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Review

# Agri-Food Supply Chain Management: Bibliometric and Content Analyses

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**Abstract:** Agri-food supply chain management (ASCM) research has gained attraction in recent years. This study aims to examine the knowledge structure, trace the evolution of, and propose future research directions for ASCM by a systematic literature review combined with bibliometric and content analyses. A total of 1770 articles were selected from Scopus for bibliometric analyses. We conducted a content analysis based on 188 articles in six clusters selected from the co-citation analysis. This review provides insights into key authors, their affiliations, journal quality, and the prestige of the reviewed articles, aspects that have not been fully captured or evaluated by previous reviews. Using bibliometric tools, we identified six clusters for ASCM, based on which, future research directions are proposed. Content analysis provides additional insights in each cluster. In particular, sustainability runs through all the themes identified except for one.

**Keywords:** bibliometric analysis; content analysis; agri-food supply chain; citation analysis; co-citation analysis

## 1. Introduction

The agri-food supply chain (ASC) concept was first proposed by scholars in the agricultural economics and management discipline [1,2]. The commonly used terms to describe this idea include agricultural supply chain, agricultural value chain, food supply chain, and food value chain. Agri-food supply chain management (ASCM) was first defined by a group of Dutch scholars, mainly from Wageningen University, The Netherlands, whose studies were published as monographs and in lower-ranking journals. ASCM refers to the management of the relationship(s) among the raw material supply for agricultural production, production processing, and product logistics and distribution [3–5]. The term ASC has been studied and used extensively in agriculture-related disciplines (agricultural science, agricultural economics, and development studies) and in business management-related disciplines (e.g., operational management and SCM). ASC was not specifically defined in the SCM literature, perhaps because SCM scholars consider ASCM a branch of SCM [6–8].

Articles that use the term agri-food value chain are also included in the present review, and its essence overlaps with the concept of ASC. The term is well recognized by agricultural economics scholars, but not by SCM scholars, because in SCM research, value chain studies focus more on value appropriation by actors throughout the chain [9–11]. Therefore, to ensure the comprehensiveness of this study, we consider agri-food value chain studies to be part of the ASC literature and include the term as one of the search keywords to avoid omitting related articles.

ASCM is naturally and closely related to sustainability. This is evidenced in our findings in which five out of six themes identified through co-citation and content analysis are focused on, or involve sustainability. Short/alternative supply chains themes focus on their role in rural development, i.e., social sustainability. The two themes of food supply chain sustainability and food safety in supply chain/supply chain traceability are directly related to sustainability. The majority of papers on the global food supply chain theme are focused around development issues. Many of the papers in food supply chain modeling concentrate on reducing food waste and improving environmental sustainability. The only theme which is not related to sustainability is food supply chain relationships/vertical coordination networks.

Several reviews focusing on certain aspects of ASC, such as traceability [12,13] or decision-making frameworks [14], have been conducted. However, a systematic review of the ASC literature using rigorous bibliometric analysis does not exist. Because ASCM is of great importance to food safety and quality [8], food system resilience [15], and agricultural development [16], the literature in this area continues to develop rapidly, and there is an urgent need to systematically understand its knowledge structure and thus make future research more vigorous.

To achieve this objective, a systematic literature review combined with bibliometric and content analyses was conducted to identify the homogeneous areas in ASC and to assess the movement and interactions within and between fields [17]. The remainder of the research is organized as follows. After the introduction, Section 2 presents the research methodology and introduces initial data statistics. Section 3 provides the bibliometric analysis, followed by a content analysis in Section 4. Section 5 discusses the findings and presents a number of future research directions for ASC. Section 6 concludes the paper.

## 2. Methodology

The systematic literature review approach was originally developed to compare the results of statistically based observational studies (e.g., medical science research) using large data sets; it has since been introduced and is increasingly recognized as a reliable evidence-based review model in management research [18]. We integrated bibliometric and content analyses into this systematic literature review to take advantage of the two approaches. The aim of literature review is to provide a critical discussion of the existing knowledge in a field of enquiry. The first step in the literature review is the retrieval of articles from databases. Then, a bibliometric analysis (including author influence, keywords statistics, affiliation statistics, citation analysis, and the subsequent co-citation analysis) is conducted, based on the previous citation analyses. Third, a content analysis is performed.

### 2.1. Search Strings and Selection Process

The review includes articles retrieved from the Scopus database, which is the largest database of peer-reviewed literature and international publishers [19,20]. To collect relevant sources, the systematic literature review was conducted using the following steps: (1) keyword identification, (2) inclusion and exclusion criteria selection, (3) quality assessment, and (4) data extraction [21].

Two key elements are crucial to the term ASC, namely “agri-food” and “supply chain” which are included to fully capture this theme. The first searching string contains agri-food related keywords, and we adopt the keywords of agricultural commodities defined by FAO [22]: agri\* OR agro\* OR farm\* OR food\* and corresponding specific foods, including livestock OR husbandry OR dairy OR fruit OR grain OR cereal OR meat OR pork OR beef OR chicken OR fish OR vegetable OR grape OR wine OR rice OR coffee OR oil OR horticulture OR maize OR wheat OR potato OR soybeans OR cassava OR tomato OR barley OR cotton OR apple OR sugar cane OR sugar beet. The second string is supply chain-related terminologies: supply chain OR supply network OR demand chain OR value chain [23,24].

A search of the “title” and “keywords” domains in the Scopus database produces 6833 articles (By Dec 2017). We then further limited the search scope to “journal articles” with the language in

“English” whilst excluding reviews, conference papers, short surveys, notes, and errata, which reduces the 6833 articles to 3563. Then, the titles and abstracts of the 3563 articles were screened based on inclusion and exclusion criteria. Specifically, we included articles discussing all the aspects of agri-food supply chain (e.g., definitions, agri-food quality and safety, member relationship of ASC, composition and governance of ASC, and factors affecting ASC development). Only peer reviewed journals were included. We exclude articles not directly related to ASC e.g., those focusing on general SCM with little covering of agri-food sector. Eventually 1770 relevant articles were selected for bibliometric analyses.

