons [73] argue that academic research is being done in a networked and participatory way and point out, together with other authors [74,75], that

metrics supported by altmetrics technology, indices based on activity in social media environments [76], are proposed in an attempt to more fully capture the influence of academic work [77].

We should specify that, for our study, we consider all types of social networks as OSNs, whether they are ASNs (e.g., ResearchGate or Publons), professional OSNs (LinkedIn and Twitter), purely social OSNs (Facebook) or mixed OSNs with various uses (e.g., Instagram). ASNs, in particular, can provide academic impact measures that can help to ascertain the relationship between academia and professional visibility [78].

3. Hypotheses, Method, and Research Model

3.1. Hypotheses

The relationship between academia and professional visibility, understood as the appearance and activity in ASNs (ResearchGate and Publons) and professional OSNs (LinkedIn and Twitter), is investigated. Based on the study carried out and previous information, we postulate the following:

Hypothesis 1 (H1). *There is a relationship between academic productivity measured through the h-index and activity in OSNs.*

Two sub-hypotheses of hypothesis 1 underlie taking into account the applied h-index.

Hypothesis 1.1 (H1.1). *There is a relationship between academic productivity according to Google Scholar's h-index and activity in OSNs.*

We seek to relate the Google Scholar h-index through citation counts that provide the rankings of an individual researcher's faculty in relation to others in their field [79] with the presence that the authors maintain in social networks.

Hypothesis 1.2 (H1.2). *There is a relationship between academic productivity according to the Web of Science h-index and activity in OSNs.*

3.2. Research Method

The research methodology employed is explanatory, using the technique of multiple regression analysis based on the study of the relationship between variables measured on a quantitative scale.

On 18 April 2020, this research was initiated by conducting a search of the main collection of the Web of Science, limiting SSCI between the years 1900 and 2020 to "all types of documents" in the theme "LinkedIn," resulting in 616 documents (of which 132 are Open Access). Refining the search by document type to "items only" yielded 411 items, and then refining it again by business* manage* company* gave a result of 211 items. A total of 588 authors or coauthors were counted. It should be noted that the maximum number of authors per article found was 23. Of the 588 authors, we finally focused on the search for data from 521, as some of them participated in more than one article [80].

Another search was also performed by adding the term LinkedIn to Twitter, which extended the results to 1111 articles. We decided to focus on LinkedIn only due to the professional nature of the network, although in the empirical part of our work, we have included the presence of researchers on Twitter as an additional tool that provides us with more data on the professional profile of the academic. LinkedIn, as they define themselves, have as their vision "to create economic opportunities for every member of the global labor market through the continuous development of the world's first economic chart" and have as their mission "to connect professionals from all over the world to help them be more productive and achieve all their career goals" [81], while Twitter is a generalist communication tool, defining themselves as "advocates for free expression and protecting the health of the public conversation around the world" [82].

The basic research objective, as stated above, is to see the degree of connection between academia and professional visibility, understood today as the appearance and level of activity in the main professional networks on the Internet: LinkedIn and Twitter. For academic activity, we used two productivity measurement indices: WOS h-index and Google Scholar h-index. For the activity in OSNs, we focused on LinkedIn and Twitter; in addition, we collected the activity in ASN ResearchGate and presence in Publons. As intermediate instruments to find academics, when it is difficult to locate them through the previously discussed networks, we will use Facebook, YouTube or Instagram.

The 211 articles resulting from our selection written by 521 research authors on the subject of "business" have given rise to two types of analysis items, the article item and the author item. From the item article, we extracted the following data: Keywords, Theories used in the study, Type of analysis (Quantitative/qualitative, Theoretical/empirical), Conclusions, Indexation in Journal Citation Reports (Quartile), Category, and Observations.

From the item author, we extracted the following data: Name, Gender, ORCID, Contact Academic, University, Country, h-index WOS, h-index Google Scholar, Profile in Publons, ResearchGate presence/number of items, ResearchGate Score, RG Photo, RG Number of Followers, RG Number of Followed People, LinkedIn Presence, LinkedIn Number of Contacts, LinkedIn Photo, Twitter professional profile, Tw Number of Tweets, Tw Number of followers, Tw Number of followed people, and Observations.

In our work, we used two data sets. First was data obtained from 211 articles filtered from the Web of Science (SSCI) with the criteria that have been detailed in the methodology, analysing the information from 7 records extracted from each of these articles. This resulted in a total of 1477 data points in this first set.

