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Exploring the food value chain using open innovation: a bibliometric review of the literature

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Abstract

Purpose – This paper reviews the literature, foundational works and current trends related to the adoption of open innovation (OI) practices in the food industry, with a particular focus on the food value chain, using a bibliometric and content analysis approach.

Design/methodology/approach – This study is based on 84 published documents in the field of food OI obtained using the Scopus database. First, a bibliometric analysis was conducted using a bibliographic coupling and co-citation analysis approach to understand the common themes and key clusters of food OI research. It further highlighted authors, countries, journals, years of publication and subject areas to comprehend the scope of the established literature. Second, a content analysis was undertaken to examine the titles and abstracts of the documents to explore the intersection of OI and the food value chain.

Findings – This study provides an integrated framework of the intersection of OI and the food value chain, including information about under-researched and emerging areas in the field of food innovation. It also highlights the critical challenges associated with OI food research and practices.

Practical implications – Practitioners can use the findings to uncover areas with limited open innovation adoption in the food value chain. They can identify extended research areas to explore the food value chain using an open innovation perspective, in different contexts within the food and beverage (F&B) industry. The framework can also be used for conducting comparative studies of current food innovation trends across different contexts within the F&B industry.

Originality/value – By adopting a multi-step approach involving a computer-assisted bibliometric examination complemented by a manual review undertaken through the lens of the food value chain, this

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literature review provides fresh and unique insights into past and present research on OI in the food industry and paves the way for future studies by laying out specific research avenues.

Keywords Open innovation, Food value chain, Bibliometric analysis, Food innovation trends, VosViewer
Paper type Research paper

1. Introduction

The world's population has increased from 3 billion to over 7.8 billion in the last 60 years. The food supply has increased simultaneously, with farmers consistently growing enough food to feed 1.5 times the population of the day (Holt-Giménez *et al.*, 2012; Richie and Rose, 2020). However, the OECD (2020) reports that over 800 million people have less food than they need, and even larger populations remain malnourished. Technological breakthroughs afforded by the fourth industrial revolution are creating new opportunities for large-scale and rapid change in food systems: how we produce, process and consume food. However, between 2010 and 2018, when healthcare enjoyed US$145 billion in technological investments, food systems received only US$14 billion (World Economic Forum, 2018). This low attraction of resources coupled with lower adoption and ability to harness the benefits of emerging technologies (e.g. big data, machine learning, the Internet of Things), calls for an overhaul that will facilitate the holistic management of our food systems. Additionally, while technical and structural changes have benefited larger, well-resourced stakeholders in the food supply chain, the future of nearly 500 million smallholder farmers who produce about 80% of the world's food remains uncertain. Economic and political instability is causing an occupation decline as young farmers search for better-paying and more attractive jobs (World Economic Forum, 2018).

Governments in developing and middle-income countries are taking steps to manage the global food system. Since the 2009 G8 Summit, China, India and other emerging nations have made significant progress in curbing hunger and stimulating innovation in food technologies. These efforts have improved crop yield and productivity but also increased food waste and global gas emissions. Nearly one-third of the world's food production goes to waste, and food systems are responsible for almost 20–30% of global greenhouse gas emissions (United Nations, 2017). Ironically, climate change due to increased greenhouse gas emissions threatens nearly a quarter of the world's crop yield (World Bank, 2017). Thus, among policymakers, academics and other stakeholders, there is a consensus that our food systems need to be more inclusive, practical, nourishing and beneficial for a sustainable future (Bogers *et al.*, 2020; Farley and Scherr, 2020; World Economic Forum, 2018).

The COVID-19 pandemic created further challenges for the global food system, with acute hunger risks increasing from 135 million people to 265 million (World Economic Forum, 2018). On the one hand, there is a need for more sustenance and food support. On the other, a sudden decrease in demand due to closures and lockdowns during COVID-19 saw farmers having to dump milk and destroy harvests that could not be delivered due to disrupted supply chains (Wiener-Bronner, 2020).

Indeed, global food systems were distorted even before COVID-19, facing challenges like hunger and obesity, production and livelihood, yield and emissions, mass production and waste. For the most part, policy and strategies related to agriculture and food systems have been developed in silos. This isolation has both benefitted and harmed a fragile yet life-forming system – increasing mass production to deliver cheaper, faster food. At the same time, increasing health risks and obesity and investing in production efficiencies have limited farmers' flexibility to adapt to changing social and environmental conditions. However, recent calls in academic journals (e.g. Dabić *et al.*, 2020; Marinova and Bogueva, 2021) and world forums (e.g. OECD, 2020; World Economic Forum, 2018) are drawing attention to the need for more holistic, open and collaborative practices in the food industry. Responding to these calls is the central purpose of this paper, which reviews the literature on open

innovation (OI) practices in the food industry to sketch theoretically informed and pragmatically grounded avenues for further research. To do so, a multi-step approach is adopted. First, a descriptive review is presented, after which a computer-assisted bibliometric analysis is performed, complemented by a narrative literature review using the food value chain (FVC) as a guiding framework.

The remainder of the paper is structured as follows: the next section provides a brief overview of this paper's core concepts. The methodology for the multi-step review process is then described, followed by a presentation of the findings. This section culminates with the production of an integrative framework that paves the way for future research avenues. The paper continues with a discussion and concludes with managerial implications and limitations.

2. Setting the scene: open innovation (OI) and the food value chain (FVC)

2.1 OI

Since Chesbrough coined OI in 2003, its popularity and underlying reality have enjoyed increased momentum in both academic and practitioner communities. OI refers to the "purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively"; according to this paradigm, firms "can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technologies" (Chesbrough, 2006). The pervasiveness of the OI paradigm across innovation studies is undeniable. However, most research has focused on knowledge-intensive, high-tech industries and largely overlooked contexts characterized by lower levels of knowledge intensiveness or exhibiting lower levels of technological sophistication (Flor *et al.*, 2019). The food industry, which is traditionally depicted as a low-tech industry (Eurostat), has been largely ignored in the mainstream OI literature (Bayona-Saez *et al.*, 2017; Martinez *et al.*, 2014). Scholars (Blasi *et al.*, 2015; Devaux *et al.*, 2018) have examined the level of innovativeness within the food industry at an organizational level by examining activities in the FVC. However, the theoretical research in the FVC context is limited to anecdotal reporting and needs a more systematic explanation.

2.2 The FVC

The FVC model has been widely used in the literature to examine different innovation contexts (Caiazza *et al.*, 2014; Diamond and Barham, 2012; Rao *et al.*, 2017). According to Humphrey and Memedovic (2006), the FVC consists of four key stages – input, production, processing (manufacturing) and output. The first stage consists of supplier-based activities related mainly to sourcing. The suppliers of different biological (seeds, soil and animal and plant health items) and non-biological (equipment, chemical-based items and services) goods and services provide those products and services to their primary consumers: farmers. In the second stage, the key activities produce raw materials such as crops, livestock, animal and plant breeding and farm management. Farmers supply raw materials to their primary customers, food and beverage processing and manufacturing companies. The third stage is when all manufacturing-related activities take place. The manufacturing and processing companies use raw materials to generate food and beverage products for distribution through multiple channels to downstream intermediaries and end consumers. In the fourth stage, retailers and wholesalers sell products to consumers. Although some relevant research has been conducted to understand food industry innovation, there is limited information available about the intersection and integration of OI practices and the FVC. It is thus essential, given the wide acceptance of the FVC approach both academically and in practice, to identify what has been examined to establish future research areas.

3. Methodology

3.1 Data collection

The literature for this paper was explored using a bibliometric analysis and a thematic content analysis approach to answer the following research question: "What are the current and emerging research practices in the food sector related to open innovation?" In the bibliometric analysis, a combination of bibliographic coupling and co-citation analysis methods was applied, with the VosViewer 1.6.16 software used to present the results.

3.2 Inclusion and exclusion criteria

The researchers initiated the search with a keyword analysis using a Boolean search by running a query with the terms "Food" AND "Open Innovation" in titles, abstracts or keywords. The keyword search was conducted using the Scopus database. Scopus has been demonstrated to be a comprehensive and widely accepted database consisting of most of the journals indexed by Web of Science and Google Scholar (Gölgeci *et al.*, 2021; Harzing and Alakangas, 2016; Martín-Martín *et al.*, 2018; Mongeon and Paul-Hus, 2016). Scopus is also an effective tool for searching literature as it facilitates searching by allowing the use of whole search strings such as "food" and "open innovation" (Bouzembrak *et al.*, 2019).