Two co-authors performed the filtering independently, compared results, and reached agreements on 1770 articles (included or excluded). The inter-rater reliability was 100%. No time limit was placed on the search; therefore, all the contributions to the ASC literature were included to achieve a comprehensive understanding. In contrast to other bibliometric analysis articles that directly import the search results from databases for analysis, we manually filtered the irrelevant articles based on the inclusion and exclusion criteria, which reduced noise and increased the accuracy of the results.

## 2.2. Initial Data Statistics

The 1770 screened articles were published between 1985 and 2017 (inclusive). As illustrated in Figure 1, the number of papers published each year has increased since 1998, with the exception of 2010 (71); this shows that interest in ASC among the academic community is increasing (Figure 1).

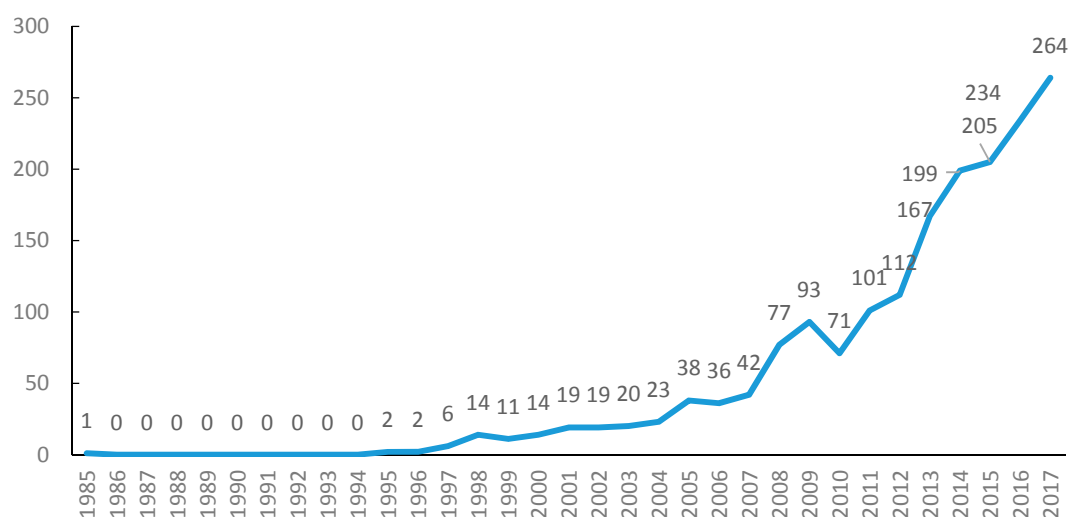


Figure 1. Number of publications (N = 1770).

## 2.3. Bibliometric and Content Analyses

### 2.3.1. Bibliometric Analysis

Bibliometrics is a statistical analysis of academic publications, including citation analysis, co-citation analysis, and so on [25]. In this paper, BibExcel software is used for bibliometric analysis and preparing the raw data for co-citation analysis because Bibliometrics is capable of handling large datasets and it is compatible with other software, including Excel, Pajek, and Gephi [26]. Gephi software is used for network analysis, because of its ability to efficiently process large graphs by comparing them with the existing network analysis software, such as Pajek or VOSviewer [27].

### 2.3.2. Content Analysis

We also performed a content-based literature review of the 188 articles identified for six clustering results of the co-citation analysis. Content analysis is an effective technical tool for examining a sample of documents in a systematic way [28]. One of the most important rules of content analysis is that

the dimensions and related analytic categories that allow the reviewed material to be classified can be derived deductively (based on theories) or inductively (based on the reviewed materials) ([29,30]). We adopted the clustering results of the co-citation analysis to code the articles (i.e., the deductive approach) and then adopted an inductive approach to identify sub-themes within each cluster by synthesizing the findings of the articles.

### 3. Bibliometric Analysis

Section 3 presents bibliometric analysis, including author influence, keywords statistics, affiliation statistics, journal quality, citation analysis, and co-citation analysis.

#### 3.1. Author Influence and Affiliation Statistics

The author field was extracted from the data file, which was later analyzed by BibExcel to record the frequency of occurrence of all authors. Top 20 authors that make the most contributions are listed in Table 1, with other associated information like affiliations, research fields, and the number of published papers. There are two authors who contributed more than ten articles each, including Van Der Vorst (21 articles) and Fearne (12 articles). Altogether the top 20 authors contributed 9.5% of the total 1770 papers.

**Table 1.** Top 20 cited authors of agri-food supply chain management (SCM).

Author	No. of Cited Times	Author	No. of Cited Times
Van Der Vorst, J.G.A.J.	21	Fritz, M.	7
Fearne, A.	12	Marimin	7
Gellynck, X.	10	Meuwissen, M.P.M.	7
Trienekens, J.H.	10	Tan, K.H.	7
Manning, L.	9	Vermeulen, W.J.V.	7
Trienekens, J.	9	Collins, R.	6
Beulens, A.J.M.	8	Engelseth, P.	6
Bourlakis, M.	8	Hanf, J.H.	6
Maye, D.	8	Hobbs, J.E.	6
Swinnen, J.	8	Jie, F.	6

Table 2 lists the top 20 organizations publishing the most articles for ASC. Wageningen University and Research Centre contributed the most with 117 articles, followed by Michigan State University, and Cardiff University.

**Table 2.** Top 20 organizations contributing to the area of agri-food SCM.

Affiliation	No. of Publications	Affiliation	No. of Publications
Wageningen University and Research Centre	117	University of Göttingen	13
Michigan State University	27	Pennsylvania State University	12
Cardiff University	22	Cornell University	12
Ghent University	22	University of Guelph	12
Universität Bonn	19	University of Bologna	12
KU Leuven	17	Iowa State University	11
University of Queensland	15	Purdue University	11
University of Pretoria	14	French National Institute for Agricultural Research	11
Cranfield University	13	University of Liverpool	11
Imperial College London	13	Bogor Agricultural University	11

#### 3.2. Keywords Statistics

A similar analysis has also been carried out to track words and phrases frequently mentioned in keyword list. Based on the pool of 5985 keywords from 1770 papers, the top 20 most popular

keywords are summarized in Table 3. Supply chain, food, agriculture, and value chain are among the top keywords identified. The five most popular words on top of the list in Table 2 occur because they were the search keywords chosen in this study. The keywords of ‘Sustainability’ and ‘Sustainable development’ are the most interesting since there is an implication that much of ASC research concentrates on sustainability issues of ASC.

