Knowledge Intermediaries and Innovation Systems: Exploring a Neglected Theoretical Potential

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Abstract

Based on Howells (2006), the text evaluates the incorporation of intermediation and intermediaries in a systemic context, in particular, in the evolutionary perspective of innovation systems (IS), because in it the scope (theoretical and empirical) of this incorporation is unclear. For this purpose, a semi-systematic review is carried out which shows that empirical work predominates. These reveal that intermediaries enhance IS performance; that through intermediation they solve systemic problems such as the closing of gaps between IS subsystems; and for this purpose they act as mechanisms for coordination and generation of synergies, or for the development of IS actor capabilities. The evidence also indicates that systemic characteristics, such as the prevailing modes of innovation in the IS, condition the role and intensity of the intermediary intervention. These results reveal, in short, a high theoretical potential of the IS-intermediation articulation.

Keywords: knowledge intermediaries, intermediation, innovation systems, innovation, systemic innovation, innovation policy.

Submitted: April 19, 2024 / Approved: October 12, 2024

1. Introduction

Howells (2006) in his notion of intermediation, which became a reference point and inspiration for many publications on the subject, conceives of intermediaries as those organizations that support innovative companies by mediating collaboration with other actors to enhance their innovation processes. Such a notion fits the market environment. Extending it to innovation systems (IS) requires adapting it to a systemic logic. This has been done in the literature on technological transitions (Kivimaa, Boon, Hyysalo and Klerkx, 2019a) embedded in a systemic perspective.

However, in the literature on national, sectoral and regional innovation systems, the meaning and scope of the incorporation of this notion remain unclear. For example, it is not clear if the term has been articulated in the IS analysis framework, enriching it; or if, on the contrary, this incorporation has modified and enriched the notion of intermediation itself; or if the work is empirical and, therefore, if it allows for establishing the impact on the articulation or performance of IS. As a result, this paper seeks to establish what the contribution of this literature is to the understanding of the role of intermediation in IS, whether this has been predominantly empirical or whether it has a theoretical scope.

Establishing this contribution is useful especially for economies such as the Latin American ones where, despite having IS and science, technology and innovation (STI) policies to support them, the articulation between IS components is weak (Porto-Gomez, Zabala-Iturriagagoitia and Leydesdorff, 2019; Malaver and Vargas, 2005, 2013). That is, there are fractures also called systemic failures. And intermediaries could help to overcome them, by serving –by definition– as mechanisms to enhance the interaction between their components.

To achieve these objectives, the text has a literature review –articles registered in Wos and Scopus– of semi-systematic character –qualitative– (Snyder, 2019). From it, we first establish the general features of the body of work addressing intermediation from the IS perspective, and then evaluate the most relevant articles to answer the questions posed. The review finds the contribution of intermediaries to closing gaps between IS components, to improving their performance and, above all, to raising the effectiveness of IS-supported innovation policies to be high positive. It also shows that there is less theoretical and conceptual reflection and, therefore, the need and potential for new theoretical developments derived from a better understanding of intermediation –in IS–.

2. Analytical context: intermediaries, intermediation and IS.

Although the notion of intermediation has relevant antecedents –as Hargadon and Sutton (1997)–, that of Howells (2006) marks a turning point in the academic production on this issue. Since its appearance, it has become a reference for different approaches to the subject. For Howells, an intermediary is 'an organization or body that acts as an agent or connector between two or more parties at any stage of the innovation process' (Howells, 2006, p. 720). And he specifies that this is an 'organization that provides support for collaboration' during that process (De Silva, Howells and Meyer, 2018, p. 70). In such work, it acts as an intermediary of transactions between two or more parties, as a mediator between organizations that collaborate –facilitating their interaction–, or helping to find support or funding to achieve the results of such collaborations (Howells, 2006).

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The high impact of Howells' (2006) proposal is confirmed by the number of empirical works based on his notion of intermediation; the typologies of intermediaries it has inspired (Colombo, Dell'era and Fratini, 2015; McPhillips, 2020; Kivimaa et al., 2019a); and the high number of citations it has received. Moreover, its influence has spread by nurturing other notions –such as open innovation–, or by nurturing technological services –such as KIBS (knowledge Intensive Business Services)–, or innovation spaces –such as clusters or innovation ecosystems (Lefebvre, 2013; Ystrom and Aspenberg, 2017; McPhillips, 2020)–.

However, for the purposes of this paper it is essential to establish what has happened to the notion of intermediation when it has been applied in the IS context. Why? Because it is in the light of the core IS approaches that it is possible to understand how the notion of intermediation and the role of intermediaries fit there. It should be noted that Howells points out the applicability of the term in IS, but his view is *focused on intermediaries and their supporting role in specific firm innovation processes*, not in a systemic perspective.

There are different approaches to the notion of IS. In general, they agree that a system is made up of components/actors and functions, and that their interaction generates synergies that enhance individual and system performance (Lundvall, 2010). But the intensity and depth with which intermediation is assumed varies significantly in the different IS strands.

One perspective, that of Innovation Technology Systems (ITS), focuses on the core technologies of specific industries or activities, and emphasizes that the function of the system is the generation, diffusion and use of new knowledge and innovations (Bergek, Jacobsson, Carlsson, Lindmark and Rickne, 2008; Hekkert, Suurs, Negro, Kuhlmann and Smits, 2007; Edquist, 2011). In the literature on sustainable technology transitions, which draws on ITS approaches, the importance given to intermediation is notable. In this literature, Howells' notion of intermediation has been recontextualized and developed. It emphasizes the fundamental role of intermediaries as catalysts –changers– of the different phases and levels of a technological transition (Kivimaa et al., 2019a and Kivimaa, Hyysalo, Boon, Klerkx, Martiskainen and Schot, 2019b). Intermediaries are thus assigned a fundamental, changing role, determined by the systemic needs of the transition process.

From there, the notion of intermediaries is redefined and resignified, understood as:

> 'actors and platforms that positively influence sustainable transition processes, linking actors and activities, and their related resources and skills, or connecting the transition of visions and demands of actor networks with existing regimes for the purpose of creating *momentum* for Socio-Technical System change, to create new collaborations within/among niche technologies, ideas and markets, and to *disrupt* dominant unsustainable socio-technical configurations' (Kivimaa et al., 2019a, p. 1072).

This development of the notion of intermediary supports, in this case, the formulation of typologies of intermediaries that incorporate these conceptual developments thusly facilitate the comparison, interpretation and learning derived from the analysis of empirical work.

Another IS perspective is framed within the evolutionary theory of innovation (Nelson and Winter, 1982), which has its seminal works in Freeman (1987) and Lundvall (1988), and later in Nelson (1993) and Edquist (1997). Within this, there are important differences and nuances. Three (3) stand out here. One, the vision of Nelson and Winter (2002), is focused on science and technology driven industries or, in other words, on the STI way of innovating (Jensen, Johnson, Lorenz and Lundvall, 2007), where innovation with R&D predominates and universities, laboratories and research centers are central. This is expressed, equally, in the national and sectoral IS.

Another is the approach of Lundvall (2010), which considers Nelson's (1993) as a *narrow view* of IS and, therefore, proposes a *broader view* that includes the DUI way of innovating (Jensen et al., 2007). It emphasizes the construction of competences in the workplace through learning by doing, using and interacting (Lundvall, 2010, p. 332), and interaction as an intrinsic characteristic of the innovation process. Indeed, innovation is the result of interactive processes shaped by feedback from the actors involved in the different phases of innovation. Innovation networks are thus generated (Kline and Rosenberg, 1986). The institutional architectures –called IS– are designed precisely to support firms' innovation processes by strengthening and consolidating these networks through public STI policies (Arocena and Sutz, 2000). Such processes are influenced by national –institutional– particularities (Lundvall, 2010) and even regional ones, so much so that regional innovation systems (RIS) are considered as institutionalized learning processes (Cooke, 1996 and 2001).