As Figure 1 shows, the initial keyword search identified 182 documents; after an inclusion criterion – selected documents that were published in English and peer reviewed – 162 documents remained. Peer review serves as a valuable exclusion criterion, as documents reviewed by scholars are considered high quality and contain more reliable findings than non-peer-reviewed documents (Gölgeci *et al.*, 2021; Secinaro and Calandra, 2020; Tang and Musa, 2011). To further ensure the relevance of the documents, the researchers read the titles and abstracts of the 162 documents and excluded 78 that did not primarily examine OI in a food industry-related discipline. This resulted in a refined sample of 84 documents for the final analysis which were all retrieved from Scopus ($N = 84$).

3.3 Data analysis

Using the final sample of 84 documents, the data were examined using bibliometric analysis and then a thematic content analysis approach. In previous bibliometric studies, a combination of methods including bibliographic coupling, co-citation analysis and content analysis has been considered reliable as it provides a comprehensive understanding of the theoretical roots and defines the intricate links between established and emerging research areas (Casprini *et al.*, 2020; Lyu *et al.*, 2020; Opejin *et al.*, 2020; Zeba *et al.*, 2021). For example, the content analysis approach allowed Casprini et al. 2020 to link the findings from the co-citation approach to the results of bibliographic coupling, which provided a holistic view of future research areas. Zeba *et al.* (2021) applied a content analysis approach to gather a hierarchical clustering of keywords that co-occurred and find links between the past and current literature. Lyu *et al.* (2020) and Opejin *et al.* (2020) applied content analysis to generate key research themes and trends from the documents they studied.

3.3.1 Bibliometric analysis. Bibliometric analysis is a well-recognized and practical, non-biased data analysis approach in food innovation and OI research (Dabic *et al.*, 2020; Luo *et al.*, 2018; Lyu *et al.*, 2020; Randhawa *et al.*, 2016; Vlačić *et al.*, 2020; Vila-Lopez and Küster-Boluda, 2020). The 84 documents extracted from Scopus were analysed based on publication year and classified by author, affiliation, country, type, subject area and funding sponsors. The data are represented using a variety of tables and graphs with a summarised description of the critical indicators. The sample was then analysed using the VosViewer software, which facilitated building a network visualization (Bouzembrak *et al.*, 2019). That software allowed the researchers to conduct a quantitative analysis of a large volume of literature for mapping

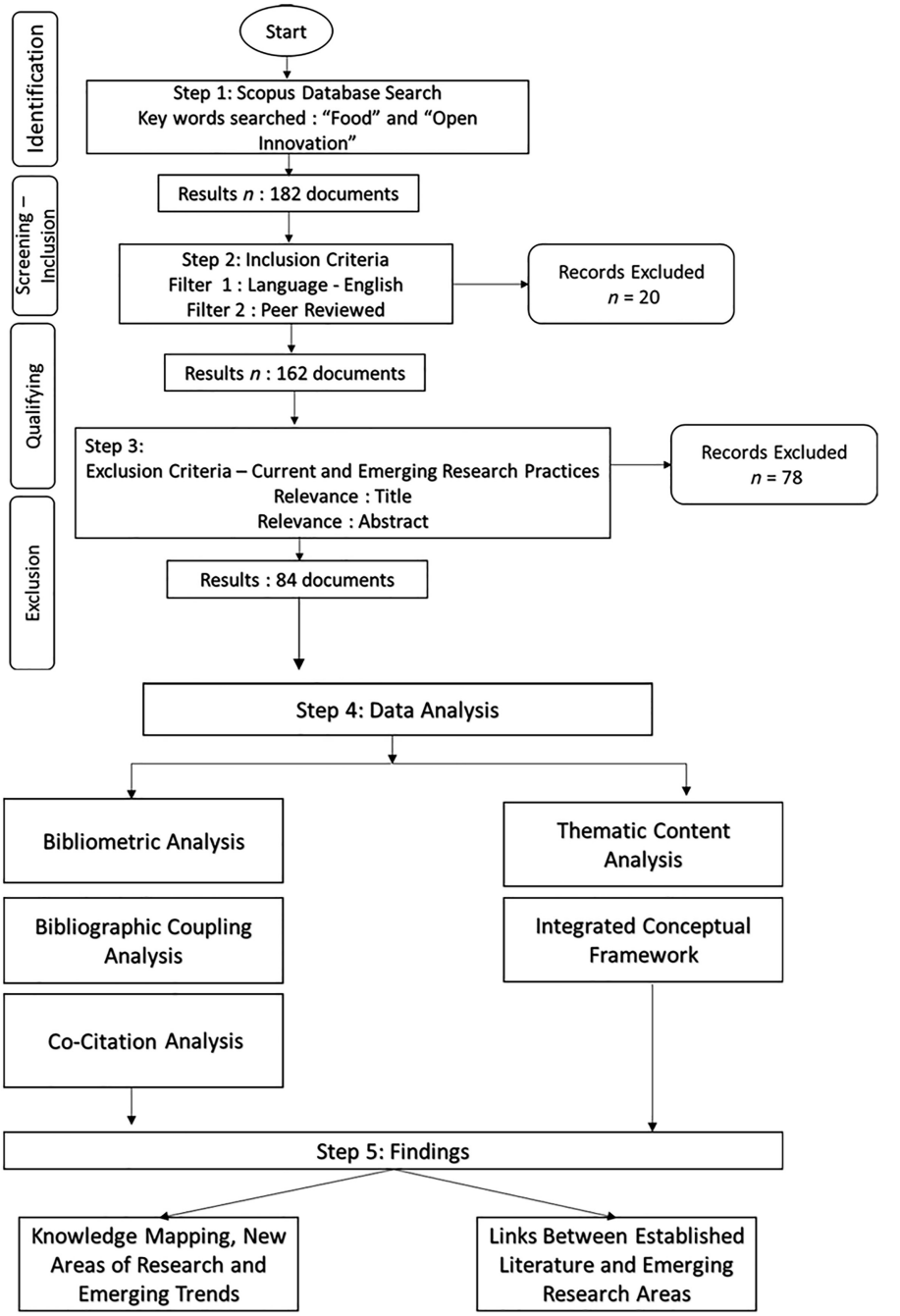

Figure 1.
Flowchart of research methodology

knowledge, new research areas and hotspots, future trends and emerging research paths in the food OI field (Meng *et al.*, 2020; Van Eck *et al.*, 2010). The network and overlay visualization techniques illustrate different knowledge domains' hierarchies (Bouzembrak *et al.*, 2019; Chen and Hsieh, 2007). The bibliometric analysis was conducted using the bibliographic coupling approach to identify key emerging research themes, while the co-citation analysis was used to identify the links between emerging research themes and previously established research (Casprini *et al.*, 2020; Dabic *et al.*, 2020; Meng *et al.*, 2020; Vlačić *et al.*, 2020). In addition, a hybrid network visualisation approach such as a combination of bibliographic coupling and co-citation analysis has proven to be a useful combination of techniques to comprehensively capture complex research links and address a wide range of research problems within a given context (Yan and Ding, 2012).

3.3.2 Bibliographic coupling. A bibliographic coupling approach analysis was conducted using VosViewer 1.6.16 (Casprini *et al.*, 2020; Meng *et al.*, 2020). The coupling approach clusters recent documents by linking documents that quote the same set of cited papers and evaluating the links between citing documents (Boyack and Klavans, 2010; Van Oorschot *et al.*, 2018). Using the 84 documents in the final set, the software returned four clusters. The cluster resolution was one, and the minimum cluster size (size = 1) maintained the default values of random start at 10, with iterations equal to 10. Each cluster was examined based on the key concepts, theoretical framework, research problem, methodology and critical findings.

3.3.3 Co-citation analysis. A co-citation analysis was conducted using VosViewer 1.6.16 (Casprini *et al.*, 2020; Meng *et al.*, 2020; Vlačić *et al.*, 2020). A co-citation analysis enables the identification of documents cited in several other sources, which helps establish the links between the papers for thematic evaluation (Casprini *et al.*, 2020; Ferreira, 2018). From the 4,433 cited references in the 84 papers, using the minimum number of five cited references, 20 papers met the threshold and were grouped into three clusters. The abstracts and keywords were collected to categorize the clusters under a thematic cluster name for all documents in the three clusters. All papers were manually analysed to understand the links between them and identify future research areas within food OI.