**Table 3.** Most frequently used keywords in the topic of agri-food SCM.

Keywords	Frequency	Keywords	Frequency
Supply Chain Management	391	Sustainable Development	72
Supply Chains	357	Decision Making	67
Food Supply	259	Marketing	64
Supply Chain	241	Food Market	60
Agriculture	161	Agricultural Products	59
Food Industry	142	Optimization	59
Food Safety	103	Traceability	59
Food Supply Chain	103	Innovation	53
Value Chain	96	Logistics	53
Sustainability	93	Value Chains	50

### 3.3. Journal Quality

Twenty journals with 89 or more publications form the main source of ASC-related articles included in this review (Table 4). In terms of the journal quality of the top 20 journals, the IFs (Impact Factors) range from 0.443 to 5.715. There is also one journal without an IF. Generally, journals with an IF higher than one are considered good journals in the social sciences [31]. In addition to the IF, Table 4 also lists the SCImago Journal Rank (SJR) and Source Normalized Impact per Article (SNIP) indicators of the top 20 journals. SJR and SNIP are both widely used to measure the value of a citation and the impact of a journal. SJR reflects the scientific prestige of a journal, while the SNIP measures the contextual citation impact. For these indices, the higher the number, the better the journal’s quality. For the SNIP, a value  $\geq 1$  indicates that the journal is at or above average quality in its field, while a value lower than one means that it is below average [31]. Compare to the IF, CS (CiteScore) is a new metrics standard that gives a more comprehensive, transparent, and current view of a journal’s impact in Scopus.

**Table 4.** Top 20 journals contributing to the area of agri-food SCM.

Source Title	No. Articles	IF	SJR	CiteScore	SNIP
British Food Journal	89	1.206	0.466	1.47	0.756
Supply Chain Management	58	4.072	1.864	4.48	1.873
International Food and Agribusiness Management Review	55	0.443	0.311	0.75	0.963
Food Policy	39	3.086	1.681	3.56	1.943
International Journal of Production Economics	36	3.493	2.216	4.28	2.179
Journal of Cleaner Production	31	5.715	1.615	5.83	2.382
Journal on Chain and Network Science	25	1.128	0.199	0.66	0.327
Advance Journal of Food Science and Technology	22	0.565	0.123	N/A	0.306
European Journal of Operational Research	22	3.297	2.505	3.83	2.339
Journal of Food Engineering	22	3.099	1.479	3.71	1.842
Sustainability	20	1.789	0.524	1.96	0.911
Computers and Electronics in Agriculture	19	2.201	0.896	3.27	1.836
International Journal of Logistics Systems and Management	19	1.61	0.429	1.32	0.649
Food Control	17	3.496	1.462	3.86	1.719
International Journal of Supply Chain Management	17	N/A	0.209	0.46	0.529
Agrekon	16	0.224	0.228	0.46	0.382
Agriculture And Human Values	16	2.337	0.854	1.94	1.065
American Journal of Agricultural Economics	16	1.829	1.428	2.01	1.641
World Development	16	2.848	2.205	3.24	2.427
Industrial Management and Data Systems	15	2.205	0.768	2.59	1.214



### 3.4. Citation Analysis

The top 10 articles based on the frequency of local citations and global citations are illustrated in Table 5. Local citation is the number of times that an article has been cited by other articles within the 1770-article network, while global citation refers to the overall number of citations for these articles. The noticeable gap between the local citation and global citation values; Table 5 indicates that ASC has also attracted the attention of scholars with different backgrounds. (i.e., the articles have been cited by articles not included in the 1770 articles analyzed herein). Furthermore, the order of articles based upon local citation does not necessarily match the global citation order. For instance, Ahumada and Villalobos [8] is ranked 10th locally but 4th globally. This is an interesting result showing that the citation for Ahumada and Villalobos [8] appear to be more popular outside the realm of ASC.

**Table 5.** The top 10 articles by citation data.

Authors (Year)	Local Citations <sup>1</sup>	Global Citations <sup>2</sup>
Renting et al., 2003	180	559
Marsden et al., 2000	113	333
Maloni and Brown, 2006	107	311
Hill and Scudder, 2002	85	157
Hingley, 2005	79	143
Ilbery and Maye, 2005	77	167
Van Der Vorst and Beulens, 2002	73	240
Barrientos et al., 2003	72	173
Roth et al., 2008	58	203
Ahumada and Villalobos, 2009	57	282

<sup>1</sup> Local citations: number of citations within the 1770 articles; <sup>2</sup> Global citations: actual number of Scopus citations.

### 3.5. Co-Citation Analysis

Co-citation visualization mapping is one kind of exploratory data analysis that leverages graph theory [32]. A network of co-citation consists of node set indicating articles and edge set indicating the co-occurrence of nodes/articles [33]. Co-citation analysis is used to map and classify the ASC literature. It has been shown that articles are more likely to be related and belong to a similar subject area when they are cited together by other articles [34].

After generating “.net” file from BibExcel, we use Gephi to open it for further co-citation mapping. The initial result from Gephi revealed that 447 articles had been co-cited by other articles within 1770 articles. To make our analysis more precise, we chose articles whose local citation number is greater than or equal to 7 ( $N \text{ value} \geq 7$ ). We choose this  $N$  value based on the content of articles, as mapping articles with an  $N$  value of 0–6 does not show clear clusters. Conversely, if we make the lower bound of  $N$  greater than 7, we may omit certain key articles. Ultimately, 188 articles are selected for further co-citation analysis.