The third evolutionary vision, by Edquist, shares with ITS authors the idea that the analysis of functions makes it possible to capture IS dynamics and performance (Bergek et al., 2008). In this regard, he considers that research on IS has paid more attention to their components (organizations and institutions) and less to their dynamic– processes– and how they change. What happens in IS can be captured through *activities*, defined as the factors that influence the direction and speed of the development and diffusion of innovations. Thus, the emphasis on activities or determinants is crucial for both innovation theory and policy development (Edquist, 2019). Therefore, he defines IS as 'all important economic, social, political, organizational, institutional factors (activities) that influence the development, diffusion and use of innovations' (Edquist, 1997, pp. 3, 11-12).

However, with regard to intermediation, it can be stated that, unlike what has occurred in the literature on technological transitions, the incorporation of this notion is opaque in the evolutionary perspective of IS. This, despite the fact that in this perspective, as noted, the interaction –facilitated by intermediation– is consubstantial to innovation.

Therefore, the aim here is to establish how intermediaries are incorporated into –national, sectoral and regional– IS and what the role given to intermediation is: whether this incorporation redefines intermediation and its role in the IS framework; whether it enriches the conceptualization of IS; or whether, on the contrary, empirical applications of intermediation predominate and, if so, what evidence they provide about their role in the functioning and performance of IS.

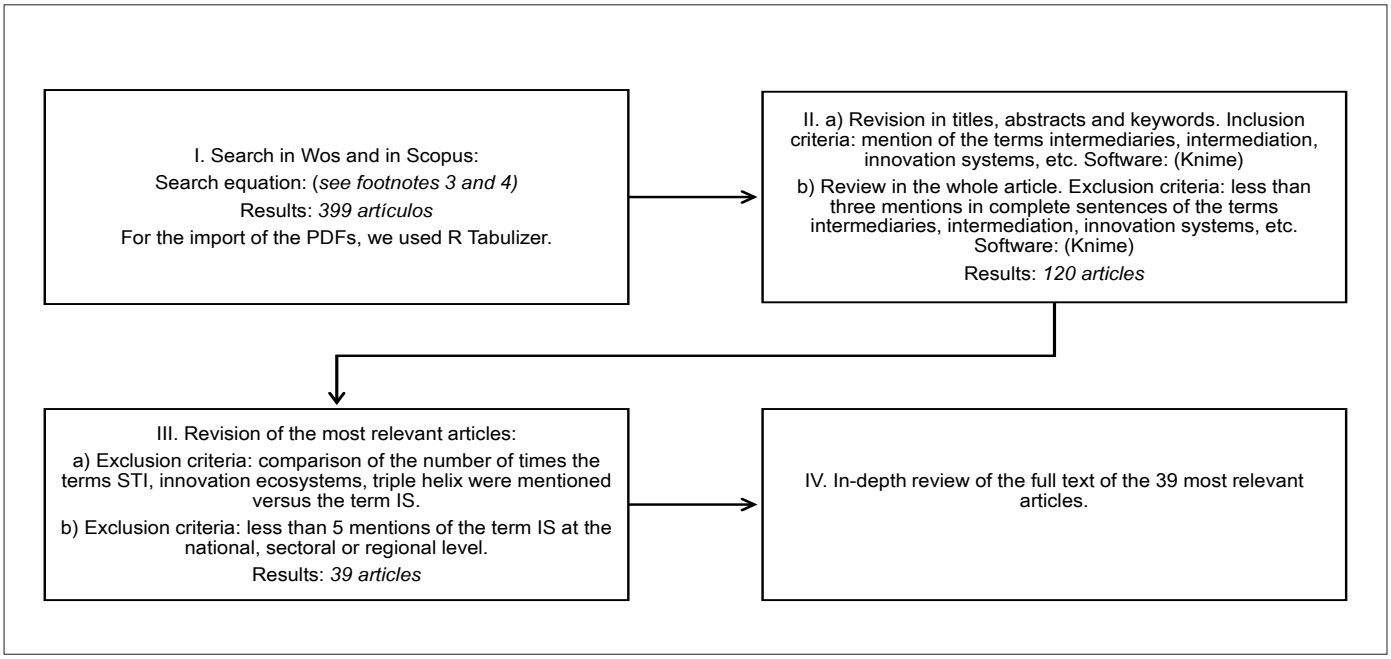
3. Methodology

In accordance with the nature of the review article, a preliminary inquiry showed that intermediation has been approached from various disciplinary perspectives and with different purposes, levels of generality, conceptualizations and methodologies; and that, in addition, empirical studies of a qualitative nature predominate, such as case studies. Therefore, this literature does not admit a systematic review and, even less, a meta-analysis (Siddaway, Wood and Hedges, 2019). It admits a qualitative review, but differences in approaches preclude a systematic qualitative review –a metasynthesis– . It applies more a semi-systematic review (Snyder, 2019). This makes it easier to establish, in the literature reviewed, how intermediation has been incorporated in IS, on what topics and levels it has been focused on; with what objectives and methodologies; and with what results. In this way, the review allows the objectives of the article to be achieved.

The following procedure was designed for the review:

i) To identify the academic production related to the topic, the review began with a search for the most relevant authors and papers on intermediation. To this end, a search equation was defined and applied in Wos[1] and Scopus[2] . The research covered from 2001 onwards, for reasons of data availability in these bibliographic databases, and because it allows confirmation of the effect of the appearance of Howells' text in 2006. This exercise identified, after eliminating repetitions, a total of *399* articles[3] (see Figure 1).

Figure 1. Stages of the review process



Source: Own elaboration

ii) Then, to better identify those articles that approached intermediation from IS perspectives, inclusion criteria were applied –relevance–, searching in the titles, abstracts and keywords for the terms intermediaries, intermediation, national, sectoral and regional innovation systems, using Knime software (Tursi and Silipo, 2019). Then, this sample of articles was decanted, extending the search for the term *innovation system* to the entire text of the article, identifying and extracting the *complete sentences* in which that term was mentioned, to establish the context in which it was used. And to ensure that the topic is indeed the object of analysis in the text, those papers that mentioned the term

[1](((TS= (knowledge intermediaries; OR intermediary organization; OR innovation intermediaries; OR technology intermediaries; OR intermediating knowledge; OR intermediating innovation; OR intermediation))) AND (((TS= (innovation; OR technological opportunities; OR window of opportunity; OR technological trajectory; OR technological change; OR catching up; OR new technology; OR technology transfer))) NOT ((TS= (bank OR financier))) AND LANGUAGE: (English OR Spanish) AND DOCUMENT TYPES: (Article)
[2](((TITLE-ABS-KEY (knowledge intermediaries; OR intermediary organization; OR innovation intermediaries; OR technology intermediaries; OR intermediating knowledge; OR intermediating innovation; OR intermediation))) AND (((TITLE-ABS-KEY (innovation; OR technological opportunities; OR window of opportunity; OR technological trajectory; OR technological change; OR catching up; OR new technology; OR technology transfer))) AND NOT ((TITLE-ABS-KEY (bank OR financier))) AND (LIMIT-TO (DOCTYPE, Article)) AND (LIMIT-TO (SUBJAREA, Business) OR LIMIT-TO (SUBJAREA, Economy)) AND (LIMIT-TO (LANGUAGE, English) OR LIMIT-TO (LANGUAGE, Spanish))
[3]For the import of the PDFs of the articles, the tool in R Tabulizer was used (Leeper, 2018).

innovation system less than three (3) times were excluded. This procedure reduced *the number of articles* that made up the *corpus* subjected to a basic bibliometric analysis to *120*[4].

iii) The analysis of the 120 articles showed the need to further refine the corpus by excluding those that, although they address the topic from a systemic viewpoint, do so from perspectives other than national, sectoral or regional IS, such as ITS, technological transitions, innovation ecosystems and the triple helix. To this end, the number of times these terms were mentioned was compared with the term IS. In addition, to ensure that IS are the central object of study in the articles, those that used the term less than 5 times at the *national, sectoral or regional level* were excluded from the corpus. Thus, the corpus was reduced to *39 articles*, the text of which was reviewed in depth in a fourth phase.