Second, each of the authors who signed the articles was analysed, with a total of 521 authors, of which a total of 22 records were collected from each of them, ranging from affiliation to different indicators of academic productivity, as well as other indicators of each of the social networks analysed in the articles, such as ResearchGate, LinkedIn, and Twitter. This results in a total of 11,462 data points in this second set. All of this information has brought the size of the total data set of our research to 12,939 data points. Therefore, the sample size in our study, based on previous research, is considered appropriate [83].

In summary, the methodology is compiled in Table 1:

Table 1. Methodology.

Research Start day	18 April 2020
Objective:	To find out the degree of connection between academia and professional visibility on the internet in professional networks: LinkedIn and Twitter.
Method:	Search in Web of Science main collection, limiting SSCI between the years 1900 and 2020 to all types of documents, on the topic LinkedIn.
Result after refining:	211 articles with 521 authors; 12,939 total records.
Indices used:	WOS h-index and Google Scholar h-index.

Source: Own elaboration.

3.3. Model Variables

The variables used in the proposed models (Table 2), both dependent (h-index of Web of Science and h-index of Google Scholar) and independent (the rest of them), are presented and defined below:

Table 2. Variables used in the study.

Dependent Variables	h-index Web of Science h-index Google Scholar	Quantitative value Quantitative evaluation
Independent Variables	JCR	(0, 1, 2, 3, 4)
	ORCID	(0, 1)
	AC	(0, 1)
	PUB	(0, 1)
	RGPres	(0, 1)
	RGS	Quantitative value
	RGPh	(0, 1)
	RGFWers	Quantitative value
	RGFWing	Quantitative value
	LKPres	(0, 1)
	LKNc	Quantitative value
	LKPh	(0, 1)
	TWPres	(0, 1)
	TWFWers	Quantitative value
	TWFWing	Quantitative value

Source: Own elaboration.

H-index of Web of Science (hindexWOS): the index that the Web of Science gives for each author.

H-index of Google Scholar (hindexGoogleScholar): the index that Google Scholar offers for each author.

JCR: indexing of the Journal in the Journal Citation Reports list on the Web of Science and, if applicable, the quartile in which it is located. It takes the values (0, 1, 2, 3, 4), 0 in the case of non-indexation or 1 to 4 depending on the quartile in which the journal is positioned at the time of the search [84].

ORCID: Open Research and Contributor ID is a unique identifier whose main purpose is to provide researchers with a persistent and unambiguous author code that clearly distinguishes their scientific production and avoids confusion linked to scientific authorship and the existence of similar names [85]. It takes the values (0, 1), 0 if no ORCID and 1 if yes.

Academic contact (AC): e-mail of the university or affiliation centre that the author puts either in the article or in social or professional networks to be contacted. It takes the values (0, 1) in the case of inexistence or existence.

Publons (PUB): presence on your website [86]. On this platform, part of Web of Science, the author follows the impact of his publications, as well as his reviews of other works. It takes the values (0, 1) in the case of inexistence and existence of a profile.

ResearchGate (RG): purely academic social network. They define themselves as "the professional network for scientists and researchers. Over 17 million members from all over the world use it to share, discover, and discuss research. We're guided by our mission to connect the world of science and make research open to all."

In our study, RG will be represented by a composite index. To calculate it, a factorial analysis has been done as a method of validation of the same [87] with the idea of looking for the minimum number of dimensions capable of explaining the maximum of information contained in the data. The variables taken into account to carry out the factorial analysis were:

RGPresence: takes the value 0 when there is no presence in this network. It takes a numerical value equal to or greater than 1 when the author has put contributions in this network depending on the number of items he has updated.

RGScore (RGS): takes the value 0 when it has no mark in this network, and a positive value otherwise.

RGPhoto (RGPh): takes the values (0, 1) depending on the existence or absence of a personal photo.

RGFollowers (RGFWers): quantitative value in the interval of 0 to the maximum number of followers in the network.

RGFollowing (RGFWing): quantitative value in the interval of 0 to the maximum number of followed academics.