### 3.6. Data Clustering: Topical Literature Classification

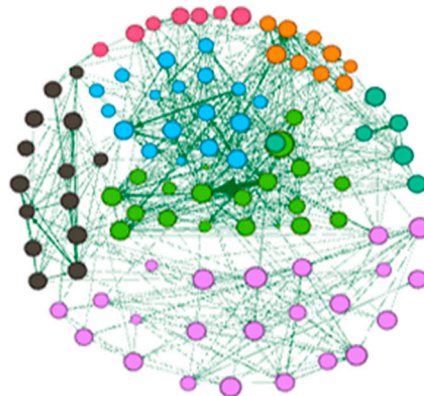
The nodes/articles of a network can be separated into ‘clusters’ [35–37]. Each cluster is regarded as a group of well-connected articles in a theme whilst having little connection to the nodes in other clusters. Data clustering allows for the topological analysis of a co-citation network and for identifying topics, interrelations, and collaboration patterns [38].

We applied the Louvain algorithm in Gephi to determine the optimal number of partitions to maximize the modularity index [39]. Six major clusters were generated by the Louvain algorithm for the filtered 188-node articles by adopting a value of 6 for the degree range node from the 447-node co-citation network in Gephi. The number of articles in each cluster varies from 10 articles in cluster 5 to 54 articles in cluster 6. Figure 2 shows a layered configuration of the six clusters in which the articles in each cluster are included in one separate orbit/circle. The modularity index in Figure 2 is equal to 0.478,

indicating the strong relationship between the nodes within each cluster but a stronger relationship between the nodes in different clusters. This result is evident when comparing the configurations with and without the edges/arcs, as shown in Figures 2 and 3.



**Figure 2.** The layered configuration of the six clusters.



**Figure 3.** The layered configuration with arcs between nodes.

To determine the research focus of each cluster, we needed to identify the “lead articles” in each cluster. This practice is common in other bibliometric analysis articles [39]. A PageRank measure is used to identify the leading articles which are chosen to determine the theme of each cluster (Table 6 lists the 10 leading articles for each cluster identified). After reading the lead articles identified by PageRank, we were able to name the theme of each of the six clusters (Table 7). A detailed content analysis of the six clusters is provided in the next section.

**Table 6.** The lead articles of each cluster: co-citation and PageRank results.

Cluster 1	Cluster 2	Cluster 3
Marsden et al., 2000	Yakovleva et al., 2012	Zanoni and Zavanella, 2012
Renting et al., 2003	Vermeulen, 2010	Shukla and Jharkharia, 2013
Le, 2003	Soosay et al., 2012	Vlajic et al., 2012
Tudisca et al., 2014	Vermeulen and Seuring, 2009	Van Der Vorst et al., 2009
Ilbery and Maye, 2005	Wiese and Toporowski, 2013	Wang et al., 2009
Mikkola, 2008	Maloni and Brown, 2006	Yu and Nagurney, 2013
Starbird, 2005	Teuscher et al., 2006	Salin, 1998
Loader and Hobbs, 1999	Penker, 2006	Rong et al., 2011
Marsden et al., 1999	Sonesson and Berlin, 2003	Wognum et al., 2011
Ilbery et al., 2004	Mintcheva, 2005	Oglethorpe and Heron, 2013



Table 6. Cont.

Cluster 4	Cluster 5	Cluster 6
Tallontire et al., 2011	Taylor, 2006	Zylbersztajn and Filho, 2003
Unnevehr, 2015	Beulens et al., 2005	Whipple et al., 2009
Wilkinson, 2006	Ziggers and Trienekens, 1999	van Hoek, 1999
Tran et al., 2013	Schiefer, 2002	Van Der Vorst and Beulens, 2002
Tallontire et al., 2005	Lindgreen, 2003	Wagner and Young, 2009
Schuster and Maertens, 2013	Stringer and Sang, 2009	Taylor and Fearn, 2006
Schipmann and Qaim, 2011	Fearn et al., 2001	Taylor and Fearn, 2009
Ouma, 2010	Deimel et al., 2008	Taylor, 2005
Reardon, 2015	Engelseth, 2009	Roth et al., 2008
Ponte and Ewert, 2009	Hobbs et al., 1998	Van Der Vorst and Van Dijk, 2001

Table 7. The 6 major research clusters based on co-citation analysis (N = 188).

Cluster	No. of Articles	Area of Research Focus
1	21	Short/alternative supply chains and their role in rural development
2	24	Food supply chain sustainability
3	44	Food supply chain modeling
4	35	Global agri-food supply chains
5	10	Food safety and food supply chain transparency/traceability
6	54	Food supply chain relationships/vertical coordination/networks

#### 4. Discussion

A content analysis based on the six clusters and their evolutions (Table 8) obtained from the co-citation analysis is conducted to identify the detailed sub-themes and insights. A reference list of the 188 publications for content analysis is provided in supplementary materials Table S1.

Table 8. The number of published papers in each cluster.

Year	No. of Published Articles (N = 188)					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
1997						2
1998			1		1	3
1999	3				1	3
2000	1					1
2001	1				1	4
2002	1	1	1		1	4
2003	2	4		2	1	3
2004	1					1
2005	3	1	1	2	1	5
2006	1	3	3	2	1	4
2007	1	1	2	1		3
2008	2		6	2	1	3
2009		3	7	6	2	8
2010		3	1	1		3
2011	1	3	3	2		1
2012		3	7	5		2
2013	2	1	9	5		2
2014	2	1	3	4		
2015				3		2
Total	21	24	44	35	10	54

#### 4.1. Cluster 1: Short/Alternative Food Supply Chains

Cluster 1 is a cluster consisting of 21 articles; we labeled the articles in this cluster in short/alternative ASC studies. As shown in Table 8, Cluster 1 emerged in 1999. One or two papers were published each year between 1999 and 2014 with the exceptions of 1999 and 2005 (3 papers for each). This indicated that the alternative supply chain studies have not gained much attention from ASC scholars. Articles in this cluster can be further classified into the following four sub-themes: (1) definitions of short ASC, (2) antecedents of short ASC's emergence and evolution, (3) short ASC practices, and (4) impact of short ASCs.