The procedure designed and the exercises carried out ensure that the articles selected addressed intermediation from the IS and that this analytical framework guided the analyses. And their replicability ensures the reliability of the selection.

iv) To achieve the objectives of this study, the in-depth analysis of the 39 articles sought to identify whether they addressed intermediation at the theoretical level (i.e., redefining the concept in light of the evolutionary framework of IS) or at the empirical level (i.e., establishing whether and how intermediation contributes to improving IS articulation or performance). The results of this exercise, viewed as a whole, make it possible to establish whether the incorporation of the concept of intermediation in IS contributes to a better understanding of the concept itself, of IS or their performance.

4. Results

The findings of the research are presented in two parts. The first presents the results of comparing basic bibliometric indicators of publications that address intermediation from a general perspective with articles focused on IS, to identify the characteristic features of the latter. The second part presents the findings on the contribution of intermediation to the understanding of IS at the conceptual or operational level.

4.1 Basic features of the literature on intermediation

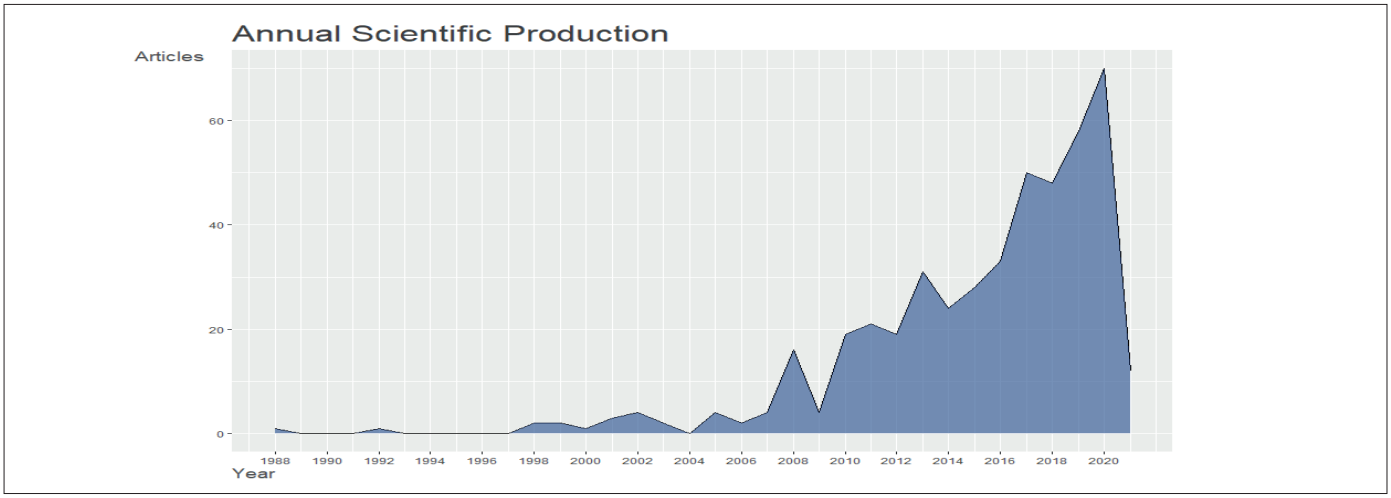
At the general level, a quick glance shows the impact of the Howells (2006) article. **Table 1** shows that between its appearance in 2006 and mid-2021 that article achieved 921 citations, that is, at an average of 61 citations per year. For the purposes of this review, the article inspired the 399 articles focused on intermediation/intermediaries. This equates to 26 articles per year, and with an increasing trend (**Figure 2a**). On the contrary, the volume of articles on intermediation from the IS perspective is small (**Figure 2b**). In fact, between 2006 and 2021 the number of articles registered in Wos and Scopus barely reaches an annual average of 8. In summary, the publication of articles on intermediation (Figure 2a) is proportionally greater and growing, while in IS the average is lower and decreasing (Figure 2b).

Table 1. Most relevant articles by citation

Year	Authors	No. of citations
2006	Howells, J.	921
2012	Mair, J., Marti, I., Ventresca, M.J.	448
2006	He, J.	347
2005	Balkin, DB., Gianiodis, P.T., Markman, G.D., Phan, P.H.	306
2010	Ahonen, M., Antikainen, M., Mäkipää, M.	208
2010	Clarysse, B., Knockaert, M., Spithoven, A.	201
2008	Hyysalo, S., Stewart, J.	160
2013	Kilelu, C.W., Klerkx, L., Leeuwis, C.	153
1999	El Sawy, O.A., Gosain, S., Malhotra, A., Young, K.M.	134

Source: Wos and Scopus

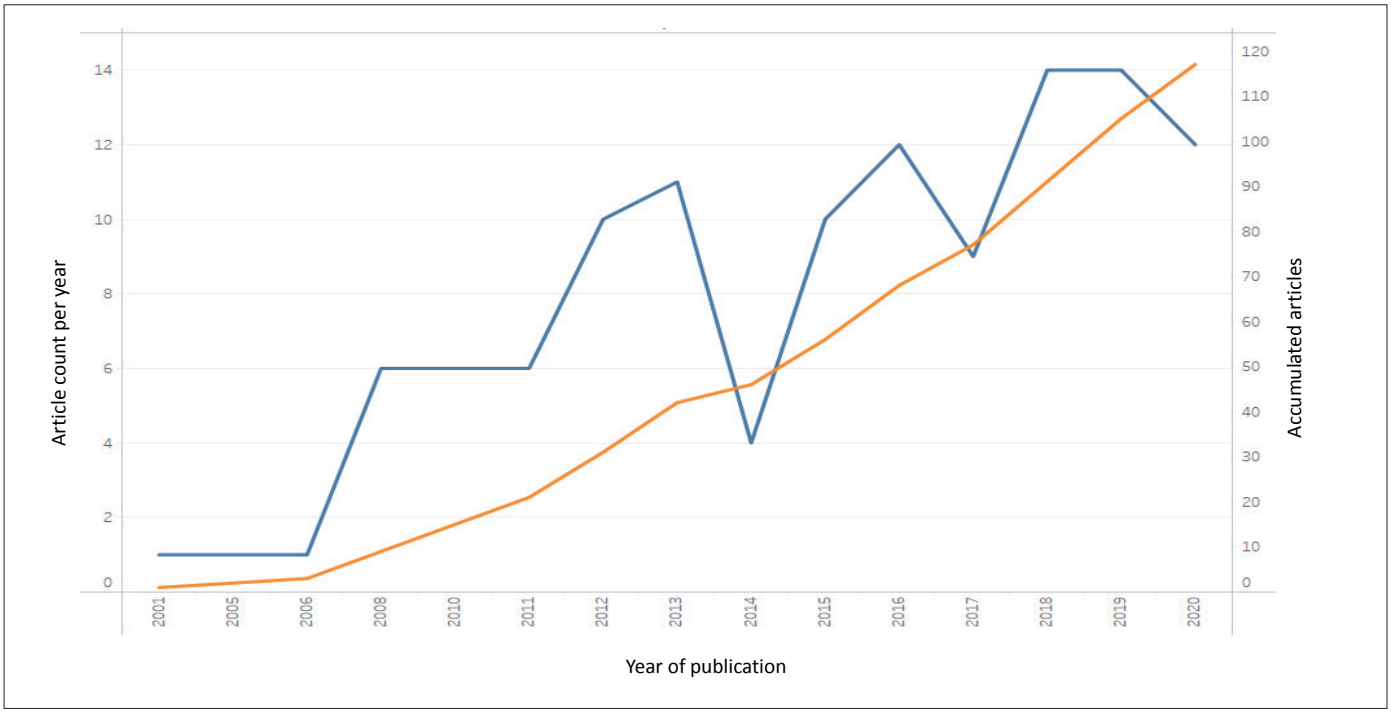
Figure 2a. Global intermediation (Number of articles per year)