3.3.4 Content analysis: developing an integrative framework. The bibliographic coupling and co-citation analyses resulted in clusters that provided sufficient information about existing knowledge on food OI. Those analyses produced clusters with 49 documents, of which 29 met the bibliographic coupling criteria and 20 met the co-citation analysis criteria. While the cluster analysis provides profound information about established literature, it was essential to review the remaining documents to determine whether there were topics that remain unexplored in the field of food OI. The in-depth analysis of the remaining 35 documents was also deemed necessary, given that the present study aims to identify future research areas in food OI. Hence, a detailed examination of the titles and abstracts of the 84 documents was conducted using a thematic content analysis approach that enables the researcher to capture potential information about valuable concepts, methods applied and important themes and to assemble a wider range of future research directions (Gao *et al.*, 2020; Lyu *et al.*, 2020).

For the analysis, we used the four stages of the FVC process as an analytical tool. We first identified the stages of the FVC process, and the activities conducted in each stage. The 84 documents were then classified and categorized based on how much the context of each document aligned with which stage of the FVC: input, production, manufacturing and output. Then, each document's title and abstract were further examined through a food OI lens, which allowed the researchers to map the intersection between food OI and the FVC. The authors developed an integrative framework during the final stage of the analysis. The identified themes were then studied to seek links between the established literature and emerging research areas.

4. Research findings

4.1 Visibility of authors in food OI

Table 1 shows a ranking of authors by number of publications (including co-authored documents). Most documents published by the top 10 authors were published in the 2014–2020 period. The main subject areas of focus include agricultural and biological sciences, business management and accounting, engineering and computer science, suggesting a wide range of inter-disciplinary collaboration ranging from science, technology, engineering and mathematics (STEM) fields to business.

Authors (top 10)	No. of documents	Years published	Subject areas	Countries
Saguy, I.S.	4	2018, 2016, 2013, 2011	Agricultural and biological sciences Engineering Chemistry	Israel, Australia, USA, Ireland, Switzerland
Lazzarotti, V.	3	2017, 2014	Business management and accounting, economics, econometrics and finance, social science, agricultural and biological science, computer science, engineering	Italy, Spain, UK
Manzini, R.	3	2017, 2014	Business management and accounting, economics, econometrics and finance, social science, agricultural and biological science, computer science, engineering	Italy, Spain, UK
Tóth, J.	3	2020, 2016, 2014	Agricultural and biological science, business management and accounting, energy, environmental science, social science	Hungary, Belgium, Italy, Netherlands, Romania
Bigliardi, B.	2	2019, 2016	Business management and accounting, economics, econometrics and finance	Italy
Chesbrough, H.	2	2020, 2014	Business management and accounting, agricultural and biological science	USA., Denmark, Italy
Cohen, E.	2	2018, 2016	Agricultural and biological science, chemistry, engineering	Australia, Israel, Ireland
Costa, A.I.A.	2	2016, 2018	Agricultural and biological science, biochemistry, genetics and molecular biology, decision sciences	Portugal, Italy
Fortuin, F.T.J.M.	2	2014, 2009	Business management and accounting, agricultural and biological science, computer science	Netherlands
Galati, F.	2	2019, 2016	Business management and accounting, economics, econometrics and finance	Italy

Table 1.
Documents by author visibility

4.2 Year of publications

For this paper, a time-related exclusion criterion was not applied to ensure that a thorough search was conducted, so all peer-reviewed documents related to this topic were captured. As Table 2 shows, the first documents for this paper were completed in 2008. From 2008 to 2012, the number of published documents ranged between two and four per year, suggesting a steady pace that was not overwhelming in terms of volume. However, there was a dramatic

Year of publication	Subject area	No. of authors
2020	Social science, business management and accounting, environmental science, economics, econometrics and finance, energy, agriculture and biological science, psychology	46
2019	Agricultural and biological science, business management and accounting, decision sciences, economics, econometrics and finance, medicine, multidisciplinary, pharmacology, toxicology and pharmaceutics, psychology	32
2018	Agricultural and biological science, business management and accounting, engineering, chemistry, computer science, decision sciences, economics, econometrics and finance, energy, environmental science, materials science, medicine, nursing, social science	44
2017	Agricultural and biological science, business management and accounting, economics, econometrics and finance, decision sciences, social science	33
2016	Agricultural and biological science, business management and accounting, economics, econometrics and finance, decision sciences, engineering, social science, veterinary science	34
2015	Agricultural and biological science, business management and accounting, economics, econometrics and finance, energy, environmental science, pharmacology, toxicology and pharmaceutics, social science	7
2014	Agricultural and biological science, business management and accounting, economics, econometrics and finance, computer science, social science, engineering, pharmacology, toxicology and pharmaceutics	21
2013	Agricultural and biological science, business management and accounting, arts and humanities, computer science, engineering, environmental science, social science	27
2012	Business management and accounting	7
2011	Agricultural and biological science, business management and accounting, computer science, biochemistry, genetics and molecular biology	8
2010	Agricultural and biological science, business management and accounting, computer science, decision science	8
2009	Agricultural and biological science, business management and accounting, economics, econometrics and finance, medicine, pharmacology, toxicology and pharmaceutics	4
2008	Agricultural and biological science, biochemistry, genetics and molecular biology	3

Table 2.
Documents by year of publication

rise in the number of publications between 2011 and 2015. The largest number of published documents appeared in 2020.

4.3 Geographic distribution by countries and territories

The graph in Figure 2 presents the documents based on country with research on food OI; this provides insights into different research collaborations and partners in research (Le *et al.*, 2019; Wambu *et al.*, 2017). The figure shows that authors from 34 countries published food OI research between 2008 and 2020 and that researchers in 15 countries made critical contributions in the field. The countries' ranking was based on the total number of documents produced by authors from those countries.

4.4 Bibliographic coupling analysis

A total of 31 documents met the bibliographic coupling threshold of a minimum of 10 citations. The most extensive set of related items is 29. The analysis revealed four clusters (see Figure 3) that showed the most concentrated research focus areas in food OI.

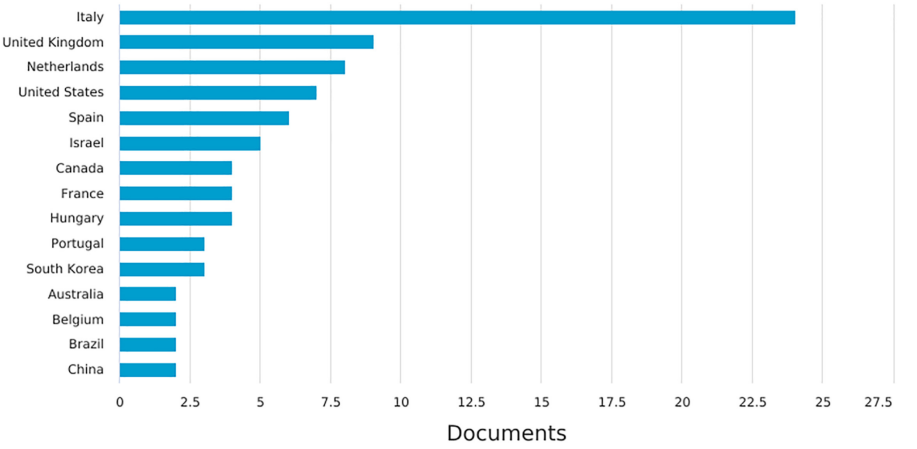

Figure 2.
Documents by country or territory

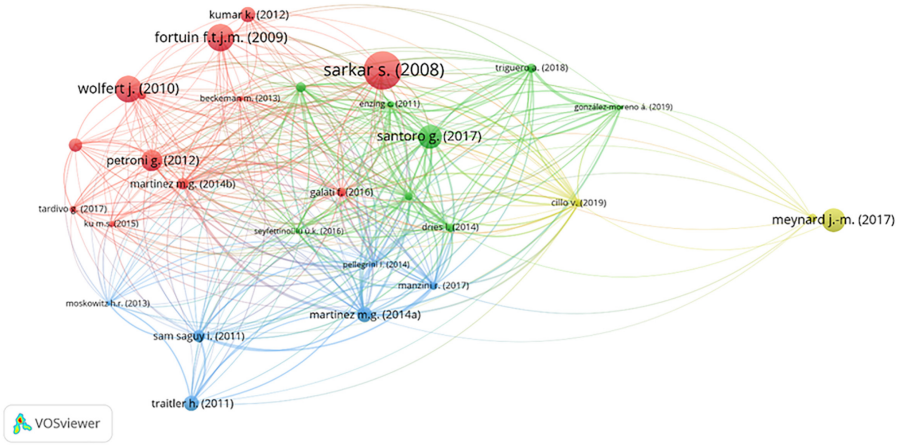

Figure 3.
Bibliographic coupling (minimum 10 citations)