In alternative food networks (AFN) and short ASC (SFSC) areas, ASC is defined as a newly emerging network of producers, consumers, and other actors that embody alternatives to the more standardized industrial mode of food supply [40]; several categories of short food supply chains are identified and discussed, including organic farming, quality production, and direct selling [1,41].

Regarding the antecedents of short ASCs, including the driving forces and barriers to the formation of short ASCs, driving forces such as increasing cross-border competition caused by liberalization/globalization [42,43], consumers' concerns regarding food quality [40,44], regulations, laws and policies [40,45], continuing industry concentration [46], and new patterns of consumption and new technology [43]. Important barriers noted include the following, the small number and size of alternative producers, the restrictive influence of bureaucracy, the shortage of key intermediaries in food chains, and the poor provision of key physical infrastructure [42].

With regard to practices of short ASCs, articles of this theme discuss the growth trajectory of specialist food producers and business networks [41,43]. Regarding the impact on, or consequences of alternative ASC with respect to rural development, the impacts of SFSCs on rural development include their contribution to quality enhancement [42], agricultural sustainability [1,47], value creation [48,49], and, most importantly, SC synergy [1,42].

#### 4.2. Cluster 2: ASC Sustainability

Cluster 2 consists of 24 articles, which emerged in 2002 and grew quickly after 2009 (2–3 papers published each year). The cluster is dynamic and has the potential to grow as sustainability in ASC receives more and more attention. We have found papers on food waste management (e.g., Mena et al., 2011; Parfitt et al., 2010), which might be a new and interesting sub-theme of food supply chain sustainability studies. Articles in this cluster focus on ASC sustainability. There are three sub-themes: (1) antecedents of ASC sustainability, (2) its practices, and (3) its consequences.

The forces driving the implementation of sustainable ASCs include alignment with corporate strategy [50], consumer demand [51,52], and government concerns regarding environmental and social issues [50]. The barriers mentioned include information asymmetry [53] and lack of coordination between companies and NGOs [54].

The second sub-theme concerns how sustainable ASC is practiced. Articles in this sub-theme focus on performance indexes/indicators of ASC sustainability development [55–57], value chain analysis (VCA) [51,58], life cycle analysis (LCA) [59,60] and measurements of ecological embeddedness [61]. It is generally agreed that, in ASC, the stakeholders need to be coordinated to achieve increased economic, social, and environmental performance [62].

The third sub-theme concerns the consequences of incorporating sustainability into ASCs. The only article [63] in this cluster notes that by valuing the environmental and social performance of ASCs in corporate goals, companies will gain a competitive advantage through product differentiation.

#### 4.3. Cluster 3: Modeling ASC Traceability, Risk Management, and Optimization

This cluster is the second largest in the ASC literature and it focuses on the modeling of ASC decision issues. It includes 44 articles that emerged in 1998, but it has started to gain momentum since 2006. Generally, there are 2–4 papers published between 2005 and 2015, but there were 6–7 papers

published in 2008, 2009, and 2012, and 9 papers published in 2013. Studies in this area tend to adopt operational research methods, and as a result, mathematical and computerized models are widely performed. This cluster contains the sub-themes: (1) traceability, (2) risk management, (3) logistics and inventory management, and (4) ASC optimization.

Studies in the first sub-theme of ASC traceability apply analytic models to explore how to improve food safety and quality as well as the traceability of ASCs. The models applied in these studies included network-based SC models [64,65], improved newsvendor models [66], fuzzy models [67], suitable tracking and tracing process, decision models [68], and event-driven process chain methodology [69].

The second sub-theme is ASC risk management. Studies published before 2014 mainly propose conceptual models. The conceptual models include qualitative models [70], design planning methods to match supply and demand uncertainties [71], single-retailer models [72], and case studies [15].

The third sub-theme is related to ASC logistics and inventory management. The models applied include multi-attribute decision-making approaches (e.g., TOPSIS) [73], mixed-integer linear programming [74], and geographic information system (GIS) and Route LogiX software [75]. All these models were implemented to reduce inventory cost/losses and to improve logistical efficiency.

The fourth sub-theme is ASC optimization. Different types of models are applied to solve SC optimization problems in the food sector, such as food production, distribution planning [76], and operational efficiency optimization [77]. Ahumada and Villalobos [8] review the planning models used in the ASC literature and found that linear programming (LP), dynamic programming (DP), and stochastic modeling approaches tend to be adopted.

#### 4.4. Cluster 4: Global ASCs

Cluster 4 includes 28 articles emerged in 2003; 1–2 papers were published per year until 2009 and between 2012 and 2015 with 3–5 papers published each year. The studies primarily discuss ASC in a global context. There are four sub-themes: (1) the impact of global trade on ASC in developing countries, (2) the impact of global trade on smallholder farmers, (3) ASC management practices in developing countries, (4) and ethnicity/gender-related value chain studies.

The first sub-theme dominates this cluster and focuses on the impact of global trade on ASC in developing countries. Most of the articles in this sub-theme discuss the impact of food safety standards imposed by importing countries on developing countries and how food safety standards influence importing companies' sourcing strategy [78–80].

The second sub-theme in this cluster analyses is how global trade has influenced smallholder farmers in developing countries. Articles in this cluster focus on the following, first, how participation by small farmers in global trade has helped developing countries reduce poverty [81,82]; second, small farmers' choices of market channels [83] and buyer-supplier relationships [84].

The articles in the third sub-theme discuss detailed ASC management practices in developing countries within an international trade context. The studies are diverse, focusing on different stakeholders in the SC, such as cross-country farmers' participation in contract farming [85], SMEs' transformation [16], global value chain governance [86], and the role of farmers' organizations in food sectors [87].

The fourth sub-theme is focused on the employment conditions of women and other informal workers involved in global value chains. This sub-theme is small and contains only three articles. The articles address the importance of gender issues and propose that institutional transformations and the focal company's social responsibility initiatives contribute to solving gender issues in global value chains [88–90].