To determine the degree of presence of the authors in social networks, we used various indicators derived from their appearance on LinkedIn and Twitter. A social network presence metric that jointly integrates both networks has not been found in the academic literature. All of the authors use as metrics those thrown by each social network [88]. In the case of LinkedIn, presence is measured through the existence of an account, the number of contacts, and the existence of a photo. Regarding Twitter, the data we extracted as indicators of presence in this network are the existence of a professional Twitter profile and the numbers of Tweets, Followers, and People Followed. Karampela et al. [89] use as a scale of measurement of social presence the variables of Ou et al. [90] adapted to their study (There is a sense of human contact on supplier X's social media. There is a sense of personalness on supplier X's social media. There is human warmth on supplier X's social media).

In our case, we created a composite indicator taking into account the five variables referred to ResearchGate, which is adjusted, although the variables explain only 59.24% of the index created. The most irregular items are photo included, with a coefficient extracted from the factor analysis of 0.418 and number of people followed, with a coefficient extracted from the factor analysis of 0.370, so these variables are not advisable to measure the constructed index. The remaining variables (RGPres, RGS, and RGFWers) have an acceptable coefficient because they are closer to one. We perform a second factorial analysis for this index by eliminating these two items. The result is a much tighter model with a Bartlett's significance of 0.000 and a total variance explained of 80%, where the variables that compose its RGPres, RGS, and RGFWers have a coefficient extracted from the second factorial analysis between 0.760 and 0.817.

LinkedIn (LK): They define themselves as the world's largest professional network with over 645+ million users in over 200 countries and territories whose vision it is to create economic opportunities for every member of the global labour market through the continued development of the world's first economic chart and whose mission it is to connect professionals around the world to help them be more productive and achieve all their career goals [81].

LinkedIn is a composite indicator obtained through factorial analysis. The variables that have been taken into account in its creation are:

LKPresence (LKPres): takes the values (0, 1) based on if the profile exists in this network.

LKNumberofContacts (LKNc): if yes, number of contacts in the network.

LKPhoto: LKPh: takes the values (0, 1) for the existence or absence of a photo in this network.

The variable LKNc has a very low value, very close to 0 (coefficient extracted from the factorial analysis of 0.014), so it must be extracted from the composition of the index. We carry out a second factorial analysis for this index, eliminating this item. The result is a very tight model with a Bartlett's significance of 0.000 and a total explained variance of 85%, where both variables that compose it, LKPres and LKPh, have a coefficient extracted from the second factorial analysis of 0.850.

Twitter (TW): professional network specialized in communication. On their website, they state as their "philanthropic mission to spread and expand the power of Twitter and the talent of our employees through direct civic interaction, staff volunteerism, charitable contributions, in-kind donations, and using the Twitter service in a positive way" [82].

Twitter is a composite indicator also obtained through factorial analysis. The variables that have been taken into account for its formation are:

TWPresence (TWPres): takes the values (0, 1) depending on the presence of the researcher in this network.

TWFWers: quantitative value indicating the number of followers in the network.

TWFWing: quantitative value indicating the number of people followed by the researcher in the network.

The result is a poorly adjusted model with a very low value of the item TWPres (coefficient extracted from the factor analysis of 0.072), so it must be removed from the composition of the indicator. When the factorial analysis is performed again, the result is that the TWFWers and TWFWing variables that now make up the indicator explain 70% of it, being well adjusted with a Bartlett significance of 0.000 and a coefficient extracted from the second factorial analysis of 0.997.

To test our hypothesis, we proposed two models, one with each of the dependent variables, the h-index of Google Scholar (h_indexGS) and the h-index of Web of Science, as follows:

$$h_indexGS = \alpha + \beta 1\ JCR + \beta 2\ ORCID + \beta 3\ AC + \beta 4\ PUB + \beta 5\ RG + \beta 6\ LK + \beta 7\ TW \quad \text{(Model 1)}$$

$$h_indexWOS = \alpha + \beta 1\ JCR + \beta 2\ ORCID + \beta 3\ AC + \beta 4\ PUB + \beta 5\ RG + \beta 6\ LK + \beta 7\ TW \quad \text{(Model 2)}$$

It must be taken into account when evaluating the results of both models that Google Scholar has more flexibility and is more generic in nature because it is freely accessible and each author designs his or her own academic profile, while Web of Science has restricted access and follows strict control of references to indexed documents and the author does not have access to his or her profile (it is the system itself that includes them), resulting in a certain index [91].

It should be noted that the variables RG, LK, and TW have been included in the model as composite indices resulting from the grouping of each of the individual reference variables.