Cluster one (red) comprises 12 contributions between 2008 and 2016 and contains essential research on food OI; accordingly, we call it "Drivers of OI in the food industry". The cluster includes a mix of quantitative and qualitative approaches, though it predominantly consists of qualitative case study-based techniques using small food firms as the context (Beckeman *et al.*, 2013; Filieri, 2013; Galati *et al.*, 2016; Martinez *et al.*, 2014; Siedlok *et al.*, 2010; Tardivo *et al.*, 2017; Wolfert *et al.*, 2010). This cluster's primary emphasis is on understanding the key drivers and approaches to managing OI in food firms. Filieri (2013), Tardivo *et al.* (2017) and Martinez *et al.* (2014) emphasized the integration of co-creation practices as a valuable tool for generating value through OI in food and beverage firms. Co-creation practices involve consumers in the innovation process to create competitive value-based innovation outcomes. This research stream has confirmed that embedding co-creation practices stimulates the OI process in a competitive direction, especially among functional SMEs in the food industry. In a similar vein, Galati *et al.* (2016) identified two strategic approaches (open market pull and open technology push) that drive OI in small firms. The former involves integrating consumers into innovation, and the other consists of

collaborating with external entities to develop impactful innovations. Petroni *et al.* (2012), Fortuin and Omta (2009) and Siedlok *et al.* (2010) also established important driving factors for OI in the food industry such as market competition, stakeholder demands, time to market and unequal power distribution in the supply chain, explicitly indicating the supporting and competitive role of networks in food and beverage OI. The studies conducted by Ku (2015), Beckeman *et al.* (2013), Kumar *et al.* (2012), Wolfert *et al.* (2010) and Sarkar and Costa (2008) in this cluster indicate the growing importance of OI practices in the food sector. Empirical evidence is provided from a range of studies demonstrating that the successful orientation of food-based SMEs and food manufacturers towards an OI mindset and designing OI-centric business models is a practical approach to growth in the food sector. While implementing OI strategies is gaining attention, it is still a nascent and developing approach within the food sector.

The second cluster (green) consists of eight contributions that appeared between 2011 and 2019 and represents a growing number of recent studies in the food OI field. A quantitative methodological approach is used by most of these studies (Bayona-Saez *et al.*, 2017; Dries *et al.*, 2014; Enzing *et al.*, 2011; González-Moreno *et al.*, 2019; Santoro *et al.*, 2017; Seyfettinoğlu, 2016; Triguero *et al.*, 2018). Santoro *et al.* (2017) is the most frequently cited document in this cluster, which we call "OI impact on food and beverage organization performance". The type of innovation approach influences the competitive performance of a firm. Implementation of a collaborative approach for innovation has been recognized in any number of studies. This cluster indicates a similar research focus, with most studies examining the role of a collaborative OI approach and its impact on the performance of food and beverage organizations and on the type of innovation that those organizations generate (Arcese *et al.*, 2015; Bayona-Saez *et al.*, 2017; Dries *et al.*, 2014; Enzing *et al.*, 2011; González-Moreno *et al.*, 2019; Santoro *et al.*, 2017; Seyfettinoğlu, 2016; Triguero *et al.*, 2018). Another critical characteristic of a group of contributions in this cluster is applying an OI approach through a sustainability lens (Arcese *et al.*, 2015; González-Moreno *et al.*, 2019; Triguero *et al.*, 2018). Open, sustainable innovation approaches provide several advantages to food and beverage organizations by reducing expenditures, providing rapid access to market, decreasing environmental impacts and alleviating food insecurity and negative social impacts (Arcese *et al.*, 2015). Inbound OI (i.e., sourcing external knowledge for in-house innovation activities) has been identified as a critical driver of eco-innovation in the food and beverage industry. The collaborative nature of OI facilitates the extensive use of external knowledge for developing eco-innovations (Triguero *et al.*, 2018). In addition, González-Moreno *et al.* (2019) extended this by understanding the link between the innovating food firm and its stakeholder interactions and found that such cooperative relationships positively influence the development of eco-products and eco-processes. A group of studies in this cluster also focuses broadly on a the OI approach's capability to leverage external knowledge for developing new products in the food and beverage sector. Bayona-Saez *et al.* (2017) and Santoro *et al.* (2017) suggest a positive relationship between OI practices and an organization's innovation performance, which should be effectively employed in the food and beverage sector to gain competitive advantage through new product development. Seyfettinoğlu (2016) confirmed that applying an OI approach in the food industry can increase productivity. In addition, food OI practices that consist of more open and diverse network relationships increase a product's market performance (Enzing *et al.*, 2011). All these results suggest a constructive association between firm performance and OI approaches.

In contrast to OI practices' positive influence, a group of scholars in the cluster applied a process-based approach to understand OI practices. These researchers found that OI practices should be limited to certain stages of the innovation process, specifically idea generation. They also found that an overreliance on OI can hamper production efficiency and

firm performance, specifically in the development and commercialization stages (Dries *et al.*, 2014; Santoro *et al.*, 2017; Seyfettinoğlu, 2016).

In cluster three (blue), six contributions spanning from 2011 to 2017 were linked; the cluster is concerned with the "New precursors of OI" in the food industry. This research stream provides information about the different models and frameworks that explain the antecedents that are important for successful OI implementation to achieve valuable innovation outcomes in food and beverage organizations. Pellegrini *et al.* (2014) highlight the need for the food and drink sector to open up its innovation processes, a point that managers and academics have previously made when discussing how to obtain advanced knowledge in OI practice. For example, Traitler *et al.* (2011) suggest using an interdependent, sharing-is-winning (SiW) and innovation partnerships approach for reinventing research and development (R&D) structures and consumers' role in an OI ecosystem. The application of an SiW approach enables the co-development of sustainable innovation with less effort. It reduces resource and time management complexities by efficiently allowing for the division of key activities amongst innovation partners. Saguy (2011) offers another example regarding the implications of the SiW and innovation partnership approach in academia and the food industry setting for better using OI's benefits. This would allow academia to conduct valuable fundamental research and engage industry in inventions. Moskowitz and Saguy (2013) studied the changing role of consumer research in OI to improve new product development. Their research pushes boundaries by suggesting that the role of consumer research is to move beyond testing towards design and gatekeeping for consumer responses, change leaders and intellectual capital providers. Other important precursors of OI include the context, business environment and degree of firm openness (Martinez *et al.*, 2014). Technology pressure exerted by ever-changing trends pushes innovating firms to collaborate extensively with external partners, which is a fundamental element of all OI practices. This further increases the degree of openness and leads to better innovation outcomes. The need for greater transparency is also reported by Manzini *et al.* (2017) in their study of the Lindt approach to innovation. Despite the successful implementation of a closed innovation approach, a stout requirement for a sophisticated degree of openness was identified for the focal firm to increase creativity to sustain its place in the European Union market. The identified precursor for OI in such cases is competitive pressure.