Source: Wos and Scopus

[4]Tableau and VosViewer were used to visualize the results of the bibliometric analyses (van Eck and Waltman, 2009).

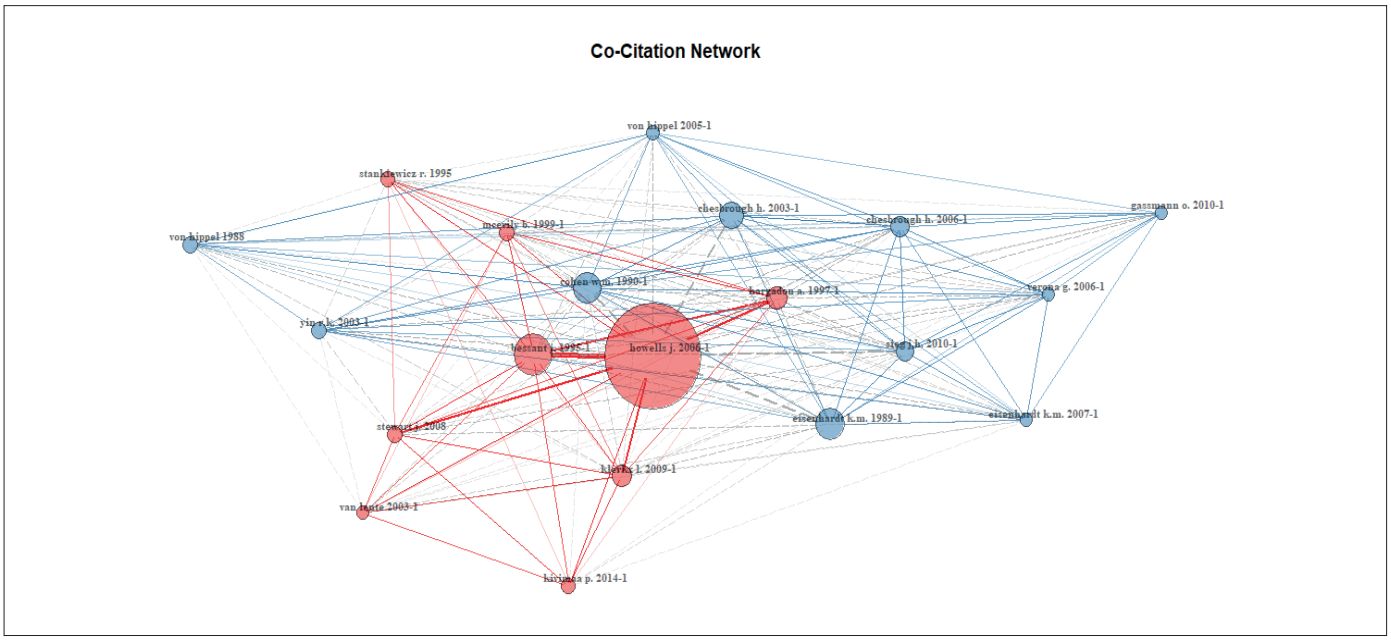
Figure 2b. Intermediation in IS (Number of articles per year)



Source: Wos and Scopus

A look at the total number of ***citations*** reveals two clearly defined networks (**Figure 3**). One is made up of authors who focus on innovation management, including Howells, Chesbrough, Von Hippel, Cohen and Levinthal, and Eisenhardt. Another, configured around technological transitions, where Howells, Klerkx, Kivimaa, Hyysalo, Van Lente stand out. In this scenario, no authors related to IS are highlighted, indicating that none of them is a main reference for those who study intermediation.

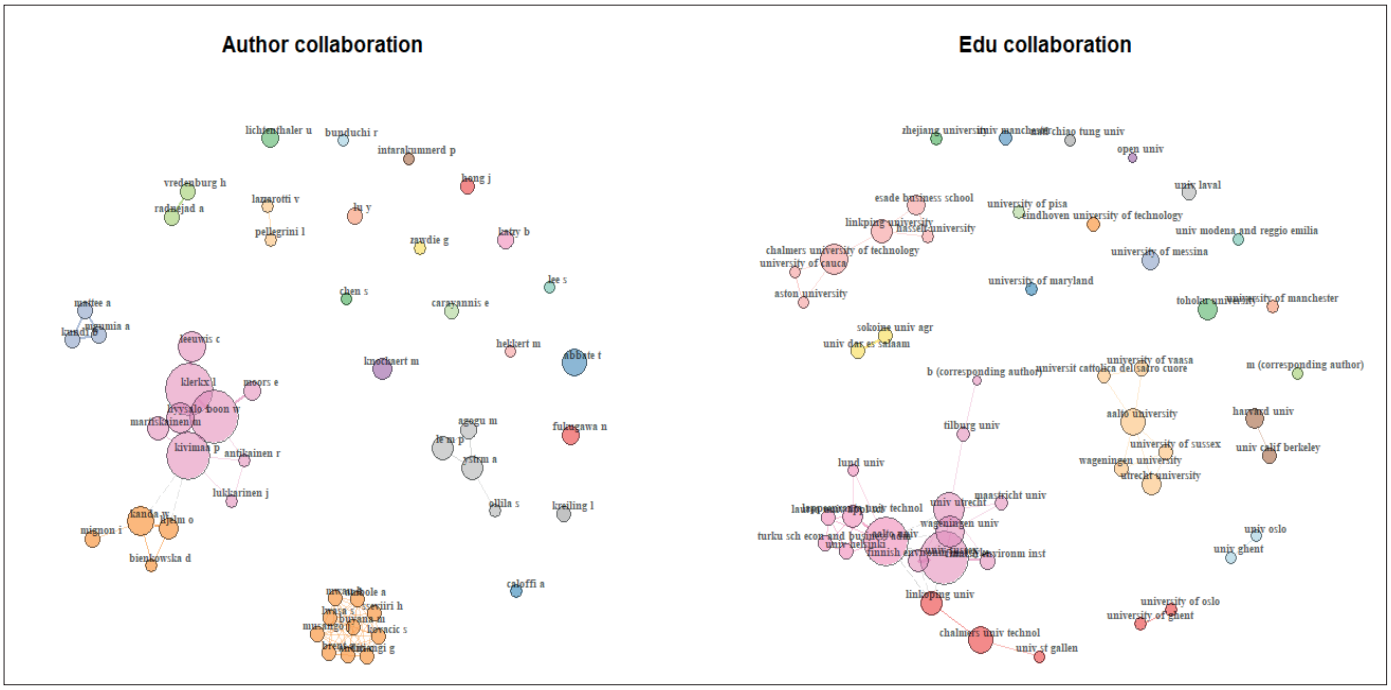
Figure 3. Co-citation (Global Intermediation)