#### 4.5. Cluster 5: ASC Transparency and Traceability

Cluster 5 is the smallest cluster of ASC studies; 10 articles were all published between 1998 and 2009. This cluster emerged in 1998, but it has never been dynamic. This may be because the key food security issues are also covered in other clusters such as Cluster 2 (ASC sustainability) and

Cluster 3 ASC modeling. We believe that, given the concerns over food security, Cluster 5 may become popular in the future. The articles in this cluster are divided into three sub-themes and concentrate on discussing (1) SC traceability, (2) SC transparency, and (3) the relationship between SC coordination and food safety.

With regard to studies related to food safety and SC traceability (sub-theme 1), researchers mainly discuss how to detail the certifications and supporting systems developed in the ASC traceability ecosystem [91].

ASC transparency (sub-theme 2) is a new and emerging theme. Beulens, et al. [92] pose several important questions: What are the costs and benefits of adopting food chain transparency best practices? How should transparency be measured? Deimel, et al. [93] presented empirical evidence to provide a more comprehensive understanding of the determinants and the effects of various degrees of transparency in German pork and dairy SCs.

Some studies identify the links between food safety and SC coordination in the ASC (sub-theme 3). Researchers found that SC coordination and successful partnerships can contribute to food safety and environmental sustainability.

#### 4.6. Cluster 6: ASC Relationships/Vertical Coordination/Networks

Cluster 6 is the largest cluster of ASC studies. It contains 52 articles that emerged in 1997 and is evergreen from the start i.e., there were 3–5 papers published each year during the whole duration and 8 papers were published in 2009. It is still considered a promising research direction for ASC. Articles in this cluster are focused on ASC relationships/vertical coordination networks. There are four sub-themes: (1) driving forces of and barriers to ASC vertical coordination/collaborations in ASCs, (2) the strategic design of ASCs from the perspective of focal firms, (3) the role of SC collaboration in value creation in ASCs, and (4) ASC risk management and resilience.

With respect to the first sub-theme, Fearne [94] identified the driving forces of SC coordination, which include changing consumer demand, food safety scandals, and SC risks. Anastasiadis and Poole [95] noted that barriers include incomplete information sharing, coordination difficulties due to the number of linking entities, lack of trust among stakeholders, malfunctions originating from diverse strategic planning practices, different entrepreneurial mentalities, and failure to understand opportunities in agri-food sectors.

For the second sub-theme, the research focuses on different types of ASC strategies (i.e., lean, agile, and hybrid). Discussions of lean and agile SC strategies are common in studies of British red meat and UK beef chains [96]. It is commonly recognized that the competitiveness of SC strategies may be promoted by a more efficient procurement system, better coordination [97], and postponement management [98,99].

Studies in the third sub-theme focused on the role of ASC collaboration in value creation, offering solutions to improve value added methods and reduce cost and waste along the chain. The means that improve the economic performance of ASCs which were necessary to include were the improvement of information sharing [100,101] and adoption of efficient consumer response (ECR) [102,103]. A factor that hindered value creation throughout the chain was outdated information on market demand [104].

The fourth sub-theme is small and concentrates on ASC risk management and resilience. The risks noted include food safety incidents [105]; changes in markets, products, technology, competitors, and governmental regulations [106]; demand uncertainty [107]; environmental uncertainty; and information asymmetry [108].

## 5. Discussion and Future Research Directions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

Based on the results of the bibliometric and content analyses, several implications for future ASC research can be identified and are derived from individual clusters and from general categories that cut across clusters (Table 9).

**Table 9.** Research gap and future directions based on clusters and categories.

Clusters/Categories	Gap/Issue	Research Direction
Cluster 1	Dominated by studies from the UK and EU Countries	Alternative/short food supply chains in developing countries/regions
Cluster 2	Lack of research on how sustainability practices are implemented in ASC	How to implement sustainable initiatives and integrate sustainable criteria in supplier selection and development
Cluster 3	Dominated by modeling micro-level risk sources in supply chains	Modeling of macro-level (policy) risks in supply chains
Cluster 4	Lack of detailed mechanisms of global ASC management; lack of research on the effects of global ASC on women	Examine the role of agricultural cooperatives in global ASC management Call for more research on the effects of global ASC on women and minority groups
Cluster 5	Mechanism by which supply chain coordination influences ASC traceability and transparency is under-explored	Exploring the mechanism is fundamental to food safety research within ASC
Cluster 6	New topics received inadequate attention	Focus on new topics, such as e-commerce in the food supply chain, corporate social responsibility (CSR) in the food supply chain, and relationship marketing
Disciplines	Studies were conducted in a disciplinary silo	Call for a cross-disciplinary approach
Research method	Dominated by case studies/conceptual research/modeling methods	Quantitative research providing statistical evidence based on survey or secondary data is needed
Geographic area	Dominated by developed countries, especially European countries	Extend to developed countries other than European countries and to developing countries
Unit of analysis	Focus on individual actors in ASC	Adopt multi-tier supply chains as the unit of analysis
Longitudinal/snapshot	There are few longitudinal studies	Conduct more longitudinal studies
Underpinning theory	Grand theories (e.g., resource-based view (RBV) and Transaction Cost Economics (TCE) adopted are very limited	Apply or develop different theories for ASC research
Research topics	Lack of attention to emerging issues/practices (e.g., e-commerce in ASC)	General SCM research topics, e.g., ASC resilience and ecommerce adoption in ASC, should be more closely examined in an ASC context

### 5.1. Future Research Directions Derived from Individual Clusters

Cluster 1 (short ASCs) contains studies almost exclusively from the UK (e.g., Marsden et al., 2000; Ilbery and Maye, 2006) and EU countries (e.g., Renting et al., 2003; Blundel, 2002), while studies from other developed countries and developing countries are few. This predominance of studies from the UK and EU may be because short/alternative ASCs are not as developed in other areas than the UK and EU. However, this does not mean that there are no alternative ASCs in developing countries. With changes in consumer demand, different types of short ASCs are emerging in developing countries. Studies on alternative ASCs in developing countries may be a future research direction for this cluster.