Cluster four (yellow) comprises three contributions (Berthet *et al.*, 2018; Cillo *et al.*, 2019; Meynard *et al.*, 2017). These papers provide a new perspective on OI's application in the food and beverage industry; hence, the cluster is named "Nuanced OI approaches in agriculture". The level of OI knowledge in this cluster provides a higher degree of complexity in implementing OI strategies in the agriculture industry. The cluster sheds light on the open design, coupled innovations and technologically integrated OI approaches to knowledge management. For example, Berthet *et al.* (2018) examined OI using a co-design and co-innovation perspective in an agricultural context. Meynard *et al.* (2017) applied a coupled innovation approach to explain the importance of combining the dynamics of two different domains of the agricultural system and focusing on design as a critical stage of innovation. Adopting a digital perspective, Cillo *et al.* (2019) studied crowdfunding platforms' integration in agri-food businesses to understand their relationship with the OI approach's successful implementation. All studies in this cluster propose findings that instigate discussions around future implications and expand the OI approach. It is also worth noting that this cluster focuses explicitly on the upstream end of the FVC, concentrating on the food and beverage industry's agricultural activities. This is a further indication of the lack of sufficient FVC research focused on the downstream end of the chain (see Table 3) (see Figure 3).

Cluster number	Colour	Number of items	Timespan	Total link strength	Keywords	Authors	Cluster re-named
1	Red	12	2008–2016	22–156	Open innovation, Food firms, SMEs, Low tech, Customer orientation, business process management, Knowledge management, R&D organization, Customer co-creation	Tardivo *et al.* (2017) Galati *et al.* (2016) Ku (2015) Martinez *et al.* (2014) Beckeman *et al.* (2013) Filieri (2013) Kumar *et al.* (2012) Petroni *et al.* (2012) Siedlok *et al.* (2010) Wolfert *et al.* (2010) Fortuin and Omta (2009) Sarkar and Costa (2008)	Drivers of OI in the food industry'
2	Green	8	2011–2019	104–183	Open innovation, Innovation network, Innovation performance, Dynamic capabilities, Food sector, New product development, Eco-innovation	González-Moreno *et al.* (2019) Triguero *et al.* (2018) Santoro *et al.* (2017) Bayona-Saez *et al.* (2017) Seyfettinoğlu (2016) Arcese *et al.* (2015) Dries *et al.* (2014) Enzing *et al.* (2011)	OI impact on food and beverage organization performance'
3	Blue	6	2011–2017	49–241	Food industry, Open innovation, Collaborative innovation strategies, Consumer research, Paradigm shift, Innovation partnerships, strategic alliances	Manzini *et al.* (2017) Pellegrini *et al.* (2014) Martinez (2014) Moskowitz and Saguy (2013) Saguy (2011) Traitler *et al.* (2011)	New precursors of OI

(*continued*)

Table 3.
The four clusters of bibliographic coupling

Cluster number	Colour	Number of items	Timespan	Total link strength	Keywords	Authors	Cluster re-named
4	Yellow	3	2017–2019	2–125	Knowledge exploitation, Knowledge exploration, Knowledge management, Network management, Open innovation, Value chain, Innovative design	Cillo *et al.* (2019) Berthet *et al.* (2018) Meynard *et al.* (2017)	Nuanced OI approaches in agriculture

Table 3.

4.5 Co-citation analysis

In the second stage of the bibliometric analysis, a co-citation analysis was conducted to identify the different theoretical perspectives that are relevant and make contributions to the field of food OI, as shown in Table 4 (Figure 4). The perspectives were categorized into three clusters.

As Figure 5 shows, the first cluster (red) consists of eight contributions that run from 1990 to 2013. The primary sources of publication were *Trends in Food Science and Technology* (2) and *Agribusiness* (2). The major contributions include Cohen and Levinthal (1990), Bigliardi and Galati (2013) and Traill and Meulenberg (2002). The documents in this cluster focus primarily on understanding the internal and external factors that will shape future OI processes and portfolios of food-based organizations. Therefore, the cluster is named "Convergence in OI". Studies conducted by Huizingh (2011) and Cohen and Levinthal (1990) can be applied to understand the influence of internal factors on OI in a broad sense. Examples include the context in which an OI process operates and its dependence on that context, an organization's absorptive capacity and its influence on the innovation activities related to adoption and diffusion. Internal factors are a firm's R&D capabilities, demographics, strategic approaches, process orientation and innovation type, all of which influence OI's successful implementation. Traill and Meulenberg (2002) and Sarkar and Costa (2008) emphasize that a firm's method of innovation, motivation, choice of product versus process orientation, nature of ownership, technological and marketing capabilities and size are some of the internal factors that can wield significant influence on the organization's innovation decisions. Another internal perspective applied by authors in this cluster is the ability to collaborate for resource management. Huston and Sakkab (2006) suggest the "connect and develop model" to explain the role of networking and engagement capabilities and their influence on innovation. In addition, Capitanio *et al.*'s (2010) findings highlighted that successful product development in the food industry relies heavily on an organization's capacity to build relationships. Huston and Sakkab (2006) explain the role of external collaboration in OI using Procter and Gamble's strategic OI approach, which leads to enhanced product quality and reduces development costs and time to market. In his state of the art, sector-agnostic article, Huizingh (2011) suggests that other external factors include the market environment and the impact of globalization, technological fusion and innovative business models. Bigliardi and Galati (2013) examined a specific food category and its innovation future in the context of the influence of health trends, technological processes and design approaches. This importance of external influence had been previously explored by Sarkar and Costa (2008), who found that OI in the food industry was still an emerging approach.

Cluster number	Colour	Number of items	Timespan	Total link strength	Key contributions	Cluster re-named
1	Red	8	1990–2013	4–12	Bigliardi *et al.* (2019) Bigliardi and Galati (2013) Capitanio *et al.* (2010) Cohen and Levinthal (1990) Huizingh (2011) Huston and Sakkab (2006) Sarkar and Costa (2008) Traill and Meulenberg (2002)	Convergence in OI
2	Green	7	2003–2016	3–9	Bianchi *et al.* (2011) Chesbrough (2003) Dahlander and Gann (2010) Laursen and Salter (2006) Parida *et al.* (2012) Vrontis *et al.* (2016) West and Bogers (2014)	Degree of openness
3	Blue	5	1986–2010	5	Chesbrough (2003) Enkel *et al.* (2009) Fortuin and Omta (2009) Gassmann *et al.* (2010) Teece (1986)	Emerging arenas of OI

Table 4.
The three clusters of co-citation analysis

However, its effectiveness can be improved by incorporating actors both internal and external to the FVC. Actors involved in the FVC perceive innovation differently, based on which they form collaborative relationships that support the innovation process. Bigliardi *et al.* (2010) indicated that not all actors in the FVC had adopted the OI paradigm to the same extent. While the downstream actors (manufacturers and customers) were actively participating and implementing the OI approach, the upstream end (suppliers) was still learning.

In the second cluster (green), which is shown in Figure 6, seven key contributions were included, bridging research from 2003 to 2016. The main contributions of the cluster were Dahlander and Gann (2010), Laursen and Salter (2006) and Chesbrough (2003). The cluster relies mainly on examining the importance of openness in innovation from a theoretical point of view, leading to the cluster being named "Degree of openness". The cluster's core contributions examine the role of openness and its influence on innovation outcomes (Bianchi

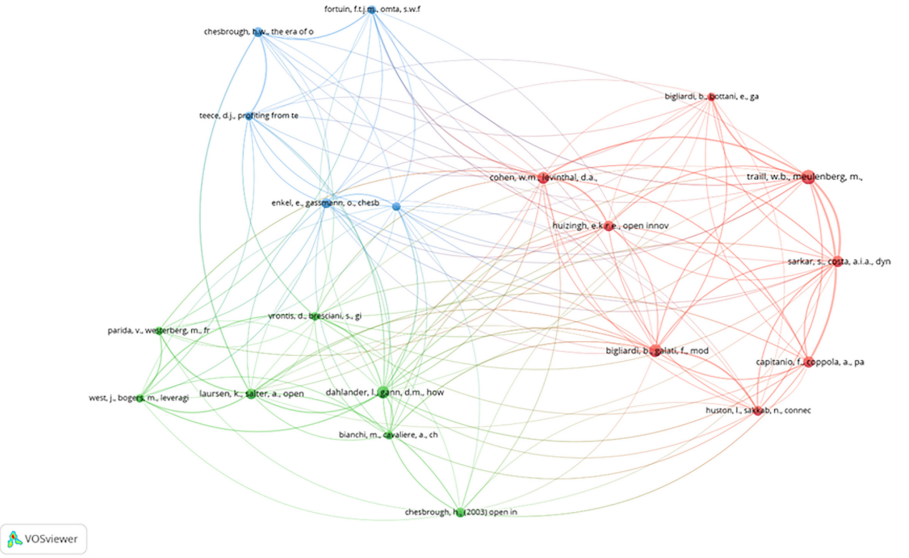

Figure 4.
Co-citation analysis (minimum five citations)