Source: Wos and Scopus

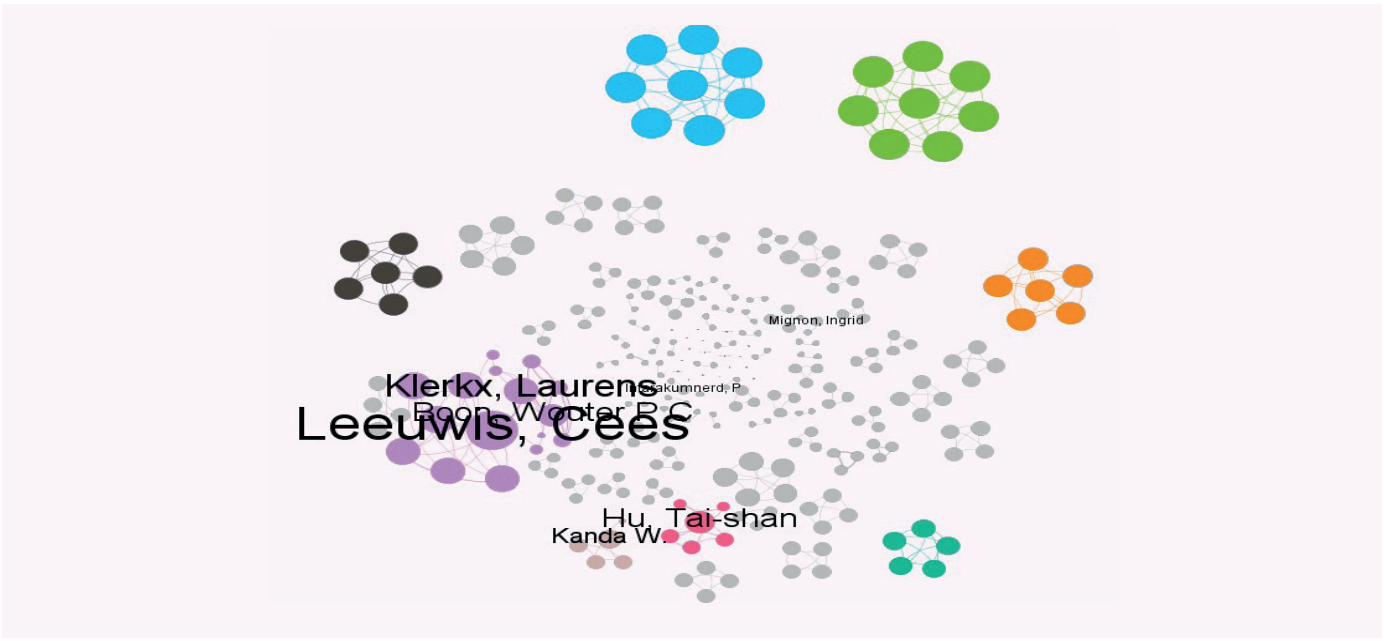
In addition, the configuration of the ***collaboration networks*** confirms that those working on intermediation have woven a network whose central authors are linked to technological transitions –Klerkx, Kivimaa, Lewis, Hyysalo, Boom, etc.– (**Figure 4a**). In stark contrast, the rest of the literature on intermediation is characterized by fragmentation or, at most, the formation of small micro– networks relatively isolated from the rest (**Figure 4b**). And this applies to the literature on intermediation from the IS.

Figure 4a. Global intermediation (Collaboration networks between authors)



Source: Wos and Scopus

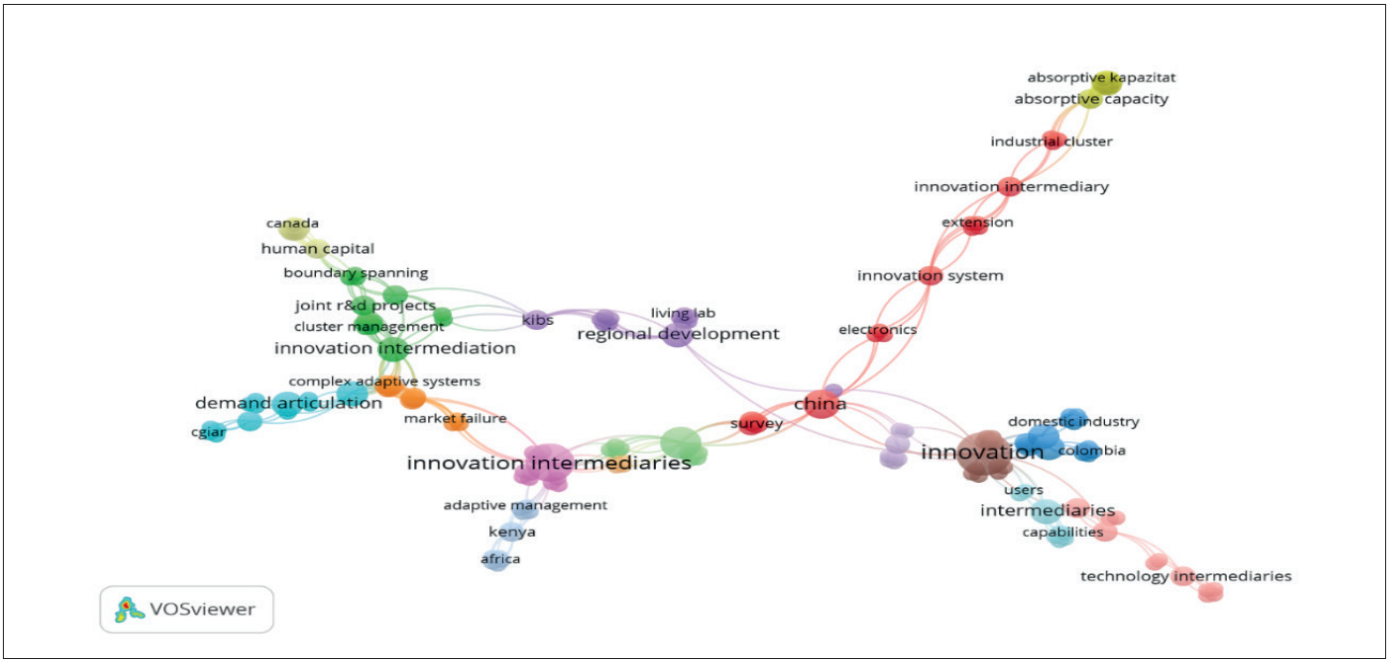
Figure 4b. Intermediation in IS (Collaboration networks between authors)