Cluster 2 (sustainability in ASCs) focuses on the introduction of sustainability practices in large food companies (i.e., Nestlé) [109,110] and on the sustainable performance/sustainable value chains of ASCs using the LCA method or scenario analysis [51,57]. However, few of these studies have a theoretical basis. The one exception relies on agency theory [53].

Therefore, the first future direction for sustainable ASCM researchers is to integrate theory, i.e., the resource-based view (RBV), resource dependence theory, dynamic capabilities, agency theory,

social network theory, and organizational learning theory, into their work. For example, a recent study by Wilhelm et al. (2016) studied the double agency role of tier 1 suppliers (who serve as the agent for focal firms and the principle for sub-tier suppliers) of a focal company in a multi-tier SC using four cases in different food sectors, extending agency theory to multi-tier SSCM.

Second, although there are articles discussing certification and standards adoption in sustainable food SCM [111,112], there is a lack of detail regarding how to implement sustainable initiatives in ASCs, i.e., detailed recommendations for how to incorporate sustainable criteria into supplier selection and development and discussion of how the adoption of certification is linked to firm performance. In the SSCM literature, two methods are being used to investigate certification adoption and firm performance. One is content analysis of sustainability reports [113] and the other is secondary data analysis [114]. Future research can adopt either but should focus on agricultural sectors by examining the effects of adoption of fair trade or Forest Stewardship Council certification on firm performance using secondary data analysis or the content analysis method.

For Cluster 3 (ASC modeling), we identified five future research directions based on the research gaps that we found. First, the uncertainties from new types of risks need to be taken into account when conducting research on ASC modeling for risk optimization. For example, macro-level risks, such as environmental risks and policy risks, which have a substantial influence on SC performance [115], need to be addressed. Our review reveals that current studies focus more on modeling micro-level risks, such as demand management uncertainty [116], supply management uncertainty [117], production management uncertainty [118], information management risk [119], and food safety uncertainty (Wang et al., 2009), while macro-level risks have not been fully explored. Attempts to model weather risks have been made [72,120], but attempts to model policy uncertainties have not. Therefore, a future direction for this cluster may be modeling farmers' adaptations to climate change, such as farm-level decisions on production, selling, purchasing, and storage under different weather conditions, and modeling agricultural structural change under policy uncertainties, particularly in developing countries, where policies governing the agricultural sector (i.e., subsidy and environmental protection policies) change constantly.

Another risk that has been neglected is endogenous uncertainty related to collaborative activities [121]. Specifically, uncertainties may arise from the opportunistic behaviors that occur during collaborations among supply chain stakeholders. For example, in the agri-food system, farmers in developing countries may be more likely to fail to fulfill their contracts due to the small-scale farming-dominated supply structure and fluctuating market price [87], which makes the agricultural system more complex than the manufacturing sector. The only relevant paper we found was that by Burer, Jones and Lowe [72], which examines contract practices between suppliers and retailers in the seed industry. Therefore, modeling small farmers' behavior under different types of buyer-supply relationships (i.e., short-term contract, long-term contract, strategic alliance, and vertical integration) would be a useful research aim and would help cooperatives/firms/intermediaries to make decisions on the types of relationships they establish with small farmers in developing countries.

The second future research direction concerns the methodologies/models used in risk optimization. The existing research has adopted stochastic programming [122,123] and robust programming [124,125] to optimize agricultural decision-making under uncertainty. The models commonly applied include TSP, SP, and fuzzy-elements-added models; however, dynamic and stochastic processes are rarely addressed simultaneously [117] using stochastic dynamic models (SDP) or multi-stage programming (MSP). Therefore, models such as SDP and MSP should be applied in the future to further relax the assumptions when designing models, assuming the uncertainty of both the stochastic and dynamic dimensions. For example, when modeling farm-level operating decisions, SDP or MSP can be adopted to optimize the decision by considering weather change/yield risk (stochastic dimension) and the price fluctuation/dynamic behavior of contracted farmers (dynamic dimension) simultaneously.



Third, it is found that the current literature proposes single-objective models for the related logistical problems [126], while companies must actually balance multiple objectives in logistics management. Moreover, these objectives may be in conflict with each other, for example, profit vs. sustainability and quality vs. cost. Therefore, researchers need to develop multi-objective programming models to handle decision problems in logistics management.

Fourth, quantitative modeling methods for supply chain traceability [127,128] and food waste in supply chain management [126] are still lacking, despite the fact that there are many issues to be solved in these two areas that require modeling methods; examples include how agri-food firms determine the optimal level of investment of RFID/IT technology [66] and the design and operation of pack houses to increase traceability [129].

The last future research direction could be to extend the modeling from the supply chain perspective to the supply network perspective in the agricultural sector, and such research (supply network modeling) has been performed for manufacturing supply chains [130–132] using social network analysis. The concept of a supply network has been noted in agri-food supply chain studies [133]; however, few modeling studies adopting a supply network perspective have been performed. A recent paper [134] develops a risk propagation model for agri-food supply chain risk management based on the susceptible-infected-remove (SIR) model, which models the evolution process of risk in a supply chain network. It is argued that an agri-food supply network has a large number of inter-connected nodes and is much more complex than a supply chain, and modeling of an agri-food network better captures reality than modeling of an agri-food supply chain. Therefore, more research could be conducted to model risks in the agri-food supply network.

It appears that Cluster 4 (Global ASC) is a well-developed research area in ASC studies, which means that a broad range of topics have been discussed using various methods. The effects of food safety certification have been extensively researched. However, it is not clear what the detailed mechanisms of global ASC management are. Future research can examine the role of agricultural cooperatives in managing the global ASC [135–137]. Due to the difficulties of collecting data on social sustainability, the effects of the global ASC on women and minority groups remain under-researched [88–90]. More research in this direction is warranted.

The themes of Cluster 5 (food safety/traceability) are of great importance in ASC studies; however, there are few articles in this cluster, and it is in a state of inertia. The mechanisms by which SC coordination affect ASC traceability are not well understood. Some authors (e.g., Lindgreen, 2003) began focusing on the role of trust (as a coordination mechanism) in shaping ASC traceability and transparency. Future research can explore the detailed relations among coordination mechanisms, SC traceability/traceability, and food safety.