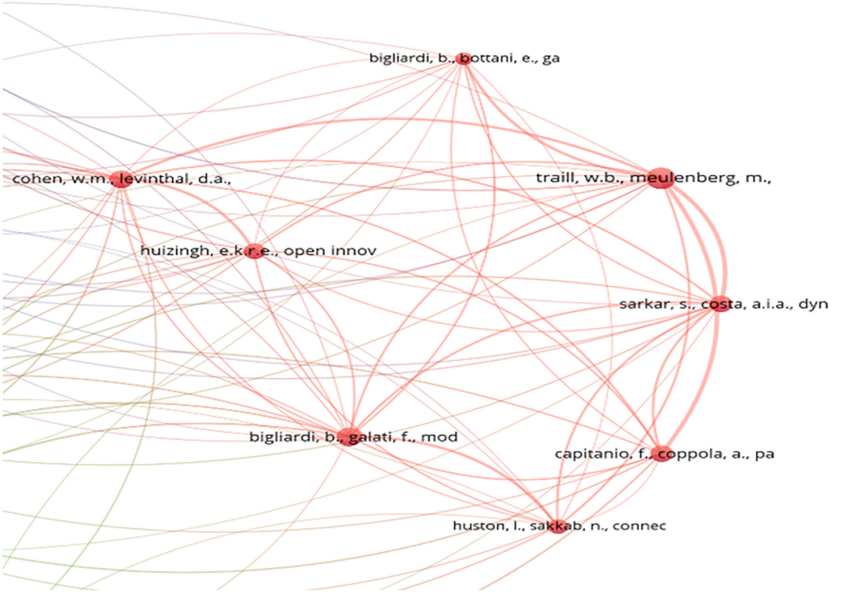

Figure 5.
Co-citation analysis cluster 1 (red)

et al., 2011; Dahlander and Gann, 2010; Laursen and Salter, 2006; Parida *et al.*, 2012; West and Bogers, 2014). This cluster consists of critical contributions to OI, with Chesbrough (2003) establishing OI's theoretical foundation and its implementation as a robust innovation strategy. That foundation is reflected in several contributions in this cluster, as in Laursen and Salter (2006), who extend the understanding of OI by examining the concepts of "breadth and depth" as crucial components of openness in firms and their effect on the firms'

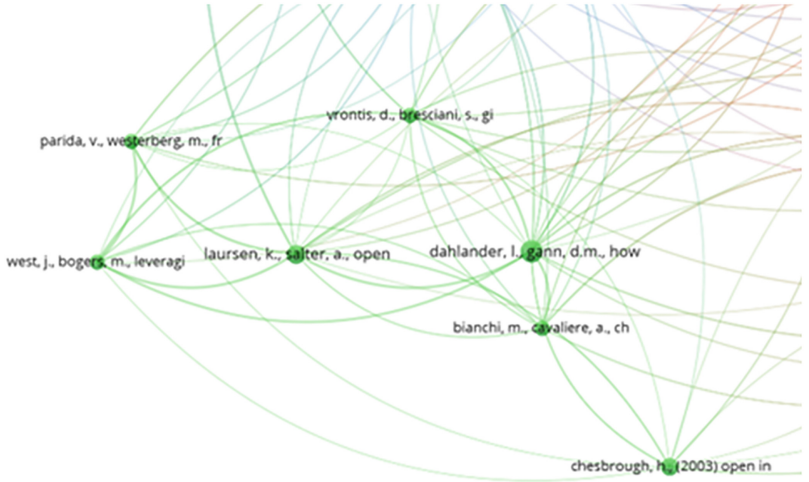

Figure 6.
Co-citation analysis cluster 2 (green)

innovation performance. The findings accord with Chesbrough's (2003) perspective of exploring the external environment to gather more innovation opportunities using a balanced OI approach. In their bibliometric analysis, Dahlander and Gann (2010) confirmed that the established OI literature suggests that openness is necessary, at least to some extent and at selected stages of innovation, depending on context. Some attributes of creation should be accessible, while others should remain closed. Assessing the success of a given OI strategy should be carried out on a case-by-case basis across different technologies and industries to better understand the barriers and enablers linked to OI implementation.

It is notable that the foundational work of Bianchi *et al.* (2011) offers a major advance in understanding the different combinations of organizational modes of collaboration and inbound and outbound OI strategies; of particular importance is the authors' emphasis on the degree of openness. Their findings indicated that increases in external partners and alliances to access resources had improved the new product development process. In the same vein, Vrontis *et al.* (2016) report that combining tradition and innovation strategies can provide competitive innovative outcomes. The cluster offers a good mix of studies examining large and small organizations. For example, Bianchi *et al.* (2011) used a mix of large and small pharmaceutical firms as a context to study openness, while Parida *et al.* (2012) examined the impact of integrating an open approach in SMEs. Their findings confirm that implementing an OI approach in SMEs led to improved innovation performance with different types of innovation. It is striking that researchers across other innovation domains have extensively supported the integration of external collaborations; however, the level of openness for the exploitation of innovation is not well grounded (West and Bogers, 2014).

Cluster three (blue), shown in Figure 7, comprises five contributions that range from 1986 to 2010. The primary sources are *R&D Management* (2) and *Research Policy* (1). Chesbrough (2003) and Enkel *et al.* (2009) have the most frequently cited contributions. A deeper analysis reveals that the cluster thematically focuses on identifying OI's most promising research areas, indicating the need for further research using multiple perspectives to examine OI's implementation in different industry contexts. Therefore, the cluster is named "Emerging arenas of OI" This cluster's core contributions emphasize the need for more research to understand the OI approach and its management in SMEs (Chesbrough, 2003; Enkel *et al.*, 2009; Gassmann *et al.*, 2010).

Further research is also needed to identify intellectual property and patent management issues (Teece, 1986; Gassmann *et al.*, 2010; Enkel *et al.*, 2009). Other areas of need include

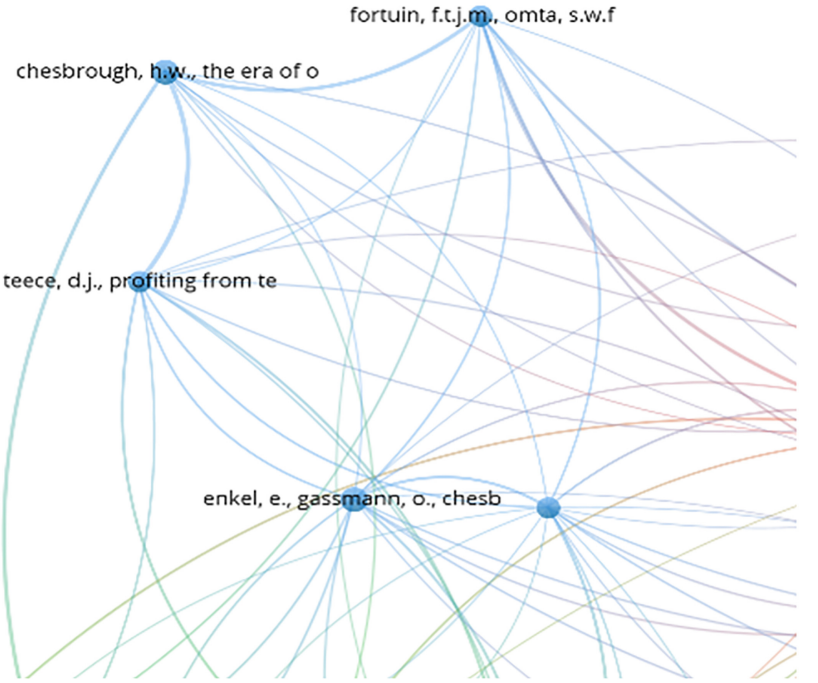

Figure 7.
Co-citation analysis cluster 3 (blue)

developing OI models that integrate boundaries for innovation from a spatial perspective. The cluster highlights some critical areas that future authors can explore using an FVC approach to emerging research areas in food OI.