Source: Wos and Scopus

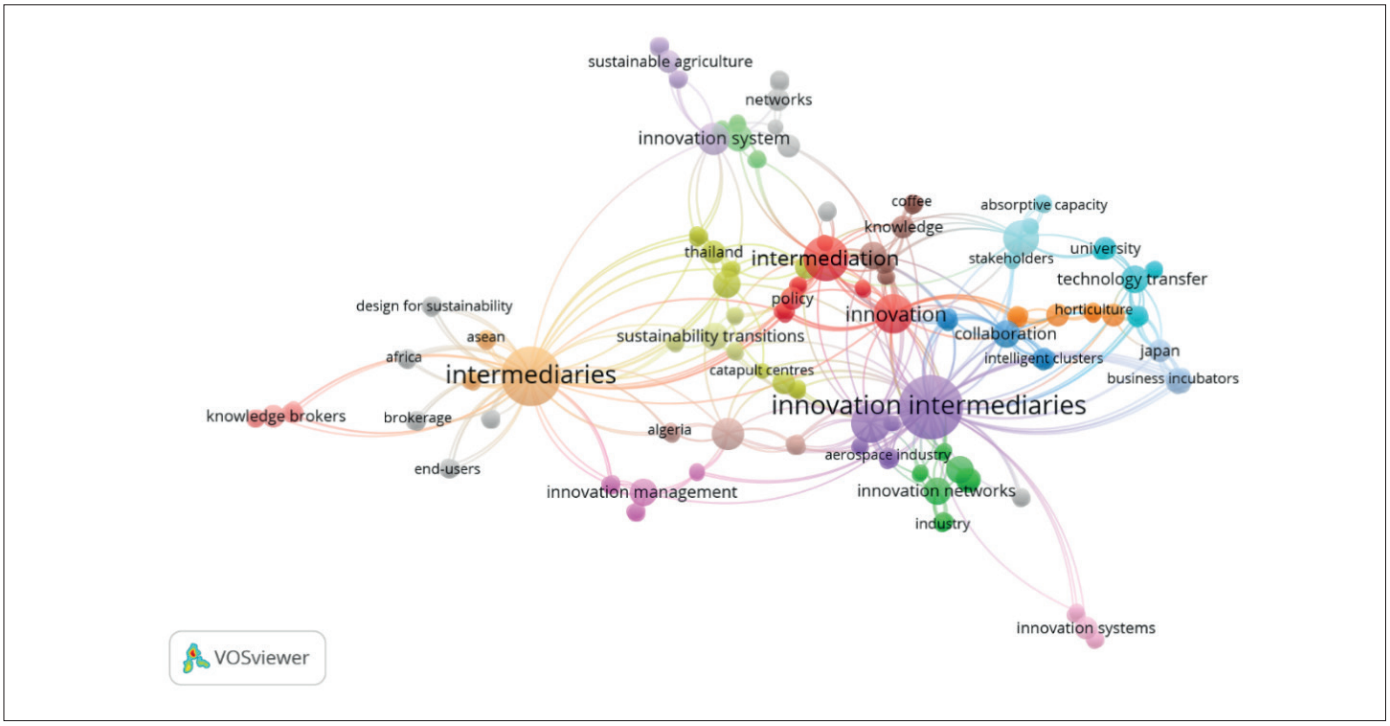
The **keywords** used by the authors of the 120 articles that address intermediation from IS complement and at the same time corroborate the previous results. Indeed, very few articles associate IS with intermediation or intermediaries, as illustrated in **Figure 5a** and **Figure 5b**; in stark contrast, the connection between technological transitions, innovation and intermediaries and intermediation is clear and intense.

Figure 5a. Keywords (Intermediation in IS) (Period 2001-2014)



Source: Wos and Scopus

Figure 5b. Keywords (Intermediation in IS) (Period 2015-2021)



Source: Wos and Scopus

However, in the universe of the 399 articles on intermediation, a weak linkage with IS is corroborated by the fact that innovation, intermediaries and intermediation predominate in the key words indicated by the authors, with very little mention of IS (**Table 2**).

Table 2. Keywords (global intermediation)

Order	Keywords authors	No. of items
1	Innovation	59
2	Open Innovation	54
3	Innovation intermediaries	51
4	Intermediaries	46
5	Intermediation	33
6	Innovation intermediary	21
7	Technology transfer	21
8	Innovation policy	16
9	Intermediary	15
10	Collaboration	14

Source: Wos and Scopus

In summary, the publication on intermediation in the IS field is low and decreasing; it is relatively disjointed and, associated with this, its authors are not recognized as referents for their contribution to the literature on intermediation.

4.2 The incorporation of intermediation in IS

In accordance with the research questions, the review of the contents of the literature that studies intermediation in the IS framework showed the need to present the results differentiating those of a basically empirical nature from those of a more conceptual or theoretical nature, i.e., those that problematize the concept in terms of the systemic needs of intermediation, or attempt to adapt it to the analytical structure of IS.

4.2.1 Empirical work with IS as a backdrop

With regard to the question of the incorporation of Howells' notion of intermediation in the IS literature, the review showed that articles of a theoretical nature are exceptional. There is a predominance of empirical articles that adopt and apply this notion to the contexts they study, but without integrating it into the IS framework of analysis and logic. In general, they evaluate the contribution of intermediaries to innovation in IS.

Most of the articles study the intermediation deployed by some *actor* immersed in an IS. This may be an *individual actor* –such as a university, research center, technology park, etc.– operating within some –national, sectoral/regional– system of innovation (Theeranattapong, Pickernel and Simms, 2021); or it can be a *collective actor*, such as a research consortium, a cluster or private-public organizations, created to implement a specific function of a regional strategy –for example, the European smart specialization strategy– (Spithoven and Knockaert, 2012; McPhillips, 2020; Vidmar, 2019). In all these cases, the role of the intermediary and its contribution to the specific objectives of its creation and, with few exceptions, to the performance of the IS as a whole is assessed.

These articles agree that intermediaries achieve the objectives for which they were created and contribute to improving the performance of the empirical realities in which they operate. Thus, they reveal the high potential of intermediaries to contribute to improve the performance of ISs –as will be seen below–. But in these articles, IS constitute the space where intermediation occurs, i.e., the backdrop.

4.2.2 Extended intermediation in IS due to contextual changes

One source of advances in the use of the notion of intermediation in the IS literature comes from the confluence of changes in analytical and empirical contexts. For example, the concurrence of the emergence of concepts such as open innovation and the development of services such as KIBS amplified the use and enhanced the role of intermediaries. New technological realities, such as the digitalization of the economy, have reinforced this potential.

The review confirms that contexts matter. When, as a result of digitization, the intermediary makes intensive use of new information technologies and the Internet, it facilitates open innovation practices that allow innovative firms to access more distant and dispersed knowledge (McPhillips, 2020; Wang, Vanhaverbeke and Roijakkers, 2012). The same is true for knowledge-intensive service firms (KIBS) that act as innovation intermediaries in the context of digitization (Colombo et al., 2015; Hsieh, Chen, Wang, & Hu, 2016). In both cases, under the influence of these new notions or technologies, the intermediary has a positive impact on business innovation and, ultimately, also on the IS where it operates, contributing to making them more open and internationalized.

Hsieh et al. (2016) highlight how globalization –strengthened by digitization– drives demand (Miles, 2005) and the importance of KIBS as knowledge brokers in the United States and the European Union (Doloreux, Freel and Shearmur, 2010). They are also fundamental for transferring knowledge (Miles, 2008) and fostering collective learning, which is central to KIBS (Cooke and Leydersdoff, 2006). Hsieh et al. (2016) analyze the role of KIBS as mediators –providers, connectors, transformers and disseminators– of knowledge in high tech industries in regional contexts (Taiwan metropolitan areas). They find, moreover, that their role differs because in the larger and more technologically developed core regions of Taiwan, KIBS play a multifunctional, multiregional role with informal relationships; while in the medium-sized regions, where the technological development of firms is lower, there is a smaller and more specialized base of KIBS, but their role is larger.