4. Analysis

The statistical analysis of this study was carried out using the statistical package SPSS (Statistical Package for the Social Sciences), version 25. The multiple linear regression procedure was used (with a probability for the input F of $p = 0.05$ and the output $p = 0.10$) to analyse both the relationship between academic productivity indicators (Google Scholar's h-index and WOS h-index) and different independent variables related to the academic and professional world. It was previously analysed if they had outliers (abnormally extreme scores) because they could bias the regression coefficients [92], which went undetected.

Following the usual protocol Cohen [93] to avoid problems of multicollinearity, focused scores were used. Interaction analyses were carried out using the procedure of [94].

Two multiple regressions were performed for each of our dependent variables (Google Scholar h-index and WOS h-index).

Model 1: Regression for the Google Scholar h-Index dependent variable

The determination coefficient indicates that the constructed regression model explains 58% of the variance of the Google Scholar h-index (adjusted $R^2 = 0.586$). Cohen [93] argues that a magnitude of R^2 greater than 0.26 indicates a large effect size (Table 3).

Table 3. Google Scholar h-index Regression Statistics (Model 1).

Model 1	R	R^2	R^2 Adjusted	Standard Error of the Estimation
1	0.765	0.586	0.580	9.135

Source: SPSS.

The validation of the predictive model was performed with ANOVA (Table 4), which indicates whether the variance explained by the regression is significantly different and greater than the unexplained variance. The model was found to be statistically significant ($F = 103.06$; $p = 0.000$), thus improving the prediction of the Google Scholar h-index and assuming a real effect of the predictor variables on the dependent variable.

For the regression model coefficients, t-scores indicate that the variables taken into account provide significance to the prediction model and that the values obtained can be generalized to the population. In this study, the dependent variables ORCID ($t = 1710$;

$p = 0.000$), Twitter ($t = -8146$; $p = 0.000$) and ResearchGate ($t = 24{,}403$; $p = 0.000$) contribute significantly to the predictive model of Google Scholar's h-index (Table 5). The variable that has the most weight is ResearchGate (β = 0.772), followed by Twitter (β = −0.248) and ORCID (β = 0.066).

Table 4. ANOVA result for Model 1.

	Sum of Squares	df.	Mean Square	F	Sig.
Regression	60,201.252	7	8600.179	103.064	0.000
Waste	42,557.051	510	83.445		
Total	102,758.303	517			

Source: SPSS.

Table 5. Estimation of Model 1.

Independent Variables	Non-Standardized Coefficients	Standardized Coefficients			
	B	Error	Beta	*t*	Sig.
JRC	0.634	0.371	0.049	1.710	0.088
ORCID	2.516	1.140	0.066	2.208	0.028 *
AC	−0.641	0.836	−0.022	−0.767	0.443
TW	0.000	0.000	−0.248	−8.146	0.000 *
RG	0.040	0.002	0.772	24.403	0.000 *
LK	0.446	0.454	0.029	0.982	0.327
PUB	0.728	0.879	0.025	0.828	0.408

Source: SPSS0. * $p < 0.05$.

Model 2: Regression for the Web of Science h-index dependent variable

The determination coefficient indicates that the constructed regression model explains 13.5% of the Web of Science h-index variance (adjusted $R^2 = 0.135$) (Table 6).

Table 6. Web of Science h-index Regression Statistics (Model 2).

Model 2	R	R^2	R^2 Adjusted	Standard Error of the Estimation
2	0.384	0.147	0.135	9.327

Source: SPSS.

The model has been proven to be statistically significant ($F = 12.519$; $p = 0.000$), improves the prediction of the Web of Science h-index and allows us to assume a real effect of the predictor variables on the dependent variable (Table 7).

Table 7. ANOVA result for Model 2.

	Sum of Squares	df.	Mean Square	F	Sig.
Regression	7623.242	7	1089.035	12.519	0.000
Waste	44,190.547	508	86.989		
Total	51,813.789	515			

Source: SPSS.

In this case, the dependent variables ResearchGate ($t = 1710$; $p = 0.000$), Publons ($t = -8146$; $p = 0.000$), AC (academic contact) ($t = 24{,}403$; $p = 0.000$) and LinkedIn ($t = -1991$; $p = 0.047$) contribute significance to the predictive model of the WOS index h (Table 6). The variable that has the most weight, as in the case of the results obtained for Google Scholar's h-index, is ResearchGate (β = 0.268) (Table 8).