Cluster 6 (ASC relationships) is a research area that continues to receive attention in ASC studies. However, we observe that resilience in ASC is under-explored. Within agricultural SCs, risks are inherent and varied due to a range of factors, including current climate sensitivity, the sensitive nature of biological processes, the complex structure of the industry, the pronounced seasonality of production and adverse changes in market prices, geographical separation between producers and end users, and the unique social and economic uncertainty of food and agriculture sectors, both domestic and international [138]. Creating more resilient SCs may provide a better approach to managing and mitigating such risks and challenges facing businesses today and in the future. SC resilience encompasses the ability to prepare for unforeseen disruptions and to respond to, and recover from, them better than competitors do [139,140]. Most of the studies on SC resilience have been conducted in a non-ASC context. In future, more research on ASC resilience should be conducted.

## 5.2. Future Research Directions Based on General Categories

In addition to the directions for future research derived from the six clusters, further directions are derived from general categories that cut across all the 188 articles reviewed and have implications for future research (Table 9).

After reviewing the 188 articles, we found they tend to belong to the disciplines of operations management/supply chain management (OM/SCM), agricultural economics and food (AE), development studies, and operations research (OR). The studies also tended to use disciplinary methods (LCA, modeling, and case studies); the remaining disciplinary silos and the number of cross-disciplinary studies were small (only 9 articles in total). There is a need for a cross-disciplinary approach combining the strengths of individual disciplines. For example, OM and OR methods are complementary and can be used in the same ASC study. The case study methods of OM research and the econometric methods of AE research can be integrated to obtain more robust results and insights.

Regarding research methods, ASC studies are dominated by case studies and conceptual framework development research. Though such studies provide abundant case-based evidence of ASC practice, quantitative research methods such as surveys or secondary data analysis are also needed to provide statistical data to test hypotheses. Modeling is widely adopted by OR researchers in the ASC field. Longitudinal studies are rarely found in ASC research (only 9 articles in total used longitudinal data). Our literature review reveals that the dynamic evolution process of implementing ASC initiatives based on a multi-stakeholder approach offers additional insights into the adoption of ASC initiatives. Chris, et al. [141] advised that longitudinal case study research can yield powerful in-depth insights (though limited in generalizability) and can address the problems caused by other methods, as the longer the period in which the phenomena were studied, the greater the opportunity there is to observe the sequential relationships of events, which is ideal for theorizing. Therefore, exploration of food SCM using longitudinal data will create new insights for ASC in the future.

Regarding the geographic areas of the studies, current ASC studies are concentrated in developed countries, including EU countries (45 articles), the UK (42), the USA (12), Australia (3), New Zealand (2), and multiple developed countries (9). The total number of articles that focused on developed countries was 129 (56.1%). The number of articles that focused on developing countries was 50 (21.7%, including both single country and multiple country studies). Fifty-three studies did not provide country information. Given the large number of developing countries, the percentage of studies devoted to developing countries and published in international journals was low. Developing countries that received the most attention in ASC research (only single-country studies were counted), included Kenya (5), South Africa (4), Indonesia (3), China (2), Turkey (2), Brazil (1), and India (1). It is clear that more ASC research needs to be conducted in developing countries in all six clusters.

Regarding the unit of analysis, ASC studies tend to be focused on small farmers/producers [1,81,83,87,142], large companies [110], consumers [43], institutions, and government [50]. There is a lack of research adopting the ASC as a whole as a unit of analysis. In general SCM research, multi-tier SCs are a new research topic [143]; future ASC research should increasingly adopt whole chain or whole supply networks as a unit of analysis to obtain a comprehensive view of ASC topics.

ASC studies tend to be atheoretical (without theoretical basis) and are primarily descriptive; they provide empirical evidence for SCM studies using case studies/conceptual building/modeling (articles adopting case study methodology tend to be descriptive and are not theory-building-driven). Thus, the application of high level theories of the firm (e.g., RBV, Transaction Cost Economies (TCE), and agency theory) to develop middle-range theories in SCM [144] remains rare. Future research should link the topic/phenomenon to grand theory and strive to develop and extend grand theories to an ASC context.

Finally, several emerging general SCM research topics are under-represented in ASC research but might be interesting to investigate in the future, e.g., ASC power dynamics and supply network analysis, the institutional environment of the global ASC, ASC risk management and resilience and the adoption of e-commerce in ASC. The incorporation of e-commerce into ASCs in China presents a good example of how the internet helps smallholder farmers obtain access to the global market [145]. In the future, some of the general SCM research topics should be closely examined in an ASC context.

## 6. Conclusions

This paper uses a systematic literature review method combined with citation and co-citation analyses to gain insight into the knowledge structure of ASC research. Six clusters are obtained from the co-citation analysis. ASC has been identified as an important and significant research field and is multi-disciplinary in nature. The upward trend of the number of publications in this area confirms this tendency. Bibliometric analysis tools are used to analyze the ASC literature, to explore the evolution of this research field and to identify emerging trends. Furthermore, we conducted a content analysis to provide more distinct insights into each theme/cluster in this field and to complement the co-citation analysis. Based on the findings, we propose a number of actionable future research directions.

This research makes several important contributions. First, this is the first paper to systematically review the ASC literature and report the knowledge structure of ASC research. Second, the knowledge structure reveals six main themes and shows their evolution, highlighting the mature and new/emerging fields. Third, based on all the analyses, a number of future research directions are proposed.

Despite its scholarly contributions, this study is not without limitations. The greatest limitation of this study may be that the major reason underlying the choice to use the combined approach is to conduct an analysis of the literature in a more objective manner, thus limiting researcher bias. Nevertheless, subjectivity remains, especially in terms of selecting the most relevant articles for final review. However, we believe that having more than two researchers involved in the selection process limited the subjective bias.

**Supplementary Materials:** The following are available online at <http://www.mdpi.com/2071-1050/10/5/1573/s1>, Table S1: Content analysis of the 188 papers.

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