4.6 An integrative framework of FVC and OI

The proposed integrative framework provides directions for future research by drawing on the links between existing food OI research and the four stages of the FVC. In Table 5, a matrix shows the intersection of the FVC and published food OI research. The table shows how the four stages of the FVC intersect with existing research regarding types of OI approaches, knowledge management capabilities, antecedents of OI, barriers to OI and the impact of OI across different stages of the FVC. The authors categorised the content from the titles and abstracts of 84 documents based on the FVC stages and present the observations under different research indicators in the matrix in Table 5. That table reveals areas where scholarship has made rigorous contributions and highlights areas where there is room for theoretical development. In the matrix, the large black spaces indicate a lack of research at a given area of intersection.

To fully understand the intersection of OI and the FVC, it is crucial to view the stages of FVC through an innovation lens. The integration of OI can be mapped by type of innovation activity undertaken at the various FVC stages. A divergent value creation and innovation approach is applied at different stages of the FVC based on the diverse requirements of stakeholders and primary customers (Henriksen *et al.*, 2010).

The framework will help scholars observe the FVC from an OI perspective. The critical questions here are, "What is the influence of OI on the FVC? What are the areas in an OI-integrated FVC that remain uncharted and need research, and how is that research to be conducted?" Below we discuss the observations that emerged most prominently from the framework.

FVC/OI intersection	Input	Production	Processing	Output
OI approaches	R&D Collaborations, OI business model, Ecosystem model,	Information technology Integration, stakeholder management, co-creation approach, coupled innovation, radical circles, co-design, co-innovation, crowdfunding	Eco-innovative, inter-firm transactions, university collaborations, new product development process, service blueprint, consumer-based pro-sumption, traditions, value-cocreation, process innovation, organisational structures	Hybrid business model approach, consumer integration, open sustainability innovation, integrating lead users, radical circles
Knowledge management capabilities	Knowledge Valorisation	User-centric approach, customary seed sharing, knowledge sharing ecosystems, model of knowledge generation, technology transfer mechanisms, exploitation capabilities	Absorptive capacity, external revealing of knowledge, knowledge network, hackathons and crowdsourcing, external knowledge sourcing, convergence and reorientation, sharing-is-winning model	Technological modularity, regional and company-specific factors, value capture mechanisms
Antecedents of OI	Multilateral systems, synthesis of stakeholders	IP management, technical, regulatory factors, trust-based relationships, responsible research and innovation tools	Innovation sources, type of innovation, market and consumers, open market pull and technology push, innovation models, open behaviour, collaboration breadth and depth, early customer integration, innovation patterns, strategic orientation,	
Barriers of OI	Access to capital and human resources, legislative barriers, knowledge sharing risk	Mental innovation space, inexperience with innovation	Degree of openness, innovation resource management, power of distribution	Regulatory mechanisms, policy and governance Impact
Impact of OI	R&D in agribusiness, best practices approaches, benefits for government and farmers, agricultural exploitation	Enhanced prototyping, validating	Financial sustainability, promote eco-innovations, sustainability, competitive advantage, adoption, innovation performance, durability, improved product quality	Development of superior value propositions, competitive advantage, adoption process

Table 5.
Integrative framework of FVC and OI

4.6.1 Research distribution across the stages of FVC. The analysis showed that stage three (the processing stage) of the FVC is prevalent amongst OI scholars. A total of 52 documents were linked to that stage, whereas 17 were related to the production stage, making it the second most researched stage. Eight documents were related to output and only five to input, making it the least explored area of the FVC from the OI perspective (see Figure 8).

4.6.2 OI approaches. As Table 5 shows, all stages of the FVC have been examined using different OI approaches. The most prevalent perspectives include stakeholder management, consumer integration, process innovation, crowdfunding approaches, sustainable or eco-innovation and R&D collaborations. The production and processing stages of the FVC have been examined more intensively than input and output. Most authors have framed their analysis by understanding different actors' roles (individual, organizational, technological) and contributions to various innovation activities. One interesting OI approach uses the eco-innovation and sustainability perspective on the FVC's processing and output stages.

The authors of the present study developed an adaptive model (see Figure 9) to show that scholars have focused on understanding the different OI approaches more by exploring

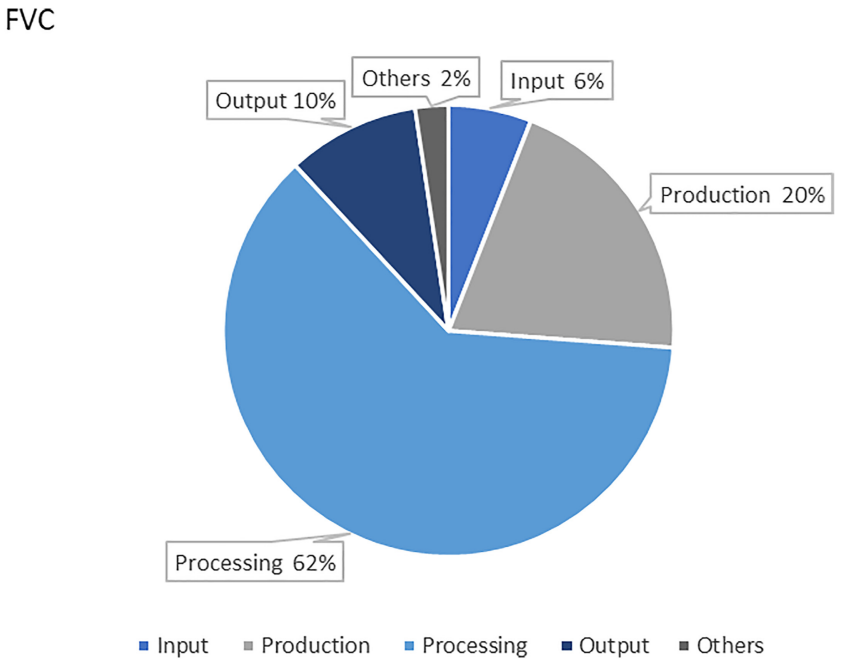

Figure 8.
Distribution of documents: Intersection of FVC and OI

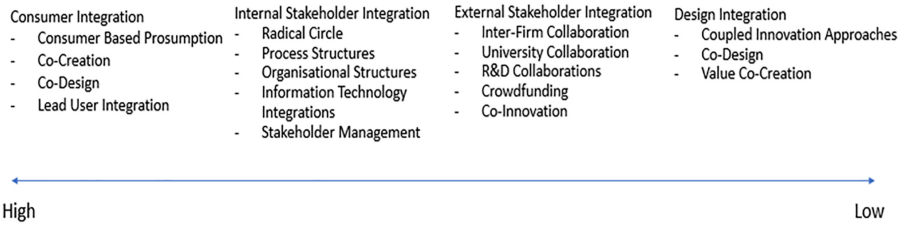

Figure 9.
An adapted model of the range of OI perspectives examined in the FVC

consumer or customer involvement in the innovation process. The dominant approaches were consumer-based integration, co-creation, co-design and lead user integration. The least explored perspective was the integration of design experts in the innovation process. In the middle of the spectrum were other general perspectives exploring the roles of internal and external stakeholders.

4.6.3 Knowledge management perspective. The integration of OI has been examined from a knowledge management capability (KMC) perspective. KMC refers to a firm's ability to create, share and use knowledge across its operational limits (Lichtenthaler and Lichtenthaler, 2009). A limited number of studies focused on examining the FVC input and output stages using a KMC perspective. In the processing and production stages, the KMC assessment was predominantly applied to uncover how knowledge is shared using customary seed sharing and knowledge sharing ecosystems, technology transfer mechanisms, external revealing of knowledge and the sharing-is-winning approach. The research also refers to how knowledge is created with the user-centric model of knowledge generation, hackathons and crowdsourcing and the external knowledge sourcing approach. However, the ways knowledge is used are analysed using only a few approaches (exploitation capabilities, convergence and reorientation) and is not well-grounded.

4.6.4 OI antecedents. The analysis of the antecedents' variables – the critical external and internal drivers – revealed that most of the studies of antecedents focused on the processing stage; there was scarce research on the input and production stages and no research linked to the output stage. The external precursors identified across the input, processing and production stages include technical and regulatory factors, innovation sources, market and consumers, open market pull and technology push. The main internal antecedents include synthesis of stakeholders, intellectual property management, responsible research and innovation types, models, patterns and behaviours. It quickly became clear that only limited research has been conducted to examine external FVC antecedents when compared to the range of internal FVC antecedents.