Table 8. Model 2 Estimate.

	Non-Standardized Coefficients		Standardized Coefficients	
Independent Variables	**B**	**Error**	**Beta**	**t**
JRC	0.397	0.379	0.043	1.047
ORCID	1.312	1.169	0.048	1.122
AC	−2.196	0.857	−0.106	−2.563
TW	7.254×10^{-5}	0.000	0.082	1.877
RG	0.010	0.002	0.268	5.879
LK	−0.926	0.465	−0.083	−1.991
PUB	2.591	0.899	0.126	2.883

Source: SPSS.

To ensure the validity of the model, the assumptions of the linear regression model were checked. The collinearity between the predictors could produce problems as a very unstable regression coefficient. For this purpose, the tolerance of the independent variables and the variance inflation factors (VIF) was checked for both the Google Scholar h-index and the WOS h-index. The tolerance of an independent variable corresponds to the proportion of the variance that is not associated with the other dependent variables. The tolerance values of all independent variables, for both the Google Scholar h-index and the WOS h-index, exceed the minimum of 0.200 [95]. In turn, the VIF of the independent variables indicates for both indices that the assumption of non-multicollinearity is fulfilled because neither exceeds the limit of 10 [96]. The independence of the errors between them (not autocorrelation) was studied with the Durbin-Watson test, obtaining a value of 1.846 in the case of model 1 and 1.591 in the case of model 2 [97]. Through White's test, it was proven that the variance of the residues is constant (homoscedasticity) and following the central limit theorem that stipulates that the distribution of the mean tends to a normal distribution as the sample size increases, we consider that, in both models, the sample is normal.

5. Discussion; Open Innovation for Business Academic Productivity

From the literature review relating scientific research to open innovation, we found that according to Raunio el al. [98], the logic of open innovation and open co-creation is increasingly applied to interactions between university, industry, and society. This makes the collaborative culture of universities more permeable. Innovation platforms form new environments for interaction, which foster a culture of open innovation and a collaborative way of working.

For Vélez-Rolón et al. [99], the factors that drive companies to engage with universities in open innovation activities are the development of an innovative business model and the complexity of the technology. It is important to develop tools that stimulate interaction, knowledge creation, and that expand the network of contacts. This is made possible, in part, by networking, which improves researchers' attitudes towards knowledge transfer with business and society at large [100]. Although for Striukova and Rayna [101] the involvement of universities in open innovation goes beyond simple knowledge sharing, having a key intermediary role in providing a trusted environment for collaboration.

Many authors argue that online communities and networking are important factors in making open innovation a reality between the university and the business world and/or society in general [20,102,103].

Following the first research question, one aim of this research was to explain the possible relationship between the productivity of business researchers measured in terms of index h (from Google Scholar and Web of Science) and their activity in OSNs, both academic (ResearchGate or Publons) and professional (LinkedIn and Twitter), as well as

the existence of academic contact and its registration in ORCID, using a multiple linear regression statistical model.

It has been seen in the review of the literature carried out that the researchers themselves have been interested in online social networks as a field of knowledge, as well as a source of information for their work and tool for understanding the habits, uses, and value of their users [25,53]. This has demonstrated the importance of OSNs in the academic world and in the specific field of business researchers.

Based on the Technology Acceptance Model (TAM), the conclusions reached in this study take on special meaning. While OSNs occupied a secondary place for academia as a basis of communication in its early days, they have now become a vitally important element as a means of exchanging information and knowledge, where contacts can be established while generating a symbiotic relationship between academic and professional networks.

Another of the concepts included in the theoretical framework, the performativity of technology, has full practical application in the research that we are dealing with because it has been demonstrated with our analysis that professional OSNs represent an opportunity for emerging researchers to create academic networks to develop networking and thus increase their productivity. The users of the different OSNs identify themselves with a specific target depending on the social or professional group to which they belong.

The empirical results of our analysis have led us to accept the two hypotheses raised, although for the second, the relationship is very weak because the independent variables explain a very low percentage of the model. In both cases, the relationship is in the opposite direction.

6. Conclusions

Among the main conclusions drawn from our research, we found that ResearchGate have a significant and positive relationship with each of the h-indices (Google Scholar and Web of Science), coinciding with authors such as Yu et al. [68] and Nicholas et al. [67], who defend that it is an indicator of academic reputation. Furthermore, this relationship is particularly strong in the case of Google Scholar because it has a higher β coefficient. The symbiosis between these platforms is clear and responds to the need to network and connect scientists working internationally in the same branch of knowledge.