The role of intermediaries in contexts of low technological development differs from that deployed in advanced ones. In this regard, Spithoven and Knockaert (2012) evaluate the role of Collective Research Centers (CIC) in Belgium as generators of collective research and technology transfer. In those Low-Tech sectors SMEs do little R&D and lack

absorptive capacities (AC), and therefore turn to CICs. There, the intermediaries, through technology monitoring and absorption, co-research –development– and technology transfer, contribute to developing the SMEs' CA. And they are unique in this task.

4.2.3 Conceptual incorporation of Intermediaries in IS

The review did not identify any articles that problematize the concept of intermediation because of its incorporation within IS. And very few papers articulate the notion of intermediaries within the analytical framework and conceptual structure of IS. Thus, there are no conceptual developments as there are in the literature on technological transitions. The paper that most structurally addresses this link is Hsieh et al. (2016), who connect the role of KIBS as knowledge intermediaries with the conceptual structure of IS and, moreover, with innovation patterns –modes of innovating– in Taiwanese regions.

These authors, following Cooke (2001), identify two subsystems in the SRI: one, made up of firms, clients, suppliers and industries related to innovation; the other, made up of support entities and infrastructures associated with research, such as universities and research centers (Hamdouch and Moulaert, 2006). KIBS, as intermediaries, stimulate the flows and interactions between these two subsystems, strengthening the SRI (Cooke, 2001). Furthermore, Hsieh et al. (2016) articulate the modes of innovating (Jensen et al. 2007) –which they call innovation patterns– with SRIs. They relate the STI mode to a strict view of SRI, which includes R&D by universities, research institutes and firms (Coenen and Asheim, 2006; Jensen et al., 2007; Doloreux et al., 2010). And the DUI mode is associated with a broad definition of SRI as it includes all actors that influence learning and the generation of knowledge and innovation (Asheim and Gertler, 2005; Lundvall, 2007). Finally, these links connect them with the spatial logic –the proximity– that is key in SRI.

Under the STI pattern, innovation is driven by the advancement of scientific knowledge, which flows geographically (Moodysson, 2008). There, KIBS link the local to the international level, facilitating clusters and region to access external knowledge (Bathelt, Malmberg and Maskell, 2004; Kautonen and Tuhkunen, 2008; Hsieh et al., 2016). In the DUI mode, knowledge emerges from the firms' experience when facing their technological and business challenges. That learning is facilitated by spatial proximity and collaboration –with customers and suppliers– accumulating as tacit knowledge. Proximity is vital to exchange that knowledge, and KIBS to turn it into applicable knowledge for their customers.

Other papers provide evidence on the position and role of intermediaries in IS –although it is not their central objective–; and on the highly positive effect of intermediation in these systems. Wang et al. (2012) show how firm innovation strategies, such as open innovation, affect IS. These strategies diversify networks within IS. Intermediaries, which they consider to be emerging structural –actors– elements of the system, are important because they support and catalyze interaction, connecting research with technological development. They do this through co-research and intensive use of the Internet, beyond the IS.

Intermediaries are, then, structural components of the IS, with the transversal function of serving as a bridge between actors from different components of the system and with external sources. They leverage the capabilities of their actors and promote cooperation within and outside the system; they reduce transaction costs and R&D costs for innovation and technology absorption and, in this way, enhance the efficiency and effectiveness of the IS. Thus, they are coordination mechanisms –beyond the market– key to innovation policies.

Wu and Xu (2013) attempt to establish whether the effect of intermediaries varies by sectors and types of innovation in an SRI through a comparative study across 31 Chinese provinces and use of panel data analysis. For Wu and Xu, technology intermediaries serve as bridges, change agents or matchmaking platforms, which can: i) provide technology brokering and commercialization services from the laboratory to pre-commercialization, and connecting developers of a new invention or technique with potential users; ii) connect firms with complementary expertise, knowledge and resources; iii) support joint projects between SMEs and research institutions (Smedlund, 2005).

These authors find the main benefits of intermediaries in two areas: economically, they reduce firms' search and transaction costs (Zhang and Li, 2010); and strategically, they provide resources for their partners –such as knowledge, support services, business ideas–, facilitate their access to complementary resources and capabilities, and make innovation opportunities more evident. In addition, intermediaries amplify positive R&D and innovation spillovers; and have a positive effect on product innovation and more efficient innovation performance of SRIs, being higher in high-tech industries.

In the same direction, in Spithoven and Knockaert (2012) technology intermediaries bridge and close the gaps between the main IS actors. To this end, as in other cases, they absorb and transfer knowledge and technology by developing their own CA –via endogenous R&D–. In addition, they develop the CA of SMEs in low-technology sectors, contributing to technological progress and innovation, with lower government R&D expenditures. Thus, they correct market failures and systemic failures in the Sectoral Innovation Systems (SSI) where they operate (Sutthijakra and Intarakumned, 2015).

In contrast to the previous articles, Vidmar (2019) analyzes the role of intermediaries from a policy perspective, in particular, the European Strategy for Smart Specialization –S3 by its initials in English–. The author indicates that in this sectoral–geographic innovation policy, nurtured by inputs from SRIs, two approaches compete: entrepreneurial discovery (Hausmann and Rodrik, 2003; Foray and Goenaga, 2013) and regional advantage building (Boschma, 2013). According to Vidmar (2019), in the operationalization of S3, little has been studied of intermediaries. This is a fundamental gap because they are providers of 'institutionalized learning',which is central to the conceptualization of SRI.

For Vidmar (2019), S3 policies are divided by their objectives: either to create new opportunities (Foray and Goenaga, 2013), by targeting entrepreneurial discovery –specializations in new competitive niches–,

or, to correct systemic failures, in development based on regional advantages (Boschma, 2013). It proposes overcoming this dichotomy (Boschma, 2013), taking advantage of intermediaries as bridges between policy intentions and economic activities; in particular, in their pivotal role of supporting SMEs.

Vidmar studies the space industry in Scotland and Slovenia (Higgs Centre for Innovation; Space–SI). There he analyzes the configuration of intermediaries, their activities and target users, and proposes a model derived from combinations of their interventions, focused on business development or R&D support. He finds that in Scotland there is more tradition of (EU) policies supporting the building of regional competitive advantages; greater inclination to diversification and efficiency; and greater support for business. In contrast, Slovenia lacks such a tradition, and thus is more favorable to niche specialization by entrepreneurial discovery and academia-driven applied R&D investment.

Vidmar (2019) proposes, in summary, to balance investment in R&D and business development, i.e., the promotion of new niches by entrepreneurial discovery and the development of businesses with previous competitive advantages. And to identify theoretical and policy insights, he proposes studies that contrast the interventions of intermediaries in different regions or in different sectors of the same region.

5. Discussion and conclusions

It should be recalled that this article arises from the question of how the notion of intermediation has been incorporated in the IS-based literature, and what contributions derive from it. The review shows that, in general, this literature assumes Howells' (2006) definition, without problematizing it. This is opposite to what happened in the technological transitions literature where intermediation is reconceptualized to fit the systemic –structural and dynamic– requirements of technological transition processes (Kivimaa et al., 2019a and Kivimaa et al., 2019b). There, intermediaries are considered as catalysts of transitions, and their role changes according to the phases and levels of the transition. Based on this, typologies of intermediaries and functions are proposed to facilitate the evaluation of their role in each case.