4.6.5 OI barriers. The type of OI barriers was analysed across all four stages. There are more OI-related barriers associated with the input and output stages than the other two stages. Some common obstacles include access to capital, degree of openness, legislative barriers and power of distribution. Some distinctive concepts such as "mental innovation space" were also applied at the production stage and are an essential issue related to OI barriers across the FVC. Identifying barriers across all four stages is an important aim because it could improve the design of policy interventions.

4.6.6 Impact of OI. The framework examined the link between studies that examined OI's impact at different organizational dimensions in the food context. The research revealed only limited links between the production stage and OI impact. The impact of OI on the FVC is most visible in R&D in the production stage, generating benefits for stakeholders, promoting eco-innovation, encouraging innovation performance and gaining a competitive advantage.

5. Discussion and future directions

Several scholars have shown increasing interest in mapping innovation activities across the FVC (Caiazza *et al.*, 2014; Diamond and Barham, 2012; Zilberman *et al.*, 2019). Still, the role of OI has grown dramatically in importance amongst a wide range of food innovation scholars.

The analysis revealed a gradual increase in the scholarly literature on food innovation in recent years. It remains well aligned with the emergence of new techniques, novel modified raw materials, emerging technologies and food demands. The highest number of documents in this field were from Europe, followed by the United States and Canada, proving the food industry to be a priority in these areas of the world. The geographic distribution of researchers and affiliations provides an opportunity for future researchers to consider

collaborations with authors from different regions and is an opportunity for researchers from other regions to conduct similar studies to examine multiple food innovation-related contexts and improve the generalizability of the research results.

Most authors explore specific innovation activities that create value at different stages in the FVC; while they provide a comprehensive view of the influence of OI on certain FVC activities, none of the studies focuses on providing a holistic view using a process-based approach to examine the influence of OI on the FVC, which offers opportunities for future research. The statistical analysis of the subject areas reveals that the study of food innovation is gradually maturing and migrating from core research fields like agricultural and biological sciences and moving towards food business management, manufacturing, packaging, economics and management. From an innovation perspective, this multidisciplinary feature indicates an emerging research area lying at the intersection of food technology and collaborative food innovation. It is also expected that research on the UN's Sustainable Development Goals, the economics of food development, food innovation policies and social levels will show a gradual improvement in the theoretical framework and more detail in the patterns revealed.

Most authors who applied a qualitative approach used interviews and case studies to collect data over a relatively short period of time. The initial input and processing stages of the FVC primarily involve agricultural and initial product development practices, which are long-term processes; to examine the impact of OI in these stages demands longitudinal research that uses a process-mapping approach to thoroughly understand how innovation practices can be enhanced.

An important issue of food safety remains underexplored within this context. A process mapping study would provide practitioners, stakeholders and managers with essential information to improve collaboration and refine management strategies. Future research can guide food practitioners and policymakers in deploying procedures and practices that assist in the implementation of advanced OI approaches for better management of food R&D practices.

Given the growing demand for research in this field, several scholars have examined OI drivers in the FVC. Studies on the FVC and food OI (Galati *et al.*, 2016; Schroder and McEachern, 2004; Tardivo *et al.*, 2017) have suggested integrating consumers as a critical driver of innovation in the FVC, which can also lead to successful innovation outcomes.

The findings further confirm the need for consumer integration to improve innovation outcomes and gain competitive advantage. However, more research is needed to identify the specifics of consumers' roles at different stages of the FVC, especially the input stage.

More broadly, this study shows that OI practices tend to be restricted to the processing and production phases stages of the FVC. A step-by-step approach aimed at understanding OI's barriers and enablers at each stage would provide more profound insights into how to foster open and collaborative innovation practices in the food industry. These insights could then inform and guide policy interventions. In addition, although a few studies have made some effort to understanding the role of sustainability to address the "grand challenge" within the food context, there is a need for further research to understand the intersection of sustainability oriented OI practices and their role in and influence on the food industry's R&D and manufacturing processes. This calls for developing a research design for regular monitoring and evaluation of innovation practices to understand the factors that hinder the successful implementation of sustainability-related approaches for food innovation.

High-tech firms have thus far been the central area of focus for food innovation research. A deeper understanding of the innovation behaviours in an FVC of SMEs or low-tech firms and the involvement of external stakeholders across all stages of the FVC is needed. This is a crucial research area because some studies presented in this analysis have proposed adopting an OI-centric approach for food-related SMEs and larger food manufacturers. An external

variable influencing this research area is the increasing automation and digital technology integration in the food industry (Coronado Mondragon *et al.*, 2020), which calls for research into digitalized innovation in the FVC.

Overall, the studies presented in this analysis (Arcese *et al.*, 2015; Bayona-Saez *et al.*, 2017; Dries *et al.*, 2014; Enzing *et al.*, 2011; Gonzalez-Moreno *et al.*, 2019; Santoro *et al.*, 2017; Seyfettinoğlu, 2016; Triguero *et al.*, 2018) show that collaborative approaches have been well-understood from the OI perspective. Studies have mainly examined the impact on innovation performance. However, OI impacts other variables in the FVC that need further analysis. For example, most research has examined the initial stages of the food OI approach; there is limited research looking at performance at the FVC distribution stage. This is relevant because the food industry relies heavily on marketing and communication and sales channels. This area will be interesting to develop for scholars and managers from the commercialization strategy perspective. Distribution can also be characterized by a process of gradual diffusion of innovation in the market, which calls for research projects analysing the impact of OI in generating pathways for efficient adoption of food-based innovations, especially in lower-level economic communities.

This research field should be explored in depth all the way from the stages involving agricultural collaborative practices through the collaborative output stage (in the form of food-based products and services). In the future, researchers and practitioners should pay attention to sustainable innovation in FVC management and development from an economic, environmental, social, technological and policy-making perspective.

6. Conclusion

As the food industry grows dramatically and more and more technologies are being developed to meet the demands of an industry in need of innovation, reviewing the existing body of knowledge to sketch future research agendas is timely, if not urgent. Based on an extensive bibliometric analysis and thematic review, this study offers an integrative framework showing the intersection of OI research along the FVC, which provides researchers with insights into current gaps and directions of relevance and significance for future studies.

The present study shows the influence and challenges of OI across the several stages of the FVC. While the papers identified in our search and referred to in the proposed framework have been linked to specific stages of the FVC, no single paper has considered the entire FVC as a critical context or applied the same perspective to examine innovation activities within a single firm. Accordingly, we call for further research on food OI that adopts a broad FVC perspective.

By adopting a comprehensive methodological approach and using VosViewer as a tool for conducting bibliometric analysis, this study provides researchers with directions for conducting future content analysis-based studies by assessing clusters and themes using a cited reference-based approach. It also provides a foundation for learning network-based visualizations of data to show the interconnectedness between different research areas and researchers for future collaborations in related fields. In addition, the study can serve as a guide for new researchers because it offers a review of the food OI research conducted in the recent past, which leads to pathways for the future.

7. Limitations

The analysis presented here is based on 84 articles published in food and OI research from Scopus data. While Scopus is a high-quality database, other databases could be included in future research studies conducting similar analyses. More keywords can be applied to find

more papers with extended applications of OI in the FVC context. The search results were confined to papers in their final stage of publication to assure quality. However, it would also be interesting to include grey literature (e.g. policy-oriented reports from the Food and Agriculture Organization of the United Nations) and papers in their initial stages to map the newest research areas in food OI across the FVC.

This study also showed that OI has a vital role in reshaping food systems (Food and Agriculture Organization of the United Nations, 2018). This message will resonate as world leaders convene for the 2021 Food Systems Summit and develop an action framework for the UN Convention on Biological Diversity. Stead (2019) argues that a broader look at how various food system elements interact and using system thinking to envision future scenarios is long overdue. Of note for the OI agenda is to (1) reimagine food supply chains to be fairer, more efficient and cleaner, (2) connect policies to practices (such as tracking and managing the health of humans, crops and habitats) and (3) democratize food processing by enhancing the digital capabilities of local producers and suppliers. The framework developed in this study also provides policy-makers with insights into how to design the best possible policies, spanning the different areas of the FVC and contingent on the type of novelties that they seek to promote.

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