The use of social networks by academics is increasingly common because they provide another opportunity to present themselves and their work to a wide audience [57], although studies on this subject have thus far emphasized the exchange of information through websites [104] or the study of scientific blogging [105,106]. The result of our study fills the gap in the current scientific literature, showing that, in the case of Google Scholar, the influence of Twitter exists but in a negative sense, as in the case of Web of Science, where a LinkedIn influence is demonstrated but also in the opposite direction.

Therefore, researchers with a greater presence on LinkedIn or Twitter have low Google Scholar or WOS h indices, and it could be argued that established authors in their areas of knowledge do not need the dissemination provided by professional social networks and that their presence on academic social networks is sufficient. In the case of WOS, it is also clear that the academic contact that appears in most cases is that of authors with a lower level of scientific publication.

These results link to an observation found during the conduct of the study in the case of the coauthors. Two situations were normally presented. First, an author is unknown and is the first author, so we understand that he is the one who has put in the most work, i.e., mechanical-type work. Second, among several authors, there is always one or several who are more academic and another or others who are more professional. Some authors have more information in academic networks versus others who have more information in professional networks, being co-authors in the same article. This indicates that, in these cases, the combination of academia and professional practice is optimal.

Both the ORCID variable and the profile-related variable in PUBLONS are significant with respect to the Google Scholar h-index and the WOS h-index, respectively. Both

variables are of academic character, and the results obtained are consistent. Moreover, in the case of PUBLONS, it is a platform that forms part of WOS since it is used to follow the peer reviews that each researcher carries out on research projects.

However, it is clear that there is currently a dissociation between academic and professional networks; the latter are focused from a business point of view and not as a platform for knowledge dissemination [89], something that does not help the applicability of research in society, the ultimate goal of any search for knowledge.

6.1. Implications

This work has consequences both for the research/academic world and for society in general. Firstly, this study contributes to the recognition by the academic literature of the importance of Social Networks. Specifically, Social Networks have transcended the recreational, familiar, or social field to reach the scientific field.

This insight is important because the fact that Social Networks have become the object of study by academics demonstrates researchers increasingly use academic and research social networks to show their work and progress in science.

Secondly, the research focuses on the Technology Acceptance Model applied to social networks and its relationship with the Performativity of technology.

On a practical front, our research provides the distinction, within social networks (OSNs), those of an academic/researcher nature (ASNs) such as ResearchGate or Publons, professional OSNs (LinkedIn or Twitter), purely social OSNs (Facebook) or mixed OSNs with various uses (e.g., Instagram).

Our findings help to evaluate the practical utility of OSNs for academic research, as well as to reflect on the role that universities can play, not only in the provision of knowledge and technologies, but also in processes of co-creation of innovations in the context of quadruple and quintuple helix models [98,102,107]. Meanwhile, the results of the study reveal a gap in the knowledge transfer between academia and OSNs. Finally, it should be noted that on a practical level, although it is true that research consumes time and money, universities produce many research articles per year, which are published in numerous indexed Scientific Journals, although very little of this research is being transferred to the classroom, as well as to OSNs.

We believe this study can play an important role in transmitting research results to society at large by using all kinds of social networks, helping to bridge the gap between academia and the real world through knowledge transfer.

6.2. Limits and Future Research

We consider a limitation of this study to be the inclusion of only ResearchGate, LinkedIn, and Twitter in the models. Expanding to include the presence of researchers in social networks such as Facebook or Instagram would offer interesting results.

The interrelation between open innovation and scientific production needs to be analysed in greater depth, as the active participation of universities in open co-creation networks could imply significant changes in terms of the actors, structures, dynamics, and processes of generation and dissemination of knowledge and innovations, breaking down institutional, disciplinary, and geographical barriers.

The following research work, already undertaken from the data set extracted, consists of comparing business researchers according to their gender, university, and country of origin.

Likewise, from the results of this study, important information can be extracted regarding the specific researchers in the area of business that have the highest level of connection between academia and practice. Having detected these authors, we intend to survey them through OSNs to provide practical solutions, from a business and employment point of view, to overcome the international health and economic crisis that we are currently experiencing.

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