In the field of IS –national, sectoral, regional– the term is not problematized in terms of systemic logics and needs. The work is not theoretical but empirical in nature. They do not analyze whether its incorporation enriches the theoretical framework–conceptual framework of IS or whether, on the contrary, it reconceptualizes the notion of intermediation itself. They do not problematize –theoretically– how the intermediary fits and its role within the IS, its structure or functions. Rather, the notion is taken up and applied, and the activities and functions of intermediaries are extended according to the specificity of the empirical reality studied in the respective article. Nevertheless, some articles illuminate these conceptual links, and their empirical potentialities.

In this regard, the analysis of Hsieh et al. (2016) would make it possible to show how intermediaries constitute a mechanism to connect the components –research and innovation subsystems (Cooke, 2001)– of the SRI, enhancing the interaction and flow of knowledge between them. It would also illustrate how, in line with Lundvall's (2010) approaches on the modes of learning and innovation in IS –STI or DUI (Jensen et al., 2007)–, the role of intermediaries changes according to the prevailing modes of innovation in the sectors or clusters included in the SRI. Thus, systemic characteristics and needs redefine intermediation and the role and importance of intermediaries.

Wang et al. (2012) provide a more detailed visualization of these intermediary-IS conceptual links. They consider intermediaries as emerging structural elements that play a coordinating role in IS. This is activated by firms that use open innovation strategies, enhanced by the intensive use of the Internet. Beyond what Edquist (2019) and Borras and Edquist (2013) have stated about specific activities, this function is transversal as it serves as a bridge between actors from different components of the system, and with actors external to it. Indeed, intermediaries foster cooperation within and outside the IS, reducing transaction and R&D costs for innovation and technology absorption. In this way they enhance the efficiency and effectiveness of the IS.

In the same direction of Wang et al. (2012), Spithoven and Knockaert (2012) illustrate, for Low Tech industries, how technological intermediaries build those bridges and close gaps between the main IS actors; and how to do so they develop CA in SMEs, from their own CA –via endogenous R&D–. Thus they correct market failures and systemic failures in IS (Sutthijakra and Intarakumned, 2015), contributing to technological advancement and innovation, with lower government expenditures on R&D.

In summary, the review shows the high potential for theoretical contribution derived from conceptually articulating intermediaries in IS analytical frameworks. They enrich IS components and, above all, illustrate a rich variety of intermediation mechanisms that enhance interaction within IS. In this sense, the review shows that intermediaries –as emerging structures– fulfill a function –intermediation– that, beyond the market, solves systemic problems, acting as coordination mechanisms, generating synergies and developing the capacities of IS actors, thus enhancing IS performance.

In general, the literature reviewed does not delve deeply into the conceptual links between intermediaries and IS, but rather into the empirical analysis of the positive effects of intermediaries on IS performance. In this, there is agreement between publications that take Howells (2006) as a reference and that approach such effects from a broad spectrum of approaches: IS levels (national, sectoral or regional) and their combinations -sectoral differences in an IS (Wu and Xu, 2013)-; degrees of technological development of the context (sectors or regions with high or low technological development); innovation and learning patterns (STI or DUI); and the nature of intermediaries (innovation consortia, KIBS, technology parks, etc.). Emphases on positive effects also vary; some focus on mechanisms and degrees of coordination that reduce transaction costs (Zhang and Li, 2010); others on levels of cooperation that generate synergies; and others on the development of capabilities to innovate, absorb or protect new knowledge.

These articles show, in short, that intermediaries enhance innovation and IS performance. This justifies efforts to identify, systematize and interpret empirical regularities; and, furthermore, invites new theoretical developments nourished by these empirical results –appreciative in terms of Nelson and Winter (2002)–, and to strengthen innovation policies.

There is little work that systematically addresses the potential of intermediaries to strengthen innovation policies. In this regard, Vidmar (2019) addresses two promising proposals *for* sectoral–regional innovation *policies*. One, specific to the Smart Specialization Strategy, S3, seeks to overcome the dichotomy between boosting niches by entrepreneurial discovery (Hausmann and Rodrik, 2005; Foray and Goenaga, 2013) and business development based on previously achieved competitive advantages (Boschma, 2013). Another, more general, is to take advantage of the role of intermediaries as bridges between policy intentions and economic activities. In this sense, the role of intermediaries extends from a cross-cutting support function –connecting components and functions– of an IS to being a bridging instrument between the formulation of innovation policies and their materialization in innovative business practices within those IS (Vidmar, 2019).

Now, on a *more general level*, of intermediation itself, the reviewed literature extends and updates its application. In the first case, intermediaries are expanded –for example, KIBS (Colombo et al., 2015; Hsieh et al., 2016)–, and their role –for example, as an instrument to deploy open innovation (Wang et al., 2012)–. In the second, contextual changes such as digitization or of technological transitions towards clean technologies energize its role (McPhillips, 2020; Kivimaa et al., 2019a). This intensification of intermediation, enabled by conceptual and technological environment advances, could nurture theoretical developments and innovation policy proposals derived from the IS framework.

Lines of future research

The ample evidence on the benefits of intermediaries for IS and the theoretical potential of the conceptual articulation of intermediaries with IS show the fundamental importance of theoretical advances. Systematization of empirical results would facilitate such developments. Promising avenues would be inquiries into: intermediaries as a structural component but distinct from the conventional –of generation, dissemination and use of new knowledge and technologies–; or their role as a bridge and generator of synergies that enhance IS interaction and performance.

Equally interesting and promising is the theoretical inquiry for the relationship between the specificities of innovation patterns and the role of intermediaries. These could be differentiated along the lines of Nelson (1993 and 2017) or Lundvall (2010). Such exploration could also be deepened by levels of technological development and institutional contexts (Vidmar, 2019; Cooke, 2001). Such sectoral patterns and levels of development are key to understanding the sectoral heterogeneity of innovation within an RIS, and how this conditions the differentiated capabilities required of intermediaries to serve the same RIS. This could give rise, for example, to more elaborate typologies for diagnoses and evaluations, as well as for specifying the contents of innovation policies.

In the case of Latin America, intermediation could contribute to overcome weak linkages in IS (Porto-Gomez et al., 2019; Malaver and Vargas, 2005). At the theoretical level, the review sheds light when it shows that intermediation mechanisms should be in line with the broad vision of IS (Lundvall, 2010), due to the predominance in the region of the DUI mode of innovation and low R&D intensity industries (Malaver and Vargas, 2013). At the policy level, deepening the specificity of such mechanisms would increase the effectiveness of IS strengthening and innovation promotion policies.

These conceptual developments in ISs and innovation policy approaches should be nourished by the lessons learned from the expansion of intermediation made possible by changes in the environment, for example, the new digital contexts which, as we have seen, make it possible to rethink both the organizational structures and the internal and international articulation of an IS.

Finally, systematizing the way in which intermediaries contribute to overcoming systemic coordination problems and thereby increasing knowledge and innovation flows would make it possible to improve the instruments, mechanisms and, in short, the content and operationalization of evidence-based innovation policies. This is also a promising area for research.

Funding

This study was supported by the Pontificia Universidad Javeriana.

Declaration of competing interest

The author(s) declare no conflict of interest.

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